FINAL

QUALITY ASSURANCE PROJECT PLAN

RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION
Military Munitions Response Program
Former Gun and Trench Mortar Range Munitions Response Site (RFAAP-002-R-01)
Radford Army Ammunition Plant
Radford, Virginia

Contract No.: W912DR-15-D-0022
Delivery Order No.: W912DR18F0492

Prepared For:

U.S. ARMY CORPS OF ENGINEERS
Baltimore District, Baltimore, Maryland

and

RADFORD ARMY AMMUNITION PLANT
Radford, Virginia

Prepared By:

WESTON SOLUTIONS, INC.
2 Eaton Street, Suite 603
Hampton, Virginia 23669

JUNE 2020

This Page Intentionally Left Blank

TABLE OF CONTENTS

Section **Page**

INTRODUCTION **1**

WORKSHEET # 1 AND #2 - TITLE AND APPROVAL PAGE **2**

WORKSHEET # 3 AND #5 - PROJECT ORGANIZATION AND QAPP DISTRIBUTION **4**

WORKSHEET # 4 , #7, AND #8 - PERSONNEL QUALIFICATIONS AND SIGN-OFF SHEET **7**

WORKSHEET # 6 - COMMUNICATION PATHWAYS AND PROCEDURES **9**

WORKSHEET # 9 - PROJECT PLANNING SESSION SUMMARY **12**

WORKSHEET # 10 - CONCEPTUAL SITE MODEL **15**

10.1 OVERVIEW 15

10.2 FACILITY PROFILE, SITE DESCRIPTION AND BACKGROUND 15

10.2.1 Site Location 15

10.3 SITE HISTORY AND USE 15

10.4 PREVIOUS INVESTIGATIONS 17

10.4.1 Site Inspection 17

10.4.2 Topographical Fill Analysis Report 18

10.4.3 Identification of MEC and MC Known or Suspected to be Present 24

10.5 PHYSICAL PROFILE 25

10.5.1 Topography 25

10.5.2 Vegetation 25

10.5.3 Soils and Geology 26

10.5.4 Hydrology and Hydrogeology 26

10.5.5 Climate 27

10.5.6 Cultural Resources 27

10.5.7 Ecological Profile 28

10.5.8 Site Access and Areas Inaccessible for Investigation 28

10.6 RELEASE PROFILE 28

10.6.1 Land Use Exposure Profile 28

10.6.1.1 Current Land Use 28

10.6.1.2 Anticipated Future Land Use 29

10.6.1.3 Potential Receptors and Exposure Pathways 29

10.6.1.4 Associated Munitions Constituents 29

10.7 CONCEPTUAL SITE MODEL SUMMARY 30

WORKSHEET # 11 - PROJECT/DATA QUALITY OBJECTIVES **34**

WORKSHEET # 12 - MEASUREMENT PERFORMANCE CRITERIA **44**

TABLE OF CONTENTS (CONTINUED)

Section **Page**

WORKSHEET # 13 - SECONDARY DATA USES AND LIMITATIONS 48

WORKSHEET # 14 AND #16 - PROJECT TASKS AND SCHEDULE 49

WORKSHEET # 15 - PROJECT ACTION LIMITS AND LABORATORY-SPECIFIC DETECTION/QUANTITATION LIMITS 55

WORKSHEET # 17 - SURVEY DESIGN AND PROJECT WORK FLOW 58

17.1 THREE-PHASE INSPECTION PROCESS 58
17.1.1 Preparatory Phase 58
17.1.2 Initial Phase 62
17.1.3 Follow-up Phase 63
17.2 DFW 1: MOBILIZATION 63
17.3 DFW 2: SITE PREPARATION 65
17.4 DFW 3: VEGETATION CLEARANCE 65
17.5 DFW 4: PROFESSIONAL LAND SURVEY AND GRID ESTABLISHMENT 65
17.6 DFW 5: GEOPHYSICAL SYSTEM VERIFICATION 66
17.6.1 IVS 66
17.6.2 BLIND SEEDING PROGRAM 67
17.7 DFW 6: EM31-MK2 SURVEY 68
17.8 DFW 7: DYNAMIC DETECTION SURVEY (AGC METALMAPPER 2X2) 68
17.9 DFW 8: CUED SURVEY (AGC METALMAPPER 2X2) 69
17.9.1 Classification 70
17.9.1.1 Site Specific Library 70
17.9.1.2 Library Matching 71
17.9.1.3 Cluster Analysis/Feature Space Analysis 71
17.9.2 Verification and Validation Plan 72
17.9.2.1 Target Selection Verification 72
17.9.2.2 Library-Match Threshold Verification 72
17.9.2.3 Cluster Analysis Verification 73
17.9.2.4 Feature Analysis Verification 73
17.10 DFW 9: INTRUSIVE INVESTIGATION, ANALOG MAG AND DIG, AND MECHANICAL TRENCHING 73
17.10.1 Analog Surveys 73
17.10.2 Intrusive Investigation 74
17.10.3 Mechanical Trenching/Test Pitting 75
17.11 DFW 10: G-858 SURVEY OF AREA A (NEW RIVER) 75
17.12 DFW 11: DIVE OPERATIONS OF AREA A (NEW RIVER) 76

TABLE OF CONTENTS (CONTINUED)

Section **Page**

17.13 DFW 12: MPPEH/MEC AND MDAS HANDLING, CERTIFICATION, AND DISPOSAL 78
17.13.1 MEC Identification 78
17.13.2 MEC Removal 78
17.13.3 MEC Storage 78
17.13.4 MEC Disposal 78
17.13.4.1 General MEC Disposal Procedures 78
17.13.4.2 Material Potentially Presenting an Explosive Hazard 80
17.13.4.3 Material Documented As Safe 80
17.13.4.4 Material Potentially Presenting an Explosive Hazard Documentation 81
17.14 DFW 13: MC SAMPLING 82
17.14.1 MC Characterization – DU1 Area Lead Concentrations 82
17.14.2 MC Characterization – Damaged/Corroded Munitions Areas 85
17.14.3 Area A Sediment Sampling Activities 85
17.15 DFW 14: SITE RESTORATION 86
17.16 DFW 15: DEMOBILIZATION 86
17.17 REPORTING 86
17.17.1 RFI Report 86
17.17.1.1 Human Health Evaluation 87
17.17.1.2 Environmental Evaluation 87
17.17.1.3 MEC Risk Assessment 87
17.17.1.4 MRSPP 87
17.17.2 CMS 88
17.17.3 Internal Draft Army Decision Document 88
WORKSHEET # 18 - SAMPLING LOCATIONS AND METHODS 89
WORKSHEET # 19 AND #30 - SAMPLE CONTAINERS, PRESERVATION, AND HOLD TIMES 90
WORKSHEET # 20 - FIELD QUALITY CONTROL SUMMARY 91
WORKSHEET # 21 - FIELD STANDARD OPERATING PROCEDURES 92
WORKSHEET # 22 - FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION 96
WORKSHEET # 23 - ANALYTICAL STANDARD OPERATING PROCEDURES 107
WORKSHEET # 24 - ANALYTICAL INSTRUMENT CALIBRATION 108
WORKSHEET # 25 - ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION 111

TABLE OF CONTENTS (CONTINUED)

Section **Page**

WORKSHEET # 26 AND #27 - SAMPLE HANDLING, CUSTODY, AND DISPOSAL 112

WORKSHEET # 28 - ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION 113

WORKSHEET # 29 - DATA MANAGEMENT, PROJECT DOCUMENTS AND RECORDS 117

WORKSHEET # 31 , #32, AND #33 - ASSESSMENTS AND CORRECTIVE ACTION 124

WORKSHEET # 34 - DATA VERIFICATION AND VALIDATION INPUTS 130

WORKSHEET # 35 - DATA VERIFICATION PROCEDURES 132

WORKSHEET # 36 - DATA VALIDATION PROCEDURES 138

WORKSHEET # 37 - DATA USABILITY ASSESSMENT 140

37.1 DUA PROCESS SUMMARY FOR GEOPHYSICS 140

37.2 DUA DOCUMENTATION 141

37.3 DUA PROCESS SUMMARY FOR SOIL/SEDIMENT SAMPLING 141

REFERENCES 143

LIST OF TABLES

Table **Page**

Table 10-1 1949 Aerial Photograph Features of Interest 20
Table 10-2 MEC Conceptual Site Model Pathway Analysis Summary 31
Table 12-1 Measurement Performance Criteria for DGM/AGC Surveys and Intrusive Investigations 44
Table 12-2 Measurement Performance Criteria Table –Project Metals by EPA Method 6010C 46
Table 12-3 Measurement Performance Criteria Table – Explosives Method USEPA SW-846 8330B 47
Table 17-1 Project Field Team 64
Table 17-2 Minimum Separation Distances 79
Table 22-1 Dynamic Detection Survey (Instrument: EM31-MK2) 96
Table 22-2 Dynamic Detection Survey (Instrument: G-858) 97
Table 22-3 Dynamic Detection Survey (Instrument: MM2X2) 98
Table 22-4 Cued Survey (Instrument: MM 2x2; Classification Tool: Geosoft Oasis Montaj UX-Analyze Adv) 100
Table 22-5 Intrusive Investigation (Area A) 104
Table 22-6 Intrusive Investigation (Analog) 105
Table 22-7 Intrusive Investigation (AGC) 106
Table 29-1 Minimum Required Documents and Records 119
Table 29-2 Minimum Required Documents and Records for Soil/Sediment Sampling 122
Table 31-1 Assessments 124
Table 31-2 Corrective Action 127
Table 31-3 Assessments for Soil Sampling 129

LIST OF FIGURES

Figure **Page**

Figure 17-1 Geophysical Classification Decision Tree – Preliminary Tasks and Anomaly Detection Survey 59

Figure 17-2 Geophysical Classification Decision Tree – Cued Survey 60

Figure 17-3 Geophysical Classification Decision Tree – Intrusive Investigation 61

LIST OF APPENDICES

Appendix A – Site Maps

Figure A-1 – Radford Army Ammunition Plant Location Map
Figure A-2 – Former Gun and Trench Mortar Range and Area A Site Map
Figure A-3 – Topographic Change within the Former Gun and Southern Trench Mortar Ranges
Figure A-4 - Topographic Change within the Former Trench Mortar Range
Figure A-5 – Fill Areas within the Former Gun and Southern Trench Mortar Ranges
Figure A-6 – Fill Areas within the Former Trench Mortar Range
Figure A-7 – Geophysical Investigation Map
Figure A-8 – MC Sampling Map

Appendix B – DAGCAP Certifications

Appendix C – Technical Project Planning Meeting Minutes

Appendix D – Final Topographic Fill Analysis Report

Appendix E – MC Sampling Memorandum

Appendix F – Blind Seed Firewall Plan

Appendix G – Contractor Forms *(Provided on CD)*

Appendix H – Field Standard Operating Procedures *(Provided on CD)*

Appendix I – Project Schedule

Appendix J – Analytical SOPs *(Provided on CD)*

Appendix K – Quality Control Plan

Appendix L – Environmental Protection Plan

Appendix M – Advanced Geophysical Classification SOPs *(Provided on CD)*

Appendix N – Verification and Validation Plan

Appendix O – Explosives Site Plan *(Provided on CD)*

Appendix P – Explosives Management Plan

Appendix Q – Human Health and Ecological Risk Assessment Methodology

Appendix R – MEC Risk Management Methodology

Appendix S – Laboratory QA Manual *(Provided on CD)*

ACRONYMS AND ABBREVIATIONS

β	beta
%	percent
%R	percent recovery
AEDB-R	Army Environmental Database - Restoration
AGC	advanced geophysical classification
AGC-QAPP	Advanced Geophysical Classification – Quality Assurance Project Plan
AHA	activity hazard analysis
APP	Accident Prevention Plan
ASR	Archives Search Report
AVS	assisted visual survey
B.A.	Bachelor of Art
BAE	BAE Systems, Inc.
BATFE	Bureau of Alcohol, Tobacco, Firearms and Explosives
bgs	below ground surface
BIP	blow-in-place
B.S.	Bachelor of Science
BSEn	Bering Sea Environmental, LLC
CA	corrective action
CAMBL	Continuous Automated Multi-Base Line
CAR	correction action request
CAS	Chemical Abstract Service
CCV	continuing calibration verification
CENAB	U.S. Army Corps of Engineers Baltimore District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS	corrective measures study
CoC	chain of custody
COR	Contracting Officer's Representative
CSM	conceptual site model
CQM-C	Construction Quality Management for Contractors
DAGCAP	DoD Advanced Geophysical Classification Accreditation Program
DDESB	Department of Defense Explosives Safety Board
DEM	digital elevation model
DFW	definable features of work
DGM	digital geophysical mapping
DID	data item description

ACRONYMS AND ABBREVIATIONS (CONTINUED)

DL	detection limit
DMM	discarded military munitions
DOC	demonstrations of capability
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
DU	Decision Unit
DUA	Data Usability Assessment
Eco-SSL	ecological soil screening level
EDD	Electronic Data Deliverable
EM	Engineering Manual
EMI	electromagnetic induction
EMP	Explosives Management Plan
EOD	explosive ordnance disposal
EPP	Environmental Protection Plan
ESL	ecological screening level
ESS	Explosives Safety Submission
ESTCP	Environmental Security Technology Certification Program
FCA	Function Check Area
ft	feet
FTP	file transfer protocol
GCO	Geophysical Classification Organization
GDS	Geospatial Data Submission
GIS	geographic information system
GPS	global positioning system
GSV	geophysical system verification
H&S	health and safety
HE	high explosive
HFD	hazardous fragment distance
HRR	Historical Records Review
ICAL	initial calibration
ICV	initial calibration verification
IDQTF	Intergovernmental Data Quality Task Force
IDW	investigation-derived waste
ISM	incremental sampling methodology
ISO	industry standard object

ACRONYMS AND ABBREVIATIONS (CONTINUED)

ITS	instrument test strip
IVS	instrument verification strip
KO	Contracting Officer
LANL	Los Alamos National Laboratory
lb	pound
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LiDAR	Light Detection and Ranging
LOD	limit of detection
LOQ	limit of quantitation
m	meter
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
MFD-H	maximum fragmentation distance – horizontal
mg/kg	milligrams per kilogram
MGFD	munitions with the greatest fragmentation distance
MM	MetalMapper
mm	millimeter
MMRP	Military Munitions Response Program
MPC	measurement performance criteria
MPPEH	material potentially presenting an explosive hazard
MQO	measurement quality objectives
MRS	Munitions Response Site
MRSPP	Munitions Response Site Prioritization Protocol
M.S.	Master of Science
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolt
NA	not applicable
NE	not established
NG	nitroglycerin
NGIS	Northrop Grumman Innovative Systems
NMRD	non-munitions related debris
NTCRA	Non-Time-Critical Removal Action

ACRONYMS AND ABBREVIATIONS (CONTINUED)

OESS	Ordnance and Explosives Safety Specialist
OSHA	Occupational Safety and Health Administration
PA	Preliminary Assessment
PAL	project action level
PDF	portable document format
PDT	project delivery team
P.G.	Professional Geologist
PgM	Program Manager
PLS	Professional Land Surveyor
PM	Project Manager
POC	point of contact
PPE	personal protective equipment
QA	quality assurance
QAPP	quality assurance project plan
QASP	Quality Assurance Surveillance Plan
QC	quality control
QM	Quality Manager
QSM	Quality Systems Manual
QSR	Quality Systems Requirements
RAO	remedial action objective
RCA	root cause analysis
RCRA	Resource Conservation and Recovery Act
RFAAP	Radford Army Ammunition Plant
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RMS	root mean square
ROC	receiver operating characteristic
ROD	Record of Decision
RPD	relative percent difference
RSD	relative standard deviation
RSL	Regional Screening Level
RTK	real-time kinematic
RTS	robotic total station
SARA	Superfund Amendments and Reauthorization Act
SCUBA	Self-Contained Breathing Apparatus
SEDD	Staged Electronic Data Deliverable

ACRONYMS AND ABBREVIATIONS (CONTINUED)

SI	Site Inspection
SNR	signal to noise ratio
SOP	standard operating procedure
SSHP	Site Safety and Health Plan
SUXOS	Senior Unexploded Ordnance Supervisor
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TBD	to-be-determined
THQ	target hazard quotient
TNT	trinitrotoluene
TO	task order
TOI	target of interest
TP	Technical Paper
TPC	Third-Party Certification
TPP	Technical Project Planning
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plan
URS	URS Group, Incorporated
U.S.	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTL	Upper Tolerance Limit
UTM	Universal Transverse Mercator
UXO	unexploded ordnance
UXOQCS	Unexploded Ordnance Quality Control Specialist
UXOSO	Unexploded Ordnance Safety Officer
VDEQ	Virginia Department of Environmental Quality
VSP	Visual Sample Plan
WESTON®	Weston Solutions, Inc.
WWII	World War II
XRF	X-ray fluorescence

INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been prepared in support of the Military Munitions Response Program (MMRP) Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) planned for the Former Gun and Trench Mortar Range Munitions Response Site (MRS), Radford Army Ammunition Plant (RFAAP), Radford, Virginia (**Figure A-1**, **Appendix A**). This work is being performed by Weston Solutions, Inc. (WESTON®) under Contract W912DR-15-D-0022, Delivery Order W912DR18F0492.

RFAAP was issued and operates under the Hazardous Waste Management Permit for Corrective Action (EPA ID No. VA1210020730), dated April 2016. The Permit summarizes final remedies for the Solid Waste Management Unit (SWMU) sites and the other corrective action units. The Department of Defense (DoD) primarily uses Comprehensive Environmental Restoration, Compensation and Liability Act (CERCLA) for munitions responses; however, the RFAAP is under a RCRA Corrective Action Permit, and RCRA will be the primary regulatory driver. Therefore, specific investigations for corrective actions, including the RFI and corrective measures study (CMS) will be adhered to following the RCRA Corrective Action Program. RCRA has no special provisions for dealing with explosive safety; therefore, technical requirements and guidance associated with the MMRP and CERCLA will be utilized during performance of the work. RFAAP munitions responses for this MRS will be performed under CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), National Oil and Hazardous Substances Contingency Plan requirements, and with regulatory coordination, as appropriate, with the Virginia Department of Environmental Quality (VDEQ). The RFI is being conducted pursuant to the Environmental Restoration Defense Account and the Defense Environmental Restoration Program, Chapter 160 of SARA.

The purpose of this RFI is to determine the nature and extent of munitions and explosives of concern (MEC) and munitions constituents (MC), if present, at the Former Gun and Trench Mortar Range MRS and adjacent Area A overlapping the New River (**Figure A-2**, **Appendix A**). The RFI will consist of statistically-based digital geophysical mapping (DGM) surveys, advanced geophysical classification (AGC), intrusive investigation of detected anomalies, dive operations to identify MEC in the New River, and environmental media sampling. Results of the field investigation will be used to assess hazards and risks posed by MEC and MC where encountered and determine if further response action under RCRA is warranted. Based on the findings presented in the RFI Report, a CMS will be prepared for the MRS where alternative remedy options are evaluated if an unacceptable risk is identified due to MEC and/or MC.

This QAPP follows the format of the Intergovernmental Data Quality Task Force (IDQTF) Uniform Federal Policy for Quality Assurance Project Plans Manual (UFP-QAPP) (IDQTF, 2005), and the UFP-QAPP optimized worksheets (IDQTF, 2012). This document also meets the requirements and elements set forth in the Department of Defense Quality Systems Requirements for AGC (DoD QSR), Version 2.0, (DoD, 2018). DoD requires organizations implementing AGC to be accredited under the DoD Advanced Geophysical Classification Accreditation Program (DAGCAP). WESTON is DAGCAP accredited as of 21 December 2017. A copy of WESTON's certificate of accreditation is provided in **Appendix B**.

WORKSHEET # 1 AND #2 - TITLE AND APPROVAL PAGE

1. Project Identifying Information:	
a. Site Name/Project Name:	RFI for the Former Gun and Trench Mortar Range MRS
b. Site Location Number	Army Environmental Database – Restoration (AEDB-R) No.: RFAAP-002-R-01
c. Lead Organization	United States Army Corps of Engineers (USACE) Baltimore District
d. Contractor	WESTON
e. Contract Number:	W912DR-15-D-0022, Delivery Order W912DR18F0492

2. Lead Organization:

a. USACE Project Manager (PM):

Nicole Walworth
Printed Name

7/7/2020
Signature/Date

b. USACE Geophysicist/ Quality Assurance (QA) Manager:

David King
Printed Name

7/7/2020
Signature/Date

c. RFAAP Installation Point of Contact (POC)

James McKenna
Printed Name

Signature/Date

3. Prime Contractor

a. WESTON PM

Anthony Pace
Printed Name

6/25/2020
Signature/Date

b. WESTON Quality Manager:

Stacie Popp-Young
Printed Name

6/25/2020
Signature/Date

c. WESTON Geophysical Classification Organization (GCO) Program Manager (PgM)/Quality Manager (QM):

Ryan Steigerwalt, Professional Geologist (P.G.)
Printed Name

6/25/2020
Signature/Date

4. List plans and reports from previous investigations relevant to this project:

MacDonald and Mack. 1984. *Historic Properties Report, Radford Army Ammunition Plant (Including the New River Unit), Radford, Virginia*. August.

Weston Solutions, Inc. (WESTON®). 1992. *Preliminary Assessment Report Addendum for Radford Army Ammunition Plant, Virginia*. March.

USACE. 1993. *Archives Search Report, New River Ordnance Plant, Radford Virginia*. St. Louis District. September.

URS Group, Incorporated (URS). 2003. *Final Master Work Plan, Quality Assurance Plan, Radford Army Ammunition Plant, Radford, Virginia*. August.

Bering Sea Environmental, LLC (BSEn). 2018a. *Final Work Plan, Site Investigation,* Former Gun and Trench Mortar Range MRS, Radford Army Ammunition Plant.

BSEn. 2018b. *Final Site Investigation Report,* Former Gun and Trench Mortar Range MRS, Radford Army Ammunition Plant. September.

WESTON. 2019. Final Topographic Fill Analysis Report, Former Gun and Trench Mortar Range MRS, Radford Army Ammunition Plant. March.

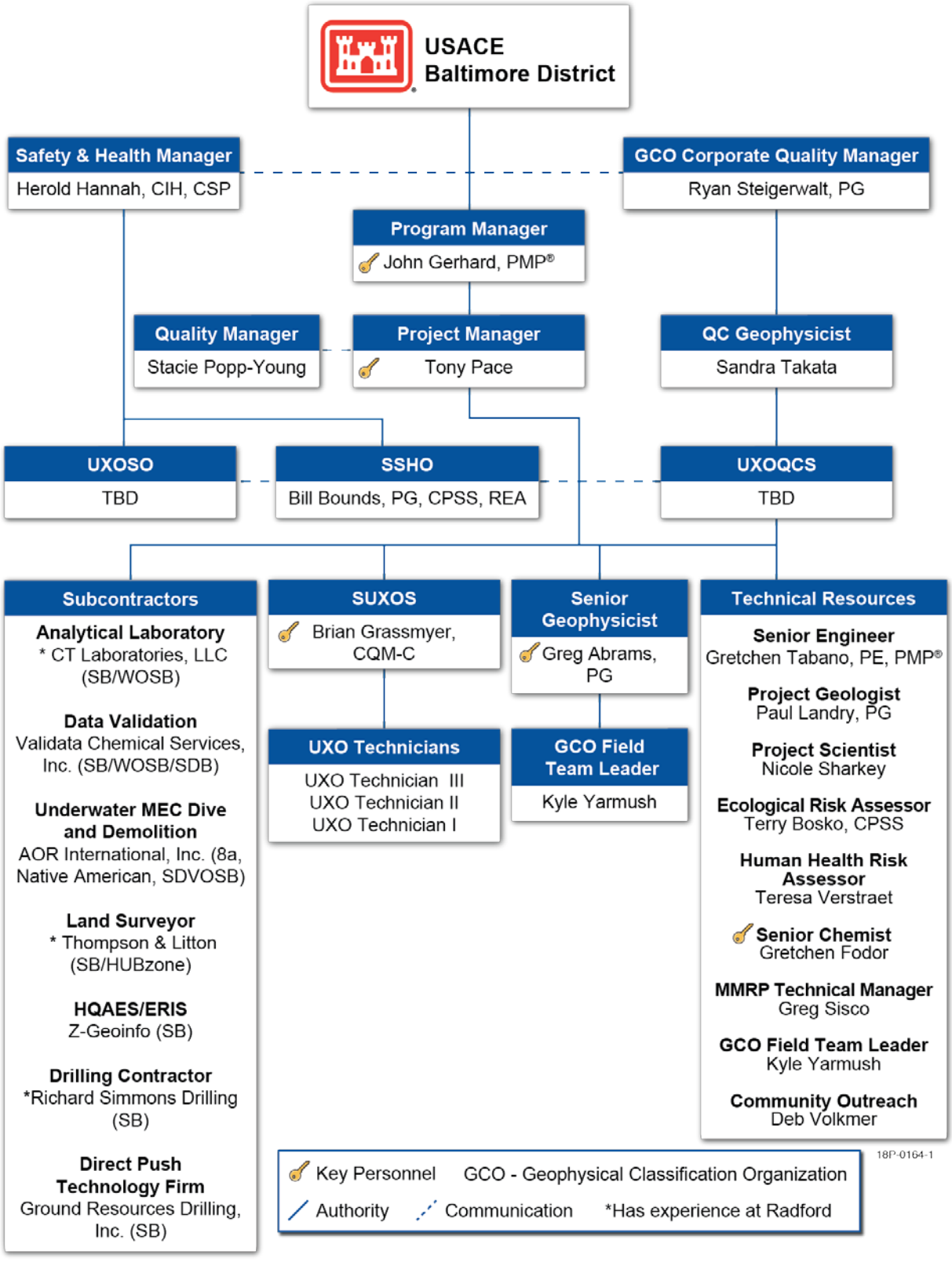
WORKSHEET # 3 AND #5 - PROJECT ORGANIZATION AND QAPP DISTRIBUTION

QAPP Recipients	Title	Organization/Address	Telephone Number	Email Address
Laura Wade	Contracting Officer (KO)	USACE Baltimore District 2 Hopkins Plaza Attn: CENAB-CT Baltimore, MD 21201	410-962-2675	Laura.A.Wade@usace.army.mil
Travis McCoun	Contracting Officer's Representative (COR)	USACE Baltimore District 2 Hopkins Plaza Attn: CENAB-ENE-M, Room 09-F-04 Baltimore, MD 21201	410-962-6728	Travis.McCoun@usace.army.mil
Nicole Walworth	Project Manager	USACE Baltimore District 2 Hopkins Plaza Attn: CENAB-ENE-M, Room 09-F-08 Baltimore, MD 21201	410-962-6735	Nicole.U.Walworth@usace.army.milg
Marty Holmes	Ordnance and Explosives Safety Specialist	USACE Baltimore District 2 Hopkins Plaza Attn: CENAB-ENE-HI, Room 09-E-02 Baltimore, MD 21201	410-962-2258	Marty.A.Holmes@usace.army.mil
James McKenna	RFAAP Installation Point of Contact (POC)	RFAAP Installation Point of Contract Route 114, Peppers Ferry Road ATTN: SJMRF-OP-EQ (James McKenna, Bldg. 220) Radford, VA 24143	540-731-5782	james.j.mckenna16.civ@mail.mil
Tom Colozza	Geophysicist/ QA Manager/ AGC Subject Matter Expert	USACE Baltimore District ATTN: CENAB-EN-GG 2 Hopkins Plaza Baltimore, MD 21201	410-962-6647	Thomas.S.Colozza@usace.army.mil
Mary Ellen Maly	Environmental Support Manager	USAEC 2450 Connell Road JBSA Fort Sam Houston, TX 78234	210-455-1870	Mary.e.maly.civ@mail.mil
Kurt Kochan	Project Manager	Virginia Department of Env. Quality 1111 East Main Street Suite 1400 Richmond, VA 23219	703-583-3825	Kurt.kochan@deq.virginia.gov
Anthony Pace	Project Manager	Weston Solutions, Inc. 2 Eaton Street, Suite 603 Hampton, VA 23669	757-819-5310 (W) 757-362-2461 (C)	Pacea@westonsolutions.com

WORKSHEET # 3 AND #5 – PROJECT ORGANIZATION AND QAPP DISTRIBUTION (CONTINUED)

QAPP Recipients	Title	Organization/Address	Telephone Number	Email Address
Ryan Steigerwalt	GCO Quality Manager	Weston Solutions, Inc. 1400 Weston Way West Chester, PA 19380-1492	267-258-2672	Ryan.Steigerwalt@westonsolutions.com
Sandra Takata	Quality Control (QC) Geophysicist	Weston Solutions, Inc. 1400 Weston Way West Chester, PA 19380-1492	610-701-3119	Sandra.Takata@westonsolutions.com
Greg Abrams	Project Geophysicist/Data Analyst	Weston Solutions, Inc. 1400 Weston Way West Chester, PA 19380-1492	703-599-2840	Greg.Abrams@westonsolutions.com
Kyle Yarmush	GCO Field Team Leader	Weston Solutions, Inc. 1400 Weston Way West Chester, PA 19380-1492	610-701-3740	Kyle.Yarmush@westonsolutions.com
Mike Link	Field Geophysicist	Weston Solutions, Inc. 1400 Weston Way West Chester, PA 19380-1492	480-477-4906	Mike.Link@westonsolutions.com
Brian Grassmyer	Senior Unexploded Ordnance (UXO) Supervisor (SUXOS)	Weston Solutions, Inc. 1400 Weston Way West Chester, PA 19380-1492	757-650-3607	Brian.Grassmyer@westonsolutions.com
TBD	UXO Safety Officer (UXOSO)	Weston Solutions, Inc.	TBD	TBD
TBD	UXO Quality Control Specialist (UXOQCS)	Weston Solutions, Inc.	TBD	TBD
Stacie Popp-Young	Quality Manager	Weston Solutions, Inc. 1400 Weston Way West Chester, PA 19380-1492	610-701-3637	Youngsp@westonsolutions.com
Gretchen Fodor	Project Chemist	Weston Solutions, Inc. 1400 Weston Way West Chester, PA 19380-1492	703-724-0544	Gretchen.Fodor@WestonSolutions.com
Brett Szymanski	Project Manager	CT Laboratories LLC	608-356-2760	Bszymanski@ctlaboratories.com

Project Organizational Chart



WORKSHEET # 4, #7, AND #8 - PERSONNEL QUALIFICATIONS AND SIGN-OFF SHEET

This worksheet is used to identify key project personnel for each organization performing tasks defined in this QAPP. This worksheet lists individuals' project titles or roles; qualifications; and any specialized/non-routine training, certifications, or clearances required by the project.

Organization	Name	Project Title/Role	Education/Experience	Specialized Training/Certification[1]	Signature and Date[2]
WESTON	John Gerhard, PMP	Program Manager	Bachelor of Science (B.S.), Environmental Resource Management; 23 years of MMRP experience, 18 years of project management experience, and 3 years of program management experience.	Project Management Professional	6/30/2020
WESTON	Anthony Pace	Project Manager	B.S., Civil Engineering; 30 years of project management experience and 20 years of MMRP experience		7//2020
WESTON	Ryan Steigerwalt, P.G.	GCO PgM/GCO QM	Master of Science (M.S.) Geology/Geophysics, B.S. Geology; 17 years of munitions response experience. Experienced Principal Investigator on Environmental Security Technology Certification Program (ESTCP) demonstrations and AGC projects.	P.G.	6/30/2020
WESTON	Sandra Takata	Senior Geophysicist/ QC Geophysicist	B.S. Applied Earth Sciences, Geophysics; 30 plus years of geophysical experience with 15 years on MMRP and environmental remediation projects.	Oasis Montaj Geophysical Data Processing for UXO 3 day UXAnalyze instruction by ESTCP	6/30/2020
WESTON	Brian Grassmyer	SUXOS	Graduate of United States (U.S.) Navy Basic Explosives Ordnance Device (EOD) School including Navy Diver Classes; U.S. Navy Advanced EOD Course; over 25 years of experience supervising UXO Technicians conducting MEC/EOD removal and disposal operations.	Construction Quality Management for Contractors (CQM-C)	7/1/2020
WESTON	Gretchen Fodor	Senior Chemist	B.S., Chemistry, M.S., Environmental Studies; over 30 years of experience.		6/30/2020
WESTON	Greg Abrams, P.G.	GCO Task Manager/Project Geophysicist/ Data Analyst	B.S. Physics; 12 years of MMRP geophysical experience. Experienced in collection and analysis of advanced electromagnetic induction (EMI) sensor data.	WESTON GCO DOCs 1 and 2[3]; Oasis Montaj Geophysical Data Processing for UXO 3-day UXAnalyze instruction by ESTCP	7/1/2020
WESTON	Kyle Yarmush	GCO Field Team Leader	B.S., Geology; 5 years of experience as a geoscientist and field geophysicist	WESTON GCO DOC 1; Experienced in the collection of Advanced Geophysical Data.	7/1/2020

WORKSHEET #4, #7, AND #8 - PERSONNEL QUALIFICATIONS AND SIGN-OFF SHEET (CONTINUED)

Organization	Name	Project Title/Role	Education/Experience	Specialized Training/Certification[1]	Signature and Date[2]
WESTON	Stacie Popp-Young	Quality Manager	B.S., Chemical Engineering; M.S., Chemical Engineering; 32 years of experience in environmental assessment and CERCLA hazardous waste site investigation and cleanup, including field laboratory method development, data quality reviews, QAPP preparation, and laboratory coordination.	Professional Engineer	Stacie A. Popp 6/30/220
WESTON	TBD	UXOSO	The UXOSO will meet the requirements of Department of Defense Explosives Safety Board (DDESB) TP18 for the UXOSO position[1].	DDESB TP-18 UXOSO, OSHA 30-Hour Construction, OSHA 8-Hour Supervisory Training, USACE Construction Quality Manager Training, over 5 years of experience in safety role.	
WESTON	TBD	UXOQCS	The UXOQCS will meet the requirements of DDESB TP18 for the UXOQCS position[1].	DDESB TP-18 UXOQCS, OSHA 30-Hour Construction, OSHA 8-Hour Supervisory Training, USACE Construction Quality Manager Training (optional), over 5 years of experience in safety role.	
Validata Chemical Services (Data Validation)	Kevin Harmon	Project Manager	B.S., Environmental Chemistry, M.S., Organic Chemistry, 20 years of experience in data validation.		

Notes:
[1]All UXO personnel will meet the requirements set forth in DDESB TP 18, *Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities* (DDESB, 2016). All field team personnel will complete the OSHA 40-hour training course for hazardous waste site workers as required by the specific task. Additional site-specific training, in accordance with 29 Code of Federal Regulations (CFR) 1910.120 and EM 385-1-1 (USACE, 2014), and this QAPP will be provided to all personnel upon their initial mobilization. A medical surveillance program will be in place for each member of the field team, with the most recent exam for each member having occurred within the last 12 months.
[2]Signatures indicate personnel have read and agreed to implement this QAPP as written.
[3]Copies of DOCs for WESTON GCO personnel are provided in **Appendix B**.

WORKSHEET # 6- COMMUNICATION PATHWAYS AND PROCEDURES

Communication Drivers	Initiator	Recipient	Procedures
General communication between USACE and other project delivery team (PDT) members	USACE PM	Appropriate PDT member(s)	Direct project lead. Maintain lines of communication between USACE, Stakeholders, Regulatory Agencies, and WESTON PM. Communicates directly as needed (verbally and/or in writing).
Regulatory interface	RFAAP, USACE PM or designee	Virginia Department of Environmental Quality (VDEQ)	Project materials and information will be forwarded to VDEQ by RFAAP, the USACE PM or designee, or by the WESTON PM with permission from RFAAP and the USACE PM.
Regulatory oversight	VDEQ	RFAAP, USACE PM	Communicate directly as needed (verbally and/or in writing).
Project management, Task Order (TO) administration, and logistics	WESTON PM	USACE PM and appropriate PDT member(s)	Communicate directly as needed (verbally and/or in writing). The WESTON PM will communicate project-related issues, including changes in schedule or scope of fieldwork to the USACE PM by phone or e-mail by close of business next business day. The WESTON PM will also provide project information to the USACE PM through monthly progress reports, e-mail updates, teleconference calls, and meetings. Any deviations from this QAPP, including those resulting in corrective action (CA), will be documented in a memoranda to the USACE PM.
Daily Reports	WESTON SUXOS	WESTON PM and WESTON technical lead	Documents progress in daily reports and submits to WESTON PM for onward distribution to PDT. Daily reports will be submitted to USACE PM within 24 hours of work completion that day whenever possible. Field progress reports will vary based on objectives of each definable feature of work (DFW). Examples of these reports are geophysical surveying, intrusive investigation, and daily production reports.
Stop work due to safety issues	WESTON UXOSO or USACE (Ordnance and Explosives Safety Specialist (OESS)	WESTON SUXOS, USACE OESS, and other field personnel	If unsafe work conditions are noted, the UXOSO will stop work immediately. Work will not resume until the unsafe condition is corrected. The UXOSO will also notify WESTON's Corporate Health and Safety (H&S) Officer immediately when a stop work situation is encountered. In naturally occurring cases, such as inclement weather (for example, lightning), no CA is required and work may resume when the UXOSO determines that conditions allow.
	WESTON SUXOS	WESTON PM	As soon as possible following discovery, the SUXOS informs the WESTON PM by phone of critical safety issues and generates follow-up Stop Work Memorandum and implements CA as necessary.

WORKSHEET # 6- COMMUNICATION PATHWAYS AND PROCEDURES (CONTINUED)

Communication Drivers	Initiator	Recipient	Procedures
	WESTON PM	USACE PM, BAE Systems, Inc. (BAE)	The WESTON PM will notify the USACE PM and BAE Explosives Safety Department verbally or via e-mail as soon as possible after work stoppage.
QAPP changes before fieldwork	WESTON PM	USACE PM	If errors or changed conditions require modifications of the QAPP before fieldwork begins, the WESTON PM will coordinate preparation of revised text for submittal to the USACE PM and other members of the PDT. All changes to the QAPP require final approval from USACE and regulatory agencies.
QAPP changes during project execution	WESTON PM, WESTON SUXOS, WESTON Project Geophysicist, Field Team Leader	WESTON PM, USACE PM, RFAAP POC, BAE, regulatory agencies	The SUXOS, Field Team Leader, and/or Project Geophysicist will notify the WESTON PM of field deviations from the QAPP the same day and provide rationale for changes. The WESTON PM will notify the USACE PM, RFAAP POC, and BAE (including Explosives Safety Department) of field deviations from the QAPP within two business days and provide rationale for changes. Changes in the field will be documented in the daily progress reports to the WESTON PM, who will review field operations daily and evaluate the need for field CAs (in collaboration with the USACE PM and document CAs in the daily reports and in memoranda to USACE. All changes to the QAPP will require final approval from USACE and regulatory agencies.
Geophysical QC variance	WESTON QC Geophysicist	WESTON Project Geophysicist, WESTON GCO QM, WESTON Corporate QC Manager, and WESTON PM	WESTON QC Geophysicist notifies WESTON Project Geophysicist, WESTON GCO QM, WESTON Corporate QC Manager, and WESTON PM immediately.
	WESTON PM	USACE PM, regulatory agencies	USACE PM within 24 hours. USACE PM notifies regulatory agencies as necessary.
Geophysical QC concerns	USACE Geophysicist	WESTON PM, WESTON GCO QM, and technical personnel	WESTON responds to geophysical QA concerns within 24 hours with a CA plan.
Discovery of MEC item(s)	WESTON SUXOS	WESTON PM, USACE OESS	WESTON SUXOS verbally notifies WESTON PM and USACE OESS immediately and then awaits permission to respond and/or conduct disposal operations.
	WESTON PM	USACE PM, RFAAP, BAE	Verbally notifies USACE PM, RFAAP, and BAE (Explosives Safety Department) immediately.
	RFAAP, USACE PM	Regulatory agencies and other PDT members	RFAAP notifies regulatory agencies and RFAAP, USACE PM notifies other PDT members as necessary.
Field team ready to conduct MEC disposal operations	WESTON SUXOS	WESTON PM and personnel listed in Worksheet #17	WESTON PM notifies personnel listed in Worksheet #17 and other members of the PDT as necessary
	WESTON PM	USACE PM, RFAAP, BAE, and PDT	WESTON PM notifies USACE PM/COR and RFAAP (POC and BAE POC) verbally, and other members of the PDT via email.

WORKSHEET # 6- COMMUNICATION PATHWAYS AND PROCEDURES (CONTINUED)

Communication Drivers	Initiator	Recipient	Procedures
Field CAs	WESTON SUXOS, Project Geophysicist, Field Team Leader	WESTON PM	CA resulting from either failure to follow QAPP requirements or due to changes in site conditions will be documented by the WESTON SUXOS, Project Geophysicist or Field Team Leader. The WESTON SUXOS will communicate the need for CAs to the WESTON PM on the same business day. The WESTON SUXOS may initiate interim CAs in the field subject to the final approval of the WESTON PM and the WESTON GCO QM.
Reporting Laboratory Data Quality Issues	Laboratory PM	WESTON Project Chemist	All QA/QC issues with project field samples will be reported by Laboratory PM to WESTON Project Chemist within two business days. If corrective measures are required, WESTON Project Chemist will notify the Quality Manager and PM.

WORKSHEET # 9- PROJECT PLANNING SESSION SUMMARY

Project Name: RFI for the RFAAP Former Gun and Trench Mortar Range MRS **PM:** Tony Pace, WESTON	**Site Name:** Former Gun and Trench Mortar Range MRS (RFAAP-002-R-01) **Site Location:** RFAAP, Radford, Pulaski County, Virginia

Date of Planning Session: 18 December 2018
Location: Radford Army Ammunition Plant, VA
Purpose: TPP #1 Meeting[1]
Participants:

Name	Organization	Title/Role	Email/Phone #
Kim Gross	USACE Baltimore District	Project Manager	Kimberly.u.gross@usace.army.mil / 410-962-3457
Tom Colozza	USACE Baltimore District	Senior Geophysicist	Thomas.s.colozza@usace.army.mil / 410-962-6647
Kiera Hearn	USACE Baltimore District	Chemist	kiera.m.hearn@usace.army.mil / 410-962-2842
Cliff Opdyke	USACE Baltimore District	Risk Assessor	Clifford.a.opdyke@usace.army.mil / 410-962-6765
Julie Kaiser	USACE Baltimore District	Environmental Specialist	Julie.e.kaiser@usace.army.mil / 443-447-4277
Mary Ellen Maly	USAEC	Environmental Support Manager	Mary.e.maly.civ@mail.mil / 210-466-1870
James McKenna	Radford AAP	Installation Restoration Manager	James.j.mckenna16.civ@mail.mil / 540-731-5782
Jody Hawks	BAE Systems	Sr. Environmental Specialist	Jody.hawks@baesystems.com / 540-639-7701
Jim Cutler	VDEQ	Federal Facilities Project Manager	James.cutler@deq.virginia.gov / 804-362-2461
Kyle Newman	VDEQ	Risk Assessor	Kyle.newman@deq.virginia.gov / 804-698-4452
Kurt Kochan	VDEQ	RCRA Project Manager	Kurt.kochan@deq.virginia.gov / 703-583-3825
Tony Pace	WESTON	Project Manager	pacea@westonsolutions.com / 757-362-2461
Ryan Steigerwalt	WESTON	Technical Manager	Ryan.steigerwalt@westonsolutions.com / 410-612-5900
Greg Abrams	WESTON	Project Geophysicist	Greg.abrams@westonsolutions.com / 703-599-2840
Nicole Sharkey	WESTON	Project Engineer	Nicole.sharkey@westonsolutions.com / 610-701-3425

[1]A copy of the 18 December 2018 TPP #1 Meeting Minutes and Sign-In Sheet are provided in **Appendix C**.

WORKSHEET # 9- PROJECT PLANNING SESSION SUMMARY (CONTINUED)

Project Name: RFI for the RFAAP Former Gun and Trench Mortar Range MRS **PM:** Tony Pace, WESTON	**Site Name:** RFI for the RFAAP Former Gun and Trench Mortar Range MRS (RFAAP-002-R-01) **Site Location:** RFAAP, Radford, Pulaski County, Virginia

Date of Planning Session: 13 February 2019

Location: Radford Army Ammunition Plant, VA

Purpose: MEC Demolition Location Planning Meeting

Participants:

Name	Organization	Title/Role	Email/Phone #
Kim Gross	USACE Baltimore District	Project Manager	Kimberly.u.gross@usace.army.mil / 410-962-3457
Marty Holmes	USACE Baltimore District	OESS	Marty.a.holmes@usace.army.mil / 410-982-9724
James McKenna	Radford AAP	Installation Restoration Manager	James.j.mckenna16.civ@mail.mil / 540-731-5782
Chucky Williams	BAE Systems	BAE Explosives Safety	Chucky.williams@baesystems.com
Jody Hawks	BAE Systems	Sr. Environmental Specialist	Jody.hawks@baesystems.com / 540-639-7701
Tony Pace	WESTON	Project Manager	pacea@westonsolutions.com / 757-362-2461
Ryan Steigerwalt	WESTON	Technical Manager	Ryan.steigerwalt@westonsolutions.com / 410-612-5900
Nicole Sharkey	WESTON	Project Engineer	Nicole.sharkey@westonsolutions.com / 610-701-3425

WORKSHEET # 9- PROJECT PLANNING SESSION SUMMARY (CONTINUED)

Project Name: RFI for the RFAAP Former Gun and Trench Mortar Range MRS **PM:** Tony Pace, WESTON	**Site Name:** RFI for the RFAAP Former Gun and Trench Mortar Range MRS (RFAAP-002-R-01) **Site Location:** RFAAP, Radford, Pulaski County, Virginia
Date of Planning Session: TBD **Location:** TBD **Purpose:** TPP #2 Meeting **Participants:** TBD	

Name	Organization	Title/Role	Email/Phone #

WORKSHEET # 10 - CONCEPTUAL SITE MODEL

10.1 OVERVIEW

The primary purpose of this worksheet is to describe the conceptual site model (CSM) for the Former Gun and Trench Mortar Range MRS and adjacent Area A (i.e., the New River). To provide the basis for the CSM, this worksheet also summarizes observations from previous investigations, secondary data and information from site reports, and other relevant supporting information.

10.2 FACILITY PROFILE, SITE DESCRIPTION AND BACKGROUND

10.2.1 SITE LOCATION

The Former Gun and Mortar Trench Range MRS (RFAAP-002-R-01) is located adjacent to the New River in the west-central portion of the RFAAP. The MRS consists of 115 acres and is comprised of two adjacent ranges: the Former Gun Range (28 acres) and the Former Trench Mortar Range (87 acres). Area A, the designated portion of the New River, is an adjacent area to the Former Gun and Trench Mortar Range MRS that has been included in the investigation and totals 31 acres in size. The portions of the MRS consisting of the Active Production Facility (approximately 50 acres) and Active Test Range Area (8 acres) are considered inaccessible areas and are excluded from the planned field investigation area. The MRS and Area A are depicted in **Figure A-2**.

10.3 SITE HISTORY AND USE

The Former Gun and Former Trench Range MRS began operations in 1941. Based on information gathered from RFAAP employee interviews, operations were discontinued after the end of World War II (WWII). The 87-acre Former Trench Mortar Range portion of the MRS was used to test-fire 4.2 inch, 60 millimeter (mm), and 81mm mortar rounds to verify the quality of propellants manufactured at the facility. According to the interviewees, the propellant manufactured at RFAAP during the 1940s was comprised of 52 percent (%) cellulose, 38% nitroglycerin (NG), and a small fraction (exact amount not disclosed) of potassium nitrate (BsEn, 2018a).

Available information gathered during the Historical Records Review (HRR) and interview process provided no information on the exact test procedures employed or the location of the range firing point(s), munitions storage area(s), or impact zone(s). However, information gathered from interviews with RFAAP personnel indicates that the mortars were generally fired in an upward direction for testing, suggesting the impact area was near the firing point.

Information gathered during the HRR and interview process also suggested that the test mortars were not filled with high explosive (HE), but rather various fillers, including concrete, gravel, Halowax, and possibly antifreeze. It was disclosed during the interview process that, while constructing the active production and Continuous Automated Multi-Base Line (CAMBL) facilities on the MRS, numerous “piles” of mortars were discovered and disposed by RFAAP personnel. Several interviewees stated that one round discovered between 2011 and 2012 may have contained white phosphorus. The presence of white phosphorus filler was never confirmed through testing and analysis or documented in RFAAP safety reports or Explosive Ordnance

Incident Reports. One interviewee described a 4.2-inch mortar found on the MRS as containing a liquid that "sloshed" when moved. The 4.2– inch mortar was disposed by demolition.

Three Explosive Ordnance Incident Reports dated 10 April 2012, 9 September 2012, and 28 May 2014 were made available by BAE Systems, Inc. (BAE Systems). The incident reports detailed findings of two 60mm mortars and one unknown round within the Former Gun and Mortar Range MRS (RFAAP-002-R-01) and the subsequent actions taken to resolve the incidents. For each finding, an Explosive Ordnance Disposal (EOD) unit was called in from Fort Bragg in North Carolina to handle the removal of the munition.

The 10 April 2012 report states that an unidentified item (referred to as a UXO) was found and disposed of with no additional details presented in the report. The 9 September 2012 report states that an inert 60mm mortar was discovered in the active production facility within the Former Gun and Mortar Range MRS (RFAAP-002-R- 01). The mortar was reported to likely be filled with concrete. The 28 May 2014 EOD Report states that an unidentifiable 60mm item (referred to as a UXO) was safely removed from the active production facility and disposed of via demolition at an undisclosed location on RFAAP (BSEn, 2018b). Additional communication with Chuckie Williams of BAE Systems in 2019 indicated that approximately three munitions items encountered within the active production facility (as discussed above) were all encountered in the subsurface. However, approximately four or five munitions items encountered and disposed of from the northeast end of the MRS were all encountered on the surface, with a couple of the items located outside of the fence along the steep slope adjacent to the New River.

The 28-acre Former Gun Range was historically used to test propellant by test-firing munitions into a hillside using howitzers and/or cannons. Apparently, holes were dug (caves) into the hillside and filled with sand to reduce the impact of the rounds. The only reported ordnance test fired was 100-pound shells. No information on the type(s) of propellant tested was contained in the HRR or obtained during the interview process. Furthermore, no information was found to indicate the location of the sand-filled caves. The 8-acre Active Test Range within the Former Gun Range was not included in the Site Inspection (SI). The Active Test Range contains the Inert Gun Testing Facility that is currently used by Northrop Grumman Innovative Systems (NGIS) to test propellant by firing inert projectiles. It is not known if this 8 acres includes the hillside used for test-firing. No information presented in the HRR or gathered during the interview process indicates that munitions have ever been discovered that could be associated with the Former Gun Range. This includes munitions lying on the ground surface or unearthed by erosion or excavation (BSEn, 2018a).

The investigation area was expanded from the SI to include the Former Gun and Former Trench Range MRS and a section of the New River designated as the 31-acre Area A. This expansion was made due to possible overshoots from the former ranges and the potential for MEC or MC migration from the MRS to the river. This method of deposition into the river would likely result in potential munitions items located primarily along the northern bank of the river with the potential to travel away from the bank as items are being washed down river.

With extensive development of the Former Gun and Trench Mortar Range MRS after its discontinued use and no documented firing point or impact locations, these areas may be located underneath process facilities or infrastructure that were constructed after the range closed. These process facilities include the active production facility and the defunct CAMBL facility. The active

production facility is in a continual state of production, while the CAMBL facility was built, but never went into production and is being demolished. Due to the construction of these process facilities, considerable earthwork was conducted at the MRS including grading to level uneven terrain and creation of earthen berms to serve as blast walls.

10.4 PREVIOUS INVESTIGATIONS

10.4.1 SITE INSPECTION

A Site Inspection (SI) was completed in September 2018 and recommended the Former Gun and Trench Mortar Range MRS for further investigation for the presence of MEC and MC (BSEn, 2018b). Evidence of an inert 60mm mortar was observed lying exposed in a drainage ditch during the reconnaissance site walk; however, it could not be determined if the mortar was inert or contained HE. Results and findings of the SI field activities are summarized below:

- No Material Potentially Presenting an Explosive Hazard (MPPEH) was found during the assisted visual survey (AVS) data collection or during the collection of incremental sampling methodology (ISM) and discrete sediment samples. However, the presence of 60mm, 81mm, and 4.2-inch mortars has previously been documented at the MRS. The majority of these discoveries were made during construction and/or maintenance activities performed at the production facilities.
- No apparent firing, impact, or other range related features were identified during the AVS data collection or collection of media samples.
- Chemical results revealed that explosives, perchlorate, and semi-volatile organic compounds (SVOCs) are not present at the MRS at concentrations exceeding the method detection limit, EPA regional screening levels (RSLs), or EPA EcoSSLs.
- The mean lead concentration in ISM sample Decision Unit (DU) 1, located in the Former Gun Range portion of the Former Gun and Trench Mortar Range MRS, was 1,909 mg/kg, which exceeded the background level (26.8 mg/kg), United States Environmental Protection Agency (USEPA) RSL Composite Worker RSL (800 mg/kg) and EcoSSLs for soil invertebrates (1,700 mg/kg), mammalian wildlife (56 mg/kg), avian wildlife (11 mg/kg), and plants (120 mg/kg).
- The mean antimony concentration in ISM sample DU1 exceeded the Ecological Soil Screening Levels (EcoSSL) for mammalian wildlife (0.27 mg/kg); the mean manganese concentration exceeded the EcoSSL for plants (220 mg/kg) and soil invertebrates (450 mg/kg); and the mean vanadium concentration exceeded the EcoSSL for avian wildlife (7.8 mg/kg). The mean manganese and vanadium concentrations were less than their respective background levels (2,543 mg/kg and 108 mg/kg). No background level was established for antimony.
- The mean cadmium concentration in ISM sample DU2, also located in the Former Gun Range portion of the Former Gun and Trench Mortar Range MRS, exceeded the EcoSSL for mammalian wildlife (0.36 mg/kg); the mean lead concentration exceeded the EcoSSL for avian wildlife (11 mg/kg); and the mean vanadium concentration exceeded the EcoSSL for avian wildlife (7.8 mg/kg). The mean lead and vanadium concentrations were less than their respective background concentrations (26.8 mg/kg and 108 mg/kg). No background level was established for cadmium.

- The lead concentration in discrete sediment sample RFAAP-FGMR-SSD-001 exceeded the RFAAP background level (26.8 mg/kg) and EcoSSLs for mammalian wildlife (56 mg/kg), avian wildlife (11 mg/kg), and plants (120 mg/kg).
- Antimony, selenium, and vanadium concentrations in all four discrete sediment samples exceeded one or more of the EcoSSLs.
- Lead and manganese concentrations exceeded one or more of the EcoSSLs in two discrete sediment samples.
- Only lead was detected in discrete sediment samples at a concentration that exceeded the RFAAP background level (26.8 mg/kg).
- The surface MEC exposure pathway of handle/tread underfoot is considered potentially complete for Current and Future Visitors, Site Workers, Construction Workers, and Trespassers. The subsurface MEC exposure pathway of handle/tread underfoot is considered potentially complete for Current and Future Construction Workers.
- The surface MC exposure pathways of ingestion, dermal contact, and inhalation (dust) are considered complete for Current and Future Visitors, Site Workers, Construction Workers, and Trespassers and biota. The subsurface MC exposure pathways of ingestion, dermal contact, and inhalation (dust) are considered potentially complete for Current and Future Construction Workers and biota. The MC vegetation food chain pathway is considered potentially complete for biota. The MC wildlife food chain pathway is considered potentially complete for Current and Future Site Workers and Trespassers and biota.

The SI recommended additional investigation related to MEC and MC in site soils and sediment.

10.4.2 TOPOGRAPHICAL FILL ANALYSIS REPORT

A Topographic Fill Analysis Report (WESTON, 2019) (provided as **Appendix D**) was prepared to compare and assess historical and present day topography to quantify cut and fill across the Former Gun and Trench Mortar Range MRS. Military munitions have been encountered during construction work at depths ranging from 8 to 10 feet (ft) below ground surface (bgs) at the Former Gun and Trench Mortar Range MRS. The depth that these munitions were located may be due to the extensive development of the MRS after the discontinued use of the ranges. The RFI fieldwork approach needs to consider the locations of past munitions use of the MRS, in addition to locations of subsequent cut and fill during earthmoving activities as potential "source areas", because the cut and fill activities may have moved or covered MEC. Fill locations were of particular focus because of the potential for MEC firing points or target areas to be located underneath infrastructure or general earthwork areas. Results and recommendations from the report were used to enhance the MRS CSM and finalize the overall characterization strategy to achieve RFI data quality objectives (DQOs).

The methodology for the topographic change analysis involved the production of a digital elevation model (DEM) using stereoscopy to highlight topographic feature changes between 1949 and present day. Four overlapping aerial images from 1949 showed the MRS. Photograph frames were corrected for radiometric and geometric variation and georeferenced to create an orthoimage.

Agisoft software was then used to produce an unreferenced 3-dimensional surface model from the four original images. Ground control points were based on elevation from the 2018 imagery and DEM, with total 3-dimensional error of 1.47 meters (m) (x: 0.164 m, y: 0.72 m, z: 1.27 m). Exterior orientation values were available for bearing and focal length; flight elevation was assumed to be 10,500 ft; and pitch and roll were assumed to be zero. Elevation at ground control points and exterior orientation estimates were applied to the unreferenced model to back-calculate the flight location. Last, an ultra-high density point cloud was generated for elevation throughout the image, producing a 1.69-meter (m) resolution digital surface model.

To assess topographic changes in elevation within the MRS over time, the difference in elevation between the 1949 and the 2018 DEM was calculated in ArcGIS Pro.

The southern portion of the Former Gun and Trench Mortar Range MRS adjacent to Area A (New River) is more susceptible to error because of the dramatic change in topography. The appearance of fill along the southern boundary of the MRS and overlapping within portions of Area A is a manifestation of actual topography changes from 1949 to present day coupled with the greater than typical error of the stereo pair analysis. Regions of the MRS with shallower slopes show less sensitivity to sources of error and are the focus of our interpretations.

The calculated change within the accessible portion of the Former Gun Range varies between -16 ft and 15 ft. The present day topographic surface within this area is an average of 3.3 ft below the 1949 topographic surface. Approximately 28% of the accessible portion of the Former Gun Range area exhibits a higher topography than in 1949.

The calculated change within accessible regions of the Former Trench Mortar Range varies between -43 ft and 19 ft. Excluding the steep slope beside the river, the present day topographic surface is an average of 1.2 ft above the 1949 topographic surface within the accessible region. Approximately 53% of the area of the accessible portion of the Former Trench Mortar Range exhibits a higher topography than in 1949. **Figures A-3 and A-4** present the topographic changes since 1949.

Topographic changes were then reviewed against the 1949 and present day aerial photographs. Larger and/or horizontally contiguous areas of fill are generally attributed to building construction or other infrastructure that is currently in place. The location of present day infrastructure (buildings, roadways, parking areas and other above ground structures) is depicted on the figures to show correlation with fill. Infrastructure and fill associated with infrastructure will be avoided during RFI fieldwork.

The primary focus of this analysis is the other areas of fill that are not associated with present day infrastructure. These fill areas vary from several feet in size to several hundred feet in diameter such as the area located in the western side of the Former Gun Range. Each fill location was then compared to the 1949 historical aerial image to determine whether there was any correlation to potential scarring or other notable features. Fill areas that exceed or nearly exceed predicted detection capability of planned RFI geophysical surveys are also of particular interest because mechanical excavation may be the only opportunity to verify whether there is a munitions-related source.

Identified features of interest are fill areas that do not correlate with infrastructure, are co-located with historical aerial photograph disturbances, and/or are beyond planned RFI geophysical surveys. Identified features of interest are fill areas that do not correlate with infrastructure, are co-

located with historical aerial photograph disturbances, and/or are beyond planned RFI geophysical surveys are further described in **Table 10-1** below. The locations of the features of interest are also presented in **Figure A-5** and **Figure A-6.**

Table 10-1 1949 Aerial Photograph Features of Interest

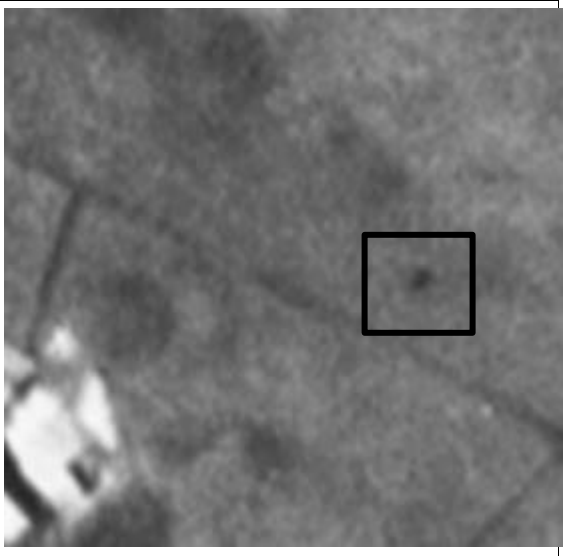
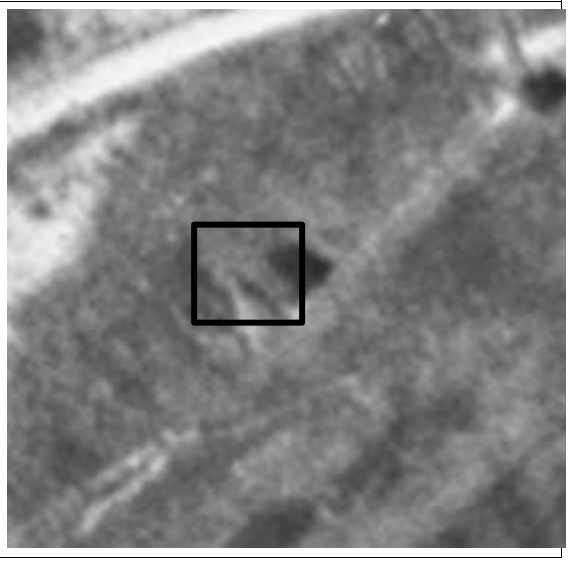
MRS Location	Feature ID and Description	Feature Image
Former Gun Range	**FGR-01**: Shadow observed in 1949 aerial photograph. Estimated at approximately 8 ft of fill.	
	FGR-02: Fill area that exceeds 8 ft. Adjacent to structure that is also present in 1949 aerial photograph.	

Table 10-1 1949 Aerial Photograph Features of Interest (Continued)

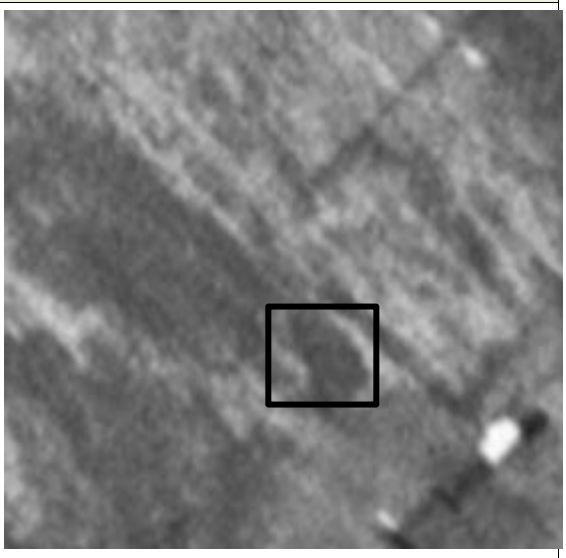
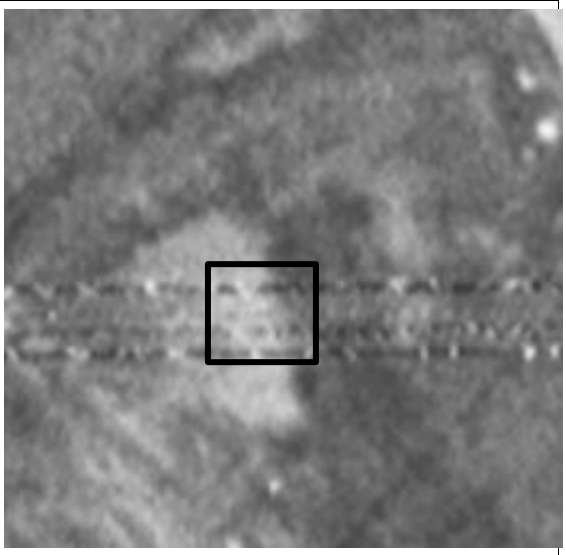
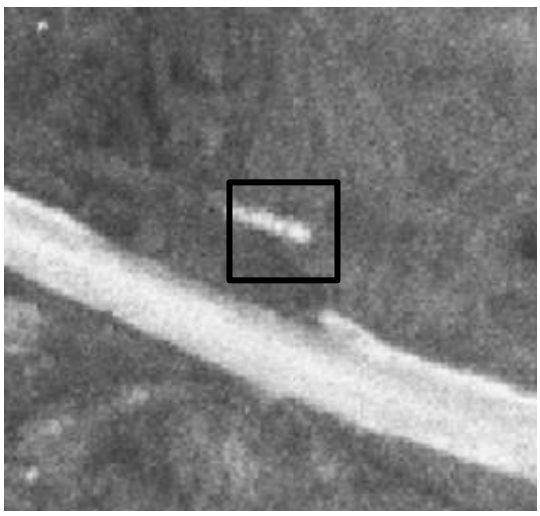
MRS Location	Feature ID and Description	Feature Image
	FGR-03: Approximately 6 ft of fill but within a discrete fill area that is atypical from surroundings. Shadow also observed in 1949 aerial photograph.	
	FGR-04: Large fill area, approximately 13 ft thick. Correlates to variation in 1949 aerial photograph. Striping due to faulty image.	
Former Trench Mortar Range	**FTMR-01**: Linear feature adjacent to former roadway. Present day topography is 6 ft to 8 ft higher in elevation than 1949 topography.	

Table 10-1 1949 Aerial Photograph Features of Interest (Continued)

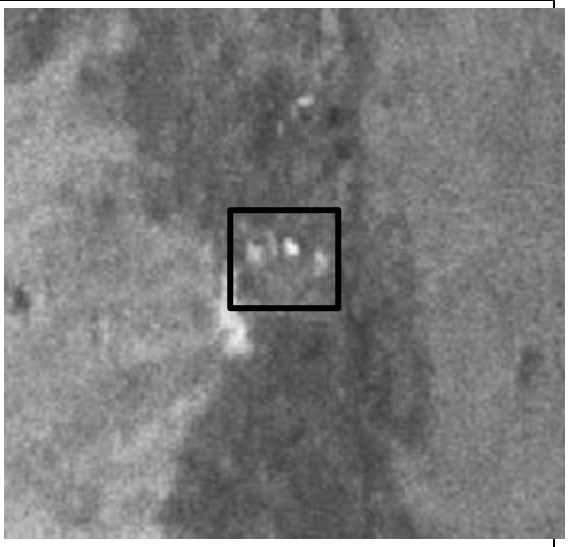
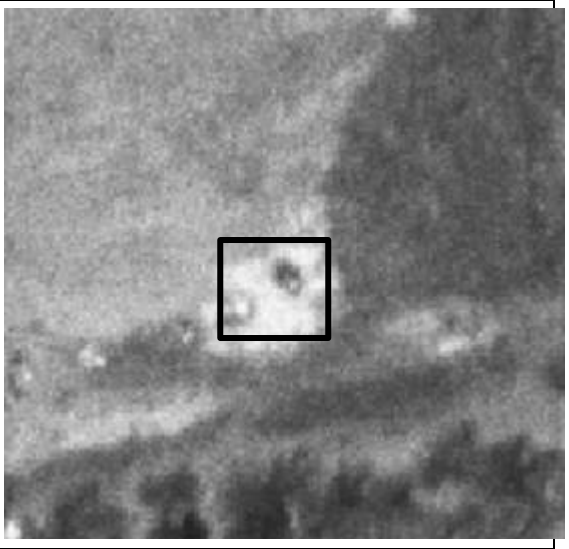
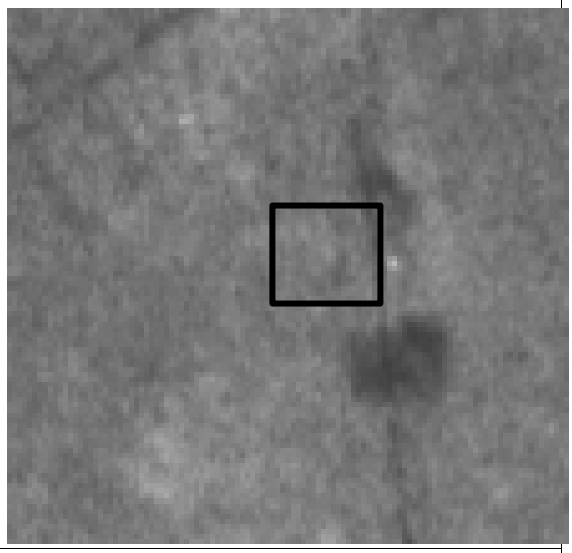
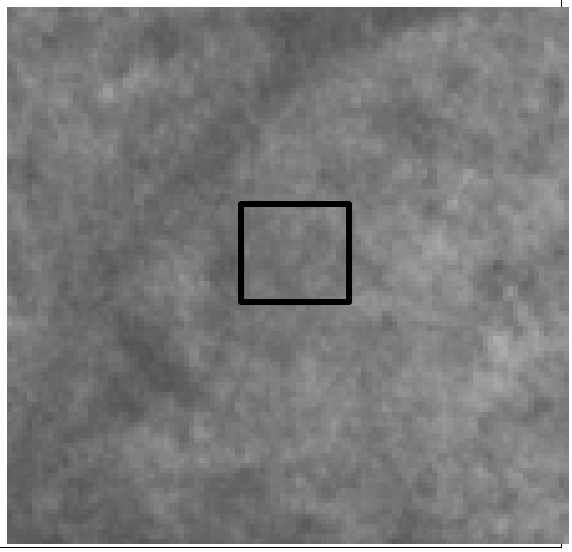
MRS Location	Feature ID and Description	Feature Image
	FTMR-02: Fill area exceeding 13 ft. Several reflective features clustered in a single area observed in 1949 aerial photograph.	
	FTMR-03: Approximately 6 ft of fill. Located in a scarred area in 1949 aerial photo. Potential former structures visible.	
	FTMR-04: Scarring feature located next to former roadway with significant fill.	

Table 10-1 1949 Aerial Photograph Features of Interest (Continued)

MRS Location	Feature ID and Description	Feature Image
	FTMR-05: Peak observed in 1949 elevation model. Estimated at approximately 7 ft of fill. No corresponding feature in the 1949 aerial photograph was observed.	
	FTMR-06: Peak observed in 1949 elevation model. Estimated at approximately 8 ft of fill. No corresponding feature in the 1949 aerial photograph was observed.	

When compared to present day conditions, the results from this topographic fill analysis suggest cut and fill activities have occurred at the Former Gun and Trench Mortar Range MRS since munitions-related activities ceased in the mid-1940s. Significant fill elevations from 1949 to the present can be attributed to building and other infrastructure construction activities. However, there are remaining areas within the MRS where MEC may be present that are now covered with fill due to earthwork. In some cases MEC may be deeper than anticipated depth of detection capability of geophysical technologies (estimated to be 8 ft). A total of 10 features of interest based on a 1949 aerial photograph and topographic analysis were identified because the fill areas do not correlate with infrastructure, are co-located with historical aerial photograph disturbances, and/or are beyond planned RFI geophysical surveys.

Based on these findings, the recommended sequence of work for the RFI included the following steps:

1. Perform EM31-MK2 survey transects across accessible portions of the MRS.

2. Identify anomalies of interest based on the EM31-MK2 surveys that may require further investigation as part of the RFI.

3. Determine if the anomalies of interest from the EM31-MK2 survey are co-located with feature of interest locations identified in **Table 10-1** and presented in **Figures A-5** and **Figure A-6**.

4. Reacquire features of interest from **Table 10-1** and the EM31 survey to assess topography and accessibility for intrusive work.

5. Conduct mechanized test pitting/trenching of each feature of interest in **Table 10-1** and/or based on the EM31-MK2 survey to the 1949 surface if possible.

6. Conduct planned field work in Area A (New River) including a geophysical survey using a Jon boat on the surface equipped with the G-858 magnetometer, intrusive dive work using divers equipped with self-contained breathing apparatus (SCUBA) in deeper waters and snorkels in shallower waters, and MC sampling.

7. Note and record findings as part of the RFI.

Detailed results of the assessment are provided in the Topographic Fill Analysis Report (WESTON, 2019).

10.4.3 IDENTIFICATION OF MEC AND MC KNOWN OR SUSPECTED TO BE PRESENT

Based on the HRR and past interviews, anecdotal and physical evidence indicates that MEC and/or munitions debris (MD) associated with mortars were discovered during construction of the active production and inactive CAMBL facilities. Specific locations and depths are unknown; however, subsurface munitions items were encountered in the active production facility area, and munitions

items on the ground surface were noted in the northeast end of the MRS. No MEC has been encountered or investigated within Area A.

SI analytical results revealed that explosives, perchlorate, and SVOCs are not present at the MRS at concentrations exceeding the method detection limit, EPA RSLs, or EPA EcoSSLs. Select metals (antimony, cadmium, lead, manganese, and vanadium) were detected in soils and sediments at concentrations above RSLs and/or EcoSSLs but most were below background levels. No background level was established for antimony, cadmium, or manganese. The mean lead concentration in ISM sample DU1 of 1,909 mg/kg located within the Former Gun Range exceeded background, the industrial soil RSL, and various EcoSSLs. MC has not been characterized within Area A (New River). The background levels consist of the 95% upper tolerance limit (UTL) background level from Facility-Wide Background Study Report (IT Corporation, 2001).

10.5 PHYSICAL PROFILE

10.5.1 TOPOGRAPHY

The Former Gun and Mortar Range MRS is located within a portion of the Main Manufacturing Area that is characterized by gently to steeply sloping ridges. The physiography at RFAAP is typical of karst topography. The southern boundary of the Former Gun and Mortar Range MRS abuts a steep bluff that drops down to the New River. The original topography at the MRS was altered significantly with the construction of processing facilities. The resulting topography and current condition can best be described as hummocky. During the construction of the facilities, the process buildings and containment vessels were partially buried, while soil was mounded around the remaining exposed exterior walls to contain a catastrophic event. Large mounds of soil were also constructed between buildings that serve as blast berms to limit the impact of a catastrophic event to surrounding buildings. In addition, several portions of the Former Gun and Mortar Range MRS were graded to create level areas for administrative offices and storage areas (BSEn, 2018a).

A topographic change analysis was conducted to evaluate changes in topography from 1949 (the period when the MRS was in use) and today as discussed in detail in Section 10.4.2. The calculated change within the accessible portion of the Former Gun Range (**Figure A-3**) varies between -16 ft and 15 ft. The present day topographic surface within this area is an average of 3.3 ft below the 1949 topographic surface. Approximately 28% of the accessible portion of the Former Gun Range area exhibits a higher topography than in 1949. The calculated change within accessible regions of the Former Trench Mortar Range (**Figure A-4**) varies between -43 ft and 19 ft. Excluding the steep slope beside the river, the present day topographic surface is an average of 1.2 ft above the 1949 topographic surface within the accessible region. Approximately 53% of the area of the accessible portion of the Former Trench Mortar Range exhibits a higher topography than in 1949.

10.5.2 VEGETATION

Vegetation found at the MRS is primarily influenced by past human activities, topographic setting, soil types, and surface water features. Most of the MRS has, at one point, been cleared of vegetation due to construction of the Active Production Areas and CAMBL facilities. In general, the flora and fauna at the MRS consist of commonly and widely distributed species that would be expected in ecologically altered landscapes.

The MRS is located primarily within the early successional habitat. Early successional habitats typify areas of RFAAP that received heavy and protracted disturbance from operations associated with the plant. Much of the MRS is landscaped with grassed areas mixed with shrubs with clusters of trees in certain areas such as within the Former Gun Range. The steep slope along the southeastern side of the MRS is densely covered with vegetation including mature trees, understory shrubs, and vines.

10.5.3 SOILS AND GEOLOGY

The Former Gun and Mortar Range MRS is located in the New River Valley, which crosses the Valley and Ridge Province. The subsurface geology consists of alluvium and residual deposits comprised of clay and silt with some sand and gravel overlying bedrock. The MRS is underlain by the Braddock Loam soil type. This soil type has a variable slope between 2% and 30% and does not have a seasonal high water table within 6 ft of the surface. Based on the depth of trenches and washed out gullies located within the active production facility on the MRS observed during the SI field activities, the clays and silts extend to a minimum depth of 10 ft bgs. Soils within forested areas of the MRS were observed to be dark brown silty. Permeability of the Braddock Loam soil is moderate and organic matter content is moderately low. This soil type is generally acidic or very strongly acidic with a pH range of 4.5–5.5.

A saprolitic layer, formed from in situ weathering of the carbonate bedrock, immediately overlies the competent bedrock. The saprolite is up to 10 ft in thickness and consists of yellowish-red and red clay. The clay has low to medium plasticity. Bedrock consists of the Elbrook Formation. Depth to bedrock ranges from 18 to more than 60 ft bgs. The Elbrook Formation is highly fractured and is composed of thickly bedded, blue-gray dolomite interspersed with blue-gray to white limestone; brown, green, and red shale; argillaceous limestone; and brecciated limestone. The Max Meadows Breccia is evident in outcrops along the slope leading to the river. In the outcrop along the slope, the tectonic breccias and the limestone and dolostone are highly weathered with many solution cavities.

Three deep soil borings (B43SB11, B43SB15, and B43SB17) were installed as part of an RFI at the Building 4343 site, which is located approximately 400 ft northwest of the Former Gun Range (Shaw, 2004). Borings depths ranged from approximately 20 to 60 ft bgs. Logging descriptions indicate that the subsoil is yellowish-red and red clay down to bedrock. The clay is the result of weathering of carbonate bedrock formations. The clay has low to medium plasticity and is dry to slightly moist. The clays are underlain by bedrock of the Elbrook Formation with depth to bedrock ranging from 18 to more than 60 ft bgs.

10.5.4 HYDROLOGY AND HYDROGEOLOGY

No permanent surface water bodies are present within the Former Gun and Trench Mortar Range MRS. Storm water drainage occurs primarily via infiltration and overland flow in ditches along engineered roadways. The Former Gun and Mortar Range MRS borders the New River, which flows along the southern boundary of the MRS. The river flow varies due to water management at Claytor Dam, approximately 9 miles upstream (south) of RFAAP (URS, 2003).

The hydrogeologic framework at RFAAP is based on generalized stratigraphic succession, with indurated sedimentary rocks of the Paleozoic age forming predominant units. Groundwater flow paths are typically short, commonly extending no more than several miles in their longest dimension. The largest groundwater supplies are produced from the carbonate rocks, especially where they are associated with thick regolith, an important storage reservoir throughout the entire area. The regolith stores recharge that would otherwise be rapidly diverted to overland flow. It also slowly releases water to underlying carbonate aquifers. Because of the widespread distribution of carbonate rocks and associated regolith, abundant precipitation in a humid climate, and relatively steep hydraulic gradients, this region (and locality) is one of the major karstlands in the eastern United States.

Although the Elbrook Formation was encountered during the Building 4343 RFI field investigations, no groundwater was encountered to a depth of 60 ft bgs. These conditions are expected to be similar to the Former Gun and Trench Mortar Range MRS due to similar topography and elevation throughout this area. The average depth to groundwater at RFAAP is approximately 70 ft bgs (URS, 2003). Along ridgelines where the MRS is located, the depth to groundwater averages around 100 ft bgs.

Groundwater supplies in the Valley and Ridge Province are generally good quality compared to surface water supplies. However, due to extended contact with minerals, many groundwater supplies contain higher levels of dissolved solids than the streams into which they discharge. Because of sinkholes and underground caverns in karst aquifers, there is a high potential for groundwater to be impacted by direct infiltration of contaminated surface water. There is, however, no evidence of sinkholes on the MRS (BSEn, 2018).

No federal or state wetlands are located within the MRS boundary (United States Fish and Wildlife Service [USFWS], 2019a; VADEQ, 2019).

10.5.5 CLIMATE

RFAAP lies in the humid, subtropical climate zone of Virginia. Average high temperatures ranges from 42ºF in January to 84ºF in July with lows ranging from 22ºF in January to 61ºF in July. Precipitation occurs on average 71 days per year with 209 sunny days per year. Average seasonal rainfall is approximately 37 inches per year and snowfall is about 24 inches per year. Wind conditions are at their greatest during the period of December through March with primary wind directions out of the west-northwest, west, and northwest.

10.5.6 CULTURAL RESOURCES

Cultural and archaeological resources have not been evaluated on a facility wide basis at RFAAP. No facilities on RFAAP are currently listed in the National Register of Historic Places, although it is possible that some of RFAAP may be eligible based on the long history of operation of the plant. It is not anticipated that any of the infrastructure located on the Former Gun and Mortar Range MRS is eligible for inclusion in the NRHP (BSEn, 2018b).

10.5.7 ECOLOGICAL PROFILE

The Former Gun and Trench Mortar Range MRS is located in an upland habitat. The non-developed portion of the MRS includes habitat that could support terrestrial species, and the adjacent Area A, located within the New River, could support aquatic species. The USFWS does not list any critical habitat for threatened or endangered species within the boundaries of, or in the nearby vicinity of the MRS. The USFWS Environmental Conservation Online System lists the following threatened and endangered species as present in Pulaski and/or Montgomery Counties: Indiana bat, Virginia big-eared bat, Roanoke logperch, Virginia fringed mountain snail, Cumberland bean (pearlymussel), and James spinymussel (USFWS, 2019b). These species are discussed more in the EPP as well as reasons why other listed species are not believed to be located within the MRS (BSEn, 2018b).

Vegetation at the MRS consists of grassy areas, small shrubs, and mature trees. Vegetation clearance is expected to be minimal in order to collect required RFI data. No trees will be removed; however, they may be pruned.

10.5.8 SITE ACCESS AND AREAS INACCESSIBLE FOR INVESTIGATION

RFAAP is a secure facility. Access to the installation must be obtained through the main gate. The field team will coordinate with the RFAAP POC or a designee to gain access to the installation, the MRS, and Area A (New River).

The MRS is approximately 115 acres; however, much of the MRS has been extensively developed. The Active Production Facility (approximately 50 acres) and Active Test Range Area (8 acres) are considered inaccessible areas and are excluded from the planned field investigation area. The field team will coordinate with the RFAAP POC on a daily basis to determine whether there are any specific work restrictions imposed on that day due to activities at the Active Production Facility and Active Test Range Area.

There are no identified access issues associated with the MRS and Area A. The boat ramp located along the southern edge of the New River within RFAAP will be utilized for access to Area A for planned field work (e.g., geophysical survey, dive work, and MC sampling).

10.6 RELEASE PROFILE

10.6.1 LAND USE EXPOSURE PROFILE

10.6.1.1 Current Land Use

All RFAAP tenants are involved with industrial enterprises and no tenants are commercial businesses with customer traffic (BSEn, 2018b). The MRS is located on land owned by the U.S. government that is utilized for industrial purposes (propellant manufacturing) and is currently part of the RFAAP designated Active Production Facility and Active Test Range Areas. RFAAP is an actively guarded facility with perimeter fencing that is patrolled by armed guards. The MRS is not completely fenced; however, all visitors must be escorted by RFAAP personnel while inside the MRS boundary. Area A is a portion of the New River and is utilized by the public for recreational purposes.

10.6.1.2 Anticipated Future Land Use

There is no anticipated change in future land use for this site, and the site will continue to be used for industrial purposes and development is unlikely within the foreseeable future.

10.6.1.3 Potential Receptors and Exposure Pathways

The pathway analysis portion of a CSM identifies all complete, potentially complete, or incomplete pathways for both current and reasonably anticipated future land uses for the MRS. Each pathway must include a source, a receptor, and the interaction between them (access and activity).

Sources are those areas where MEC and/or MC have entered the site. A receptor is an organism (human or ecological) that contacts the source. Interaction describes access and activities that facilitate receptors coming into contact with a source. For sites, such as the Former Gun and Trench Mortar Range MRS and Area A (New River), where both MEC hazards and MC risk must be considered, the CSMs are typically separated into MEC-based or MC-based scenarios, reflecting the key differences between the types of risks or hazards that may be present.

There is the potential, based on former firing activities, for military munitions and MC to be present within various areas of the MRS. There is also a potential for military munitions from the MRS to have migrated into Area A (New River). The tables describe the known or suspected contamination sources, potential/suspected location and distribution of contamination, contamination source or exposure medium, current and future receptors, and potentially complete exposure pathways. The CSM is a "living document" based on existing knowledge and will be updated as more information becomes available.

The MEC CSM is based on the historical range activities within the MRS boundary where a former gun range and former trench mortar range were operational. Data are not available to establish the configurations of the range fans. There is a potential for overshoots from the two former firing ranges towards Area A, New River. There is also the potential for migration of military munitions from the MRS to Area A through surface runoff. Based on the time of usage and incomplete records, a complete list of potential military munitions is not available.

10.6.1.4 Associated Munitions Constituents

Based on the type of munitions historically used at the MRS and the SI assessment, a listing of specific chemicals that may be present was developed to provide a rationale for MC that will be assessed during the Investigation. During the SI, ISM soil and discrete sediment samples were collected and analyzed for explosives, perchlorate, SVOCs, and metals. Analytes that were retained and will be analyzed during the investigation include select metals (antimony, cadmium, lead, manganese, selenium, and vanadium) and explosives. The associated MC analytes and compounds identified are subsequently highlighted in this UFP-QAPP in Worksheet 15, which provides the project screening levels and analytical quantitation limits for the Investigation, and Worksheet 17, which details the sampling plan and rationale, including munitions constituents selected for analysis.

10.7 CONCEPTUAL SITE MODEL SUMMARY

The CSM Pathway Analyses for the MRS and Area A (New River) are summarized in **Table 10-2**. This table describes the known or suspected contamination sources, potential/suspected location and distribution of contamination, contamination source or exposure medium, current and future receptors, and potentially complete exposure pathways. The CSM is a "living document" based on existing knowledge and will be updated as more information becomes available.

Table 10-2 MEC Conceptual Site Model Pathway Analysis Summary

Site Details	Known or Suspected Contamination Source	Potential/Suspected Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Potentially Complete Exposure Pathway
Name: Former Gun and Trench Mortar Range MRS **Acreage:** MRS - 115 acres (Former Gun Range – 28 acres/Former Trench Mortar Range – 87 acres) **Suspected Past DoD Activities *(release mechanism)*:** Firing from two former ranges to test propellants to target locations within the MRS. **Current and Future Land Use:** Part of the Active Production Facility and Active Test Range Areas.	**Former Trench Mortar Range:** MEC from the test-firing of 4.2 inch, 60mm, and 81mm mortar rounds to verify the quality of propellants manufactured at the facility. **Former Gun Range:** MEC from the historical testing of propellant by test-firing projectiles into a hillside using howitzers and/or cannons. The only reported ordnance test fired was 100-pound shells.	Mortars have been encountered within the MRS and removed and disposed of by EOD. Specific locations and depths of these encounters are unknown; however, subsurface items were encountered in the active production facility area, and surface encounters were noted in the northeast end of the MRS.	MEC in surface soil (0-0.5 ft bgs) and in subsurface soil (>0.5 ft bgs).	Current and Future Visitors, Site Workers, Construction Workers, and Trespassers.	Human receptors may encounter surface and/or subsurface MEC through walking, maintenance activities, or intrusive work activities.
Name: Area A (New River) **Acreage:** 31 acres **Suspected Past DoD Activities *(release mechanism)*:** Overshots from the two former firing ranges and potential migration of munitions from the MRS through runoff from the steep slope area. **Current and Future Land Use:** Area A portion of the New River is used for recreational activities.	Potentially same as land-based portion of the MRS. However, movement of MEC from years of river flow is expected.	No MEC has been investigated or encountered. However, military munitions have been identified along the steep slope area adjacent to Area A.	MEC in surface sediment (0-0.5 ft bgs) and in subsurface sediment (>0.5 ft bgs).	Recreational users (e.g., fishing, boating, wading, and/or swimming).	Human receptors may encounter surface and/or subsurface MEC through recreational activities where they or their possessions may contact the river bottom.

Table 10-2 MC Conceptual Site Model Pathway Analysis Summary (Continued)

Site Details	Known or Suspected Contamination Source	Potential/Suspected Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Potentially Complete Exposure Pathway
Name: Former Gun and Trench Mortar Range MRS **Acreage:** MRS - 115 acres (Former Gun Range – 28 acres/Former Trench Mortar Range – 87 acres) **Suspected Past DoD Activities *(release mechanism)*:** Firing from two former ranges to test propellants to target locations within the MRS. **Current and Future Land Use:** Part of the Active Production Facility and Active Test Range Areas.	*Metals:* ▪ Antimony ▪ Cadmium ▪ Lead ▪ Manganese ▪ Selenium ▪ Vanadium *Explosives: (see list in **Appendix E**)*	DU1 area where elevated lead concentrations were noted during the SI. Where damaged and/or heavily corroded individual MEC items are discovered with visible signs of an MC release (e.g., stained sediment or soil under MEC) or in low visibility scenarios, tactile signs of a potential MC release (e.g., cracks, holes).	MC in surface soil and sediment (0-0.5 ft bgs) and/or subsurface (>0.5 ft bgs) soil and sediment.	Current and Future Visitors, Site Workers, Construction Workers, and Trespassers. Potential ecological receptors.	Human receptors may be exposed to surface MC in soil and sediment through dermal contact, incidental ingestion, and/or inhalation pathways for all human receptors. Only construction workers should be exposed to subsurface MC in soil and sediment. Ecological receptors may be exposed to MC in surface soil, surface water, and sediment (0-0.5 ft bgs) through dermal contact, incidental ingestion, inhalation, and/or the food chain.

Table 10-2 MC Conceptual Site Model Pathway Analysis Summary (Continued)

Site Details	Known or Suspected Contamination Source	Potential/Suspected Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Potentially Complete Exposure Pathway
Name: Area A **Acreage:** 31 acres **Suspected Past DoD Activities *(release mechanism)*:** Overshots from the two former firing ranges and potential migration of munitions from the MRS through runoff from the steep slope area. **Current and Future Land Use:** Area A portion of the New River is used for recreational activities.	Potentially same as land-based portion of MRS. However, movement of MEC from years of river flow is expected to remove potential sources of MC.	Where damaged and/or heavily corroded individual MEC items are discovered with visible signs of an MC release (e.g., stained sediment under MEC) or in low visibility scenarios, tactile signs of a potential MC release (e.g., cracks, holes).	MC in surface sediment (0-0.5 ft bgs) and/or subsurface (>0.5 ft bgs) sediment.	Recreational users (e.g., fishing, boating, wading, and/or swimming). Potential ecological receptors.	Human receptors may be exposed to surface and/or subsurface MC in sediment through dermal contact, incidental ingestion, and/or inhalation pathways. Ecological receptors may be exposed to MC in surface soil, surface water, and sediment (0-0.5 ft bgs) through dermal contact, incidental ingestion, inhalation, and/or the food chain.

WORKSHEET # 11 - PROJECT/DATA QUALITY OBJECTIVES

This worksheet is used to document DQOs, which are developed during project planning sessions using a systematic planning process. The project DQOs were developed in accordance with the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4) (USEPA, 2006).

DQO Element	Data Quality Objective (DQO) Activity Description
1. State the Problem	▪ The nature and extent of MEC and MC has not been defined in the MRS and Area A (New River). ▪ Based on historical encounters with munitions items in various locations within the Former Trench Mortar Range, MEC in the form of UXO or discarded military munitions (DMM) is potentially present at the MRS, resulting from use of the MRS in the 1940s as propellant testing ranges. As discussed in Worksheet #10, due to the development of the MRS over time that included placing fill, it is unknown to what extent MEC may be present in the subsurface soils at the areas identified in the Topographical Fill Analysis Report (WESTON, 2019). If present, the MEC may present an unacceptable risk to receptors. ▪ In addition, lead was detected above risk screening criteria within DU1 within the Former Gun Range during the SI. ▪ Specific locations for firing and impact areas are unknown although the hillside is a potential impact area for the Former Gun Range based on historical interviews. ▪ The actual occurrence and approximate density of MEC/MPPEH, if present, has not been verified. ▪ The extent of lead contamination at DU1 has not been delineated. In addition, the source of lead contamination has not been identified. ▪ It is unknown if MC is present due to MEC/MPPEH being damaged, leaking/corroded, or otherwise potentially releasing MC into the environment.
2. Identify the Goal of the Study	Identify the principal study goal: The overall goal of the RFI is to determine the presence or absence of MEC and MC at the Former Gun and Trench Mortar Range MRS, and if present, then the nature and extent of MEC and MC on the ground surface and subsurface and in adjacent surface waters (Area A of the New River) will be determined. Additional goals include: ▪ To determine the presence or location of any suspected burial pits and/or trenches. ▪ To utilize Visual Sample Plan (VSP) software to calculate the appropriate coverage using AGC to achieve 95% confidence in determining that there are less than 0.5 MEC per acre in areas associated with potential DMM burial features. VSP will also be utilized to determine coverage in the New River. ▪ To determine the nature and extent of MEC if it is determined to be present at quantities greater than 0.5 MEC per acre. ▪ To evaluate whether MEC, if identified, presents an unacceptable or acceptable hazard to human health by utilizing the USACE Risk Management Methodology. ▪ To evaluate the nature and extent (horizontal and vertical) of lead in soil at the Former Gun Range, which was previously identified during the SI at DU1 above background and human and ecological screening levels. Concentrations in on-site samples will be compared to the project human health screening levels listed in Worksheet #15. ▪ To determine the source of the lead contamination identified during the SI at DU1.

DQO Element	Data Quality Objective (DQO) Activity Description
	▪ To determine whether a MC release to soil has occurred at locations where MEC/MPPEH is observed to be damaged, corroded, or otherwise potentially releasing MC into the environment. The biased soil samples will be analyzed for select metals (antimony, cadmium, lead, manganese, selenium, and vanadium) and explosives. ▪ To delineate the vertical and horizontal extent if MC is observed to have impacted soils in these locations. ▪ To determine whether MC is present in sediment above screening levels as a result of surface water runoff and erosion transporting MC outside the MRS toward and in the New River (Area A), and if present to determine the nature and extent. ▪ Based on the historical usage of the MRS, SI analytical results, and depth to groundwater (greater than 80 ft bgs), impacts to groundwater are not anticipated; therefore, no groundwater sampling is planned. However, if analytical data detect subsurface soil at significant levels above RSLs that could impact groundwater quality, then groundwater assessment will be evaluated. ▪ To determine if a risk to human health or ecological receptors is present based upon the delineated MC in soil, surface water, sediments, and/or groundwater and to evaluate whether future response actions need to be considered. ▪ The necessary information will be collected in order to develop, screen, and analyze corrective measure alternatives in the CMS and to revise the Munitions Response Site Prioritization Protocol (MRSPP) scoring. <u>State how the data will be used in solving the problem:</u> ▪ DGM/AGC Data (land): DGM (full coverage EM31-MK2 survey to evaluate the presence of pits and/or trenches) will be used across all accessible areas of the MRS (approximately 57 acres) and AGC (dynamic and cued surveys using a MetalMapper 2x2) will be used to determine if anomalies need to be investigated for potential MEC or left in place because they are likely related to non-hazardous scrap metal. Selected areas of interest based on EM31-MK2 data will be further assessed using intrusive investigations. VSP will determine the appropriate AGC coverage at each portion of the MRS (Former Trench Mortar Range and Former Gun Range). Selected anomalies based on dynamic detection surveys will be further assessed using AGC cued surveys. Cued data will be used to classify anomalies as follows: 1) target of interest (TOI) (i.e., highly likely to be DMM or UXO); 2) non-TOI (i.e., highly unlikely to be DMM or UXO); or 3) inconclusive. Detected items classified as TOI and inconclusive items will be intrusively investigated. Items classified as non-TOI will be left in place. ▪ Trenching/Test Pitting: Topographic and aerial photographic data from the topographic fill analysis have been used to identify potential areas of concern requiring mechanical trenching/test pitting to evaluate the presence of munitions. This activity will be performed as recommended in Section 10.4.2. ▪ Analog Surveys: Areas inaccessible to AGC methods (including the steep slope area on the southeast side of the MRS) will undergo analog geophysical surveys and anomalies will be investigated as they are detected. Additional areas of concern where analog surveys will be conducted will be identified during field activities (geophysical and intrusive investigations) where there is a potential for MEC to have migrated. ▪ DGM (New River Area A): DGM (transect coverage boat-mounted G-858 survey to evaluate the presence of anomalies) will be used in the Area A portion of the New River (approximately 31 acres) to determine if anomalies need to be investigated for potential MEC. VSP will be used to determine the appropriate DGM coverage.

DQO Element	Data Quality Objective (DQO) Activity Description
	▪ Intrusive Investigations: Anomalies identified in the land and water geophysical survey investigations and analog surveys will be investigated to determine the nature and extent of MEC in the subsurface. ▪ Environmental Sampling: MC samples (soil, sediment, and potentially groundwater) will be collected based on historical environmental sampling and the findings of the MEC investigation (land and New River Area A) findings to assess the nature and extent of MC at the MRS and Area A.
3. Identify Information Inputs	Additional data collection will be performed based on the results from previous studies, including the SI and historical photograph analysis. These previous studies were used to develop the CSM and to focus MEC and MC characterization during the development of the UFP-QAPP. Specifics include: <u>Updated CSM based on previous studies:</u> RFI objectives, site histories/uses, site boundaries, types/quantities of MEC, MEC distribution, MEC incident reports, topography/ geology/vegetation, future use/receptors/exposure/access (see Worksheet #10). <u>EM31-MK2 (land) and G-858 (water) survey results, including:</u> ▪ Areas covered; ▪ System QC test results; ▪ Unique anomaly/feature identification numbers and locations; ▪ EM31-MK2/G-858 survey data maps; and ▪ Updated CSM. <u>Dynamic detection survey results, including:</u> ▪ Areas covered; ▪ System QC test results; ▪ Instrument Verification Strip (IVS) results; ▪ Background data; ▪ Surveyed validation seed and QC seed locations and types; ▪ Unique anomaly identification numbers and locations; ▪ Site-specific munitions library; ▪ Classification of anomalies with confidence metric; ▪ Dynamic survey data validation report; ▪ Dynamic survey data usability evaluation; and ▪ Updated CSM. <u>Cued survey results, including:</u> ▪ System QC results; ▪ Instrument Verification Strip (IVS) results; ▪ Background data; ▪ Surveyed validation seed and QC seed locations and types; ▪ Unique anomaly identification numbers and locations; ▪ Site-specific munitions library; ▪ Classification of anomalies with confidence metric; ▪ Cued survey data validation report; ▪ Cued survey data usability evaluation; and ▪ Updated CSM. <u>Intrusive Investigation results (land-based and dive work), including:</u> ▪ Excavation results (database); ▪ Photos; ▪ Disposal records;

DQO Element	Data Quality Objective (DQO) Activity Description
	▪ Stop-Dig Threshold verification; ▪ Comparison of excavated "classification validation targets" to predictions; ▪ Final data usability evaluation; and ▪ Final CSM. <u>MC sampling results, including:</u> ▪ Collection of soil samples at the MRS based on the SI results and results of DGM/AGC and intrusive investigations (land-based and dive work) to assess the nature and extent of contamination. ▪ Collection of soil samples from within DU1 which was located at the Former Gun Range to assess extent of lead in soil. Lead was detected in DU1 during the SI field investigations. ▪ Collection of sediment samples at drainage ditches, if present, near DU1 within the MRS and Area A if MC can be transported from the MRS through drainage ditches to Area A based on initial analytical results from the drainage ditches and from within the MRS and Area A based on results of MEC investigations (land-based and underwater work) where potential MC releases from corroded or damaged MEC could have occurred. ▪ Collection of groundwater samples, if warranted, at the MRS based on the MC soil results. ▪ Collection of background sediment samples upstream of Area A to be used to evaluate RFI Area A sediment samples exceeding project screening levels. ▪ Soil and drainage swale data will be compared to the existing RFAAP background dataset (IT Corporation, 2001) so collection of background soil samples is not required.
4. Define the Boundaries of the Study	▪ The MRS is approximately 115 acres; however, much of the MRS has been extensively developed. The Active Production Facility (approximately 50 acres) and Active Test Range Area (8 acres) are considered inaccessible areas and are excluded from the planned field investigation area. ▪ The accessible area of the MRS that will be included in the RFI characterization is 57 acres, located in the southwestern and northeastern portions of the MRS. The DGM/AGC surveys, analog surveys, intrusive investigation results, and MC sampling results collected within representative portions of this area will be used to assess MEC hazards and risk to human health and the environment associated with MC. ▪ Area A, which is a portion of the New River to be included in the RFI characterization, is 31 acres and is located southeast of the MRS. ▪ The vertical depth boundary for the MRS will be constrained for the detection depth of the DGM and AGC instrumentation. The geophysical detection threshold for Former Trench Mortar Range Area will be demonstrated against the 60mm projectile because it is the most difficult item to detect that is anticipated based on the historical records and previous investigations. The geophysical detection threshold for the Former Gun Range will be demonstrated against the 100-lb shell. All detection thresholds will be set above 5 times the root mean square (RMS) background noise to ensure adequate signal to noise ratio. Horizontal boundaries correlate with the MRS and Area A boundary as shown on **Figure A-2, Appendix A**. ▪ The vertical depth boundary within Area A sediment will be constrained by the depth at which divers can effectively investigate anomalies detected in the sediments (i.e., approximately 1 ft).

DQO Element	Data Quality Objective (DQO) Activity Description
	▪ The target population for MC characterization consists of the analytical samples collected at biased soil, sediment, and groundwater (if warranted) locations. Details for each sample are presented as follows: - The location of the elevated lead during the SI (i.e., DU1) will be gridded into a 30-ft grid and discrete samples will be collected in 6- inch increments from the grid nodes. If elevated lead is observed above risk screening criteria, additional subsurface soil samples will be collected to vertically delineate the extent of contamination. - Areas where an MC release is suspected in soil as a result of observing high densities of corroded or damaged MEC/MPPEH during RFI geophysical and intrusive investigations will be assessed for MC. - If individual suspected MEC/MPPEH items are observed to be damaged or leaking, each item will warrant discrete grab soil sampling from the 6 inches of soil directly below the item. Additional samples will be collected vertically and from locations where MC is identified above screening levels in the initial samples. See Worksheet 17 for additional MC sampling details. - Only samples collected from 0 to 2 ft bgs will be used to assess ecological risk. Human health risk will be assessed using all samples collected during the RFI, regardless of depth. - For surficial sediment sampling of MRS drainage areas and within Area A, each sampling type (drainage ditch, New River) will be evaluated separately. - For subsurface sediment sampling of MRS drainage areas and within Area A, discrete sampling will be conducted below the locations where exceedances of screening criteria in the surface sample were observed until the vertical extent of contamination is delineated. See Worksheet 17 for additional MC sampling details. - Groundwater sampling is not anticipated so details for the sampling were not developed. Should groundwater sampling be required based on the results of the subsurface soil sampling, a separate groundwater sampling memorandum will be prepared to document the number, type, and location of samples to be collected. ▪ MEC/MPPEH or MC characterization may extend beyond the boundaries of the investigation areas if results indicate that hazards extend beyond the current MRS or Area A boundaries based on the new RFI data collected. Samples required to establish background levels (if needed for risk assessment) would be collected outside the MRS boundary and upstream of Area A to assess media not impacted by historical use of munitions at the MRS and thus representative of local background conditions.
5. Develop the Project Data Collection and Analysis Approach	▪ If MEC is not present in the Former Trench Mortar Range Area, the Former Gun Range, or Area A, then that portion of the investigation area will be identified as not having an explosive hazard. If MEC is present, then the extent of contamination will be determined and a MEC risk assessment will be performed utilizing USACE Risk Management Methodology. ▪ Where lead concentrations were identified above project screening levels during the previous SI, additional sampling in the form of X-ray fluorescence (XRF) screening and off-site laboratory definite confirmation sampling is warranted to define the nature and extent of contamination.

DQO Element	Data Quality Objective (DQO) Activity Description
	▪ If lead is noted at concentrations greater than the PALs at the perimeter grid nodes for the DU1 grid sampling program, then additional step-out lead sampling and analysis is warranted to define the extent of lead contamination. ▪ If lead is identified above project screening levels and background in any of the samples collected from DU1 at the Former Gun Range, the area will be confirmed to be contaminated. Grid nodes with lead below project screening levels and background will be confirmed to be non-contaminated. ▪ If the source of the lead contamination identified during the SI at DU1 is not identified, then it will be assumed that the contamination is due to former gun range-related activities. If another source for the lead is identified during field activities, then it will be evaluated to determine which cleanup program will be appropriate to manage the contamination moving forward. ▪ If MC is suspected in soil as a result of observing corroded or breached munition items during intrusive investigations, then discrete soil sampling will be performed to assess MC (target metal analytes and explosives compounds). ▪ If MC is detected above project screening levels and background (metals only) in surface soils, then the extent of vertical contamination will be determined through discrete sampling. ▪ If drainage ditches are identified adjacent to DU1 that could transport lead from the DU1 Area to other downstream areas within the MRS and potentially into Area A of the New River, then discrete sediment sampling will be conducted within these drainage ditches until the extent of lead above project screening level is fully delineated laterally and vertically. ▪ If MC is present in sediment collected from drainage swales, above screening levels and background, as a result of surface water runoff and erosion transporting MC outside the MRS toward and in the New River (Area A), then the extent of contamination will be delineated within these swales and Area A. ▪ If MC is suspected in sediment in the MRS or Area A as a result of observing corroded or breached munition items during intrusive investigations (land-based and dive work), then discrete soil sampling will be performed to assess MC (target metal analytes and explosives compounds). ▪ If MC is detected at concentrations greater than the project screening levels in soil or sediment, then risk assessments will be conducted to determine whether unacceptable risk to receptors is posed by contaminants and to determine whether future response actions need to be considered. ▪ Based on the historical usage of the MRS, SI analytical results, and depth to groundwater (greater than 80 ft bgs), impacts to groundwater are not anticipated; therefore, no groundwater sampling is planned. However, if analytical data detect subsurface soil at significant levels above RSLs that could impact groundwater quality, then groundwater assessment will be evaluated. If results from soil sampling indicate that soil is not contaminated at levels that could migrate to groundwater, then no investigation of groundwater is required. ▪ If EM31-MK2 surveys indicate anomalies that may be indicative of a potential burial trench, then those areas will be considered for intrusive investigations. ▪ If G-858 surveys completed in Area A identify subsurface anomalies, then all anomalies will be investigated during follow-on intrusive dive investigations.

DQO Element	Data Quality Objective (DQO) Activity Description
	▪ If anomalies are detected using AGC methods, then results from AGC dynamic and cued surveys will be used to classify anomalies as TOI, non-TOI, or inconclusive. The final product will be a ranked anomaly list ordered from most likely to be TOI to most likely to be non-TOI. TOI and inconclusive results will be placed on the dig list for intrusive investigation. ▪ If analog geophysical surveys identified subsurface anomalies, then all anomalies will be investigated as detected during analog geophysical surveys. ▪ The project approach involves three primary components: MEC burial pit/trench (EM31-MK2) surveys, AGC dynamic data collection, AGC cued data collection, and analog geophysical surveys. Decision rules for these components are listed as follows: **Dynamic Detection (G-858) Surveys** Parameters of interest: Measurements with a response amplitude, size, and a signal to noise ratio (SNR) as identified in the IVS Report. Type of inference: Measurements meeting the criteria noted above will be considered to be potential targets and will be selected for further evaluation during the intrusive dive survey. Decision rule: IF G-858 response is above the threshold defined in the initial IVS report, THEN it will be selected for evaluation using intrusive dive surveys. **Dynamic Detection (EM31-MK2) Surveys** Parameters of interest: Measurements with a response size, amplitude, and a signal to noise ratio (SNR) as identified in the Survey Report. Type of inference: Measurements meeting the criteria noted above will be considered to be potential areas of concern and selected for further evaluation during the intrusive trench survey. Decision rule: ▪ IF EM31-MK2 response is indicative of that determined to identify a potential trench, THEN it will be selected for evaluation using intrusive trench surveys. **Dynamic Detection Surveys** Parameters of interest: Measurements with a response amplitude and a signal to noise ratio (SNR) as identified in the IVS Memorandum. Additionally, we will test using an observed data fit value and library match as identified in the IVS memorandum. Type of inference: Measurements meeting the criteria noted above will be considered to be potential TOI and selected as anomalies for further evaluation during the cued survey. Decision rule: ▪ IF target thresholds in excess of that determined to identify a TOI as stated in the initial IVS memorandum, THEN it will be selected for evaluation using cued surveys, as documented in the Target Selection Memorandum to be reviewed and approved by the Government. **Cued Data Collection** Parameters of interest: Spatial extent of detected anomaly, cued measurement SNR, inversion fit coherence, and inversion outputs of β1, β2, β3, x, y, and z. Type of inference: If any of the following criteria are met, the anomaly will be selected as a TOI and added to the dig list for intrusive investigation:

DQO Element	Data Quality Objective (DQO) Activity Description
	1). The polarizability matches (within specifications established on worksheet #22) that of an item in the project-specific TOI library; 2). Estimate if an item could be munitions related; 3). There is a group (cluster) of five or more anomalies having similar polarizabilities that, after investigation, are discovered to be TOI; and 4). Anomalies with poor inversion fit coherence that, after considering all available information, cannot be ruled as non-TOI (i.e., the data are inconclusive). Decision rules: ▪ IF the cued data quality has been confirmed and any of the following three criteria are met, THEN the anomaly will be selected as a TOI: 1) the polarizability matches that of an item in the project-specific TOI library, 2) estimates of the size, shape, symmetry, and wall thickness calculated from the polarizability, indicates the item is long, cylindrical, and thick-walled; or 3) there is a group (cluster) of 5 or more anomalies having similar polarizabilities that, after investigation, are discovered to be TOI. Inconclusive anomalies with poor observed data fit that, after considering all available information, cannot be ruled as non-TOI will be added to the TOI list. ▪ IF intrusive results do not agree with the source or sources predicted by the AGC data, THEN the UXO Team will be sent back to confirm that no additional sources remain at the predicted location. ▪ IF an anomaly is classified as non-TOI, THEN it will not be included on the dig list nor investigated, unless identified as a verification dig. ▪ IF dynamic detection data show areas with SNRs that cannot reliably detect TOI or locations that interfere with geophysical detection requirements, such as structures or reinforced concrete, to effectively perform cued surveys and classification, THEN the area will be documented as presented in the final report. ▪ IF MEC is recovered, THEN it will be documented, photographed, and disposed. **Analog Geophysical Surveys of Steep Slope Area** Decision rules: ▪ IF an area is determined to be inaccessible to the AGC survey, THEN it will be surveyed using analog methods. ▪ IF a subsurface anomaly is detected using analog geophysical instrumentation, THEN it will be intrusively investigated. ▪ IF MEC, material potentially presenting an explosive hazard (MPPEH), MD, or non-munitions-related debris (NMRD) is recovered, THEN it will be removed, documented, photographed, and disposed.
6. Specify Performance or Acceptance Criteria	Project-specific Measurement Performance Criteria (MPC) are presented in Worksheet #12. Project-specific MPCs are the criteria that collected data must meet to satisfy the DQOs. Failure to achieve the MPCs may have an adverse effect on end uses of the data. Military Munitions Investigation MPCs: ▪ DGM/AGC project-specific MPCs are presented in Worksheet 12. Project-specific MPCs are the criteria that collected data must meet to satisfy the DQOs. Failure to achieve the MPCs may have an impact on end uses of the data, which will be discussed in the Data Usability Assessment (DUA) Report. ▪ Updates to MPCs may be made based on IVS results and site-specific variations.

DQO Element	Data Quality Objective (DQO) Activity Description
	MC Investigation MPCs: ▪ All data will be reviewed and verified to ensure that they are acceptable for the intended use. ▪ All data will be validated in accordance with the procedures specified in the DoD Quality Systems Manual for Environmental Laboratories and EPA National Functional Guidelines. MPC for the analytical data are listed in Worksheet #12, Table 12-2, and QC criteria for analytical data are listed in Worksheet #28. ▪ Decision errors will be limited to the extent practicable for the EPA methods and applicable standard operating procedures (SOPs) listed in Worksheet #21. ▪ Specific details regarding MC investigation performance and acceptance criteria during sample collection and analytical data processing are specified in this UFP-QAPP. Any deviations from the QAPP will be documented.
7. Survey Design and Project Work Flow	▪ Analog geophysical instrumentation will be used in potential drainage pathways on the steep slope on the southeastern side of the MRS, based on terrain and accessibility. Specific locations will be determined after initial DGM and intrusive investigations have been completed and the identification of drainage patterns has been conducted. All (100%) of all anomalies detected during the analog mag and dig surveys will be investigated to determine the source of the elevated signal. ▪ A full-coverage EM31-MK2 survey over the accessible portion of the MRS is planned to detect and define potential pits or trenches. We anticipate 45-acres of accessible survey area based on topographic analysis and the extent of various hardscapes (e.g., structures, parking lots, roadways). Both quadrature and in-phase EM31 data will be evaluated to identify anomalies requiring further investigation and will be reviewed in the context of MRS features and local background noise/interference conditions. All areas (100%) of elevated responses that cannot be reconciled with existing MRS features will be further investigated to determine the source of anomalies. ▪ Intrusive investigations in the form of manual digs will be conducted for single point anomalies identified for specific anomalies identified by the AGC cued surveys. ▪ Intrusive investigations in the form of diving operations will be conducted for 100% of anomalies identified by the DGM survey work along transects in Area A. ▪ Mechanical trenching/test pitting will be conducted for the areas of concern identified during the topographic fill analysis and the EM31-MK2 survey. ▪ The measurement quality objectives (MQOs) for the DGM and AGC surveys will be achieved to ensure equipment is functioning to specification and the surveys are achieving design requirements. ▪ All MEC/MPPEH and MD will be subject to a dual inspection and verification system on-site to identify suspected munitions and any associated hazard, and to determine proper handling and disposal requirements. This process will be completed by two qualified UXO Technicians (Level III) performing independent inspections. ▪ MC parameters (i.e., explosives and metals) will be determined based on geophysical and intrusive investigation findings to develop focused analyte/compound lists for MC associated with the types of munitions recovered. Verification and validation of analytical MC data will be performed by a third-party in accordance with DoD Quality System Manual (QSM) and federal guidelines and communicated to the Army prior to data incorporation into data evaluation/risk screening activities to make project decisions.

DQO Element	Data Quality Objective (DQO) Activity Description
	▪ MC sampling plan design and assessment parameters will be refined based on geophysical and intrusive findings and documented for RFAAP, U.S. Army Corps of Engineers, Baltimore District (CENAB), and stakeholders in a technical memorandum during RFI execution. ▪ Project screening levels will initially be set equivalent to EPA Regional Screening Levels (RSLs) for direct contact exposure at a target cancer risk of 1E-06, or non-carcinogenic target hazard quotient (THQ) of 0.1, for human health, and based on conservative published ecological benchmarks for point-by-point comparison to MC concentrations observed in each sampling unit assessed. Risk assessment protocols will follow EPA procedures as appropriate. ▪ MC sample results will also be screened against project screening levels discussed above and to Radford AAP background values as established in the Facility Wide Background Study Report (IT Corporation, 2001). ▪ If warranted, based on the presence of corroded or leaking munitions items within Area A from the dive operations, local background sediment samples for MC (metals) will be collected upstream of Area A and assessed to support risk assessment during identification of site-related chemicals of potential concern as those that exceed both screening level criteria and background concentrations. ▪ Specific analytical requirements for MC sampling are presented in **Appendix E**.

WORKSHEET # 12- MEASUREMENT PERFORMANCE CRITERIA

Table 12-1 Measurement Performance Criteria for DGM/AGC Surveys and Intrusive Investigations

Measurement Performance Activity (or DFW)	Data Quality Indicator (DQI)	Specification	Activity Used to Assess Performance
Site Preparation	Completeness/ Accuracy	Perform vegetation removal so that geophysical surveys can be completed. Establish 200-ft x 200-ft grids, set control points, and mark out MRS boundaries using wooded stakes and flagging, or equivalent.	Review of Daily Reports
QC Seeding (Analog)	Representativeness	UXOQCS or designee seeds small industry standard objects (ISOs) as blind QC seeds and coverage seeds for the analog survey.	Review of Production Area QC Seeding Report
QC Seeding (Survey)	Representativeness	Blind QC seeds will be placed at the site by WESTON. Blind QC seeds must be detectable as defined by the DQOs and located throughout the horizontal and vertical survey boundaries defined in the DQOs as described in the Blind Seed Plan (**Appendix F**). Seed items will consist of small and medium ISOs. Blind QC seeds will be distributed such that the field team can be expected to encounter between one and three seeds per day.	Review of Production Area QC Seeding Report
QC Seeding (New River Survey)	Representativeness	Blind QC seeds will be placed at the site by WESTON. Blind QC seeds must be detectable as defined by the DQOs and located throughout the horizontal and vertical survey boundaries defined in the DQOs as described in the Blind Seed Plan (**Appendix F**). Seed items will consist of Medium ISOs. Blind QC seeds will be distributed such that the field team can be expected to encounter between one and three seeds per day.	Review of Production Area QC Seeding Report
Dynamic Detection (MM 2x2) Survey	Completeness	100% of the accessible portions of the MRSs is surveyed.	Verification of conformance to MQOs for in-line spacing and cross-line spacing (See Worksheet 22).
Dynamic Detection (MM 2x2) Survey	Sensitivity	A detection threshold will be established based on 5X the RMS background noise for a conservative project threshold.	Initial and ongoing function tests and IVS surveys, blind QC and validation seed detection, analysis of background variability across the site.
Dynamic Detection (MM 2x2) Survey	Accuracy/ Completeness	100% of all QC and validation seeds (if applicable) must be correctly detected and classified.	Review of validation seed detection results per survey unit.
Dynamic Detection (MM 2x2) Survey	Completeness/ Comparability	Complete project-specific databases and target lists delivered.	Data verification/data validation.
Cued Classification (MM 2x2) Survey	Completeness/ Comparability	Library must include signatures for all munitions known or suspected to be present at the MRSs, as listed in the CSM.	Verification of site-specific library.

Table 12-1 Measurement Performance Criteria for DGM/AGC Surveys and Intrusive Investigations (Continued)

Measurement Performance Activity (or DFW)	Data Quality Indicator (DQI)	Specification	Activity Used to Assess Performance
Cued (MM 2x2) Survey	Representativeness/ Accuracy	Background data will be collected at least once every two hours of cued survey data collection. Background locations will be selected such that background data will be representative of the various subsurface conditions expected to be encountered within each survey unit at the site.	Data verification/data validation.
Cued (MM 2x2) Survey	Completeness	All detected anomalies classified as: 1) TOI; 2) Non-TOI; 3) Inconclusive.	Data verification.
Cued (MM 2x2) Survey	Accuracy/ Completeness	Cued survey must correctly detect and classify 100% of all QC and validation seeds (if applicable).	Review of validation seed classification results.
Cued (MM 2x2) Survey	Completeness/ Comparability	Background data, cued survey data, library, inversion results, and supporting documentation are delivered.	Data verification, data validation.
Cued (MM 2x2) Survey	Accuracy	100% of predicted non-TOI that are intrusively investigated are confirmed to be non-TOI.	Visual inspection of recovered items from classification validation
Intrusive Investigation (classification validation)	Accuracy	Inversion results correctly predict one or more physical properties (e.g., size, symmetry, or wall thickness) of the recovered items (specific tests and test objectives established during project planning).	Visual inspection and qualitative evaluation of items recovered during classification validation
Intrusive Investigation (land-based)	Completeness/ Comparability	Reacquisition and visual identification of 100% of anomalies planned for intrusive investigation.	Visual inspection, identification, and removal.
Intrusive Investigation (Area A dive work)	Completeness/ Comparability	Reacquisition and visual identification of 100% of anomalies planned for intrusive investigation.	Visual inspection, identification, removal, and transfer to land-based UXO team for disposition.
MEC/MPPEH Management	Accuracy	If MEC/MPPEH is encountered, only UXO-qualified personnel (UXO Technician II or above) will perform identification of the item and ascertain its condition. The SUXOS and UXOSO must be in agreement on the nature and condition of a MEC/MPPEH item before any action is taken.	Joint SUXOS and UXOSO determination that a MEC/MPPEH item is acceptable to move. After determining an item is acceptable to move, the SUXOS and UXOSO will determine the most expeditious route for safe movement of the MEC item to the disposal point. UXOQCS verifies that material documented as safe (MDAS) is properly documented in a DoD Form 1348-1A (**Appendix G**).

Table 12-2 Measurement Performance Criteria Table –Project Metals by EPA Method 6010C

Matrix	Soil		
Analytical Group or Method	Project Metals/EPA 6010C/MT 009		
Concentration Level	Low		
DQIs	**MPC**	**QC Samples and/or Activity to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S and A)**
Accuracy/Bias	One per preparatory batch. No analytes detected > 1/2 limit of quantitation (LOQ) or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Method Blank	A
Accuracy/Bias	One per preparatory batch per matrix or one per 20 samples, whichever is more frequent. QSM 5.1 Appendix C Table C-3 control limit shown in Worksheet 15.1.	Laboratory control sample (LCS) and laboratory control sample duplicate (LCSD)	A
Accuracy/Bias	One set per extraction batch when sufficient sample volume is provided or as requested per client. QSM 5.1 Appendix C Table C-3 control limit shown in Worksheet 15.1.	Matrix spike and matrix spike duplicate (MS/MSD)	A
Accuracy/Representativeness	4ºC ± 2ºC	Cooler temperature indicator	S
Precision (laboratory)	Relative percent difference (RPD) ≤ 20%.	LCS/LCSD	A
Precision (matrix interference)	RPD ≤ 20%.	MS/MSD	A
Overall Precision	RPD ≤ 50% when analytes are detected in both samples ≥ LOQ.	Field duplicate	S and A
Sensitivity	Project action limit (PAL) > LOQ and/or limit of detection (LOD) for target analytes	Comparison of PALs with laboratory detection limits (LOQ, LOD, DL)	A
Completeness	≥ 95%.	Data completeness check	S and A

Table 12-3 Measurement Performance Criteria Table – Explosives Method USEPA SW-846 8330B

Matrix	Soil
Analytical Group or Method	Explosives/ EPA 8330B/ SV 010
Concentration Level	Low

DQIs	MPC	QC Samples and/or Activity to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S and A)
Accuracy/Bias	One per preparatory batch. No analytes detected > 1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Method Blank	A
Accuracy/Bias	One per preparatory batch per matrix or one per 20 samples, whichever is more frequent. QSM 5.1 Appendix C Table C-37 control limits as shown in Worksheet 15.2.	LCS/LCSD	A
Accuracy/Bias	One set per extraction batch when sufficient sample volume is provided or as requested per client. QSM 5.1 Appendix C Table C-37 control limits as shown in Worksheet 15.2.	MS/MSD	A
Accuracy/Bias	Recovery limit for 1,2-Dintrobenzene: 78-119 percent recovery (%R)	Surrogate	A
Accuracy/Representativeness	4ºC ± 2ºC	Cooler temperature indicator	S
Precision (laboratory)	RPD ≤ 20%.	LCS/LCSD	A
Precision (matrix interference)	RPD ≤ 20%.	MS/MSD	A
Overall Precision	RPD ≤ 50% when analytes are detected in both samples ≥ LOQ.	Field duplicate	S and A
Sensitivity	PAL > LOQ and/or LOD for target analytes	Comparison of PALs with laboratory detection limits (LOQ, LOD, DL)	A
Completeness	≥ 95%.	Data completeness check	S and A

WORKSHEET # 13 - SECONDARY DATA USES AND LIMITATIONS

Information on secondary (existing) data that will be used for the project, the data source, and how the secondary data will be used are provided in this worksheet. If the secondary data do not meet the same quality objectives as the current investigation, limitations for use of the data are discussed.

Data Type	Data Source (originating organization, report title and date)	Data Uses Relative to Current Project	Factors Affecting the Reliability of Data and Limitations on Data Use
Topographic maps and digital elevation models	▪ U.S. Geological Survey (USGS) Topographic Maps (1950 and 1965) ▪ USGS 2018 Digital Elevation Model ▪ 1949, 1953, and 1960 Historical Aerial Photographs, Sanborn, Blacksburg, Virginia, LiDAR (2015)	Analog and digital topographic maps provide indications of features that can mobilize MEC and can be integrated with geophysical maps to support interpretation and validation. Historical topographic maps and aerial photographs provide evidence of terrain modifications, and these are reviewed in the range history assessments. Such alternations can affect the depth of detection or can provide evidence of the extent of historical MEC removal actions.	Dates data was collected. Terrain modifications.
Range History	▪ Historic Properties Report (MacDonald & Mack, 1984). ▪ Preliminary Assessment (PA) (WESTON, 1992). ▪ Archives Search Report (ASR) (USACE, St. Louis District, 1993). ▪ Site Inspection (SI) Report (BSEn, 2018b).	Background information supports MEC/MC results or lack thereof. Required for Classification Library, target selection threshold, and size threshold development. Also key to developing the classifier rules.	Terrain, depth of targets, and level of operator experience
Munitions Use and Disposal	▪ Historic Properties Report (MacDonald & Mack, 1984). ▪ PA (WESTON, 1992). ▪ ASR (USACE, St. Louis District, 1993). ▪ SI Report (BSEn, 2018b).	Required for TOI Classification Library, target selection threshold, and size threshold development	Survey approach and instrumentation used in RI investigation.

WORKSHEET # 14 AND #16 - PROJECT TASKS AND SCHEDULE

The activities to be conducted on the Former Gun and Trench Mortar Range MRS and Area A to achieve the project DQOs (Worksheet #11) comprise the following six primary components: QC seeding (MRS), detection survey (MRS and Area A), classification survey (MRS), intrusive investigation (MRS and Area A), analog survey (MRS), and MC sampling (MRS and Area A). Although these six primary components are the focus of the project, the field operations involve multiple elements, or DFWs that will be required to achieve the project goals. This subchapter provides a summary of these DFWs and the associated component tasks. A detailed discussion of each of the primary project components and the related DFWs is included on Worksheet #17, and the specific field procedures to be used for the activities described in this summary are included in the various SOPs included in **Appendix H**. The project schedule is included in **Appendix I**.

Project Tasks:

DFW (Activity)	Associated Tasks	Responsible Party[1]	Planned Duration[2]	Related SOP(s) (see Worksheet #21)	Deliverable(s)	Deliverable Due Date[2]
DFW 1: Mobilization	Establish site	WESTON PM, SUXOS, UXOSO, UXOQCS, Project Geophysicist	1 day	All SOPs	Daily Reports	Daily
DFW 2: Site Preparation	Equipment Training Site Preparation Utilities Clearance	WESTON PM, SUXOS, UXOSO, UXOQCS, Project Geophysicist	3 days	All SOPs	Daily Reports	Daily
DFW 3: Vegetation Clearance	Remove vegetation to make areas accessible for geophysical sensors	WESTON UXO Tech II or higher	2 days	MEC Anomaly Avoidance (MR-SOP-1)	Daily Reports	Daily

WORKSHEET # 14 AND #16 - PROJECT TASKS AND SCHEDULE (CONTINUED)

DFW (Activity)	Associated Tasks	Responsible Party[1]	Planned Duration[2]	Related SOP(s) (see Worksheet #21)	Deliverable(s)	Deliverable Due Date[2]
DFW 4: Professional Land Survey and Grid Establishment	Professional Land Surveyor (PLS) will establish MRS boundaries and install six (6) Control Points. UXO Technicians will then establish 200-ft x 200-ft grids.	WESTON UXO Tech II or higher	3 days	Surveying (SOP G-10), MEC Anomaly Avoidance (MR-SOP-1)	Survey Report Daily Reports	7 days after completion Daily
DFW 5: Geophysical System Verification	Blind Seeding	WESTON QC Geophysicist	2 days	Production Area Seeding (GCO-SOP-13)	QC Seed Report Daily QC Report Daily Geophysical Report	7 days after completion Daily Daily
	IVS Installation – Dynamic Detection Survey and Cued Survey	WESTON QC Geophysicist	2 days	Advanced Classification IVS (GCO-SOP-12)	IVS Technical Memorandum	2 days after completion

WORKSHEET # 14 AND #16 - PROJECT TASKS AND SCHEDULE (CONTINUED)

DFW (Activity)	Associated Tasks	Responsible Party[1]	Planned Duration[2]	Related SOP(s) (see Worksheet #21)	Deliverable(s)	Deliverable Due Date[2]
DFW 6: EM31-MK2 Survey	EM31 Assembly and Initial Function Test	WESTON Field Geophysicist	1 day	Operational Use of the EM31-MK2 (GEO-SOP-5)	DGM QC Checklist Daily Report	7 days after completion
	Dynamic (EM31-MK2) Data Collection. Full coverage survey over accessible area using EM31-MK2 (excludes inaccessible areas due to slope/terrain)	WESTON Field Geophysicist	9 days	Operational Use of the EM31-MK2 (GEO-SOP-5)	Raw Data, Weekly Reports, QC Results	Weekly during dynamic (EM31-MK2) collection
	Dynamic (EM31-MK2) Data Processing and Target Selection	WESTON Project Geophysicist/ Data Analyst	7 days	Quality Control Procedures and Geophysical Data Processing (GEO-SOP-50)	Processed Data, Target List, QC Results	7 days after completion
DFW 7: Dynamic Detection Survey (AGC MetalMapper 2X2)	MM 2x2 Assembly and Initial Function Tests	WESTON Field Geophysicist	2 days	2x2 Sensor System Assembly and Correct Operation Verification (GCO-SOP-11)	Daily reports	Upon Completion
	Dynamic data collection over each selected survey location	WESTON Field Geophysicist	8 days	Collecting Dynamic AGC Measurements (GCO-SOP-29)	Raw Data, Weekly Reports, QC Results	Weekly during cued collection
	Dynamic Data Processing	WESTON Project Geophysicist/ Data Analyst	7 days	Processing Dynamic Advanced EMI Data (GCO-SOP-30)	Processed Data, QC Results	7 days after completion

WORKSHEET # 14 AND #16 - PROJECT TASKS AND SCHEDULE (CONTINUED)

DFW (Activity)	Associated Tasks	Responsible Party[1]	Planned Duration[2]	Related SOP(s) (see Worksheet #21)	Deliverable(s)	Deliverable Due Date[2]
	Generate Cued Target list	WESTON Project Geophysicist/ Data Analyst	8 days	Processing Dynamic Advanced EMI Data (GCO-SOP-30)	Ranked and Classified Target List, QC Results	7 days after completion
DFW 8: Cued Survey (AGC MetalMapper 2X2)	Cued data collection over each selected anomaly location to classify anomalies	WESTON Field Geophysicist	8 days	Collecting Cued Target Measurements (GCO-SOP-19)	Raw Data, Weekly Reports, QC Results	Weekly during cued collection
	Cued Data Processing	WESTON Project Geophysicist/ Data Analyst	8 days	Processing Cued Advanced EMI Data (GCO-SOP-20)	Processed Data, QC Results	7 days after completion
	Classification of Cued Targets	WESTON Project Geophysicist/ Data Analyst	8 days	Processing Cued Advanced EMI Data (GCO-SOP-20)	Ranked and Classified Target List, QC Results	7 days after completion
DFW 9: Intrusive Investigation, Analog Mag and Dig, and Mechanical Trenching	Reacquisition/flagging of selected TOI and Inconclusive items	WESTON SUXOS	1 day	Anomaly Reacquisition (GCO-SOP-33)	SUXOS Daily Report	Daily during reacquisition activities
	Intrusive investigation of geophysical targets	WESTON SUXOS	4 days	MR-SOP-2, MR-SOP-3	Intrusive Results, Photographs, Weekly Reports	Weekly during intrusive activities
	Subsurface mag and dig investigation of remaining areas	WESTON SUXOS	2 days	Analog Detection and Removal Operations (MR-SOP-2) Digital Anomaly Removal Operations (MR-SOP-3)	Intrusive Results, Photographs, Weekly Reports	Weekly during mag and dig activities

WORKSHEET # 14 AND #16 - PROJECT TASKS AND SCHEDULE (CONTINUED)

DFW (Activity)	Associated Tasks	Responsible Party[1]	Planned Duration[2]	Related SOP(s) (see Worksheet #21)	Deliverable(s)	Deliverable Due Date[2]
	Mechanical Trenching	WESTON SUXOS	3 days	Analog Detection and Removal Operations (MR-SOP-2)	Daily Reports Daily SUXOS Reports Daily QC Reports	Daily Daily Daily
DFW 10: G-858 Survey of Area A (New River)	G858 Assembly and Initial Function Test	WESTON Field Geophysicist	1 day	Operational Use of the G858 (GCO-SOP-37)	DGM QC Checklist Daily Report	7 days after completion
	New River DGM Data Collection. Transect coverage survey using G858 magnetometer	WESTON Field Geophysicist	9 days	Operational Use of the G858 (GCO-SOP-37)	Raw Data, Weekly Reports, QC Results	Weekly during G858 collection
	New River G858 Data Processing and Target Selection	WESTON Project Geophysicist/ Data Analyst	7 days	Quality Control Procedures and Geophysical Data Processing (GCO-SOP-37)	Processed Data, Target List, QC Results	7 days after completion
DFW 11: Dive Operations of Area A (New River)	Intrusive investigation of geophysical targets	WESTON SUXOS	4 days	AOR-SOP-01	Intrusive Results, Photographs, Weekly Reports	Weekly during intrusive activities
DFW 12: MPPEH/MEC and MDAS Handling, Certification and Disposal	Identification, removal, storage, and disposal of MPPEH/MEC and MDAS	WESTON SUXOS and UXOSO Also, USACE OESS	2 days	MPPEH Management (MR-SOP-4)	SUXOS Daily Report DD Form 1348-1A Chain of Custody (CoC) Certification of Destruction Letter	Daily during field work activities Upon completion Upon completion Upon completion

WORKSHEET # 14 AND #16 - PROJECT TASKS AND SCHEDULE (CONTINUED)

DFW (Activity)	Associated Tasks	Responsible Party[1]	Planned Duration[2]	Related SOP(s) (see Worksheet #21)	Deliverable(s)	Deliverable Due Date[2]
DFW 13: MC Sampling	Collection of soil and sediment samples (discrete, direct-push)	WESTON Project Scientist	3 days	Field Sample Numbering (SOP G-3), QA/QC Sampling (SOP G-4), Decontamination (SOP G-6), Management of Investigation Derived Waste (SOP G-7), Sample Chain of Custody (SOP G-8), Sample Packing and Shipping (SOP G-9), Sediment Sampling (SOP SS-3), Soil Sampling (SOP SS-2 and SOP SS-4)	Daily Report Lab results	Daily Upon delivery from lab
DFW 14: Site Restoration	Fill in intrusive investigation areas, restore site conditions.	WESTON SUXOS	6 days over 5 mobilizations	All SOPs	SUXOS Daily Report	Upon Completion
DFW 15: Demobilization	Final decontamination of equipment prior to off-site removal.	WESTON SUXOS	2 days			

[1] Responsible party may not be physically present on-site for the entire project duration.
[2] Refer to the detailed project schedule included in **Appendix I**. The schedule will be updated as the project progresses.

WORKSHEET # 15 - PROJECT ACTION LIMITS AND LABORATORY-SPECIFIC DETECTION/QUANTITATION LIMITS

Worksheet 15.1 — Metals Analysis in Soil and Sediment - EPA 6010C

		Human Health Screening Levels[1a]		Project Human Health Screening Level	Ecological Screening Levels[1b]			Project Ecological Screening Level	Facility-Wide Background [5]	Achievable Laboratory Limits[2]			Precision and Accuracy Method Performance Criteria[3]	
		USEPA Residential RSL[4]	USEPA Industrial RSL		USEPA Eco SSL	LANL ECORISK - No Effect ESL	EPA Region 3 BTAG			DL	LOD	LOQ	LCS and MS/MSD	
Analyte	CAS Number	Soil (mg/kg)	Soil (mg/kg)	Soil (mg/kg)	Soil (mg/kg)	(Soil/ Sediment) (mg/kg)	Freshwater Sediment (mg/kg)	(mg/kg)	Soil (mg/kg)	Soil (mg/kg)	Soil (mg/kg)	Soil (mg/kg)	QC Limit (%R)	RPD (%)
Antimony	7440-36-0	3.1 n	47 n	47 n	0.27	2.3/45	2	0.27	NA	0.13	0.4	0.8	79-114	≤ 20
Cadmium	7440–43–9	7.1 n	98 n	98 n	0.36	0.27/0.30	0.99	0.27	NA	0.006	0.02	0.04	82-113	≤ 20
Lead	7439–92–1	400	800	800	11	11/26	35.8	11	26.8	0.04	0.125	0.25	81-112	≤ 20
Manganese	7439-96-5	39 n	580 n	580 n	0.52	0.52/0.72	2	0.52	NA	0.025	0.075	0.15	84-114	≤ 20
Selenium	7782–49–2	180 n	2,600 n	2,600 n	220	220/460	460	220	2,543	0.06	0.2	0.4	78-111	≤ 20
Vanadium	7440-62-2	39 n	580 n	580 n	7.8	4.7/29	NA	4.7	108	0.012	0.04	0.08	82-114	≤ 20

1. The PAL used for comparison to analytical data is the lowest of the following:
   a. USEPA 2018 = USEPA RSL, Residential Soil (target hazard quotient=0.1; target cancer risk=1E-06); (updated November 2018 at http://www.epa.gov/region9/superfund/prg/). C = cancerous and n = noncancerous
   b. Minimum ecological risk-based soil/sediment screening levels were obtained from the following: (1) EPA Ecological Soil Screening Levels (Eco-SSLs) (various publication dates); (2) Los Alamos National Laboratory (LANL) (2017) ECORISK Database (Version 4.1); and (3) BTAG R3. The most stringent of the available screening levels is presented for each source.
2. The achievable laboratory limits presented in this table reflect the most recently reported values by the laboratory; therefore, they may differ from those values presented in the associated SOP found in **Appendix J**.
3. The QA/QC criteria presented in this table reflect values presented in the DoD QSM Version 5.2 (LCS/MS/MSD = Laboratory control sample/MS/MSD).
4. Because the MRS has an industrial land use, the Residential RSLs are only applicable to a secondary human health risk assessment, which is necessary to evaluate the unlimited use and unrestricted exposure remedial alternative in the CMS.
5. The background levels consist of the 95% upper tolerance limit (UTL) background level from Facility-Wide Background Study Report (IT Corporation, 2001).

Acronyms

%R: percent recovery
CAS: Chemical Abstract Service
DL: detection limit
ESL: ecological screening level
LANL: Los Alamos National Laboratory
LCS: laboratory control sample
LOD: limit of detection
LOQ: limit of quantitation
MDL: method detection limit
mg/kg: milligram per kilogram
MS/MSD: matrix spike/MS duplicate
NA: not available
QA/QC: quality assurance/quality control
RPD: relative percent difference
RSL: Regional Screening Level
SOP: standard operating procedure
SSL: Soil screening level
USEPA: US Environmental Protection Agency

Worksheet 15.2 — Explosives Analysis in Soil and Sediment - EPA 8330B

		Human Health Screening Levels [1a]		Project Human Health Screening Level	Ecological Screening Levels [1b]		Project Ecological Screening Level	Achievable Laboratory Limits[2]			Precision and Accuracy Method Performance Criteria[3]	
		USEPA Residential RSL[4]	USEPA Industrial RSL		LANL ECORISK - No Effect ESL	EPA Region 3 BTAG		DL	LOD	LOQ	LCS and MS/MSD	
Analyte	CAS Number	Soil (mg/kg)	Soil (mg/kg)	Soil (mg/kg)	Soil/ Sediment (mg/kg)	Freshwater Sediment (mg/kg)	Soil (mg/kg)	Soil (mg/kg)	Soil (mg/kg)	Soil (mg/kg)	Soil (%R)	Soil (RPD)
1,3,5-Trinitrobenzene (TNB)	99-35-4	220 n	3,200 n	3,200 n	10/1.1	NA	1.1	0.05	0.15	0.3	80-116	≤ 20
1,3-Dinitrobenzene	99-65-0	0.63 n	8.2 n	8.2 n	0.072/1.1	NA	0.072	0.03	***0.1***	***0.2***	73-119	≤ 20
2,4,6-Trinitrotoluene (TNT)	118-96-7	3.6 n	51 n	51 n	7.5/25	0.092	0.092	0.05	***0.1***	***0.2***	71-120	≤ 20
2,4-Dinitrotoluene	121-14-2	1.7 c	7.4 c	7.4 c	6/0.29	0.0416	0.0416	***0.06***	***0.15***	***0.3***	75-121	≤ 20
2,6-Dinitrotoluene	606-20-2	0.36 c	1.5 c	1.5 c	4/8.6	NA	4	0.06	0.15	0.3	79-117	≤ 20
2-Amino-4,6-dinitrotoluene	35572-78-2	15 n	230 n	230 n	12/14	NA	12	0.03	0.1	0.2	71-123	≤ 20
2-Nitrotoluene	88-72-2	3.2 c	15 c	15 c	9.8/25	NA	9.8	0.03	0.1	0.2	70-124	≤ 20
3,5-Dinitroaniline	618-87-1	NA	NA	NA	NA	NA	NA	0.04	0.1	0.2	86-118	≤ 20
3-Nitrotoluene	99-08-1	0.63 n	8.2 n	8.2 n	12/21	NA	12	0.04	0.1	0.2	67-129	≤ 20
4-Amino-2,6-dinitrotoluene	19406-51-0	15 n	230 n	230 n	14/17	NA	14	0.05	0.1	0.2	64-127	≤ 20
4-Nitrotoluene	99-99-0	25 n	140 c	140 c	21/46	4.06	4.06	0.06	0.15	0.3	71-124	≤ 20
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	390 n	5,700 n	5,700 n	16/130	NA	16	0.05	0.1	0.2	74-124	≤ 20

Worksheet 15.2 — Explosives Analysis in Soil and Sediment - EPA 8330B (Continued)

		Human Health Screening Levels [1a]		Project Human Health Screening Level	Ecological Screening Levels [1b]		Project Ecological Screening Level	Achievable Laboratory Limits[2]			Precision and Accuracy Method Performance Criteria[3]	
		USEPA Residential RSL[4]	USEPA Industrial RSL		LANL ECORISK - No Effect ESL	EPA Region 3 BTAG		DL	LOD	LOQ	LCS and MS/MSD	
Analyte	**CAS Number**	**Soil (mg/kg)**	**Soil (mg/kg)**	**Soil (mg/kg)**	**Soil/ Sediment (mg/kg)**	**Freshwater Sediment (mg/kg)**	**Soil (mg/kg)**	**Soil (mg/kg)**	**Soil (mg/kg)**	**Soil (mg/kg)**	**Soil (%R)**	**Soil (RPD)**
Nitrobenzene	98-95-3	5.1 c	22 c	22 c	2.2/24	NA	2.2	0.05	0.1	0.2	67-129	≤ 20
Nitroglycerin	55-63-0	0.63 n	8.2 n	8.2 n	13/1500	NA	13	0.12	0.3	0.6	73-124	≤ 20
pentaerythritol tetranitrate (PETN)	78-11-5	13 n	160 n	160 n	100/1300	NA	100	0.12	0.3	0.6	72-128	≤ 20
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	8.3 c	38 c	38 c	2.3/3.2	0.013	2.3	0.06	0.15	0.3	67-129	≤ 20
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	16 n	230 n	230 n	1.5/91	NA	1.5	0.06	0.15	0.3	68-135	≤ 20

1. The PAL used for comparison to analytical data is the lowest of the following:
   a. USEPA 2018 = USEPA RSL, Residential Soil (target hazard quotient=0.1; target cancer risk=1E-06); (updated November 2018 at http://www.epa.gov/region9/superfund/prg/) C = cancerous and n = noncancerous.
   b. Minimum ecological risk-based soil/sediment screening levels were obtained from the following: (1) Los Alamos National Laboratory (LANL) (2017) ECORISK Database (Version 4.1) and (2) BTAG R3. The most stringent of the available screening levels is presented for each source.
2. The achievable laboratory limits presented in this table reflect the most recently reported values by the laboratory; therefore, they may differ from those values presented in the associated SOP found in Appendix J.
3. The QA/QC criteria presented in this table reflect values presented in the DoD QSM Version 5.1 (LCS/MS/MSD = Laboratory control sample/MS/MSD).
4. Because the MRS has an industrial land use, the Residential RSLs are only applicable to a secondary human health risk assessment which is necessary to evaluate the unlimited use and unrestricted exposure remedial alternative in the CMS.

Acronyms

%R: percent recovery
CAS: Chemical Abstract Service
DL: detection limit
LCS: laboratory control sample
LOD: limit of detection
LOQ: limit of quantitation
mg/kg: milligram per kilogram
MS/MSD: matrix spike/MS duplicate
NA: not available
NE: not established
PAL: project action level
QA/QC: quality assurance/quality control
RPD – relative percent difference
RSL: Regional Screening Level
SOP: standard operating procedure
USEPA: US Environmental Protection Agency

Laboratory limits with ***Bold Italics*** exceed the selected ecological screening level.

WORKSHEET # 17 - SURVEY DESIGN AND PROJECT WORK FLOW

The purpose of this RFI is to perform an investigation to determine the presence or absence of MEC and MC at the Former Gun and Trench Mortar Range MRS, and if present, to determine the nature and extent of MEC and MC in the MRS and in adjacent sediments (Area A of the New River). The scope of this RFI primarily includes digital geophysical alone or in combination with advanced classification surveys on land and in water, analog geophysical investigations, intrusive investigations on land and in water, and MC characterization of the MRS and Area A. Decision trees for these primary field investigations are presented in **Figures 17-1** through **17-3**.

Information collected during the RFI will be used to fill data gaps to determine the nature and extent of MEC and MC, update the CSM, evaluate potential human health and ecological risks, and conduct a MEC risk assessment that will be performed utilizing the USACE Risk Management Methodology. Results from the RFI will be used to develop and evaluate corrective action alternatives and to provide recommendations for a CMS if required.

This worksheet describes the project design and the tasks that will be required to successfully complete field operations during this project and achieve the DQOs described in Worksheet #11. An RFI will be performed within the accessible portions of the MRS and within Area A (portion of the New River adjacent to the MRS) as shown on **Figure A-2, Appendix A**. EM31-MK2 and AGC (dynamic and cued) surveys will be performed over all accessible areas of the MRS while a boat-mounted G-858 survey will be conducted within Area A. The steep sloped area between the MRS and Area A will be surveyed using an analog geophysical approach. Areas paved or covered with buildings will not be surveyed. MC sampling and analysis will be conducted to assess the extent of lead contamination around DU1 in the Former Gun Range portion of the MRS and assess any potential releases at any encountered corroded or damage MEC/MPPEH.

17.1 THREE-PHASE INSPECTION PROCESS

Prior to and during execution of field activities, WESTON will ensure quality through utilization of the Three-Phase Inspection Process described in the following subsections. WESTON forms and checklists associated with completion of the preparatory, initial, and follow-up phase activities are included in the Quality Control Plan in **Appendix K**.

17.1.1 PREPARATORY PHASE

The preparatory phase will be completed before beginning each DFW. A meeting will be scheduled in advance of each work activity, if deemed necessary by the PDT to facilitate coordination of project activities. The following activities will be completed during this phase:

- Review specifications, references, and plans.
- Verify field equipment to ensure readiness for intended use.
- Assign responsibilities and ensure field staff have necessary knowledge, training, expertise, and information to perform jobs.
- Verify arrangements for support services.
- Inspect work area to verify that required preliminary work has been completed.
- Review appropriate activity hazard analyses (AHAs).
- Ensure that applicable processes and procedures have been approved by the PM/COR.

Figure 17-1 Geophysical Classification Decision Tree – Preliminary Tasks and Anomaly Detection Survey

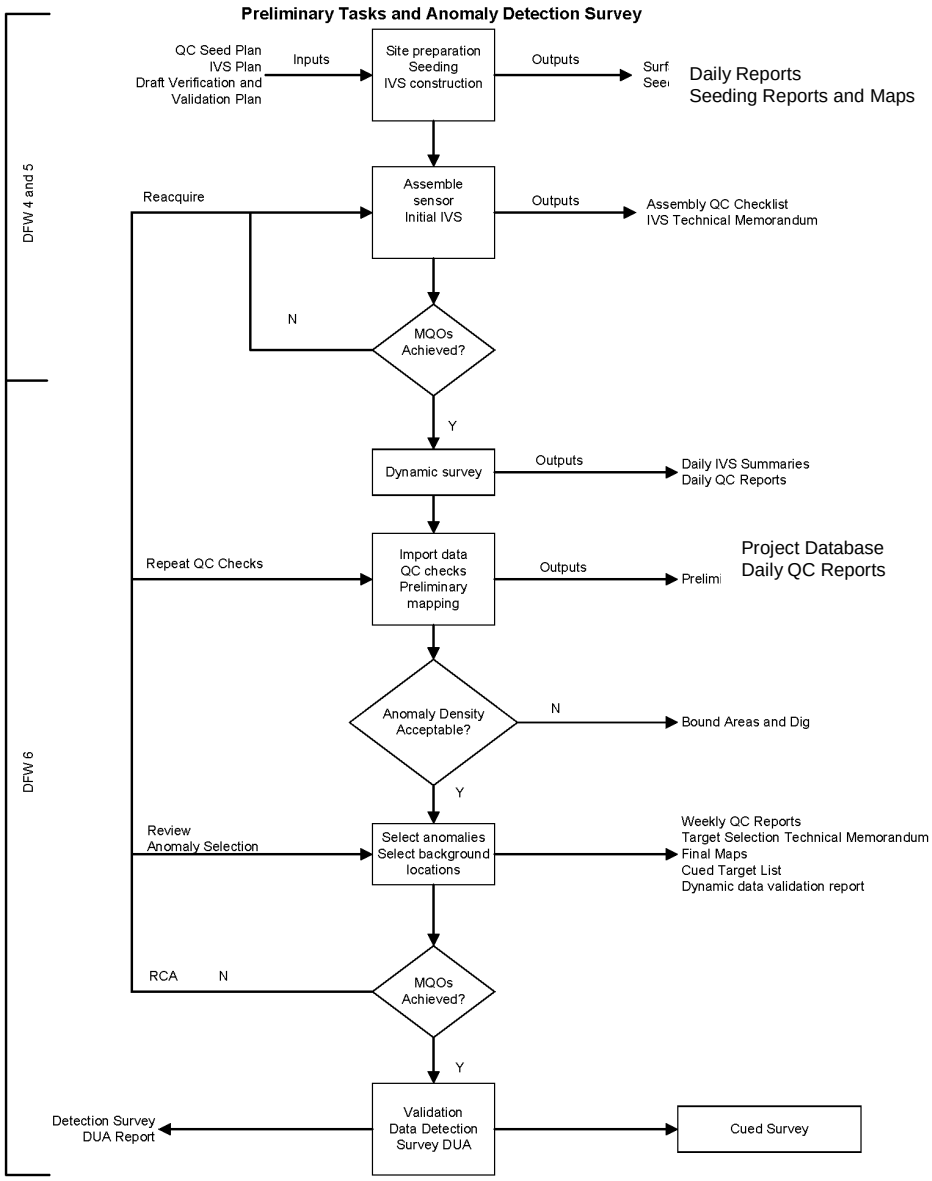


Figure 17-2 Geophysical Classification Decision Tree – Cued Survey

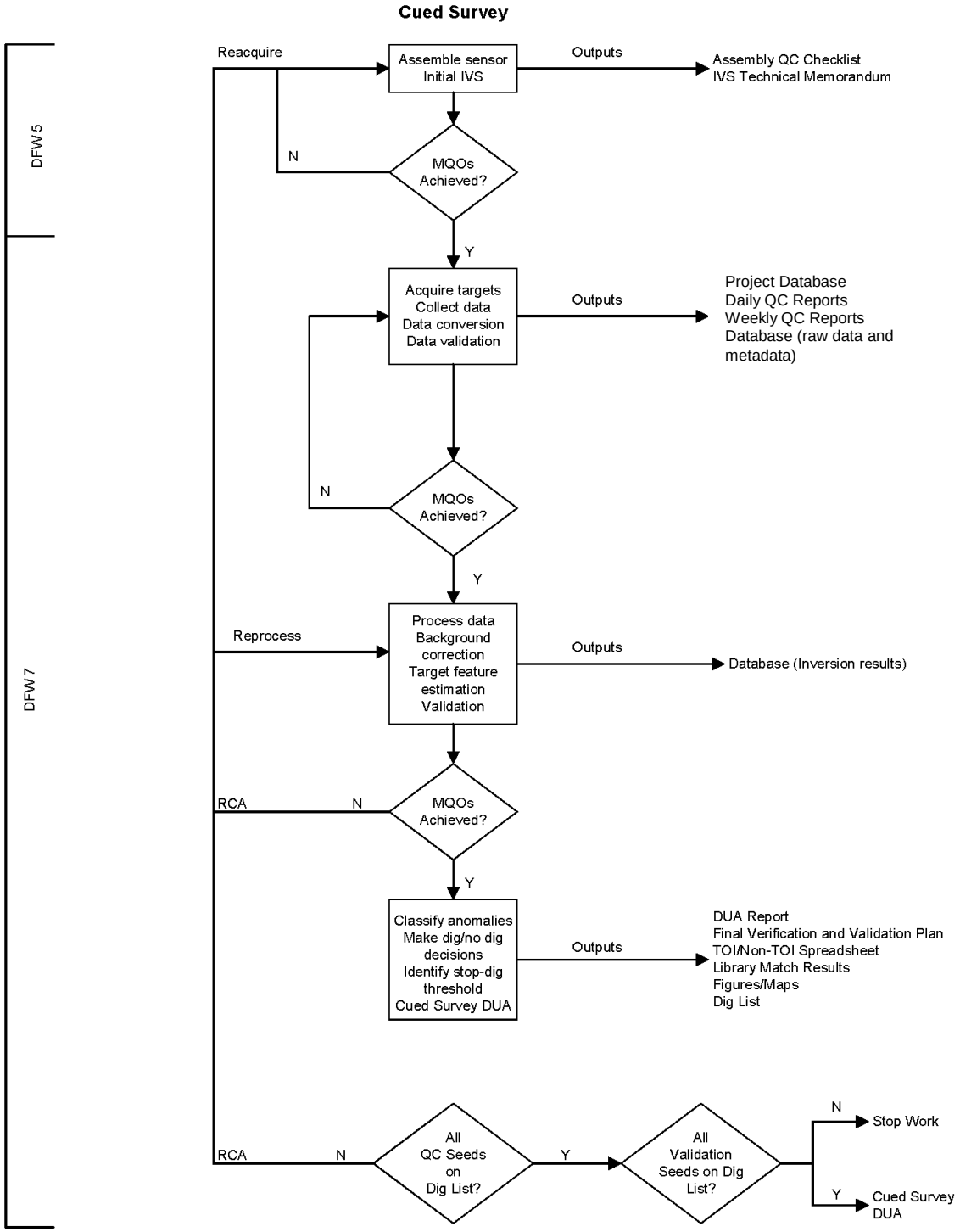
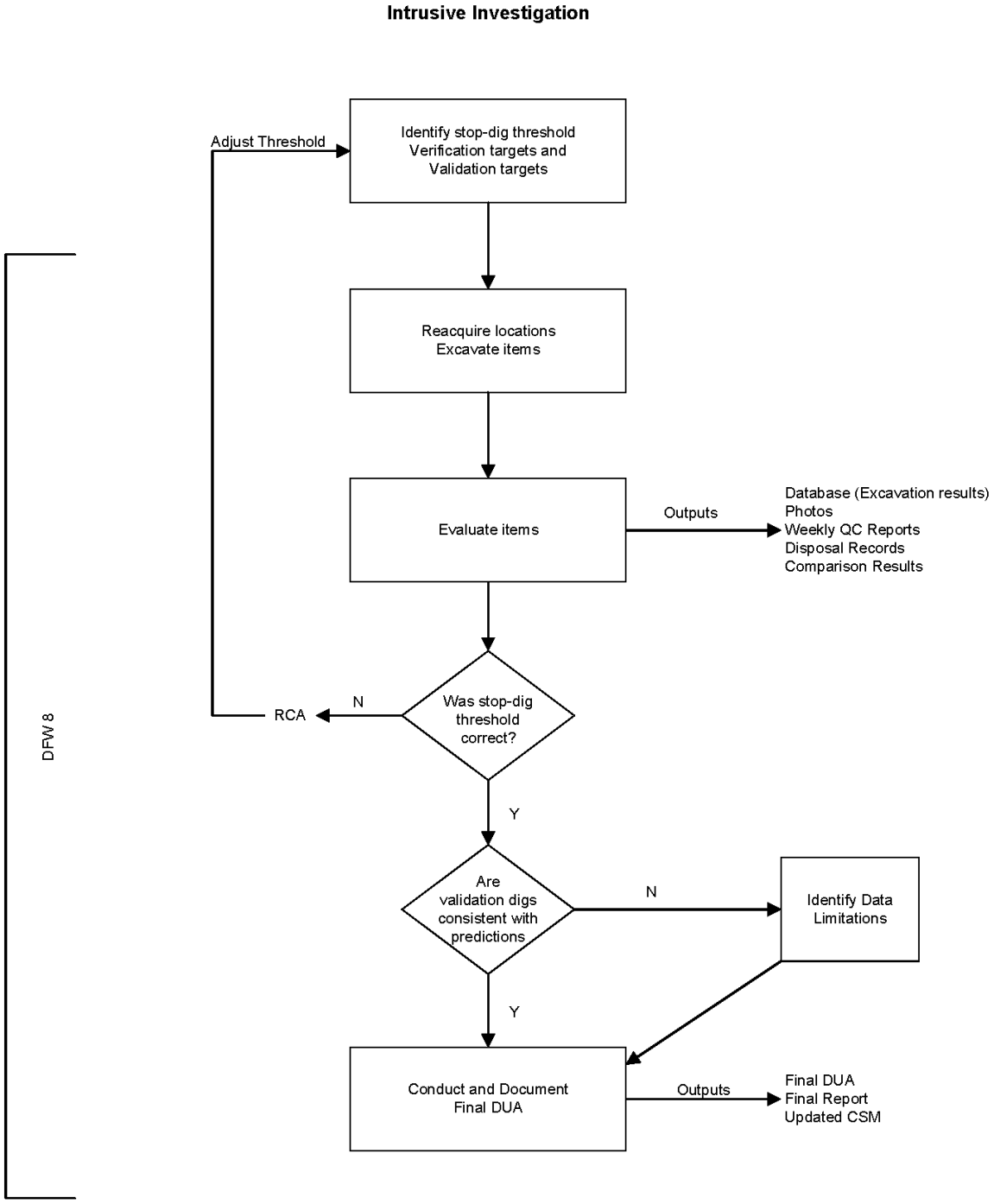


Figure 17-3 Geophysical Classification Decision Tree – Intrusive Investigation



The UFP-QAPP and SOPs will be reviewed by the SUXOS, UXOSO/UXOQCS, and QC geophysicist during this phase to ensure that they describe prequalifying requirements or conditions, equipment, materials, methodology, and QC provisions. Discrepancies between existing conditions and approved plans and procedures will be resolved, or CAs will be taken for unsatisfactory and nonconforming conditions identified during a preparatory phase inspection. This will be verified by the UXOQCS or his designee before approval to begin work is granted.

The SUXOS, UXOSO/UXOQCS, project geophysicist, and field team leaders will review the Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP) (separate document) and the appropriate AHAs to ensure that applicable safety requirements have been achieved. Preparation phase inspection results will be documented using the Preparatory Phase Checklist and will be summarized in the Daily QC Report. The personnel qualifications checklist will be used to ensure that personnel meet or exceed the training standards outlined by DoD, USACE, and OSHA, including applicable hazardous waste operator training.

17.1.2 INITIAL PHASE

This phase will be performed when the fieldwork has been initiated for a given DFW. The purpose of this phase will be to accomplish the following:

- Inspect the work in progress for compliance with QC requirements.
- Verify adequacy of QC controls to ensure full contract compliance.
- Establish an acceptable level of workmanship.
- Review field operations for compliance with appropriate SOPs.
- Verify that documentation related to field activities is complete.
- Verify that required personal protective equipment (PPE) and other safety procedures are in compliance with the QC specifications contained in the APP/SSHP and AHAs.
- Resolve differences of interpretation that may affect the quality of work.

Additional preparatory and initial phases may be conducted on the same work being performed if 1) the quality of ongoing work is unacceptable, 2) there are changes in the on-site production supervision or work crew, 3) work is resumed after a substantial period of inactivity (two weeks or more), or 4) other problems develop.

The UXOSO/UXOQCS, SUXOS, Project Geophysicist, or Field Team Leader will be responsible for ensuring that all discrepancies between site practices and approved plan specifications are identified, documented, and resolved. CAs for unsatisfactory conditions or practices will be verified by the UXOQCS or his designee before granting approval to proceed. Initial phase results will be documented on the Initial Phase Checklist and summarized in the Daily QC Report.

17.1.3 FOLLOW-UP PHASE

This phase will be conducted for each DFW until it has been completed. The purpose of this phase is to ensure compliance with contract requirements, and it will include the following activities:

- Verify that the work has been completed in compliance with contract requirements and applicable standards.
- Ensure that the quality of workmanship was maintained and achieved.
- Validate all fieldwork to ensure that no data gaps exist and schedule additional field activities to address any existing data gaps.
- Verify that all safety and quality inspections were performed.

The UXOQCS is responsible for on-site monitoring of the practices and operations taking place and for verifying continued compliance with the specification and requirements of the contract, approved project plans, and procedures. The UXOQCS will oversee and observe activities as specified in the initial inspection and will verify that CAs for unsatisfactory or nonconforming conditions have been taken before granting approval to continue work. Final follow-up phase checks will be conducted and all deficiencies corrected before starting additional DFWs. Final follow-up checks will be documented and summarized in the Daily QC Report.

17.2 DFW 1: MOBILIZATION

WESTON will coordinate with RFAAP and BAE Systems to determine the required training, documentation and permitting for area entry, digging, hot work, and equipment operation prior to mobilization for field investigations. The WESTON PM will conduct a readiness review with technical staff to ensure that the team has the proper tools, equipment, and safety gear to complete field tasks in accordance with this UFP-QAPP and associated plans and procedures. Following completeness of the readiness review, WESTON will mobilize initial personnel and equipment and begin site setup operations. Prior to beginning site work, the UXOSO/UXOQCS will establish and review personnel files to verify work and safety qualifications are in place. Personnel qualifications and records will be maintained on-site for review and tracking.

An office trailer and equipment storage facilities will be sited at a RFAAP-approved laydown area. Marine equipment will be staged at a location to be determined based on communications with RFAAP personnel. This area will serve as command for all field operations and will house equipment, IVS, MDAS storage, and first aid triage stations.

Staggered personnel mobilizations are anticipated for this project based on the DFW underway on an as-needed basis and include the following:

- Mobilization for site preparation activities which include equipment setup, training, and vegetation clearance;
- GSV and blind seeding program;
- Dynamic data collection surveys;
- Cued data collection;

- Intrusive investigations (hand digs and mechanical trenching/test pitting);
- MC sampling (soil and sediment) to include on-site XRF analysis, off-site laboratory discrete and confirmation sampling, and subcontracted Direct Push Technology for subsurface sampling;
- DGM of Area A (New River);
- Intrusive investigation and MC sampling of Area A (New River); and
- MEC demolition operations.

After personnel are on-site, the SSHO and UXOSO/UXOQCS will provide an overview presentation of the UFP-QAPP and a safety briefing during which emergency procedures will be reviewed. Personnel will read the APP/SSHP and sign an acknowledgement form confirming they understand the provisions laid out in the documents prior to performing any field work. The purpose of this training is for supervisors and site personnel to fully understand the procedures and methods used during investigation activities, individual duties and responsibilities, and safety and environmental practices and procedures associated with field operations.

A summary of the anticipated members of the Project Field Team is provided in **Table 17-1**. Mobilization includes deploying personnel and equipment, establishing work laydown areas and storage facilities and hosting a safety briefing prior to the start of work.

Table 17-1 Project Field Team

UXO Field Team (8 Total)	DGM/AGC Field Team	MC Sampling Field Team	Subcontractors
SUXOS UXOSO UXOQCS UXO Technician III UXO Technician II (2 each) UXO Technician I (2 each) Dive Team: Dive Supervisor, Dive Tender, Standby Diver, and Diver	UXO Technician II Project Geophysicist QC Geophysicist[1]	Project Geologist Project Engineer Project Scientist	Thompson & Litton (Virginia PLS) Ground Resource Drilling Inc. (DPT Drill Rig) AOR International LLC (dive operations at Area A) CT Laboratories LLC (Analytical Laboratory) Austin Powder, Daleville, VA. (Donor Explosives) MDAS Disposal (TBD)

[1]The QC Geophysicist will be on-site during initial AGC field activities, including IVS set up and initial IVS testing and blind seeding.

If MEC is encountered during the initial tasks (e.g., site preparation, vegetation clearance, surveying, grid establishment, and DGM/AGC surveys) when WESTON has only one UXO Tech II on-site for MEC avoidance, WESTON personnel will guard the item while awaiting arrival of the WESTON UXO demolition team to handle demolition of the item(s). Any MEC-related corrective actions during the field investigations will be approved by the BAE Explosives Safety Manager prior to implementation, and work will not resume until BAE has verified that the unsafe condition has been corrected.

17.3 DFW 2: SITE PREPARATION

The RFAAP Utilities Department will be contacted after mobilization as part of the initial site preparation activities and prior to vegetation clearance activities (**Section 17.4**) and professional land surveying (**Section 17.5**). These DFW are discussed below.

17.4 DFW 3: VEGETATION CLEARANCE

Some vegetation thinning will be required to complete land-based DGM/AGC work along transects and/or within grids. Vegetation that hinders geophysics operations or sampling teams will be removed to the extent necessary to gain access for personnel and equipment and will be limited to what is necessary to facilitate quality data collection, while ensuring safe working conditions.

Each brush clearing equipment operator will be escorted by a UXO Technician II or above meeting the qualifications required in DDESB TP18 Chapter 4 (DDESB, 2016) throughout clearing activities at the MRS. The UXO Technician is required as a result of the possibility of encountering MEC/MPPEH items. In the event MEC/MPPEH items are discovered during vegetation clearance activities, work stoppage may be necessary to provide a safe distance for personnel/property and for the establishment of the necessary exclusion zones. Any MEC-related corrective actions during the field investigations will be approved by the BAE Explosives Safety Manager prior to implementation, and work will not resume until BAE has verified that the unsafe condition has been corrected.

All vegetation removal activities will be performed in accordance with the EPP provided in **Appendix L** and only to the extent required to support the clearance objectives of each transect or grid. The project geophysicist, in conjunction with the SUXOS (or UXOSO/UXOQCS), will identify the areas requiring vegetation clearance. Anomaly avoidance will be practiced during all vegetation clearance operations.

No trees will be removed at the MRS; however, branches may be pruned or cut to aid in the geophysical survey. Such thinning will be performed manually with pruners or hand-held gas-powered brush cutters or chain saws only to remove branches necessary to enable access for the geophysical survey. Any vegetative debris or mulch derived from the vegetation clearance process will be distributed on the ground surface in areas that do not require mowing (such as the naturally wooded portions along the New River to the south of the MRS).

Large pieces of surface metal unrelated to MEC/MPPEH will be removed during vegetation removal, or identified and located for later removal prior to geophysical data collection.

17.5 DFW 4: PROFESSIONAL LAND SURVEY AND GRID ESTABLISHMENT

Surveying services will be provided by a VA-licensed land surveyor. Survey operations will be performed prior to surface and subsurface removals and will be performed in compliance with EM 200-1-15 (USACE, 2015).

A UXO Technician II or above will accompany the survey crew during all field activities. The UXO Technician escort will use a White's all metals magnetometer, or equivalent, to perform

anomaly avoidance prior to setting any stakes. Stakes will not be installed without approval from the UXO Technician escort.

Prior to conducting field DGM activities, six survey control points will be established to support data collection. Two control points will be set at each of the three geophysical survey areas; (1) Former Gun Range/western end of the Former Trench Mortar Range, (2) eastern end of the Former Trench Mortar Range, and (3) Area A. One control point will be used for real-time kinematic (RTK) global positioning system (GPS) base station positioning.

The second point at each location will be used to confirm positional accuracy upon RTK GPS setup each day as a QC function test. A record of control points will be maintained with the RFI data. The surveyor will also survey the (Instrument Verification Strip) IVS seed items, survey and mark all geophysical grid corners, and survey the locations of all blind seeds within the grids.

The surveyor or field crews will install 4-ft long, weather-resistant wooden stakes next to survey pins, or equivalent, at each geophysical grid corner for visibility, labeled with North American Datum (NAD) 1983 Universal Transverse Mercator (UTM) Zone 17 North meter coordinates. Flagging will be placed at the top of each stake. The surveyor will maintain a field logbook detailing all field activities, including daily entries of the personnel on-site, time of day work started and ended, weather conditions, delays, survey data, equipment used, and field sketches. Survey data points will be input into Microsoft Excel format.

A survey report for all benchmarks used during and established for the project will be submitted and will also be included in the RFI Report and entered in the GIS data. The grids and boundary survey will be incorporated into the overall project Geospatial Data Submission (GDS).

17.6 DFW 5: GEOPHYSICAL SYSTEM VERIFICATION

The Geophysical System Verification (GSV) is a two part program consisting of an Instrument Verification Strip (IVS) and a Blind Seeding Program (BSP). The MetalMapper 2X2 system will be assembled as described in GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification (**Appendix M**). Following assembly and operation verification, a GSV approach will be utilized to verify and monitor the MetalMapper 2x2 functionality during field investigations.

17.6.1 IVS

AGC equipment functionality will be verified and monitored using an IVS. A single IVS will be constructed at the RFAAP for use on both the Trench Mortar MRS and the Former Gun and Mortar Range MRS in accordance with GCO-SOP-12, Advanced Classification IVS (**Appendix M**). The IVS will be approximately 9 meters long and contain one small schedule 80 ISO, two medium schedule 80 ISOs, and one blank space. Each item will be separated by approximately 3 meters in accordance with GCO-SOP-12. Planned IVS construction will be as follows:

IVS Seed Descriptions				
ID	**Down-line (m)**	**Description**	**Orientation**	**Depth (m)**
IVS-01	0	Small ISO80	Horizontal, Across-Track	.2
IVS-02	3	Blank Space	N/A	N/A
IVS-03	6	Medium ISO80	Vertical	.3
IVS-04	9	Medium ISO80	Horizontal, Across-Track	.3

The initial IVS survey will be used to confirm that the Field Geophysicists and Technicians and the geophysical system is capable of meeting project MQOs in both dynamic and cued mode. Initial IVS survey procedures are detailed in WESTON GCO-SOP-12, Advanced Classification IVS. An IVS Technical Memorandum documenting the system verification will be submitted to the USACE QA Geophysicist for approval.

During the AGC data acquisition phases, WESTON will conduct two daily surveys of the IVS with the geophysical equipment to confirm the continued proper operation of the system, in accordance with GCO-SOP-12, Advanced Classification IVS. Results from these IVS surveys will be monitored against predetermined MPCs (see Worksheet #12A) designated to verify that the system is capable of achieving the stated detection goals. Final detection thresholds will be defined and established based on initial IVS testing and data analysis.

Water-based G858 equipment functionality will be verified and monitored using a separate IVS constructed in Area A. Our water-based IVS approach uses one large ISO and two medium ISOs fixed to a line between two jack stay anchors. Each ISO will be separated by at least 20 ft to avoid overlapping signals. Breakaway floats are attached to each ISO for collection of RTK GPS coordinates. This process also provides a means for recovering items at project completion.

17.6.2 BLIND SEEDING PROGRAM

A seeding program using ISOs will be placed across the MRS at a frequency of at least one item for each day's data collection to monitor detection performance and positional accuracy of geophysical instrumentation. Blind seeds will consist of medium ISOs to represent the expected munitions on-site but may also include small ISO items in AGC and analog investigation areas. The blind seeding team will place blind seeds prior to conducting the geophysical surveys. The seeding team will consist of the QC Geophysicist (or designee), a PLS to record seed location, and a UXO Technician II to provide MEC avoidance. Members of the seed team will have no further role in the collection, processing, or analysis of the geophysical data. At no time will the QC Geophysicist, or designee, provide the geophysical survey team information regarding the seed locations or types of seeds emplaced. QC seed information will be controlled as described in the Blind Seed Firewall Plan (included in **Appendix F**).

Performance of the blind seeding program will be documented in the Production Area Seeding Report. Blind seeds will not be used to measure EM31 performance since the equipment is not designed or intended for a BSP.

17.7 DFW 6: EM31-MK2 SURVEY

EM31-MK2 surveys will be performed over all accessible area, approximately 28.19 acres of the Former Trench Mortar Range and the 17.48 acres of the Former Gun Range (**Figure A-7**). EM31-MK2 operations will be performed in accordance with the USACE Performance Requirements for Removal Actions using DGM Methods as presented in EM 200-1-15 (USACE, 2015).

An RTK GPS (GCO-SOP-31) will be integrated with the EM31-MK2 for accurate data positioning. The precise position of each EM31-MK2 measurement will be calculated by translating the GPS antenna location to the sensor location during collection.

Data will be collected at a line spacing of 10 ft to locate burial features and to provide the data density necessary for detection of suspected burial trenches on site. The data will be collected at the speed demonstrated at the IVS to ensure that along-line spacing between data points is less than 0.25 meter. Line spacing will be maintained by placing visual markers for the technician to follow or by use of navigation display system on the data logging system.

Dynamic EM31-MK2 data will be stored by the supplied data acquisition system on a hard disk and downloaded to the field processing computer via portable digital media (e.g., thumb drives). The dynamic EM31-MK2 data will be processed as described in GEO-SOP-5. The Data Analyst will assess the data to identify any areas where instrument responses are indicative of subsurface disturbances or possible burial trenches. Areas determined to contain potential burial trenches will be considered for intrusive trench investigations as described in MR-SOP-2 (**Appendix H**) and DFW 10.

17.8 DFW 7: DYNAMIC DETECTION SURVEY (AGC METALMAPPER 2x2)

Prior to dynamic data collection, the MetalMapper 2x2 will be assembled and verified in accordance with GCO-SOP-11, 2X2 Sensor System Assembly and Verification. Dynamic data will be collected over 100% of the designated survey area in accordance with GCO-SOP-29, Performing Dynamic Surveys with MetalMapper 2x2. Data coverage was designed using VSP to test the hypothesis that we can be 95% confident that there is less than or equal to 0.5 TOI within the Former Trench Mortar Range and Former Gun Range portions of the MRS. Approximately 4.13 acres (20.75%) of the Former Gun Range and 3.03 acres (8.29%) of the Former Trench Mortar Range require investigation for a 95% confidence that there are less than 0.5 MEC per acre. Data will be collected in VSP generated 100-ft by 100-ft grids at a line spacing of 0.5 meters (m) to ensure full coverage to provide the data density necessary for detection of the smallest TOI and accurate target selection.

Dynamic data will be stored by the supplied data acquisition system on a hard disk and the field team will electronically transfer the MetalMapper2X2 data to the data processor at the end of each survey day at a minimum. Dynamic data will be processed in accordance with GCO-SOP-30, Processing Dynamic Survey Data MetalMapper2X2. Anomalies will be identified using a threshold based on the z-component of the dynamic data. The site threshold will be based on the site noise for a conservative approach and will be established based on the initial IVS measurements. Target amplitude thresholds will be set greater than 5 times RMS of the background

noise on site. Raw amplitude detection lists will be screened for high-probability clutter items using Informed Source Selection filtering. Thresholds will be presented in the IVS Memorandum and will be approved by the government prior to target list development.

All of the targets picked above the target selection threshold will be inverted for a polarization tensor model that includes an estimated target location and depth. Inversion results for each target pick will allow for a comparison of polarizabilities and source locations for nearby picks and an objective decision to be made on whether multiple picks represent the same source. If a significant number of fast decaying anomalies are encountered at a site, a combination of size and decay features obtained from the dynamic data inversions will be used to screen out anomalies that are too small or too fast decaying to be considered TOI.

All dynamic data will be reviewed by the QC Geophysicist who will ensure that the blind seeds were detected, and that all MQOs defined in Worksheet #22 have been achieved. The QC Geophysicist will also review geophysics Daily Reports and SOP checklists to ensure the field teams and Data Analysts are working in accordance with the QAPP and SOPs. The QC process will be documented each day in a Daily QC Report. Validation of the dynamic data will be performed through comparison of the data to the MQOs specified in Worksheet #22 and as described in Worksheet 35.

17.9 DFW 8: CUED SURVEY (AGC METALMAPPER 2x2)

Each of the anomaly locations selected during the dynamic survey will be reacquired for cued investigation. Single-target and multi-target inversion routines in UX-Analyze will be used to determine the parameters of a target (single–target inversion), or constellations of targets (multi-target inversion), that would produce responses that closely match the observed responses. These parameters include extrinsic parameters (location and orientation) as well as the intrinsic parameters related to the object size, shape, and composition. These intrinsic parameters are the principal axis polarizabilities, otherwise known as betas (β), and are the parameters used for classification.

The single-target inversion solves for a single target and the multi-target inversion posits multiple targets. The multi-source solver not only estimates the parameters for multiple source objects, but also produces a number of candidate "realizations" of target combinations. Each candidate realization proposes a configuration of targets whose combined modeled response reasonably fits the observed data. For example, one candidate realization may have three targets, whereas a second candidate realization for the same measurement may have two, three, or four targets. This process reflects the fact that, with an unknown number of potential targets of different sizes and shapes, a number of different model combinations can closely match the observed data. A separate fit coherence value is derived for each candidate realization as well as for the single solver.

Background locations for the cued survey will be selected based on the DGM survey results. Background locations will be selected to meet the requirements described in GCO-SOP-18, Collection of Static Background Measurements (**Appendix M**). Each background location selected will be verified by collecting five cued advanced EMI sensor points at the selected location and offset approximately 0.4 meter in each cardinal direction. If comparison of the decays for any of the five cued data points indicates the presence of metallic objects, that location will

either be cleared and rechecked, or will not be used for background data collection during the cued survey.

Cued data acquisition will be performed in accordance with GCO-SOP-19, Collection of Cued Target Measurements (**Appendix M**), and will not commence until after the cued target list has been reviewed and approved by the project team. Any anomalies added to the cued target list based on the project team's review of the Target Selection Memorandum, the data validation results, and the data anomaly list will be collected before the cued data collection team demobilizes from the site. A DUA will be completed for the DGM data using the four-step process described in Worksheet #37 following the project team's acceptance of the final cued target list.

Cued target data will be processed using UX-Analyze-Advanced in accordance with GCO-SOP-20, Processing of Cued Target Data (**Appendix M**). After the cued data are downloaded from the data acquisition computer, the Data Analyst will review the dataset to validate that it meets the MQOs listed on Worksheet #22, including the following:

- Instrument function test;
- IVS-derived polarizabilities;
- IVS-derived positions;
- GPS quality;
- Offset from selected to measured position;
- Production area background measurements;
- Transmit current levels;
- Offset between multiple sensors; and
- Valid inertial measurement unit function.

The results of these checks will be summarized in the project QC database and Weekly QC Reports.

17.9.1 CLASSIFICATION

Objective, numeric criteria will be used to classify the anomalies. These criteria will be used to create a prioritized list with high likelihood TOI placed at the top of the dig list (just after digs classified as "training data" and "can't analyze") and high likelihood non-TOI placed at the bottom. The primary method for classification will be library matching, supplemented by cluster analysis and feature space analysis as described in the following subsections.

17.9.1.1 Site Specific Library

A site-specific AGC library of βs will be utilized for classification of munitions items. The DoD TOI AGC library will be obtained from USACE prior to mobilization and will be modified to include all DoD library records of items identified as TOIs in **Table 10-2** as well as all ISO items. A qualified UXO Technician will confirm the entries in existing libraries as representative (i.e., the same caliber, model, and configuration) of the anticipated TOI. Intrinsic parameters for TOI items that do not have an entry in the existing library will be derived from test measurements (if items are available) prior to the start of the classification process.

17.9.1.2 Library Matching

The classifier will be based primarily on the confidence metric generated by UX-Analyze during a comparison of the β values estimated for each surveyed target and the β values in the munitions library developed for the project. The confidence metric indicates the fit correlation between a target and the best fit item in the library, with higher metrics indicating a better fit between the target and the corresponding item in the library. The library fit analysis will match the following four combinations of betas to those of the candidate library TOIs:

- β1, β1/β2, β1/β3
- β1, β1/β2
- β1/β2, β1/β3
- β1

This library matching process will be performed for each single-solver model and every target model in each of the multi-solver candidate realizations. For each flag position, the best library fit from the single-solver and multi-solver targets will be used to derive a decision metric. This decision metric will be used to rank the target list in descending order of likelihood of being a TOI. The list will be divided into TOI (dig) and non-TOI (no-dig) based upon the threshold. The threshold is the decision metric threshold below which all items are classified as non-TOI.

Objects will be classified into one of the following three categories:

- Category 1: TOI (highly likely to be MEC)
- Category 2: Non-TOI (highly unlikely to be MEC)
- Category 3: Inconclusive (data cannot be analyzed)

Objects will be placed on a ranked anomaly list, arranged in order from highest likelihood the object is a TOI to highest likelihood the object is a non-TOI. A stop-dig threshold between TOI and Non-TOI (i.e., the last TOI on the dig list) will be defined by the Data Analyst. Prior to acceptance, USACE will review the classification results with regard to the validation seeds and other pertinent validation data. Changes may be made to the classifier used and the dig list as necessary, prior to acceptance.

17.9.1.3 Cluster Analysis/Feature Space Analysis

To detect instances of potential TOI that are found throughout the MRS but not included in the library, the Data Analyst will perform a cluster analysis. This analysis involves identifying groups of anomalies that have similar β signatures. The Data Analyst will select representative samples of these clusters to be intrusively investigated as part of the set of calibration digs. If the intrusive investigation identifies a hazardous item, these signatures will be placed in the library and the matching process will be repeated to ensure that all similar items are classified as TOI.

The Data Analyst will also perform a feature space analysis to identify individual items that do not match any library items but have βs that indicate a large, axially symmetric, thick-walled object. These items will be investigated as part of calibration dig program and added to the library if they are identified as TOI.

17.9.2 VERIFICATION AND VALIDATION PLAN

The Verification and Validation Plan (**Appendix N**) is designed to provide assurance that there are no native TOI classified as non-TOI. As discussed above, there are three ways for a target to be classified as a TOI:

1. Match any of the candidate TOI items in the library.
2. Be a member of a cluster or group of similar βs that are identified as TOI through calibration digs.
3. Have features that are typical of TOI (axial symmetry, thick walled, large).

The verification process will be performed by selecting approximately 200 digs directly beyond the stop dig point to test the assumptions inherent in the classification approach. The final number of verification digs required will depend on multiple factors, including USACE/stakeholder requirements, performance against the QC and QA seeds, and the quality of the partial receiver operating characteristic (ROC) curves derived from the intrusive investigations.

Data validation is a detailed evaluation of data for conformance to stated requirements, e.g., those contained in the contract, SOPs and Worksheet #22. The project team will select the 200 classification validation targets, review the draft Verification and Validation Plan, and make changes as necessary. The 200 targets selected as validation digs will be selected randomly or based on judgment, such as magnitude response, degree of axial symmetry, physical size, etc.

The Verification and Validation Plan is located in **Appendix N** and will be amended based on the classification approach and results.

The following discussion presents an initial approach to classification verification for each mode of classification, with emphasis on describing what thresholds will be tested and the rationale for these tests. Verification failures will require a root cause analysis (RCA), and appropriate procedural modifications will be developed and implemented in consultation with USACE.

17.9.2.1 Target Selection Verification

For the MetalMapper2X2 dynamic survey anomaly selections, a subset of the rejected anomalies that are at or below the cutoff threshold will be sampled by marking them for cued investigation and follow-up intrusive investigation to ensure these thresholds are appropriate. A verification failure will result if any targets are found to be MEC.

17.9.2.2 Library-Match Threshold Verification

Similarly, the threshold used to declare an anomaly as non-TOI will be confirmed by sampling through intrusive investigation beyond this threshold. The number of digs required to achieve this confirmation will largely depend on the dig results – particularly for anomalies that were ranked prior to the analyst cut-off threshold. Partial ROC curves showing a steep ascent early in the prioritized list (indicating most targets are TOI), followed by a small section of "flat line response" indicating the absence of TOI in the latter part of the prioritized list are indicative of successful classification. Partial ROC curves that do not display a distinct inflection point between the TOI

and non-TOI sections and have TOI in proximity (on the prioritized list) to the cut-off threshold, will require more verification digs. A verification failure will result if any TOI are found in the set of verification investigations.

17.9.2.3 Cluster Analysis Verification

The cluster analysis is designed to detect unexpected TOI found in the MRS. This is achieved by first identifying groups of items with similar βs, then sampling these clusters to determine if they are comprised of TOI or non-TOI. The underlying assumption is that within a cluster, the items will all be similar in size, shape, and composition. Clusters identified as TOI will result in an additional entry into the library, and items in this cluster will be classified as TOI. Accordingly, the verification for these items will proceed with verification of the rest of the library match results. For each cluster that is not found to be comprised of TOI, additional verification digs will be performed to confirm the finding. A verification failure will result if any TOI are found in the set of verification investigations.

17.9.2.4 Feature Analysis Verification

Additional verification digs will be performed to verify that the cut-off thresholds for feature space identification of potential TOI will be performed. Values related to size, axial symmetry, and decay (longer decays are indicative of thick-walled objects) are calculated from the βs. A set of verification digs will be derived to test the cut-off threshold used for each of these parameters. A verification failure will result if any TOI are found in the set of verification investigations.

17.10 DFW 9: INTRUSIVE INVESTIGATION, ANALOG MAG AND DIG, AND MECHANICAL TRENCHING

17.10.1 ANALOG SURVEYS

The survey design at RFAAP has been designed by VSP to ensure a statistically defensible investigation plan. Some areas that require intrusive investigation will not be traversable (e.g., sloped areas on the southeastern side of the Former Trench Mortar Range) for AGC technology deployment. These AGC untraversable areas will be intrusively investigated using a full-coverage analog geophysical survey approach, where possible based on terrain and other factors that will be determined in the field.

Subsurface analog removal will be performed using hand-held magnetometers in accordance with MR-SOP-2 (**Appendix H**). Subsurface analog removal will be conducted using handheld sensors, such as a White's all-metals magnetometer (or equivalent analog instruments) with the capability of ground balancing to reduce detection of magnetic soils and/or rocks ("hot rocks") to identify subsurface anomalies based on the audible output to the analog sensor. Analog geophysical instruments will be brought on-site in a ready state. Analog geophysical instruments will be operationally tested on a test strip to ensure that adequate instrument setting for specific tasks is achieved. Blind seeds will be placed in areas designated for analog investigations at a frequency to ensure that a minimum of one seed item is identified per operator per day. Any failure to identify a blind seed will result in an RCA and may require re-visiting areas to ensure they have been properly surveyed.

Analog surveys will be conducted concurrently with intrusive investigation activities (described in Section 17.10.2). As anomalies are identified by the instrument operator(s), they will be investigated as detected ("mag and dig").

17.10.2 INTRUSIVE INVESTIGATION

All anomalies that are selected as TOI, inconclusive, or are inclusive of QC/QA anomalies will be reacquired using RTK GPS or RTS for intrusive work. The SUXOS and UXOSO/QCS will oversee and assist the reacquisition team. The SUXOS will schedule operations such that the minimum team separation distance is maintained at all times in accordance with the Explosive Safety Submissions (ESSs) (WESTON, 2017d and 2017e). The UXOSO/QCS will monitor team separation distances.

One seven-man intrusive investigation team will be utilized during intrusive investigations. The team will consist of one Technician III (Team Leader), two UXO Technician IIs, and four UXO Technician Is. The UXO Technician III will supervise the intrusive operations for the team. Technician Is will always work under the supervision of a Technician II or Technician III, in accordance with DDESB TP 18 (DDESB, 2016).

Predicted depths based on AGC will be provided to the UXO Team. The team will record offsets from waypoint locations, target description, size, depth, and orientation of items recovered. Dig results will be digitally recorded to increase efficiency and reduce transcription errors. Digital photographs will be taken of identifiable MEC and significant MD found during the investigation.

The MPPEH will be carefully uncovered and examined to determine the item and its condition. Each item will be identified on WESTON grid sheets to include x, y, and z coordinates. The Team Leader will also record all intact MEC item locations using a GPS unit. The GPS unit will be checked each day against two known control points to ensure accuracy within prescribed limits. Results of this daily test will be logged. Additionally, MEC that may require detonation/venting will be marked with red flags for future demolition or venting operations.

If a MEC item is located that differs from what is expected in the area, the SUXOS or UXOSO will notify the USACE OESS and USACE PM so the situation can be evaluated. If a larger minimum separation distance expanding the exclusion zone is required, the SUXOS and UXOSO will implement the new minimum separation distance.

An accounting of intrusive investigation findings will be included in an appendix to the RFI Report. Team Leaders will record anomaly production data and will include the location, ordnance designation, and associated descriptive data of individual MEC items, number of digs, pounds of MD, and pounds of non-MD so that the results can be compared to the specific classification.

These results will be reported daily to the WESTON PM and USACE PM. A copy of the form will be transmitted to WESTON's project GIS Specialist, who will input the data into the project GDS. A running log and status map will be produced weekly and transmitted to the field for QC review against on-site records.

17.10.3 MECHANICAL TRENCHING/TEST PITTING

The mechanical trenching program will be based on the EM-31 results and the topographic fill analysis findings. Because there were no documented munitions items encountered at a depth within the planned investigation area of the MRS (munitions were encountered in the subsurface at the active production facility, but that is an inaccessible area for this investigation), no mechanical trenching locations have been identified for the historical munitions items encountered within the investigation area of the MRS.

Potential munition burial area excavations based on EM31-MK2 survey results will involve earthmoving equipment. A technical memorandum will be prepared after completion of the EM31-MK2 survey to present the findings and identify any potential munition burial areas that require mechanical trenching and test pitting for further characterization.

As discussed in Section 10.4.2, a topographic final analysis was conducted to compare and assess historical and present day topography to quantify cut and fill areas within the MRS. Trenches/test pits will be excavated as the 10 locations recommended based on the Topographic Fill Analysis Report (WESTON, 2019) to assess the nature and to delineate the vertical extent of buried materials and/or MEC. For the test pitting associated with the topographic and historical aerial photograph analysis conducted, the vertical depth of the test pit will terminate 3 ft into the 1949 grade to ensure that the intrusive investigation may encounter munitions items from former firing activities and not just into the overlying fill that has been placed in the area after firing activities terminated. Test pits will not be excavated deeper than 13 ft bgs because the maximum extent of fill identified in the areas of the planned test pits is 10 ft above the 1949 grade.

The trench and test pitting will be considered complete when MEC/MPPEH, MD, or evidence of MC is no longer observed for the pits associated with the EM31 results or when the excavator has penetrated 3 ft into the 1949 grade elevation for the pits associated with the topographic report findings. Due to the anticipated depths (deeper than 5 ft and up to 13 ft bgs) of the pits associated with the findings of the topographic report, there will be no UXO technician entry into the test pits for safety reasons.

For the EM31 associated test pits, a UXO Technician will guide the excavation to within 12 inches of any identified anomalies. After that point, the remaining intrusive operations will be conducted carefully using hands and hand tools. If a subsurface contact proves to be MD or non-MD, the item will be removed and the hole rechecked with a Schonstedt. If the hole is “clear” of MEC/MPPEH, MD, or non-MD related material, it will be refilled and tamped. Following inspection, identified MD will be certified as free of explosive hazards and will be transported off-site for recycling. Identified non-munitions related materials will be transported off-site for disposal as solid waste, subject to recycling pending material identification. Any material that could be of cultural significance will be reported to USACE.

17.11 DFW 10: G-858 SURVEY OF AREA A (NEW RIVER)

Recreational users and the morphology of New River represent a risk driver for this project. Numerous boat launches along the New River are located near the RFAAP, including Riverview Park, Dudley’s Landing, and Radford University, among others upstream and downstream of the

RFAAP. The depth of the water requires professional divers to investigate anomalies at the deepest part of the river channel. We currently plan to coordinate with the river keeper to perform river work when water levels are low to reduce the amount of diver-related services as possible and avoid times when recreational use is high.

Based on the CSM, there is a potential for munitions to migrate from the MRS to the New River. This method of deposition into the river would likely result in potential munitions items located primarily along the northern bank of the river with the potential to travel away from the bank as items are being washed down river. Therefore, the DGM coverage was derived using the *Target of Interest Rate Estimation/ Comparison* module in VSP. For the purposes of this RFI, a MEC density of 1.0 MEC per acre with 95 percent statistical confidence will demonstrate the required MEC density hypothesis for Area A.

Approximately 2.9 acres (9.35 percent) of Area A requires investigation for 95 percent confidence that there are less than 1.0 MEC per acre. DGM data will be collected over parallel transects in Area A MRS with a bias toward the northern shoreline as shown in **Figure A-7**. The northern shoreline is most likely lined with vegetation and fallen trees that may interfere with planned transect coverage; therefore, a meandering transect approach will be used near the shoreline to collect data where physically possible.

The Geometrics G-858 cesium vapor magnetometer coupled with a Trimble RTK DGPS for survey grade positioning will be used. The G-858 will provide the greatest detection range for the items of interest in the New River. A small Jon Boat (or similar) with an electric trolling motor will be used to complete the DGM survey in Area of the New River. The survey approach will use a vessel mounted magnetometer rather than a towed sensor to maintain better control of the sensor and a higher level of safety while navigating around obstacles close by the shoreline. This configuration will also allow for more accurate positioning that can be compromised when towing sensors through moving water. The G-858 will be mounted from the front of the vessel offset to minimize interference from the vessel and motor.

Sensor-boat/motor offset testing will be conducted at the site prior to finalizing the survey platform configuration. G-858 sensors will be encased in polyvinyl chloride (PVC) to protect the sensors while surveying at or below water level. The GPS antenna will be fixed to the boat and sensors offsets will be measured and accounted for during DGM surveys. Data acquisition will take place at approximately 2 knots and be adjusted to meet measurement quality objectives. WESTON plans to use the RFAAP boat ramp located on the south side of the New River for launching all boats being used for the field work (DGM and dive work) within Area A.

G-858 marine DGM transect survey operations will be performed in accordance with the USACE Performance Requirements for RIs using Digital Methods in EM 200-1-15 and DID MMRP-009-004 for Geophysics.

17.12 DFW 11: DIVE OPERATIONS OF AREA A (NEW RIVER)

A multifaceted anomaly investigation approach is needed because of the dynamic conditions of Area A within the New River such as current, river level fluctuation, river bottom topography, morphology, obstacles, water depth, and most importantly, diver safety. WESTON's

subcontractor, AOR, will provide dive operations for the project. WESTON will provide logistical support during dive operations and a land-based UXO team will be present during dive operations.

Low water conditions provide a safer and easier technical environment for dive operations because there is an associated reduction in flow and energy that should increase the diver's ability to acquire the anomaly under safer conditions. Details on specific conditions (e.g., water levels, water clarity) that are considered suitable for dive work in the New River will be evaluated prior to dive team mobilization. Coordination with American Electric Power (AEP) and monitoring river levels on the AEP website will be critical in determining potential impacts from dam releases of water from Claytor Lake. Data from the Peppers Ferry Road monitoring station provide information on river levels at the closest location to the Area A portion of the New River. The National Weather Service provides a forecast of water flows for this monitoring gauge.

All dive operations will be conducted by two qualified boat operators, a Dive Supervisor, a Dive Tender, a Standby Diver, and a Diver. Site management will be provided by our land-based UXO team including the SUXOS and UXOQCS/UXOSO. All UXO Technicians will meet or exceed DDESB TP 18 requirements for their respective positions. In accordance with EM 385-1-1 30.A.03, a self-contained underwater breathing apparatus (SCUBA) will be used for dive operations in Area A. SCUBA is the safest method for use in the New River due to the expected high flow conditions where surface supplied air (SSA) cannot be used. SCUBA conforms to USACE and OSHA 29 CFR Part 1910, Subpart T regulations. EM 385-1-1 30.C.01.c states SSA operations shall not be conducted against currents exceeding 1 knot. Divers will also use snorkels in shallow water along the shoreline to maximize productivity while adhering to safety and accuracy in reporting.

The SSA Dive Station will be located on the dive platform in a dive boat anchored in place during anomaly reacquisition and investigation.

All surface items will be recorded (NMRD, MEC/MPPEH, and MD). All MEC/MPPEH and MD will be brought to the surface for inspection and to confirm the diver's characterization unless the items are too large or unacceptable to move. Whether an item is too large to move depends on the weight, river conditions, and depth of burial. Items on the surface weighing over 25 pounds will likely need assistance to move to the surface. The dive boat will be equipped with a hoisting unit should larger items need to be recovered. Options for moving large items may also including air jetting to loosen the item, floating bags, and harnesses. NMRD will be left in place.

The divers will also be equipped with an underwater magnetometer, a Fisher Aquanaut 1280x or the Minelab Excalibur II (or equivalent). The location of all anomalies encountered will be recorded. All anomalies will be intrusively investigated. Once the selected anomaly's signature is detected and pinpointed, tactile searching techniques will be used to investigate the outside edges. The use of hand tools may be needed to assist in exposing an edge or end of the object, making sure not to dig on top of the item. Dialogue and direction from the topside Dive Supervisor to the diver are maintained through in-water voice communications during all dives. Once the item is uncovered and properly characterized, the item will be removed or left in place depending on the disposition of the anomaly discovered. In addition, if MEC/MPPEH item(s) are found to be damaged and/or heavily corroded via visible or tactile indications, sediment samples will be collected from 0 to 0.5 ft below the item.

If an item is located with potential cultural/historical significance the RFAAP POC and USACE PM will be consulted to determine whether the item(s) has cultural/historical significance and should be managed by and turned over to the appropriate authorities.

All munitions items will be transferred by the Dive Team to the land-based UXO team for final disposition.

Additional details on dive operations and safety procedures are provide in the Dive Plan, which was submitted as a separate document.

17.13 DFW 12: MPPEH/MEC AND MDAS HANDLING, CERTIFICATION, AND DISPOSAL

17.13.1 MEC IDENTIFICATION

Any MPPEH that cannot be verified to be free of explosive hazards or is suspected to present an explosive hazard will be considered MEC. Any MEC encountered during intrusive investigations will be clearly marked, and its position will be recorded by RTK GPS or RTS. Data regarding type, size, depth, condition, location of each MEC item recovered during NTCRA activities will be recorded, and all MEC encountered will be photographed. The Team Leader (UXO Technician III) will evaluate each item found and immediately report the condition of the item to the SUXOS and UXOSO. The SUXOS and UXOSO must be in agreement about the nature and condition of each MEC item before any action is taken. If a MEC/MPPEH item is suspected the area will be secured for safety and all MEC/MPPEH items will be guarded until they are properly addressed.

17.13.2 MEC REMOVAL

If the source of an excavated anomaly is considered to be MPPEH, it will be uncovered sufficiently to obtain a positive identification of the item. If the item is identified as MEC, a determination will be made about whether the item is deemed acceptable to move. After determining if an item is acceptable to move, the SUXOS and UXOSO will determine the most expeditious route for safe movement of the MEC item to an approved consolidation point. The approved consolidation point will be determined by the SUXOS and UXOSO, based on safety considerations and through coordination with the USACE PM. The approved consolidation point will also be approved by the USACE OESS and documented in daily production reports.

17.13.3 MEC STORAGE

No MEC will be stored on-site.

17.13.4 MEC DISPOSAL

17.13.4.1 General MEC Disposal Procedures

During disposal of MEC and related material, safety will be the primary concern. The primary requirements are to protect personnel, the public, and the environment from fire, blast, noise, fragmentation, and toxic release. Planned detonation of explosives will be conducted in accordance with the requirements outlined in DoD 6055.09-M (DoD, 2012) and in the WESTON Demo SOP

(**Appendix H**) and the applicable Fragmentation Data Review Forms, which will be available in the Government provided approved Explosives Site Plan (ESP) (**Appendix O**).

Standard electric or nonelectric demolition equipment may be used, including remote firing devices. The UXOSO has the overall responsibility to comply with the minimum requirements listed in the following paragraphs and has the authority to upgrade requirements as each situation dictates.

Demolition operations will not begin at a work site until all non-essential personnel are outside the minimum separation distances established for the ordnance and net explosive weight being detonated. MEC that cannot be moved will be blown-in-place (BIP). Engineering controls may be used to reduce the intentional detonation minimum separation distances. The goal of engineering controls during MEC disposal operations is to avoid and minimize the potential impacts on the environment. If implemented, these controls will be used in accordance with the ESP.

The April 2018 Draft Remedial Investigation ESP for the MRS indicates that the minimum separation distance for unintentional detonations is 242 ft for the munitions with the greatest fragmentation distance (MGFD) (81mm M45) as shown in **Table 17-2**.

Table 17-2 Minimum Separation Distances

MRS	MGFD	Minimum Separation Distance – feet			
		Unintentional Detonations		Intentional Detonations	
		HFD	Team Separation Distance (K40)	Without Engineering Controls (MFD-H)	Using Engineering Controls
Former Gun and Trench Mortar Range	81-mm HE Round	242[1]	66[1]	1,579[2]	200[3]

1. M45
2. M43A1
3. The EC distance is 125 feet; however, a 200-ft distance around the demo operation will be secured for safety reasons.

HE high explosive
HFD Hazardous Fragment Distance
MFD-H Maximum Fragmentation Distance – Horizontal
MGFD Munition with the Greatest Fragmentation Distance
MRS Munitions Response Site

Austin Powder located in Daleville, Virginia will provide donor explosives as required. An explosive storage magazine will not be sited. WESTON will have a Virginia-licensed Blaster on staff and UXO Technicians who hold Commercial Driver's Licenses (CDLs) with hazardous materials (HAZMAT) endorsement to allow transport of explosives in accordance with U.S. Department of Transportation (DOT) regulations. Donor explosives will be transported in a day box affixed to a dedicated vehicle. Coordination to bring donor explosives on-site will be done in advance with RFAAP and BAE Systems.

Disposal operations will be under the direct supervision of the demolition team leader, an experienced and trained UXO Technician III charged with the responsibility for all demolition activities within the area. The UXOSO will be responsible for training all personnel regarding the nature of the materials handled, the hazards involved, and the necessary precautions to be taken, and will also be present during all on-site disposal operations. The UXOSO will ensure that the appropriate authorities are notified prior to any on-site demolitions.

The following will be in place prior to disposal operations:

- All licenses/permits required authorizing WESTON to purchase, store, transport, or use explosives.
- WESTON UXO management personnel will have a Type 33-User of High Explosives License from the Bureau of Alcohol, Tobacco, Firearms, and Explosives (BATFE).
- WESTON magazine data cards.

The following entities will be notified of intent to detonate prior to detonation:

- RFAAP;
- USACE;
- Pulaski County Sheriff's office; and
- Radford Fire and Rescue Department.

Completion of detonation operations will be evaluated by the SUXOS using the MPCs described on Worksheet #12. More information can be found in the Environmental Management Plan (EMP) (**Appendix P**).

17.13.4.2 Material Potentially Presenting an Explosive Hazard

MPPEH will be processed and disposed of in accordance with Chapter 1, Section 11 of EM 385-1-97 (USACE, 2013). Additionally, site personnel will adhere to MR-SOP-4 (**Appendix H**), which establishes overall practices for WESTON UXO-qualified personnel inspecting, processing, securing, safeguarding, and managing MPPEH during MEC activities. Certification and disposal of MPPEH and MDAS will be monitored by the UXOQCS using the MPCs described on Worksheet #12.

Within or adjacent to each grid actively undergoing subsurface clearance, a UXO Technician III will establish a temporary collection point for MD. Smaller MD items will be placed in plastic buckets or suitable containers. During operations, surface clearance teams will inspect each surface anomaly for the presence of explosives. MD items that are free of explosives contamination and do not require venting will be placed in the grid collection point. At the end of each day, the MD in the temporary collection points will be collected and secured. The UXO Technician III will perform a second inspection of the material to ensure that it is free of explosives and/or other hazardous materials. The SUXOS will certify the inspection of each item a third time as the MD is placed in secured containers. The OESS or UXOQCS will verify that all MD and items placed in secured containers are free of explosive hazards and HAZMATs.

17.13.4.3 Material Documented As Safe

MPPEH that is inspected, verified, and certified to be free of explosive hazards will be classified as MDAS. MDAS generated during the project will be stored in a secure area inside locked containers. Once the field investigation is complete, the sealed containers will be shipped to a DoD-approved facility for proper disposal. Certification and disposal of MDAS will be monitored by the UXOQCS using the MPCs described in Worksheet #12.

17.13.4.4 Material Potentially Presenting an Explosive Hazard Documentation

The SUXOS will certify and the USACE OESS or UXOQCS will verify that debris is free of explosive hazards. If the OESS is not available, the UXOQCS will sign as the verifier. DD Form 1348-1A (**Appendix G**) will be used as the certification/verification documentation. All DD 1348-1A forms will clearly show the typed or printed names of the SUXOS and OESS/UXOQCS, as well as the organization, signature, and home and field office telephone numbers for the persons certifying and verifying that the debris is free of explosive hazards. The form will state the following if only MD is being processed:

> *This certifies and verifies that the munitions debris listed has been 100 percent properly inspected and, to the best of our knowledge and belief, if free of explosive hazards.*

The container will be closed and clearly labeled on the outside with the following information: the first container will be labeled with a unique identification that will start with RFAAP/RFAAP-002-R-01 MRS/WESTON/001/Seal Unique Identification information. Subsequent containers will be labeled sequentially. The SUXOS will ensure that a DD Form 1348-1A is completed for each container prior to transfer. The form will contain the following information:

- Location of where material was obtained;
- Basic material content (type of metal: for example, steel or mixed);
- Estimated weight;
- Unique identification number of each container; and
- Seal identification number.

In addition to the DD Form 1348-1A, MDAS shipments will be transferred to the recycler under a CoC.

All material will be accounted for in the daily and weekly reports. All MDAS will be disposed of at a recycler, where it will be processed through a smelter prior to resale or release in accordance with all governing regulations. If it is discovered during the material transfer and shipping process that a seal has been broken or the CoC of the material cannot be verified, the material in question will be subject to re-inspection following the established MPPEH process. The MDAS subcontractor will provide two documents:

1. CoC: Upon receiving the unopened labeled containers, each with its unique identified and unbroken seal ensuring a continued CoC, and after reviewing and concurring with all provided supporting documentation, the MDAS recycler will sign for having received and agreed with the provided documentation that the sealed containers contained no explosive hazards when received. This document will be signed on company letterhead and state that the contents of sealed containers will not be sold, traded, or otherwise given to another party until the contents have been smelted and are only identifiable by their basic content.
2. Certification of Destruction Letter: The MDAS recycler will send notification and supporting documentation verifying that the sealed containers have been smelted and are, therefore, only identifiable by their basic content. This documentation will be submitted as an appendix to the RFI Report.

17.14 DFW 13: MC SAMPLING

One of the primary purposes of the RFI is to perform an investigation to determine the presence or absence of MC at the Former Gun and Trench Mortar Range MRS, and if present, to determine the nature and extent of MC on the ground surface and subsurface and in adjacent sediment (Area A of the New River).

MC may be present at the MRS as a result of former military munitions operations. The scope of this section primarily documents the decision logic and summary of the proposed MC sampling approach for MC characterization within the Former Gun Range, where lead was detected above risk screening criteria during the SI (DU1). The MC sampling approach is also discussed for the Former Gun and Trench Mortar Range MRS and adjacent Area A (portion of the New River) where MC may be present in soil and/or sediment due to damaged and/or corroded MEC/MPPEH. The results of the MC characterization will be used to perform a baseline human health risk assessment and a screening level ecological risk assessment and to support Munitions Response Site Prioritization Protocol (MRSPP) scoring.

MC characterization will be conducted during two mobilizations after all geophysical and intrusive investigations have been conducted. The initial mobilization will include discrete soil sampling in the area of the former DU1, at identified damage/corroded MEC/MPPEH locations in the MRS; and sediment sampling (both at damaged/corroded MEC/MPPEH locations and in areas where potential runoff from the MRS has occurred) within Area A. The second mobilization (after initial analytical data have been evaluated) will include subsurface soil and sediment samplings at the MRS to determine the vertical extent of contamination and additional discrete surface soil sampling to fully define the lateral extent of MC contamination, if warranted.

A direct push drill rig will be used to collect the upland area soil samples in locations that are accessible for heavy equipment within the MRS while a hand-held auger will be used in the areas more difficult to access. A UXO technician will provide MEC avoidance services during all MC sampling activities.

No groundwater sampling is planned because impacts to groundwater are not anticipated because depth to groundwater is greater than 80 ft bgs based on data from various SWMU wells located above the steep slope to the New River. Although unexpected, if analytical data indicate subsurface soil at significant levels above RSLs that could impact groundwater quality, groundwater assessment may be warranted.

Soil sampling will be performed in accordance with the SOPs listed in Worksheet #21 and provided in **Appendix H**.

17.14.1 MC CHARACTERIZATION – DU1 AREA LEAD CONCENTRATIONS

Incremental sampling methodology (ISM) was conducted at DU1 during the Site Investigation (SI). DU1 is 300-ft by 335-ft in size and was situated on a hillside within the Former Gun Range area of the MRS. DU1 is a mix of thick weed open area and a mixed hardwood/pine forest. One hundred soil increments were collected for the ISM sample within DU1. The 100 ISM soil increments were collected and combined for each of the three replicates. The ISM sample was

collected with a dedicated step probe set from the top 2.5 cm of soil. The lead concentrations for the three replicates were 454 mg/kg, 173 mg/kg, and 5,100 mg/kg. The mean lead concentration was 1,909 mg/kg.

Due to the potential uncertainty associated with the extent of lead within the soil of the DU1 area as determined during the SI, additional soil samples are warranted to further refine the extent of lead contamination within the DU1 area. A grid system (**Figure A-8**) will be established in the field using GPS to further characterize the extent of lead contamination within the vicinity of DU1. Each grid will be 30-ft by 30-ft with a discrete surface soil sample (0 to 6 inch depth) being collected at each grid node. Discrete soil samples will be collected in the field using unused, disposable plastic scoops and placed in resealable plastic bags. The sample material will be sieved to remove large organic debris and non-representative material (i.e., twigs, leaves, roots, rocks, and metallic debris), homogenized while inside the bag by rotational shaking and kneading of the bag, and then an aliquot will be removed from the bag for drying and XRF analysis. Field screening of the soil samples will be conducted on site using a real-time field portable Vanta™ XRF analyzer. After analysis of the aliquot has been conducted, it will be returned to the bag and the entire sample will be archived for possible confirmation sample analysis. This rapid acquisition of data results will allow the field team to make decisions regarding the extent of potential contamination, such as the location of hot spots or whether step-out sampling is needed outside the DU1 boundary. Based on the former DU1 size, 110 grid nodes will be initially sampled. The pre-designated sample locations within each grid will be loaded onto a handheld GPS unit for navigation in the field. The grid system will have an alphanumeric numbering system (e.g., A1, A2, A3), and the soil samples collected from each grid note will be labeled based on the numbering system and sample depth (e.g., A1 [0-6], A2 [0-6]).

The source of lead contamination was not identified during the SI; therefore, during sampling activities, the field team will note the location of any potential sources (i.e., small arms, fragments, or debris).

XRF sampling will be conducted in accordance with EPA Solid Waste (SW) 846 Method 6200 (attached) and fixed base laboratory correlation samples for metals using SW846 Method 6010C. The EPA industrial land use screening level of 800 mg/kg will be used as the project screening level for lead. The ecological screening level listed in Worksheet 15 will be utilized in the ecological risk assessment, but the site will not be delineated to this value as the ecological screening levels are not a driver from a regulatory standpoint as no critical species were identified that would warrant defining the nature and extent to ecological screening levels or background levels.

Laboratory correlation samples will consist of a minimum of 20% of the soil samples screened with the XRF and will be submitted for off-site laboratory analysis for total lead. At the selected locations, the previously dried aliquot will be returned to the bag with the remaining soil and the entire bag will be submitted to the off-site laboratory for correlation analysis. Locations for correlation laboratory analysis will be selected to represent a range of lead concentrations (low to high), to verify the XRF field screening results, and to develop a correlation of the XRF results to the laboratory analytical results. The selection of these samples will be horizontally and vertically distributed, as much as possible, within the constraints of representing a range of concentrations. The XRF field screening results will be used to determine extent of lead contamination within the

Former Gun Range area. Both the correlation sample results and the XRF sample results will be used in the Human Health and Ecological Risk Assessments, if the correlation coefficient is 0.9 or higher[1]. However, for locations where both laboratory and XRF results exist, the laboratory correlation sample concentrations will be used preferentially as only one concentration can be used for each location in the risk assessments.

Subsurface soil sampling (two depths: 6 to 12 inches and 12 to 24 inches below grade) will be conducted at locations where lead contamination exceeds the project screening level in the XRF and/or laboratory samples for the gridded surface soil samples collected from DU1. The same sampling procedures, including use of unused plastic scoops, homogenization, and drying will be employed as outlined for the initial DU1 gridded surface soil samples. Laboratory samples will be submitted for off-site laboratory analysis for total lead from 20% of the subsurface locations. The collection of additional deeper samples will be warranted if lead concentrations exceed the project screening levels in the deepest sampled interval.

Additional step-out surface soil sampling will be conducted if lead contamination exceeds the project screening level in the XRF and/or laboratory confirmatory samples within the sampling grids along the perimeter for the established grid system. The 30-ft by 30-ft sampling grid system will be extended to determine the extent of lead contamination, by employing the same sampling procedures as outlined for the initial grid DU1 investigation.

Surface sediment sampling is not currently planned within the vicinity of the former DU1 area unless there is a clear migration pathway from the lead-contaminated soils such as the presence of a drainage swale that could transport lead-contaminated particulate matter. Drainage swales could provide a pathway for contamination to accumulate and potentially migrate off-MRS or into the New River, which could present a risk to receptors. Surface sediment samples may be collected in the vicinity of the SI sediment sample (SSD-001), located in the Inaccessible Area of the MRS near the Former Mortar Range, where lead concentrations (451 mg/kg) exceeded the ecological screening level and the EPA residential screening level. Because the sample is located within the Active Production Facility, which is considered an inaccessible area for the RFI field investigations, drainage patterns will be evaluated in the field near that location to determine if there are any migration pathways within the investigation area of the MRS. If a drainage area is located near DU1 or the area where SI sample SSD-001 was collected, then discrete surface sediment samples (0 to 6 inches below grade) will be conducted to determine the extent of lead by sampling every 50 ft within the identified drainage swale(s) until a lead concentration below the project screening level is reached using XRF. If the lead concentration detected by XRF is greater than the project screening level in the surface sediment sample, then additional vertical sampling will be conducted in 6-inch increments below the initial sample until XRF results for lead are lower than the project screening level.

A laboratory confirmation sample will be collected at a 20% rate and at the furthest downstream sample collected to confirm that the extent of lead contamination within the drainage swale has

[1] In accordance with EPA Method 6200, at a correlation coefficient of 0.7, XRF data indicate the presence or absence but do not provide reliable concentrations and are usable for screening purposes only, such as for determination of extent. At a value of 0.9 or greater, the XRF data can be used for risk assessment purposes.

been fully characterized. A minimum of three discrete sediment samples will be collected for off-site laboratory analysis. The collection of additional deeper sediment samples will be warranted if lead concentrations exceed the project screening levels in the deepest sampled interval.

17.14.2 MC CHARACTERIZATION – DAMAGED/CORRODED MUNITIONS AREAS

As part of the RFI, geophysical surveys and intrusive investigations will be performed to investigate the potential presence of MEC on the ground surface, in the subsurface, and in the sediments of Area A (adjacent portion of the New River). As anomalies are identified by the analog instrument operator(s), they will be investigated as detected ("mag and dig") to determine whether MEC or munitions debris (MD) is present. If the geophysical surveys identify targets of interest, these targets will be investigated to determine whether MEC or MD is present. The presence of MEC or MD may indicate the potential presence of MC (i.e., explosives and select metals). During the RFI, in addition to the planned lead sampling associated with the previous DU1 SI results, MC investigations will also be initiated when any of the following conditions are encountered:

- Individual corroded or breached MEC/MPPEH are discovered.
- High densities of corroded or breached MEC/MPPEH areas indicative of a potential MC release in soils.

Biased, discrete soil or sediment samples will be collected near breached munitions items and areas containing high densities of corroded munitions items, including MD, where there is visual evidence of a release. If breached munitions items are found and determined safe to move, the preferred location for sample collection will be directly below the item. The biased discrete soil and sediment samples will be analyzed for select metals (antimony, cadmium, lead, manganese, selenium, and vanadium) and explosives. If MC concentrations exceed project screening levels in the initial soil or sediment sample, then additional discrete sampling will be required for nature and extent purposes. A background level is not available for antimony; therefore, the sample results will be compared to the screening levels only. The additional sampling will consists of four step out samples 5 ft from the initial sample at the same depth of the initial sample and additional subsurface samples will be collected in 6-inch increments below the initial sample to a maximum depth of 24 inches bgs (i.e., 6 to 12, 12 to 28, and 18 to 24 inches). The additional subsurface samples will be collected at the same time as the initial sample to reduce the need for additional mobilizations, but will be held by the laboratory for analysis based on the results of the initial sample.

Biased, discrete soil samples will also be collected in areas containing high densities of breached or corroded munitions items, where there is visual evidence of a release. The preferred locations for sample collection will be directly below the items. Based on the size of the high density area, the number of discrete samples will be then be established. If MC concentrations exceed project screening levels in the initial soil sampling, then additional discrete subsurface samples will be collected (four step out samples 5 ft from the initial sample at the same depth and from a 2-ft interval below the initial sample[s]) for nature and extent purposes.

17.14.3 AREA A SEDIMENT SAMPLING ACTIVITIES

Sediment samples will be collected below encountered damaged or corroded munitions items from 0 to 0.5 ft bgs by divers using disposable scoops. The sediment will be placed into resealable

plastic bags for transfer to the river surface. The sediment will then be transferred to a disposable plan for appropriate homogenization using dedicated disposable scoops prior to transfer to pre-cleaned and labeled sample containers.

17.15 DFW 14: SITE RESTORATION

Following intrusive investigation activities, intrusive excavation sites will be filled to grade using existing materials on-site. When the SUXOS and UXOQCS have documented that all intrusive investigation is complete, the UXOQCS will conduct a MPPEH/Explosives Records Assessment to ensure that all MPPEH and donor explosives are accounted for. MDAS will be properly documented and shipped off-site. The EM31-MK2 will be shipped back. and The MetalMapper 2x2 will be disassembled and re-packed for shipping in accordance with WESTON GCO-SOP-28, 2x2 Sensor System Disassembly and Packing (**Appendix M**). Following successful completion of the records assessment and the site restoration activities, the tools, equipment, and safety gear will be shipped from the site and personnel will demobilize. All pin flags, survey stakes, survey pins will be removed and disposed of. All site restoration activities will be coordinated with RFAAP.

17.16 DFW 15: DEMOBILIZATION

In general, all rental equipment, unless otherwise needed for the demobilization effort, will be cleaned and demobilized as early as possible upon completion of use for its intended purpose. Likewise, personnel, unless otherwise needed for the demobilization effort, will be demobilized as early as possible upon completion of their respective tasks. The SUXOS, UXOSO, and UXOQCS will be the last personnel to demobilize from the site.

17.17 REPORTING

17.17.1 RFI REPORT

RFI findings will be reported through the TPP to identify data gaps and/or gain stakeholder concurrence. The CSM for the MRS and Area A will be revised and the MRSPP will be re-applied using the new data collected to revise site information and priority rating. The RFI Report will be prepared in accordance with the *EPA Interim Final RFI Guidance document (EPA 530/SW-89-031)* and the MMRP RI/FS guidance because the RCRA correction action process does not have special investigation requirements for munitions and explosive safety.

The RFI Report will summarize environmental setting, site background information, RFI field effort, and analyze the results. The validated analytical data will be used to assess baseline risks, including MEC hazards and MC risks to human health and the environment, to update the CSM, and to evaluate fate and transport dynamics. Conclusions and recommendations will provide further delineation within the MRS boundaries if possible, and whether the MRS should proceed to an interim corrective action or to a CMS. The following hazard and risk evaluations will be conducted as part of the RFI report. A detailed discussion of the human health and ecological risk assessment methodology is presented in **Appendix Q**.

17.17.1.1 Human Health Evaluation

The potential for current and future risks to human health posed by exposure to MC will be evaluated by preparation of a baseline human health risk assessment (HHRA). The HHRA will be prepared in accordance with EM 200-1-4 (Volume I) and the EPA's *Risk Assessment Guidance for Superfund (RAGS),* and will consider the most current EPA risk assessment guidance. Although this MRS is covered under RCRA, it is not expected that the Virginia Unified Risk Assessment Model (VURAM) will be used because it primarily is set up with default parameters while we anticipate the more appropriate utilization of site-specific parameters to calculate site risk for human receptors.

17.17.1.2 Environmental Evaluation

A screening-level ecological risk assessment (SLERA) will be prepared in accordance with EM 200-1-4 (Volume II) and the EPA's *Ecological Risk Assessment Guidance for Superfund (ERAGS)* (EPA, 1997 and updates). Observations made during the RFI field activities will be used to refine the conservation assumptions that will be used to initiate the remainder of the ERA process.

17.17.1.3 MEC Risk Assessment

A MEC risk assessment will be performed, in accordance with the Trial Period Extension for Risk Management Methodology (RMM) at Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP) Projects (USACE, 2019) (**Appendix R**). The purpose of the risk assessment is to provide USACE with decision logic to differentiate acceptable versus unacceptable site conditions at an MRS. The approach for the risk assessment is to use matrices using site-specific CSM data to relate accessibility, munitions sensitivity, and severity of an explosive event if it were to occur, to determine baseline risks. This will be conducted using four different matrices:

- Matrix 1, the Likelihood of Encounter;
- Matrix 2, the Severity of an Incident;
- Matrix 3, the Likelihood of Detonation; and
- Matrix 4, combines the results of the above categories to differentiate Acceptable and Unacceptable Site Conditions.

More information on this risk assessment can be found in the USACE Risk Management Methodology (USACE, 2019).

17.17.1.4 MRSPP

The DoD is required to assign each MRS a relative priority for response actions. The MRSPP evaluates the potential explosive, chemical agents, and environmental hazards at an MRS to support programmatic goals of prioritization for further actions and funding based on risk. An MRSPP is derived from MEC and MC data according to 32 CFR § 179. The initial MRSPP scoring for the Former Gun and Mortar Range MRS was developed during the SI and resulted in a Priority ranking of 4 (out of 8) for the MRS (BSEn, 2018b). Data from this RFI will be used to revise the MRSPP scoring.

17.17.2 CMS

Based on the findings presented in the RFI Report, a Corrective Measures Study (CMS) will be prepared for the MRS in accordance with the EPA RCRA Final Corrective Action Plan Guidance (1994) and the RCRA Corrective Measures Study Bulletin (2016). All data collected to date will be compiled and presented in a concise manner using graphics to support findings. The CMS will identify corrective measures objectives, potential technologies to remediate the contamination at the MRS and/or within Area A, corrective measure development, and an evaluation of the effectiveness, implementability, and cost for each corrective measure assessed. A CMS Report outline will be developed for USACE approval prior to starting preparation of the CMS Report. If a finding of no unacceptable risk for MEC and MC is identified for the MRS, then a CMS will not be required.

17.17.3 INTERNAL DRAFT ARMY DECISION DOCUMENT

WESTON will prepare an internal draft Army DD in accordance with RCRA guidance, applicable information form the EPA's *Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents* (1999), and DoD MMRP guidance. The internal draft DD will specify the final remedial goals to protect human health and the environment, including treatment, engineering, and institutional control components, or document that no further action (NFA) is required. The internal draft DD will also consolidate information and the chosen corrective action for the Administrative Record.

WORKSHEET # 18- SAMPLING LOCATIONS AND METHODS

Soil sampling will be performed, if needed, as described in Worksheet #17. Samples will be numbered in accordance with the procedures in SOP G-1. Analytical and Field QC Sample Criteria are presented in Worksheet #20, and Laboratory and Field QC Sample Analysis criteria are presented in Worksheet #28. Project sampling SOPs are introduced in Worksheet #21 and are presented in **Appendix H**.

Anticipated Samples

MRS Sampling Location/Description	Matrix	Depth (inches)	Analytical Group	Number of Samples (identify field duplicates) (note 1)	Sampling SOP Reference	Laboratory SOP
DU1, Former Gun Range	Surface Soil	0 to 6 inches	Lead	110 discrete samples (XRF analysis) + 11 duplicates (at least 10%) 22 discrete samples (off-site laboratory confirmation samples, 20% of XRF samples) + 3 duplicates (at least 10%)	See Worksheet #21	See Worksheet #23, Table 21-1
DU1, Former Gun Range	Subsurface Soil	>6 to 12 and >12 to 24 inches	Lead	TBD (XRF analysis) + TBD duplicates (at least 10%) TBD discrete samples (off-site laboratory confirmation samples, 20% of XRF samples) + TBD duplicates (at least 10%)	See Worksheet #21	See Worksheet #23, Table 21-1
DU1 Area, Former Gun Range	Sediment	0 to 6 inches	Lead	TBD discrete samples (XRF analysis) + TBD duplicates (at least 10%)	See Worksheet #21	See Worksheet #23, Table 21-1
MRS/Area A Damaged/ Corroded Munitions Items and Areas	Soil/ Sediment	0 to 6, >6 to 12, >12 to 18, and >18 to 24 inches	Metals and Explosives	TBD discrete samples + TBD duplicates (at least 10%)	See Worksheet #21	See Worksheet #23, Table 21-1

Notes:
(1) Additional samples may be required to fully define the extent of soil and/or sediment contamination.

WORKSHEET # 19 AND #30 - SAMPLE CONTAINERS, PRESERVATION, AND HOLD TIMES

Laboratory (name, sample receipt address, point of contact (POC), e-mail, and phone numbers):
CT Laboratories, 1230 Lange Court, Baraboo, WI 53913
Laboratory POC: Brett Szymanski (Laboratory PM); email: bszymanski@ctlaboratories.com; telephone: (608) 356-2760
List any required accreditations/certifications/accreditation expiration date:
DoD Environmental Laboratory Accreditation Program (DoD)
Virginia Environmental Laboratory Accreditation Program (VA)
Back-up Laboratory: None
Sample Delivery Method: Federal Express

Analyte/ Analyte Group	Matrix	Method/ SOP	Accreditation Expiration Date	Containers (number, size, & type per sample)	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround
Project Metals	Soil/Sediment (discrete)	EPA 6010C	DoD: 4/30/2020 VA: 12/14/2019	1 x 8 oz. WM glass jar	Cool $\leq$ 6 °C	included in analytical holding time	180 days	21 days
Explosives	Soil/Sediment (discrete)	EPA 8330B	DoD: 4/30/2020 VA: 12/14/2019	1 x 8 oz. WM glass jar	Cool $\leq$ 6 °C	14 days	40 days	21 days

Notes:
Additional volume is needed for the laboratory MS/MSD sample analysis.
Project metals include antimony, cadmium, lead, manganese, selenium, and vanadium.
WM = wide mouth

WORKSHEET # 20 - FIELD QUALITY CONTROL SUMMARY

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD	No. of Field Blanks	No. of Equip. Blanks [1]	No. of Proficiency Testing Samples	Total No. of Samples to Laboratory
Soil/Sediment (Discrete)	Metals	TBD	One per ten samples	One per 20 samples	0	0	0	TBD
Soil/Sediment (Discrete)	Explosives	TBD	One per ten samples	One per 20 samples	0	0	0	TBD

Notes:
[1]Disposable sampling equipment is planned for this effort. Equipment blanks will only be collected if non-disposable sampling equipment is used.

WORKSHEET # 21 - FIELD STANDARD OPERATING PROCEDURES

SOPs are located in **Appendix H**. The below table provides the list of SOPs per EM 200-1-15 (USACE, 2015) for planned activities specific to this project. The topics of some SOPs are discussed in the main text of the QAPP or in other SOPs. The "Comments" column provides a cross-walk for the locations of these topics.

Reference (Attachment) Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Yes/No)	Comments
AOR-SOP-001	Analog Geophysical and Intrusive Operations	AOR International	Ebinger electromagnetic induction analog detector or equivalent, ropes and buoys, buckets and floating baskets, tape measure, hand tools	No	Appendix H
SOP G-1	Field Documentation	WESTON	Field logbooks, field forms	No	Appendix H
SOP G-3	Field Sample Numbering	WESTON	Sample labels, pen with indelible ink	Yes	Appendix H
SOP G-4	Quality Assurance/Quality Control Sampling	WESTON	American Society for Testing and Materials Type II reagent-grade water	No	Appendix H
SOP G-6	Decontamination[1]	WESTON	Potable water and cleaning agent (Liquinox).	No	Appendix H
SOP G-7	Management of Investigation-Derived Waste (IDW)[1]	WESTON	Drums or other containers, 5-gallon buckets, labeling material	No	Appendix H
SOP G-8	Sample Chain of Custody (CoC)	WESTON	Laboratory supplied CoC, waterproof resealable bags, CoC seals, labels, pens, markers, tape, scissors	Yes	Appendix H
SOP G-9	Sample Packing and Shipping	WESTON	CoC, custody seals, tape, ice, cooler, plastic re-sealable bags, packing material (bubble wrap, etc.)	No	Appendix H
SOP G-10	Surveying	WESTON	Surveying equipment	No	Appendix H
SOP G-21	Demolition Activities	WESTON	Camera, radios, Rothenbuhler, wire cutters, electrical tape, single strand firing line, hand tools (shovels, rakes, etc.), etc.	No	Appendix H
MR-SOP-1	Anomaly Avoidance	WESTON	Field logbook, flagging, magnetometer	No	Appendix H
MR-SOP-2	Analog Detection and Removal Operations	WESTON	Analog geophysical instrument, PPE, intrusive tools, bucket, camera, radio, line/rope, pin flags	No	Appendix H

WORKSHEET # 21 - FIELD STANDARD OPERATING PROCEDURES (CONTINUED)

Reference (Attachment) Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Yes/No)	Comments
MR-SOP-3	Digital Anomaly Removal Operation	WESTON	Analog geophysical instrument, EM31-MK2, PPE, intrusive tools, bucket, camera, radio, line/rope, pin flags, communication device	No	Appendix H
MR-SOP-4	Management of MPPEH	WESTON	Analog geophysical instrument, PPE, intrusive tools, bucket, camera, radio, line/rope, pin flags, communication device	No	Appendix H
GEO-SOP-5	Setup and Operation of the EM31	WESTON	EM31-MK2	No	Appendix H
SOP SS-2	Soil Sampling Using a Geoprobe	WESTON	Field logbook, color chart, paper towels, pens, gloves, sample jars, CoC, Geoprobe rig and sampler, etc.	No	Appendix H
SOP SS-3	Sediment Sampling	WESTON	Field logbook, color chart, paper towels, pens, gloves, sample jars, CoC, sampling device, etc.	No	Appendix H
SOP SS-4	Soil Sampling	WESTON	Field logbook, color chart, paper towels, pens, gloves, sample jars, CoC, sampling device, etc.	No	Appendix H
SOP SS-5	Test Pit Excavation	WESTON	Field logbook, excavator (or equivalent), etc.	No	Appendix H
GCO-SOP-11	2x2 System Assembly and Correct Operation Verification	WESTON	MM 2x2	No	Appendix M
GCO-SOP-12	Advanced Classification Instrument Verification Strip (IVS)	WESTON	Medium ISOs, flagging, tape measures, or MM 2x2, RTK GPS	No	Appendix M
GCO-SOP-13	Production Area Seeding	WESTON	Medium ISOs, RTK GPS, Logbook	No	Appendix M
GCO-SOP-18	Collecting Static Background Measurements	WESTON	MM 2x2, RTK GPS	No	Appendix M
GCO-SOP-19	Collecting Cued Target Measurements	WESTON	MM 2x2, RTK GPS	No	Appendix M

WORKSHEET # 21 - FIELD STANDARD OPERATING PROCEDURES (CONTINUED)

Reference (Attachment) Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Yes/No)	Comments
GCO-SOP-20	Processing Cued Data	WESTON	Geosoft UX-Analyze 9.2	No	Appendix M
GCO-SOP-21	Verifying Recovered Objects are Compatible with Predictions	WESTON	Not Applicable	No	Appendix M
GCO-SOP-22	Validating the Classification Process	WESTON	Not Applicable	No	Appendix M
GCO-SOP-27	Estimating Measurement Uncertainty	WESTON	Not Applicable	No	Appendix M
GCO-SOP-28	2x2 Sensor System Disassembly and Packing	WESTON	MM 2X2	No	Appendix M
GCO-SOP-29	Performing Dynamic Surveys with MetalMapper 2x2	WESTON	MM 2X2	No	Appendix M
GCO-SOP-30	Processing Dynamic Surveys with MetalMapper 2x2	WESTON	MM 2X2	No	Appendix M
GCO-SOP-31	Setup and Operation of RTK GPS Navigation System	WESTON	RTK GPS	No	Appendix M
GCO-SOP-32	Setup and Operation of RTS Navigation System	WESTON	RTS Navigation System	No	Appendix M

WORKSHEET # 21 - FIELD STANDARD OPERATING PROCEDURES (CONTINUED)

Reference (Attachment) Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Yes/No)	Comments
GCO-SOP-33	Anomaly Reacquisition	WESTON	RTK GPS Navigation System, Metal detector, tape measures, field map, dig sheet, pin flags (or equivalent)	No	Appendix M
GCO-SOP-37	Setup and Operation of the G-858 Magnetometer	WESTON	G-858 Magnetometer	No	Appendix M

Notes:
[1]It is not anticipated that decontamination will be needed for this field work as disposable sampling methods are planned to be used. Additionally, no IDW soil or sediment is expected to be generated for this project because any excess soil will be placed back in the soil boring.

WORKSHEET # 22- FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION

This worksheet documents procedures for performing testing, inspections, and quality control for all field data collection activities.

Table 22-1 Dynamic Detection Survey (Instrument: EM31-MK2)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/Report Method/Verified by	Acceptance Criteria	Failure Response
Verify correct assembly	DFW 6/ GEO-SOP-5	Once following assembly	Field Geophysicist/ Instrument Assembly Checklist/Project Geophysicist	As specified in equipment manual	RCA/CA: Make necessary adjustments and re-verify.
In-line measurement spacing	DFW 5/ GEO-SOP-5	Verified for each survey unit using Geosoft Sample Separation QC tool	Project Geophysicist/ running QC summary/QC Geophysicist	98% $\leq$ 0.25 meter between successive measurements	RCA/CA
Coverage (using electronic positioning)	DFW 6/ GEO-SOP-5	Verified for each survey unit using Geosoft Foot Print Coverage QC tool	Project Geophysicist/running QC summary and survey unit validation report/QC Geophysicist	98% coverage at 10 ft cross track measurement spacing (excluding site-specific access limitations, e.g., obstacles, unsafe terrain)	RCA/CA
Valid position data	DFW 6/ GEO-SOP-5	Per measurement	Field Team Leader/running QC summary/Project Geophysicist	GPS status flag indicates RTK fix and dilution of precision less than 4.0	RCA/CA: Out-of-spec data rejected

Table 22-2 Dynamic Detection Survey (Instrument: G-858)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/Report Method/Verified by	Acceptance Criteria	Failure Response
Verify correct assembly	DFW 10/GCO-SOP-37	Once following assembly	Field Geophysicist/ Instrument Assembly Checklist/Project Geophysicist	As specified in equipment manual	RCA/CA: Make necessary adjustments and re-verify.
In-line measurement spacing	DFW 10/ GCO-SOP-37	Verified for each survey unit using Geosoft Sample Separation QC tool	Project Geophysicist/ running QC summary/QC Geophysicist	98% ≤ 0.25 meter between successive measurements	RCA/CA
Coverage (using electronic positioning)	DFW 10/ GCO-SOP-37	Verified for each survey unit using Geosoft Foot Print Coverage QC tool	Project Geophysicist/running QC summary and survey unit validation report/QC Geophysicist	Achieve required coverage as determined by VSP (2.9 acres)	RCA/CA
Valid position data	DFW 10/ GCO-SOP-37	Per measurement	Field Team Leader/running QC summary/Project Geophysicist	GPS status flag indicates RTK fix and dilution of precision less than 4.0	RCA/CA: Out-of-spec data rejected

Table 22-3 Dynamic Detection Survey (Instrument: MM2X2)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/Report Method/Verified by	Acceptance Criteria	Failure Response
Verify correct assembly	DFW 6/GCO-SOP-11	Once following assembly	Field Geophysicist/ Instrument Assembly Checklist/Project Geophysicist	As specified in GCO-SOP-11	RCA/CA: Make necessary adjustments and re-verify.
Initial sensor function test	DFW 6/GCO-SOP-11	Once following assembly	Field Geophysicist/ Initial IVS Memorandum/ Project Geophysicist	As specified in GCO-SOP-11	RCA/CA: Make necessary adjustments and re-verify.
Initial detection survey positioning accuracy (IVS)	DFW 5/GCO-SOP-12, Advanced Classification IVS	Once prior to start of detection survey data acquisition	Project Geophysicist/IVS Memorandum/QC Geophysicist	Derived positions of IVS target(s) are within 25 centimeters of the ground truth locations	RCA/CA: Make necessary adjustments and re-verify.
Ongoing instrument function test	DFW 5/ GCO-SOP-11 GCO-SOP-12, Advanced Classification IVS	A minimum of every 2 hours as well as each time instrument is turned on	Field Geophysicist/ Running QC Summary/ Project or QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all channels	RCA/CA: Make necessary adjustments and re-verify.
Ongoing detection survey positioning precision (IVS)	DFW 5/GCO-SOP-12, Advanced Classification IVS;	Beginning and end of each day	Project Geophysicist/ running QC summary/QC Geophysicist	Derived positions of IVS target(s) within 25 centimeters of the average locations	RCA/CA
In-line measurement spacing	DFW 5/ GCO-SOP-29	Verified for each survey unit using Geosoft Sample Separation QC tool	Project Geophysicist/ running QC summary/QC Geophysicist	99% $\leq$ 0.25 meter between successive measurements	RCA/CA

Table 22-3 Dynamic Detection Survey (Instrument: MM2X2) (Continued)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/Report Method/Verified by	Acceptance Criteria	Failure Response
Coverage (using electronic positioning)	DFW 6/ GCO-SOP-29	Verified for each survey unit using Geosoft Foot Print Coverage QC tool	Project Geophysicist/running QC summary and survey unit validation report/QC Geophysicist	99% at ≤0.7 meter cross-track measurement spacing (excluding site-specific access limitations, e.g., obstacles, unsafe terrain)	RCA/CA
Sensor TX Current	DFW 6/ GCO-SOP-29	Evaluated by survey unit	Project Geophysicist/ running QC summary and survey unit validation report/QC Geophysicist	Current must be ≥ 3.5A	RCA/CA
Detection survey performance	DFW 6/ GCO-SOP-29	Evaluated by survey unit	QC Geophysicist/survey unit validation report/lead organization QA Geophysicist	All blind QC and validation seeds must be detected and positioned within 40-centimeter radius of ground truth	RCA/CA
Valid position data	DFW 6/ GCO-SOP-29	Per measurement	Field Team Leader/running QC summary/Project Geophysicist	GPS status flag indicates RTK fix and dilution of precision less than 4.0	RCA/CA: Out-of-spec data rejected

Table 22-4 Cued Survey (Instrument: MM 2x2; Classification Tool: Geosoft Oasis Montaj UX-Analyze Adv)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/Report Method/Verified by	Acceptance Criteria	Failure Response
Verify correct assembly	DFW 7/GCO-SOP-11, 2x2 System Assembly and Correct Operation	Once following assembly	Field Geophysicist/ GCO-SOP-11 Sensor System Assembly QC Checklist/ Project Geophysicist	As specified in GCO-SOP-11 QC Checklist	RCA/CA: Make necessary adjustments and re-verify.
Initial sensor function test	DFW 7/GCO-SOP-11, 2x2 System Assembly and Correct Operation	Once following assembly	Field Geophysicist/ GCO-SOP-11 Sensor System Assembly QC Checklist/Project Geophysicist	The results are within 20% of the reference values for the ISO80 and instrument configuration	RCA/CA: Make necessary adjustments and re-verify.
Initial IVS background measurement (five background measurements, one centered at the flag and one offset at least 35 cm in each cardinal direction)	DFW 5/GCO-SOP-12, Advanced Classification IVS; GCO-SOP-18, Collecting Static Background Measurements; GCO-SOP-20, Processing Cued Advanced EMI Data	Once during initial system IVS test	Field Team Leader/ Initial IVS memorandum/Project Geophysicist	All five measurements (decay amplitude) within the noise level of each other and library match from all four offset measurements >0.9	RCA/CA: Reject/replace background location.
Initial derived polarizabilities accuracy (IVS)	DFW 5/GCO-SOP-12, Advanced Classification IVS; GCO-SOP-20, Processing Cued Advanced EMI Data	Once during initial system IVS test	Project Geophysicist/ Initial IVS memorandum/QC Geophysicist	Library Match metric ≥ 0.9 for each set of inverted polarizabilities	RCA/CA
Derived target position accuracy (IVS)	DFW 5/GCO-SOP-12, Advanced Classification IVS; GCO-SOP-20, Processing Cued Advanced EMI Data	Once during initial system IVS test	Project Geophysicist/ Initial IVS Memorandum/QC Geophysicist	All IVS item fit locations within 0.25 meter of ground truth locations	RCA/CA

Table 22-4 Cued Survey (Instrument: MM 2x2; Classification Tool: Geosoft Oasis Montaj UX-Analyze Adv) (Continued)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/Report Method/Verified by	Acceptance Criteria	Failure Response
Ongoing IVS background measurements	DFW 5/ GCO-SOP-12, Advanced Classification IVS GCO-SOP-20, Processing Cued Advanced EMI Data	Beginning and end of each day as part of IVS testing	Project Geophysicist/ tracking summary/QC Geophysicist	All decay amplitudes lower than project threshold	RCA/CA CA assumption: rejection of background measurement (unless RCA indicates system failure).
Ongoing derived polarizabilities precision (IVS)	DFW 5/GCO-SOP-12, Advanced Classification IVS; GCO-SOP-20, Processing Cued Advanced EMI Data	Beginning and end of each day as part of IVS testing	Project Geophysicist/ tracking summary/QC Geophysicist	Library Match to initial polarizabilities metric ≥ 0.9 for each set of three inverted polarizabilities	RCA/CA
Ongoing derived target position precision (IVS)	DFW 5/GCO-SOP-12, Advanced Classification IVS; GCO-SOP-20, Processing Cued Advanced EMI Data	Beginning and end of each day as part of IVS testing	Project Geophysicist/ tracking summary/QC Geophysicist	All IVS items fit locations within 0.25 meter of average of derived fit locations	RCA/CA
Initial measurement of production area background locations and background verification (five background measurements: one centered at the flag and one offset at least ½ sensor spacing in each cardinal direction)	DFW 7/GCO-SOP-18, Collecting Static Background Measurements	Once per background location	Field Team Leader/ background location report/Project Geophysicist	All five measurements (decay amplitude) within the noise level of each other and library match from all four offset measurements >0.9	RCA/CA: Reject background location and find alternate.

Table 22-4 Cued Survey (Instrument: MM 2x2; Classification Tool: Geosoft Oasis Montaj UX-Analyze Adv) (Continued)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/Report Method/Verified by	Acceptance Criteria	Failure Response
Ongoing production area background measurements	DFW 7/GCO-SOP-18, Collecting Static Background Measurements	Background data collected a minimum of every two hours during production	Field Team Leader/failures noted in field log and tracking summary/Project Geophysicist	Original and ongoing measurements at each location differ by a factor of five or less	RCA/CA: Document environmental changes. Project Geophysicist must approve before proceeding.
Ongoing instrument function test (MM 2x2)	DFW 7/GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification; GCO-SOP-12, Advanced Classification IVS	Each time instrument is turned on	Field Team Leader/ tracking summary/ Project Geophysicist	Response within 20% of predicted response	RCA/CA: Make necessary repairs and re-verify.
Transmit current levels (MM 2x2)	DFW 7/GCO-SOP-20, Processing Cued Advanced EMI Data	Evaluated for each sensor measurement	Field Team Leader/ tracking summary/ Project Geophysicist	Current must be ≥5.5A	RCA/CA: Stop data acquisition activities until condition corrected.
Confirm all background measurements are valid	DFW 7/GCO-SOP-20, Processing Cued Advanced EMI Data GCO-SOP-22, Validating the Classification Process	Evaluated for each background measurement	Project Geophysicist/Background summary/QC Geophysicist	Ensure background variation does not impact ability to classify correctly	RCA/CA: Background measurement rejected and removed from active background measurements.
Confirm adequate spacing between units (MM 2x2)	DFW 7/GCO-SOP-19, Collecting Cued Target Measurements	Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/ Project Geophysicist	Minimum separation of 25 meter	RCA/CA: Re-collect all coincident measurements.
Confirm inversion model supports classification (1 of 3)	DFW 7/GCO-SOP-20, Processing Cued Advanced EMI Data	Evaluated for all models derived from a measurement (i.e., single item and multi-item models)	Project Geophysicist/ Measurement QC summary/ QC Geophysicist	Derived model response must fit the observed data with a fit coherence ≥ 0.8	Follow procedure in SOP or RCA/CA.

Table 22-4 Cued Survey (Instrument: MM 2x2; Classification Tool: Geosoft Oasis Montaj UX-Analyze Adv) (Continued)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/Report Method/Verified by	Acceptance Criteria	Failure Response
Confirm inversion model supports classification (2 of 3)	DFW 7/GCO-SOP-20, Processing Cued Advanced EMI Data	Evaluated for derived target	Project Geophysicist/ Measurement QC summary/ QC Geophysicist	Fit location estimate of item ≤ 0.4 m from center of sensor	Follow procedure in SOP or RCA/CA.
Confirm inversion model supports classification (3 of 3)	DFW 7/GCO-SOP-20, Processing Cued Advanced EMI Data	Evaluated for all QC and validation seeds	QC Geophysicist/ Measurement Inversion model QC summary/lead organization QA Geophysicist	100% of predicted QC and validation seed positions ≤ 0.25 m radially from known position (x, y) Z ≤ .15 m)	RCA/CA
Confirm reacquisition GPS precision	DFW 7/GCO-SOP-21, Verifying Recovered Objects are Compatible with Predictions	Daily	UXO tech or field tech/Daily QC Report/Project Geophysicist	Benchmark positions repeatable to within 10 cm	RCA/CA
Classification performance	DFW 7/GCO-SOP-22, Validating the Classification Process	Evaluated for all seeds	QC Geophysicist; USACE QA Geophysicist/ Ranked Dig List/ USACE QA Geophysicist	100% of QC and validation seeds placed on dig list	RCA/CA

Notes:
[1]Fit coherence is defined as the square of the correlation coefficient between data and model

Table 22-5 Intrusive Investigation (Area A)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified By:	Acceptance Criteria	Failure Response
Confirm Anomaly Resolution (1 of 2)	DFW 9/MR-SOP-2, Analog Operations	Evaluated for all recovered items	Project Geophysicist/ Measurement QC Summary or intrusive database/ QC Geophysicist	100% of recovered item positions ≤ 0.40 m from predicted position (x, y)	RCA/CA
Confirm Anomaly Resolution (2 of 2)	DFW 8/GCO-SOP-21, Verification Recovered Objects are Compatible with Predictions	Evaluated for all recovered items	UXO Dig Team/Dig List and intrusive database/Project or QC Geophysicist	Verification of anomaly footprint after excavation, using original instrument, confirms anomaly is resolved AND Reported excavation findings match expectations	RCA/CA
Documenting recovered sources	DFW 8/GCO-SOP-21, Verification Recovered Objects are Compatible with Predictions	Evaluated for all recovered items	UXOQC/ GIS data recorded/ QC Geophysicist	All metallic debris collected is documented for the following attributes: Designation as UXO, MD, RRD or OD; UXO and MD described by type, weight, depth, and as TOI or non-TOI. Photos displaying all MD recovered (individual MD photos not necessary).	RCA/CA: Document questionable information in database.

Table 22-6 Intrusive Investigation (Analog)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified By:	Acceptance Criteria	Failure Response
Instrument Functionality (analog system)	DFW 2, 3, 4, 5, 9/ WESTON MR-SOP-2, Analog Operations	Daily	Operator/Daily QC Report/UXOQCS	All instruments pass test strip checks twice a day. Instrument operator successfully locates each seed item in test strip.	RCA/CA: Repair or replace instrument, then repeat test. Instrument operator undergo remedial training and retest on ITS.
Coverage, detection, and recovery	DFW 4/ WESTON MR-SOP-2, Analog Operations	Blind analog seeds will be placed at anticipated project depths with a frequency to ensure that each operator will encounter a minimum of one seed each day.	UXOQCS/Daily QC Report/ Technical Manager	All coverage seeds are detected within 40cm of ground truth.	IF all seed items are not detected, THEN re-survey full coverage survey area or segment covered that day based on the root cause analysis and corrective action.
Accuracy and completeness	DFW 4/ WESTON MR-SOP-2, Analog Operations	Daily and as required (a minimum of 10% of the mag and dig survey areas).	UXOQCS/Daily QC Report/ Technical Manager	Verification of anomaly footprint after excavation, using original instrument, confirms anomaly is resolved.	IF metallic items remain, THEN re-survey full coverage survey area or segment based on the root cause analysis and corrective action.
Anomaly Resolution	DFW 4/WESTON MR-SOP-2, Analog Operations	Rate varies depending on lot size (see Table 6-6 of EM 200-1-15). Lot size is based on 1 day of work.	UXOQCS/Daily QC Report/ Technical Manager	UXOQCS or designee checks open holes using same instrument utilized for detection to determine 90% confidence <1% unresolved anomalies.	CA: Redo lot.

Table 22-7 Intrusive Investigation (AGC)

Measurement Quality Objective	DFW/SOP Reference	Frequency	Responsible Person/ Report Method/ Verified By:	Acceptance Criteria	Failure Response
Confirm derived features match ground truth (1 of 2)	DFW 8/GCO-SOP-21, Verification Recovered Objects are Compatible with Predictions	Evaluated for all recovered items	Project Geophysicist/ Measurement QC Summary or intrusive database/ QC Geophysicist	100% of recovered (excluding inconclusive category) item positions ≤ 0.25 m from predicted position (x, y).	RCA/CA
Confirm derived features match ground truth (2 of 2)	DFW 8/GCO-SOP-21, Verification Recovered Objects are Compatible with Predictions	Evaluated for all recovered items	UXO Dig Team/Dig List and intrusive database/Project or QC Geophysicist	100% of recovered object size estimates (excluding inconclusive category) qualitatively match predicted size.	RCA/CA
Verification of TOI/non-TOI threshold	DFW 8/GCO-SOP-21, Verification Recovered Objects are Compatible with Predictions	Dig 10% (not to exceed 200) anomalies beyond last TOI on Dig List, unless 200 anomalies past the last TOI (stop dig point) have already been investigated. Anomalies will likely include some above and below the stop-dig threshold.	Project Geophysicist/ Verification and Validation Report/QC Geophysicist	100% of predicted non-TOI intrusively investigated are non-TOI.	Adjust threshold
Classification validation	DFW 8/GCO-SOP-22, Validating the Classification Process	Random selection of 200 non-TOI	Project Geophysicist/ Verification and Validation Report/QC Geophysicist	100% of predicted non-TOI qualitatively matches predictions.	Document in DUA

WORKSHEET # 23 - ANALYTICAL STANDARD OPERATING PROCEDURES

Laboratory SOPs are located in **Appendix J**. The laboratory QA Manual is in **Appendix S**.

Lab SOP Number	Title, Revision Date, and/or Number (include URL if available)	Definitive or Screening Data	Matrix and Analytical Group	SOP Option or Equipment Type	Modified for Project Work? (Yes/No)
	Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment	Screening	Soil/Sediment / Metals	X-ray fluorescence	No
MT 007	*MT 007 Acid Digestion of Solids and Semi-solids for Total Metals by GFAA and ICP*, Revision 6.1, Effective Date 07/05/2018.	Definitive (Preparation)	Soil/Sediment / Metals	Hot-block digester	No
MT 009	*MT 009 Inductively Coupled Plasma (ICP) Emission – ICP-OES 6000*, Revision 5.2, Effective Date 07/06/2018.	Definitive	Soil/Sediment / Metals	ICP-AES	No
SV 010	*SV 010 Explosives by Modified Method 8330B*, Revision 5, Effective Date 05/24/2018.	Definitive	Soil/Sediment / Explosives	HPLC/UV	No
QA-001	*Quality Assurance Manual, CT Laboratories, LLC, 1230 Lange Court, Baraboo, WI 53913*, Revision 15.7. Effective Date 09/21/2018. (See **Appendix S**)	NA	NA	NA	No

Notes:

The laboratory will adhere to the most current limits and SOPs.

NA = Not applicable

WORKSHEET # 24 - ANALYTICAL INSTRUMENT CALIBRATION

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria[1]	CA	Title/Position Responsible for CA	SOP Reference
ICP-AES / 6010C	Initial calibration (ICAL)	Daily prior to sample analysis. Minimum one high standard and a calibration blank.	If a single-point calibration, there is no acceptance criterion. If there is a multipoint calibration, the linear regression correlation coefficient $r^2 \geq 0.995$	Correct problem, repeat ICAL	Analyst / Supervisor	MT 009 Rev 5.2
ICP-AES / 6010C	Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	Percent recovery 90 to 110 percent	Correct problem. Rerun ICV. If rerun fails, repeat ICAL.	Analyst / Supervisor	MT 009 Rev 5.2
ICP-AES / 6010C	Continuing Calibration Verification (CCV)	After every 10 sample injections and at the end of the run	Within ± 10% of true value.	Recalibrate, and reanalyze all affected samples since the last acceptable CCV; or Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst / Supervisor	MT 009 Rev 5.2
ICP-AES / 6010C	Low-level Calibration Check	Daily.	All reported analytes within ± 20% of true value.	Correct problem and repeat ICAL.	Analyst / Supervisor	MT 009 Rev 5.2
ICP-AES / 6010C	Initial and Continuing Calibration Blank (ICB/CCB)	Before beginning a sample run, after every 10 field samples, and at the end of the analysis sequence.	No analytes detected > LOD.	Correct problem and repeat ICAL. All samples following the last acceptable calibration blank must be reanalyzed.	Analyst / Supervisor	MT 009 Rev 5.2

WORKSHEET # 24- ANALYTICAL INSTRUMENT CALIBRATION (CONTINUED)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria[1]	CA	Title/Position Responsible for CA	SOP Reference
ICP-AES / 6010C	Interference Check Solutions (ICS)	After ICAL and prior to sample analysis.	ICS-A: Absolute value of concentration for all non-spiked project analytes < LOD (unless they are a verified trace impurity from one of the spiked analytes); ICS-AB: Within ± 20% of true value.	Terminate analysis; locate and correct problem; reanalyze ICS, reanalyze all samples.	Analyst / Supervisor	MT 009 Rev 5.2
HPLC / 8330B	Initial Calibration (ICAL)	At instrument setup and after ICV or CCV failure, prior to sample analysis. Minimum of 5 levels for linear and 6 levels for quadratic.	ICAL must meet one of the three options below: Option 1: RSD for each analyte ≤ 15%; Option 2: linear least squares regression for each analyte: $r^2 \geq 0.99$; Option 3: non-linear least squares regression (quadratic) for each analyte: $r^2 \geq 0.99$.	Correct problem then repeat ICAL. No samples may be run until ICAL has passed.	Analyst / Supervisor	SV 010 Rev 5
HPLC / 8330B	Initial Calibration Verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All reported analytes and surrogates within ± 20% of true value.	Correct problem. Rerun ICV. If that fails, repeat ICAL. No samples will be analyzed until the problem has been corrected.	Analyst / Supervisor	SV 010 Rev 5

WORKSHEET # 24- ANALYTICAL INSTRUMENT CALIBRATION (CONTINUED)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria[1]	CA	Title/Position Responsible for CA	SOP Reference
HPLC / 8330B	Continuing Calibration Verification (CCV)	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within ± 20% of the true value.	Recalibrate, and reanalyze all affected samples since the last acceptable CCV; or Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst / Supervisor	SV 010 Rev 5

Notes:
[1]This is a summary of the acceptance criteria; refer to the method SOP for specific or more information.

WORKSHEET # 25- ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	Reference
ICP-AES (Metals)	Clean torch assembly and spray chamber when discolored, clean/change nebulizer, check argon supply. Replace disposables. Check coolant water level, check rinse solution, check waste container, check/replace cleanliness of instrument air filters, check computer instrument computer date and time.	Metals	Torch, nebulizer chamber, pump and pump tubing, vacuum source, waste container	Daily, weekly, or as needed	ICAL and CCV pass criteria	Repeat maintenance activity or remove from service.	Lab Section Supervisor	MT 009
HPLC (Explosives)	Fill solvent bottles, change pre-column, column frits, flush column, clean pump head	Explosives & Propellants	Torch, nebulizer chamber, pump and pump tubing, vacuum source, waste container	Daily prior to calibration	Acceptable calibration	Repeat maintenance activity or remove from service.	Lab Section Supervisor	SV 010

WORKSHEET # 26 AND #27 - SAMPLE HANDLING, CUSTODY, AND DISPOSAL

Sampling Organization: WESTON
Laboratory: CT Laboratories
Method of Sample Delivery (shipper/carrier): Federal Express
Number of days from reporting until sample disposal: 6 months

Activity	Organization and title or position of the person responsible for the activity	SOP Reference
SAMPLE COLLECTION, PACKAGING, AND SHIPMENT		
Sample Collection	Sampling Personnel, WESTON	SOP-SS-2 and SS-4 Soil Sampling SOP-SS-3 Sediment Sampling SOP-G-3: Field Sample Numbering SOP-G-9: Sample Packing and Shipping SOP-G-8: Sample Chain-of-Custody
Sample Packaging	Sampling Personnel, WESTON	
Coordination of Shipment	Sampling Personnel, WESTON	
Completion of CoC	Sampling Personnel, WESTON	
Type of Shipment/Carrier	Laboratory Courier/Federal Express – Priority Overnight	
SAMPLE RECEIPT AND ANALYSIS		
Sample Receipt	Receiving Supervisor, CT Laboratories, Baraboo, WI	The laboratory will notify WESTON of sample receipt electronically. CT Laboratories' sample custody procedures are described in Section 23 of their Quality Assurance Manual (**Appendix S**). Sample receipt is described in Section 23.2; sample storage and archiving in Section 23.4; and sample disposal in Section 23.7.
Sample Custody and Storage	Sample Custodian, CT Laboratories, Baraboo, WI	
Sample Preparation	Organic and/or Inorganic Prep Supervisor, CT Laboratories, Baraboo, WI	
Sample Determinative Analysis	Organic and/or Inorganic Laboratory Analyst, CT Laboratories, Baraboo, WI	
Sample Disposal	CT Laboratories, Baraboo, WI	

WORKSHEET # 28- ANALYTICAL QUALITY CONTROL AND CORRECTIVE ACTION

Worksheet 28.1 – QC Samples Table for Metals

Matrix	Soil
Analytical Group	Metals
Analytical Method/SOP Reference	6010C / MT 009

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Title/Position Responsible for CA	Data Quality Indicator (DQI)	Project Specific MPC
Method Blank (MB)	One per preparatory batch of 20 or fewer samples of similar matrix.	No analytes detected > ½ LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Correct problem. If required, reprep and reanalyze MB and all samples processed with the contaminated blank.	Analyst/ Supervisor	Accuracy/Bias (Contamination)	No Target analytes >1/2 LOQ
Laboratory Control Sample (LCS)	One per preparatory batch of 20 or fewer samples of similar matrix.	DoD QSM 5.0 LCS limits used, if available. Otherwise, in-house control limits used for any compounds not specified in QSM 5.1. In-house control limits may not be > ± 3 times the standard deviation of the mean LCS recovery.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst/ Supervisor	Accuracy/Bias	QSM 5.1 limits shown in Worksheet 15.1
Matrix Spike (MS)	One per preparatory batch of 20 or fewer samples of similar matrix.	DoD QSM 5.0 LCS limits are used, if available. Otherwise, in-house control limits are used for any compounds not specified in QSM 5.0. In-house control limits may not be > ± 3 times the standard deviation of the mean LCS recovery.	Examine project-specific requirements. Contact client as to additional measures to be taken. If MS results are outside limits, data shall be evaluated to determine source(s) of difference (i.e., matrix effect or analytical error)	Analyst/ Supervisor	Accuracy/Bias	QSM 5.1 limits shown in Worksheet 15.1

Worksheet 28.1 – QC Samples Table for Metals (Continued)

Matrix	Soil
Analytical Group	Metals
Analytical Method/SOP Reference	6010C / MT 009

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Title/Position Responsible for CA	Data Quality Indicator (DQI)	Project Specific MPC
Matrix Spike Duplicate (MSD) or Matrix Duplicate (MD)	One per preparatory batch of 20 or fewer samples of similar matrix.	DoD QSM 5.0 LCS limits used for a MSD, if available. Otherwise, in-house control limits used for any compounds not specified in QSM 5.0 In-house control limits may not be > ± 3 times standard deviation of the mean LCS recovery. MSD or MD: RPD of all analytes ≤ 20% (between MS & MSD or sample & MD).	Examine project-specified requirements. Contact client as to additional measures to be taken. The data shall be evaluated to determine the source of difference.	Analyst/ Supervisor	Precision	QSM 5.1 limits shown in Worksheet 15.1
Dilution Test (Serial Dilution)	One per preparatory batch of 20 or fewer samples of similar matrix if MS or MSD fails.	Five-fold dilution must agree within ± 10% of the original measurement. Only applicable for samples with concentrations > 50 x LOQ (prior to dilution).	No specific CA, unless required by the project.	Analyst/ Supervisor	Precision	%D ±10% for analytes with concentrations > 50x LOQ.
Post-Digestion Spike (PDS) Addition	Perform if MS/MSD fails. One per preparatory batch (using the same sample as used for the MS/MSD if possible) of 20 or fewer samples of similar matrix.	Recovery within 80-120%.	No specific CA, unless required by the project.	Analyst/ Supervisor	Accuracy/Bias	Recovery within 80-120%R.
Method of Standard Additions (MSA)	When dilution test or post digestion spike fails and if required by project.	N/A.	N/A.	Analyst/ Supervisor	Accuracy	Document use of MSA in the case narrative.

Notes:
Laboratory SOPs are listed on Worksheet #23.
Where applicable, the Acceptance Limits are consistent with the DoD QSM v5.1.

Worksheet 28.2 – QC Samples Table for Explosives

Matrix	Soil
Analytical Group	Explosives
Analytical Method/SOP Reference	8330B / SV 010

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Title/Position Responsible for CA	Data Quality Indicator (DQI)	Project Specific MPC
Method Blank (MB)	One per preparatory batch of 20 or fewer samples of similar matrix.	No analytes detected > ½ LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Correct problem. If required, reprep and reanalyze MB and all samples processed with the contaminated blank.	Analyst/Group Leader	Accuracy/Bias (Contamination)	No Target analytes >1/2 LOQ
Laboratory Control Sample (LCS)	One per preparatory batch of 20 or fewer samples of similar matrix.	DoD QSM V 5.0 LCS limits used, if available. Otherwise, in-house control limits used for compounds not specified in QSM 5.0. In-house control limits may not be > ± 3 times the standard deviation of the mean LCS recovery.	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.	Analyst/Group Leader	Accuracy/Bias	QSM 5.1 limits shown in Worksheet 15.2
Matrix Spike (MS)	One per preparatory batch of 20 or fewer samples of similar matrix.	DoD QSM V 5.0 LCS limits are used, if available. Otherwise, in-house control limits are used for any compounds not specified in QSM 5.0. In-house control limits may not be > ± 3 times the standard deviation of the mean LCS recovery.	Examine project-specific requirements. Contact client as to additional measures to be taken. If MS results are outside limits, the data shall be evaluated to determine the source(s) of difference (i.e., matrix effect or analytical error).	Analyst/Group Leader	Accuracy/Bias	QSM 5.1 limits shown in Worksheet 15.2

Worksheet 28.2 – QC Samples Table for Explosives (Continued)

Matrix	Soil
Analytical Group	Explosives
Analytical Method/SOP Reference	8330B / SV 010

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Title/Position Responsible for CA	Data Quality Indicator (DQI)	Project Specific MPC
Matrix Spike Duplicate (MSD) or Matrix Duplicate (MD)	One per preparatory batch of 20 or fewer samples of similar matrix.	DoD QSM V 5.0 LCS limits are used for a MSD, if available. Otherwise, in-house control limits are used for compounds not specified in QSM 5.0. In-house control limits may not be > ± 3 times the standard deviation of mean LCS recovery. MSD or MD: RPD of all analytes ≤ 20% (between MS & MSD or sample & MD).	Examine project-specified requirements. Contact client as to additional measures to be taken. The data shall be evaluated to determine the source of difference.	Analyst/Group Leader	Precision	QSM 5.1 limits shown in Worksheet 15.2
Surrogates	All field and QC samples.	QC acceptance criteria specified by the project, if available; otherwise DoD QSM Version 5.0 limits are used.	Correct problem, reprep and reanalyze all failed samples for all surrogates in associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst/Group Leader	Precision	78-119%R for 1,2-dinitrobenzene
Confirmation of positive results (second column)	All positive results must be confirmed.	Calibration and QC criteria for second column are the same as for initial or primary column analysis. Results between primary and secondary column RPD ≤ 40%.	Report from both columns	Analyst/Group Leader	Precision	RPD ≤ 40% for dual column concentrations.

Notes:
[1] Laboratory SOPs are listed on Worksheet #23.
[2] Where applicable, the Acceptance Limits are consistent with the DoD QSM v5.1

WORKSHEET # 29 - DATA MANAGEMENT, PROJECT DOCUMENTS, AND RECORDS

This worksheet provides 1) minimum specifications for all data management tasks and deliverables and 2) procedures for controlling project documents, records, and databases. The following subsections list records to be used and maintained for the RFI as well as the personnel responsible for generating and verifying the records. All records should be maintained in the WESTON project files for a minimum of five years.

The WESTON PM will establish a document control and records management system (project database). All project personnel will be made aware of the proper use of and access to the project database. The system will be accessible to field personnel to post records during the field activities, will include a minimum file structure as shown below, and will be maintained throughout the execution of the field activities. Files (hard copies and electronic) will be transferred to Project File upon completion of the project. All final document files, including reports, figures, and tables, will be submitted in electronic format. Any document files, logs, reports, figures, and tables will be made available to the on-site USACE OESS upon request.

A project-specific GIS will be used to store and manage relevant geospatial-related data and information. WESTON will manage and maintain project data in GIS in accordance with the data item description (DID) HNC-006.02 (USACE, 2010), EM 200-1-2 (USACE, 2016a), EM 200-1-12 (USACE, 2012), EM 200-1-15 (USACE, 2015), and applicable Interim Guidance Documents. The final GIS deliverable will include all documentation, reports, meeting minutes, and databases created, developed, or modified under this contract in original and portable document format (PDF) format.

All geophysical, target, and intrusive results and QC data will be managed by the Project Geophysicist, who will coordinate transfers of data to project staff and will facilitate QC review of UXO and geophysical data as appropriate. Dynamic and cued target data will be recorded in logbooks or on electronic devices, downloaded, backed up daily, and stored in a manner to secure data in the event of a computer failure. The Project Geophysicist or the SUXOS (if intrusive investigation data) will review each day's inputs for inconsistencies and ensure the completeness of the records. QC personnel will conduct an audit of the database and document the results in the Daily QC Reports and appropriate SOP checklists. The results of the database audit will be provided to the WESTON PM and QC Geophysicist.

DGM data files will be delivered in accordance with the requirements in Attachment C of DID WERS-004.01. It is expected that all EMI sensor data transfer will be accomplished via file transfer protocol (FTP) site. If the large size of the advanced EMI sensor data files makes the process cumbersome, the data will be transferred onto an external hard drive.

Cued data will be split or consolidated into survey units for storage and target selection; however, initial QC checks for all data, with the exception of coverage, will be performed by date. Coverage QC will be performed for entire survey units. Raw cued data will be named by target ID, and processed cued data will be organized, stored, and QC checked by date. Daily QC files (i.e., IVS, static, and function checks) and advanced EMI sensor background files will be stored in separate

databases and folders from the production data, although they will also be named and organized by date in their respective folders.

Geophysicists will use the latest version of UX-Analyze for processing and interpreting advanced EMI sensor data. TOI libraries used for classification will be developed using the library provided with UX-Analyze, data collected during previous projects, and data collected as part of ESTCP's ongoing library expansion project (MR-201424). The TOI libraries will be included in advanced EMI sensor data deliverables to document what library was used for classification.

Table 29-1 Minimum Required Documents and Records

Document/Record	Purpose	Completion/Update Frequency	Format/Storage Location/ Archive Requirements
SUXOS Log	Document daily activities during UXO operations	Daily	Hard copy or electronic/field office, project file/archived electronically
Verification Plan	Document the QC seeding and IVS requirements	Before mobilization	Electronic/AGC-QAPP, project file/archived electronically
QC Firewall Plan	Document the procedures to maintain a firewall between the QC seed information/ intrusive results and the Project Geophysicist/Processing Geophysicist	Before mobilization	Electronic/AGC-QAPP, project file/archived electronically
Daily Status Reports	Document daily activities during geophysics operations	Daily	Hard copy or electronic/field office, project file/archived electronically
Daily QC Reports	Document QC activities performed in the field	Daily	Hard copy/field office/archived electronically
Daily Geophysical QC Report	Document geophysical QC results	Daily	Electronic/project file/archived electronically
Team Leader Log(s)	Provide record of UXO Team's activities (clearance, MEC/MD/other debris identified, targets excavated)	Daily	Hard copy/field office/archived electronically
Monthly Progress Reports	Provide monthly updates on the project, field work, and schedule.	Monthly	Electronic/project file/ archived electronically
Root Cause Analysis	Required for MQO failures and Non-Conformance Reports	When required	Electronic/project file/archived electronically
Production Area QC Seeding Records	Document as built QC seeding results	Once after QC blind seeding is complete	Electronic/project file/archived electronically

Table 29-1 Minimum Required Documents and Records (Continued)

Document/Record	Purpose	Completion/Update Frequency	Format/Storage Location/ Archive Requirements
IVS Technical Memorandum	Report establishing the mV/amp threshold for target detection, demonstrating geophysical systems are operational and capable of performing the work, and defining the expected response for daily IVS checks	Completed following initial IVS data collection and submitted to client for approval and with final report	Electronic/project file/archived electronically
Third-Party Certification (TPC) Checklists	Document TPC inspections for DFWs	See Worksheet #31, 32 & 33	Hard copy or electronic/field office and project file/archived electronically
Data Usability Assessments (dynamic (EM31-MK2) survey, cued survey, and final DUA)	Discuss the usability of the data, including MPC and MQO Results	See Worksheet # 14/16	Electronic/project file/archived electronically
Daily Quality Control Checklists (IVS, Function Check Area [FCA])	Document daily QC procedures	Daily	Hard copy or electronic/field office and project file/archived electronically
Internal DOC Forms	Document DOC	Once per operator/processor	Hard copy or electronic/field office and project file/archived electronically
Final Amplitude Response Anomaly List	Document detected/selected anomalies	After detection survey is complete	Electronic/project file/archived electronically
Final Classified and Ranked Dig List	Document classification of anomalies	After classification is complete	Electronic/project file/archived electronically
QC Database	Document MQO results	Weekly	Electronic/project file/archived electronically
Intrusive Investigation Results	Document intrusive investigation results	Weekly	Electronic/project file/archived electronically

Table 29-1 Minimum Required Documents and Records (Continued)

Document/Record	Purpose	Completion/Update Frequency	Format/Storage Location/ Archive Requirements
Decision Plots	Provide data plots used in the classification decision-making process	After classification is complete	Electronic/project file/archived electronically

Table 29-2 Minimum Required Documents and Records for Soil/Sediment Sampling

Record	Generation	Verification	Storage Location/Archival
Sample Collection Documents and Field Records			
Field Notebooks	Field Scientist	Delegated QA Manager	Project File
Daily QC Report	UXOQCS	Delegated QA Manager	Project File
Site Maps	Field Scientist	Delegated QA Manager	Project File
CoC Forms	Field Scientist	Delegated QA Manager	Project File
Custody Seals	Field Scientist	Delegated QA Manager	Project File
Air Bills	Field Scientist	Delegated QA Manager	Project File
On-Site Analysis Documents and Records			
Soil Sampling			
Daily observations and notes, personnel on site, samples collected, date, time, communications, tailgate safety meeting items, etc.	Field Scientist	Delegated QA Manager	Project File
Documenting sample points, notations of site conditions	Field Scientist	Delegated QA Manager	Project File
Soil/sediment classification, sample depth, sample numbers, nos. of containers, requested analyses, preservation	Field Scientist	Delegated QA Manager	Project File
Data Assessment Documents and Records			
Project QAPP	Project Staff	PM	Project Files
Validation reports on applicable samples	Project Staff	PM	Project Files
Laboratory Records			
Data Validation Reports	Delegated QA Manager	PM	Project File
Sample Receipt, Sample Condition, Custody, and Internal Tracking Records	Laboratory Sample Receiving	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Laboratory Information Management System login	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Run logs – sample chronology	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Standard traceability logs	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Calibration logs	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
QC Sample identification (blanks, duplicates, LCS, MS/MSD)	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File

Table 29-2 Minimum Required Documents and Records for Soil/Sediment Sampling (Continued)

Record	Generation	Verification	Storage Location/Archival
Laboratory data qualifiers	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Instrument calibration logs	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Instrument maintenance logs	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Electronic Data Deliverables (EDDs)	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Case narrative	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Laboratory sample identification	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
QA/QC forms	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
DL/LOQ Studies	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Laboratory Accreditation Certificates	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
QA Manual	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Analytical SOPs	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File
Sample disposal records	Laboratory Technician/Laboratory QA Manager	Laboratory PM/Delegated QA Manager	Laboratory and Project File

WORKSHEET # 31, #32, AND #33 - ASSESSMENTS AND CORRECTIVE ACTION

Assessments:

This worksheet is used to document responsibilities and procedures for conducting project assessments, documenting assessments, responding to assessment findings, and implementing CA. The type, frequency, and responsible parties of planned assessment activities to be performed for the project are summarized in the table below.

Table 31-1 Assessments

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing CAs	Person(s) Responsible for Monitoring Effectiveness of CAs
Fieldwork Readiness Review	Once before mobilization	Internal	WESTON	WESTON Program Manager	WESTON Project Manager	WESTON Project Manager	WESTON Program Manager
H&S Assessment	Once during field activities	Internal	WESTON	WESTON Project H&S Officer, or designee	WESTON UXOSO	WESTON UXOSO	WESTON Project H&S Officer and SUXOS
Site Preparation Assessment	Following completion of vegetation removal and grid placement	Internal	WESTON	WESTON Project Geophysicist (grid locations) and Site Geophysicist (adequacy of brush clearing)	WESTON SUXOS	WESTON SUXOS	WESTON Site Geophysicist

Table 31-1 Assessments (Continued)

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing CAs	Person(s) Responsible for Monitoring Effectiveness of CAs
Seeding Assessment	Following completion of seeding	Both	WESTON/ USACE	WESTON QC Geophysicist and USACE Geophysicist	WESTON QC Geophysicist	WESTON QC Geophysicist	WESTON QC Geophysicist and USACE Geophysicist
DGM Data Deliverable Assessment	Weekly	Internal	WESTON	WESTON QC Geophysicist	WESTON Project Geophysicist	WESTON Project Geophysicist	WESTON QC Geophysicist
Classification Assessment	Once prior to submittal of ranked dig list	Internal	WESTON	WESTON QC Geophysicist	WESTON Project Geophysicist	WESTON Project Geophysicist	WESTON QC Geophysicist
Analog Removal Assessment	Per grid	Internal	WESTON	WESTON QC Geophysicist	WESTON SUXOS	WESTON SUXOS	WESTON QC Geophysicist
Anomaly Resolution Assessment	Per grid	Internal	WESTON	WESTON UXOQCS	WESTON SUXOS	WESTON SUXOS	WESTON UXOQCS
Intrusive Results Assessment	Weekly	Internal	WESTON	WESTON QC or Project Geophysicist	WESTON SUXOS	WESTON SUXOS	WESTON QC or Project Geophysicist
MPPEH/ Explosives Records Assessment	Once prior to demobilization	Internal	WESTON	WESTON SUXOS	WESTON SUXOS	WESTON SUXOS	WESTON UXOQCS

Table 31-1 Assessments (Continued)

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing CAs	Person(s) Responsible for Monitoring Effectiveness of CAs
Review Geospatial Data	For each GIS data submittal	External (see Quality Assurance Surveillance Plan (QASP)	USACE	Applicable USACE PDT Members	WESTON GIS Manager	WESTON GIS Manager	WESTON GCO Program Manager
Field Activities	See QASP	External (see QASP)	USACE	Applicable USACE PDT Members	WESTON PM and relevant personnel	WESTON SUXOS and other relevant personnel	WESTON UXOQCS and QC Geophysicist
Geophysical Surveys	See QASP	External (see QASP)	USACE	USACE Project Geophysicist	WESTON GCO Program Manager, and Project Geophysicist	WESTON Project Geophysicist	WESTON QC Geophysicist
Review RFI REPORT	For each submittal	External (see QASP)	USACE	Applicable USACE PDT Members	WESTON PM	WESTON PM and relevant personnel	WESTON PM

Corrective Action:

Based on the findings of project assessments above, CA may be required. A CA is defined as an action taken by a project team to eliminate the cause(s) of nonconformity in order to prevent recurrence. For assessment findings that require CA, deficiencies will be documented and communicated to the appropriate project personnel. CA will then be implemented and a follow-up assessment will be performed to verify the results of the CA. Procedures for handling UFP-QAPP deviations during each type of assessment are summarized in the table below.

Table 31-2 Corrective Action

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Time Frame of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response	Time Frame for Response
Fieldwork Readiness Review	Internal e-mail	WESTON Project Manager	3-5 business days	Internal e-mail	WESTON Program Manager	3-5 business days
Preparatory, Initial, and Follow-up Inspections	Internal e-mail	WESTON Project Manager, SUXOS	1-3 business days	Follow-up inspection	WESTON Project Manager, WESTON SUXOS	24 hours after notification
H&S Assessment	Written assessment report	WESTON SUXOS, WESTON PM, UXOSO	3-5 business days	Letter or memo	WESTON Project H&S Officer	24 hours after notification
QAPP Compliance and MEC Operations Assessment	Written assessment report	WESTON PM, WESTON SUXOS, WESTON UXOQCS	3-5 business days	Letter or memo	WESTON GCO PgM, WESTON Corporate QC Manager	3-5 business days
Site Preparation Assessment	Internal e-mail	WESTON SUXOS	1-3 business days	Internal e-mail	WESTON Site Geophysicist and Project Geophysicist	24 hours after notification
Surface Clearance Assessment	Internal e-mail	WESTON SUXOS	24 hours	Internal e-mail	WESTON SUXOS	24 hours after notification
Seeding Assessment	E-mail	WESTON QC Geophysicist	24 hours	E-mail and/or RCA	WESTON QC Geophysicist and USACE Geophysicist	24 hours after notification
DGM Data Deliverable Assessment	Internal e-mail, SOP checklist(s) noting deficiency	WESTON Site Geophysicist and Project Geophysicist	1-5 business days	Internal e-mail and/or RCA	WESTON QC Geophysicist	24 hours after notification

Table 31-2 Corrective Action (Continued)

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Time Frame of Notification	Nature of CA Response Documentation	Individual(s) Receiving CA Response	Time Frame for Response
Classification Assessment	Internal e-mail	WESTON Project Geophysicist	1-2 business days	Internal e-mail and/or RCA	WESTON QC Geophysicist	1-2 business days
Analog Removal Assessment	Internal e-mail	WESTON SUXOS	1-2 business days	Internal e-mail and/or RCA	WESTON UXOQCS	1-2 business days
Anomaly Resolution Assessment	Internal e-mail	WESTON SUXOS	24 hours	Internal e-mail and/or RCA	WESTON QC or Project Geophysicist	24 hours
Intrusive Results Assessment	Internal e-mail	WESTON SUXOS	1-5 business days	Internal e-mail and/or RCA	WESTON UXOQCS	1-2 business days
MPPEH/ Explosives Records Assessment	Internal e-mail	WESTON SUXOS	24 hours	Internal e-mail	WESTON UXOQCS	24 hours
Review Geospatial Data	Electronic submittal QA Form, Geospatial QA Form	WESTON GCO PgM and WESTON GIS Manager	14 calendar days	E-mail or appropriate QA Form with responses	USACE PM and USACE Project Geophysicist	10 business days
Field Activities	Corrective Action Request (CAR), Geophysical QA Forms, Quality Assurance Review, Memorandum for Record	WESTON PM and SUXOS (and other technical personnel if appropriate)	1-5 business days (immediately if serious deficiency)	E-mail or appropriate QA Form with responses	USACE PM, RFAAP POC	1-2 business days
Geophysical Surveys	CAR, Geophysical QA Forms	WESTON GCO PgM and Project Geophysicist	1-5 business days (immediately if serious deficiency)	E-mail or appropriate QA Form with responses	USACE PM and USACE Project Geophysicist	1-2 business days
Review RFI Report	RFI Report Comments Transmittal Memo	WESTON PM	14 calendar days	Revised RFI Report with response to comments	USACE PM	10 business days

Table 31-3 Assessments for Soil Sampling

Assessment Type	Responsible Party and Organization	Frequency	Estimated Dates	Assessment Deliverable	Deliverable Due Date
Review of QAPP, SOPs and Daily QC Report with Field Scientist	WESTON PM	Once prior to sampling start up	TBD	Daily QC Report would be amended with a CA.	Immediate within 24 hours.
Daily Logbook and Field Forms	WESTON Field Scientist	Daily	TBD	Daily QC Report would be amended with a CA.	Immediate within 24 hours
Laboratory assessment for appropriate certifications, capacity and QAPP Review with Staff	WESTON Project Chemist / WESTON QA Manager CT Laboratories QA Manager/Laboratory PM	Once prior to sampling start up	TBD	Response to email.	48 hours after notification.
Field Sampling and CoC Review Against QAPP Requirements	WESTON Field Scientist/ WESTON QA Manager/ WESTON PM	Daily	TBD	Response to email.	48 hours after notification.
Laboratory Report Deliverables and Analytical Results Against QAPP Requirements	WESTON Project Chemist/ WESTON QA Manager/ CT Laboratories PM	Per Sample Delivery Group	TBD	If required, laboratory reports will be amended and corrections noted in the analytical narrative.	72 hours after notification.
Data Verification	WESTON Project Chemist/ WESTON QA Manager/ CT Laboratories PM	Per Sample Delivery Group	TBD	If required, laboratory reports will be amended and corrections noted in the analytical narrative and contained with the validation report.	Up to seven days.
Data Validation	WESTON Data Validator/ WESTON Project Chemist	Per Sample Delivery Group	TBD	If required, laboratory reports will be amended and corrections noted in the analytical narrative and contained with the validation report.	Up to seven days

WORKSHEET # 34- DATA VERIFICATION AND VALIDATION INPUTS

This worksheet presents the inputs that will be used during data verification, validation, and usability assessment. Inputs include planning documents and field records.

Requirements/Specifications:

Item	Description	Verification (Completeness)	Validation (Conformance to Specifications)	Usability (Achievement of DQOs and MPCs)
Field Records				
1	QC Seeding Records	X	X	X
2	Field Logbooks (Digital)	X		
3	Grid Establishment Records	X	X	X
4	IVS Checklists	X	X	
5	FCA Checklists	X		
6	TPC Checklists	X	X	X
7	Daily QC Reports	X		
8	Weekly Status Reports	X		
9	Daily/Weekly SUXOS Reports	X		
10	Sensor Function Test Results	X	X	
Electronic Data				
11	Raw Data Files (EMI, GPS)	X		
12	Converted Data Files	X	X	
13	Data Processing Checklists	X		
14	QC Database	X	X	X
15	Amplitude Response Anomaly List	X	X	X
16	Final Data Archive (for each delivered area subset)	X	X	X
17	Classification Decision Plots (PDF files)	X		
Interim and Final Reports/Deliverables				
18	Production Area Seed Report	X	X	X
19	IVS Technical Memorandum	X	X	X
20	Site-specific Classification Library	X	X	X
21	Classified and Ranked Dig List	X	X	X
22	RFI Report and DUA			X

Requirements/Specifications (Continued):

Item	Description	Verification (completeness)	Validation (conformance to specifications)
Planning Documents/Records			
1	Approved UFP-QAPP	X	
2	Contract	X	
3	Field SOPs	X	
4	Laboratory SOPs	X	
5	Laboratory QA Manual	X	
6	Laboratory Certifications	X	
7	Personnel Training Records and Qualifications	X	
8	Permits		
Field Records			
9	Field Logbooks	X	
10	Equipment Calibration Records	X	
11	CoC Forms	X	
12	Sampling Diagrams/Surveys	X	
13	Relevant Correspondence	X	
14	Change Orders/Deviations	X	
15	Field Audit Reports	X	
16	Field CA Reports	X	
17	Sample Location Verification	X	
Analytical Data Package			
18	Cover Sheet (laboratory identifying information)	X	X
19	Case Narrative	X	X
20	Internal Laboratory CoC	X	X
21	Sample Receipt Records	X	X
22	Sample Chronology (i.e., dates and times of receipt, preparation, & analysis)	X	X
23	Communication Records	X	X
24	LOD/LOQ Establishment and Verification	X	X
25	Standards Traceability	X	X
26	Instrument Calibration Records	X	X
27	Definition of Laboratory Qualifiers	X	X
28	Results Reporting Forms	X	X
29	QC Sample Results	X	X
30	CA Reports	X	X
31	Raw Data	X	X
32	EDD	X	X

WORKSHEET # 35 - DATA VERIFICATION PROCEDURES

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
General MEC Field Documentation	UFP-QAPP	Verification only, confirm documentation is complete for each day of field activities and any required signatures are included.	UXOQCS	UXOQCS Daily QC Report
			SUXOS	Daily Status Reports
			SUXOS	Team Leader Logbook(s)
			SUXOS	Field Change Request Form
			UXOQCS/WESTON Project Geophysicist	RCA
			UXOQCS	Photographic Log
		Verification; confirm documentation is complete for each day of field activities and any required signatures are included. Validation; ensure the results of all relevant MPCs are attained and correctly documented in the deliverable.	UXOQCS	Daily QC Report
			UXOQCS	Surface Clearance Seeding QC Tracking Log
			UXOQCS	Analog Removal Seeding QC Tracking Log
General Geophysics Documentation	UFP-QAPP	Verification only; confirm documentation is complete for each day of field activities and required signatures are included.	WESTON Project Geophysicist	Field logbooks
		Verification; confirm Weekly Geophysical QC Reports on file cover entire duration of field effort. Validation; ensure the results of all relevant MQOs are attained and correctly documented in the deliverable.	WESTON Project Geophysicist (verification), QC Geophysicist (validation)	Weekly Geophysical QC Report Final Data Archive (for each delivered survey unit)
Detection Survey - IVS	UFP-QAPP; GCO-SOP-12	Verification; confirm documentation is complete, including dates and applicable signatures. Validation; Initial IVS surveys have been conducted according to GCO-SOP-12. All specifications have been achieved or exceptions noted. If appropriate, CAs have been completed.	WESTON QC Geophysicist	IVS Technical Memorandum

WORKSHEET # 35 - DATA VERIFICATION PROCEDURES (CONTINUED)

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Detection Survey - Seeding	UFP-QAPP, GCO-SOP-13	Verification; confirm documentation is complete, including dates and applicable signatures. Validation; Seeding has been conducted according to GCO-SOP-13 and the Blind Seeding Firewall Plan. All specifications have been achieved or exceptions noted. If appropriate, CAs have been completed.	WESTON QC Geophysicist	Production Area QC Seeding Report or QC Seed Tracking Log
			WESTON QC Geophysicist	Production Area Seeding QC Checklist
Detection Data Collection	UFP-QAPP, GCO-SOP-30	Verification only; confirm documentation is complete for all processing steps.	WESTON Project Geophysicist	Weekly Geophysical QC Report
		Verification; confirm documentation is complete, including dates and applicable signatures. Validation; MQOs have been achieved, with any exceptions noted. If appropriate, CAs have been completed.	WESTON Project Geophysicist	DGM data
Detection Data Processing	UFP-QAPP, GCO-SOP-30	Verification; confirm documentation is complete, including dates and applicable signatures. Validation; Sensor Function Test Results meet project MQOs and processing has been completed according to GCO-SOP-30, as appropriate. MQOs have been achieved, with any exceptions noted. If appropriate, CAs have been completed.	WESTON Project Geophysicist	Sensor Function Test Results (detection survey)
Cued IVS Survey	UFP-QAPP, GCO-SOP-12	Verification; confirm documentation is complete, including dates and applicable signatures. Validation; Initial IVS survey has been conducted according to GCO-SOP-12. All specifications have been achieved or exceptions noted. If appropriate, CA have been completed.	WESTON Project Geophysicist	Instrument assembly checklist (cued survey)

WORKSHEET # 35 - DATA VERIFICATION PROCEDURES (CONTINUED)

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Cued Data Collection	UFP-QAPP, GCO-SOP-11, GCO-SOP-19	Verification; confirm documentation is complete, including dates and applicable signatures. Validation; instrument assembly and data collection have been completed according to GCO-SOP-11 and GCO-SOP-19, as appropriate. Sensor function test results meet project MQOs with any exceptions noted. If appropriate, CAs have been completed.	WESTON Project Geophysicist	Weekly Geophysical QC Report, cued measurement data (target measurement data, background measurement data, and target features database)
Cued Data Processing	UFP-QAPP, GCO-SOP-20	Verification; confirm documentation is complete, including dates and applicable signatures. Validation; cued data processing has been completed according to GCO-SOP-20. MQOs have been achieved with any exceptions noted. If appropriate, CAs have been completed.	WESTON Project Geophysicist	Processed cued databases
Classification	UFP-QAPP, GCO-SOP-20	Verification only; confirm documentation is complete for each cued anomaly. Verification; confirm documentation is complete, including dates and applicable signatures.	WESTON Project Geophysicist	Classification images (pdf/png files)
		Validation; classification has been completed according to GCO-SOP-20. MQOs have been achieved with any exceptions noted. If appropriate, CAs have been completed.	WESTON QC Geophysicist	QC seed tracking log
Intrusive work at TOI and other selected anomalies	UFP-QAPP, MR-SOP-1, MR-SOP-2	Verification; confirm that intrusive results are on file listing items recovered from all investigated anomalies. Validation; ensure dig sheet data are complete and adequately describe the reacquisition results and dig results, including the correct item type, MEC type, nomenclature, description, quantity, and post dig response, for all listed items; ensure that items “left in place” are clearly noted and described; ensure that anomalies not investigated are clearly noted and explained.	WESTON UXOQCS/ WESTON Project Geophysicist	Intrusive results

WORKSHEET # 35 - DATA VERIFICATION PROCEDURES (CONTINUED)

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Analog Removal	UFP-QAPP, MR-SOP-1	Verification; verify that all magnetometer/metal detector test data, analog removal records, and analog grid status sheet are on file spanning the duration of the project. Validation; ensure the results of all relevant MPCs are attained and correctly documented in the deliverable.	WESTON UXOQCS	Daily Instrument Test Report, Analog Grid Status Log, Analog Removal Records
Explosives Storage and Transport	GCO-SOP-21	Verification; confirm that DD Form 1348-1As are on file spanning the duration of the project. Validation; ensure all MDAS handled and transported off-site is accounted for and that the CoC for those transfers is correctly documented.	WESTON SUXOS and UXOQCS	DD Form 1348-1A
		Verification; verify that Explosives Usage Records are on file for all demolition operations conducted during the project. Validation; ensure the record of each demolition event agrees with the related Magazine Data Card entries.	WESTON SUXOS	Explosive Usage Record
Explosives Storage and Transport	GCO-SOP-21	Verification; verify that the inventory records are on file for all magazines spanning the duration of the project. Validation; Ensure the record of each demolition event agrees with the related Explosive Usage Records; ensure that there is no remaining inventory of donor explosives.	WESTON SUXOS	Magazine Data Card
Demolition Operations	GCO-SOP-21	Verification; verify that Demolition Summary Sheet is on file for demolition operations conducted during the project. Validation; ensure all MEC destroyed by demolition and all demolition events are listed.	WESTON SUXOS	Demolition Summary Report

WORKSHEET # 35 - DATA VERIFICATION PROCEDURES (CONTINUED)

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Demolition Operations	UFP-QAPP, EMP, WESTON SOP 5	Verification; verify that the shot records are on file for all demolition operations conducted over the duration of the project. Validation; ensure the record of each demolition event agrees with the related dig sheet or Magazine Data Card entries.	WESTON SUXOS	Demolition Shot Record
MPPEH Handling	UFP-QAPP; MR-SOP-4	Verification; verify that all MDAS Disposal Documentation has been received and are on file for all MDAS shipped off-site during the project. Validation; ensure disposal documents account for all shipments of MDAS transported off-site and they certify the disposal of the material in accordance with project requirements.	WESTON SUXOS	MDAS Disposal Documentation

WORKSHEET # 35 - DATA VERIFICATION PROCEDURES (CONTINUED)

Records Reviewed	Required Documents	Process Description	Responsible Person
Field Logbook, Field Sheets, Sample Diagrams/Surveys	QAPP	Verify that records are present and complete for each day of field activities. Verify that all planned samples including field QC samples were collected and that sample collection locations are documented. Verify that meteorological data were provided for each day of field activities. Verify that changes/exceptions are documented and were reported in accordance with requirements. Verify that any required field monitoring was performed and results are documented.	WESTON PM
CoC Forms	QAPP	Verify the completeness of CoC records. Examine entries for consistency with the field logbook. Check that appropriate methods and sample preservation have been recorded. Verify that the required volume of sample has been collected and that sufficient sample volume is available for QC samples (e.g., MS/MSD). Verify that all required signatures and dates are present. Check for transcription errors.	WESTON PM CT Laboratories PM
Laboratory Deliverable	QAPP	Establish that all QAPP required QC samples were collected. Establish that the collected QC samples met the required limits as established in the QAPP. Ensure that from the CoC generated in the field to the delivery of the analytical data that the appropriate analytical samples have been collected, appropriate site identifications have been used, and the correct analytical methods have been applied. Review the analytical reports to establish that all required forms, case narratives, samples, CoC, logbooks, and raw data have been included. Review laboratory analytical met the project quantitation limits specified in QAPP Worksheet #15. Review and add PALs to the laboratory EDD. Flag samples and notify PM of samples that exceed the PALs. Data Verification will be performed on all samples. Data verification that sample analysis was performed as stated in the QAPP and per the laboratory SOPs.	WESTON Project Chemist, WESTON QA Manager, WESTON, CT Laboratories PM
Audit Reports, CA Reports	QAPP	Verify that all planned audits were conducted. Examine audit report. For any deficiencies noted, verify that CA was implemented according to plan.	WESTON PM, WESTON Project Chemist, CT Laboratories PM

WORKSHEET # 36 - DATA VALIDATION PROCEDURES

Data Validator: TBD[3]

Analytical Group/ Method	Data Deliverable Requirements	Analytical Specifications	MPC[1,2]	Percent of Data Packages to be Validated	Percent of Raw Data Reviewed	Percent of Results to be Recalculated	Validation Procedure	Validation Code	Electronic Validation Program/ Version
Metals / 6010C	Level 4 (validatable data package) and Staged Electronic Data Deliverable (SEDD) format	Worksheet 28.1, SOP MT 009	Project Validation Criteria from QAPP Worksheets #12, #15, #19,#24, #28, and #37, DoD QSM 5.1, USEPA National Functional Guidelines (2017), USEPA Method 6010C.	100%	100%	5%	Stage 4	S3VEM	TBD
Explosives / 8330B	Level 4 (validatable data package) SEDD format	Worksheet 28.2, SOP SV010	Project Validation Criteria from QAPP Worksheets #12, #15, #19, #24, #28, and #37, DoD QSM 5.1, USEPA National Functional Guidelines (2017), USEPA Method 8330B.	100%	100%	5%	Stage 4	S4VEM	TBD

Notes:

[1]Project Validation Criteria as per QAPP Worksheets #12, #15, #19,#24, #28, and #37, DoD QSM version 5.1, USEPA National Functional Guidelines. Project Validation Criteria in accordance with QAPP Worksheets #12, #15, #19, #24, and #28 and cited in USEPA SW-846 methodology.

[2]The hierarchy of validation will be the QAPP; the DoD QSM (Version 5.1); USEPA National Functional Guidelines (2017 versions); the EPA method. If needed, the CT Laboratories SOP will be consulted.

[3]Validation will be completed by a third party (small business) or by a third party in WESTON not involved in the project in any other capacity. The data validator will receive all laboratory packages and analytical results electronically. Additionally, the validator will be required to submit final validation reports via pdf format and must provide an annotated laboratory analytical result EDD with applicable data validation qualifiers and/or result value modifications.

Advanced Geophysical Classification Validation

The Verification and Validation Plan is included in **Appendix N**. The Verification and Validation Plan describes how each of the decision-making thresholds for detection and classification will be tested and identifies how anomalies will be selected for the threshold verification and validation digs. It addresses the QC seeding plan, the threshold verification digs, and validation digs. (The placement of government validation seeds is addressed in the QASP.)

The number, type, and placement of QC seeds depend on project-specific DQOs. The final number and distribution of threshold verification digs and validation digs depends on the DQOs, as well as the actual performance in the field against established MPCs. For that reason, the validation approach evolves as the project is implemented. The Verification and Validation Plan is finalized following data processing.

WORKSHEET # 37 - DATA USABILITY ASSESSMENT

The DUA is an evaluation based on the results of data verification and validation in the context of the overall project decisions or objectives. The assessment determines whether the project execution and resulting data meet the project DQOs (see Worksheet #11) and the MPCs (see Worksheet #12). All types of data (e.g., DGM, intrusive) will be considered with the ultimate goal of assessing whether the final, qualified results support the decisions to be made with the data. The following sections summarize the processes to determine whether the collected data are of the right type, quality, and quantity to support the environmental decision-making activities for the project. The following sections also describe how data quality issues will be addressed and how limitations of the use of the data will be handled.

37.1 DUA PROCESS SUMMARY FOR GEOPHYSICS

Data gaps may be present if 1) data are not collected, 2) data are not evaluated with regard to the necessary parameters, or 3) data are determined to be unusable. The need for further investigation or CA will be determined on a case-by-case basis, depending on whether the data can be recovered, extrapolated from other data, and/or whether the missing data are needed based on the results of other recorded data. Once completed, the DUA Report will be included as an appendix to the RFI Report.

The following individuals will participate in the DUA:

- USACE PM
- WESTON PM
- Project Geophysicist
- QC Geophysicist
- Government QA personnel
- Other technical personnel as necessary

The following documents will be reviewed as part of the DUA:

- Project Work Statement Specifications
- UFP-QAPP
- QASP
- Daily QC Reports
- Non-Conformance Reports
- Production Area Seed Report
- IVS Technical Memorandum
- Site-Specific Classification Library
- QC Database
- SOP Checklists
- Target List
- Classification Technical Memorandum
- Dynamic and Cued Data
- Intrusive Investigation Results
- ROC Curve
- Analog Removal Grid Records

The DUA will follow a four-step process as follows:

Step 1	**Review the objectives of the project and sampling design** Review the DQOs. Are underlying assumptions valid? Were the project boundaries appropriate? Review the sampling design as implemented for consistency with stated objectives. Were sources of uncertainty accounted for and appropriately managed? Summarize any deviations from the planned sample design.
Step 2	**Review the data verification/validation outputs and evaluate conformance to MPCs documented in Worksheet #12** Review the site-specific project library for completeness. Review available QC reports, including daily/weekly QC reports, non-conformance reports, and CA reports. Evaluate the implications of unacceptable QC results. Evaluate conformance to MPCs documented on Worksheet #12. Summarize the impacts of non-conformances on data usability.
Step 3	**Document data usability, update the CSM, and draw conclusions** Determine if the data can be used as intended, considering implications of deviations and CAs. Assess the performance of the sampling design and identify any limitations on data use. Update the CSM and document conclusions.
Step 4	**Document lessons learned and make recommendations** Summarize lessons learned and make recommendations for changes to DQOs or the sampling design for future similar studies. Prepare the data usability summary report.

37.2 DUA DOCUMENTATION

The detection and cued survey DUAs will be documented in a detection survey DUA report and cued survey DUA report, respectively. Once completed, the data usability report will be included as an appendix to the RFI Report.

37.3 DUA PROCESS SUMMARY FOR SOIL/SEDIMENT SAMPLING

The usability assessment is an evaluation of data based upon the results of data validation and verification for the decisions being made. In the usability step, reviewers will assess whether the process execution and resulting data meet quality objectives based on criteria established in this UFP-QAPP. The usability assessment will consider data from sampling activity, off-site laboratory, and validation reports. The usability assessment will be performed by the data assessment team and documented in the RFI Report by the Project Chemist. The data assessment team will consist of the PM, Quality Manager, Project Chemist, and Database Manager.

The data assessment team will:

- Identify project requirements and verify field activities were performed in accordance to the SOPs (**Appendix H**);
- Review the project DQOs and data validation process detailed in Worksheets #34, #35, and #36;
- Verify that all samples and analytical data collected meet the DQOs;

- Evaluate validated data to assess whether they satisfy DQOs and are adequate to make the decision regarding additional investigation for the MRS; and
- Provide input on the suitability of the results for the purposes intended.

In the Usability Assessment, the team will determine the impacts of any deviations from the planned procedures documented in this AGC-QAPP, guidance documents, or SOPs, for the following items:

Sampling Locations	Holding Times	SOPs and Methods
CoCs	Damaged Samples	

In addition, the team will evaluate the possible effects of outliers or anomalous data from the following:

QC Samples	Comparability	Meteorological Data and Site Conditions
Matrix	Completeness	

The DUA will include an evaluation of the data quality indicators (precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity). The impact of any data gaps or deviations from planned procedures will be evaluated. This includes rejected data based on the results of the data validation process. The usability assessment will evaluate the overall dataset for the entire site, and any trends, relationships, or correlations will be described.

After the data usability assessment has been performed, data deemed appropriate for use will be presented in the RFI Report.

REFERENCES

BSEn (Bering Sea Environmental, LLC). 2018a. *Final Work Plan, Site Investigation, Former Gun and Trench Mortar Range MRS, Radford Army Ammunition Plant*.

BSEn. 2018b. *Final Site Investigation Report. Former Gun and Mortar Range Munitions Response Site (RFAAP-002-R-01).* September.

DoD (Department of Defense). 2012. Manual 6055.09-M: *DoD Ammunition and Explosives Safety Standards.* Issued 29 February 2008. Administratively Reissued 4 August 2010. Incorporating Change 1, 12 March 2012.

DoD. 2017. *QSM for Environmental Laboratories, Version 5*.1. January.

DoD. 2018. *Department of Defense Quality Systems Requirements for Advanced Geophysical Classification (DoD QSR).* Version 2.0. December.

DDESB (Department of Defense Explosives Safety Board). 2016. *TP 18: Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities.* September.

IDQTF (Intergovernmental Data Quality Task Force). 2005. *Uniform Federal Policy for Quality Assurance Project Plans. Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs. Part 1: UFP-QAPP Manual. Final. Version 1.* March.

IDQTF, 2012. *Uniform Federal Policy for Quality Assurance Project Plans Optimized UFP-QAPP Worksheets.*

IT (IT Corporation). 2001. *Facility-Wide Background Study Report, Radford Army Ammunition Plant, Virginia*. December.

LiDAR (Light Detection and Ranging). 2015. 1949, 1953, and 1960 Historical Aerial Photographs, Sanborn Blacksburg, Virginia.

MacDonald and Mack. 1984. *Historic Properties Report, Radford Army Ammunition Plant (Including the New River Unit), Radford, Virginia*. August.

National Resources Conservation Service. 2016. U.S. Department of Agriculture *Web Soil Survey*. 13 September. http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Shaw (Shaw Environmental, Inc.). 2004. *Final RCRA Facility Investigation/Corrective Measures Study Report*, Building 4343, Radford Army Ammunition Plant, Radford, Virginia. February.

URS (URS Corporation). 2003. *Final Master Work Plan, Quality Assurance Plan, Health and Safety Plan.* Radford Army Ammunition Plant, Radford, VA. August 2003.

USACE (U.S. Army Corps of Engineers). 1993. *Archives Search Report, New River Ordnance Plant, Radford Virginia*. St. Louis District. September 1993.

USACE. 2010. *Geospatial Information and Electronic Submittals.* DID HNC-006.02. January 2010.

USACE. 2012. *Conceptual Site Models.* EM 200-1-12. December 2012.

USACE. 2013. *Explosive Safety and Health Requirements Manual.* Engineer Manual (EM) 385-1-97. Change 1. 12 April. Originally published 15 September 2008.

USACE. 2014. *Safety and Health Requirements*. Engineer Manual (EM) 385-1-1. November 2014.

USACE. 2015. *Technical Guidance for Military Munitions Response Actions.* EM 200-1-15. October 2015.

USACE. 2016a. *Environmental Quality: Technical Project Planning Process.* EM 200-1-2. February 2016.

USACE. 2019. Trial Period Extension for Risk Management Methodology (RMM) at Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP) Projects, 07 February 2019.

USEPA. 2005a. Ecological Soil Screening Level for Antimony, Interim Final. OSWER Directive 9285.7-61. February.

USEPA. 2005b. Ecological Soil Screening Level for Lead, Interim Final. OSWER Directive 9285.7-70. March 2005.

USFWS (U.S. Fish and Wildlife Service). 2019a. National Wetlands Inventory, Wetlands Mapper accessed 16 July 2019, http://www.fws.gov/wetlands/Wetlands-Mapper.html.

USFWS. 2019b. Environmental Conservation Online System. Available online at: https://ecos.fws.gov/ecp/.

U.S. Geological Survey (USGS). 1965. Topographic maps, 1950 and 1965.

USGS. 2018. Digital Elevation Model.

VADEQ (Virginia Department of Environmental Quality). 2019. Wetland Condition Assessment Tool (WetCAT). Accessed 16 July 2019, http://cmap2.vims.edu/WetCAT/WetCAT_Viewer/WetCAT_VA_2D.html.

WESTON (Weston Solutions, Inc.). 1992. *Preliminary Assessment Report Addendum for Radford Army Ammunition Plant, Virginia*. March.

WESTON. 2019. *Final Topographic Fill Analysis Report, Former Gun and Trench Mortar Range Munitions Response Site*, Environmental and Munitions Response Services, Radford Army Ammunition Plant. Radford, Virginia. March.

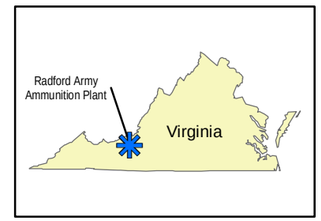
APPENDIX A

SITE MAPS

Figure A-1 – Radford Army Ammunition Plant Location Map
Figure A-2 - Former Gun and Trench Mortar Range and Area A Site Map
Figure A-3 - Topographic Change within the Former Gun and Southern Trench Mortar Ranges
Figure A-4 - Topographic Change within the Former Trench Mortar Range
Figure A-5 – Fill Areas within the Former Gun and Southern Trench Mortar Ranges
Figure A-6 – Fill Areas within the Former Trench Mortar Range
Figure A-7 – Geophysical Investigation Map
Figure A-8 – MC Sampling Map

Legend

Imagery Source:
ESRI, Imagery Mapping Service, 2017



N

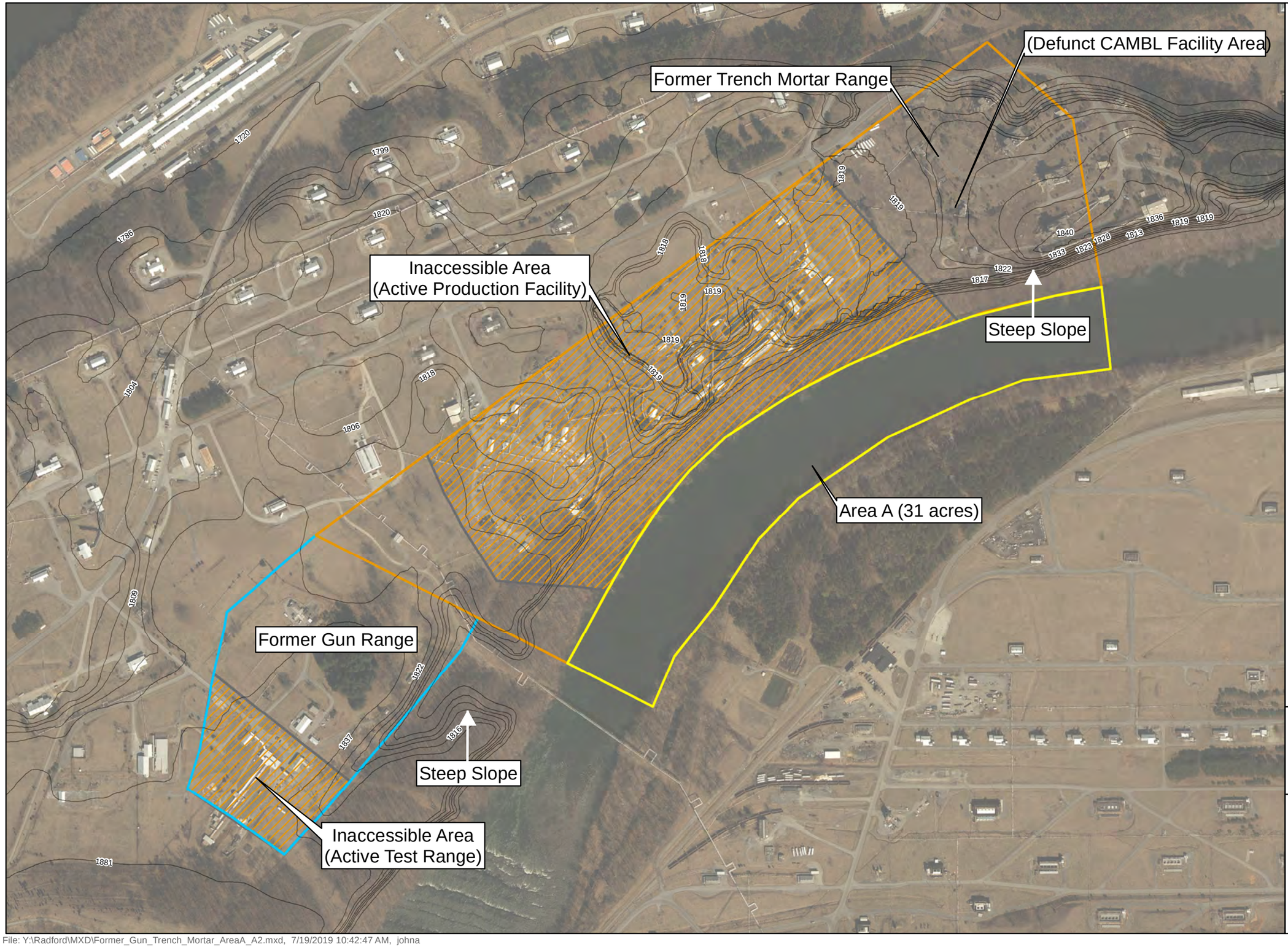
0 2 4
Miles

Prepared By:

Baltimore District

FIGURE A-1
RADFORD ARMY AMMUNITION
PLANT LOCATION MAP
RADFORD, VIRGINIA

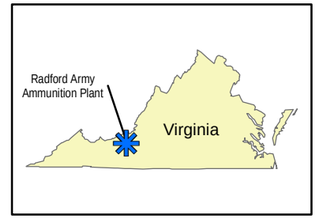
File: Y:\Radford\MXD\Radford_Regional_Map.mxd, 4/30/2019 3:58:05 PM, johna



Legend

- Contours (Feet)
- Area A
- Inaccessible Area
- Former Trench Mortar Range
- Former Gun Range

Imagery Source:
ESRI, Imagery Mapping Service, 2018



N

0 165 330 660
Feet

Prepared By:
Baltimore District

FIGURE A-2
FORMER GUN AND TRENCH
MORTAR RANGE AND AREA A SITE MAP
RADFORD, VIRGINIA

File: Y:\Radford\MXD\Former_Gun_Trench_Mortar_AreaA_A2.mxd, 7/19/2019 10:42:47 AM, johna

Inaccessible Area

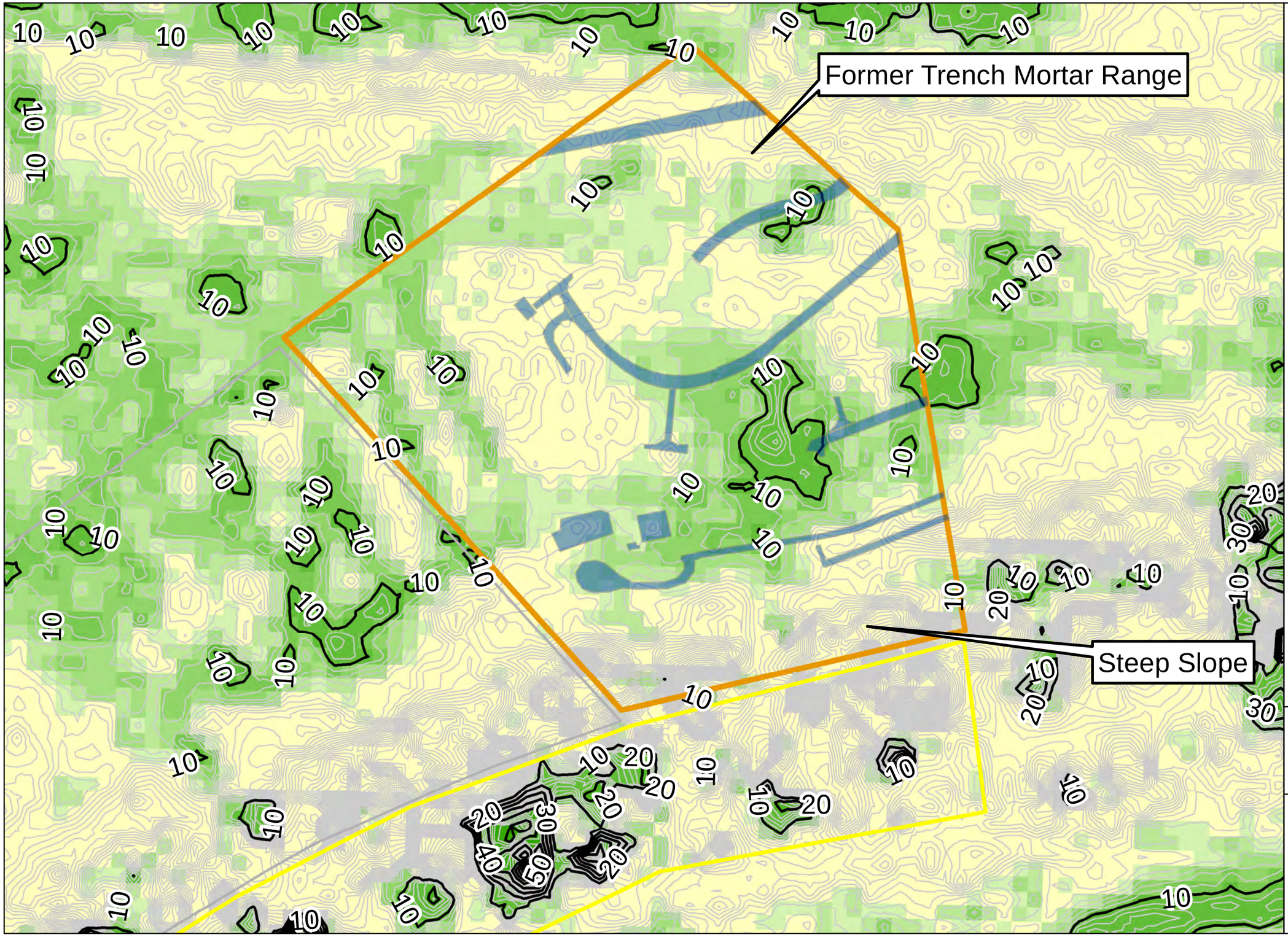
Former Gun Range

Former Trench Mortar Range

Area A

Inaccessible Area

10 10 10

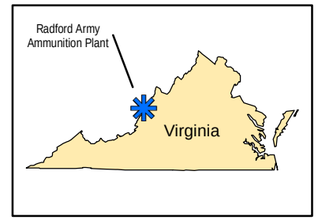


Legend

- Hardscape
- Area A
- Inaccessible Area
- Former Trench Mortar Range (FTMR)
- Cut/Fill Depth Index
- Cut/Fill Contour (2')

Fill Depth (ft)

<0	8
2	10
4	20
6	>20
	>30



N

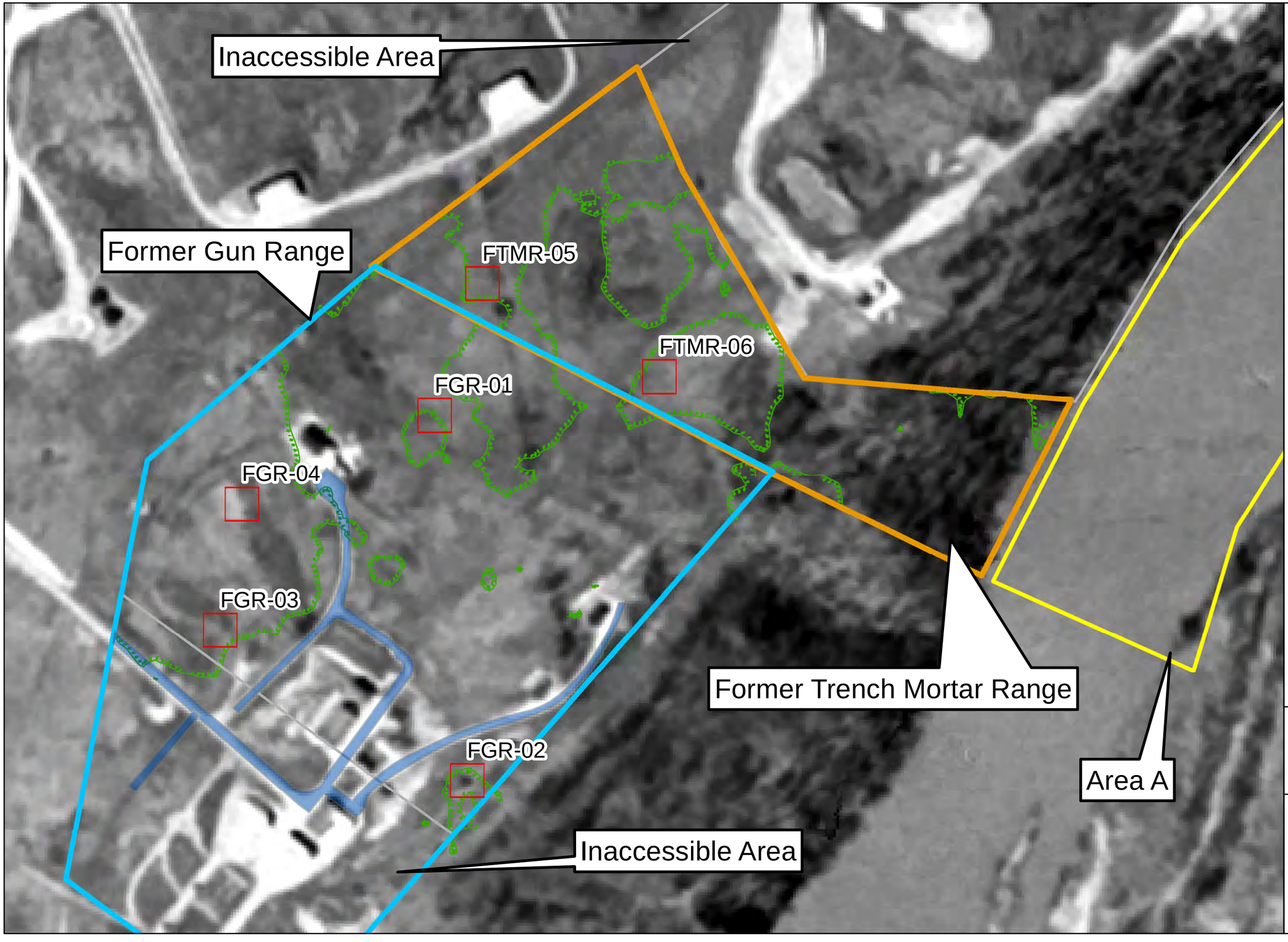
0 65 130 260

Feet

Prepared By:

Baltimore District

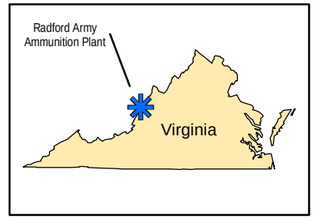
FIGURE A-4
TOPOGRAPHIC CHANGE WITHIN THE FORMER TRENCH MORTAR RANGE
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

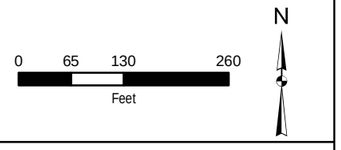


Legend

- Hardscape
- Area A
- Inaccessible Area
- Former Gun Range (FGR)
- Former Trench Mortar Range (FTMR)
- Proposed Pitting/Trenching Locations
- Fill

AERIAL PHOTOGRAPH
FEATURE ID FROM TABLE 10-1:
FGR-01,-02, -03, AND -04
FTMR-05 AND -06

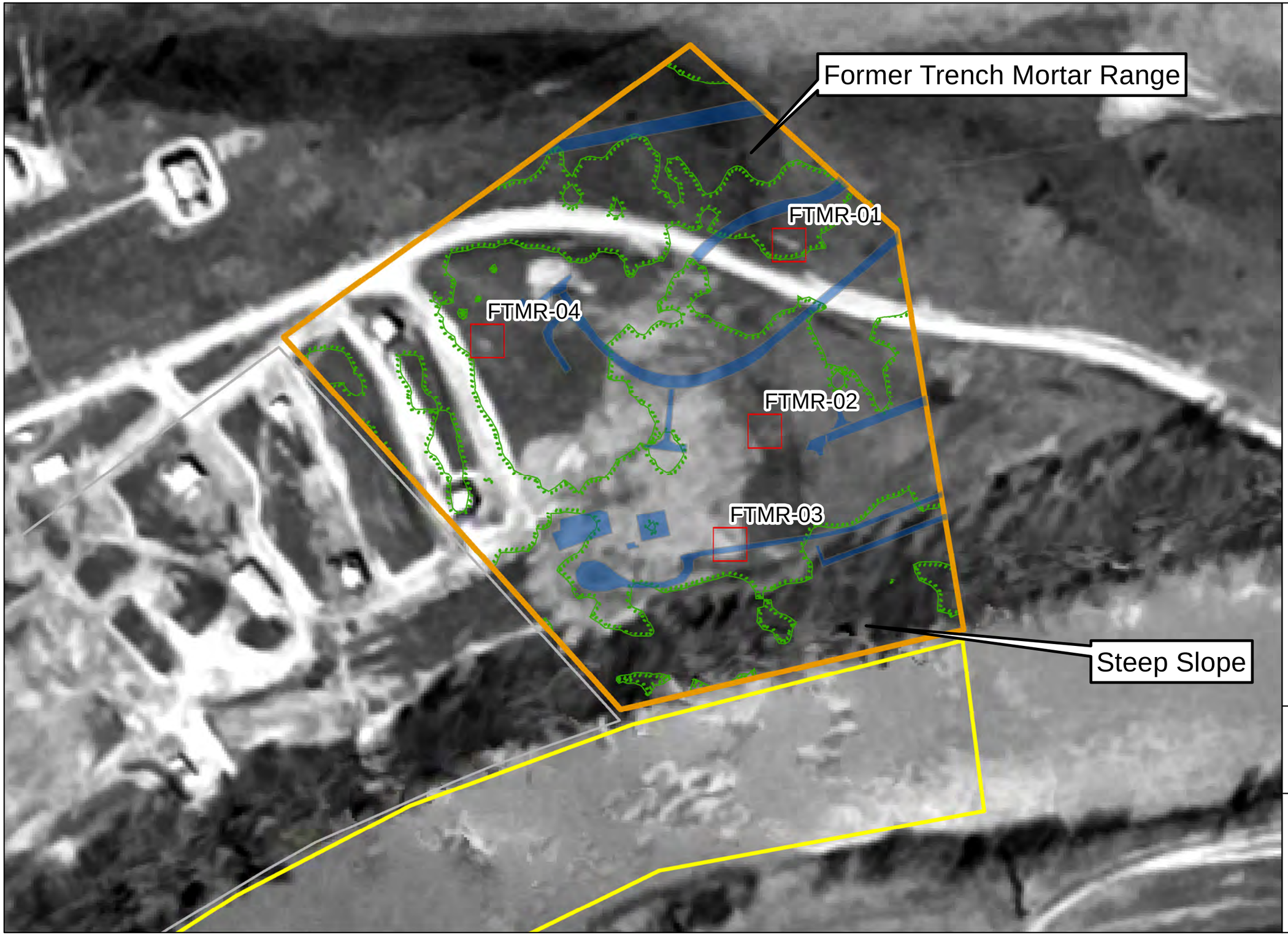




Prepared By:

Baltimore District

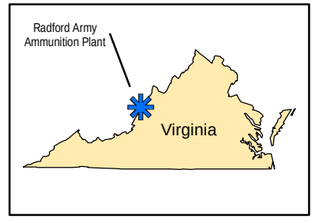
FIGURE A-5
FILL AREAS WITHIN THE
FORMER GUN AND SOUTHERN
TRENCH MORTAR RANGES
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA



Legend

- Hardscape
- Area A
- Inaccessible Area
- Former Trench Mortar Range (FTMR)
- Proposed Pitting/Trenching Locations
- Fill

AERIAL PHOTOGRAPH
FEATURE ID FROM TABLE 10-1:
FTMR-01,-02, -03, AND -04



N

0 65 130 260
Feet

Prepared By:

Baltimore District

FIGURE A-6
FILL AREAS WITHIN THE
FORMER TRENCH MORTAR RANGE
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

Former Trench Mortar Range
(37 acres)

Inaccessible Area

Steep Slope

Area A
(31 acres)

Former Gun Range
(28 acres)

Steep Slope

Inaccessible Area

TM-1
TM-2
TM-3
TM-4
TM-5
TM-6
TM-7
TM-8
TM-9
TM-10
TM-11
TM-12
TM-13

GR-1
GR-2
GR-3
GR-4
GR-5
GR-6
GR-7
GR-8
GR-9
GR-10
GR-11
GR-12
GR-13
GR-14
GR-15
GR-16
GR-17
GR-18

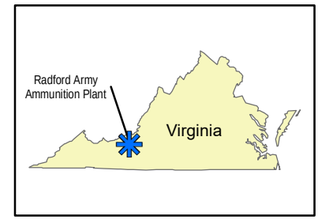
AA-1
AA-2
AA-3
AA-4
AA-5
AA-6
AA-7
AA-8

1720 1786 1819 1799 1883 1845 1820 1819 1840 1836 1819 1813 1823 1828 1817 1818 1819 1819 1819 1819 1804 1806 1818 1809 1837 1816 1822 1881

Legend

- Planned DGM Transects – Area A
- Contours (Feet)
- Trench Mortar Grids – AGC Survey
- Gun Range Grids – AGC Survey
- Area A
- EM-31 Area
- Inaccessible Area
- Former Trench Mortar Range
- Former Gun Range
- Buildings

Imagery Source:
ESRI, Imagery Mapping Service, 2018



N

0 165 330 660
Feet

Prepared By:
Baltimore District

FIGURE A-7
GEOPHYSICAL INVESTIGATION MAP
RADFORD, VIRGINIA

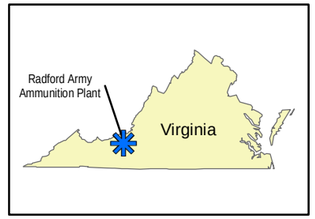
File: Y:\Radford\MXD\Geophysical_Investigation_Map_04302019.mxd, 7/9/2019 1:09:23 PM, johna



Legend

- Sampling Points
- Contours (Feet)
- SI Incremental Sampling Decision Unit
- Inaccessible Area
- Former Trench Mortar Range
- Proposed XRF Sampling Grid (30 X 30 Ft.)
- Former Gun Range
- Buildings

Imagery Source:
ESRI, Imagery Mapping Service, 2018



N

0 45 90 180
Feet

Prepared By:
Baltimore District

FIGURE A-8
MC SAMPLING MAP
RADFORD, VIRGINIA

File: Y:\Radford\MXD\Former_Gun_Range_Grids_Rev04302019.mxd, 5/17/2019 3:47:17 PM, johna

APPENDIX B

DAGCAP CERTIFICATIONS

CERTIFICATE OF ACCREDITATION

ANSI National Accreditation Board

11617 Coldwater Road, Fort Wayne, IN 46845 USA

This is to certify that

Weston Solutions, Inc.

1400 Weston Way
West Chester, PA 19380

has been assessed by ANAB and meets the requirements of international standard

ISO/IEC 17025:2017

and the

U.S. Department of Defense Advanced Geophysical Classification Accreditation Program (DAGCAP) DoD QSR V2

while demonstrating technical competence in the field of

TESTING

Refer to the accompanying Scope of Accreditation for information regarding the types of activities to which this accreditation applies

AT-2538

Certificate Number

ANAB Approval

Certificate Valid Through: 12/21/2021
Version No. 002 Issued: 11/14/2019

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

ANSI National Accreditation Board

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

and

U.S. DEPARTMENT OF DEFENSE ADVANCED GEOPHYSICAL CLASSIFICATION ACCREDITATION PROGRAM (DAGCAP) DOD QSR V2

Weston Solutions, Inc.

1400 Weston Way
West Chester, PA 19380

Ryan Steigerwalt
267-258-2672

TESTING

Valid to: **December 21, 2021** Certificate Number: **AT-2538**

Subsurface Munitions

Technology	Methods Used
Electromagnetic Induction (EMI)	Advanced Geophysical Classification

Note:
1. This scope is formatted as part of a single document including Certificate of Accreditation No. AT-2538.

Vice President

Attachment 2

Internal Demonstration of Capability (DOC) 2 Form

Internal DOC 2 *is designed for individuals to demonstrate the following minimum skills:*

- Quality control checks of field data (unknown targets and background)
- Background correction
- Source selection (dynamic selection only)
- Parameter extraction
- Appropriate use of the parameter
- Classification, to include effectively reducing clutter

Successful completion of ***Internal DOC 2*** *meets the minimum requirements for individuals to perform the role of Data Analyst on Advanced Geophysical Classification (AGC) projects performed by the WESTON GCO.*

WESTON GCO Personnel	Name: Greg Abrams Position: Technical Manager
SOP Number *(with revision number and effective date)*	GCO-SOP-23, Demonstrations of Capability Rev # 2.0 Date: 11/13/17
DOC Type	☐ Initial ☒ Ongoing
Reason(s) for this DOC	☐ New Data Analyst ☐ New Method ☐ Change to Procedure ☒ Refresher Demonstration (Ongoing)
DOC Data Source *(What procedures did you use to perform this DOC?)*	GCO-SOP-17, Processing Dynamic Survey Data – TEMTADS 2x2[2] Rev # 2.0 Date: 11/13/17 Initial: GA GCO-SOP-20, Processing Cued 2x2 Data (to include an effective demonstration to reduce clutter) Rev # 4.0 Date: 11/13/17 Initial: GA

Summary Chart

	SOP	Demonstrated Experience	Pass/Fail*
1)	GCO-SOP-17, Processing Dynamic Survey Data – TEMTADS 2x2[2] Review Date: 11/13/17 Initials: GA	Project: Blossom Point Grid02 Role: Data Analyst Date: 11/13/17 Initials: GA	Pass
2)	GCO-SOP-20, Processing Cued 2x2 Data Review Date: 11/10/17 Initials: GA	Project: Blossom Point Grid02 Role: Data Analyst Date: 11/13/17 Initials: GA	Pass

☒ **PASS** ☐ **FAIL**

CONTROLLED COPY

Internal Demonstration of Capability (DOC) 2 Form (continued)

Greg Abrams		11/13/17
Data Analyst Name (print)	Data Analyst Signature	Approval Date
Ryan Steigerwalt		11/13/17
Reviewer Name (print)	Reviewer/Manager Signature	Approval Date

CONTROLLED COPY

[2]A similar GCO SOP for another type of AGC sensor may substitute, such as GCO-SOP-30, Processing Dynamic Survey Data with MetalMapper 2x2, per the discretion of the QM.

Attachment 1

Internal Demonstration of Capability (DOC) 1 Form

Internal DOC 1 *is designed for individuals to demonstrate the following minimum skills:* • Instrument assembly and operation • Continuous operation within specifications • Dynamic operation • Cued operation *Successful completion of* ***Internal DOC 1*** *meets the minimum requirements for individuals to perform the role of* ***Field Team Leader and/or Field Geophysicist*** *on Advanced Geophysical Classification (AGC) projects performed by the WESTON GCO.*	
WESTON GCO Personnel	Name: Mike Link Position: Field Geophysicist
SOP Number *(with revision number and effective date)*	GCO-SOP-23, Demonstrations of Capability Rev # 1.0 Date: 28 August 2017
DOC Type	☒ Initial ☐ Ongoing
Reason(s) for this DOC	☒ New Geophysicist ☐ New Method ☐ Change to Procedure ☐ Refresher Demonstration (Ongoing)
DOC Data Source *(What procedures did you use to perform this DOC?)*	GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification Rev # 1.0 Date: 22-Aug-17 Initial: ML GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) Rev # 1.0 Date: 22-Aug-17 Initial: ML GCO-SOP-15, Performing Dynamic Surveys with TEMTADS 2x2[1] Rev # 2.0 Date: 6-Sept-17 Initial: ML GCO-SOP-18, Collection of Static Background Measurements Rev # 1.0 Date: 24-Aug-17 Initial: ML GCO-SOP-19, Collection of Cued Target Measurements Rev # 1.0 Date: 24-Aug-17 Initial: ML

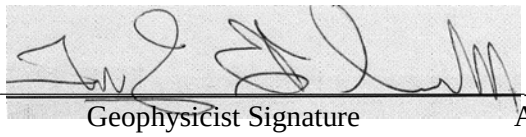
[1] A similar GCO SOP for another type of AGC sensor may substitute, such as GCO-SOP-29, Performing Dynamic Surveys with MetalMapper 2x2, per the discretion of the QM.

Internal Demonstration of Capability (DOC) 1 Form (continued)

Summary Chart

	SOP	Demonstrated Experience	Pass/Fail*
1)	GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification Review Date: 7-Sep-17 Initials: ML	Project: Blossom Point Practice Session Role: Field Geophysicist Date: 11-Sep-17 Initials: ML	Pass
2)	GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) Review Date: 7-Sep-17 Initials: ML	Project: Blossom Point Practice Session Role: Field Geophysicist Date: 11-Sep-17 Initials: ML	Pass
3)	GCO-SOP-15, Performing Dynamic Surveys with TEMTADS 2x2[1] Review Date: 7-Sep-17 Initials: ML	Project: Blossom Point Practice Session Role: Field Geophysicist Date: 12-Sep-17 Initials: ML	Pass
4)	GCO-SOP-18, Collection of Static Background Measurements Review Date: 7-Sep-17 Initials: ML	Project: Blossom Point Practice Session Role: Field Geophysicist Date: 13-Sep-17 Initials: ML	Pass
5)	GCO-SOP-19, Collection of Cued Target Measurements 7-Sep-17 Initials: ML	Project: Blossom Point Practice Session Role: Field Geophysicist Date: 13-Sep-17 Initials: ML	Pass

☒ **PASS** ☐ **FAIL**

Mike Link		20-Sep-17
Geophysicist Name (print)	Geophysicist Signature	Approval Date
Greg Abrams		20-Sep-17
Reviewer Name (print)	Reviewer/Manager Signature	Approval Date

Attachment 1

Internal Demonstration of Capability (DOC) 1 Form

Internal DOC 1 *is designed for individuals to demonstrate the following minimum skills:* • Instrument assembly and operation • Continuous operation within specifications • Dynamic operation • Cued operation *Successful completion of* ***Internal DOC 1*** *meets the minimum requirements for individuals to perform the role of* ***Field Team Leader and/or Field Geophysicist*** *on Advanced Geophysical Classification (AGC) projects performed by the WESTON GCO.*	
WESTON GCO Personnel	Name: Kyle Yarmush Position: Field Geophysicist/Team Lead
SOP Number *(with revision number and effective date)*	GCO-SOP-23, Demonstrations of Capability Rev # 1.0 Date: 8/28/17
DOC Type	☒ Initial ☐ Ongoing
Reason(s) for this DOC	☒ New Geophysicist ☐ New Method ☐ Change to Procedure ☐ Refresher Demonstration (Ongoing)
DOC Data Source *(What procedures did you use to perform this DOC?)*	GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification Rev # 1.0 Date: 8/22/17 Initial: KY GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) Rev # 1.0 Date: 8/22/17 Initial: KY GCO-SOP-15, Performing Dynamic Surveys with TEMTADS 2x2[1] Rev # 1.0 Date: 8/24/17 Initial: KY GCO-SOP-18, Collection of Static Background Measurements Rev # 1.0 Date: 8/24/17 Initial: KY GCO-SOP-19, Collection of Cued Target Measurements Rev # 1.0 Date: 8/24/17 Initial: KY

[1] A similar GCO SOP for another type of AGC sensor may substitute, such as GCO-SOP-29, Performing Dynamic Surveys with MetalMapper 2x2, per the discretion of the QM.

CONTROLLED COPY

Internal Demonstration of Capability (DOC) 1 Form (continued)
Summary Chart

	SOP	Demonstrated Experience	Pass/Fail*
1)	GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification Review Date: 8/28/17 Initials: KY	Project: Blossom Point Training Role: Geophysicist Date: 6/14/17 Initials: KY	Pass
2)	GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) Review Date: 8/28/17 Initials: KY	Project: Blossom Point Training Role: Geophysicist Date: 6/15/17 Initials: KY	Pass
3)	GCO-SOP-15, Performing Dynamic Surveys with TEMTADS 2x2[1] Review Date: 8/28/17 Initials: KY	Project: Blossom Point Training Role: Geophysicist Date: 6/15/17 Initials: KY	Pass
4)	GCO-SOP-18, Collection of Static Background Measurements Review Date: 8/28/17 Initials: KY	Project: Blossom Point Training Role: Geophysicist Date: 6/15/17 Initials: KY	Pass
5)	GCO-SOP-19, Collection of Cued Target Measurements Review Date: 8/28/17 Initials: KY	Project: Blossom Point Training Role: Geophysicist Date: 6/15/17 Initials: KY	Pass

CONTROLLED COPY

[X] **PASS** [ ] **FAIL**

Kyle Yarmush	Kyle Yarmush	8/29/17
Geophysicist Name (print)	Geophysicist Signature	Approval Date
Greg Abrams		8/29/17
Reviewer Name (print)	Reviewer/Manager Signature	Approval Date

Attachment 2

Internal Demonstration of Capability (DOC) 2 Form

Internal DOC 2 *is designed for individuals to demonstrate the following minimum skills:*

- Quality control checks of field data (unknown targets and background)
- Background correction
- Source selection (dynamic selection only)
- Parameter extraction
- Appropriate use of the parameter
- Classification, to include effectively reducing clutter

Successful completion of ***Internal DOC 2*** *meets the minimum requirements for individuals to perform the role of Data Analyst on Advanced Geophysical Classification (AGC) projects performed by the WESTON GCO.*

WESTON GCO Data Analyst	Name: Kevin Kingdon Position: QC Geophysicist
SOP Number *(with revision number and effective date)*	GCO-SOP-23, Demonstrations of Capability Rev # 3.0 Date: 1/12/18
DOC Type	☒ Initial ☐ Ongoing
Reason(s) for this DOC	☒ New Data Analyst ☐ New Method ☐ Change to Procedure ☐ Refresher Demonstration (Ongoing)
DOC Data Source *(See Summary Chart)*	I certify that the individual signed below has successfully met the WESTON GCO DOC 1 Requirements associated with data collection for the following equipment: ☐ **2x2 Sensor** ☒ **MPV** Greg Abrams — Assessor Name (print) — Assessor Signature — 5/31/18 — Date Kevin Kingdon — Data Analyst Name (print) — Data Analyst Signature — 5/31/2018 — Date

CONTROLLED COPY

Internal Demonstration of Capability (DOC) 2 Form (continued)

Summary Chart

SOP		Demonstrated Experience	Pass/Fail*
2x2 Sensor (TEMTADS and/or MetalMapper)			
1)	GCO-SOP-17, Processing Dynamic Survey Data – TEMTADS 2x2 and/or GCO-SOP-30, Processing Dynamic Survey Data with MetalMapper 2x2 Review Date:_____ Initials (Data Analyst):_____	Project:_____ Role: _____ Date:_____ Initials (Assessor):_____	☐ **PASS** ☐ **FAIL**
2)	GCO-SOP-20, Processing Cued 2x2 Data Review Date:_____ Initials (Data Analyst):_____	Project:_____ Role: _____ Date:_____ Initials (Assessor):_____	☐ **PASS** ☐ **FAIL**
MPV			
1)	GCO-SOP-38, Processing Dynamic Survey Data - MPV Review Date: 5/31/2018 Initials (Data Analyst): KK	Project: ESTCP MR-1421 Role: Principal Investigator Date:_____ Initials (Assessor): GA	☒ **PASS** ☐ **FAIL**
2)	GCO-SOP-39, Processing Cued Survey Data - MPV Review Date: 5/31/2018 Initials (Data Analyst): KK	Project: ESTCP MR-1421 Role: Principal Investigator Date:_____ Initials (Assessor): GA	☒ **PASS** ☐ **FAIL**

CONTROLLED COPY

Gregory M. Abrams

Qualifications Summary

- Technical Manager of DAGCAP accredited program
- Over 11 years of experience as a geophysicist specializing in MMRP investigations
- 10 years of experience processing geophysical data using Geosoft Oasis Montaj
- 6 years of experience working with UXO Advanced Classification
- 5 years of experience working with marine geophysical surveys
- 5 years of experience using GIS

Credentials

Professional Geoscientist (No. 235), Louisiana (2014)

Education

B.S., Physics with Geology Minor - Radford University (2007)

Training, Memberships & Awards

- 40-Hour Hazardous Waste Site Training Course, OSHA 29 CFR 1910.120(e)(3), All American Environmental Services, Inc. (2008)
- 8-Hour Hazardous Waste Refresher Course, OSHA 29 CFR 1910.120/29 CFR 1926.65, Underwriters Laboratories (2019)
- Adult First Aid/CPR/AED, American Red Cross (2015)
- Bloodborne Pathogens Refresher Training, OSHA 29 CFR 1910.1030, Underwriters Laboratories (2019)
- Hazard Communication, WESTON (2019)
- ISO/IEC 17025 Training & DAGCAP QSR Roundtable (2015)
- 10-Hour Construction Safety Training, OSHA 29 CFR 1926 (2013)

Employment History

2017 to Present Weston Solutions Inc.

2011 to 2017 AECOM

2007 to 2011 Earth Resources Technology, Inc.

2006 to 2007 U.S. Geological Survey

2005 to 2007 Radford University Reed Curie Technology Lab

Key Projects

Winchester Hills, Winchester Hills, UT, Utah National Guard, Project Geophysicist. Project Geophysicist for the Winchester Hills investigation in Utah. Responsible for processing geophysical data, recommending approaches, and reporting on results. Processed geophysical data collected with a 3 coil EM61-MK2 towed array system integrated with a Trimble RTK DGPS. [3-19 to Present]

Camp Bowie, Brownwood, TX, USACE, QC Geophysicist. Responsible for conducting quality control inspections of data and data deliverables. Responsible for controlling QC seed information and ensuring our blind seed firewall plan is followed. [4-19 to Present]

Spring Valley FUDS AGC, Washington, DC, USACE, Project Geophysicist. Project Geophysicist for the Spring Valley FUDS AGC investigation in Washington DC. Responsible for designing and conducting geophysical approach, coordinating with AGC subcontractors and equipment vendors, processing geophysical data, and producing data deliverables and reports. Responsible for collecting initial dynamic geophysical survey data using an MPV and G-858 integrated with RTS. [1-18 to Present]

Environmental Security Technology Certification Program (ESTCP), Live Site Demonstrations, Spencer, TN, Project Geophysicist. Project Geophysicist and Site Manager of Environmental Security Technology Certification Program (ESTCP) Spencer range project. Responsible for conducting daily site safety meetings. Collected initial dynamic geophysical survey data using an EM61 integrated with RTK DGPS and RTS. Collected dynamic and cued mode data using the TEMTADS 2X2 system. Collected dynamic and cued mode data using the advanced MetalMapper system. Processed advanced sensor data and performed advanced analysis on MetalMapper data. [4-12 to 7-12]

Spring Valley Residential FUDS Investigations, Geophysicist. Led geophysical investigations, including using EM-61 and G-858 gradiometer to locate potential UXO targets within residential properties of Spring Valley in Washington, D.C. Project duties included organization of field activities, conducting safety briefings, data collection, data processing, reporting, participating in technical project planning process, and presentations at anomaly review board meetings and reporting. Established survey control for project. [10-07 to 10-10]

Spring Valley Dalecarlia Woods FUDS Investigations, Geophysicist. Led geophysical investigations, including using EM-61 and G-858 gradiometer to locate potential UXO targets within the Dalecarlia Woods property in Washington, D.C. Project duties included organization of field activities, conducting safety briefings, data collection, data processing, reporting, participating in technical project planning process, and presentations at anomaly review board meetings and reporting. Established survey control for project. [10-08 to 10-10]

NDNODS Montana National Guard, Multiple Locations, Senior Geophysicist/Deputy Project Manager. Senior Geophysicist and Site Manager for five separate MMRP sites throughout Montana. Developed the technical approach for the proposal and work plan. Assisted in development of AHA and safety documents related to geophysical investigation. Conducted site safety meetings during field investigations. Led geophysical field investigations using dynamic collection of EM61 DGM data. Processed DGM data and developed target lists for intrusive investigations. [6-14 to 12-16]

MMRP Remedial Investigation, Beale AFB, Geophysicist. Led portions of geophysical investigation and anomaly reacquisition using an EM-61 integrated with Real-Time Kinematic (RTK) Differential Global Positioning System (DGPS) at Beale AFB. Collected geophysical data, reacquired target anomalies, and performed quality control review of geophysical field activities. [7-12 to 1-17]

MMRP Investigation, Aberdeen, Geophysicist. Led geophysical investigation using an EM-61 integrated with RTK DGPS over a parking lot after the discovery of a hand grenade. Collected and processed data, performed quality control review of geophysical field activities, and generated a project report. [8-09 to 1-17]

US Army Engineer District Alaska, Sagami Army Depot, Japan, Geophysicist. Performed multiple geophysical investigations using an EM61, EM31, and ground penetrating radar (GPR) integrated with DGPS and RTK. Project included mapping electromagnetic anomalies, mapping underground utilities, and data processing. Performed quality control review of geophysical field activities. [10-10]

US Army Engineer District Alaska, Zama Camp, Japan, Geophysicist. Performed a geophysical investigation including digital geophysical mapping (DGM) using an EM61, EM31, and GPR integrated with DGPS and RTK. Project included mapping electromagnetic anomalies, mapping underground utilities, and data processing. Performed quality control review of geophysical field activities. [10-10]

Aquatic UXO Investigation, Quantico Marine Base, Virginia, Geophysicist. Performed an aquatic UXO investigation using a G-882 marine magnetometer integrated with RTK DGPS in a tidal portion of Chopawamsic Creek. Established an aquatic instrument verification strip (IVS), collected and processed data, performed quality control review of geophysical field activities, and generated a project report. [6-09 to 7-09]

Superfund Investigation, Ft Wainwright, AK, Geophysicist. Led geophysical investigation, including DGM using an EM61 integrated with RTK DGPS. Project included designing geophysical tow platform, mapping electromagnetic anomalies, mapping underground utilities, and data processing. Performed quality control review of geophysical field activities. [10-08 to 1-09]

Remedial Investigation, Ft Miles, DE, Geophysicist. Led geophysical investigation, including developing the RI technical approach using Visual Sample Plan (VSP), and the collection and processing of EM61 data. Performed quality control review of geophysical field activities. Led environmental soil and X-ray fluorescence (XRF) sampling activities. [9-08 to 3-09]

Remedial Investigation, Ft Hancock, NJ, Geophysicist. Led geophysical investigation, including the development of the RI technical approach using VSP, and the collection and processing of G-858 gradiometer data. Performed quality control review of geophysical field activities. Served as primary geophysicist during geophysical prove-out activities. [9-10 to 3-11]

Hingham Former Burning Ground, Wompatuck State Park, Senior Geophysicist. Senior Geophysicist for investigation of small suspected burning ground located in Wompatuck State Park. Responsibilities included EM61 data collection and developing an alternative technical approach due to difficult field conditions. Directed analog field approach with real-time statistical analysis of results. [8-14 to 9-14]

Area 41, Williams J. Hughes Technical Center, QC Geophysicist. QC Geophysicist for the Area 41 UXO investigation.in Atlantic City, NJ. Responsibilities included installation of QC and comparison seed items, generate IVS report, ensure detection of seed items, and review of EM61 and TEM-8g ground based data. [6-15 to 7-15]

Michael B. Link

Qualifications Summary

- More than 6 years of professional experience.
- Proficient in dust control planning and operations.
- Project, excavation, and soil works oversight.
- UXO experience, including digital geophysical mapping (DGM) using the EM61-MK2A metal detector and incremental soil sampling.
- Proficient with various GPS equipment, including Trimble RTK units and Pathfinder ProXRT.
- Emergency response, including Level B and C work.
- Drum staging and sampling and materials inventory.
- Remediation system operations and maintenance for soil vapor extraction and air stripping.
- Experience with multiple facets of air, water, and soil investigation, monitoring, and sampling.
- Proficient with various construction equipment, including operating Bobcat front-end loaders.

Education

B.S., Environmental Health Science - Ohio University (2009)

Training, Memberships & Awards

- 40-Hour Hazardous Waste Site Training Course, OSHA 29 CFR 1910.120(e)(3), New Environment, Inc. (2010)
- 8-Hour Hazardous Waste Refresher Course, OSHA 29 CFR 1910.120(e)(8), WESTON (2020)
- First Aid/CPR/AED Training, American Heart Association (2018)
- Bloodborne Pathogens Refresher Training, OSHA 29 CFR 1910.1030, WESTON (2020)
- 30-Hour Construction Safety and Health Training Course, OSHA 29 CFR 1926 (2018)
- 8-Hour Managers and Supervisors Course (SHSC), OSHA 29 CFR 1910.120(e)(4), WESTON (2012)
- Hazard Communication 29 CFR 1910.1200, WESTON (2013)
- Confined Space Entry and Rescue Training, OSHA 29 CFR 1910.146, Inland Waters of Ohio, Inc. (2011)

- Rule 310 Comprehensive Dust Control Training, Maricopa County Air Quality Department (2014)

Employment History

2014 to Present WESTON

2011 to 2014 WESTON

2010 to 2011 Inland Waters of Ohio, Inc.

2010 Stiebig Excavating

2009 to 2010 Brunner Healthcare

2004 to 2009 Ohio University

Key Projects

Enbridge Pipeline Release, Submerged Oil Recovery Operations, Marshall, MI, Michigan Department of Environmental Quality (MDEQ), Assistant Geoscientist. Provided oversight of submerged oil assessment. [7-16 to 8-16]

Digital Geophysical Mapping, (DGM), Ft. Ord, Seaside, CA, Fort Ord Reuse Authority, Geophysicist. Performed digital geophysical mapping (DGM) using a towed-array four coil Geonics EM61-MK2A metal detector system and a single coil Geonics EM61-MK2A metal detector system, surveying DGM transects totaling 45 acres inside the munitions response site (MRS); ensured the Trimble RTK GPS was operable and paired with the EM61-MK2A; and downloaded data from the Allegro Field PC Data Collector. [3-17 to 5-17]

Digital Geophysical Mapping (DGM), Volk Field, Camp Douglas, WI, United States Army Corps of Engineers - Omaha, Geophysicist. Performed digital geophysical mapping (DGM) using a single coil Geonics EM61-MK2A metal detector, surveying DGM transects totaling 39 acres inside the munitions response site (MRS); ensured the Trimble RTK GPS is operable and paired with the EM61-MK2A; and downloaded data from the Allegro Field PC Data Collector. [9-16 to 10-16]

Digital Geophysical Mapping (DGM) and Incremental Soil Sampling, Dugway Proving Ground, Dugway, UT, United States Army Environmental Command (USAEC), Geophysicist. Performed digital geophysical mapping (DGM) using a single coil Geonics EM61-MK2A metal detector, surveying DGM transects totaling 95 miles over 34.5 acres inside the munitions response site (MRS), as well as 100% coverage of 22 100 ft x 100 ft grids totaling 5.05 acres. Performed reacquisition of DGM-targeted anomalies using Trimble RTK GPS unit. Performed incremental soil sampling to evaluate the presence of munitions constituents (MC) in selected locations. A total of six incremental sampling units were placed within the MRS. [9-15 to 11-15]

Removal Oversight, Ashtabula Iron and Metals Scrap Yard, Ashtabula, OH, USEPA, Assistant Geoscientist. Project involved the removal of approximately 280 tons metal shavings, drum sampling and the removal of 103 drums containing hazardous liquids, waste oil, flammable liquid, broken glass, and other corrosive liquids. Monitored excavation subcontractor activities during excavation and removal approximately 1,800 tons of oil-contaminated soil. Other duties included air monitoring using Area RAEs and pDA dust monitors during removal activities, written and photographic documentation during removal activities and managing files and waste manifests and report writing. [12-13 to 4-14]

Soil Removal Oversight, Springville Marsh, Findlay, OH, USEPA, Assistant Geoscientst. Performed once a week visits to a marsh site to oversee the excavation and removal of contaminated soil throughout the marsh and to conduct air monitoring with pDA dust monitors during removal activities. Soil was contaminated with carbon waste and small amounts of non-friable asbestos transite panels. Approximately 2200 tons of non-hazardous soil waste and 1 55-gallon drum of non-friable asbestos was removed from the Site. Clean backfill and topsoil were placed into the excavation area following the removal of impacted soil. Other duties included managing files and waste manifests and conducted written and photo documentation of removal activities. [8-12 to 11-12]

Removal Oversight, Ohio National Acme, Cleveland, OH, USEPA, Assistant Geoscientist. Performed oversight of waste and asbestos removal at an unregulated municipal waste dump site. Conducted perimeter air monitoring during removal activities, written and photographic documentation of removal activities, oversight of municipal solid waste removal, managing files and waste manifests, oversight of friable and non-friable asbestos removal, screening for the presence of mercury using a Lumex Mercury Vapor Analyzer, and oversight of mercury cleanup. [7-13 to 8-13]

Phase I Environmental Site Assessments, Various Clients, Assistant Geoscientist. Perform Phase I Environmental Site Assessments at various commercial and industrial sites. These sites included vacant storage facilities, vacant warehouses, gas stations, automobile repair garages and other general purpose industrial sites. Duties include interviewing landowners or business owners, walking the site, thorough written/photo documentation, reviewing site records, and investigation of past activity on-site. [10-11 to Present]

Targeted Brownfields Assessment (TBA), Beeline Dragway and Gravel Pit, Assistant Geoscientist. Oversaw excavation contractor during g trenching activities at the gravel pit and oversaw direct-push drilling activities. Collected soil samples within the trenches and from each soil boring location. Performed written and photographic documentation of site assessment activities and documented wastes uncovered during trenching activities. [8-14 to 9-14]

Targeted Brownfields Assessment (TBA), Memorial Airpark, Assistant Geoscientist. Performed written and photographic documentation of site assessment activities, including direct-push drilling. Conducted soil sampling and screening using a MiniRAE for VOC detection at each boring location. [10-14]

Preliminary Assessment/Site Inspection (PA/SI), Cherry Creek Mines, Cottonwood, AZ, USFS, Assistant Geoscientist. Collected soil, sediment, and waste rock samples at six separate mine sites within the Cherry Creek Mining District as part of a CERCLA PA/SI. Obtained measurements of waste rock piles for volume estimation and documented geographic coordinates for adit and shaft locations. Performed written and photographic documentation of site assessment activities. Contributed to preparation of the project Sampling and Analysis Plan and final project report. [12-14]

Preliminary Assessment/Site Inspection (PA/SI), Mingus Area, Cottonwood, AZ, USFS, Assistant Geoscientist. Collected soil and sediment samples at three different areas located in Prescott National Forest as part of CERCLA PA/SI. Performed written and photographic documentation of site assessment activities. Contributed to preparation of the project Sampling and Analysis Plan and the final project report. [3-15]

Preliminary Assessment/Site Inspection (PA/SI), Georgetown Mines, Silver City, NM, USFS, Assistant Geoscientist. Collected soil and waste rock samples at five different mine sites located in the Georgetown Mining District as part of CERCLA PA/SI. Performed written and photographic documentation of site assessment activities and obtained measurements of waste rock piles for volume estimation. Contributed to preparation of the project Sampling and Analysis Plan and final project report. [11-14]

Emergency Response, Red River Supply Warehouse, Williston, ND, USEPA, Assistant Geoscientist. Performed written and photographic documentation of remediation activities following a large fire at a warehouse. Conducted water quality monitoring of a nearby stream using a Horiba U-50 Series Multi-Parameter Water Quality Meter. Managed files and online pollution reports for the OSC. [8-14]

Site Assessment, Fostoria City Dump, USEPA, Assistant Geoscientist. Conducted written and photographic documentation during site assessment activities. Duties included surface soil sampling, collecting GPS coordinates using a Trimble GPS, and XRF-screening along a grid pattern throughout the park. [4-14]

Site Assessment, Charlevoix Municipal Well, Charlevoix, MI, USEPA, Assistant Geoscientist. Performed an assessment of a neighborhood located in a plume of organic solvent contamination. Conducted soil gas vapor sampling using Tedlar bags, oversaw installation of soil gas probes inside residences and businesses, and oversaw soil gas vapor well abandonments. Provided written and photographic documentation of all activities performed on site. [6-13 to 11-13]

Site Assessment, Federal Mogul, Assistant Geoscientist. Assisted a coworker in an airborne lead site assessment of a neighborhood adjacent to a former smelter. Completed a thorough inventory of residences throughout the area of concern, as well as written and photographic documentation of each property prior to remediation activities. Duties also included using an x-ray fluorescent meter (XRF) for screening of potentially lead contaminated soil at each property. [4-13]

Operation & Maintenance, Massillon, OH, Assistant Geoscientist. Performed weekly visits to a facility which utilizes a soil vapor extraction (SVE) system and an air stripper. Conducted routine operation and maintenance activities to ensure system was operating correctly and efficiently. Used a photo-ionization detector (PID) at monitoring points around the facility to screen for volatile organic compounds (VOCs). Other responsibilities included performing monthly NPDES sampling, and collecting outdoor vapor samples using Summa canisters. NPDES sampling was conducted at the outfall at the air stripper. [10-13 to 6-14]

Operation & Maintenance, Lexington, TN, Confidential Client. Perform monthly visits to a facility which utilizes a SVE system and an ozone-air sparge system. Conduct routine operation and maintenance activities to ensure system is operating correctly and efficiently. Screen monitoring points for VOCs using a photo-ionization detector (PID). Other responsibilities include performing quarterly low-flow groundwater sampling at monitoring wells throughout the property and the surrounding residential community, and collecting indoor and outdoor vapor samples using Summa canisters. Groundwater sampling is conducted using a bladder pump, and parameters are measured using a YSI water quality meter and turbidimeter. [8-12 to Present]

Baseline Water Sampling, Multiple Locations, Assistant Geoscientist. As a lead sampler, collected groundwater and surface water samples for a baseline representation of water quality prior to natural gas drilling. Sampling was conducted primarily in residential areas. Interviewed homeowners to obtain pertinent information regarding general water quality in their area and water usage. Interview questions included personal usage, history of odors, taste, turbidity, and any noticeable gas in water supply, along with the geological history around their property. Water samples were evaluated for general water quality parameters and analyzed for Resource Conservation and Recovery Act (RCRA) 8 metals, light gas analysis, benzene, toluene, ethylbenzene, and total xylenes (BTEX), oil and grease, total suspended solids (TSS), total dissolved solids (TDS), and methylene blue active substances (MBAS). Sampling teams calibrated all air-monitoring equipment every morning to ensure proper operation. Air-monitoring equipment was used in baseline sampling to screen for possible explosive gases in and around the sample source, water supply, and sample location. Equipment included a Gas Explorer 611 unit, TVA 1000, and a MultiRAE. A turbidimeter was used to obtain a turbidity reading and a YSI meter was used to gather pH, specific conductance, and temperature readings. Both pieces of equipment were calibrated every day to ensure proper operation. Global positioning system (GPS) coordinates of the source(s) were collected using a Trimble Juno and site photographs were taken of the sample source, sample location, and treatment systems. Trained new hires on proper sampling techniques; equipment operation, calibration, bumping; and how to work with homeowners. [11-12 to 7-12]

Enbridge Pipeline Release, Oversight of High Priority Remedial Investigation (RI), Kalamazoo River, Marshall, MI, USEPA, Assistant Geoscientist. Provided oversight and documentation of RI operations on the Kalamazoo River. Oversaw soil core loggings of heavily affected areas along the river and riverbanks. Photographed all core logging locations and documented core-logging process in a logbook. Documentation included core-logging depth, recovery, any visible oil/sheen present in logging, and a detailed map of core-logging locations along with GPS coordinates. Documented and oversaw bathymetry throughout the river and the Morrow Lake Delta. [11-11 to 12-11; 5-13; 8-13 to 10-13]

Site Assessment, Stark Ceramics, USEPA, Assistant Geoscientist. Staged waste drums, completed an inventory, and sampled drums at a former ceramics shop. Collected soil samples from various locations and aboveground storage tanks (ASTs) at the site and documented GPS coordinates. Sampling of drums and ASTs was in Level B personal protective equipment (PPE). [10-11]

Enbridge Pipeline Release, Oversight of Submerged Oil Recovery Operations, Morrow Lake Delta, EPA, Assistant Geoscientist. Provided oversight and documentation of oil recovery operations in the Morrow Lake delta. Methods for recovery included water-jetting the sediment to agitate and release oil to the surface, and employing marsh buggies, using their tracks to agitate sediment to release oil. Photographed and documented operations in a logbook over a 2-week period. Other responsibilities included differentiating between organic sheen and submerged oil that was to be recovered, and signing off on an area. To “sign off” on an area, had to work closely with the potentially responsible party (PRP) environmental inspector to conclude an area was free of oil. [10-11]

Ryan S. Steigerwalt, P.G.
Weston Solutions, Inc.
1400 Weston Way
West Chester, PA 19380
Telephone: (267) 258-2672
Email: Ryan.Steigerwalt@WestonSolutions.com

PROFESSIONAL EXPERIENCE

2008 - **Weston Solutions, Inc.**
Senior Client Service Manager for Munitions Response
- Program and Quality Manager for Weston's Department of Defense Advanced Geophysical Classification Accreditation Program in accordance with ISO 17025:2005.
- Provides direction on strategy and technology selection to achieve project performance requirements based on anticipated military munitions, environmental conditions, theoretical geophysical detection depth and other elements of the conceptual site model.
- Evaluates project decisions through our quality management system and in terms of site land use, risk profiles and data usability.
- Serves as a resource to senior management on strategic issues impacting Military Munitions Response Program and Operational Range Clearance operations.
- Supported more than $150M in munitions response and environmental related services.

2007 - 2008 **Shaw Environmental and Infrastructure, Inc.**
Technical Manager/ Senior Geophysicist
- Project leader and task manager responsible for approach, schedule and budget on a variety of MMRP remedial investigations through removal actions.
- Developed statistical investigation strategies to determine nature and extent of military munitions at a high degree of confidence.
- Prepared and assessed remedial alternatives through Feasibility Studies based on remedial investigation information (munitions types, recovery depths, density, and accessibility) and pilot studies (use of detection technologies or other methods to assess for future site use).

2002 - 2007 **Weston Solutions, Inc.**
Senior Geophysicist
- Performed digital geophysical data collection and data analysis for munitions response and other environmental applications at more than 40 sites.
- Site manager for MMRP remedial investigations and removal actions.

2000 - 2002 **University of Akron**
Graduate Student, Teaching and Research Assistant
- Introductory geology lab instructor and undergraduate course assistant.
- Processed and interpreted deep crustal seismic reflection data.

1998 - 2000 **Pennsylvania Geological Survey**
Field Geologist

EDUCATION

2000 - 2002 M.Sc., Geology and Geophysics—University of Akron

1997 Supporting technical course—Lehigh University

1996 - 2000 B.Sc., Geology—Bloomsburg University of Pennsylvania

MEMBERSHIP, REGISTRATIONS AND ACCOMPLISHMENTS

Member, Board of Directors, National Association of Ordnance Contractors

President emeritus, National Association of Ordnance Contractors

Registered Professional Geologist, Commonwealth of Pennsylvania (No. PG004779)

Blaster's License, Commonwealth of Pennsylvania (No. BL-7590)

Security Clearance: Secret

Recipient, Interstate Technology & Regulatory Council, Industry Recognition Award, Geophysical Classification for Munitions Response

SELECT PUBLICATIONS

Steigerwalt, R.S., A. Trembanis, R. Johnson, G. Tait, V. Schmidt. 2012. "Autonomous Underwater Vehicle Magnetic Mapping System." Presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec.

Steigerwalt, R.S., A. Trembanis, R. Johnson, G. Tait, V. Schmidt. 2011. "Autonomous Underwater Vehicle Munitions and Explosives of Concern." Partners in Environmental Technology Symposium & Workshop. Washington, D.C.

Steigerwalt, R.S., A. Trembanis, R. Johnson. 2010. "Autonomous Underwater Vehicle Munitions and Explosives of Concern." Partners in Environmental Technology Symposium & Workshop. Washington, D.C.

Steigerwalt, R.S., J. Austreng, and C.S. Goulart. 2009. "Commercial Application of the Physics-Based Test Strip and Seeding Approach." UXO Countermine and Range Forum 2009, Orlando, FL. August 2009.

Ervine, M.J., R.S. Steigerwalt, and N. Fatherly. 2007. "Lines of Evidence Support New Investigation of Lake Target Outside of TOAR FUDS." UXO Countermine and Range Forum 2007, Orlando, FL. 30 August 2007.

Steigerwalt, R.S., J.A. Williams, and C.L. Evans. 2006. "Digital Geophysical Mapping Program at the Spring Valley FUDS, Washington, D.C." SERDP/ESTCP Partners in Environmental Technology Technical Symposium, Washington, DC.

Steigerwalt, R.S. 2005. "Prioritization Routine for Digital and Visual Magnetic Anomaly Evaluation." EEGS *FastTimes*.

Pasapane, B.P., J. Brzezenski, R.S. Steigerwalt, and D. Pohl. 2003. "Real-Time and 3D Delineation of Possible OE-Related Buried Materials." Mid-Atlantic SAME Conference 2003 Proceedings.

Steigerwalt, R.S. and D.N. Steer. 2002. "New Evidence for Shallow Lateral Movement within the Grenville Province: Implications for Basin Development." *GSA Bulletin*.

Steigerwalt, R.S. and D.N. Steer. 2002. "New Constraints on Transport Direction during the Grenville Orogeny: Evidence for a Basement Lateral Ramp in the Eastern Mid-Continent, North-Central Section and South-Central Section." GSA joint meeting.

Steigerwalt, R.S. and D.N. Steer. 2001. "Constraints on Transport Direction along a Shallow Detachment in the Upper Precambrian of the Eastern Midcontinent." *EOS*, Trans., AGU 82(47): F1236, Fall Meeting Supplement.

Sandra A. Takata

Qualifications Summary

- Senior Geophysicist for military munitions response program projects.
- Principal Investigator for Environmental Security Technology Certification Program (ESTCP) Advanced Geophysical Classification (AGC) Projects.
- Technical expertise with marine, airborne, and ground geophysics applied to exploration, environmental science, and engineering projects.
- Developed innovative integrated approaches for using a wide range of applied geophysical investigative techniques.
- 32 years of experience as a Geophysicist with experience in military munitions response program projects, oil shale and natural gas exploration, and mining.

Education

B.S., Honours Applied Earth Science, Geophysics Option - University of Waterloo, Ontario (1985)

Training, Memberships & Awards

- 8-Hour Managers and Supervisors Course (SHSC), Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120(e)(4), Weston Solutions, Inc. (WESTON) (2018)
- 8-Hour Hazardous Waste Refresher Course, OSHA 29 CFR 1910.120(e)(8), WESTON (2019)
- 40-Hour Hazardous Waste Site Training Course, OSHA 29 CFR 1910.120(e)(3), WESTON (2018)
- Letter of Recognition – Fort Ritchie Unexploded Ordnance (UXO) Project, United States Army Corps of Engineers (USACE) (2002)
- Commander's Coin – Fort Detrick Hazardous, Toxic, and Radioactive Waste (HTRW) Project, USACE (2003)
- Nunn-Perry Award – Mentor/ Protégé Program, Air Force Center for Engineering and the Environment (AFCEE) (2002)
- Nunn-Perry Award Mentor/ Protégé Program, AFCEE (2003)
- Technical Review Committee, National Association of Ordnance Contractors
- Planning Committee for Symposium on the Application of Geophysics to Environmental and Engineering Problems, Environmental and Engineering Geophysical Society
- Reviewer for paper publication, Society of Exploration Geophysicists

Employment History

2018 to Present Weston Solutions, Inc.
2017 Aptim Government Solutions, LLC (APTIM)
2013 to 2017 CB&I Federal Services LLC (formerly Shaw E&I)
2002 to 2013 Geophysics and Mapping, Shaw Environmental, Inc. (formerly IT Group, Inc.)
1998 to 2002 Geophysics Group, The IT Group, Inc.
1985 to 1997 Aerodat Limited

Key Projects

DAGCAP Accreditation, Knoxville, TN, Senior Geophysicist. Attained Department of Defense (DoD) Advanced Geophysical Classification Accreditation Program (DAGCAP) Accreditation by participating in development of management and technical standard operating procedures, attending audits by the accrediting body, and performing quality control at the demonstration of capabilities. [1-17 to 1-18]

Geophysical Expertise for Federal Clients, Multiple Locations, Senior Geophysicist. Provided and promoted geophysical expertise internally and commercially. Responsibilities included scheduling and coordinating projects and staff, tracking budgets and working with clients, staff, and other internal groups. Worked as part of a multi-disciplinary team with engineers, scientists, and administrative personnel. Prepared proposals including cost estimates, scope of work, work plans and reports for geophysical investigations. Specialist in electromagnetic, magnetic, and advanced geophysical classification (AGC) methods applied to munitions response projects. Worked with a combination of electromagnetic (EM), ground-penetrating radar (GPR), and magnetics; resistivity; and seismic geophysical investigative methods for the engineering, construction, transportation, environmental, and petroleum industries. [1-13 to 12-16]

Geophysics and Mapping Services, Multiple Locations, Senior Geophysicist. Responsible for technical and cost proposal development, field investigations, geophysical data processing and interpretation, modeling, and report writing. Managed schedules, invoicing issues, budgets, and personnel. Served as a liaison between clients and other technical groups. [1-02 to 12-12]

Geophysics Services, Multiple Locations, Senior Geophysicist. Responsibilities included technical and cost proposal development, field investigations, data processing and interpretation, geophysical modeling, and report writing. Management responsibilities included scheduling projects and personnel, controlling budgets, and communication with clients and staff. [1-98 to 12-01]

Special Projects and Development, Multiple Locations, Manager, Special Projects and Development. Prepared case histories and promotional material. Developed policies and job descriptions for human resource project. Provided technical support for field geophysicists and clients. Tested new software and processing procedures. Interpreted and processed survey data both in the field and in the office. Clients included government agencies, mining and exploration, and oil and gas companies both domestic and foreign. [1-85 to 12-97]

Data Processing, Geophysical Analysis, Multiple Locations, Assistant Manager, Data Processing; Senior Geophysicist. Developed and administered procedure and quality control policies. Worked closely with clients, suppliers, support companies and field operations. Wrote programs for geophysical data manipulation and analysis. [1-85 to 12-96]

Geophysical Project Coordination and Training; Data Processing and Interpretation, Multiple Locations, Project Supervisor; Geophysicist. Coordinated and trained a team of geophysicists. Ensured high standards for final map, digital, and report products. Communicated with clients. Processed and interpreted data. [1-85 to 12-96]

Geophysical Data Processing and Client Technical Support, Multiple Locations, Geophysicist. Processed high-sensitivity airborne magnetic, EM, spectrometer, very low frequency (VLF) electromagnetic, and flightpath data. Utilized basic processing procedures as well as sophisticated techniques such as fast Fourier transform (FFT) technique processing, shadow imaging, and EM inversions. Provided customers with high quality maps, digital data, and technical support. [1-85 to 12-96]

Geophysical Data Collection, Processing, and Interpretation, Multiple Locations, Geophysical Assistant. Used magnetic, horizontal loop electromagnetic (HLEM), gravity, and VLF methods to collect, process, and interpret data. [1-84 to 12-84]

Research and Document Possible Gold Exploration Targets, Toronto, ON, Geological Assistant. Studied assessment files and geological documents for gold exploration. Wrote reports on possible targets. [1-83 to 12-83]

Oil Shales Research, Toronto, ON, Geological/Geophysical Assistant. Studied downhole geophysical logs and logged core for Oil Shales research. [1-82 to 12-82]

Publications and Presentations

Takata, S., L. Pasion, B. Zelt, L. Beran, J. Jacobson, H. Ngo, R. Mehl, and T. Deignan. 2012. "Analysis of Pole Mountain Metal Mapper Cued Data." SERDP Annual Symposium, Washington DC.

Takata, S., T. Dobecki, and M. Kick. 2009. "The 'Nuclear Renaissance' and its Implications for Geophysics." SAGEEP 2009, Dallas, TX.

Kyle J. Yarmush

Education

B.S., Geology - Kutztown University of Pennsylvania (2015)

Training, Memberships & Awards

- OSHA 30 Hour Outreach Training Program - Construction, 360training (2017)
- Ladder Safety, Pure Safety (2017)
- Globally Harmonized System (HAZCOM), Pure Safety (2017)
- Confined Space Entry/Attendant Awareness, Pure Safety (2017)
- Fall Protection, Pure Safety (2017)
- Full Face SCBA and APR Quantitative Fit Tested, WESTON (2016)
- IS-800 National Response Plan, an Introduction, Emergency Management Institution (2015)
- IS-700 National Incident Management System, Emergency Management Institution (2015)
- IS-200 Basic Incident Command System, Emergency Management Institution (2015)
- IS-100 Intro to the Incident command system, Emergency Management Institution (2015)
- Fleet Defense Alert Driving Training Initial, Alert Driving (2015)
- Bloodborne Pathogens Training Course Refresher, WESTON (2019)
- 4-Hour Radiation Protection, WESTON (2016)
- RCRA Basics Refresher, WESON (2019)
- Shipping and Transporting Dangerous Goods - Admin/Field Personnel Initial, WESTON (2016)
- First Aid/CPR/AED Initial, WESTON (2018)
- Boating Safety, Commonwealth of PA Fish and Boat Commission (2016)
- Bloodborne Pathogens Training – Initial, WESTON (2015)
- 8-Hour Hazardous Waste Refresher Course, OSHA 29 CFR 1910.120(e)(8), WESTON (2019)
- 40-Hour Hazardous Waste Site Training Course, OSHA 29 CFR 1910.120(e)(3), Compliance Solutions (2015)

Key Projects

Spring Valley FUDS, Spring Valley, DC, USACE, Site Manager. Geophysical investigation of 91 residential properties and 13 federal and city lots for potential MEC utilizing Advanced Geophysical Classification (AGC) equipment. Conduct daily health and safety meetings with WESTON staff and subcontractors. Conduct daily operations meetings to discuss tasks to be completed each day. Complete daily quality control reports. Collect dynamic and cued geophysical data with Man Portable Vector (MPV), as well dynamic data with G858 magnetometers. Monitoring of subcontractor activities. Handling project scheduling.[3-18 to Present]

Ruckersville Fill Site, Ruckersville, VA, US EPA Region III, Project Team Lead. For a geophysical investigation and soil sampling event, tasks consist of preparing HASP, preparing FSP, conducting daily health and safety meetings, utility mark outs, EM-31 geophysical investigation, air monitoring, multimedia sampling with geoprobe, sample management, photo documentation, geophysical data processing and production maps, summarizing analytical data, and preparing trip report. [2-18 to Present]

Frankfort Dump Site RI, Frankfort, KY, United States Army Corps of Engineers, Baltimore, Field Geophysicist. Conducted a non-intrusive geophysical investigation using EM-61 with Trimble RTS at an industrial location to locate potential MEC burial pits. Responsibilities included field geophysicist and field safety officer for the duration of the project. Tasks included installation of Instrument Verification Strip, operating EM-61unit, performing daily instrument verification and quality control procedures, health and safety briefings, progress updates, and equipment management. Upon completion of data processing and target identification, performing reacquisition of anomalies using as Trimble RTS. [5-17 to 7-17]

Remedial Investigation of Carlisle Munitions Area, Carlisle, PA, United States Army Corps of Engineers, Baltimore, Geophysicist. Conducted a non-intrusive geophysical investigation using EM-31 and EM-61 with Trimble RTK at Carlisle Barracks to locate potential M.E.C. burial pits. Responsibilities included field geophysicist and field safety officer for the duration of the project. Tasks included installation of Instrument Verification Strip, operating EM-61unit, performing daily instrument verification and quality control procedures, health and safety briefings, progress updates, and equipment management. Upon completion of data processing and target identification, performed reacquisition of anomalies using as Trimble RTS. [4-17 to 5-17]

Westline Removal, Westline, PA, EPA Region III, Associate Geoscientist. Safety officer and responsible for ensuring compliance with erosion and sediment control plan during fabrication of stream bank stabilization plan as well as removal and capping of wood tar pits in wetland areas along the Kinzua Creek to prevent any future wood tar surface exposures. Documented all on-site activities to provide to professional engineer for as-built drawings upon completion of the project. [7-17 to 8-17]

Camp Pendleton – MMRP CSE Phase II, Virginia Beach, VA, Bay West, Geophysicist. Conducted a non-intrusive EM-61 survey using line and fiducial on Camp Pendleton, Virginia Beach, Virginia to locate potential MEC. Responsibilities included operating the EM-61, line and fiducial notes, daily log book update, preforming instrument verification and quality control procedures, health and safety briefings, daily progress updates, equipment management, and working with Bay West UXO Tech. Reacquiring of anomalies using Trimble RTK as well as tape measure methods. [2-16 to 4-16]

JBMDL DGM, Environmental Tech. Conducted a geophysical investigation using EM-61 to locate and remove potential M.E.C. items at various locations on the Air Force and Army section of the military installation such as the flight line and the golf course. EM-61 was used in conjunction with GPR to conduct a geophysical investigation on the Lakehurst section of the installation. The subsurface was mapped to locate regions where old anchors used by the Navy to secure blimps could potentially be. [10-15]

Gold King Mine Spill, Farmington, NM, EPA, Environmental Tech. Conducted surface water and sediment sampling at various locations on the Animas River, New Mexico. The Horiba water quality meter was used to measure turbidity, PH, and dissolved oxygen as well as other parameters. The samples were processed, packaged, and sent to a lab for additional analysis. [9-15 to 10-15]

APPENDIX C

TECHNICAL PROJECT PLANNING MEETING MINUTES

Final Technical Project Planning 1 Meeting Minutes

Military Munitions Response Program
Former Gun and Trench Mortar Range Munitions Response Site
Radford Army Ammunition Plant, Virginia
15 February 2019

A Technical Project Planning 1 (TPP1) Meeting was held on 18 December 2018 at Radford Army Ammunition Plant (RFAAP), Building 220, Main Conference Room, and via conference call. Representatives from the organizations listed below (Table 1) discussed the RFAAP Military Munitions Response Program (MMRP) project activities planned for the Former Gun and Trench Mortar Range Munitions Response Site (MRS). The purpose of this meeting was to bring the Army and regulatory stakeholders together to discuss project goals and specific execution strategies in order to agree upon the path forward for successfully completing the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI).

TABLE 1 – MEETING ATTENDEES

Name	Organization / Title	Email	Telephone Number
Kim Gross	USACE Project Manager	kimberly.u.gross@usace.army.mil	410-962-3457
Tom Colozza*	USACE Geophysicist	thomas.s.colozza@usace.army.mil	410-962-6647
Alan Warminski*	USACE Chemist	alan.s.warminski@usace.army.mil	410-962-7677
Cliff Opdyke*	USACE Risk Assessor	clifford.a.opdyke@usace.army.mil	410-962-6765
Julie Kaiser	USACE Environmental Specialist	julie.e.kaiser@usace.army.mil	443-447-4277
Mary Ellen Maly*	USAEC Environmental Support Manager	mary.e.maly.civ@mail.mil	210-466-1870
Jim McKenna	RFAAP POC	james.j.mckenna16.civ@mail.mil	540-731-5782
Allen Patton	BAE Sr. Environmental Specialist	mark.patton@baesystems.com	540-639-8504
Jody Hawks	BAE Sr. Environmental Specialist	jody.hawks@baesystems.com	540-639-7701
Jim Cutler	VDEQ Federal Facilities	james.cutler@deq.virginia.gov	804-698-4498
Kyle Newman	VDEQ Risk Assessor	kyle.newman@deq.virginia.gov	804-698-4452
Kurt Kochan*	VDEQ RCRA Project Manager	kurt.kochan@deq.virginia.gov	703-583-3825
Tony Pace	WESTON Project Manger	pacea@westonsolutions.com	757-362-2461
Ryan Steigerwalt*	WESTON Technical Manager	ryan.steigerwalt@westonsolutions.com	410-612-5900
Greg Abrams	WESTON Project Geophysicist	greg.abrams@westonsolutions.com	703-599-2840
Nicole Sharkey*	WESTON Project Engineer	nicole.sharkey@westonsolutions.com	610-701-3425

*Participated via teleconference.
BAE – BAE Systems
POC – Point of Contact
USACE – U.S. Army Corps of Engineers
USAEC – U.S. Army Environmental Command
VDEQ – Virginia Department of Environmental Quality
WESTON® – Weston Solutions, Inc.

Key discussion points and results of the TPP1 Meeting are presented below:

- Attendee introductions (all)
- RFAAP RFI TPP1 Meeting presentation (Mr. Tony Pace – WESTON)
- Kim Gross (USACE Project Manager) reminded the team that the RFI is being performed under RCRA, rather than the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). VDEQ stated that the RCRA and CERCLA departments share resources. Kim Gross also noted that because this is the first TPP meeting, the technical approach is still being fine-tuned, so feedback during the meeting is appreciated.
- It is important to note that the facility was not testing live mortars, but rather was testing the propellants of the mortars without high explosive filler. Mortars encountered to date have been on the surface and in the subsurface.
- It was discussed that Decision Unit (DU) 1 from the Site Investigation (SI), was located within the Former Gun Range portion of the MRS. DU1 was identified during the SI as having high concentrations of lead in soil.
- The inaccessible areas are due to active manufacturing and are excluded from field activities. Julie Kaiser from USACE asked when Area A (New River) was added to the MRS. Kim Gross responded that it was added to the scope of the RFI based on recommendations in the SI and largely due to the potential for overshot munitions and erosion along the riverbank. It was noted that the slope is very steep presenting a high potential for items to have migrated into the river from the close proximity to the range.
- VDEQ asked if the Uniform Federal Policy – Quality Assurance Project Plan (UFP-QAPP) will be a combined QAPP for munitions and explosives of concern (MEC) and munitions constituents (MC). WESTON responded in the affirmative that all field components will be included.
- The source of lead in the soil in the Former Gun Range is unknown. Julie Kaiser noted that, based on the SI, there are no anticipated small arms use or large quantities of lead azide (used in primers) to cause the elevated concentrations of lead.
- Mag & dig will be used in areas with steep slopes instead of geophysical instrumentation due to physical limitations of using the equipment. Greg Abrams from WESTON noted that a statistical analysis was conducted for the 45 acres to determine advanced geophysical classification (AGC) coverage requirements and that full coverage over the entire 45 acres will not be conducted. Kim Gross clarified that material potentially presenting an explosive hazard (MPPEH) requires further evaluation before it can be classified as an explosive hazard. Tony Pace from WESTON added that all items will be visually evaluated by the unexploded ordnance (UXO) team.
- Kim Gross asked VDEQ if they are familiar with the new MEC Risk Management Methodology. VDEQ answered in the affirmative, but noted that it is a pilot study and it is worth having a conversation after the field work is completed to determine if it is usable/meeting the needs of the project as-is due to the complexity of the site.

- VDEQ noted the Virginia Unified Risk Assessment Model (VURAM) only uses default parameters and is useful as a starting point, but they are open to a normal risk assessment performed using the Risk Assessment Guidance for Superfund (RAGS), which allows for modification based on site specific metrics. VURAM is not mandated, especially at complex sites such as RFAAP. Tony Pace noted that the WESTON Risk Assessor will discuss procedures for analysis with Cliff Opdyke (USACE Chemist).
- On Slide 20, the area within the red rectangle on the left hand figures shows ground scarring, which may indicate some type of earthwork in this location. WESTON is still working on the Topographic Fill Analysis Report. It was discussed that the purpose of the topographic fill analysis was to determine areas of cut and fill. This information would then help to inform planning of the field program. WESTON is currently comparing the topography from a 1950 topographic map to current topography to evaluate topographic difference and determine areas of potential cut and fill. The group agreed that the Topographic Fill Analysis Report would be developed for Army review only. The final document would be included as an appendix to the UFP-QAPP.
- The horizontal extent of munitions will be used to determine if geophysical investigation step-outs are required outside the MRS boundary, based on munitions items being identified near the perimeter of the MRS. If step-outs are required, the MRS boundary will be revised accordingly. However, there is a potential for the extent of potential munitions to reach into additional inaccessible areas, in which case field activities would not be conducted.
- It was noted that the types of munitions at the Former Gun Range are unknown because no munitions have been identified to date.
- Digital geophysical mapping (DGM) transects in the New River will focus on the northern bank Because of proximity to the range and the current of the river, it is unlikely that munition items would have migrated towards the center of the river.
- Greg Abrams clarified the difference between dynamic mode and cued mode with AGC. Dynamic mode is carrying the instrument over the entire grid, whereas cued mode is holding the instrument over an anomaly identified in dynamic mode to collect additional data. The additional data are then used to classify the anomalies, after extensive quality control (QC) and data processing. AGC allows for targets of interest, such as MEC, to be removed, whereas clutter will be left in place.
- VDEQ discussed a project from a testing range at Fort Lee where there were issues with AGC classifying specific munitions due to rockets with various fin designs. Greg Abrams noted that the AGC library can match multiple designs as well as targets of interest (long cylindrical items) that has characteristics of munitions, but that the library can't identify as a specific munitions type. In addition, if multiple similar responses are noted, but not identified in the database, they can be flagged in the system as a potential munitions item. Also, because the range was used to test propellant and not the mortar itself, it is unlikely that multiple mortar variations would be used on the range. The UFP-QAPP will detail the procedures in place to address multiple munition configurations and targets of interests.

- In Area A, boat operators will be instructed to follow the global positioning system (GPS) pre-loaded parallel transects; however, because of the river current, it is likely that the paths will be more meandering, which could potentially lead to greater DGM coverage. Kim Gross asked the team if there was anything they should be aware of for the New River, such as interested parties or safety hazards. Fishermen, boaters, and kayakers all commonly use the river. There are no known biological hazards, but there is a large potential for fishhooks to be present. The Commonwealth of Virginia owns the river; however, there have been no issues in the past with data collection or requiring a right-of-entry (ROE) to access the river. Tony Pace noted that the current procedure is to stop all diving work when a boat comes into the exclusion zone (EZ), and only resume after the boat has left.
- It was noted again that the path of the transects will be more of a meandering path versus a straight path shown on the DGM/AGC Transect Plan figure on Slide 27.
- WESTON is still working with the facility to identify an appropriate area within the MRS to conduct demolition using the buried explosion module (BEM) method. Using the BEM method severely limits kick outs and EZ distances needed.
- During the summer, the river depth varies from 3-8 feet, but during the winter an additional foot of water may be added. The plan is that any MPPEH identified within the water will be transported to the northern bank and handed over to the land-based UXO team for demolition.
- VDEQ asked about the schedule of field events. Tony Pace responded that the plan is for the geophysical surveys to be conducted in the river, then an underwater anomaly memo will be prepared that will identify the anomalies to be investigated. VDEQ inquired if it would be better for WESTON to produce a map with the identified anomalies and then hold a conference call with the team to approve. The group agreed this is a potential option.
- VDEQ asked if there is a potential for items to migrate during the timeframe of the underwater anomaly memo being prepared and approved. Tony Pace acknowledged that it is possible, and that the team will dive to recover all metallic anomalies in the river, including potential trash. Potential migration of anomalies would be based on the flow of the river, as there is a possibility of water pulses from the dam releasing water. BAE noted that they monitor when the dam is released and can notify WESTON, if necessary. WESTON asked if the frequency of pulsing in the river is known. BAE noted that it is scattered and mostly based on weather both up and down river. For example, the recent hurricanes caused severe flooding that required the dam to release water. There is a hydrograph for the New River in RFAAP that should usable for gauging the historical fluctuation.
- VDEQ asked about the schedule for AGC and conducting geophysics on land and in the river. The current plan is to conduct the work concurrently. EM31 surveys will be conducted on the land before AGC because it may be used to make adjustments in the placement of AGC grids outside areas that are identified for trenching.
- It was noted that, although RFAAP has an existing area used for demolition, currently planned demolition will occur within the MRS. Kim Gross stated that it would be worthwhile to have a call with the Army team to discuss the details of the Explosives Site Plan and to discuss other topics related to EZs and demolition. There are administrative issues with transporting items

outside the MRS, including EZs around the vehicles. The MRS is near active production facilities, which could present issues with conducting demolition. The EZ is based on the worst-case scenario of a munitions item with the largest fragmentation distance, but could potentially be modified based on the actual munition. Tony Pace noted that any demolition within the MRS would be conducted using the BEM method, which reduces the EZ; additional engineering controls/barriers exist and could be used to reduce the EZ.

- Intrusive work EZs may extend into inaccessible areas depending on anomaly locations. Greg Abrams noted that it is up to the project team on whether or not to dig on an item. This is the purpose of presenting the dig locations and having a team call, as discussed earlier. It was asked if it would affect the statistics if a target selected for digging was not intrusively investigated. Greg Abrams responded that it would not affect the coverage statistics, and from a QC perspective, there is the option to select a different anomaly for intrusive investigation. It was suggested that a contingency procedure be listed in the UFP-QAPP on how to rectify the issue based on safety needs of the installation. The procedure would outline how the process will be handled. An explanation for the uncertainty aspect with accessing data in the DQOs should be outlined. This is an investigation and not a removal action, so not every identified target needs to be investigated. However, enough digs are needed to quantify the buried items for further analysis of questionable anomalies.

- VDEQ asked how much importance the installation places on No Further Action (NFA) or whether they think that land use controls (LUCs) might be acceptable. VDEQ encourages facilities to think about LUCs versus NFA early in the project process. For example, if statistically it is shown that only munitions debris is present (i.e., inert items), would the facility be amenable to NFA, knowing that there is a small chance a live munition item could be present? Or, would the facility find it acceptable to leave deeper items in place and require a dig process as a form of LUCs? BAE noted that the current policy is to notify Explosive Ordnance Disposal (EOD) to identify and remove an item, hopefully to be perforated for further identification. They also noted that the RFI is to help the installation make informed decisions, as not enough data are currently known about nature and extent of MEC or MC.

- It was noted that the MC sampling strategy is still being developed. X-ray fluorescence (XRF) sampling may be used to determine, at a minimum, the extent of lead within SI DU1. The XRF may have other applications and is being assessed as part of our overall MC sampling strategy, which may also include incremental sampling methodology (ISM) and discrete sampling. Tony Pace stated that there is a potential for a phased approach with XRF used to determine initial extent, but would need to assess data assumptions to ensure that we would get enough data from XRF to transition to ISM approach. Tony Pace stated that the goal of XRF samples was to be able to determine extent of lead within the SI DU1 and if there is a potential for runoff from a contaminated area. Julie Kaiser stated concerns that the source of the lead is unknown, and she suggested that the DU for lead be reconsidered. Further, the area will be re-evaluated to determine if there are features of the area that could be the source of lead in soil, such as construction debris containing lead-based paint chips or scrap metal.

- VDEQ noted that VURAM does not assess ecological risk. Tony Pace responded that a standard screening level ecological risk assessment would be performed.

- VDEQ asked if the UFP-QAPP will use the AGC-QAPP template. Tony Pace responded that yes, non-AGC tasks will be combined into the AGC-QAPP template as the most efficient way to present the combined field approaches.

ACTION ITEMS

Item	Responsible Party	Due Date
Schedule a follow-up call with RFAAP, BAE, USACE, and WESTON to discuss munitions issues including EZs, MPPEH transport from New River to MRS for potential demolition, potential use of RFAAP demo area, and discussion of BEM process.	WESTON	Completed 13 February 2019 via a meeting/conference call at RFAAP.
WESTON to submit the MC sampling strategy to USACE for review.	WESTON	Submitted to the Army on 1/8/19.

TPP1 Meeting
Military Munitions Response Program
RCRA Facility Investigation
Former Gun and Trench Mortar Range M
Radford Army Ammunition Plant, Radford, VA

Date: **18 December 2018**

Location of Meeting: **Main Conference Room, Building 220, Radford AAP**

Purpose of Meeting: **TPP1 - RFI UFP-QAPP/Planning**

Name	Organization	Phone No.	Email
Tony Pace	Wlstan	757-362-2461	pacea@ wlestansolutions.com
Greg Abrams	Weston	703·599·2840	greg.abrams@ westonSolutions.com
Allen Patton	BAE Systems OSI	540·639·8504	mark.patton@ baesystems.com
Jody Hawks	BAE Systems	540·639·7701	jody.hawks@baesystems.com
James(Jim) McKenna	Radford Army Staff	540 731 5782	james.j.mckenna16.civ@mail.mil
Julie Kaiser	USACE-Baltimore Dist	410·962·2227	julie.e.kaiser@ usace.army.mil
Kim Gross	USACE - Baltimore Dist	410-962-3457	kimberly.u.gross@usace.army.mil
Jim Cutler	VDEQ - Federal Fac.	804-698-4498	james.cutler@deq.virginia.gov
Kyle Newman	VDEQ	804-698-4452	kyle.newman@deq.virginia.gov

APPENDIX D

FINAL TOPOGRAPHIC FILL ANALYSIS REPORT

FINAL

TOPOGRAPHIC FILL ANALYSIS REPORT

FORMER GUN AND TRENCH MORTAR RANGE MUNITIONS RESPONSE SITE

ENVIRONMENTAL AND MUNITIONS RESPONSE SERVICES
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

Contract No.: W912DR-15-D-0022
Delivery Order No.:W912DR18F0492

Prepared For:

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
2 Hopkins Plaza
Baltimore, MD 21201

Prepared By:

WESTON SOLUTIONS, INC.
2 Eaton Street, Suite 603
Hampton, VA 23669

May 2019

W.O. 03886.552.500.1010

TABLE OF CONTENTS

Section		Page
1.	INTRODUCTION	1
2.	MRS DESCRIPTION	1
3.	DATA COLLECTION AND EVALUATION	2
4.	TOPOGRAPHIC CHANGE ANALYSIS METHODOLOGY	3
5.	TOPOGRAPHIC CHANGE ANALYSIS RESULTS	4
6.	RECOMMENDATIONS	11
7.	REFERENCES	12

LIST OF TABLES

Title **Page**

Table 1 1949 Aerial Photograph Features of Interest 6

LIST OF FIGURES

Title

Figure 1 Site Layout

Figure 2 1949 Aerial Photograph for the Entire MRS

Figure 3 1949 DEM for the Entire MRS

Figure 4 2018 DEM for the Entire MRS

Figure 5 Topographic Change within the Former Gun Range

Figure 6 Topographic Change within the Former Trench Mortar Range

Figure 7 Fill regions within the Former Gun Range

Figure 8 Fill regions within the Former Trench Mortar Range

LIST OF ACRONYMS AND ABBREVIATIONS

CSM	Conceptual Site Model
DEM	digital elevation model
DQO	Data Quality Objective
EPIC	Environmental Photographic Interpretation Center
ft	feet
GIS	geographic information system
GOCO	Government-Owned Contractor-Operated
m	meter
MEC	munitions and explosives of concern
mm	millimeter
MMRP	Military Munitions Response Program
MRS	munitions response site
RCRA	Resource Conservation and Recovery Act
RFAAP	Radford Army Ammunition Plant
RFI	RCRA Facility Investigation
TNT	trinitrotoluene
USGS	U.S. Geological Survey
WESTON	Weston Solutions, Inc.

1. INTRODUCTION

Military munitions have been encountered during utility work at depths ranging from 8 to 10 feet (ft) below ground surface at the Former Gun and Trench Mortar Range Munitions Response Site (MRS), Radford Army Ammunition Plant (RFAAP), Radford, Virginia. The depth of these munitions may be due to extensive development of the MRS after discontinued use of the ranges.

A characterization strategy is being developed to determine the nature and extent of munitions and explosives of concern (MEC) as part of the Military Munitions Response Program (MMRP) Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at the MRS. The RFI fieldwork approach needs to consider the past munitions use of the MRS in addition to subsequent cut and fill during earthmoving activities, which may have moved or covered MEC.

The purpose of this Topographic Fill Analysis Report is to compare and assess historical and present day topography to quantify cut and fill across the Former Gun and Trench Mortar Range MRS. Fill locations are of particular focus because of the potential for MEC firing points or target areas to be located underneath infrastructure or general earthwork areas. Results and recommendations from this report will be used to enhance the MRS conceptual site model (CSM) and finalize the overall characterization strategy to achieve RFI data quality objectives (DQOs).

2. MRS DESCRIPTION

The Former Gun and Trench Mortar Range MRS (RFAAP-002-R-01) is located adjacent to the New River in the west-central portion of the RFAAP. The MRS is comprised of 115 acres (**Figure 1**). The Former Gun Range portion of the MRS is 28 acres, and the Former Trench Mortar Range portion of the MRS is 87 acres.

The individual Former Gun and Former Trench Mortar Ranges began operations in 1941. Based on information gathered from RFAAP employee interviews, operations were discontinued after the end of World War II. The Former Trench Mortar Range was used to test-fire 4.2-inch, 60-millimeter (mm), and 81-mm mortar rounds to verify the quality of propellants manufactured at the facility. The Former Gun Range was historically used to test projectile propellant by test-firing projectiles into tunnels that were dug into the hillside. Powder was tested using both chronograph and photoelectric screen methods for guns and mortars. Mortars were tested by firing

them through large loops of electric wires, which were connected to the chronograph. The fire power was established by calculating the distance of the shot and the time traveled (Neville and McClane, 1996).

Over time, the RFAAP has undergone modifications to meet production needs. In 1945, the RFAAP was put on stand-by because of cessation of hostilities, and in 1946, the RFAAP was modified to begin producing ammonium nitrate as part of the War Department fertilizer production program. In April 1949, the facility was re-modified for the manufacture of smokeless powder and placed on stand-by until it reopened in 1952. Between 1953 and 1956, the RFAAP underwent major rehabilitation of all operating areas, including expansion of the Pilot Plants and conversion to manufacturing rocket powder (MacDonald and Mack Partnership, 1984). During this time period, nearly 100 buildings deemed as surplus were demolished, including the entire pentolite and trinitrotoluene (TNT) manufacturing areas. In 1968, the facility was modernized to include some automated production lines and from 1972 to 1975, several new facilities were constructed (Neville and McClane, 1996). Additionally, two explosions occurred in the 1970s (May 1974 and January 1978) that demolished several buildings, damaged other buildings, and required manufacturing areas to be completely rebuilt.

Because there was extensive development of the Former Gun and Trench Mortar Range MRS after its use was discontinued and there are no documented firing point or impact locations, these areas may be located underneath process facilities or infrastructure that have been constructed. Because of the construction of these process facilities, considerable earthwork was conducted at the MRS, including grading to level uneven terrain and the creation of earthen berms to serve as blast walls.

3. DATA COLLECTION AND EVALUATION

Available historical and present day topographic data and aerial photographs were gathered as part of data collection activities. To assemble this information, Weston Solutions, Inc. (WESTON) contacted various archives in Virginia such as former RFAAP operation contractors and federal and state data websites, including the following:

- The National Archives at College Park, Maryland
- Radford University McConnell Library (Digital Archives Collection and Discussion)

- University of Virginia Library (Digital Archives Collection and Archivist Discussion)
- Virginia Tech Library (Digital Archives Collection)
- Geospatial Data Center
- RFAAP Administrative Record
- EPA National Exposure Research Lab's Environmental Photographic Interpretation Center (EPIC)
- Hagley Museum (Digital Archives Collection, Archivist Discussion, and Site Visit)

Data availability was found to be limited due to general record keeping practices. However, several key archives were acquired and evaluated to support the topographic analysis. The earliest useful available aerial photographs of the MRS are from 1949, 1953 and 1960. The 1953 aerial photograph mosaic was missing a key overlapping frame that precluded its use for analysis of the Former Trench Mortar Area portion of the MRS. The 1949 aerial photographs provided full coverage of the MRS and they were used as the starting point for topographic analysis (**Figure 2**). The aerial photographs also indicate little site work occurred between 1949, approximately 4 years after use of the Former Gun and Trench Mortar Range MRS ended, and the 1960s, when additional construction began at the MRS. For current imagery, a 2018 DEM was acquired from United States Geological Survey (USGS).

4. TOPOGRAPHIC CHANGE ANALYSIS METHODOLOGY

The methodology for the topographic change analysis involved the production of a digital elevation model (DEM) using stereoscopy to highlight topographic feature changes between 1949 and present day. Four overlapping aerial images from 1949 contained the MRS. Photograph frames were corrected for radiometric and geometric variation and georeferenced to create an orthoimage.

Agisoft software was then used to produce an unreferenced 3-dimensional surface model from the four original images. Ground control points were based on elevation from the 2018 imagery and DEM, with total 3-dimensional error of 1.47 meters (m) (x: 0.164 m, y: 0.72 m, z: 1.27 m). Exterior orientation values were available for bearing and focal length; flight elevation was assumed to be 10,500 feet and pitch and roll were assumed to be zero. Elevation at ground control points and exterior orientation estimates were applied to the unreferenced model to back-calculate the flight

location. Lastly, an ultra-high density point cloud was generated for elevation throughout the image, producing a 1.69 m resolution digital surface model (**Figure 3**).

To assess topographic change, the difference in elevation between the 2018 and 1949 DEM was calculated in ArcGIS Pro. The 2018 DEM for the MRS is presented in **Figure 4**. A figure showing increases in elevation at 2 ft contour intervals is presented in **Figure 5** and **Figure 6**.

5. TOPOGRAPHIC CHANGE ANALYSIS RESULTS

The topographic change results are depicted in **Figure 5** and **Figure 6** for the Former Gun Range and Former Trench Mortar Range, respectively. Both figures use a 2 ft contour interval with color ramping and labeling applied to the index contours to reduce map clutter and highlight trends. Areas exhibiting fill (positive values) indicate a lower elevation/digital surface model in 1949 versus present day suggesting material was added during earth moving work.

The Area A (New River) portion of the site is more susceptible to error because of the dramatic change in topography. The appearance of fill within Area A and along the southern boundary of the MRS is a manifestation of actual topography changes from 1949 to present day coupled with the greater than typical error of the stereopair analysis. Regions of the MRS with shallower slopes show less sensitivity to sources of error and are the focus of our interpretations.

The calculated change within the accessible portion of the Former Gun Range (**Figure 5**) varies between -16 ft and 15 ft. The present day topographic surface within this area is an average of 3.3 ft below the 1949 topographic surface. Approximately 28% of the accessible portion of the Former Gun Range area exhibits a higher topography than in 1949.

The calculated change within accessible regions of the Former Trench Mortar Range (**Figure 6**) varies between -43 ft and 19 ft. Excluding the steep slope beside the river, the present day topographic surface is an average of 1.2 ft above the 1949 topographic surface within the accessible region. Approximately 53% of the area of the accessible portion of the Former Trench Mortar Range exhibits a higher topography than in 1949.

The 1949 aerial photograph for the Former Gun Range is presented in **Figure 7,** including the portion of the MRS that exhibits fill. A similar depiction of the Former Trench Mortar Range and is presented in **Figure 8**.

Topographic changes were then reviewed against the 1949 and present day aerial photographs. Larger and/or horizontally contiguous areas of fill are generally attributed to building construction or other infrastructure that is currently in place. The location of present day infrastructure (buildings, roadways, parking areas and other above ground structures) is depicted on the figures to show correlation with fill. Infrastructure and fill associated with infrastructure will be avoided during RFI fieldwork.

The primary focus of this analysis are the other areas of fill that are not associated with present day infrastructure. These fill areas vary from several feet in size to several hundred feet in diameter such as the area located in the western side of the Former Gun Range. Each fill location was then compared to the 1949 historical aerial image to determine if there was any correlation to potential scaring or other notable features. Fill areas that exceed or nearly exceed predicted detection capability of planned RFI geophysical surveys are also of particular interest because mechanical excavation may be the only opportunity to verify if there is a munitions related source.

Identified features of interest are fill areas that do not correlate with infrastructure, are co-located with historical aerial photograph disturbances and/or are beyond planned RFI geophysical surveys. Features are further described in **Table 1**. The locations of the features of interest are also presented in **Figure 7** and **Figure 8**. Unique identification numbers are used to match **Table 1** with **Figure 7** and **Figure 8**.

Table 1 1949 Aerial Photograph Features of Interest

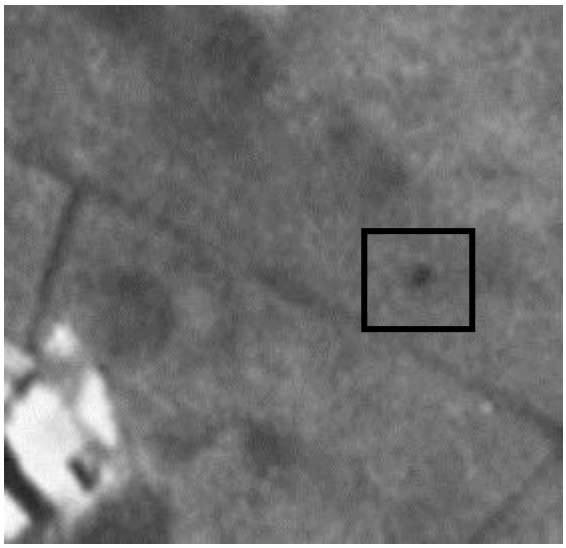
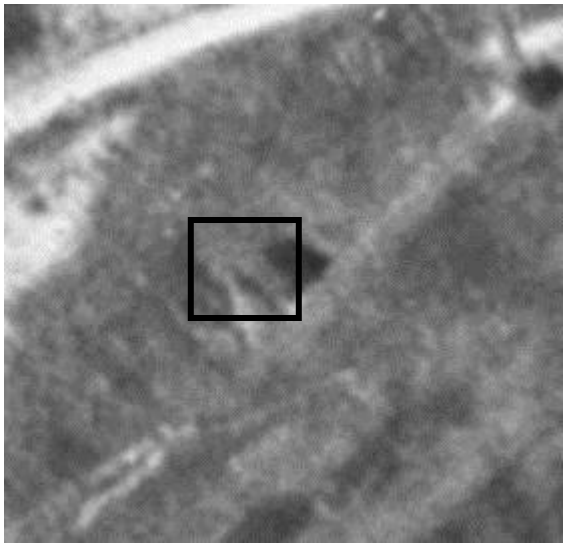
MRS Location	Feature ID and Description	Feature Image
Former Gun Range (see **Figure 7**)	**FGR-01**: Shadow observed in 1949 aerial photograph. Estimated at approximately 8 ft of fill.	
	FGR-02: Fill area that exceeds 8 ft. Adjacent to structure that is also present in 1949 aerial photograph.	

Table 1 1949 Aerial Photograph Features of Interest (Continued)

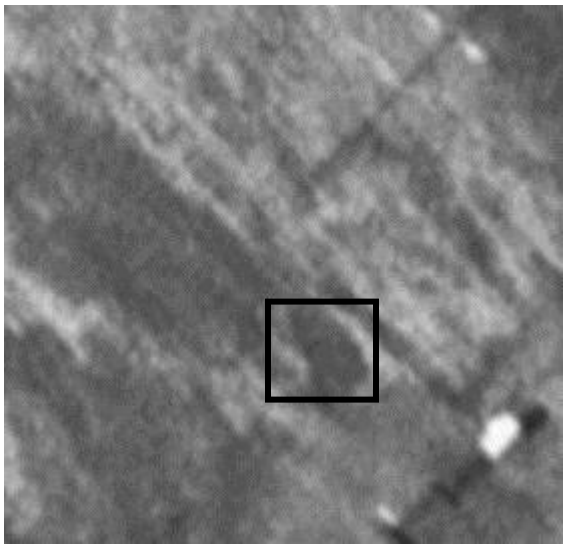
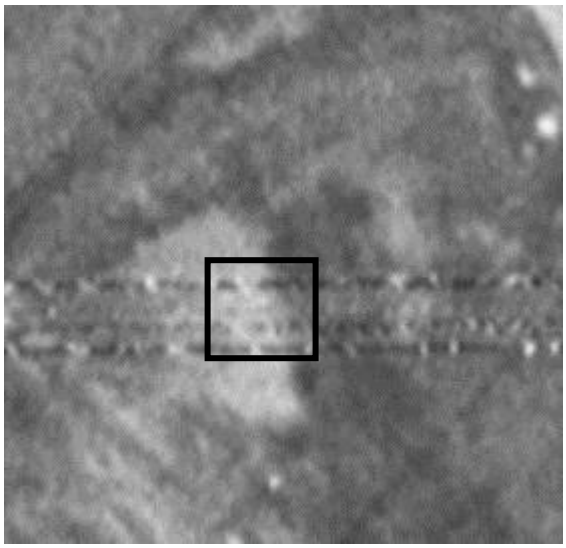
MRS Location	Feature ID and Description	Feature Image
	FGR-03: Approximately 6 ft of fill but within a discrete fill area that is atypical from surroundings. Shadow also observed in 1949 aerial photograph.	
	FGR-04: Large fill area, approximately 13 ft thick. Correlates to variation in 1949 aerial photograph. Striping due to faulty image.	

Table 1 1949 Aerial Photograph Features of Interest (Continued)

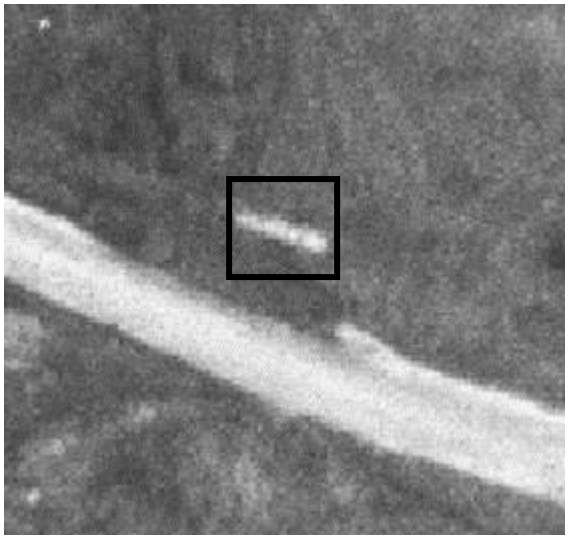
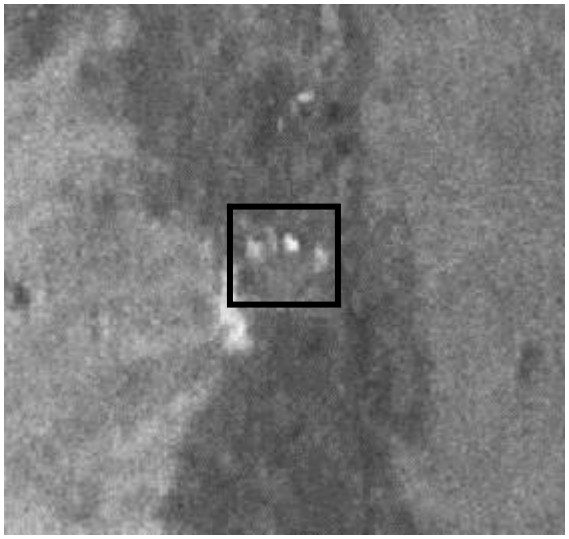
MRS Location	Feature ID and Description	Feature Image
Former Trench Mortar Range (see **Figure 8**)	**FTMR-01**: Linear feature adjacent to former roadway. Present day topography is 6 ft to 8 ft higher in elevation than 1949 topography.	
	FTMR-02: Fill area exceeding 13 ft. Several reflective features clustered in a single area observed in 1949 aerial photograph.	

Table 1 1949 Aerial Photograph Features of Interest (Continued)

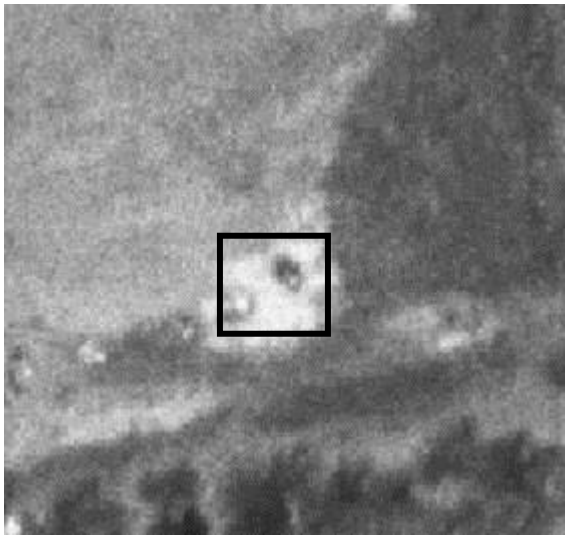
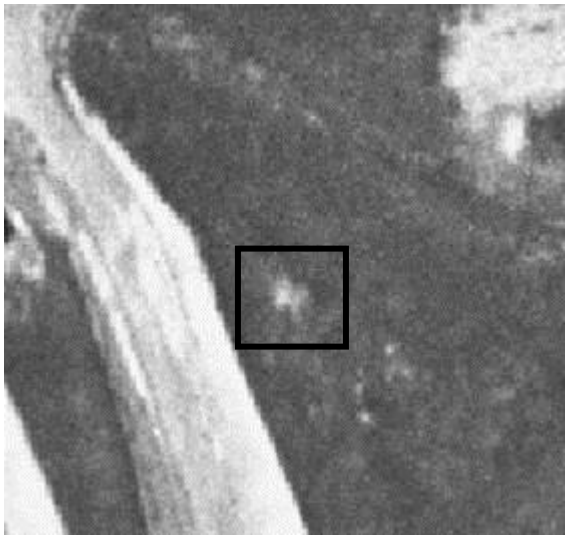
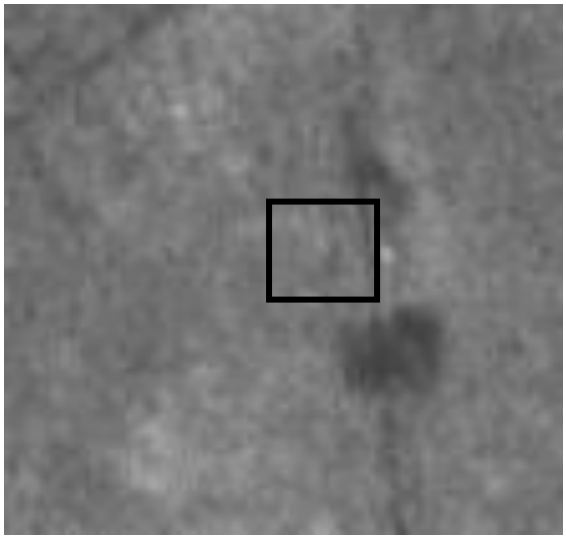
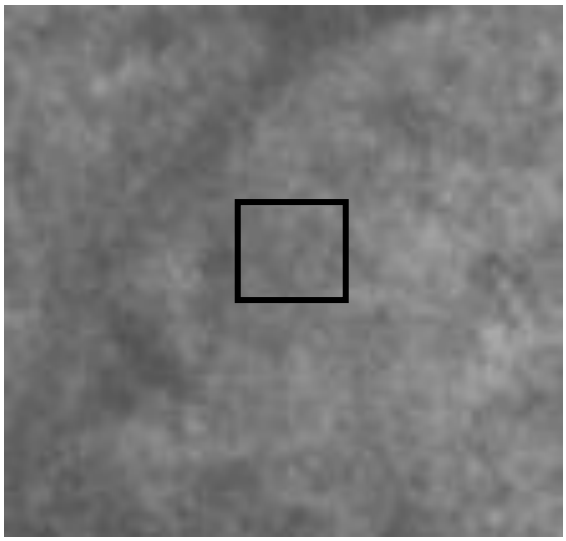
MRS Location	Feature ID and Description	Feature Image
	FTMR-03: Approximately 6 ft of fill. Located in a scarred area in 1949 aerial photo. Potential former structures visible.	
	FTMR-04: Scarring feature located next to former roadway with significant fill.	

Table 1 1949 Aerial Photograph Features of Interest (Continued)

MRS Location	Feature ID and Description	Feature Image
	FTMR-05: Peak observed in 1949 elevation model. Estimated at approximately 7 ft of fill. No corresponding feature in the 1949 aerial photograph was observed.	
	FTMR-06: Peak observed in 1949 elevation model. Estimated at approximately 8 ft of fill. No corresponding feature in the 1949 aerial photograph was observed.	

6. RECOMMENDATIONS

The results from this topographic fill analysis suggest cut and fill activities have occurred at the Former Gun and Trench Mortar Range MRS since munitions related activities ceased in the mid-1940s when compared to present day conditions. Significant fill heights can be attributed to building and other infrastructure construction activities. However, there are remaining areas within the MRS where MEC may be present that are now covered with fill due to earthwork. In some cases MEC may be deeper than anticipated depth of detection of geophysical technologies (estimated to be 8 ft).

A total of 10 features of interest identified from a 1949 aerial photograph and topographic analysis were identified because the fill areas do not correlate with infrastructure, are co-located with historical aerial photograph disturbances and/or are beyond planned RFI geophysical surveys. The specific circumstance for selecting each feature of interest is listed in **Table 1.** Feature of interest locations based on unique ID are presented in **Figure 7** and **Figure 8**.

These results and recommendations should be used as part of the RFI work planning process to refine the MRS CSM and to further develop DQOs. The recommended sequence of work for the RFI includes the following steps:

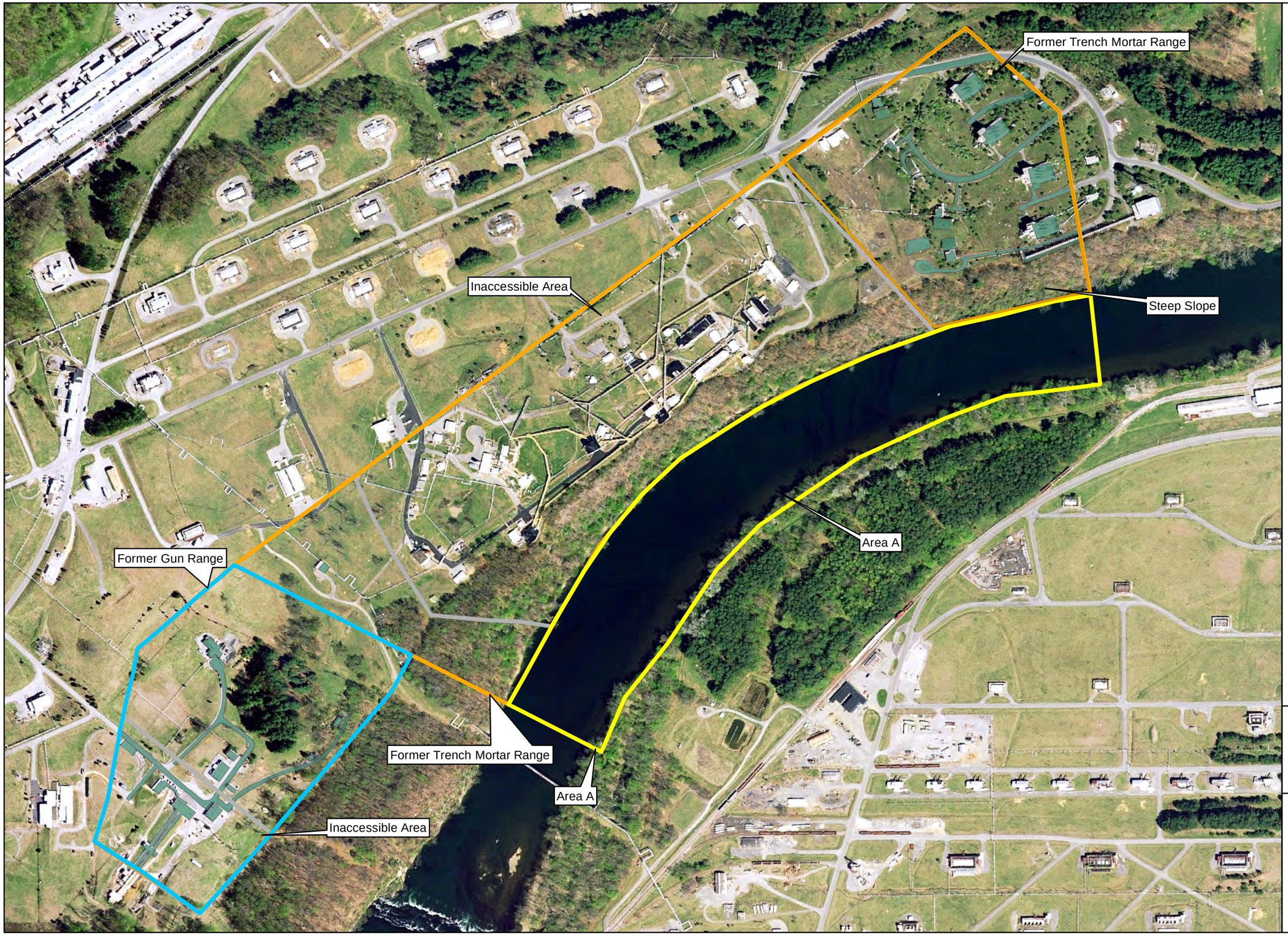
1. Perform EM31 survey transects across accessible portions of the MRS.
2. Identify anomalies of interest based on the EM31 surveys that may require further investigation as part of the RFI.
3. Determine if the anomalies of interest from the EM31 survey are co-located with feature of interest locations identified in **Table 1** and presented in **Figure 7** and **Figure 8**.
4. Reacquire features of interest from **Table 1** and the EM31 survey to assess topography and accessibility for intrusive work.
5. Conduct mechanized test pitting/trenching of each feature of interest in **Table 1** and/or based on the EM31 survey to the 1949 surface if possible.
6. Note and record findings as part of the RFI.

7. REFERENCES

MacDonald and Mack Partnership. 1984. Historic Properties Report. Radford Army Ammunition Plant (Including the New River Unit). Radford, Virginia. August 1984.

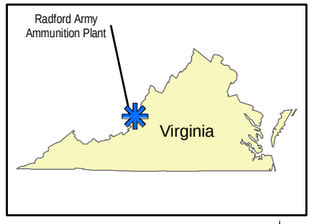
Neville, Ashley M. and McClane, Debra A (Gray & Pape, Inc. subcontractor to Geo-Marine, Inc.). 1996. The World War II Ordnance Department's Government-Owned Contractor-Operated (GOCO) Industrial Facilities: Radford Ordnance Works, Historic Investigation. Performed under U.S. Army Corps of Engineers, Fort Worth District. U.S. Army Material Command Historic Context Series Report of Investigations, Number 6A. February 1996.

FIGURES



Legend

- Hardscape
- Area A
- Inaccessible Area
- Former Gun Range
- Former Trench Mortar Range



0 150 300 600

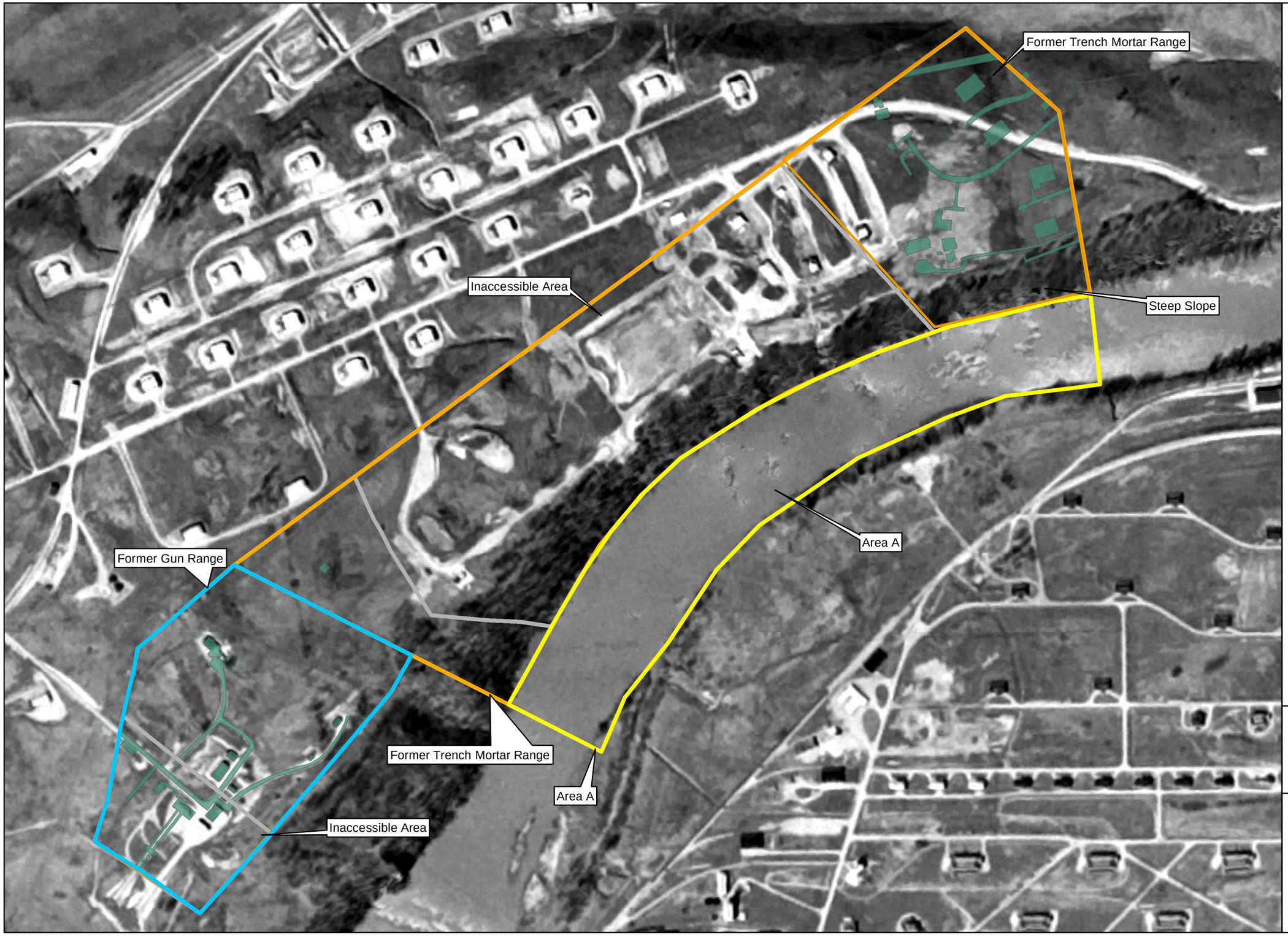
Feet

Prepared By:

Baltimore District

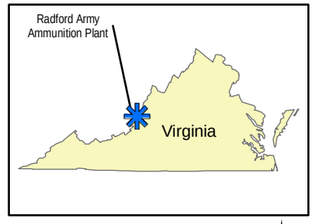
FIGURE 1
SITE LAYOUT

STEREOSCOPIC ANALYSIS REPORT
FORMER GUN AND TRENCH
MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLAN
RADFORD, VIRGINIA



Legend

- Hardscape
- Area A
- Inaccessible Area
- Former Gun Range
- Former Trench Mortar Range



0 150 300 600

Feet

Prepared By:

Baltimore District

FIGURE 2
1949 AERIAL IMAGERY
FOR THE ENTIRE MRS

STEREOSCOPIC ANALYSIS REPORT
FORMER GUN AND TRENCH
MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLAN
RADFORD, VIRGINIA

Former Trench Mortar Range

Inaccessible Area

Steep Slope

Area A

Former Gun Range

Former Trench Mortar Range

Area A

Inaccessible Area

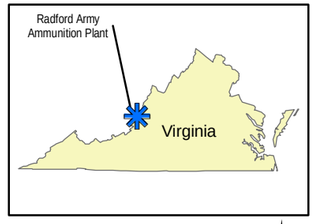
Legend

- Hardscape
- Area A
- Inaccessible
- Former Gun Range
- Former Trench Mortar Range

Elevation (ft)

High : 1949.6

Low : 1550.59



0 150 300 600

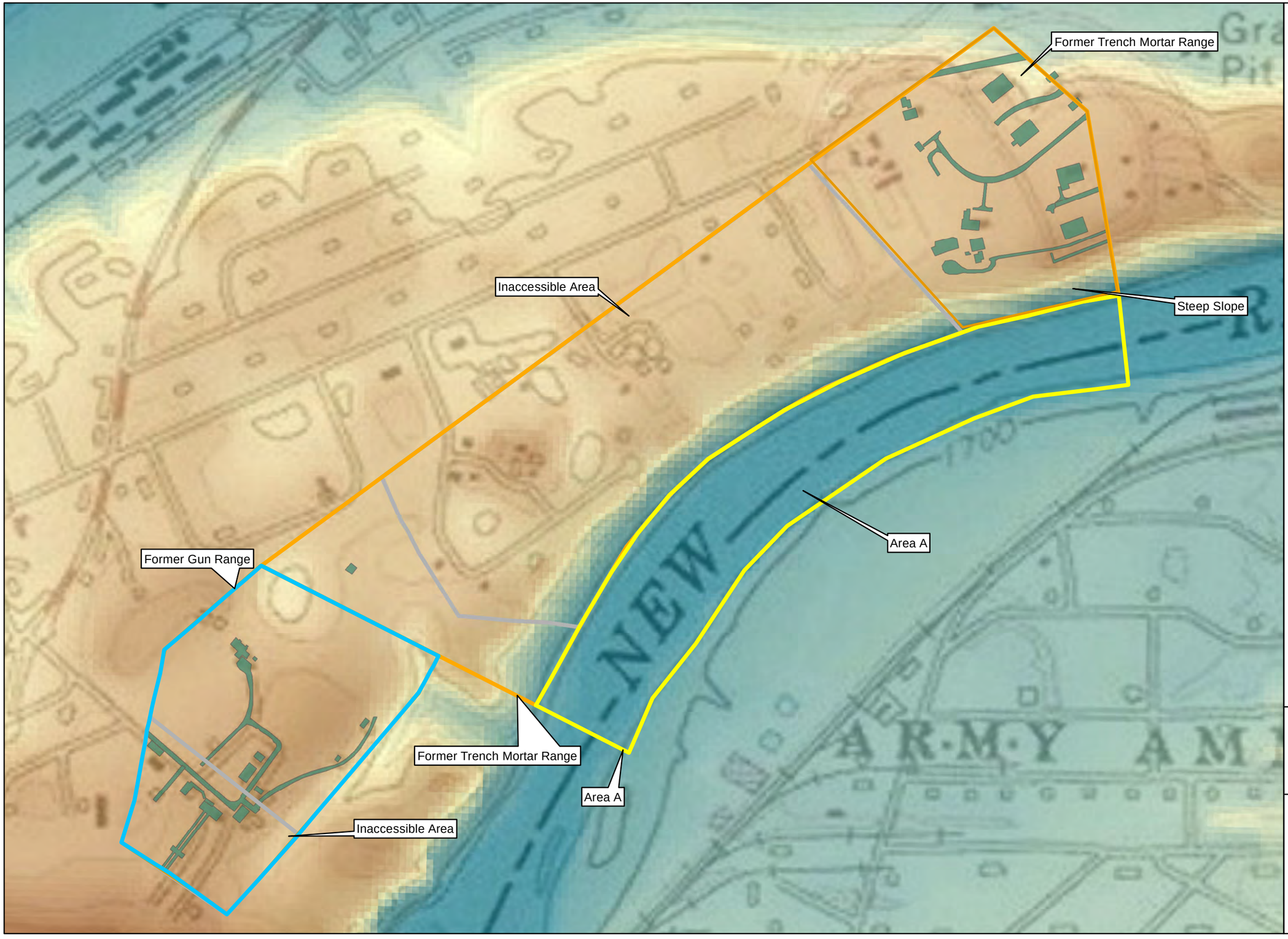
Feet

Prepared By:

Baltimore District

FIGURE 3
1949 DIGITAL ELEVATION MODEL
FOR THE ENTIRE MRS

STEREOSCOPIC ANALYSIS REPORT
FORMER GUN AND TRENCH
MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLAN
RADFORD, VIRGINIA



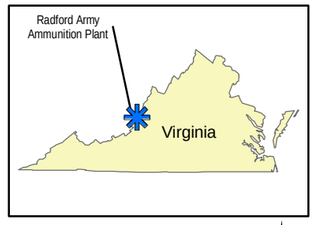
Legend

- Hardscape
- Area A
- Inaccessible
- Former Gun Range
- Former Trench Mortar Range

Elevation (ft)

High : 1939.84

Low : 1659.39



0 150 300 600

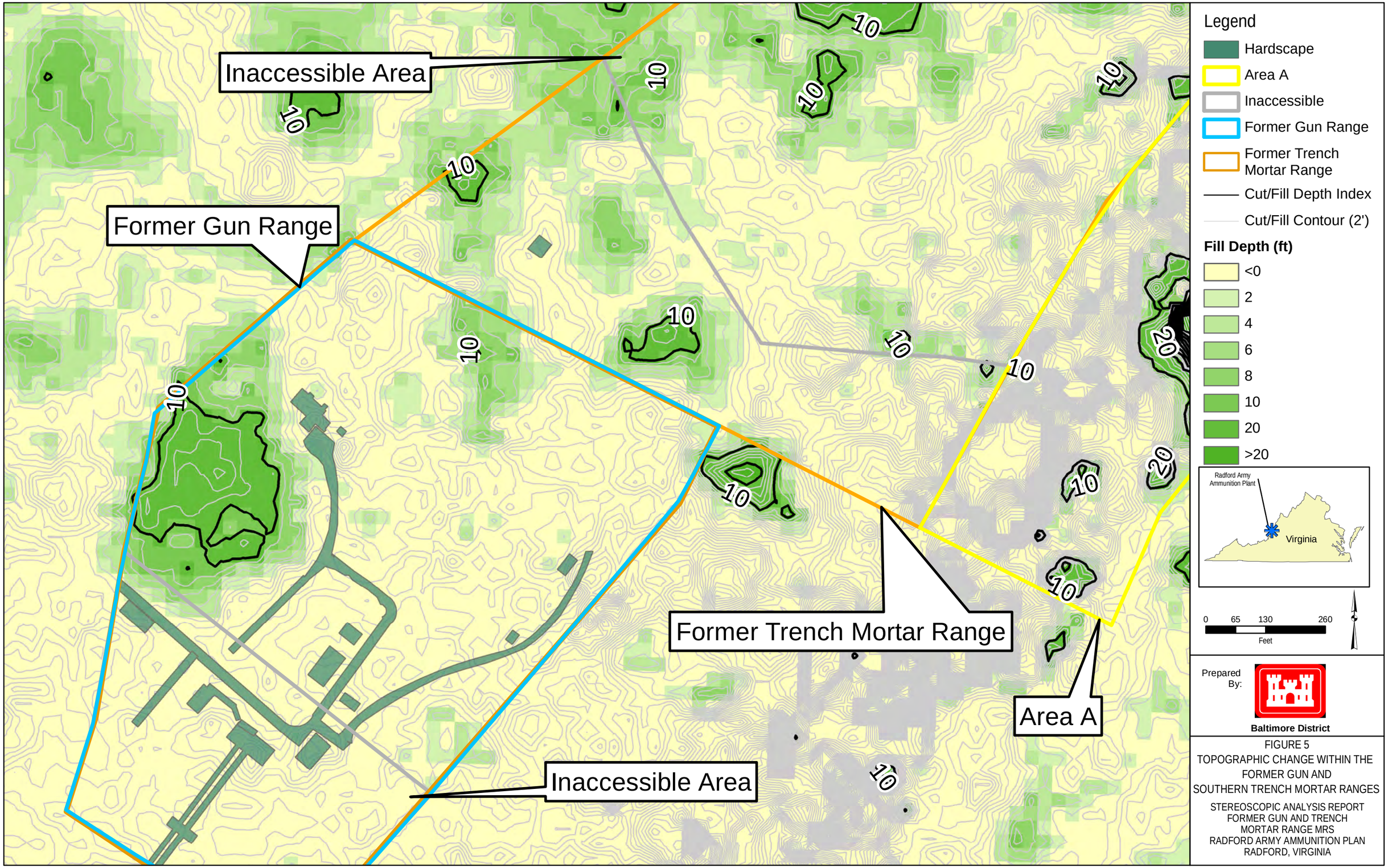
Feet

Prepared By:

Baltimore District

FIGURE 4
2018 DIGITAL ELEVATION MODEL FOR THE ENTIRE MRS

STEREOSCOPIC ANALYSIS REPORT
FORMER GUN AND TRENCH MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLAN
RADFORD, VIRGINIA


Inaccessible Area
Former Gun Range
Former Trench Mortar Range
Area A
Inaccessible Area
10
20
Legend
Hardscape
Area A
Inaccessible
Former Gun Range
Former Trench Mortar Range
Cut/Fill Depth Index
Cut/Fill Contour (2')
Fill Depth (ft)
<0
2
4
6
8
10
20
>20
Radford Army Ammunition Plant
Virginia
0 65 130 260
Feet
Prepared By:
Baltimore District
FIGURE 5
TOPOGRAPHIC CHANGE WITHIN THE FORMER GUN AND SOUTHERN TRENCH MORTAR RANGES
STEREOSCOPIC ANALYSIS REPORT
FORMER GUN AND TRENCH MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLAN
RADFORD, VIRGINIA

Former Trench Mortar Range

Inaccessible Area

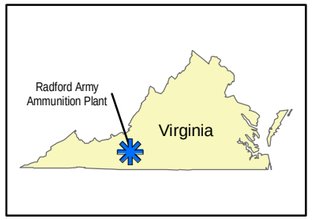
Steep Slope

Legend

- Hardscape
- Area A
- Inaccessible Area
- Former Trench Mortar Range
- Cut/Fill Depth Index
- Cut/Fill Contour (2')

Fill Depth (ft)

- <0
- 2
- 4
- 6
- 8
- 10
- 20
- >20



N

0 65 130 260

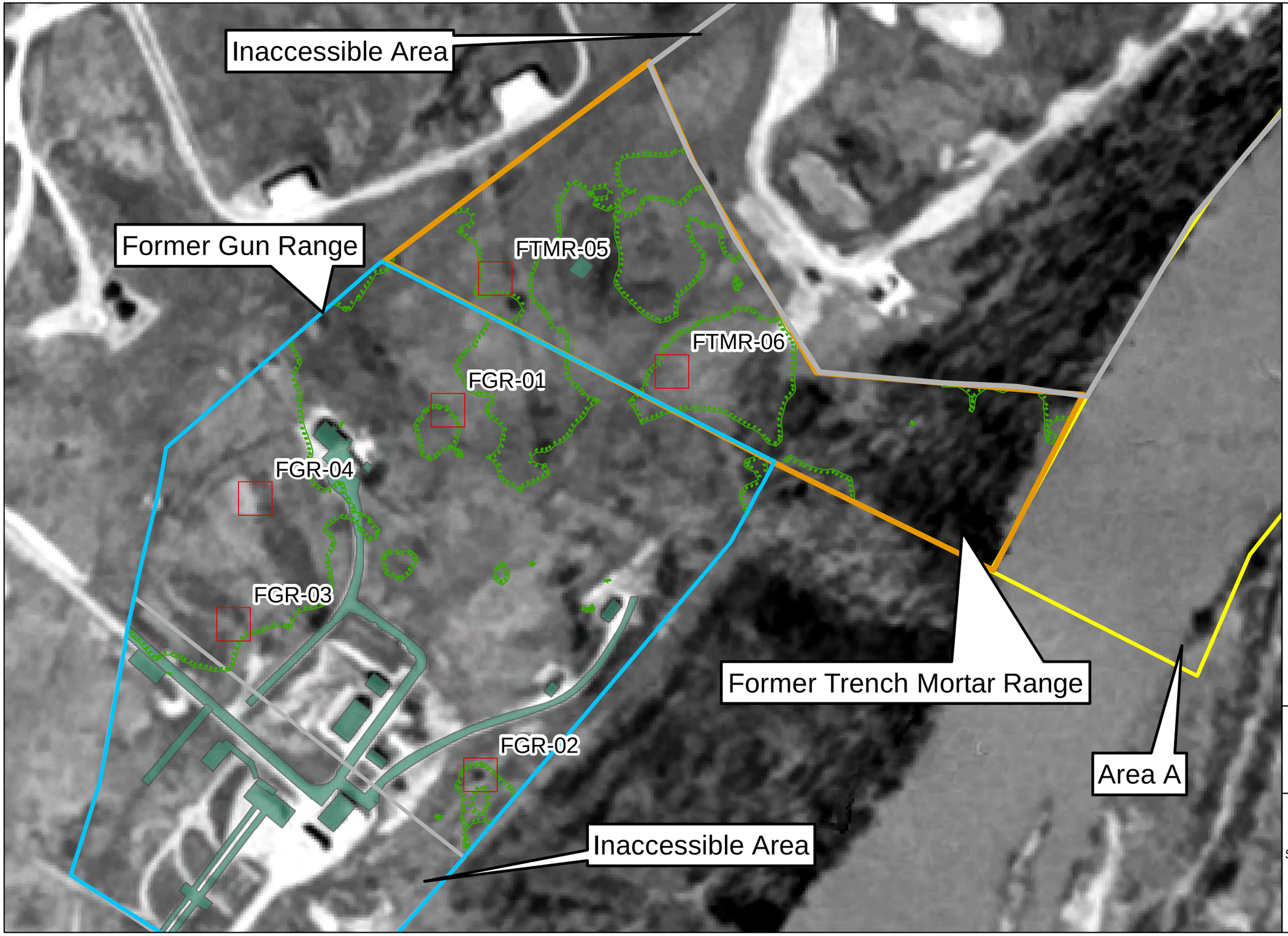
Feet

Prepared By:

Baltimore District

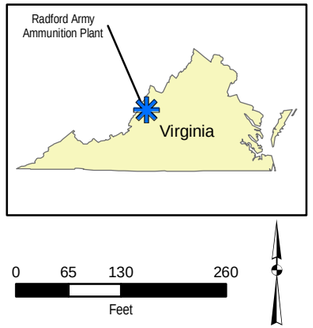
FIGURE 6
TOPOGRAPHIC CHANGE WITHIN THE FORMER TRENCH MORTAR RANGE

STEREOSCOPIC ANALYSIS REPORT
FORMER GUN AND TRENCH
MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLAN
RADFORD, VIRGINIA



Legend

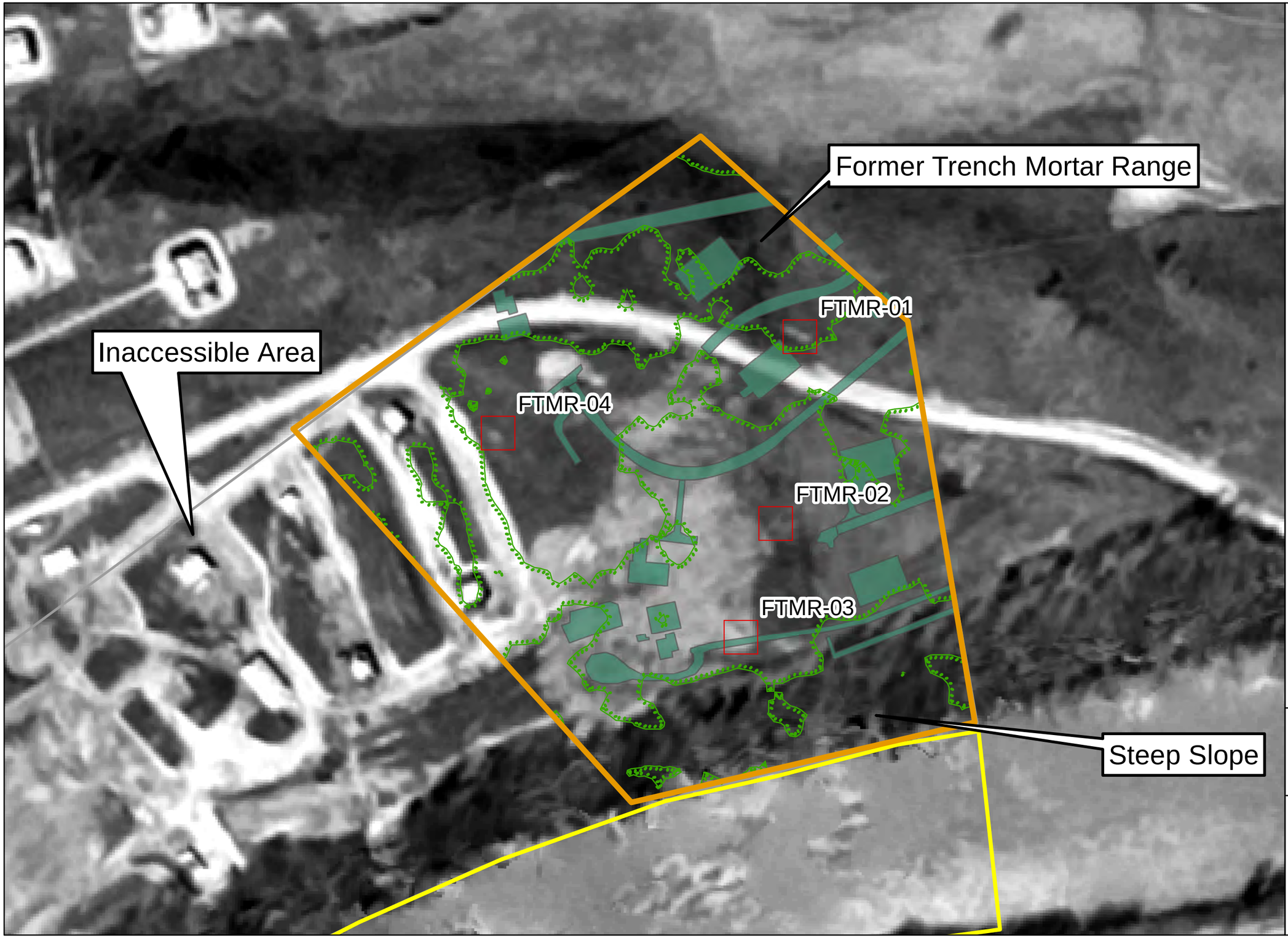
- Hardscape
- Area A
- Inaccessible Area
- Former Gun Range
- Former Trench Mortar Range
- Proposed Test Pit
- Fill



Prepared By:

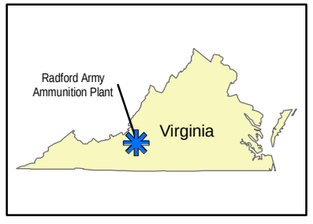
Baltimore District

FIGURE 7
FILL AREAS WITHIN THE
FORMER GUN AND
SOUTHERN TRENCH MORTAR RANGES
STEREOSCOPIC ANALYSIS REPORT
FORMER GUN AND TRENCH
MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLAN
RADFORD, VIRGINIA



Legend

- Hardscape
- Area A
- Inaccessible Area
- Former Trench Mortar Range
- Proposed Test Pit
- Fill



N

0 65 130 260

Feet

Prepared By:

Baltimore District

FIGURE 8
FILL AREAS WITHIN THE
FORMER TRENCH MORTAR RANGE

STEREOSCOPIC ANALYSIS REPORT
FORMER GUN AND TRENCH
MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLAN
RADFORD, VIRGINIA

APPENDIX E

MC SAMPLING MEMORANDUM

MC SAMPLING RATIONALE MEMORANDUM

MILITARY MUNITIONS RESPONSE PROGRAM
RCRA FACILITY INVESTIGATION
FORMER GUN AND TRENCH MORTAR RANGE MRS
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

1.0 INTRODUCTION

Munitions constituents (MC) concentrations in surface soil, subsurface soil, sediment, and groundwater will be characterized, as necessary, at the Former Gun and Trench Mortar Range MRS and adjacent Area A (portion of the New River) at Radford Army Ammunition Plant (RFAAP under the Military Munitions Response Program (MMRP). MC may be present at the MRS as a result of former military munitions operations. The results of the MC characterization will be used to perform a baseline risk assessment and to support Munitions Response Site Prioritization Protocol scoring. This MC Sampling Rationale Memorandum documents the decision logic for the MC sampling process.

Section 2 of this memorandum describes the various munitions and explosives of concern (MEC) and MC release scenarios that may be encountered at the MRS during the RCRA Facility Investigation (RFI). Section 3 details specific MC that may be present at the MRS based on former munitions and weapons systems used during historical activities.

A thorough review of numerous documents was completed to develop the information presented here. A list of these resources is presented in Attachment 1. Unless otherwise noted, all statements of fact presented in this appendix are based on the review of these documents and the *Final Site Investigation (SI) Report, Former Gun and Mortar Range MRS*, September 2018 by Bering Sea Environmental, LLC.

2.0 DECISION LOGIC AND SAMPLING CRITERIA

The Former Gun and Mortar Trench MRS (RFAAP-002-R-01) is located adjacent to the New River in the west-central portion of RFAAP. The Former Gun and Trench Mortar Range MRS consists of 115 acres and is comprised of two adjacent ranges: the Former Gun Range (28 acres) and the Former Trench Mortar Range (87 acres). The Former Gun and Former Trench Mortar Ranges began operations in 1941. Based on information gathered from RFAAP employee interviews, operations were discontinued after the end of World War II (WWII). The Former Trench Mortar Range was used to test-fire 4.2-inch, 60mm, and 81mm mortar rounds to verify the quality of propellants manufactured at the facility. The Former Gun Range was historically used to test projectile

propellant by test-firing projectiles into tunnels dug into the hillside. According to the interviewees, the propellant manufactured at RFAAP during the 1940s was comprised of 52 percent (%) cellulose, 38% nitroglycerin (NG), and a small fraction (exact amount not disclosed) of potassium nitrate.

Because there was extensive development of the Former Gun and Trench Mortar Range MRS after its use was discontinued, and there are no documented firing point or impact locations, these areas may be located underneath process facilities or infrastructure that have been constructed. These process facilities include the active production facility and the defunct Continuous Automated Multi-Base Line (CAMBL) facility. The active production facility is in a continual state of production; however the CAMBL facility never went into production after it was built and is being scrapped. Because of the construction of these process facilities, considerable earthwork was conducted at the MRS, including grading to level uneven terrain and creation of earthen berms to serve as blast walls.

Available information gathered during the Historical Records Review (HRR) and interview process provides no information on the exact test procedures employed or the location of the range firing point(s), munitions storage area(s), or impact zone(s). However, information gathered from interviews with RFAAP personnel indicates that the mortars were generally fired in an upward direction for testing, suggesting the impact area was near the firing point.

Information gathered during the HRR and interview process suggests that the test mortars were not filled with high explosive (HE), but with various fillers, including concrete, gravel, Halowax, and possibly antifreeze. It was disclosed during the interview process that, while constructing the active production and CAMBL facilities on the MRS, numerous “piles” of mortars were discovered and disposed by RFAAP personnel.

The Former Gun Range was historically used to test projectile propellant by test-firing projectiles into a hillside using howitzers and/or cannons. Apparently, holes were dug (caves) into the hillside and filled with sand to reduce the impact of the rounds. The only reported ordnance test-fired was 100-pound shells. No information on the type(s) of propellant tested was contained in the HRR or obtained during the interview process. Furthermore, no information was found to indicate the location of the sand-filled caves. The 8-acre Active Test Range within the Former Gun Range was not included in the SI. The Active Test Range contains the Inert Gun Testing Facility that is currently used by Orbital ATK to test propellant by firing inert projectiles. It is not known if these 8 acres include the hillside used for test firing. No information presented in the HRR or gathered during the interview process indicates that munitions (e.g., 100-pound shells) have ever been discovered that could be associated with the Former Gun Range. This includes munitions lying on the ground surface or unearthed by erosion or excavation.

As part of the RFI, geophysical surveys (DGM and AGC) will be performed to investigate the potential presence of MEC on the ground surface, in the subsurface, and in the sediments of Area A (adjacent portion of the New River). If the geophysical surveys identify areas of high anomaly densities, these areas will be investigated to determine whether MEC or munitions debris (MD) is

present. The presence of significant amounts of MEC or MD may indicate the potential presence of MC. During the RFI, in addition to the planned MC sampling associated with the previous SI MC results, MC investigations will also be initiated when any of the following conditions are encountered:

- Individual or multiple MEC items or significant MD locations (e.g., on the surface, in burial pits) or areas where soil staining or visible evidence of a potential MC release is observed.
- Known munitions disposal areas that potentially contain MC with or without indicators of a MEC release.
- Locations required to delineate the horizontal and vertical extent of MC or munitions-related contaminants.

An appropriately biased number of environmental samples will be collected from locations where MEC is uncovered or has been recovered during past disposal activities. Potential MEC releases identified during the RFI will be reported to the project team stakeholders. Details of the sampling methods that will be used for the RFI are presented in Worksheet 17 (Section 17.15) of the UFP-QAPP and in the SOPs presented in the UFP-QAPP.

3.0 MC ANALYSIS

This section presents the specific MC that can be anticipated at the MRS based on the historical munitions and weapons systems used. The identification of the anticipated MC permits laboratory analysis of samples collected during the RFI to focus on the specific MC that is expected to be present and indicative of potential contamination. Generally, MC at the MRS can be classified into two groups: metals and explosives.

The media to be analyzed during the RFI are surface and subsurface soil and sediment. Due to the expected deep depth (greater than 70 feet bgs) of groundwater at the MRS, impacts to groundwater quality are not anticipated.

The first step in determining the MC associated with the MRS is to identify the munitions used. The following table identifies the MC potentially associated with the munitions types and impact areas of the MRS investigated during the SI.

Name	Area Name	Munitions Type	Associated SI MC Analysis
Former Gun and Trench Mortar Range MRS	Former Gun Range	100-lb shells	Explosive constituents: 2,4-dinitrotoluene (DNT); 2,6-DNT; 2-nitrotoluene; 3-nitrotoluene; 2-amino-4,6-DNT; 4-amino-2,6-DNT; and 4-nitrotoluene; 2,4,6-trinitrotoluene (TNT); 1,3,5-trinitrobenzene; 1,3-dinitrobenzene; pentaerythritol tetranitrate (PETN); hexahydro-1,3,5- trinitro-1,3,5-triazine (RDX); nitrobenzene; tetryl; and nitroglycerin (NG) Metals: antimony, copper, iron, lead, manganese
	Former Trench Mortar Range	4.2-inch, 60mm, and 81mm Mortars	Explosive constituents: Same as above for 100-lb shells Metals: aluminum, antimony, iron, lead, zinc

Based on the information presented in the above table, the compounds potentially associated with the MRS are evaluated for the RFI MC sampling and the evaluation is presented in the following section.

4.0 MC SAMPLING

During the October 2016 SI field activities, soil samples were collected from within the MRS and analyzed for explosives, perchlorate, semivolatile organic compounds (SVOCs), and metals. No explosives constituents, SVOCs, or perchlorates were detected at concentrations above the method detection limits (MDLs). Several metals including antimony, cadmium, lead, manganese, selenium, and vanadium were detected above their respective screening limits in samples collected at the MRS.

The evaluation of potential exposure for ecological and human receptors presented in Section 5.0 of the Final SI report indicated the above metals may present potentially unacceptable risks to ecological receptors. The potential for MC at the MRS was evaluated to determine the constituents and analyses to be performed during the RFI (see the following table).

Analyte	Analysis Available?	Analysis Required?	Notes
Metals EPA Method SW-846 3010A/3050B/ 6010C			
Aluminum	Yes	No	Known MC associated with munitions; however, detections observed during the SI indicate concentrations are not expected to present an unacceptable risk to human or ecological receptors.
Antimony	Yes	Yes	Known MC associated with munitions. Surface soil detections observed during the SI indicate concentrations may present potentially unacceptable risk to ecological receptors.

Analyte	Analysis Available?	Analysis Required?	Notes
Barium	Yes	No	Known MC associated with munitions; however, detections observed during the SI indicate concentrations are not expected to present an unacceptable risk to receptors.
Bismuth	Yes	No	Known MC associated with munitions; however, it is not anticipated to be present at levels that would be potentially harmful because it is a minimal component of munitions.
Cadmium	Yes	Yes	Known MC associated with munitions. Surface soil detections observed during the SI indicate concentrations may present potentially unacceptable risk to ecological receptors. .
Chromium	Yes	No	Known MC associated with munitions; however, it is not anticipated to be present at levels that would be potentially harmful because it is a minimal component of munitions.
Cobalt	Yes	No	Known MC associated with munitions; however, it is not anticipated to be present at levels that would be potentially harmful because it is a minimal component of munitions.
Copper	Yes	No	Known MC associated with munitions. However, detections observed during the SI indicate concentrations are not expected to present an unacceptable risk to human or ecological receptors.
Iron	Yes	No	Known MC associated with munitions. However, detections observed during the SI indicate concentrations are not expected to present an unacceptable risk to human or ecological receptors.
Lead	Yes	Yes	Known MC associated with munitions. Surface soil detections observed during the SI indicate concentrations may present potentially unacceptable risk to ecological receptors.
Magnesium	Yes	No	Known MC associated with munitions; however, detections observed during the SI indicate concentrations are not expected to present an unacceptable risk to human or ecological receptors.
Manganese	Yes	Yes	Known MC associated with munitions. Surface soil detections observed during the SI indicate concentrations may present potentially unacceptable risk to ecological receptors.
Mercury	Yes	No	Known MC associated with munitions; however, it is not anticipated to be present at levels that would be potentially harmful to human health and the environment.
Nickel	Yes	No	Known MC associated with munitions; however, detections observed during the SI indicate concentrations are not expected to present an unacceptable risk to receptors.
Potassium	Yes	No	Known MC associated with munitions; however, screening criteria not available.
Selenium	Yes	Yes	Known MC associated with munitions. Surface soil detections observed during the SI indicate concentrations may present potentially unacceptable risk to ecological receptors.
Titanium	Yes	No	Known MC associated with munitions; however, it is not anticipated to be present at levels that would be potentially harmful because it is a minimal component of munitions.
Strontium	Yes	No	Known MC associated with munitions; however, it is not anticipated to be present at levels that would be potentially harmful because it is a minimal component of munitions.

Analyte	Analysis Available?	Analysis Required?	Notes
Vanadium	Yes	Yes	Known MC associated with munitions. Surface soil detections observed during the SI indicate concentrations may present potentially unacceptable risk to ecological receptors.
Zinc	Yes	No	Known MC associated with munitions; however, detections observed during the SI indicate concentrations are not expected to present an unacceptable risk to receptors.
Explosives EPA Method SW-846 3535A/8330B or 8330A			
Nitroglycerin (NG)	Yes	Yes	Known MC associated with munitions
Hexahydro-1,3,5- trinitro-1,3,5-triazine (RDX)	Yes	Yes	Known MC associated with munitions
Pentaerythritol Tetranitrate (PETN)	Yes	Yes	Known MC associated with munitions
Tetryl	Yes	Yes	Known MC associated with munitions
2,4,6-Trinitrotoluene (TNT)	Yes	Yes	Known MC associated with munitions
2,4-Dinitrotoluene (2,4-DNT)	Yes	Yes	Breakdown product of TNT
2,6-Dintrotoluene (2,6-DNT)	Yes	Yes	Breakdown product of TNT
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	Yes	Yes	Breakdown product of TNT
2-Nitrotoluene	Yes	Yes	Breakdown product of TNT
3-Nitrotoluene	Yes	Yes	Breakdown product of TNT
4-Nitrotoluene	Yes	Yes	Breakdown product of TNT
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	Yes	Yes	Breakdown product of TNT
1,3,5-Trinitrobenzene	Yes	Yes	Breakdown product of TNT
1,3-Dinitrobenzene	Yes	Yes	Breakdown product of TNT
Nitrobenzene	Yes	Yes	Breakdown product of TNT
Other Components			
Ammonium nitrate Antimony sulfate Antimony sulfide	Not available	No	Note 1
Diethylphthalate Diphenylamine Ethyl centralite	Yes (SW-846 8270C)	No	Note 2
Lead thiocyanate Mercury fulminate	Not available	No	Note 1
Perchlorate	Yes	No	May be present but was not detected during the SI.
Picric acid	Yes (SW-846 8330B)	No	Note 3
Potassium chlorate Potassium nitrate Potassium sulfate	Not available	No	Note 1
Sulfur	Yes	No	Known MC associated with munitions; however, screening criteria not available

Notes:

Note 1 – These explosives compounds do not have developed laboratory methods but methods may exist for the individual components of these compounds. Because the mass of the individual components is small, it is not anticipated that the components would be detected in the soil samples. Furthermore, the explosives used in the greatest quantity at the MRS due to propellant manufacturing and testing primarily contained nitroglycerin and cellulose/nitrocellulose, which are insoluble in water and do not hydrolyze, volatilize, or bioconcentrate under normal environmental conditions. They also have average adsorption coefficients suggesting that they will reasonably adsorb to soil and sediments and maintain low soil mobility. Also, the volatilization rate from soil is extremely low[1].

Note 2 – Based on the review of the Munitions Items Disposition Action System **(**MIDAS**)** database for munitions similar to those used at the MRS, it has been determined that this SVOC would be present only in trace amounts in munitions used at the MRS. The compound is not anticipated to be present at detectable concentrations in site soils as was indicated by the SI sampling results. Therefore, sampling is not planned for the RFI.

Note 3 – Based on the review of the MIDAS database for munitions similar to those used at the MRS, it has been determined this explosive compound would be present only in trace amounts within munitions used and is not anticipated to be present at detectable concentrations in the soils. Therefore, sampling is not planned for the RFI.

The predominant pathway for introducing MC to the environment at the MRS is from a MEC source. Source areas within the MRS include areas where MEC may potentially be distributed on the surface and in the subsurface from former firing and disposal activities. Therefore, the sampling of surface and subsurface (to the depth of observed MEC) soils and sediment is recommended. Additional delineation in soils and sediment may be warranted based on initial MC sampling in soils.

MC sampling will be conducted at the MRS and Area A during the RFI based on the initial SI results, geophysical survey and intrusive investigation results and visual observations. Based on the evaluation in the above table, the following MC analyses and analytes are proposed for samples collected during the RFI at the MRS:

- Explosives (Method EPA SW-846 8330B or 8330A): 2,4-DNT; 2,6-DNT; 2-nitrotoluene; 3-nitrotoluene; 2-amino-4,6-DNT; 4-amino-2,6-DNT; and 4-nitrotoluene; 2,4,6-TNT; 1,3,5-trinitrobenzene; 1,3-dinitrobenzene; PETN; RDX; nitrocellulose, nitrobenzene; tetryl; and NG (for soil and sediment samples where (1) individual or multiple MEC items or significant MD locations or areas where soil staining or visible evidence of a potential MC release is observed, (2) known munitions disposal areas that potentially contain MC with or without indicators of a MEC release, and (3) locations required to delineate the horizontal and vertical extent of MC or munitions-related contaminants).

- Lead (Methods EPA SW-846 6200 and 6010C) for the XRF sampling and confirmation sampling associated with sampling within and around DU1.

- Metals (Method EPA SW-846 6010C): antimony, cadmium, lead, manganese, selenium, and vanadium (all soil and sediment samples associated with corroded or damaged munitions items).

ATTACHMENT 1: REFERENCES

Army Documents

- Office of the Chief of Ordnance, Technical Division, Catalogue of Standard Ordnance Items, Volume III, 1944.
- Office of the Chief of Ordnance, Handbook Number 1939, History of Artillery Projectiles, 1921.
- Notes on Ammunition, U.S. Army Coast Artillery School, Fort Monroe, VA, 1918.
- TM 4-205, Coast Artillery Ammunition, 1940.
- TM 43-0001-27, Army Ammunition Data Sheets, Small Caliber Ammunition.
- TM 43-0001-28, Army Ammunition Data Sheets, Artillery Ammunition, Guns, Howitzers, Mortars, Recoilless Rifles, Grenade Launchers, and Artillery Fuzes.
- TM 9-1300-200, Ammunition General.
- TM 9-1300-203, Ammunition for Antiaircraft, Tank, Antitank, and Field Artillery Weapons.
- TM 9-1300-214, Military Explosives.
- TM 9-1900, Ammunition General.
- TM 9-1901, Artillery Ammunition.
- TM 9-1910, Military Explosives.
- TM 9-1990, Small Arms Ammunition.

APPENDIX F

BLIND SEED FIREWALL PLAN

FINAL
BLIND SEED FIREWALL PLAN

MILITARY MUNITIONS RESPONSE PROGRAM
RCRA Facility Investigation

Former Gun and Trench Mortar Range Munitions Response Site
(RFAAP-002-R-01)
Radford Army Ammunition Plant
Radford, Virginia

Contract No.: W912DR-15-D-0022

Prepared For:

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
2 Hopkins Place
Baltimore, MD 21201

and

RADFORD ARMY AMMUNITION PLANT
Radford, Virginia

Prepared By:

WESTON SOLUTIONS, INC.
2 Eaton Street, Suite 603
Hampton, VA 23669

MAY 2019

This Page Intentionally Left Blank

TABLE OF CONTENTS

Section **Page**

1.0 INTRODUCTION.....1

2.0 QUALITY CONTROL PERSONNEL 2

3.0 INFORMATION TRANSFER/STORAGE 3

4.0 COMMITMENT TO CONFIDENTIALITY.....4

LIST OF ACRONYMS AND ABBREVIATIONS

UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plan
MMRP	Military Munitions Response Program
MRS	Munitions Response Site
PM	Project Manager
QC	quality control
QM	Quality Manager
RFAAP	Radford Army Ammunition Plant
RFI	RCRA Facility Investigation
USACE	Army Corps of Engineers
WESTON®	Weston Solutions, Inc.

1.0 INTRODUCTION

This Blind Seed Firewall Plan has been developed as an appendix to the Uniform Federal Policy for Quality Assurance Project Plan (UFP-QAPP), prepared for the Military Munitions Response Program (MMRP) RCRA Facility Investigation (RFI) at the Former Gun and Trench Mortar Range Munitions Response Site (MRS) located at the Radford Army Ammunition Plant (RFAAP) near Radford, Virginia. This work is being performed under Contract No W912DR-15-D-0022 by Weston Solutions, Inc. (WESTON®). WESTON has prepared the UFP-QAPP for the Radford Army Ammunitions Plant and the United States Army Corps of Engineers (USACE).

This Blind Seed Firewall Plan describes general procedures for maintaining the confidentiality for the locations of blind quality control (QC) seeds placed for the analog geophysical and MetalMapper 2x2 advanced classification surveys. Only specific project personnel need to have knowledge and access to the QC seed information to ensure the integrity of the data collection, processing, analysis, and classification efforts. During the preparation of the UFP-QAPP, the WESTON QC Geophysicist and the USACE Technical Representative will agree on the number, type, and spatial distribution of QC seeds.

2.0 QUALITY CONTROL PERSONNEL

WESTON personnel involved in data collection, processing/classification, and intrusive investigation activities on the project will be prevented from having access to information related to the detailed information for the QC seeds buried at each QC seed location. The information will be provided to them only as needed for post-classification analyses, such as a root-cause analysis, and only after documented permission to share the information has been received from the USACE Technical Representative and/or USACE Project Manager (PM). The following personnel are the only members of the project team who will have access to the detailed QC seed information:

- WESTON Unexploded Ordnance Quality Control Specialist
- WESTON Corporate Quality Manager (QM)
- WESTON Geophysical Classification Organization QM
- WESTON QC Geophysicist
- USACE Technical Representative
- USACE Ordnance and Explosives Safety Specialist

3.0 INFORMATION TRANSFER/STORAGE

The QC seed information will be recorded by the WESTON QC Geophysicist upon placement of the seeds in the field. Unless permission is received from the USACE Technical Representative and/or USACE PM to share with other members of the project team, information may only be transferred between the individuals identified. The information will be stored on the WESTON geophysical project-specific server in a password-protected folder that is only accessible by the identified personnel.

4.0 COMMITMENT TO CONFIDENTIALITY

The personnel identified in this document, or others added with the USACE Technical Representative and/or PM's permission, will be required to provide a letter of confidentiality (in either e-mail or hard copy format), to comply with the requirements established herein. This letter of confidentiality will be kept on record by the WESTON Corporate QM and retained in the project files. Letters of confidentiality will be provided to the USACE PM prior to fieldwork.

APPENDIX G

CONTRACTOR FORMS

Provided on CD.

Daily Quality Control Report
RCRA Facility Investigation
Former Gun and Trench Mortar Range MRS

CONTRACT NO./D.O. NO.:	**WORK ORDER NO.:**	**DATE / TIME ON AND OFF SITE**
W912DR-15-D-0022/ W912DR18F0492	03886.552.500	

WEATHER/TEMPERATURE:

WORK LOCATION: RFAAP, Radford, VA
Subcontractor(s) On-Site: ☐ _____ ☐ _____ ☐ _____

WORK COMPLETED:

- ☐ Survey Activities
- ☐ Mapping activities (transects)
- ☐ DGM activities (transects)
- ☐ Reacquire/Investigate Anomalies
- ☐ Open Detonation
- ☐ Grid QC List (List completed grids).
- ☐ Grid QA (List completed grids).
- ☐ Munitions Constituent Sampling.
- ☐ UXO Technician Escort activities.
- ☐ Equipment Transport (mob/demob to/from site-List).
- ☐ Equipment Maintenance
- ☐ Equipment Issues (List below).
- ☐ _____
- ☐ Safety Briefing Given

Comments:

QUALITY INSPECTIONS PERFORMED: *(PP – Prep Phase; IP – Initial Phase; FP – Follow On Phase)*

Phase:	**DFW:**	**FQCY**	**Audit(s) Performed:**	**Pass**	**Fail**
Phase of TPI for DFW	Task inspected	When task was and is being check, weekly/daily		☐	☐
				☐	☐
				☐	☐
				☐	☐

Findings/Comments:

Grids/Anomalies QC'd/QA'd and disposition:

Returned for Rework:

Grid/Anomalies passed QC inspection:

MATERIALS DELIVERED (Amount, Condition, and Purpose):

PROBLEMS/RESOLUTIONS:	
DATA TRACKING:	
Comments:	
FURTHER DISCUSSION (List Topic and Comment):	
PREPARED BY:	**SIGNATURE:**

Environmental Samples

Level of Health & Safety Protection: Level D

Exposure Hours (WESTON): _____

Exposure Hours (Subcontractors): _____

Exposure Monitoring[i]: Noise: _____ Chemical: _____

_____ _____

Exposure Mileage[ii]: WESTON: Subcontractor(s):

Instrumentation Used:

Calibration(s) Performed:

Instrument Problems/Remedies:

Summary of Site Activities (Including problems encountered, corrective actions taken, and a summary of any instructions received from Government personnel):

Sample Collection Method(s):

Samples Collected[iii]:

Quality Control Samples:

Signature: _____ Title: _____

[i] Indicate the low and high readings from monitoring equipment. Attach tabulated readings.
[ii] Estimate vehicle mileage traveled during working hours.
[iii] Indicate 1) Sample Media: Groundwater, Surface Water, Soil or Sediment, 2) Sample Type: Composite, Grab, Duplicate, Incremental, Rinsate, and 3) Sample ID Numbers.

Former Gun and Trench Mortar Range Munitions Response Site
Radford Army Ammunition Plant, Virginia

Site Visitors Log

Contract No.: W912DR-15-D-0022		**D.O.: W912DR18F0492**	**Location: Radford AAP, Radford, VA**				
Date	Name	Company	Telephone Number	Safety Briefing Received	Time		Escort Required
					In	Out	

Safety Meeting Attendance Log

Date:		Time:		Contract Number:	W912DR-15-D-0022
Task Order Number:	W912DR18F0492		Location:	Radford Army Ammunition Plant, VA	
Weather Conditions:					
I. Safety Meeting Topic (Briefly describe):					
II. Attendees:					

Name (Print)	Signature	Company

Name (Print)	Signature	Company

III. Verification:

I certify that the personnel listed on this roster received the briefing described above. Site personnel not attending this meeting will be briefed before beginning their assigned duties.

Site Safety Officer Date

Safety Inspection Log

Date: _____ Time: _____ Work Order #: 03886.552.500

Contract #: W912DR-15-D-0022 DO: W912DR18F0492 Location: Radford Army Ammunition Plant, VA

Weather Conditions: _____

Type of Inspections: Daily _____ Weekly _____ Special _____ Reinspection _____

Location inspected: (List by grid number, coordinates, or description) _____

Activity: _____

II. Inspection Requirement	Satisfactory	Unsatisfactory	N/A
EM and Dig Transect Survey			
EM and Dig Grids			
Evacuation Technique			
Personal Protection Equipment			
Work Practices			
Site Control			
First Aid Equipment			
Fire Fighting Equipment			
Explosives Transportation			
Explosives Storage			
Disposal Operations			

Overall Inspection Results: Satisfactory _____ Unsatisfactory _____

III. Comments: _____

_____

Work stopped due to safety violation: Yes _____ No _____

Safety violations noted: _____

Corrective Measures _____

Reinspection required Yes _____ No _____

IV. Signatures: I acknowledge that I have been briefed on the results of this inspection and will take corrective actions (if necessary).

_____ _____

Site Safety Officer/UXO Safety Officer Sr. UXO Supervisor/Project Manager

WESTON Weekly Vehicle Safety Checklist

Operator	Location of Vehicle use RFAAP, Virginia		Home Office location		
Year and make of Vehicle License Plate	Date of Inspection	Odometer Reading	Was vehicle driven during Safety Check?	Yes ☐	No ☐

Safety Minded Drivers have Safe Equipment	Satisfactory	Unsafe	Corrected
Seat Belt (Accessible/condition)	☐	☐	☐
Lights: Headlights	☐	☐	☐
Turn Indicators	☐	☐	☐
Brake Lights	☐	☐	☐
Tail Lights	☐	☐	☐
Backup Light	☐	☐	☐
Flashers	☐	☐	☐
Instrument Panel	☐	☐	☐
Dome/inside	☐	☐	☐
Steering	☐	☐	☐
Horn	☐	☐	☐
Brakes	☐	☐	☐
Parking Brake	☐	☐	☐
Muffler (noisy)	☐	☐	☐
Tires (tread, cuts, inflated properly)	☐	☐	☐
First Aid Kit (Serviceable)	☐	☐	☐
Fire Extinguisher (Serviceable)	☐	☐	☐

Condition of Vehicle (Note items that indicate previous damage and/or represent safety hazard)

Inside: _____

Outside: _____

Other Items:

1. _____
2. _____
3. _____
4. _____
5. _____

Safety Checked: _____ By: _____

Date: Name and Signature

Daily Site Report

CONTRACT NO. / D.O.: - W912DR-15-D-0022/ W912DR18F0492	**DATE:**

WORK LOCATION: Former Gun and Trench Mortar Range MRS, RFAAP, Virginia

WORK COMPLETED:

- ☐ Survey Activities.
- ☐ Mapping activities (grids/transects)
- ☐ DGM/AGC activities (grids/transects)
- ☐ Reacquire/Investigate Anomalies.
- ☐ Grid QC List.
- ☐ Grid QA
- ☐ Munitions Constituents Sampling
- ☐ UXO Technician Escort activities.
- ☐ Magazine secured.
- ☐ Equipment Maintenance.
- ☐ Equipment Issues (List Below)
- ☐ _____
- ☐ Safety briefing given

Comments:

PROBLEMS/RESOLUTIONS:

DAILY ACTIVITIES:

Total Number/Line miles completed:

MC Sampling Summary:

MD, NMRD, MEC/MPPEH:	**Team2:**	**Team 3:**

UXO items located:

UXO Daily Total:

Remarks: SUXOS/Site Manager _____, UXOSO/QCS _____

Geophysical Teams:
Team 1:
Team 2:

Demo Team:

Sample Team:

PREPARED BY:	**SIGNATURE:**

Weston Solutions, Inc.

Demolition Material Accountability Form

1. Project: Former Gun and Trench Mortar Range MRS RF 2. Project Location: RFAAP, Virgnia 3. Project No. 03886.552.500

4. Explosive Description:_____ 5. Marks and Identification:_____

6. Manufacturer:_____ 7. Storage Location: _____

8. Date Received	9. Quantity In	10. Unit of Issue	11. Quantity Out	12. Balance	13. Date Expended	14. Printed Name and Initials

DD Form 1348-1A Issue Release/Receipt Document

1 2 3	4 5 6	7	23 24	25 26 27 28 29	45	46 47 48 49 50	51	52 53 54 55	56	57 58 59	60 61	62 63 64	65 66	67 68 69	70 71	72 73	74 75 76 77 78 79 80
DOC IDENT	RI FROM	M & S	U/I	QUANTITY	**SER**	**SUPPLE-MENTARY ADDRESS**	**SIG**	**FUND**	DIS-TRI-BU-TION	PRO-JECT	PRI	RDD EEA QLT DE	ADV				

Munitions Debris (MD) turned in as;
Materials Documented as Safe (MDAS)

24. DOCUMENT NUMBER & SUFFIX (30-44)

25. NATIONAL STOCK NUMBER & ADD (8-22)

I acknowledge that all items listed above must be shredded and or melted before resale.

Signature:_____

1. TOTAL PRICE	2. SHIP FROM	SHIP TO
UNIT PRICE DOLLARS CTS		
DOLLARS CTS		
	4. MARK FOR	

5. DOCDATE	6. NMFC	7. FRT RATE	8. TYPE CARG0	9. PS

10. QTY. REC'D	11. UP	12. UNIT WEIGHT	13. UNIT CUBE	14. UFC	15. SL

16. FREIGHT CLASSIFICATION NOMENCLATURE

17. ITEM NOMENCLATURE

Munitions Debris

18. TYCONT	19. NO CONT	20. TOTAL WEIGHT	21. TOTAL CUBE
22. RECEIVED BY			23. DATE RECEIVED

26

1 This certifies and verifies that the material listed has been 100% inspected and to the best of our knowledge and belief is inert and/or free of explosives or related materials.

2 We Certify that the MD scrap materials were demilitarized in accordance with Appendix 4, Category III, Para 6a, that were compiled with in the DOD 4160.21-M-1 and other applicable regulations.

3 Each piece of MD scrap metal has been inspected by (3) separate Senior qualified UXO Tech's (Unexploded Ordnance Technicians).

27. ADDITIONAL DATA

Signature: _____ Title: Senior UXO Supervisor, Weston Solutions Inc. Date:

Signature: _____ Title: Quality Control Officer, Weston Solutions Inc. Date:

●MB No. 1140-0026 (07/31/2014)

U.S. Department of Justice
Bureau of Alcohol, Tobacco, Firearms and Explosives

Report of Theft or Loss-Explosive Materials

For ATF Use Only

Date Received	Date Faxed to JSOC & Field Division	Unique Identifier
		Case Number

To Be Completed By Person Making Report

Upon discovery of any theft or loss of any of your explosive materials:
- First, contact ATF toll free at 1-800-461-8841 between 8:00 a.m. - 5:00 p.m. EST or after hours and weekends contact ATF at 1-800-800-3855 to report the theft or loss;
- Second, contact your local law enforcement office to report the theft or loss to obtain a police report; and
- Third, complete this form and attach any additional reports, sheets or invoices necessary to provide the required information, and fax the form with additional material(s) to the ATF U.S. Bomb Data Center (USBDC) at 866-927-4570 or email to USBDC@atf.gov.

1. Date	2. Type of Report *(Check one)*: ☐ Theft ☐ Loss ☐ Attempted Theft/Suspicious Activity ☐ Supplement
3. Full Name of Person Making the Report *(Last, First, Middle)*	4a. Licensee or Permittee Name
4b. Federal Explosives License or Permit Number	
5a. Office Address *(Street Address, City, State, and Zip Code)*	5b. Telephone Number
	5c. E-mail Address

6. Actual Location of Theft or Loss *(If different from item 5a)*

7. Theft or Loss	Date	Time	8. Name of Local Law Enforcement Officer to Whom Reported
a. Discovered			9. Name and Address of Local Authority to Whom Reported
b. When Was the Magazine Last Checked			
c. Occurred *(Show approximate if exact not known)*			
d. Reported to ATF by Telephone			10. Telephone Number
e. Reported to Local Authorities			11. Police Report Number

12. Explosive Materials Lost or Stolen *(Attach invoices or additional sheets, if necessary)*

a. Manufacturer and/or Importer	b. Brand Name	c. Date Shift Code	d. Size *(Length & Diameter)*	e. Quantity *(Pounds of Explosives, Number of Dets)*	f. Type and Description *(Dynamite, Blasting Agents, Detonators, etc. Include for each type, size, MS delay or length of leg wire, as applicable)*

13. Theft or Loss Occurred from *(Check applicable box on each row)*

a. Magazine Type:

☐ 1 ☐ 2 ☐ 2 Det. Box ☐ 3 Day Box ☐ 4 ☐ 5

☐ Outdoor ☐ Indoor

☐ Permanent ☐ Portable ☐ Mobile Truck ☐ Mobile Trailer

☐ Overnight Storage ☐ Day Storage

b. Types of Locks *(Check all that apply)*:

☐ Padlock ☐ Mortise ☐ 3-Point ☐ Puck Lock ☐ Other *(Explain)* _____

c. Location Description/Type:

☐ Licensed/Permitted Premises ☐ Remote Storage ☐ Work Site ☐ In Transit ☐ During Operations

14. Method of Entry:

☐ Door Was a Key Used? ☐ Yes ☐ No Suspected Employee-Involved Theft? ☐ Yes ☐ No

☐ Wall(s) ☐ Roof ☐ Floor/Bottom

Lock(s) Defeated? *(If yes, check additional appropriate boxes)* ☐ Yes ☐ No

☐ Lock Shackle Cut *(How?)* _____ ☐ Lock Pried, Twisted or Levered

☐ Lock Left Unlocked ☐ Lock Picked or Shimmed

☐ Keyway Drilled Out ☐ Lock Body Drilled Out or Cut

☐ Other *(Explain)* _____

Manufacturer and Model of Lock:	Location of Magazine Keys: ☐ Office ☐ Employee ☐ Other *(Address)* _____	Are All Keys Accounted For? ☐ Yes ☐ No

15. Hood Defeated? *(If yes, check all applicable)* ☐ Yes ☐ No

☐ Hood Cut ☐ Hood Removed

☐ Other *(Explain)* _____ ☐ Hood Broken

Hood Width *(Inches)* _____ Hood Length (Inches) _____

Hood Depth *(Inches)* _____ Hood Thickness (Inches) _____

16. Other Information Pertinent to the Theft, Loss or Suspicious Activity *(Any details you can provide)*

16a. Was Theft or Loss Disclosed During an ATF Inspection or Being Reported as a Result of Inspection? ☐ Yes ☐ No

16b. Additional Security Measures in Place?

☐ Alarm ☐ Security System/Service ☐ Fencing ☐ Lighting ☐ Other *(Explain)* _____

17. Signature and Title of Person Making Report	18. Date

Reporting Instructions

Email or fax this completed form to the ATF address listed below or call if no fax is available:

Bureau of Alcohol, Tobacco, Firearms and Explosives
U.S. Bomb Data Center
99 New York Ave., N.E. 8.S-295
Washington, DC 20226
Toll Free Fax: 1-866-927-4570
Email Address: USBDC@atf.gov

Questions regarding the completion of this form should be referred to the U.S. Bomb Data Center toll free at 1-800-461-8841.

Privacy Act Information

The following information is provided pursuant to section 3 of the Privacy Act of 1974 (5 U.S.C. § 522a(e)(3).

1. **Authority.** Solicitation of this information is made pursuant to Title XI of the Organized Crime Control Act of 1970 (18 U.S.C. Chapter 40). Disclosure of a theft or loss of explosive materials is mandatory pursuant to 18 U.S.C. § 842(k) for any person who has knowledge of such theft or loss from his stock.

2. **Purpose.** The purpose for the collection of this information is to give ATF notice of the theft or loss of explosive materials, and to furnish ATF with the pertinent facts surrounding such theft or loss. In addition, the information is used to confirm and verify prior notification of this theft or loss of explosive materials.

3. **Routine Uses.** The information will be used by ATF to aid in the administration of laws within its jurisdiction concerning the regulation of explosive materials and other related areas. In addition, the information may be disclosed to other Federal, State, foreign, and local law enforcement of laws within their jurisdiction. System of records notice Justice/ATF-008 Regulatory Enforcement Record System FR Vol.68 No.16 Page 3558 dated January 24, 2003.

4. **Effects of not supplying information requested.** 18 U.S.C. § 842(k) makes it unlawful for any person, who has knowledge of the theft or loss of explosive materials from his stock, to fail to report such theft or loss within twenty-four hours of discovery thereof, to the Secretary and to appropriate local authorities. The penalty for violation of this section is a fine of not more than $1,000 or imprisonment for not more than one year, or both. 18 U.S.C. § 844(b).

Paperwork Reduction Act Notice

This request in accordance with the Paperwork Reduction Act of 1995. The purpose of this information collection is to report the theft or loss of explosive materials. The information is used for investigative purposes by ATF officials. This information is mandatory by statute. (18 U.S.C. § 842)

The estimated average burden associated with this collection of information is 1 hour and 48 minutes per respondent or recordkeeper, depending on individual circumstances. Comments concerning the accuracy of this burden estimate and suggestions for reducing this burden should be addressed to Reports Management Officer, Document Services, Bureau of Alcohol, Tobacco, Firearms and Explosives, Washington, DC 20226.

An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

Demolition Shot Record

DATE/TIME: _____ TRACKING NUMBER: _____

LOCATION: _____

1. ITEMS REMOVED FROM GRID (**YES**/NO)

4. ITEMS DESTROYED ONSITE (**YES**/NO**)**

5. WHO DESTROYED ITEM(S)?

Name: _____ Organization: WESTON

Time of Detonation:_____

6. MEC ITEMS ENCOUNTERED:

TYPE	QTY	CONDITION	DISPOSITION

7. Demolition notifications made by: _____

8. COMMENTS:

_____
WESTON UXO Representative (Signature)

_____
WESTON UXO Representative (Print Name)

Corrective Action Request (CAR)

Corrective Action Request I No. (*1, 2, 3, etc. for the T.O.*)
USACE Representative: Date Issued: Issued to: (*Contractor*) Response Due: (*Based on type of nonconformance*) Contract # and T.O. # Project Name/Location:
Nonconformance Type (circle one): Critical Major Minor
Description of Condition Found:
Apparent Cause:
(The Contractor will provide the following information to the Contracting Officer and USACE PM by the "Response Due" date above. Please contact USACE Representative listed above if you have any questions)
Actual Cause: (Contractor will investigate and determine cause of condition reported above. Actual cause should be stated as specifically as possible)
Action Taken to Correct Condition: (Corrective Action should address root cause, not the symptom)
Action Taken to Prevent Recurrence:
Action Taken to Monitor Effectiveness of Corrective Action: (Generate data as proof. State the monitoring method put into place and who is responsible for reviewing data.)
Contractor Representative Signature/Title/Date Signed: (Form must be signed before returning)
(*USACE Project Team Use Only*) Review of Corrective Action: 1) Has condition improved? ___ Yes ___ No 2) Additional corrective action required? ___ Yes ___ No Comments: Completed form provided to Contracting Officer: (Date)

DIGITAL GEOPHYSICAL MAPPING
GRID NOTES

Project: Former Gun and Trench Mortar Range MRS RFI	
Site Location: Radford Army Ammunition Plant, VA	Date/ Time Duration:
Grid ID:	Dataset:

WESTON SOLUTIONS	**FIELD VARIANCE FORM**	FVF No.:
Project: Former Gun and Trench Mortar Range MRS RFI	Site Location: RFAAP, Virginia	Date:
Applicable Document/Section:		
Subject:		

FIELD CHANGE CONDITION DESCRIPTION

RECOMMENDED APPROACH/ REVISION

IMPACT ON PRESENT AND COMPLETED WORK

Requested By:

Approved By: Approval Date:

UFP-QAPP ACKNOWLEDGEMENT

Project: Former Gun and Trench Mortar Range MRS RFI, RFAAP, Virginia

Document Name: UFP-QAPP

I understand, agree to, and will conform to the information set forth in the project work plan, attachments, appendices and discussed in the daily safety tailgate meetings.

Acknowledgement

Name	Company	Signature/ Date

Attach additional pages as necessary.

APPENDIX H

FIELD STANDARD OPERATING PROCEDURES

Provided on CD.

SOP G-1

FIELD DOCUMENTATION

STANDARD OPERATING PROCEDURE G-1

FIELD DOCUMENTATION

1. SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes procedures for proper field documentation. When samples are collected for chemical or physical characteristics analysis, field surveys or measurements are performed, or oversight of field activities is undertaken, field documentation must be completed. The field logbook serves as a permanent and traceable record of all field activities related to a project and will become a part of the project files. The information presented in this SOP focuses on the completion of field logbooks and/or field forms for documenting field activities conducted by CONTRACTOR.

All data collection will be documented in either a bound field logbook or on appropriate field forms. Field logbooks will be assigned to individual field personnel for daily entries. Notes in the bound field logbooks will be made legibly, written in black or blue ink, and be as detailed and descriptive as possible so that a particular situation may be recalled without reliance on the collector's memory. No blank pages or sections of pages will be allowed. If a page is not completely filled in, a line will be drawn through the blank portion and initialed by the person keeping the log. There should be no erasure or deletions from the field notes. At the end of each day, the logbook will be signed and dated.

2. EQUIPMENT

Field logbooks
Field forms

3. RELATED PROCEDURES

None

4. PROCEDURES

4.1 FIELD LOGBOOK

The field logbook is the primary means of documenting field activities. It must be completed concurrent with field activities and present a thorough but concise summary of the activities conducted. The field logbook should enable the field activities to be reconstructed without relying on the field member's memory. Refer to the Logbook Operating Practices provided at the end of this SOP for detailed descriptions of field logbook entry procedures. Logbooks should be kept in the field member's possession or in a secure place during field work. General provisions for field logbooks include:

- Project name/location and sequential logbook number should appear on the cover.
- Contact information should be recorded inside the front cover in case the logbook is misplaced.
- Write legibly and use a black or blue ink pen for all logbook entries.
- Corrections should be made by crossing out the data with a single strike mark, which will be initialed and dated by the person making the correction. Ensure that the original entry being struck out is still readable.
- Each page of the logbook should be sequentially numbered, dated, and signed by the field team member.
- Time should be recorded in military time (24-hour clock).
- For field sampling or data collection events documented in the logbook, entries should include but not be limited to:
  - Name of author, date, and time of entry.
  - Name, company/agency affiliation, and responsibility of field team members.
  - Names, titles, and arrival/departure times of any site visitors.
  - Weather (e.g., temperature, cloud cover, humidity, wind).
  - Health and safety briefings, personal protection equipment (PPE) level, or changes or issues encountered.

- Calibration of field equipment.
- Description of task.
- Sample or data collection method.
- Number and volume of sample(s) taken.
- Date and time of collection.
- Sample identification number(s).
- Information concerning sampling changes, scheduling modifications, and change orders.
- Details of sampling locations and visual observations of matrix sampled in accordance with ASTM D2488 (e.g., soil description, odors, discolorations).
- Site sketch of sample locations.
- Sample preservation.
- Sample matrix.
- Sample analysis to be performed.
- Field observations.
- Any field measurements made.
- Decontamination procedures.
- Documentation for investigation derived wastes (IDW) (e.g., contents and approximate volume of waste, disposal method).
- Documentation of any scope of work changes required by field conditions.
- Description of photographs taken.

▪ For oversight activities of consultants and contractors, entries should include, but not be limited to:

- Name of author, date, and time of entry.
- Name, company/agency affiliation, and responsibility of field team members.
- Oversight location and task.

- Names, titles, and arrival/departure times of any site visitors.
- Weather (e.g., temperature, cloud cover, humidity, wind).
- Arrival and departure times of oversight staff.
- Observations of ongoing activities.
- Compliance with or deviation from approved plans.
- Details of sampling locations and visual observations of matrix sampled in accordance with ASTM D2488 (e.g., soil description, odors, discolorations).
- Details of any split samples collected, including location, matrix, field sample IDs.
- Description of photographs taken.

4.2 FIELD FORMS

Various field data collection forms may be used to streamline the documentation of field data. Field forms may also be customized for large data collection efforts. If field data are recorded on a field form, this data entry should be documented in the daily field logbook entry. Field form data entry should be executed with the same quality standards as field logbook data entry. Entries should be neatly written in black or blue ink and corrections made with single line strike-out and initials. Original field forms should be submitted daily to the Task Manager and be incorporated into the project file.

Examples of field forms that may be used for documenting field activities are summarized in the following sections and included in the Sample Forms section at the end of this SOP.

4.2.1 Soil Boring Log

A Soil Boring Log for Direct Push Technology (e.g., Geoprobe) or hollow-stem auger split spoon sampling (see Sample Forms section) may be completed when CONTRACTOR installs or oversees the installation of a soil boring. Information documented on the Soil Boring Log will include:

- Sample depths.

- Penetration/recoveries.
- Analytical sample IDs.
- Blow counts (if applicable).
- Soil classification and lithological description.
- Material origin (natural or fill).
- Observed product, odor, or sheen.
- Instrument readings.

4.2.2 Well Construction Log

In the event that a borehole is completed as a groundwater monitoring well or piezometer, details of the construction may be documented in a Well Construction Log (see Sample Forms section). Information documented on the Well Construction Log includes:

- Total well depth.
- Well diameter.
- Well construction materials.
- Screen interval.
- Construction details.
- Graphic depiction of well construction.

4.2.3 Well Development

Development of a newly installed monitoring well or redevelopment of an existing monitoring well may be documented on a Well Development Form (see Sample Forms section). Information documented on the Well Development Form includes:

- Well ID and construction details.
- Purge rates.
- Headspace readings.
- Turbidity readings.
- Field notes or observations.

4.2.4 Low Flow Groundwater Sampling Record

Low flow groundwater sampling will be documented on a Low Flow Groundwater Sampling Record (see Sample Forms section). Information documented on the sampling record includes:

- Well ID and construction details.
- Times, purge rates, and parameter readings during purging.
- Final parameter values.

- Times, purge rates, and parameter readings during purging.
- Final parameter values.
- Well condition survey.
- Additional field notes or observations.

4.2.5 Test Pit Log

A Test Pit Log (see Sample Forms section) may be used to record samples collected from test pits, the nature of the soil within the test pit, water entry zones, and types of material observed.

Logbook Operating Practices

Procedure

- Logbooks are permanently bound, all pages numbered.
- Entries should begin on page 1.
- Use only blue or black ink (waterproof).
- Sign entries at the end of the day, or before someone else writes in the logbook.
- If a complete page is not used, draw a line diagonally across the blank portion of the page and initial and date the bottom line.
- If a line on the page is not completely filled, draw a horizontal line through the blank portion.
- Ensure that the logbook clearly shows the sequence of the day's events.
- Do not write in the margins or between written lines, and do not leave blank pages to fill in later.
- If an error is made, draw a single line through the error and initial it.
- Maintain control of the logbook and keep in a secure location.

General Information

- Date on every page.
- Team members and initials listed at beginning of day.
- Other personnel and affiliation (e.g. OSC-Smith, OSC-Jones).
- Written legibly.
- Signatures of author at bottom of every page.
- Signatures when change of recorder.
- Corrections are single lined and corrections are initialed.
- Team members' site entries and exits are documented.
- Chargeable off-site activities are documented.
- Note End of Logbook on last page ("End of Logbook").
- Late entries noted appropriately.

Field Logbooks

- General information.
- Name, location of site, and work order number.
- Name of the Site Manager or Field Team Leader.
- Names and responsibilities of all field team members using the logbook (or involved with activities for which entries are being made).
- Weather conditions.
- Objective narratives written.
- Field observations.
- Names of any site visitors, including entities that they represent.

Sampling

- Time collected.
- Grab/composite.
- Sample location.
- Type of analysis.
- Shipping information.
- Number and types of collected samples.
- Sample location with an emphasis on any changes to documentation in governing documents (i.e., Work Plan, QAPP). This may include measurements from reference points or sketches of sample locations with respect to local features.
- Sample identification numbers, including any applicable cross-references to split samples or samples collected by another entity.
- A description of sampling methodology, or reference to any governing document (i.e., Work Plan, QAPP).
- Summary of equipment preparation and decontamination procedures.
- Sample description including depth, color, texture, moisture content, and evidence of waste material or staining.
- Air monitoring (field screening) results.
- Types of laboratory analyses requested.

Photo Logs

- Camera and PDA (IDs).
- Date of pictures.
- Time of pictures.
- Directions of photos.
- Description of photos.
- Photographer/witness.

Safety

- All safety, accident, and/or incident reports.
- Real-time personnel air monitoring results, if applicable, or if not documented in the HASP.
- Heat/cold stress monitoring data, if applicable.
- Level of protection for tasks.
- Reasons for upgrades or downgrades in personal protective equipment.
- Health and safety inspections, checklists (drilling safety guide), meetings/briefings.
- Equipment make, model, and serial number for monitoring instruments
- Calibration records for monitoring instruments.
- Site safety meeting (time/topics).
- Site objectives/ plan of activities.
- Chemical/physical hazards.
- Personnel attending.
- Special personnel information (allergies, etc.).

Equipment

- Equipment type (make and model).
- Serial nos.
- Calibration records.
- Background readings and locations.
- Monitoring readings and locations.
- Sampler(s) initials.

Contractor Oversight Activities

- Progress and activities performed by contractors including operating times.
- Deviations of contractor activities with respect to project governing documents (i.e., specifications).
- Contractor sampling results and disposition of contingent soil materials/stockpiles.
- Excavation specifications and locations of contractor confirmation samples.
- General site housekeeping and safety issues by site contractors.
- Equipment and personnel on-site.
- Duration of equipment use vs. standby.
- Inventory of shipments received (or verification of items on packing slip).
- Document inspection of disposal trucks arriving at site (e.g., visual observation of clean tankers or truck trailers, etc.).

SAMPLE FORMS

GEOPROBE Soil Boring Log

Job Name	**Boring No.**	**Logged By**
Job No.	**Page ____ of ____**	

Date Drilled	**Boring Method/ Sample Method** Geoprobe / Macrocore 4-ft 5-ft
Drilling Co.	**Completion Depth**
Drill Foreman	**Location**

Depth (Feet)	Recovery (% or inches)	PID every 6"	Visual Description	Sample No.	Comments

Depth to Groundwater: _____

Monitoring Well Installed? YES NO

Monitoring Well ID: _____

Location surveyed? Yes No GPS Surveyor Other

Backfill Type: Cuttings Cuttings/Bentonite Bentonite Asphalt / Concrete

Soil Logging Visual Descriptors

FORMAT: Moisture - Color - Soil Type (gradation) - Compactness/Consistency - Observations

EXAMPLE: Saturated brown medium SAND, little coarse gravel, trace silt, dense, odor.

Soil Type

clay	
silt	
sand	
fine	
medium	
coarse	
gravel	> 0.19"
fine	
coarse	
cobbles	3-12"
boulders	> 12"

Gradation

	%
"and"	35-50
"some"	20-35
"little"	10-20
"trace"	0-10

Observations

staining
sheen
smearing
odor
product (residual or free)
other

Moisture

Descriptor
dry
moist
wet
saturated

Color

light brown
brown
dark brown
red
red-brown
tan
dark grey
light grey
olive grey
white
orange
yellow
green
black

Compactness (coarse-grained, non-plastic)

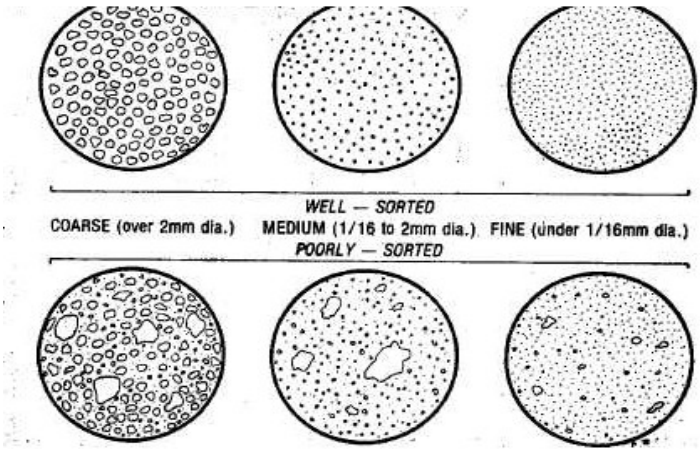
Descriptor	Blow Counts
loose	< 11
medium dense	11-30
dense	31-50
very dense	> 50

Consistency (fine-grained, some plasticity)

Descriptor	Blow Counts	
very soft	< 3	
soft	3-5	thumbtip indent- easy
medium	6-15	thumbtip indent- hard
stiff	16-25	thumbnail indent- easy
hard	> 25	thumbnail indent- hard

Sorting (Native materials/native sands only)

Well-sorted	=	uniform grain size
Poorly sorted	=	mix of grain sizes
Upward-fining	=	coarse grains at bottom of unit
Upward-coarsening	=	fine grains at bottom of unit



SPLIT SPOON Soil Boring Log

Job Name	Boring No.	Logged By
Job No.	Page ____ of ____	

Date Drilled:	Boring Method	Mud rotary Air rotary ODEX Hollow-stem auger
Drilling Co.:	Sample Method	Spoon diameter 2" 3" other _____
Driller:	Completion Depth	Boring diameter (fill in) _____

Depth (Feet)	Recovery	PID every 6"	Blow Counts for each 6"	Visual Description	Sample No.	Comments

Depth to Groundwater: _____

Monitoring Well Installed? YES NO

Monitoring Well ID: _____

Location surveyed? Yes No GPS Surveyor Other

Backfill Type: Cuttings Cuttings/Bentonite Bentonite Asphalt / Concrete

TEST PIT LOG

	Project Name:
	Project Number:
	Project Manager:
	Location:
	Test Pit ID:
	Logged By:
	Contractor:
Date Excavated:	**Remarks:**
Equipment Used:	
Total Depth:	
Dimensions:	
Water Table:	
Ground Surface Elev.:	

Depth (inches)	Field Screening Result	Sample I.D.	Sample Interval	Geologic Unit	Material Description

SOP G-3

FIELD SAMPLE NUMBERING

STANDARD OPERATING PROCEDURE G-3

FIELD SAMPLE NUMBERING

1. SCOPE AND APPLICATION

The objective of this Standard Operating Procedure (SOP) is to define the method for assigning field sample identifiers (IDs), which will be used on sample containers, field logbooks, and/or field data collection sheets. The purpose of the field sample IDs is to provide additional information about the sample to end users of the data. It is expected that this approach will add supplemental value for users who are evaluating data in tabular form, without the benefit of any other spatial reference.

Sample labels are required to properly identify samples and evidence. All samples must be properly labeled with the label affixed to the container prior to transportation to the laboratory.

In order to provide additional information in the sample ID, a set of requirements and guidance has been prepared to assist the data users in the execution of a scheme for building intelligence into the sample nomenclature. The mechanisms for recording the field sample ID are the Sample Attribute Form, the field logbook or data collection sheet, the sample container label, and the chain-of-custody forms.

From a data management perspective, the key requirement for the field sample ID is that it represents a unique name. The field sample ID and its corresponding attribute information will be captured electronically and linked within the project database.

Information on sample labels should be limited to the following:

- **Field Sample ID**—Each sample, including field control samples, collected for a project should be assigned a unique character name (see below).
- **Samplers**—Each sampler's name and signature or initials.
- **Preservative**—Whether a preservative is used and the type of preservative.

- **Analysis**—The type of analysis requested.
- **Date/Time**—The date and time the sample was taken.
- **Type of Sample**—The sample identified as either discrete or composite.

2. EQUIPMENT

Sample labels
Pen with indelible ink
Sample Attribute Forms

3. RELATED PROCEDURES

G-1 Field Documentation
G-8 Sample Chain-of-Custody

4. PROCEDURE

4.1 FIELD SAMPLE ID

The environmental and associated QC samples collected during the field investigation will be labeled with a sample ID number. The sample numbers will be recorded in the site logbook, the chain-of-custody, and the shipment documents in accordance with relevant SOPs.

The sample ID will be composed of four components:

[_ _]	[_ _]	[_ _]	[_ _]
1	2	3	4

Component 1 – Defines the site location using a number:

AI##=Area of Interest Number

WD=Waste Disposal Sample

Component 2 – Is the individual sample type and location identifier where:

SB## = soil boring

SD## = sediment sample

MW## = monitoring well

AQD# = Aqueous waste disposal number (#)

SOD# = Soil waste disposal number (#)

Component 3 – Defines QA sample type:

00 = Environmental sample

01 = Duplicate sample

02 = Equipment blank (rinsate)

03 = Trip blank

04 = Matrix spike

05 = Matrix spike duplicate

Component 4 - Indicates the soil sample depth. This component will not be included in groundwater or waste sample ID structure:

1 = 0 to 12 inches

2 = 1 to 2 ft

3 = 2 to 3 ft

4 = 3 to 4 ft

5 = 4 to 5 ft

and so on.

A typical sample may be identified as AI11-SB50-00-1. The “AI11” indicates an Area of Interest 11 sample, and the “SB” indicates the sample is a soil boring sample at location number 50. The “00” indicates that the sample is an environmental sample and the “1” indicates that the sample was collected from the boring at 0 to 12 inches bgs.

SOP G-4

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING

STANDARD OPERATING PROCEDURE G-4

QUALITY ASSURANCE/QUALITY CONTROL SAMPLING

1. SCOPE AND APPLICATION

Quality assurance/quality control (QA/QC) measures are those activities undertaken to demonstrate the accuracy (how close to the true value the results are) and precision (how reproducible the results are) in monitoring. QA generally refers to a broad plan for maintaining quality in all aspects of a program. QC consists of the steps taken to determine the validity of specific sampling and analytical procedures. Quality assessment is the assessment of the overall precision and accuracy of the data, after it is analyzed.

2. EQUIPMENT

American Society for Testing and Materials (ASTM) Type II reagent-grade water.

3. RELATED PROCEDURES

SOP G-1 Field Documentation
SOP G-3 Field Sample Numbering
SOP G-8 Sample Chain-of-Custody

4. PROCEDURES

4.1 FIELD DUPLICATES

For each sampling round, one duplicate sample is collected for every 10 routine samples. These duplicate samples are taken immediately following the collection of the samples. They are intended to duplicate the routine sample collected. Soil duplicates from split-spoons will be collected by splitting the soil in the spoon lengthwise and dividing the soil into the standard and duplicate containers. Soil and sediment field duplicate samples for organics other than volatiles

are thoroughly homogenized and then transferred into their appropriate sample containers before shipment to the analytical laboratory. A note needs to be made in the appropriate field logbook indicating that a duplicate sample was collected, and describing how it was collected. Duplicates will be handled in the same manner as all other samples.

SOP G-3, Field Sample Numbering, identifies the numbering scheme.

4.2 EQUIPMENT BLANKS

Equipment blank samples are collected daily and analyzed to determine the effectiveness of decontamination practices. Equipment blanks (also called rinse or rinsate blanks) are collected at a frequency of 5 to 10% of samples. If fewer than 20 samples are collected in a day, 1 equipment blank sample will be collected. Equipment blank samples are collected as follows:

- Sample bottles for equipment blanks are of the same type as routine sample bottles and will be prepared prior to sampling.
- Pour ASTM Type II reagent-grade water over and/or into the decontaminated sampling equipment. Then pour the water from the sampling equipment into the equipment blank sample jars.
- After all bottles are filled, label the sampling equipment with the associated routine sample ID number and use that sampling equipment to collect the environmental sample at that particular sampling location.
- Note in the field logbook that an equipment blank was collected for that particular sampling location.

Once collected, handle equipment blank samples in the same manner as routine samples.

4.3 TRIP BLANKS

The purpose of a trip blank sample is to determine whether factors during transport may have affected the sample quality of volatile organic compounds (VOCs).

A trip blank prepared in the laboratory or field consists of two VOC sample bottles filled with ASTM Type II reagent-grade water. Trip blanks will be obtained the morning prior to sampling and will accompany the associated routine sample bottles in the same cooler. When the day of sampling is completed, the trip blanks will be handled in the same manner as routine samples

and returned to the laboratory. Trip blanks will be collected at a frequency of 1 per day of VOC sample shipment. A note should be made in the field logbook that a trip blank accompanied the particular samples.

4.4 MS/MSD SAMPLES

Matrix spike/matrix spike duplicate (MS/MSD) samples are collected for the laboratory to perform internal QC checks. MS/MSD sampling involves collection of triple the volume of a routine surface water or groundwater sample. No additional volume is required for soil. MS/MSD samples are collected at a rate of 1 for every 20 samples. They are collected as separate samples immediately after the collection of the routine samples for the same parameter. The sample collection procedure is as follows:

- Additional bottles will be prepared the first day so the sampling teams will be ready to sample. For example, a routine sample for polychlorinated biphenyls (PCBs) requires two 1-liter amber glass bottles. An MS/MSD sample for PCBs requires six 1-liter amber glass bottles.
- Note in the field logbook that an MS/MSD sample was collected at that particular location. Once collected, handle samples in the same manner as routine samples.

The MS/MSD samples are identified using the standard nomenclature as outlined in **SOP G-3**, with the designation of MS/MSD on the chain-of-custody form and on the sample containers. Chain-of-custody procedures are presented in **SOP G-8**.

SOP G-6

DECONTAMINATION

STANDARD OPERATING PROCEDURE G-6

DECONTAMINATION

1. SCOPE AND APPLICATION

All personnel or equipment involved in intrusive sampling or entering an area during intrusive sampling must be thoroughly decontaminated prior to sampling and prior to leaving the site to minimize the spread of contamination and prevent adverse health effects. This Standard Operating Procedure (SOP) describes the normal decontamination of sampling and site equipment. To minimize the possibility of cross-contamination of samples (contamination of a sample by chemicals picked up at another area and transferred to an analytical sample by sampling or drilling equipment), proper decontamination procedures must be followed consistently.

Generally, solvents are used to remove organic compounds, such as volatile organic compounds (VOCs) and polychlorinated biphenyls (PCBs); nitric acid is used to remove residual metals; and detergent wash and/or steam cleaning are used to remove gross contamination and soil. All material and equipment should arrive intact and in clean condition. Recommended procedures for equipment decontamination during drilling, test pit operations, sampling, and other field investigation procedures are described in the following sections.

2. EQUIPMENT

Plastic sheeting, buckets, etc. to collect wash water and rinsates
Approved potable water
Deionized (DI) water
Medical-grade isopropanol or equivalent
Reagent grade 0.10N nitric acid
Non-phosphate laboratory detergent (Liquinox)
Aluminum foil or clean plastic sheeting
Pressure spraying, rinse bottles, brushes

Plastic garbage bags
0.01N hydrogen chloride (HCl)

3. RELATED PROCEDURES

G-7 Management of Investigation Derived Waste (IDW)

4. PROCEDURE

4.1 SAMPLE BOTTLES

At the completion of each sampling activity, the exterior surfaces of the sample bottles must be decontaminated as follows:

- Be sure the bottle lids are on tight.
- Wipe the outside of the bottle with a paper towel to remove gross contamination.

4.2 SOIL SAMPLING EQUIPMENT

Sampling equipment that will be used includes materials such as stainless steel bowls, trowels, scoops, and split-spoons. Equipment to be used during sampling will be decontaminated at a centralized decontamination area site at which the equipment is being used. All sampling equipment will be decontaminated after use to prevent cross-contamination between sampling points. Decontaminated equipment will then be wrapped in aluminum foil with the shiny side facing out. No sampling debris will be left on any site.

The procedure for decontaminating sampling equipment is as follows:

- Place dirty equipment on a plastic ground sheet at the head of the decontamination line.
- Rinse equipment with potable water to remove surface dirt and mud if necessary.
- Scrub equipment with a bristle brush using a non-phosphate detergent (e.g., Liquinox) and potable water. To clean the inside of a bailer, use a bottlebrush pulled through the bailer with a polypropylene cord.

- Rinse off soap with potable water.
- Using a squirt bottle, rinse with 10% ultrapure nitric acid (use 1% nitric acid for metallic sampling materials) if equipment will be used for the collection of metals samples. Collect nitric acid rinsate in a tub or bucket.
- Rinse with American Society for Testing and Materials (ASTM) Type II reagent-grade water.
- For equipment used to collect samples analyzed for organics, rinse with medical-grade isopropanol or equivalent. Collect solvent rinsate in a tub or bucket separate from the nitric acid rinsate.
- Rinse with ASTM Type II reagent-grade water.
- Allow equipment to air dry.
- Wrap equipment with aluminum foil (shiny side facing out).
- Sampling equipment used to collect samples for organic analyses will not be allowed to contact any type of plastic after decontamination.
- Equipment that can not be washed and rinsed (e.g., PID) should be covered with a plastic bag while sampling, with only the probe tip exposed.

At the end of the decontamination procedures, the proper disposal of the decontamination liquids will include the following steps:

- Discharge potable water in the decontamination area.
- Rinse soapy washtub in the decontamination area only.
- Dilute the detergent wash water and discharge it in the decontamination area.
- Overturn tubs to allow them to drain.
- Rinse tub bottoms and stack tubs for future use.
- The isopropanol, nitric acid, and DI rinse should be placed in a designated 55-gallon drum or other designated container for future characterization and disposal.

4.3 DRILLING EQUIPMENT

Drilling rigs will arrive on-site in clean condition and will be inspected by a WESTON geologist. After arrival at the site, all equipment, tools, and tool storage areas that will be used in the drilling, sampling, and completion of the soil borings and monitor wells will be steam cleaned

before initiating drilling at any site to remove road dirt. The frequency and procedures for decontamination of drilling equipment are as follows:

- The drill rig and all equipment will be steam cleaned when they are moved to new sites, or more often if required by CONTRACTOR.

- The drill rig (i.e., deck derrick and undercarriage) will not be steam cleaned between soil borings and wells at the same site unless gross contamination is present on the rig that could fall off and enter subsequent boreholes. It is very important during this initial decontamination of the rig to check the threads of the drilling rods and drilling bits for grease, and to remove it (with a wire brush and Liquinox detergent) if it is present. The only allowable "lubricant" on the threads is Teflon tape.

- The surfaces of the drilling equipment, including drill rods, augers, bits, and associated tools (including any tape measures), will be decontaminated at a central site-specific decontamination area using the following procedures:

  – Remove gross amounts of mud/soil using a shovel, wire brush, or other tools.

  – Transport drill rig and tools to site decontamination area.

  – Steam clean the equipment thoroughly, using a brush to remove any particulate matter or surface film. If the equipment is still not clean, proceed to the following steps. Otherwise allow the equipment to air dry.

  – If necessary, use a brush and a phosphate-free detergent/potable water solution to scrub the drilling tools that may enter a subsequent borehole. Use a brush to remove any clinging soil or surface film. If the soil/mud on the tools can be easily removed by steam cleaning, this step can be skipped.

  – Rinse the equipment thoroughly with potable water and allow it to air dry.

  – Drill rods and manmade well construction materials will be decontaminated on a steel rack (one set per rig on-site), provided by the driller, that keeps the piping 2 or 3 feet above the ground. Precautions should then be taken, by using plastic sheeting, to ensure that decontaminated casing, augers, and other equipment do not come into contact with the ground and that the storage areas on the drill rig or tender are clean.

- At the decontamination site, it may be necessary to fill out properly a Hot Work Permit, depending on the type of steam generator present.

- During split-spoon sampling, subcontractor personnel may be required to help decontaminate the used split-spoons by performing the initial gross cleaning of the split-spoon using a Liquinox (or equivalent) solution and scrub brushes. CONTRACTOR personnel will supervise the initial cleaning and then complete the balance of the decontamination procedures.

4.4 BACKHOE

If a backhoe is being used to excavate test pits in contaminated soil, or if analytical soil samples are to be collected from test pits, the following decontamination procedures should be followed:

- Prior to excavation of any test pit and between test pits, steam clean the backhoe bucket and arm using a non-phosphate detergent (i.e., Liquinox/potable water solution).
- Rinse the detergent solution from the backhoe bucket and arm by steam cleaning with potable water.

4.5 FIELD PARAMETER EQUIPMENT

- Water level indicators and transducers used for measurement of water in wells and in surface waters will be decontaminated after each use by flushing with ASTM Type II reagent-grade water prior to and after each use. If floating product or high levels of organic contamination are evident, or known to exist in a well, the full sampling decontamination procedure outlined in Subsection 4.2 will be employed.
- Water quality instrument probes will be flushed with ASTM Type II reagent-grade water between measurements. No solvents will be used to clean these probes.
- Turbidimeter sample vials will be wiped dry after being filled with a sample and prior to insertion into the turbidimeter. After the measurement is taken, the sample vial and the turbidimeter will be flushed with ASTM Type II reagent-grade water.

4.6 SUBMERSIBLE PUMP

All submersible pumps used for sampling or for well development will be decontaminated after use to prevent cross-contamination between wells. The procedure for decontaminating submersible pumps is as follows:

- Scrub pump and cord in a tub of Liquinox and potable water.
- Pump (or recirculate) at least 20 gallons of the soapy water through the pump.
- Rinse with potable water.
- Pump (or recirculate) at least 20 gallons of rinse water through the pump.
- Rinse with DI water.
- Place pump in a decontaminated, plastic garbage can, or wrap it in clean plastic.

After decontamination, the proper disposal of the decontamination liquids includes the following steps:

- Drain wash water and rinse in decontamination area.
- Rinse decontamination containers with potable water.
- Allow containers to dry overnight.

5. PRECAUTIONS

- Dispose of all wash water, rinse water, rinsates, and other sampling wastes (e.g., tubing, plastic sheeting) in properly marked, sealable containers, or as directed.
- Once a piece of equipment has been decontaminated, be careful to keep it in such condition until needed.
- Follow the health and safety plan in regard to personal protective equipment (PPE), especially with regard to eye protection and gloves.

6. BIBLIOGRAPHY

ASTM Standard D5088. 2008. "Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites." ASTM International, West Conshohocken, PA. 2008, DOI: 10.1520/D5088-02R08. www.astm.org.

SOP G-7

MANAGEMENT OF INVESTIGATION DERIVED WASTE (IDW)

STANDARD OPERATING PROCEDURE G-7

MANAGEMENT OF INVESTIGATION DERIVED WASTE (IDW)

1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe the requirements for investigation derived waste (IDW) management. The requirements of these procedures are applicable to management for wastes generated as a result of field sampling and characterization activities and not yet characterized by laboratory analysis as hazardous or non-hazardous wastes. The goal of IDW management is to minimize the amount of waste generated while following applicable regulations. Field personnel should review and understand all applicable federal, state, and local regulations regarding IDW. Regulations may prohibit disposal of certain IDW on-site.

Prior to commencing sampling of remediation, the Field Team Leader will select an area, preferably secure, for IDW storage in consultation with the On-Site Manager.

Any container used for IDW will be U.S Department of Transportation (DOT) approved. Drums will not be stacked on top of each other and will be stored in rows not larger than two drums wide, with labels facing outward for identification. Decontamination fluids and other low-volume fluids may be temporarily stored and transported in 5-gallon buckets with lids.

Different residual materials (e.g., soil and water) will not be drummed together, but will be placed in separate drums. Field screening will be used to drum materials with similar levels of contamination together, if possible.

2. EQUIPMENT

Wrangler type boxes
DOT-approved drums or other containers
Funnels
5-gallon buckets

Photoionization detector (PID) or other appropriate instrumentation
Labeling material

3. RELATED PROCEDURES

SOP G-6 Decontamination
SOP A-2 Calibration and Use of Air Monitoring Instruments

4. IDW MANAGEMENT

All soil cutting IDW will be placed back in the boring or thin spread around the borehole in accordance with EPA protocols set forth in the EPA document "Management of Investigation-Derived Wastes During Site Inspection" (EPA, 1992). As existing site information thus far has shown the groundwater to be non-hazardous, the purge water from monitoring wells will be discharged into the ground next to the well to allow infiltration. As necessary, IDW-filled drums will be transported to the secure staging area at the site in accordance with applicable DOT and U.S. Environmental Protection Agency (EPA) regulations.

The IDW-filled drums must be sampled to determine whether they contain materials classified as Resource Conservation and Recovery Act (RCRA) hazardous wastes. IDW-filled drums containing RCRA hazardous wastes must be shipped off-site within 90 days.

The EPA *Guide to Management of Investigation-Derived Wastes* (January, 1992) will be used to assist in management of IDW where necessary.

4.1 SOIL

Soil cuttings and excess samples will be returned to boring, pit, or source immediately after generation and/or spread around boring, pit, or source within the AOC.. Soil cuttings characterized as "impacted" based on visual, olfactory and field instrument readings (e.g., Photoionization detector) will be sealed and labeled in accordance with labeling practice.

4.2 LIQUIDS

Residual liquid such as water from well sampling and development will be poured on the ground next to the well. Decontamination water must be containerized. It will be placed in a temporary holding tank or DOT-approved drums or containers as appropriate. Drums will be sealed and labeled in accordance with labeling procedures. Decontamination solvents and test kit solvents will be segregated from aqueous material and allowed to evaporate as much as possible before being containerized in solvent-specified drums. Liquids drums will contain removable bungs. Funnels will be used to prevent spillage when adding liquids to the drums.

4.3 PERSONAL PROTECTIVE EQUIPMENT (PPE) AND OTHER DISPOSABLES

Project-specific provisions should be made prior to disposal of IDW. Do not assume bagged waste can be disposed of in any dumpster. All non-contaminated disposable wastes such as bags, washed gloves, and material scrap, will be kept separate from other wastes. This material will be bagged or otherwise contained and disposed of in the Field Office dumpster or other appropriate and approved location.

Contaminated disposable wastes may include disposable PPE and contaminated equipment. This material will be placed in wrangler-type boxes unless field screening results of soil and/or waste residuals indicate non-elevated results.

5. DISPOSAL OPTIONS

Wastes that have been drummed based on field criteria may be sampled for laboratory analysis to determine the appropriate type of disposal facility. The number of samples collected will depend on the homogeneity of the drummed material, the nature of the source areas, and the requirements of the disposal facility.

IDW characterized or listed as hazardous waste will be managed and disposed of in a manner consistent with local and state guidance, and federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and/or RCRA or Toxic Substances Control Act (TSCA) guidelines.

IDW determined to be non-hazardous waste will be managed and disposed of in accordance with state and/or local guidelines.

5.1 LABELING

Pending a determination of whether the IDW is hazardous or non-hazardous, containers will be labeled on the side using a weather-resistant paint pen. The following information will be included:

- Investigation Derived Waste (IDW)
- Sampling location identification.
- Sampling area designation.
- Point of contact with phone number.
- Type of material.
  - OB—Overburden soil and cuttings.
  - SD—Sediment.
  - GW—Groundwater from wells.
  - DW—Decontamination water.
  - DS—Disposables.
  - SV—Decontamination solvents.
- Water content.
  - SAT—Saturated.
  - UNSAT—Unsaturated.
- For drums containing liquids, indicate the approximate fill line on the outside of the drum. Do not fill more than two-thirds full with liquids.
- Range of field screening results and instrument type.
- Date the drum was filled and sealed.

Only IDW pending analysis may be labeled. Any wastes known to be RCRA or TSCA wastes based on knowledge of the waste material must be managed as RCRA or TSCA at the point of generation. Upon receipt of analytical results for those IDW containers, the respective containers must immediately be managed appropriately.

6. BIBLIOGRAPHY

EPA (U.S. Environmental Protection Agency). 1992. *Guide to Management of Investigation-Derived Wastes*. January 1992.

SOP G-8

SAMPLE CHAIN-OF-CUSTODY

STANDARD OPERATING PROCEDURE G-8

SAMPLE CHAIN-OF-CUSTODY

1. SCOPE AND APPLICATION

Chain-of-custody (COC) records provide documentation of the handling of each sample. Sample custody will be initiated by CONTRACTOR upon collection of samples and maintained until samples are relinquished to the shipping carrier for delivery to the laboratory. COC forms will be placed in waterproof plastic bags and taped to the inside lid of the cooler. The cooler will be sealed with COC seals. COC forms will be used for recording pertinent information about the types and numbers of samples collected and shipped for analysis. Sample identification numbers will be included on the COC form to ensure that no error in identification is made during shipment.

2. EQUIPMENT

COC forms
Waterproof plastic resealable bags
COC seals
Labels
Pen
Markers
Tape
Scissors

3. RELATED PROCEDURES

SOP G-1	Field Documentation
SOP G-3	Field Sample Numbering
SOP G-9	Sample Packing and Shipping

4. DOCUMENTATION

4.1 CHAIN-OF-CUSTODY RECORDS

COC procedures provide documentation of the handling of each sample. COC procedures are implemented so that a record of sample collection, transfer of samples between personnel, sample shipping, and receipt by the laboratory that will analyze the sample is maintained. The COC record serves as a legal record of possession of the sample. The COC record is initiated with the acquisition of the sample. The COC record remains with the sample at all times and bears the name of the person (field investigator) assuming responsibility for the samples. The field investigator is tasked with ensuring secure and appropriate handling of the bottles and samples. To simplify the COC record and eliminate potential litigation problems, as few people as possible should handle the sample or physical evidence during the investigation. A sample is considered to be under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession.
- The sample is in the sampler's view after being in possession.
- The sample was in the sampler's possession and then was locked up to prevent tampering.
- The sample is in a designated secure area.

4.1.1 Transfer of Custody and Shipment

All sample sets should be accompanied by a COC record (**Figure 1**). This form records each sample and the individuals responsible for sample collection, transfer, shipment, and receipt by the laboratory. The form must also contain pertinent information about the sampling location, date, and times, signature of sampling technician, types and numbers of samples collected and shipped for analysis in each lot and the project name.

Samples shall be accompanied by an approved and completed COC form during each step of custody, transfer, and shipment. When physical possession of samples is transferred, both the individual relinquishing the samples and the individual receiving the samples should sign, date, and note the time that he/she received the samples on the COC record. This COC record

Figure 1 Example Chain-of-Custody Form

Chain of Custody Record

Client _____ Contact Name _____
Site Name _____ Contact Phone No. _____
W.O. _____ Turn-around-Time _____
Laboratory _____ Sampler _____

Lab Batch Number:

Analysis Requested by Group by Container
(number listed for total containers per analysis group)
Preservative

Lab ID	Sample ID	Matrix QC MS	MSD	DUP	Total Num of Containers	Matrix	Date Collected	Sample Time	App.IX VOA	Total PCBs by Aroclors	Homologs	Congeners		Herbicide	Dioxin/Furan	Appx. IX Metals	CN	Sulfide	TOC	Grain Size	Method TO-4 (Air)				

Field Remarks/Comments

Lab Use Only

Temp of Cooler when Received, C°

1	2	3	4

COC Tape was present on outer package	Y	N	
COC Tape was unbroken on outer package	Y	N	
COC Tape was present on sample	Y	N	
COC Tape was unbroken on sample	Y	N	
Received in good condition	Y	N	
Labels Indicate Properly Preserved	Y	N	
Received within Holding Time	Y	N	

Relinquished by	Received by	Date	Time	Relinquished by	Received by	Date	Time

Page 1 of 1

documents transfer of custody of samples from the field investigator to another person, other laboratories, or other organizational units.

Samples sent off-site for analysis must be properly packaged for shipment, and delivered or shipped to the designated laboratory for analyses. Shipping containers must be secured by using nylon strapping tape and custody seals (see Section 4.2). The custody seals must be placed on the container so that it cannot be opened without breaking the seals. The seal must be signed and dated by the field investigator.

When previously collected samples are split with a facility, state regulatory agency, or other government agency, the agency representative must sign the COC record, if present. All samples should be accompanied by a COC record. The original of the COC record will be placed in a plastic bag taped to the inside lid of the secured shipping container and transmitted to the laboratory along with the samples. One copy of the record will be retained by the field investigator or project leader. This copy will become a part of the project file. If sent by mail, the package should be registered with return receipt requested. If sent by common carrier, an air bill should be used. Receipts from post offices and air bills should be retained. The air bill number or registered mail serial number should be recorded in the remarks section of the COC record.

4.2 CHAIN-OF-CUSTODY SEALS

The COC seal is an adhesive seal placed in areas such that if a sealed container is opened, the seal would be broken (**Figure 2**). The COC seal ensures that no sample tampering occurred between the field and the laboratory analysis.

These signed and dated seals will be placed at the junction between the lid and the jar and on the cooler by the person responsible for packaging. If the coolers or jars are opened before receipt at the laboratory, the seals will not be intact. If the COC seals are not intact, the Laboratory Project Manager will notify the CONTRACTOR'S Analytical Manager within 24 hours of receipt of the container. The CONTRACTOR'S Analytical Manager will then follow the corrective action procedures.

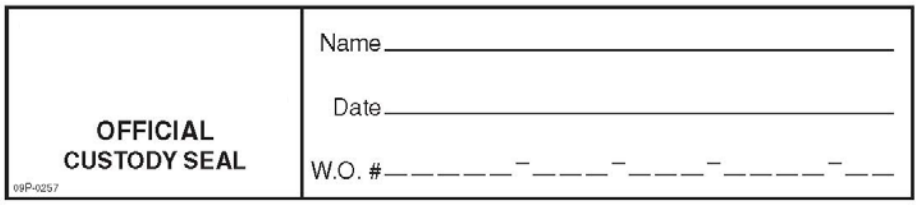


Figure 2 Chain-of-Custody Seal

4.3 SAMPLE LABELS

Every sample container will receive a label. Labels (**Figure 3**) will be completed using waterproof ink and will include the following information:

- Project name.
- Unique sample number.
- Sampling date and time.
- Initials of sampler.
- Sample media (soil, groundwater, etc.).
- Sample collection method (grab or filtered/unfiltered for groundwater).
- Analysis requested/chemical analysis parameters (analytes and EPA SW-846 method number).
- Method of sample preservation/conditioning.
- Remarks (such as photoionization detector readings) are useful.

PROJECT NAME	
SAMPLE ID	**SAMPLE DATE**
SAMPLED BY	**SAMPLE TIME**
SAMPLE MEDIA	**REMARKS**
PRESERVATIVE	**___GRAB ___ COMPOSITE**
ANALYSIS REQUESTED	

Figure 3 Jar/Bottle Label

4.4 POTENTIAL PROBLEMS

Although most sample labels are made with water-resistant paper and are filled out using waterproof ink, inclement weather and general field conditions can affect the legibility of sample labels. It is recommended that, after sample labels are filled out and affixed to the sample container, the container be placed in a plastic resealable bag. This will preserve the label, keep it from becoming illegible, and if the label falls off, the identification of the sample will still be known. In addition to label protection, COC and analysis request forms should also be protected when samples are shipped in iced coolers. Typically, these forms should be placed inside a plastic resealable bag or similar waterproof protection and taped to the inside lid of the secured shipping container with the samples.

5. CORRECTIONS

If an error is made, a single line should be drawn through the entry, and the entry initialed and dated. The erroneous information should not be obliterated. Any errors found in documentation should be corrected by the person who made the entry.

SOP G-9

SAMPLE PACKING AND SHIPPING

STANDARD OPERATING PROCEDURE G-9

SAMPLE PACKING AND SHIPPING

1. SCOPE AND APPLICATION

This section describes procedures for properly packaging and shipping environmental and/or hazardous material samples. The procedures described in this section are performed after samples have been collected and placed in the proper containers and correctly preserved. The person overseeing sample shipping is required to have current certification in the Shipping and Transporting Dangerous Goods Course.

2. EQUIPMENT

Chain-of-custody
Custody seals
Fiber strapping tape
Ice
Waterproof cooler
Plastic resealable bags
Paper towels
Bubble wrap, vermiculite, “peanuts” or other inert packing material
Air bills
Up arrows
Dangerous Goods Shipping Paperwork (if applicable)

3. RELATED PROCEDURES

SOP G-8 Sample Chain-of-Custody

4. PROCEDURE

4.1 ENVIRONMENTAL SAMPLES

Environmental samples are defined as those samples collected from environmental matrices (that are known or expected to be contaminated) such as soil, groundwater, or sediments that are being shipped for further testing. Environmental samples should be packaged for shipment as follows (refer to WESTON's *Manual of Procedures for Shipping and Transporting Dangerous Goods* [WESTON, 2009] for additional information as necessary):

1. The sample container is checked to determine if it is adequately identified, and sample labels are compared to chain-of-custody.

2. All bottles are checked to ensure that the contents are secured.

3. A waterproof cooler (such as a Coleman or other sturdy cooler comprised of metal or equivalent strength material) is typically used as a shipping container. In preparation for shipping samples, if the cooler has a drain plug, the drain plug is taped shut from the outside. Approximately 3 inches of inert packing material, such as bubble wrap, asbestos-free vermiculite, perlite, or styrofoam beads or "peanuts," is placed in the bottom of the container. Vermiculite is not to be used when analyzing for trace metals.

4. The bottles are placed upright in the cooler in such a way that they do not touch and will not touch during shipment. Bubble wrap or cardboard separators may be placed between the bottles at the discretion of the shipper.

5. All samples should be shipped to the laboratory on ice and chilled to 4 °C, except for the geotechnical and other samples that do not require shipment with ice. A temperature blank should be placed in the cooler so that it can be easily found by the laboratory when the cooler is first opened upon receipt.

6. Additional inert packing material is placed in the cooler to partially cover the sample bottles (more than halfway), to ensure they do not shift during transport. If samples are required to be shipped to the laboratory with ice, ice must be double bagged and placed around, among, and on top of the sample bottles. The cooler should then be filled with ice or inert packing material to prevent shifting and breakage of the contents.

7. The paperwork going to the laboratory is placed inside a plastic bag. The bag is sealed and taped to the inside of the cooler lid. The chain-of-custody form is included in the paperwork sent to the laboratory. The air bill must be filled out before the samples are handed over to the carrier. The contract laboratory should be notified by telephone of the shipment along with the estimated time of arrival. If another sample is being sent to another laboratory for analysis (such as dioxin), or if the shipper suspects that the sample contains any other substance that would require laboratory personnel to take additional safety precautions, the individual laboratory must be notified. Also, be sure to discuss with the appropriate laboratory whether samples will be accepted by the laboratory on Saturday. If the laboratory isn't open on Saturdays, one either couldn't sample on Friday or would have to drive the samples to the laboratory so that they were received by the laboratory before closing.

8. The cooler is closed and taped shut with strapping tape (filament-type).

9. Custody seals are placed on the cooler. Additional seals may be used if the sampler or shipper thinks more seals are necessary.

10. "This Side Up" labels must be placed on top of the cooler and on all four sides. "Fragile" labels must also be place on at least two sides.

11. While packing each cooler for shipment, the weight limit set by the shipper is not to be exceeded.

12. The cooler is handed over to the overnight carrier. A standard air bill is necessary for shipping environmental samples. The shipper should be aware of carrier weight or other policy limitations. "Environmental Samples" may be included on the air bill to indicate the nature of the goods. Be sure to affix "Saturday Delivery" stickers on the cooler and select the "Saturday Delivery" check box on the carrier air bill.

4.2 HAZARDOUS SAMPLES

Hazardous samples are defined as those that are known to or suspected to contain contaminated materials and typically include, but are not limited to, oils (liquid nonaqueous phase liquid (LNAPL) and dense nonaqueous phase liquid [DNAPL]), sludges, discarded products, source area samples, and waste profile samples. Hazardous samples must be packaged according to International Air Transport Association (IATA) regulations for air transportation and/or U.S. Department of Transportation (DOT) regulations for ground carrier shipments. Personnel with required duties pertaining to the shipment of hazardous samples and/or other dangerous goods including packaging and/or paperwork preparation will have completed required training as specified by IATA/DOT regulations. At a minimum, employees will have completed

WESTON's Function-Specific Shipping and Transporting Dangerous Goods training course with required refresher training every 2 years.

In accordance with current IATA and DOT regulations, WESTON has prepared a *Manual of Procedures for Shipping and Transporting Dangerous Goods* to instruct employees on the shipment of routine hazardous samples and dangerous goods. Only those employees that have completed the aforementioned training course are qualified to prepare shipments of dangerous goods in accordance with the provisions provided in the *Manual of Procedures for Shipping and Transporting Dangerous Goods*. For shipments not considered to be routine and not covered by the manual, a Dangerous Goods Shipping Advisor within WESTON will be contacted for assistance. Dangerous Goods Shipping Advisors have completed initial (24-hour) and refresher training (16-hour) at IATA- and DOT-endorsed training facilities.

Sample shipments that may contain hazardous constituents must be evaluated and comply with instructions within WESTON's *Manual of Procedures for Shipping and Transporting Dangerous Goods*. Based on historical site information and as part of this field sampling event, there are no planned hazardous waste samples to be shipped for analysis at the FNOD.

5. BIBLIOGRAPHY

Code of Federal Regulations. 49 CFR, Subtitle B, Other Regulations Relating to Transportation, Chapter I, Pipeline and Hazardous Materials Safety Administration, Department of Transportation, Parts 100–185.

International Air Transport Association (IATA). 2009. *Dangerous Goods Regulations*. 50th Edition. Effective from 1 January 2009 through 31 December 2009.

WESTON (Weston Solutions, Inc.). 2009. *Manual of Procedures for Shipping and Transporting Dangerous Goods*.

SOP G-10

SURVEYING

STANDARD OPERATING PROCEDURE G-10

SURVEYING

1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide technical guidance for the surveying of geophysical survey locations and environmental sampling locations. Sampling locations/stations covered in this operating practice include survey control points, geophysical grid corners, wells, piezometers, soil borings, test pits, surface soil and sediment stations, and staff gauges.

This operating practice, however, can also be referenced for surveying other data points, as necessary. The objective of this operating practice is to identify the specific data and reporting requirements for the measuring of coordinates and elevations for environmental sampling locations.

The objective of a sample location surveying effort is to provide accurate and well documented coordinate and elevation information that is referenced to an appropriate benchmark. It is equally important that the calculated coordinate and elevation information is reported in a pre-established format to facilitate the timely uploading of this information into a project's locational database. An increasing number of environmental projects have begun to use integrated geological, hydrological, analytical, and geographical databases to effectively manage, analyze, and report the large amounts of technical information. The link between the project's technical databases and the locational database provides a system for the generation of accurate data presentations (including two-dimensional (2-D) and three-dimensional (3-D) maps and cross-sections). Thus, when planning for a survey effort, or preparing a survey Request for Proposal (RFP), the scope of work (SOW) should include a detailed explanation of the deliverable format for the survey information.

2. EQUIPMENT

Surveying equipment
Calculator
Knife or small saw to notch top of casing survey point
Radio (optional)

3. RELATED PROCEDURES

SOP SS-2 Soil Sampling Using Geoprobe
SOP SS-3 Sediment Sampling
SOP SS-4 Soil Sampling
SOP SS-5 Test Pit Excavation

4. PROCEDURE

All surveying activities shall be performed under the direct supervision of a certified land surveyor. Locations and elevations surveyed shall be measured as the distance in meters from a reference location(s), which is tied to the applicable state plane coordinate system (SPCS). The surveys shall be third order Class II control surveys in accordance with the *Standards and Specifications for Geodetic Control Networks* (Federal Geodetic Control Committee, 1984). Horizontal precision shall be to the nearest 0.1 meter. In the SPCS, the x-coordinate is the east-west axis, and the y-coordinate is the north-south axis. All x,y values shall be positive. Elevations shall be surveyed to a precision of $\pm$0.01 foot and referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929) or North American Vertical Datum, 1988 Adjustment (NAVD 88) depending on project requirements. These surveys should be connected by third order leveling to the NGVD of 1929 or NAVD 1988 in accordance with the *Standards and Specifications for Geodetic Control Networks*.

4.1 SURVEYING DRILLING/SAMPLING LOCATIONS

The surveyor will survey the location (referenced to the applicable coordinate system) and ground elevations of survey grids, soil borings, test pits, and surface soil sampling points among others. Wells and piezometers will require the following survey measurements:

- Adjacent ground surface elevation.
- Adjacent concrete pad surface elevation (center of pad).
- Top of inner casing elevation.
- State plane coordinate location of inner casing.

In most instances, wells and piezometers will have a locking cap, and will be opened and re-locked by the surveyor using keys supplied by the USACE or CONTRACTOR. Elevations for both the natural ground surface (not the concrete well pad) and inner well casings will be surveyed from pre-established reference points. Either a notch of the casing rim or an arrow point painted on the

inside well casing, just below the rim, will designate a casing reference point. If no reference point is observed, the surveyor will establish a reference point. Well locations will be surveyed from the inner casing reference point.

For borings, soil samples, and test pits, the reference elevation equals the ground surface elevation.

The surveyor shall provide only the state plane coordinates for surface water/sediment sampling points; no elevation control is required. The top of each staff gage will be surveyed for state plane coordinate and elevation information.

4.2 ELECTRONIC DELIVERABLE

The survey information for each sample location shall be delivered on computer compact disk (CD) along with a hard copy. The electronic information can be in the form of either Microsoft Excel spreadsheet files or standard ASCII data files. CAD drawing (DWG-type) files may also be required.

Each electronic file MUST contain the following fields or entries for each drilling/sampling location surveyed:

- Client name.
- Site name.
- Site number (NA if not applicable).
- Location ID number.
- Location type (e.g., piezometer, soil boring, test pit).
- Northing (state plane coordinate in feet).
- Easting (state plane coordinate in feet).
- Ground surface elevation (excluding surface water/sediment sampling locations).
- Concrete pad surface elevation (excluding surface water/sediment sampling locations).
- Top of inner casing elevation (for wells and piezometers only).
- Reference elevation (see below for definitions).
- Location and ID of the control benchmark.

All fields must be filled out. If a particular field is not applicable, then “NA” should be placed in that particular field.

4.3 SURVEYOR NOTES

One copy of all field notes collected during the performance of the survey effort plus any survey data reduction notes shall be delivered to CONTRACTOR, along with the survey electronic deliverable, and shall be maintained in the project file.

All topographic survey efforts conducted under contract will be certified by a surveyor with a current surveyor's license in Virginia.

The topographic survey will be completed as near to the time of field work completion as possible. Survey field data (as corrected), including loop closures and other statistical data in accordance with the Standards and Specifications referenced above, will be provided. Closure will be within the horizontal and vertical limits given above. These data will be clearly listed in tabular form: the coordinates (and system) and elevation (ground surface and top of well), as appropriate, for all borings, wells, and reference marks. All permanent and semipermanent reference marks used for horizontal and vertical control (e.g., benchmarks, caps, plates, chiseled cuts, rail spikes) will be described in terms of their name, character, physical location, and reference value. These field data will become part of the project records.

5. BIBLIOGRAPHY

Federal Geodetic Control Committee. 1984. *Standards and Specifications for Geodetic Control Networks.*

SOP G-21

DEMOLITION/DISPOSAL OPERATIONS

STANDARD OPERATING PROCEDURE G-21

DEMOLITION/DISPOSAL OPERATIONS

1. PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide the minimum procedures and safety and health requirements applicable to conducting demolition/disposal operations of munitions and explosives of concern (MEC) for the Radford Army Ammunition Plant Former Gun and Trench Mortar Range MRS Military Munitions Response Program (MMRP).

2. SCOPE

This SOP applies to all Weston Solutions, Inc. (WESTON) site personnel, including contractor and subcontractor personnel, involved in conducting MEC demolition/disposal operations. This SOP is not intended to contain all of the requirements needed to ensure complete compliance, and should be used in conjunction with approved project plans and applicable referenced regulations. Consult the documents listed in Section 19 of this SOP for additional compliance issues.

3. RESPONSIBILITIES

3.1 PROJECT MANAGER

The Project Manager (PM) will be responsible for ensuring the availability of the resources needed to implement this SOP, and will also ensure that this SOP is incorporated into plans, procedures, and training for sites where this SOP will be implemented.

3.2 SENIOR UXO SUPERVISOR

The Senior UXO Supervisor (SUXOS) will be responsible for assuring that adequate safety measures and housekeeping are performed during site operations, including demolition activities, and will visit site demolition locations, as deemed necessary, to ensure that demolition operations are carried out in a safe, clean, efficient, and economic manner. The demolition activities will then be conducted under the direct control of the SUXOS, who will be responsible for supervising demolition operations within the area.

The SUXOS will be responsible for training on-site UXO personnel on the nature of the materials handled, the hazards involved, and the precautions necessary. The SUXOS will also ensure that the Daily Summary Report, MEC Accountability Log, WESTON Demolition Shot Records, and inventory records are properly filled out and accurately depict the demolition events and demolition material consumption for each day's operations. The SUXOS will be present during demolition operations or designate a competent, qualified person to be in charge during any absences.

3.3 UXO SAFETY OFFICER

The UXO Safety Officer (UXOSO) for the site is responsible for ensuring that all demolition operations are being conducted in a safe manner, and is required to be present during MEC demolition operations. The UXOSO will ensure the compliance of the demolition team with the above referenced

documents that are applicable to the particular task being performed. The UXOSO will be responsible for notifying the WESTON PM, United States Army Corps of Engineers (USACE) PM, and local emergency responders in the event of an accident requiring medical attention or the possibility of lost time. The emergency response plan will be used, and first aid, notification, and evacuation will be accomplished as required. The accident site will then be shut down and the scene preserved/secured for the accident investigation team.

3.4 UXO QUALITY CONTROL SPECIALIST

The UXO Quality Control Specialist (UXOQCS) is responsible for ensuring the completeness of demolition operations records and for weekly inspection of the MEC Accountability Log, the Daily Summary Report, the WESTON Demolition Shot Record, and the inventory of MEC and demolition material. The UXOQCS, assisted by demolition team personnel, will inspect each demolition pit and an area of appropriate radius after each demolition shot, in accordance with the approved explosive siting plan, to ensure that there are no kick-outs, hazardous MEC components, or other hazardous items. In addition, the pit may be checked with a magnetometer, and large metal fragments and any hazardous debris will be removed on a per use basis and stored in sealed containers at the Gorge or designated project lay down area. Any MEC or material potentially presenting an explosive hazard (MPPEH) discovered during the QC check will be properly disposed of using the demolition procedures presented in the UFP-QAPP. Extreme caution must be exercised when handling MEC or MPPEH that has been exposed to the forces of detonation. Personnel must adhere to acceptable safe practices and procedures when determining the condition of munitions and fuzes that have not been consumed in the disposal process.

4. RADFORD AAP MRS SPECIFIC ACTIONS

The following describe MRS-specific demolition activities to be followed during activities at the Former Trench and Mortar Range MRS.

- Demolition activities are planned for the northeastern end of the MRS as presented on Figure 1. This location was selected as it is one of the more isolated areas (away from existing structures) within the MRS.
- MEC items removed from within Area A (portion of the New River) will be transported by boat to the shoreline on the northeastern edge (Figure 1) of the MRS to allow for easier transport of the items to the current identified demolition area. The following methods will be followed for transfer of items from the river to the MRS shoreline:
  - Primary Mode: The MEC item will be transferred from the boat to a land-based UXO technician in a 5-gallon bucket for transport to the demolition area.
  - Secondary Mode: If the slope in this area presents a safety hazard for the UXO technician related to standing or moving along the shoreline bank in this area, then a rope will be tied to the bucket handle and with the bucket dragged up the river bank to a more stable location for the UXO technician to take control of the bucket and transport the item to the demolition area. For this mode of transfer, the MEC item will be placed in the bucket with sand placed in the bucket to stabilize the item to prevent the item from being bumped around within the bucket during the transfer.

Proposed Demolition Area

Former Trench Mortar Range

Inaccessible Area

Steep Slope

Area A (31 acres)

Former Gun Range

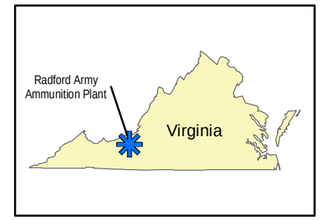
Steep Slope

Inaccessible Area

Legend

- Contours (Feet)
- Proposed Demolition Area
- Area A
- Inaccessible Area
- Former Trench Mortar Range
- Former Gun Range

Imagery Source:
ESRI, Imagery Mapping Service, 2018



N

0 165 330 660
Feet

Prepared By:

Baltimore District

FIGURE 1
PROPOSED DEMOLITION AREA MAP
RADFORD, VIRGINIA

File: Y:\Radford\MXD\Former_Gun_Trench_Prop_DemoArea.mxd, 5/20/2019 12:27:43 PM, johna

- Weston will utilize the Buried Explosion Module (BEM) methodology for all demolition activities that take place in the identified demolition area. Specific BEM protocols are presented in Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) 16. If, due to safety reasons, Weston is not able to transport MEC items up the steep slope for those items removed from Area A, demolition activities will take place along the slope with the utilization of sand bags to provide engineering control. The sandbags will be transported down the slope or via boat to the slope area for the demolition.

5. GENERAL OPERATIONAL AND SAFETY PROCEDURE

Personnel, including contractor and subcontractor personnel, involved in operations on munitions response sites (MRS) will be familiar with the potential safety and health hazards associated with the conduct of demolition/disposal operations, and with the work practices and control techniques used to reduce or eliminate these hazards.

During demolition operations, the general safety provisions listed below will be followed by demolition personnel at all times. Noncompliance with the general safety provisions listed below will result in disciplinary action, which may include termination of employment.

Safety regulations applicable to demolition activities and demolition and MEC materials involved will be complied with.

- Demolition of any kind is prohibited without an approved Explosives Site Plan (ESP).
- If a recovered item cannot be identified by the UXO Team or if the filler is unknown, the UXO Team will not perform the demolition operations. Also, if the minimum separation distances for a known item encompasses critical infrastructure (buildings and utilities) and the item cannot be moved away from the critical infrastructure, the UXO Team will not perform the demolition operations. These circumstances will require EOD support. Notify the USACE OESS.
- The quantity of MEC to be destroyed will be determined by the fragmentation and K-Factor distance calculations, as specified in the approved ESP.
- In the event of an electrical storm, dust storm, or other hazardous meteorological conditions, immediate action will be taken to cease demolition operations and to evacuate the area.
- In the event of a fire, which does not include explosives or energetic materials, put out the fire using the firefighting equipment located at the site? If unable to do so, notify the fire department and evacuate the area. If injuries are involved, remove the victims from danger, administer first aid, and seek medical attention.
- The UXOSO is responsible for reporting all injuries and accidents that occur.
- Personnel will not tamper with any safety devices or protective equipment.
- Any defect or unusual condition noted that is not covered by this SOP will be reported immediately to the SUXOS or UXOSO for evaluation and/or correction.
- Methods of demolition will be conducted in accordance with this SOP and approved changes or revisions thereafter.
- Adequate fire protection and first aid equipment will be provided at all times.

- Personnel engaged in the destruction of MEC will wear clothing made of natural fiber, close-weave clothes, such as cotton. Synthetic material such as nylon is not authorized unless treated with anti-static material.
- Care will be taken to restrict exposure to the smallest number of personnel, for the shortest time, to the least amount of hazard, consistent with safe and efficient operations.
- Work locations will be maintained in a neat and orderly condition.
- Hand tools will be maintained in a good state of repair.
- Each heavy equipment and/or vehicle operator will have a valid operator's permit or license for the equipment being operated.
- Equipment and other lifting devices designed and used for lifting will have the load rating and date of next inspection marked on them. The load rating will not be exceeded and the equipment will not be used without a current inspection date.
- Leather or leather-palmed gloves will be worn when handling wooden boxes, munitions, or MEC.
- Eye protection will be worn when handling wooden boxes, munitions, or MEC.
- Lifting and carrying require care. Improper methods cause unnecessary strains. Observe the following preliminaries before attempting to lift or carry:
  - When lifting, keep your arms and back as straight as possible, bend your knees and lift with your leg muscles.
  - Be sure to have good footing and a firm hold on the object, and lift with a smooth, even motion.
- The demolition area will be provided with two forms of communication, capable of contacting appropriate personnel or agencies (i.e., medical response, Quick Response Force (QRF).
- Exhaust systems will be kept in good mechanical repair at all times.
  - Lighting systems will be an integral part of the vehicle.
  - One Class 10B:C rated, portable fire extinguisher will, if possible, be mounted on the vehicle outside of the cab on the driver's side, and one Class 10B:C fire extinguisher will be mounted inside the cab.
  - Wheels of carriers must be chocked and brakes set during loading and unloading.
  - No demolition material or MEC will be loaded into or unloaded from motor vehicles while their motors are running.
- Motor vehicles and MHE used to transport demolition material and MEC will be inspected prior to use to determine that:
  - Fire extinguishers are filled and in good working order.
  - Electrical wiring is in good condition and properly attached.
  - Vehicles transporting energetics will have the transport area-beds lined with a non-metallic material.
  - Vehicles transporting energetics will have a clean transport area-bed free of debris or combustibles.
  - Fuel tank and piping are secure and not leaking.
  - Brakes, steering, and safety equipment are in good condition.

  - The exhaust system is not exposed to accumulations of grease, oil, gasoline, or other fuels, and has ample clearance from fuel lines and other combustible materials.
- Employees are required to wear leather, or rubber, gloves when handling demolition materials. The type of glove worn is dependent on the type of demolition material.
- Vehicles transporting energetics will stay on explosive truck routes at all times. If this is not possible, the local police will be notified and will need to approve alternate routes prior to use.
- Unless otherwise directed or authorized by the approved ESP, demolition shots will be tamped with an appropriate amount of earth/dirt.
- An observer will be stationed at a location where there is a good view of the air and surface approaches to the demolition area, before material is detonated. It will be the responsibility of the observer to order the SUXOS to suspend firing if any aircraft, vehicles, or personnel are sighted approaching the general demolition area.
- Two-way radios (to include cell phones) will not be operated in close proximity of the demolition area during the priming process and while the pit is primed. Radio transmissions will be kept at a minimum of 50 ft from the explosives.
- No demolition operation will be left unattended during the active portion of the operation (i.e., once any explosives or MEC are brought to the demolition area).
- A minimum radius (approximately 50 feet) around the demolition pit will be cleared of dry grass, leaves, and other extraneous combustible materials.
- No demolition activities will be conducted if there is less than a 2,000 ft ceiling or if the wind velocity is in excess of 20 mph.
- Demolition shots must be fired during daylight hours (minimum time for sunrise and sunset is determined by the firing procedure used (i.e., electric, non-electric, shock tube 30/60/60).
- Notification of the local authorities will be made in accordance with the site requirements.
- No more than two persons will ride in a truck transporting demolition material or MEC, and no person will be allowed to ride in the trailer/bed.
- Vehicles will not be refueled when carrying demolition material or MEC, and must be 100 ft from trailers containing such items before refueling.
- Explosive vehicles will be cleaned of visible explosive and other contamination, before releasing the vehicles for other tasks.
- After handling demolition material or MEC and prior to conducting any other task, personnel will wash their faces and hands.

6. SPECIAL REQUIREMENTS FOR DEMOLITION ACTIVITIES

The following safety and operational requirements will be met during demolition operations. Any deviations from this procedure will be allowed only after receipt of written approval from USACE and RFAAP. Failure to adhere to the requirements and procedures listed in the paragraphs below could result in serious injury or death; therefore, complete compliance with these requirements and procedures will be strictly enforced. Any deviations from the approved ESP will require a request for approval and a change to the ESP prior to implementation. The change will be submitted through appropriate channels—the Weston Project Manager, USACE PM, and the RFAAP Point of Contact.

7. GENERAL REQUIREMENTS

The general demolition requirements listed below will be followed at all times:

- The USACE "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Munitions and Explosives of Concern (MEC) Sites," will be followed when destroying multiple munitions by detonation on site. This document will be available on-site during site operations. DDESB TP 16 and/or the Demolition Tables will be used to calculate the required buried model and protective works.
- White phosphorus (WP) and propellant will be disposed of only in an approved manner and following the guidance for maximum temperature exposure (90 degrees Fahrenheit). If suspected WP is encountered, arrangements will be made through RFAAP to designate and document a WP demolition area.
- Material awaiting destruction will be stored at not less than intra-line distance, based on the largest quantity involved, from adjacent explosive materials and from explosives being destroyed. The material will be protected against accidental ignition or explosion from fragments, grass fires, burning embers, or detonating impulses originating in materials being destroyed.
- Requirements may be found in the ESP, TP 16 and or the Demolition Tables will be used to calculate the required burial and protective works. The components should be placed on their sides or in a position to expose the largest area to the influence of the demolition material. The demolition material should be placed in direct contact with the item to be detonated and held in place by tape or earth packed over the material.
- Detonations will be counted to ensure detonation of the pit. After each series of detonations, a search will be made of the surrounding area for explosive hazards. Items such as lumps of explosives or unfuzed ammunition may be picked up and prepared for the next shot. Fuzed ammunition, or items that may have internally damaged components, will be detonated in place, if possible.
- Prevailing weather condition information can be obtained from the local weather service, or other acceptable source and the data logged in the Demolition Shot Log before each shot or round of shots.
- All shots will be dual primed with an electrical/remote firing device (RFD) whenever possible.
- Whenever possible, during the excavation of the demolition pits, the ground should be contoured so that runoff water will be channeled away from the pits. If demolition operations are discontinued for more than 2 weeks, the pits should be backfilled until operations resume.
- Upon completion of the project, disturbed demolition areas will be thoroughly inspected for MEC. Depending upon contract requirements, the site may have to be backfilled and leveled. If necessary, this will be coordinated with the government representative.
- An individual who will be excavating on a demolition area will be trained in anomaly avoidance to ensure a reduced risk of encountering MEC or residue from previous demolition operations.
- Before and after each shot, the WESTON Demolition Shot Record will be filled out by the SUXOS with all applicable information. This record will be kept with the MEC Accountability Log and will reflect each shot.

8. ELECTRIC DETONATOR USE

The following requirements are necessary when using electric detonators and blasting circuits:

- Electric detonators and electric blasting circuits may be energized to dangerous levels from outside sources such as static electricity, induced electric currents, and radio communication equipment. Safety precautions will be taken to reduce the possibility of a premature detonation of the electric detonator and the explosive charges. Radios will not be operated during the priming process or while the pit is primed.
- When uncoiling or straightening the detonator leg wires, keep the explosive end of the detonator pointing away from the body and away from other personnel. When straightening the leg wires, do not hold the detonator itself; rather, hold the detonator leg wires approximately 1 inch from the detonator body. Straighten the leg wires by hand; do not throw or wave the wires through the air to loosen them.
- Prior to use, the detonators will be tested for continuity. To conduct the test, place the detonators in a pre-bored hole in the ground or place them under a sand bag, and walk facing away from the detonators and stretch the wires to their full length, being sure not to pull the detonators from the hole or sand bag. With the leg wires stretched to their fullest length, test the continuity of the detonators one at a time by un-shunting the leg wires and attaching them to the galvanometer and checking for continuity. After the test, re-shunt the wires by twisting the two ends together. Repeat this process for each detonator until all detonators have been tested. This process will be accomplished at least 50 ft from and downwind of any MEC or demolition materials and out of the demolition personnel and vehicle traffic flow pattern. In addition, all personnel on the demolition area will be alerted prior to the test being conducted.

NOTE: When testing the detonator, prior to connecting the detonator to the firing circuit, the leg wires of the detonator must be shunted by twisting the bare ends of the wires together immediately after testing. The wires will remain short circuited until time to connect them to the firing line or RFD receiver.

- At the power source end of the blasting circuit, the ends of the wires will be shorted or twisted together (shunted) at all times, except when actually testing the circuit or firing the charge. The connection between the detonator and the circuit firing wires must not be made, unless the power ends of the firing wires are shorted and grounded or the firing panel is off and locked.
- The firing line will be checked using pre-arranged hand signals. If the demolition pit is not visible from the firing point, two-way radios will be used. If radios are used, communication will be accomplished a minimum of 50 ft from the demolition pit and detonators. The firing line will be checked for electrical continuity in both the open and closed positions, and will be closed/shunted after the check is completed.
- MEC to be detonated will be placed in the demolition pit and the demolition material placed/attached in such a manner as to ensure the total detonation of the MEC. Once the MEC and demolition material are in place and the shot has been tamped, the detonators will be connected to the det cord. Prior to handling any detonators that are connected to the firing line or RFD, personnel will ensure that they are grounded. The detonators will then be carried to the demolition pit with the end of the detonators pointed away from the individual. The detonators will then be connected to the detonation cord, NON-EL, etc., ensuring that the

detonator is not covered with tamping material to allow for ease of recovery/investigation in the event of a misfire.

- Prior to making connections to the blasting machine or RFD transmitter, the firing circuit will be tested for electrical continuity and ohms resistance, or transmitting power (as applicable), to ensure the blasting machine or RFD transmitter (distance) has the capacity to initiate the shot.
- The individual assigned to make the connections at the blasting machine or panel will not complete the circuit at the blasting machine or panel, and will not give the signal for detonation, until satisfied that all personnel in the vicinity have been evacuated to a safe distance. When in use, the blasting machine, or its actuating device, will be in the blaster's possession at all times. When using the panel, the switch must be locked in the open position until ready to fire, and the single key must be in the blaster's possession.
- Prior to initiating a demolition shot(s), a warning will be given. The type and duration of such warning will be determined by the prevailing conditions at the demolition area. At a minimum, this should be an audible signal using a siren, air horn, or megaphone, which is sounded for duration of 1 minute, 5 minutes prior to the shot and again 1 minute prior to the shot.

9. NON-EL USE (SHOCK TUBE)

The following requirements are necessary when using NON-EL (shock tube) systems:

- After cutting a piece of shock tube, either immediately tie a tight overhand knot in one or both cut ends or splice one exposed end and tie the other.
- Always use a sharp knife or razor blade to cut shock tube to prevent the tube from being pinched or otherwise obstructed.
- Always cut shock tube squarely across and make sure the cut is clean.
- Use only the splicing tubes provided by the manufacturer to make splices.
- Every splice in the shock tube reduces the reliability of the priming system; therefore, keep the number of splices to a minimum.
- Always dispose of short, cut-off pieces in accordance with local laws as they relate to flammable material.

The shock tube system is a thin plastic tube of extruded polymer with a layer of pentaerythritol tetranitrate (PETN) coated on its interior surface. The PETN propagates a shock wave, which is normally contained within the plastic tubing. The shock tube offers the controlled instantaneous action of electric initiation without the risk of premature initiation of the detonator by radio transmissions, high-tension power lines, or static electricity discharge. The NON-EL system uses detonators in the bunch blocks and in the detonator assembly, which will be handled in accordance with approved procedures.

The shock tube initiating system is highly reliable because all of the components are sealed and, unlike standard non-electric priming components, cannot be easily degraded by moisture. Cutting the shock tube makes the open end vulnerable to moisture and foreign contamination; therefore, care must be taken to prevent moisture and foreign matter from getting into the exposed ends of the shock tubes.

9.1 SHOCK TUBE DEMOLITION PROCEDURES

WARNING

Although the detonation along the shock tube is normally contained within the plastic tubing, burns may occur if the shock tube is held.

9.1.1 Shock Tube Assembly

- Spool out the desired length of shock tube from the firing point to the demolition site and cut it off with a sharp knife or razor blade. Weight down the loose end of the trunk line.
- Immediately seal the shock tube remaining on the spool by tying a tight overhand knot on the cut-off end or use a push-over sealer.
- Using a sharp knife or razor, cut the sealed end off the detonator assembly.
- Push one of the shock tube ends to be spliced firmly into one of the pre-cut splicing tubes provided by the manufacturer at least ¼ inch. Push the other shock tube end firmly into the other end of the splicing tube at least ¼ inch. Secure splice with tape if needed.

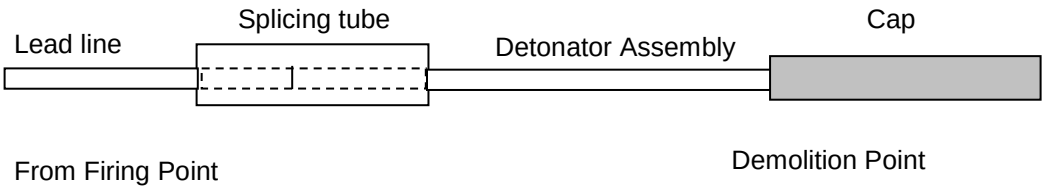


Figure 2

9.1.2 Firing Assembly Setup

1. If there are multiple items to be destroyed using bunch block(s) supplied by the manufacturer, lay out lead lines at the demolition site to the shot(s) and secure the bunch block with a sandbag, or some other item which will keep it from moving.

NOTE: No more than six leads may be used from any one bunch block.

2. If the detonator assembly has not been attached yet, use the splicing tube to splice the detonator assembly to the shock tube branch line as explained in the splicing instructions above.
3. If this is a non-tamped shot, place the detonator assembly into the demolition material. If the shot is to be tamped, prepare the demolition material with a detonating cord lead long enough to stick out of the tamping at least 1 ft.

4. Tape the detonator assembly with the cap to the detonating cord lead as shown in Figure 3.

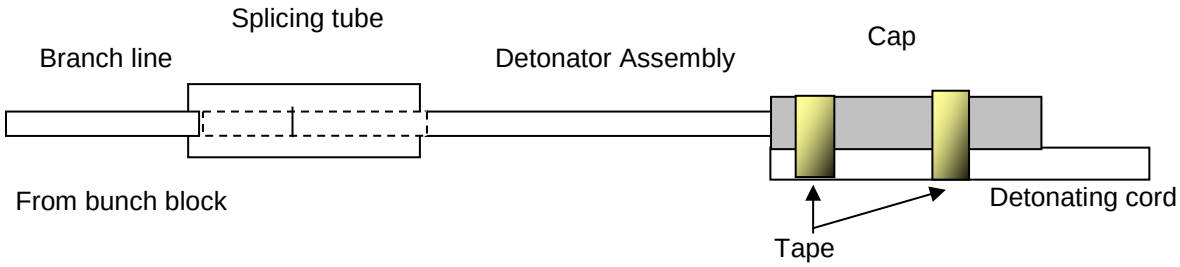


Figure 3

5. Return to the firing position.
6. Cut off the sealed end of the shock tube and proceed to the directions listed in Step 7. If you are using a previously cut piece of shock tube, use a sharp knife or razor blade to cut approximately 18 inches from the previously cut end, whether or not it was knotted in accordance with the above guidance.
7. Insert a primer into the firing device and connect the shock tube lead line to the firing device ensuring that the shock tube is properly seated in the firing device.
8. Take cover.
9. Signal **"fire in the hole"** three times and initiate charge.
10. Observe a 5-minute wait time after the detonation.
11. Remain in designated safe area until Demolition Supervisor announces **"All Clear."**

10. DETONATING CORD USE

The following procedures are required when using detonating cord (det cord):

- The det cord should be cut using approved crimpers, and only the amount required should be removed from inventory.
- For ease of inventory control, remove the det cord only in 1 ft increments.
- The det cord should not be placed in clothing pockets or around the neck, arm, or waist, and should be transported to the demolition location in an approved “day box”.
- The det cord should be placed at least 50 ft away from the detonators and the demolition materials until the det cord is ready to use. To ensure consistent safe handling, each classification of demolition material will be separated by at least 25 ft until ready to use.
- When the det cord is ready to be connected to the demolition materials or the detonator, the det cord will be secured to the item. The cord is then strung out of the hole and secured in place with soil, or filled sandbags, leaving a minimum of 6 ft of det cord exposed outside the hole.
- Once the hole is filled, make a loop in the det cord large enough to accommodate the detonator, place the detonator in the loop, and secure it with tape. The detonator’s explosive end will face down the det cord toward the demolition material or parallel to the main line.
- Always ensure that there is a minimum of 6 ft of det cord extending out of the hole to make it easier to attach and inspect the detonator and replace it should a misfire occur.

- If the det cord detonators are electric, they will be checked, tied in to the firing line, and shunted prior to being taped to the loop. If the det cord detonators are non-electric, the time/safety fuse will be prepared with the igniter in place prior to taping the detonators to the det cord loop. If the det cord detonators are NON-EL, tape the detonators into the loop as described above.
- In the event that a time/safety fuse is used, an igniter is not available, and a field expedient initiation system is used (i.e., matches), do not split the safety fuse until the detonator is taped into the det cord loop.

11. TIME/SAFETY FUSE USE

The following procedures are required when using a time/safety fuse:

- Prior to each daily use, the burn rate for the time/safety fuse must be tested to ensure the accurate determination of the length of time/safety fuse needed to achieve the minimum burn time of 5 minutes needed to conduct demolition operations.
- To ensure both ends of the time/safety fuse are moisture free, use approved crimpers to cut 6 inches off the end of the time/safety fuse roll, and place the 6-inch piece in the time/safety fuse container.
- If quantity allows, accurately measure and cut off a 6-ft-long piece of the time/safety fuse from the roll.
- Take the 6-ft section and attach a fuse igniter.
- In a safe location, removed from demolition materials and MEC, ignite the time/safety fuse, measure the burn time from the point of initiation to the "spit" at the end, and record the burn time in the SUXOS's Log.
- To measure the burn time, use a watch with a second hand or chronograph.
- To calculate the burn rate in seconds per foot, divide the total burn time (in seconds) by the length (in feet) of the test fuse.
- When using a time/safety fuse for demolition operations, the minimum amount of fuse to be used for each shot will be the amount needed to permit a minimum burn time of 5 minutes.

12. DEMOLITION INSPECTION SCHEDULE

The schedule for the demolition inspection will be followed when demolition operations are being conducted. This inspection will be conducted by the UXOSO or UXOQCS and will be documented in the Site Safety or QC Log. If any deficiencies are noted, demolition operations will be suspended and the deficiency will be reported to the SUXOS. Once the deficiencies are corrected, demolition operations may be resumed.

13. METEOROLOGICAL CONDITIONS

To control the effects of demolition operations and to ensure the safety of site personnel, the following meteorological limitations and requirements will apply to demolition operations:

- Demolition operations will not be conducted during electrical storms or thunderstorms.

- No demolition operations will be conducted if the surface wind speed is greater than 20 miles per hour.
- Demolition operations will not be conducted during periods of visibility of less than 1 mile caused by, but not limited to, dense fog, blowing snow, rain, sand storms, or dust storms.
- Demolition will not be carried out on extremely overcast days with more than 80% cloud cover, with a ceiling of less than 2,000 ft.
- Demolition operations will not be initiated until an appropriate time after sunrise, and will be secured at an appropriate time prior to sunset.

14. PRE-DEMOLITION/DISPOSAL PROCEDURES

14.1 PRE-DEMO/DISPOSAL OPERATIONAL BRIEFING

WESTON'S philosophy is that a successful operation is dependent upon a thorough briefing, covering all phases of the task, which is presented to all affected personnel. The SUXOS will brief personnel involved in demolition operations in the following areas:

- Type of MEC being destroyed.
- Type, placement, and quantity of demolition material being used.
- Method of initiation (electric, non-electric, or NON-EL).
- Means of transporting and packaging MEC.
- Route to the disposal site.
- Equipment being used (i.e., galvanometer, blasting machine, firing wire).
- Misfire procedures.
- Post-shot clean-up of demolition area.

14.2 PRE-DEMO/DISPOSAL SAFETY BRIEFING

The WESTON SUXOS, Team Leader, or UXOSO will conduct a safety brief for personnel involved in demolition operations in the following areas:

- Care and handling of explosive materials.
- Personal hygiene.
- Two man rule and approved exceptions.
- Personnel roles and responsibilities.
- Potential trip/fall hazards.
- Horseplay on the demolition area.
- Staying alert for any explosive hazards in the demolition area.
- Calling a safety stop for hazardous conditions.
- Location of emergency shelter, if available.
- Parking area for vehicles (vehicles must be positioned for immediate departure, with the keys in the ignition).
- Location of emergency vehicle.

- Wind direction (to assess potential toxic fumes).
- Locations of first aid kit and fire extinguisher.
- Route to nearest hospital or emergency aid station.
- Type of communications in the event of an emergency.
- Storage location of demolition materials and MEC awaiting disposal.
- Demolition schedule.

14.3 TASK ASSIGNMENTS

Individuals with assigned tasks will report the completion of the task to the SUXOS. The types of tasks that may be required are:

- Contact local military authorities and fire response personnel, and get air clearance, as required.
- Contact hospital/emergency response/medevac personnel, if applicable.
- Secure all access roads to the demolition area.
- Visually check demolition area for any unauthorized personnel.
- Check firing wire for continuity and shunt.
- Prepare designated pits as required.
- Check continuity of detonators.
- Check time/safety fuse and its burn rate.
- Designate a custodian of the blasting machine, RFD, fuse igniters, or NON-EL initiator.
- Secure detonators in a safe location.
- Place MEC in pit, and place charge in desired location.

14.4 PREPARING EXPLOSIVE CHARGE FOR INITIATION

To prepare the explosive charge for initiation, the procedures listed below will be followed:

- Ensure firing wire is shunted.
- Connect detonator to the firing wire.
- Isolate or insulate all connections.
- Prime the demolition charge.
- Place demolition charge on MEC.
- Depart to firing point (if using non-electric firing system, obtain head count, pull igniters, and depart to designated safe area).
- Obtain a head count.
- Give the 1 minute warning signal, using a bullhorn or siren, 5 minutes prior to detonation, and again at 1 minute prior to detonation.
- Check the firing circuit.
- Take cover.

Signal "**fire in the hole**" three times (or an equivalent warning).

- If using electric firing system, connect firing wires to blasting machine, and initiate charge.
- Remove firing wires from blasting machine and shunt or turn off RFD transmitter.
- Remain in designated safe area until SUXOS announces **"All Clear."** This will occur after a post-shot waiting period of 5 minutes and the SUXOS has inspected the pit(s).

15. POST DEMOLITION/DISPOSAL PROCEDURES

Do not approach a smoking hole or allow personnel out of the designated safe area until cleared to do so, and follow the procedures listed below:

- After the **"All Clear"** signal, check pit for low orders or kick-outs.
- Examine pit, and remove any large fragmentation, as needed.
- Back fill hole, as necessary.
- Police all equipment.
- Notify military authorities, fire department, etc., that the operation is complete.

16. MISFIRE PROCEDURES

A thorough check of all equipment, firing wire, and detonators will prevent most misfires. However, if a misfire does occur, the procedures outlined below will be followed.

16.1 ELECTRIC MISFIRES

To prevent electric misfires, one technician will be responsible for all electrical wiring in the circuit. If a misfire does occur, it must be cleared with extreme caution, and the responsible technician will investigate and correct the situation, using the steps outlined below:

- Check firing line and blasting machine connections, and make a second initiation attempt.
- If unsuccessful, disconnect and connect to another blasting machine (if available), and attempt to initiate a charge.
- If unsuccessful, commence a 30-minute wait period.
- After the maximum delay predicted for any part of the shot has passed, the designated technician will proceed down range to inspect the firing system, and a safety observer must watch from a protected area.
- Disconnect and shunt the detonator wires, connect a new detonator to the firing circuit, check the replacement detonator for continuity, and prime the charge without disturbing the original detonator.
- Follow normal procedures for effecting initiation of the charge.

16.2 NON-ELECTRIC MISFIRES

Working on a non-electric misfire is the most hazardous of all operations. Occasionally, despite all painstaking efforts, a misfire will occur. Investigation and corrective action should be undertaken only by the technician who placed the charge, using the following procedure:

- If the charge fails to detonate at the determined time, initiate a 60-minute wait period plus the time of the safety fuse, i.e., 5-minute safety fuse plus 60 minutes for a total of 65 minutes.
- After the wait period has expired, a designated technician will proceed down range to inspect the firing system. A safety observer must watch from a protected area.
- Prime the shot with a new non-electric firing system, and install a new fuse igniter.
- Follow normal procedures for initiation of the charge.

16.3 NON-EL MISFIRE

The use of a shock tube for blast initiation can result in misfires, which require the following actions:

- If the charge fails to detonate, it could be the result of the shock tube not firing. Visually inspect the shock tube. If it is not discolored (i.e., slightly black), it has not fired.
- If it has not fired, cut a 1 ft piece off the end of the tube, re-insert the tube into the firing device, and attempt to fire again.
- If the device still does not fire, wait 60 minutes and proceed down range to replace the shock tube in accordance with the instructions outlined below.
- If the tube is slightly black, then a "Black Tube" misfire has occurred, and the shock tube will have to be replaced, after observing a 60-minute wait time. When replacing the shock tube, be sure to remove the tube with the detonator in place. Without removing the detonator from the end of the tube, dispose of by demolition.

16.4 DETONATING CORD MISFIRE

WESTON uses det cord to tie in multiple demolition shots, and to ensure that electric detonators are not buried. Since det cord initiation will be either electrical or non-electrical, the procedures presented in Sections 15.1, 15.2, or 15.3, as appropriate to the type of detonator used, will be used to clear a det cord misfire. In addition, the following will be conducted:

- If there is no problem with the initiating system, wait the prescribed amount of time, and inspect the connection between the initiator and the cord to ensure that it is properly connected. If the connection was faulty, attach a new initiator, and follow the appropriate procedures for the type of initiator.
- If the initiator detonated but the cord did not, inspect the cord to determine if the problem is with the det cord and not time fuze. Also, check to ensure that there is PETN in the cord at the connection to the initiator.
- It may be necessary to uncover the det cord and replace it. This must be accomplished carefully, to ensure that the demolition charge and the MEC item are not disturbed.

17. RECORD-KEEPING REQUIREMENT

To document the demolition operation procedures and the completeness of the demolition of MEC, the following recordkeeping requirements will be met:

- WESTON (as directed) will obtain and maintain all required permits.
- The SUXOS will ensure that logs are completed accurately, and the SUXOS and UXOQCS will monitor the entries in the log for completeness, accuracy, and compliance with meteorological conditions.
- The SUXOS will enter the appropriate data on the Ordnance Accountability Log and the Demolition Shot Record, to reflect the MEC destroyed, and will complete the appropriate information on the Explosives Accountability Log, which indicates the demolition materials used to destroy the MEC.
- The quantities of MEC recovered must match the quantities of MEC destroyed or disposed.
- WESTON will retain a permanent file of demolition records, including permits, training and inspection records, waste manifests if applicable, and operating logs.
- Copies of the ATF License and required permits must be made available on site.

18. SAFETY AND PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

The following safety measures and personal protective equipment (PPE) will be used in preventing or reducing exposure to the hazards associated with MEC demolition/disposal operations. These requirements will be implemented unless superseded by site-specific requirements stated in the SSHP.

- Hard hats are required only when working around heavy equipment or when an overhead or head impact hazard exists.
- Composite toe/shank boots in accordance with EM 385-1-1 are required during surface/subsurface location of anomalies.
- Safety glasses will be required whenever an eye hazard exists, for example, when working around flying dirt/debris and using hand tools. Safety glasses will provide protection from impact hazards and, if necessary, ultraviolet radiation (i.e., sunlight).
- Positive means will be required to secure the PPE and prevent it from falling and causing an accidental detonation.
- Reflective vests will be worn when in proximity to roads or construction equipment (e.g., excavators)

19. REGULATORY GUIDANCE AND REFERENCES

Applicable sections and paragraphs in the documents listed below will be used as references for the conduct of UXO demolition/disposal operations:

- WESTON Corporate Safety and Health Program.
- OSHA General Industry Standards, 29 CFR 1910.
- OSHA Construction Standards, 29 CFR 1926.

- DDESB TP-16, Methodology for Calculation of Fragmentation Characteristics.
- HNC-ED-CS-S-98-7, Use of Sandbags for Mitigation of Fragmentation and Blast Effects Due to Intentional Detonation of Munitions.
- DoD 4160.21-M, Defense Reutilization and Marketing Manual.
- DoD Manual 6055.09-M, DoD Ammunition and Explosives Safety Standards.
- AR 385-64, U.S. Army Explosives Safety Program.
- AR 385-10, Army Safety Program.
- DA PAM 385-64, U.S. Army Explosives Safety Program.
- TM 9-1300-200, Ammunition General.
- TM 9-1300-214, Military Explosives.
- Applicable TM 60 Series Publications.
- AR 190-11, Physical Security of Arms, Ammunition, and Explosives.
- ATF 5400.7, Alcohol, Tobacco, and Firearms Explosives Laws and Regulations.
- DOT, 49 CFR, Parts 100 to 199, Transportation (applicable sections).
- EPA, 40 CFR Parts 260 to 299, Protection of Environment (applicable sections).
- AR 385-40 w/ USACE Supplement 1, Accident Reporting & Records.
- USACE EM 385-1-1, Safety and Health Requirements Manual.
- USACE 385-1-97, Explosives Safety and Health Requirements.
- AMC Regulation 385-100.

SOP SS-2

SOIL SAMPLING USING DIRECT-PUSH TECHNOLOGY

STANDARD OPERATING PROCEDURE SS-2

SOIL SAMPLING USING DIRECT-PUSH TECHNOLOGY

1. SCOPE AND APPLICATION

The objective of this standard operating procedure (SOP) is to provide guidance and general reference information on soil sampling using direct-push technology (DPT [e.g., Geoprobe® drilling rig]) and collecting representative soil samples at depth and recovering them for visual inspection and/or chemical analysis.

A DPT drill rig is a hydraulically powered drilling machine that utilizes both pressure and percussion to advance sampling and logging tools into the subsurface. DPT drill rigs and equipment can be used to perform soil core and soil gas sampling, groundwater sampling, soil conductivity and contaminant logging, grouting, and materials injection.

2. EQUIPMENT

DPT drill rig (Geoprobe® or equivalent) and tooling
Vinyl end caps and Teflon tape (if required)
Trash bags
Paper towels
Field logbook
Work plan
Folding ruler marked in tenths of an inch
Tape measure
Grain size chart
Munsell color chart
Appropriate sampling device
Stainless steel trowels
Stainless steel bowls
Plastic resealable bags (1 quart + 1 gallon size)

Sharpies or other permanent marker
Flagging
Mean Streak or other paint markers
See Soil Sampling SOP **SS-3**

3. RELATED PROCEDURES

SOP G-1	Field Documentation
SOP G-3	Field Sample Numbering
SOP G-4	Quality Assurance/Quality Control Sampling
SOP G-6	Decontamination
SOP G-7	Management of Investigation Derived Waste (IDW)
SOP G-8	Sample Chain-of-Custody
SOP G-10	Surveying
SOP G-11	MEC Anomaly Avoidance
SOP GW-1	Borehole/Well Abandonment
SOP A-2	Calibration and Use of Air Monitoring Instruments

4. PROCEDURE

4.1 GENERAL PROCEDURE

When used to collect soil samples, the assembled soil sampler is attached to the leading end of a probe rod and driven into the subsurface using a DPT soil probing machine. Additional probe rods are connected in succession to advance the sampler to depth. Depending on the type of sampling system used, the sampler may be used as an open-tube, closed-piston, or dual-tube sampler.

The simplest and most common use of the sampler is as an open-tube sampler. In this method, coring starts at the ground surface with an open-ended sampler. From the ground surface, the sampler is advanced one sampling interval and then retrieved from the hole with the first soil core. In stable soil, the open-tube sampler is inserted back down the same hole to obtain the next

core. Operators have reported coring to depths well exceeding 30 feet (9 meters) with this method.

In unstable soil, which tends to collapse into the core hole, the sampler can be equipped with a piston assembly. This assembly locks into the cutting shoe and prevents soil from entering the sampler as it is advanced to the bottom of an existing hole.

The closed-piston sampler is not designed to be driven through undisturbed soil containing gravel, asphalt, coarse sand, or rubble. In this case, the soil should be removed down to the sampling depth using an open-tube sampler, or a pilot hole may be drilled. The closed-piston sampler is then installed and the sampler is inserted or driven back down the same hole. When the leading end of the sampler reaches the top of the next sampling interval, the piston is unlocked using extension rods inserted down the inside of the probe rods, and the sampler driven through the sample interval.

For a continuous-cased boring, a dual-tube system can be used that allows collection of a continuous soil core without removing the lengths of outer casing. The outer casing bears the force of the drive hammer, while smaller inner rods are used to seat a sample liner in the cutting shoe. The inner rods and sample liner are removed to retrieve the sample, a new liner is then seated into the cutting shoe, and additional outer casing is added at the surface to continue driving the tooling string.

Soil samples are collected within a liner, which is a removable/replaceable, thin-walled tube inserted inside the sample tube for the purpose of containing and storing soil samples. Liner materials include stainless steel, brass, polytetrafluoroethylene (PTFE or Teflon®), polyvinyl chloride (PVC), cellulose acetate butyrate (CAB), and polyethylene terephtalate glycol (PETG).

4.2 GENERAL CONSIDERATIONS

1. Ensure that the driller has at least three or four samplers. This allows the collection of several samples before stopping to clean and decontaminate the equipment.

2. Ensure that a collapsible table or stand is available to hold decontaminated sampler tubes and liners. Equipment must be protected from contamination by placing it on a sheet of plastic on the ground.

3. Ensure that all soil is removed from inside the sample tube. Sand particles can bind liners in the sampler. Full liners are difficult to remove under such conditions. In extreme cases, the soil sample must be removed from the liner before it can be freed from the sample tube.

4. Obtain information about the subsurface and depth to bedrock before driving the sampler. Damage may occur if the sampler is driven into rock or other impenetrable material. The pilot hole should be made only to a depth above the sampling interval.

4.3 OPEN-TUBE SAMPLING

A representative soil sample is obtained by driving the sampler one sampling interval from ground surface into undisturbed soil. Upon retrieving the sampler, the liner and soil core are removed. The sampler is then properly decontaminated, reassembled with a new liner, and inserted back down the same hole until the top of the next sampling interval is reached. The tool string is then driven to the depth of the subsequent continuous sampling interval.

Non-cohesive soils will often collapse to the bottom of the hole. This slough material then enters the sampler as the next soil core is collected, resulting in a non-representative sample. A closed-piston sampler or dual-tube system should be used under such conditions.

4.4 CLOSED-PISTON SAMPLING

It is often difficult to collect representative soil cores from significant depths with an open-tube sampler due to soil slough. Because of this, the sampler can be equipped with a piston that locks into the cutting shoe. This allows the sealed sampler to pass through the slough material and be opened at the appropriate sampling interval.

The assembled sampler is connected to the leading end of a probe rod and driven into the subsurface. Additional probe rods are connected in succession to advance the sampler to depth. The sampler remains sealed (closed) by a piston tip as it is being driven. The piston is held in place by a stop-pin at the trailing end of the sampler. When the sampler tip has reached the top of the desired sampling interval, a series of extension rods, sufficient to reach depth, are coupled together and lowered down the inside diameter of the probe rods. After the extension rods and stop-pin have been removed, the tool string is advanced the depth of the sampling interval. The piston is displaced inside the sampler body by the soil as the sample is collected. To recover the

sample, the sampler is retrieved from the hole and the liner containing the soil sample is removed. The driller will not be allowed to over-drive the sampler.

4.5 DUAL-TUBE SAMPLING

A dual-tube system is a method of collecting continuous soil cores with the added benefit of a cased hole. One set of rods, with the leading edge equipped with a cutting shoe, is driven into the ground as an outer casing. These rods receive the driving force of the hammer and provide a sealed hole from which to collect soil samples without the threat of sloughing or cross-contamination. A second smaller set of rods is inserted into the outer casing and holds a sample liner into the cutting shoe as the outer casing is driven one sample interval. The inner rods are removed to retrieve the filled liner, and then replaced with a new liner to continue sampling at the next interval.

4.6 SOIL CORE RECOVERY

The soil sample is removed from the sampler by unscrewing the cutting shoe and pulling out the liner, or the liner is removed with the inner rods in a dual-tube system. Depending upon the sampling protocols, the soil sample may either be preserved within the liner or removed from the liner and placed in sample jars.

If soil samples are to be collected from the liner, undisturbed samples can be obtained from Teflon®, PVC, and PETG liners by splitting the liner. Clear plastic liners and Teflon® liners can be slit open with a hooked-blade utility knife or other device and the samples to be analyzed placed in appropriate containers. A manual extruder may be used to push the soil cores out of metal liner sections for transfer to other containers.

If the samples are to be preserved in the liner, the soil sample should be secured by placing a vinyl (or other appropriate material) end cap on each end of the liner. If the sample is to be segmented, the liner should be cut around the outside circumference. Metal liners come with plastic cladding on the outside of the liner to keep four 6-inch sections aligned. Remove the cladding and cut the sections apart with a knife. When using brass, stainless steel, and Teflon® liners, cover the end of the sample tube with Teflon® tape before placing the end caps on the

liner. The tape should be smoothed out and pressed over the end of the soil core to minimize headspace. However, care should be taken not to stretch and therefore thin the tape. Develop a system such as always placing a black end cap at the bottom (down end) of the sample core and a red end cap at the top (up end) of the core. Color-coding the ends of the liner will help to quickly identify the top and bottom of the sample during later analysis.

4.7 DECONTAMINATION

Before and after each use, thoroughly clean all parts of the soil sampling system according to project requirements (see **SOP G-6**). A new, clean liner is required for each sample interval.

Thoroughly clean the sampler before assembly, not only to remove contaminants but also to ensure correct operation. Dirty threads complicate assembly and may lead to sampler failure. Sand is particularly troublesome because it can bind liners in the sample tube resulting in wasted time and lost samples.

4.8 EQUIPMENT RINSATE BLANK

An equipment rinsate blank may be required to be taken on a representative sample liner prior to starting a project and at regular intervals. Because liners can become contaminated in storage, an equipment rinsate blank will prove that the liners do not carry contaminates which can be transferred to soil samples.

If an equipment rinsate blank is required, the following procedure may be used:

1. Place an end cap or other appropriate device on one end of the liner.
2. Pour distilled water (or other suitable extracting fluid) into the liner.
3. Place an end cap on the open end of the liner.
4. From the vertical position, repeatedly invert the liner so that the distilled water contacts the entire inner surface. Repeat this step for one minute.
5. Remove one end cap from the liner, empty contents into an appropriate sample container, and cap the container.
6. Perform analysis on the rinsate water for the analytes of interest to the investigation.

SOP SS-3

SEDIMENT SAMPLING

STANDARD OPERATING PROCEDURE SS-3

SEDIMENT SAMPLING

1. SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) presents instructions for collecting representative sediment samples from shore areas or surface water bodies. Sediment can be considered as any material that is submerged/saturated (at least temporarily) or suspended in any surface water body. This includes sludges, lake bottom sediments, perennial and intermittent stream sediments, and marine sediments. Sampling devices to be used are based on the following categories according to applicability: (1) surface sediments (scoop or bedload sampler), (2) subsurface sediments/shallow water (corer/tube sampler), and (3) surface sediments/deep water (Ponar sampler).

2. EQUIPMENT

Personal protective equipment (see Accident Prevention Plan)
Flame ionization detector/photoionization detector (FID/PID)
Decontamination items
Visqueen
Rinse bottles
Trash bags
Paper towels
Field logbook
Work plan
Folding ruler marked in tenths of an inch
Tape measure
Grain size chart
Munsell color chart
Appropriate sampling device
Stainless steel trowels

Stainless steel bowls

Plastic resealable bags (1 quart + 1 gallon size)

Sharpies or other permanent marker

Flagging

Mean Streak or other paint markers

3. RELATED PROCEDURES

SOP G-1	Field Documentation
SOP G-3	Field Sample Numbering
SOP G-4	Quality Assurance/Quality Control Sampling
SOP G-6	Decontamination
SOP G-8	Sample Chain-of-Custody
SOP G-10	Surveying
SOP G-11	MEC Anomaly Avoidance
SOP A-2	Calibration and Use of Air Monitoring Instruments

4. PROCEDURE

4.1 SAMPLE LOCATIONS

Depositional patterns should be considered in regard to the sample objectives when deciding the sediment sample locations. These patterns differ between standing and flowing bodies of water. Generally, for flowing water (e.g., stream or river beds), the depositional areas are normally found inside bends and downstream of islands or obstructions. Areas directly downstream from the joining of two streams should be avoided because the flows may not immediately mix. For standing water bodies, the center of the mass or a discharge point should be sampled for sediments. Selection of sample locations should be made based on the investigation objectives.

4.2 SAMPLE TYPES

The type of sample should be designated when selecting a sampling method. Sediment samples can either be discrete (grab) or composite samples.

4.3 SAMPLER SELECTION

The choice of samplers is dictated by sampling objectives (i.e., surficial versus subsurface samples) and site constraints based on water depth. Each sampling technique presents various advantages and disadvantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique.

4.4 SAMPLING OVERVIEW

Presented below are sampling instructions for the most common techniques for collecting sediment and sludge samples. Prior to sample collection, water body characteristics (e.g., size, depth, flow) should be recorded in the field logbook. Sampling should proceed from downstream locations to upstream locations so that disturbance from sampling does not affect sampling quality. Additionally, if surface water samples will be collected at the same locations as sediment samples, the water samples must be collected first. In collecting sediment samples from any source, care must be taken to minimize disturbance and sample washing as it is retrieved through the liquid column. Sediment fines may be carried out of the sample during collection if the liquid above is flowing or deep. This may result in collection of a non-representative sample due to the loss of contaminants associated with these fines.

While a sediment sample is usually expected to be a solid matrix, the sampler should not place the sample in the bottle and decant the excess liquid. If the sample is collected properly, any liquid in the bottle is representative of sediment conditions. If liquid flow and depth are minimal and sediment is easy to reach, a trowel or scoop may be used to collect the sediment sample; however, when the liquid above the sediment collection point is either flowing or greater than 6 inches in depth, a corer or other device that eliminates sample washing must be used to collect the sample to minimize washing the sediment as it is retrieved. It may be necessary to decant standing water from the top of the core. This should be done carefully and prior to transfer to the sample bottle. A decontaminated trowel should be utilized to transfer the sample from the corer directly into the bottle. After collection, the sampling device should be decontaminated before collecting the next sample.

In some instances, the dimensions of the surface water dictate that a barge or boat must be used. Generally, trowels or scoops cannot be used in an offshore situation. Instead, corers or dredges are a more efficient means for sample collection. The barge or boat should be positioned upstream (if there is flowing water) of the desired sample location. As the corer or dredge is lowered, it may be carried slightly downstream, depending upon the force of the flow. Upon retrieval, the contents of the corer or dredge should be transferred directly into the sample bottle using a decontaminated trowel. Both the corer or dredge and the trowel should be decontaminated before collecting the next sample.

4.5 SCOOP OR TROWEL

4.5.1 Applicability

The scoop or trowel method is a very accurate procedure for collecting representative surface sediment samples. This method can be used in many sampling situations, but is limited to sampling exposed sediments or sediments in surface waters less than 6 inches deep. The scoop or trowel sampler is not effective for sampling in waters more than 6 inches deep.

4.5.2 Method Summary and Equipment

The simplest, most direct method of collecting sediment samples is with the use of a stainless steel scoop or trowel. A stainless steel scoop or trowel is used to collect the sample, and a stainless steel bowl is used to homogenize the sample when applicable to the subsequent analysis.

4.5.3 Sampling Procedure

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Sketch the sample area or note recognizable features for future reference.
- Insert scoop or trowel into material and remove sample.
- Begin sampling with the acquisition of any grab volatile organic compound (VOC) samples, conducting the sampling with as little disturbance as possible to the media.

- If homogenization of the sample location is appropriate for the remaining analytical parameters, or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.
- Check that a polytetrafluoroethylene (PTFE) liner is present in the cap. Wipe away any particles clinging to the bottle threads and rim to ensure a tight seal. Secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets, and record in the field logbook.
- Decontaminate sampling equipment after use and between sample locations.

4.6 TUBE SAMPLER

4.6.1 Applicability

Discrete sediment samples from shallow to moderately deep water can be collected efficiently. Equipment for the polycarbonate tubing sampler is portable and easy to use.

4.6.2 Method Summary and Equipment

Polycarbonate tubing samplers are a simple and direct method for obtaining sediment samples. The corer is forced into the sediment. The corer is then withdrawn using a vacuum/suction technique and the sample is collected.

4.6.3 Sampling Procedure

- Probe sample location to determine approximate sediment thickness.
- Lower the polycarbonate tubing sampler until the tube contacts the top of the sediment.

- Gradually force corer into sediment (use a hammer or slambar if necessary to obtain desired sediment depth). Maintain tension on the plunger rope as sampling apparatus and tubing is advanced into the sediment. Tension will create a vacuum between the top of the sediment and the tubing, generally increasing sediment recovery.

- Remove the sampling apparatus and tubing from the sediment. Place cap on bottom of tubing and secure. Remove the tubing from the sampling apparatus and place a top on the TOP of the tubing and secure. Record the date, time, and location of the sample in the logbook and on the top cap with a permanent marker. Properly decontaminate the sampling equipment after use and between sampling locations.

- Remove sediment core from corer and place core on a clean working surface.

- Discard top of core if any organic material (e.g., leaves) is present.

- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media. If homogenization of the sample location is appropriate for the remaining analytical parameters, or if compositing of different locations is desired, the proper sample interval is sectioned from the tube and transferred to the stainless steel bowl for mixing.

- Repeat as necessary to obtain sufficient sample volume.

- Transfer sample into an appropriate sample bottle with a stainless steel spoon or equivalent.

- Remove any soil clinging to the bottle threads or rim, and secure the cap tightly.

- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.

- Place filled sample containers on ice immediately.

- Complete all chain-of-custody documents and field sheets, and record in the field logbook.

- Decontaminate sampling equipment after use and between sample locations.

4.7 PONAR SAMPLER

4.7.1 Scope and Applicability

Ponar samplers are capable of sampling most types of sludges and sediments from silts to granular materials in deep water. They are available in sizes from hand-operated to winch-operated. Ponars are relatively safe, easy-to-use, prevent escape of material with end plates,

reduce shock waves, and have a combination of the advantages of other sampling devices. Ponar grab samplers are more applicable for a wide range of sediments and sludges because they penetrate more deeply and seal better than spring-activated types (e.g., Ekman samplers). Penetration depths will usually not exceed 6 inches. Ponar samplers are not capable of collecting undisturbed samples. For example, material in the first centimeter of sediment cannot be separated from the rest of the sample. Ponars can become buried in soft sediment. The Ponar sampler is not recommended for the acquisition of volatile organic analysis (VOA) samples.

4.7.2 Method Summary and Equipment

The Ponar grab sampler is a clamshell-type scoop activated by a counter-lever system. The shell is opened, latched in place, and slowly lowered to the bottom. When tension is released on the lowering cable, the latch releases and the lifting action of the cable on the lever system closes the clamshell.

4.7.3 Sampling Procedure

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach the necessary length of sample line to a decontaminated Ponar. Solid braided 5-millimeter (mm) (3/16-inch) nylon line is usually of sufficient strength; however, 20-mm (3/4 -inch) or greater nylon line allows for easier hand hoisting.
- Measure the depth to the top of the sediment with a weighted object or pole.
- Mark the distance to the top of the sediment on the sample line with a proximity mark 1 meter above the sediment. Record depth to top of sediment and depth of sediment penetration.
- Open sampler jaws until latched. From this point, support the sampler by its lift line, or the sampler will be tripped and the jaws will close.
- Tie free end of sample line to fixed support to prevent accidental loss of sampler.
- Begin lowering the sampler until the proximity mark is reached.
- Lower the sampler rapidly through last meter until contact is felt.
- Allow sample line to slack several centimeters. In strong currents, more slack may be necessary to release mechanism.

- Slowly raise dredge to clear surface.
- Drain free liquids through the screen of the sampler, being careful not to lose fine sediments.
- Place Ponar into a stainless steel or PTFE tray and open.
- Repeat until sufficient sample volume has been collected.
- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters, or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Collect a suitable aliquot with a stainless steel laboratory spoon or equivalent and place sample into appropriate sample bottle. Remove any soil clinging to the bottle threads or rim, and secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook.
- Decontaminate sampling equipment after use and between sample locations.

4.8 BEDLOAD SAMPLER

4.8.1 Scope and Applicability

Bedload sediment samples are typically collected during high flow conditions (storm events) from river or stream channels to capture mobilized coarse grained sediments which are migrating downstream along the top of the sediment substrate. The degree to which bedload sediment is actively migrating at a given location will vary greatly with flow, sediment, and stream morphology conditions.

4.8.2 Method Summary and Equipment

There are several models of bedload samplers available depending on collection criteria, but all are designed to sit on the bedload surface with an entrance opening oriented facing upstream, which allows the migrating bedload sediments to enter the sampler and collect in a mesh sampler bag. Sampler type (i.e., hand-held or winch lowered), entrance opening (3-inch by 3-inch or 6-inch by 6-inch), chamber expansion ratio (1.4 or 3.22), and sampler bag mesh size (0.25 mm to 2.0 mm) can all be selected based on the objectives of the sampling program. Hand-held units are oriented upstream by the sampling team while winch lowered units are equipped with fins to orient the sampler to stream flow. Samples can be collected as discreet grabs or composited from multiple locations across a stream channel.

4.8.3 Sampling Procedure

- Place plastic sheeting around the sampling location to prevent cross-contamination.
- Attach the selected sampler bag to the sampler, and the sampler to the winch cable (if applicable).
- Measure the depth to the top of the sediment with a weighted object or pole.
- Mark the distance to the top of the sediment on the winch line with a proximity mark 1 m above the sediment.
- Begin lowering the sampler until the proximity mark is reached, allowing the sampler to orient to the stream flow.
- Lower the sampler slowly through last meter, allowing it to gently rest down on the sediment surface.
- Allow sampler to rest on the bottom for 2 minutes.
- Slowly raise sampler to clear surface.
- If sufficient sample volume has been collected, proceed to sample processing. If not, return the sampler to the stream bed for additional collection time. For composite samples across a stream channel, the sampler should be deployed for an equal amount of sampling time at each composite location. Record the total sample time at each location.
- Once sufficient sample volume has been collected, remove the sampler bag from the bedload sampler, and allow free water to drain from the mesh bag.

- Empty sample bag into a stainless steel bowl and remove any organic materials such as twigs and leaves.
- Thoroughly homogenize the sample in the stainless steel bowl by mixing.
- Collect a suitable aliquot with a stainless steel laboratory spoon or equivalent and place sample into appropriate sample bottle. Remove any soil clinging to the bottle threads or rim, and secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and field sheets and record information in the field logbook.
- Decontaminate sampling equipment after use and between sample locations.

4.9 SEDIMENT SAMPLING PROCEDURE IN A COBBLE SUBSTRATE

The following method will be used when the presence of a large proportion of cobbles and/or boulders precludes the use of other sediment sampling techniques:

1. Place 55-gallon drum (lid and bottom removed) onto sampling location. Push, pound, and wiggle the drum into the sediment. Remove cobbles around rim of drum as needed.
2. Remove large rocks (e.g., cobbles) from inside of drum as a 5-gallon bottomless bucket is placed inside of the drum. Push, pound, and wiggle the bucket into the sediment to partition this area from the drum.
3. Remove sediment from 0 inches to 6 inches from the entire inside of the bucket with a trowel or scoop and place into sample jars.
4. Place rubber seal in the bottom of the bucket. Pump or bail water from the bucket into a 10-micrometer (μm) filter bag. Pump/bail until water level reaches the bottom of the bucket, or until 5 gallons of water are passed through the filter bag. Remove the rubber seal from the bottom of the bucket.
5. Use a power auger to loosen the next 6-inch interval of sediment/cobbles.
6. Collect the 6-inch to 12-inch interval of sediment with trowel or scoop, and place into sample jars.
7. Repeat step 4.

8. Decontaminate the 5-gallon bucket, rubber seal, and trowel/scoop.
9. Submit all 4 samples (2 sediment, 2 filter bags) for laboratory analysis.

4.10 SAMPLE CONTAINERS AND PRESERVATION TECHNIQUES

4.10.1 Sample Containers

Refer to the Quality Assurance Project Plan (QAPP), for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

1. VOA.
2. Total organic carbon (TOC).
3. Extractable organics (base/neutral/acid [BNA] or semivolatile organic compound [SVOC]).
4. Total metals.
5. Phenols.
6. Cyanide.
7. Total solids.

4.10.2 Sample Preservation and Handling

Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in investigation programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques and sample containers that the sampler should use for each constituent or common set of parameters are specified in the QAPP, Section 19. The samples collected for VOC analysis should *never* be homogenized or composited. They should be carefully transferred directly from the sample collection device to the sample container in order to minimize contaminant loss through agitation/volatilization or adherences to another container.

4.10.3 Field Quality Control Sampling Procedures

Field quality control samples are collected by the sampling team to determine whether data are of suitable quality. They include blanks, duplicates, and/or background samples. A detailed discussion of field quality control samples is presented in **SOP G-4**.

4.10.4 Decontamination Procedures

All equipment that will enter the sediment must be decontaminated. Sampling equipment should be decontaminated as described in **SOP G-6**. Sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed on-site to ensure adequate drying time.

4.10.5 Documentation

Bound field logbooks should be used for the maintenance of field records. All aspects of sample collection and handling as well as visual observations shall be documented in the field logbooks as outlined in **SOP G-1**.

All entries in field logbooks should be legibly recorded and contain accurate and inclusive documentation of project activities.

5. BIBLIOGRAPHY

ASTM Standard D3976. 2005. "Standard Practice for Preparation of Sediment Samples for Chemical Analysis." ASTM International, West Conshohocken, PA. 2005, DOI: 10.1520/D3976-92R05. www.astm.org.

ASTM Standard D4823. 2008. "Standard Guide for Core Sampling Submerged, Unconsolidated Sediments." ASTM International, West Conshohocken, PA. 2008, DOI: 10.1520/D4823-95R08. www.astm.org.

EPA (U.S. Environmental Protection Agency) and U.S. Army Corps of Engineers (USACE). 1998. *Great Lakes Dredged Material Testing and Evaluation Manual.* Final Draft. Prepared by U.S. Environmental Protection Agency, Regions 2, 3, 5 and Great Lakes National Program Office and U.S. Army Corps of Engineers Great Lakes and Ohio Division.

SOP SS-4

SOIL SAMPLING

STANDARD OPERATING PROCEDURE SS-4

SOIL SAMPLING

1. SCOPE AND APPLICABILITY

Instructions presented in this Standard Operating Procedure (SOP) are for collecting representative soil samples. Soil sampling can be classified into two primary types: surficial and subsurface. Instructions for sampling surficial soil included in this section utilize the spade and scoop. Instructions for sampling subsurface soil included in this section utilize the following techniques: split spoon sampler and thin-walled (Shelby) tube. There are also specific sampling protocols presented for riverbank and/or floodplain sampling using hand augering.

2. EQUIPMENT

Field logbook
Muncell color chart
Grain size card
Hand lens
Clipboard
Folding rule (in feet and tenths)
Pocket penetrometer (if required)
Indelible ink markers
Squirt bottle (with deionized water)
Plastic sheeting
Paper towels
Pens (blue or black)
Eye protection
Work gloves
Surgical gloves
Sample jars
Sample jar labels

Chain-of-custody forms

Photoionization detector (PID)

Decontamination materials

Appropriate sampling device

3. RELATED PROCEDURES

SOP G-1	Field Documentation
SOP G-3	Field Sample Numbering
SOP G-4	Quality Assurance/Quality Control Sampling
SOP G-6	Decontamination
SOP G-7	Management of Investigation Derived Waste (IDW)
SOP G-8	Sample Chain-of-Custody
SOP G-10	Surveying
SOP G-11	MEC Anomaly Avoidance
SOP GW-1	Borehole/Well Abandonment
SOP A-2	Calibration and Use of Air Monitoring Instruments

4. PROCEDURE

4.1 SAMPLING LOCATIONS

Sampling at sites is usually conducted in an attempt to discover contamination and to define its extent and variability. With such an objective, it is most logical to choose sample locations that will yield the most information about site conditions. Because of the nature of the media, soil samples can vary considerably across a site. Physical properties of the soil, including grain size and cohesiveness, may limit the depth from which samples can be collected and the method required to collect them. In most soil, hand-powered equipment can be used only to a depth of approximately 4 to 5 feet. At greater depths, soil sampling is normally performed with a drill rig or other mechanically driven device.

4.2 SAMPLE TYPES

The type of sample should be designated when selecting a sampling method. Application techniques for sample methods include discrete (grab) or composite samples. A discrete (grab) sample is defined as a discrete aliquot representative of a specific location at a given point in time. The sample is collected immediately and at one particular point in the sample matrix. The representativeness of such samples is defined by the nature of the materials being sampled. In general, as sources vary over time and distance, the representativeness of grab samples will decrease. Composites are samples composed of two or more specific aliquots (discrete samples) collected at various sampling locations and/or different points in time. Analysis of this type of sample produces an average value and can, in certain instances, be used as an alternative to analyzing a number of individual grab samples and calculating an average value. It should be noted, however, that compositing can mask the presence of contaminants by diluting isolated concentrations of analytes that may be present in the environmental matrix.

4.3 SAMPLE COLLECTION

Each sampling technique presents various advantages and disadvantages for its application. For example, sample disturbance, sample volume, chemical/physical reactivity between potential contaminants and sampling tool materials, and ease of decontamination vary from technique to technique. Subsurface soil conditions themselves will restrict the application of certain samples. For example, the thin-walled tube sampler is not applicable for sampling sands.

Presented below are sampling instructions for the most common techniques of collecting soil samples. Prior to sample collection, the soil sampling location and characteristics (e.g., soil type, depth) should be recorded in the field logbook. Selection of soil sampling equipment is usually based on the depth of the samples. Manual techniques are usually selected for surface or shallow subsurface soil sampling. At greater depths, mechanically driven equipment is usually required to overcome torque induced by soil resistance and depth.

4.3.1 Surficial Sampling

4.3.1.1 Spade and Scoop

The spade and scoop method is a very accurate, representative method for collecting surface and shallow subsurface soil samples. This method is usually limited to soil depths less than 1 foot.

Method Summary and Equipment

The simplest, most direct method of collecting surface soil samples is to use a spade and stainless steel scoop. A typical garden spade can be used to remove the top cover of soil to the required depth, and the smaller stainless steel scoop can be used to collect the sample.

Sampling Procedure

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Carefully remove the top layer of soil to the desired sample depth with a pre-cleaned or decontaminated spade.
- Using a pre-cleaned or decontaminated stainless steel scoop or trowel, collect the sample aliquot for volatile organic compound (VOC) analysis first (if applicable), then homogenize enough soil in a stainless steel bowl for the remaining sample containers.
- Transfer sample into the appropriate sample bottle with a stainless steel laboratory spoon or equivalent.
- Remove any soil clinging to the bottle threads or rim, and secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Complete the label carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and record in the field.
- Prepare samples for shipping.
- Decontaminate sampling equipment after use.

4.3.2 Subsurface Sampling

4.3.2.1 Split-Spoon Sampler

The split spoon sampler is used for sampling subsurface soil in cohesive and non-cohesive type soils. It is used extensively for collecting subsurface soil samples for chemical analysis. The split spoon sampler will require a drill rig and crew for collecting samples at a depth greater than 5 feet. The split-spoon sampler will be the primary subsurface sampling device used.

Method Summary and Equipment

The split spoon sampler is typically a 2- or 3-inch-diameter, thick-walled, steel tube that is split lengthwise. If a 2-inch-diameter split spoon sampler is used, then standard penetration tests can be taken to determine the density of the soil (ASTM D1586). A cutting shoe is attached to the lower end; the upper end contains a check valve and is connected to the drill rods. When a boring is advanced to the point that a sample is to be taken, drill tools are removed, and the sampler is lowered into the hole on the bottom of the drill rods. The sampler is driven into the ground in accordance with the standard penetration test.

Sampling Procedure

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Assemble the sampler by aligning both sides of the barrel and then screwing the drive shoe on the bottom and the heavier headpiece on top.
- Place the sampler in a perpendicular position on the material to be sampled.
- Drive the tube utilizing a sledge hammer or drill rig if available. Do not drive past the bottom of the headpiece because this will result in compression of the sample.
- Record the length of the tube that penetrated the material being sampled and the number of blows required to obtain this depth. Typically, the number of blows per 6 inches of depth is recorded.
- Withdraw the sampler and open it by unscrewing the drive shoe and head, and splitting the barrel. If split samples are desired, a decontaminated stainless steel knife should be utilized to split the tube contents in half longitudinally.

- Begin sampling with the acquisition of any grab VOC samples, conducting the sampling with as little disturbance as possible to the media.
- If homogenization of the sample location is appropriate for the remaining analytical parameters or if compositing of different locations is desired, the sample is transferred to the stainless steel bowl for mixing.
- Transfer sample into an appropriate sample bottle with a stainless steel laboratory spoon or equivalent.
- Remove any soil clinging to the bottle threads or rim, and secure the cap tightly.
- Label the sample bottle with the appropriate sample label. Be sure to label the bottle carefully and clearly, addressing all the categories or parameters.
- Place filled sample containers on ice immediately.
- Complete all chain-of-custody documents and record in the field.
- Prepare samples for shipping.
- Decontaminate sampling equipment after use and between sampling locations.

4.3.2.2 Thin-Walled (Shelby) Tube Sampler

Applicability

Thin-walled tube samplers allow collection of undisturbed samples in cohesive type soil (i.e., clays). They are primarily used for collecting soil samples for certain geotechnical tests. Thin-walled tube samplers are not the ideal container for transporting samples to the laboratory for chemical analysis. The opportunity for describing the soil is diminished because most of the soil is concealed in the tube. The Shelby Tube will be used only in clayey material where an undisturbed sample is required, and the field crew has specifically been instructed to use a Shelby Tube sampler.

Method Summary and Equipment

The thin-walled tube sampler is designed to take undisturbed samples in cohesive type soils. The thin-walled tube sampler is available in brass, galvanized steel, plain steel, or stainless steel, and is manufactured in either 30- or 36-inch lengths. It is available in 2-, 3-, and 5-inch diameters;

however, the 3-inch diameter is the most commonly used. Thin-walled tube samplers are usually used for sampling cohesive soils for geotechnical evaluation, rather than chemical analysis.

Sampling Procedure

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Place the sampler in a perpendicular position on the material to be sampled.
- Push the tube into the soil by a continuous and rapid motion, without impact or twisting. In no instance should the tube be pushed further than the length provided for the soil sample.
- When the soil is so hard that a pushing motion will not penetrate the sample sufficiently for recovery, it may be necessary to collect a disturbed sample with the split-spoon sampler. Extremely dense and hard soil may result in damage to the thin-walled tube sampler.
- Before pulling out the tube, rotate the tube at least two revolutions to shear off the sample at the bottom. For geotechnical analysis, seal the ends of the tube with wax or rubber packers to preserve the moisture content. In such instances, the procedures and preparation for shipment should be in accordance with ASTM Method D1587. For chemical samples, seal the ends of the tube with teflon-lined plastic caps or equivalent. Seal each end cap with plastic electrical tape.
- Label the sample tube with the appropriate sample label. Be sure to complete the label carefully and clearly, addressing all the categories or parameters.
- Complete all chain-of-custody documents and record in the field.
- Prepare samples for shipping.
- Decontaminate sampling equipment after use and between sampling locations.

4.3.2.3 Hand Augering—Riverbank and Floodplain Sampling

Instructions presented in this SOP are for collecting representative soil samples at riverbank and/or floodplain locations.

Applicability

Hand augering is an accurate and efficient method for sampling soil. Soil samples are removed at discrete depths. Hand augering proves inefficient where the subsurface contains large gravel, or when the surface and subsurface are frozen.

Method Summary and Equipment

The auger is attached to an auger handle. Typically, there are three standard size augers available for use (with internal diameters of 4, 2, and 1 inch, respectively). A single auger can be used to collect a discrete sample at a specified depth or the augers can be used in succession (from highest to lowest internal diameter) to take three discrete samples at different depths (such as 0 to 6 inches, 12 to 18 inches, and 24 to 30 inches below ground surface (bgs)) at the same location.

Sampling Procedure (discrete samples/different depths)

- Place plastic sheeting on the ground around the sampling location to prevent cross-contamination.
- Attach the 4-inch internal diameter auger on the auger handle.
- Clear the area of any vegetation, if necessary.
- Begin augering at the sample location. Auger to a depth of 6 inches.
- Remove all soil from the auger and place in a clean stainless steel bowl for homogenizing. This is the first sample with a depth of 0 to 6 inches bgs.
- If it is too difficult to auger to a depth of 6 inches, remove soil sequentially until reaching the 6-inch depth.
- After collecting the first sample, use the same auger (4-inch internal diameter) to auger the soil from 6 to 12 inches bgs. Remove the auger from the auger handle and set aside. Be careful to let the soil from the 6- to 12-inch depth remain in the auger.
- Replace surgical gloves (to prevent cross-contamination) and attach a clean 2-inch internal diameter auger to the auger handle.
- Auger from 12 to 18 inches bgs. This is the second sample. Carefully place this soil in a second clean stainless steel bowl for homogenizing.
- Using the same auger, auger to a depth of 24 inches. Remove the auger from the auger handle, again keeping the soil in the auger.

- Replace surgical gloves (to prevent cross-contamination) and attach a 1-inch internal diameter auger on the auger handle and collect the third sample. The third sample is the soil at a depth of 24 to 30 inches. Place this soil in a third clean stainless steel bowl for homogenizing.

- Once the three samples have been collected, place the soil in the first two augers back in the sample location.

- Homogenize the soil in the third bowl. Use a new pair of gloves to avoid cross-contamination. Document the soil description and place soil in desired jars as necessary. Label the jars with the correct sample identifier (ID) number and other necessary information (see **SOP G-3**).

- Place the sample jars in a cooler filled with ice as soon as possible.

- Repeat this procedure for the other two soil samples. If any soil remains, place in the same sampling hole to avoid spreading possible contamination.

- Prepare samples for shipping.

- Decontaminate all sampling equipment after use and between sampling locations.

4.4 FIELD MEASUREMENT PROCEDURES

The purpose of this section is to identify methods for field screening soil. Visual assessment and instrument readings will be used to screen field samples and residual samples. Residual materials may include excess samples, cuttings, and other materials.

4.4.1 Preparation

- Review screening procedures and equipment operation manuals.

- Calibrate field screening instruments in accordance with the manufacturer's instructions and operating procedures (see **SOP A-1**).

- Document calibrations in the field logbook.

- Determine the ambient air temperature. If the ambient air temperature is below 15 ^{o}C, select an area where soil samples can be kept warm for head space readings.

4.4.2 Field Screening

Prior to and during collection of a soil or sediment sample, visually observe the sampling area, and sample for signs of releases that include the following:

- Surface discoloration or staining.
- Stressed or discolored vegetation.
- Physical evidence of hydrocarbons or other contamination.

Record visual observations of the sampling area in the field logbook. Include a sketch and dimensions of any area where visual signs of a release are observed.

4.4.3 Instrument Readings

Take instrument readings prior to sampling to monitor ambient air for health and safety purposes. Record this information in the field logbook.

Soil and/or sediment headspace readings are taken in the following manner:

- Place soil/sediment sample in a clean, dry, glass jar so that the jar is not more than half full. Cover the jar with aluminum foil and replace the lid.
- If the ambient temperature is low, bring the jarred samples to an area where they can be warmed.
- Gently shake the jar to aid sample volatilization.
- Remove the lid and insert the probe through the aluminum foil, but not into the sample since this will clog the instrument. Record the instrument reading of the area on the log reserved for headspace readings.
- Do not submit the jarred sample for laboratory analysis.
- Dispose of the jarred sample in accordance with residual management protocols.

4.5 SOIL SAMPLING FOR VOLATILE ORGANIC COMPOUNDS

4.5.1 EnCore™ Sampler

The EnCore Sampler has been approved for collection of samples, and this method is the preferred sampling method for use at the site. The EnCore Sampler (or equivalent) selects a small volume (about 5 grams) of soil that is stored in a chamber that is submitted to the analytical laboratory. *The sample must be received, prepped, and analyzed within 2 days of collection; therefore, all samples must be shipped the day they are collected.*

Two or three EnCore samplers will be required per analytical sample:

- One EnCore sampler for low-concentration analysis.
- One EnCore sampler for high-concentration analysis or low-concentration duplication.
- One EnCore sampler for repreparation.
- One volatile organic analyte (VOA) jar with Teflon cap for moisture determination.

The EnCore Sampler is a single use device. It can not be cleaned and/or reused. The following is the procedure for using the EnCore Sampler:

- Hold the coring body and push the plunger rod down until the small o-ring rests against the tabs. This will ensure that the plunger moves freely.
- Depress the locking lever on the EnCore T-Handle. Place the coring body, plunger end first, into the open end of the T-Handle, aligning the two slots on the coring body with the two locking pins in the T-Handle.
- Twist the coring body clockwise to lock the pins in the slots. Check to ensure the sampler is locked in place. The sampler is now ready for use.
- Turn the T-Handle with the T up and the coring body down. This positions the plunger bottom flush with the bottom of the coring body (ensure that the plunger bottom is in position).
- Using the T-Handle, push the sampler into the soil until the coring body is completely filled. When full, the small o-ring will be centered in the T-Handle viewing hole.
- Remove the sampler from the soil and wipe any excess soil from the exterior of the coring body.
- Place a cap on the coring body while it is still in the T-Handle. Push and twist the cap over the bottom until the grooves on the locking arms seat over the ridge on the coring body. The cap must be seated to seal the sampler.
- Remove the capped sampler by depressing the locking lever on the T-Handle while twisting and pulling the sampler from the T-Handle.
- Lock the plunger by rotating the extended plunger rod fully counter-clockwise until the wings rest firmly against the tabs.
- Attach a completed circular label from the EnCore Sampler bag to the cap on the coring body.

- Complete the outside label on the EnCore Sampler bag and add a custody seal.
- Return the full EnCore Sampler to a resealable plastic bag. Seal the bag and place on ice.

It should be noted that EnCore Samplers can be used for all soil sampling activities, i.e., surface soil, sediment, etc., by sub-sampling the sampling device (e.g., shovel, coring device, split spoon). In a soil matrix that is noncohesive, the EnCore Sampler's plunger can be retracted, filled with the required sample volume, and then capped.

5. BIBLIOGRAPHY

ASTM Standard D4700. 2006. "Standard Guide for Soil Sampling from the Vadose Zone." ASTM International, West Conshohocken, PA. 2006, DOI: 10.1520/D4700-91R06. www.astm.org.

ASTM Standard D3550. 2007. "Standard Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils." ASTM International, West Conshohocken, PA. 2007, DOI: 10.1520/D3550-01R07. www.astm.org.

ASTM Standard D1452. 2009. "Standard Practice for Soil Exploration and Sampling by Auger Borings." ASTM International, West Conshohocken, PA. 2009, DOI: 10.1520/D1452-09. www.astm.org.

ASTM Standard D1586. 2008. "Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils." ASTM International, West Conshohocken, PA. 2008, DOI: 10.1520/D1586-08a. www.astm.org.

ASTM Standard D1587. 2008. "Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes." ASTM International, West Conshohocken, PA. 2008, DOI: 10.1520/D1587-00R07E01. www.astm.org.

SOP SS-5

TEST PIT EXCAVATION

STANDARD OPERATING PROCEDURE SS-5

TEST PIT EXCAVATION

1. SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) defines the safe methods to be followed during the excavation, logging, and sampling of test pits. Included in this discussion are procedures for obtaining representative samples and proper documentation of sampling activities.

1.1 DISCUSSION

The scope of this document is limited to project activities relating to test pit construction, soil and waste description, and sample collection. The objectives of test pit excavation are to:

- Describe the physical nature of consolidated or unconsolidated subsurface earthen materials.
- Characterize disposal areas.
- Describe waste materials.
- Determine subsurface soil characteristics.
- Collect representative samples of materials encountered.

2. EQUIPMENT

2.1 HEALTH AND SAFETY ITEMS

Gloves
Hard hat
Steel-toed boots
Rain gear
Ear plugs
Field first-aid kit
Flame ionization detector (FID)/photoionization detector (PID)

2.2 PAPER WORK

Field logbook

Work Plan

Site map

Test pit logs

Chain-of-custody forms

2.3 MEASURING EQUIPMENT

Folding ruler marked in 0.10 of an inch

100-foot fiberglass tape measure

Grain size chart

Color chart

2.4 SAMPLING EQUIPMENT

Stainless steel trowels

Stainless steel scoopulas

Stainless steel bowls

2.5 MISCELLANEOUS

Camera

Stakes

Flagging

“Caution” tape

Identification tags for staked locations

Mean Streak or other paint markers

Drum liners

Bung wrench/crescent wrench

Straw and grass seed

Decontamination supplies

3. RELATED PROCEDURES

SOP G-1	Field Documentation
SOP G-3	Field Sample Numbering
SOP G-4	Quality Assurance/Quality Control Sampling
SOP G-6	Decontamination
SOP G-7	Management of Investigation Derived Waste (IDW)
SOP G-8	Sample Chain-of-Custody
SOP G-10	Surveying
SOP G-11	MEC Anomaly Avoidance
SOP A-2	Calibration and Use of Air Monitoring Equipment

4. PROCEDURE

4.1 PREPARATION

Field Team Leaders and other key project members must meet with the Project Manager to discuss requirements for test pit activities. At a minimum, this discussion needs to address the following items:

- The extent of the test pit field effort. Determine the number, location, and type of samples to be collected, including Q/A and Q/C samples. Review available background information (i.e., topographic maps, soil survey maps, geologic survey maps, other site reports). If appropriate, prepare a work and sampling plan with appropriate site maps.

- Review associated operating practices for information on the performance of all relevant field activities that will be required to complete near surface or shallow soil sampling activities.

- Determine necessary sampling and monitoring equipment. Decontaminate or pre-clean equipment. Inspect and test, if possible, all equipment to determine the operating condition of equipment to be utilized prior to performance of field activities.

- Verify that the client representatives have been notified of test pit activities, including dates, times, equipment, subcontractors, number of personnel, duration, operations clearances, utility clearances, and other information affecting site operations and client personnel or safety. All test pit locations are required to be utility-cleared by the client or utility companies in writing prior to any intrusive activities. Verify utility clearances have been completed prior to sampling. Obtain a field logbook and the appropriate Test Pit (see Sample Forms section of SOP G-3) for documenting test pit activities. If project requirements specify another form for recording test pit information, obtain those form(s).

- Prepare schedules and coordinate with staff, client, and regulatory agencies, if appropriate.

- Notify analytical laboratory of sample types, the number of samples, and approximate arrival date.

- Confirm that all equipment has arrived, has been decontaminated or pre-cleaned before sampling, and is operational.

- Conduct a site survey prior to site entry in accordance with the Accident Prevention Plan.

- Identify and locate all test pit areas. Stake anticipated limits of excavation as indicated on the site map, and mark stakes with the test pit number. Ensure that site access to excavation areas has been obtained and cleared with appropriate personnel. Confirm utility clearances from the client representative and other utility representatives in accordance with CONTRACTOR standard practices. If test pits are in a high-traffic area, set up an exclusion zone using yellow marking tape strung from stakes or other semi-permanent objects.

4.2 TEST PIT EXCAVATION

Excavate test pits with a backhoe that uses a 2- to 3-foot-wide bucket capable of efficient excavation to the appropriate depth.

- At those sites requiring restoration or containing contaminated materials, remove and stockpile the topsoil or contaminated material. Make shallow cuts of 1- to 2-foot depths, and stockpile the material on the downwind or downslope side of the trench. Maintain ample space (a minimum of 2 feet) between the stockpiled material and test pit to maneuver excavation equipment.

- Depending on the strength of the surficial deposits being trenched, mapping may occur concurrently with the advancement of the trench. The site geologist and an assistant should conduct the mapping of the trench wall at a safe distance behind the backhoe, lessening the risk of exposure to caving induced by backhoe vibrations.

- When appropriate, restrict access to the trench area(s). Use barricades with flashing lights to preclude vehicle and pedestrian traffic, and delineate a perimeter that contains the trench, windbreak, and topsoil/contaminated material stockpiles.

- Do not stand near the edge of the pit because of the danger of collapse.

- Sketch the development of the test pit in map view in the field logbook. Complete vertical profiles at several locations along the length of the test pit. Sketch a longitudinal section of the test pit. Indicate the lateral changes in soil or fill conditions.

- Record physical attributes of units that are distinct because of lithology, texture, or color. Utilize the ground surface adjacent to the test pit as the reference elevation. In addition to bedding planes and lithologic interfaces, geologic features (like cobble strings) may aid in following stratum continuity, particularly if individual units are difficult to discern.

- Describe samples using the soil field classification system designated for the project. Photographs are useful. Reference photographs in the field logbook.

- Excavated material will be placed on plastic and isolated from contact with surface soil to the extent practical. Arrange the excavated material in such a way that it can be placed in the test pit in the approximate reverse order from which it was removed.

- Samples will be collected as described in Section 4.3.

- Backfill the test pit with the material excavated. Replace the material in the reverse order from which it was removed. Compact the material after replacement of each foot of backfilled material. Mound the surface slightly to allow for subsidence of the backfill.

- Stabilize the surface soil of the test pit by seeding and covering with hay or straw to minimize erosion, if required by the project scope of work.

- The pits are <u>not</u> to remain as open excavations overnight. Plan test pits to be completed within one work day. Test pits are required to be backfilled the same day as excavated.

- Decontaminate backhoe equipment between test pits as specified in SOP G-2.

4.3 TEST PIT SAMPLING

- When required, collect samples from material excavated by the equipment during excavation of the test pit. <u>Do</u> <u>not</u> enter the test pit. Collect samples at locations and frequencies specified in the Work Plan or as determined during office preparation activities.

- Select parts of excavated material not contacting the bucket of the excavation equipment by scraping the surface layer away with a clean sampling implement. Use a second clean implement to collect the sample.

- If sampling for volatile organic analytes (VOAs), collect this sample first from a fresh surface to minimize effects of aeration. Place the soil in the sample container, remove any soil clinging to the bottle threads or rim, and seal without delay.

- When composite samples are specified, collect an equal volume of each discrete homogeneous sample. Place discrete samples in a stainless steel or tempered container, and mix thoroughly to obtain a composite sample representative of the sampling interval. Using a decontaminated or disposable sampling tool, place the sample in appropriately marked laboratory-provided containers.

- When discrete sampling is specified, direct the backhoe operator to excavate a bucket from the specified depth or use a shovel if depth is easily accessible. Using the appropriate sampling tools, collect the soil from the backhoe bucket and place into the appropriate jars.

- Samples may also be sieved through a 0.25- or 0.375-inch sieve. Sieving serves to remove non-soil debris, reduce sample size, and promote sample homogeneity.

- Record pertinent information about each sample in a field logbook or on a Test Pit Logging Form.

4.4 POST OPERATION

- Ensure that all equipment is accounted for and ready for shipment.

- Ensure that a chain-of-custody is completed and included as part of shipping documents.

- Make sure all test pit locations are properly identified and location markers are readily visible.

- Deliver the original field forms and field notebook to the Project Manager (or his designee). The original forms should be copied and filed.

- Follow the Quality Assurance/Quality Control (QA/QC) regimen established for the data. At a minimum, this should include documentation of all corrections or changes to the field forms whenever they are made. Field personnel should review these changes for accuracy at appropriate times during the QA/QC process.

4.5 SAMPLE CONTAINERS AND PRESERVATION TECHNIQUES

4.5.1 Sample Containers

Information about sample containers is included in the Quality Assurance Project Plan (QAPP) or in the specific analytical method for information on the required size and type of sample containers. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common parameters follows:

1. VOA.
2. Total organic carbon (TOC).
3. Extractable organics (base/neutral/acid (BNA) or semivolatile organic compound (SVOCs)).
4. Total metals
5. Phenols.
6. Cyanide.
7. Total solids.

4.5.2 Sample Preservation and Handling

Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in soil investigation programs are not chemically stable; therefore, sample preservation is required. Appropriate preservation techniques and sample containers that the sampler should use for each constituent or common set of parameters for various parameters are specified in the QAPP, Section 19.

The following general precautions should be taken when sampling:

1. A clean pair of new, disposable gloves should be worn each time a different location is sampled, and gloves should be donned immediately prior to sampling.

2. Sample containers for source samples or samples suspected of containing high concentrations of contaminants should be placed in separate plastic bags immediately after collecting, preserving, tagging.

3. Samples of waste or highly contaminated samples should never be placed in the same ice chest as environmental samples.

4. If possible, one member of the field team should take notes and fill out sample tags and field sheets while the other members collect the samples.

5. Sample collection activities should proceed progressively from the suspected least contaminated area to the suspected most contaminated area.

6. Field personnel should use equipment constructed of Teflon, stainless steel, or glass that has been properly pre-cleaned. Teflon or glass is preferred for collecting samples where trace metals are of concern.

7. Adequate field control samples should be collected.

4.5.3 Field Quality Control Sample Procedures

Field control samples are collected by the sampling team to determine whether the data are of suitable quality. They include blanks, duplicates, and/or background samples. A detailed discussion of field control samples is contained in SOP G-8.

4.5.4 Decontamination Procedures

All sampling equipment must be decontaminated prior to its use. Sampling equipment should be decontaminated as described in SOP G-2. The sampling equipment should be placed in plastic bags until immediately prior to use. Additional sampling devices may be needed on-site to ensure adequate drying time.

4.5.5 Documentation

Bound field logbooks should be used for the maintenance of field records. All aspects of sample collection and handling, as well as visual observations, shall be documented in the field logbooks as outlined in SOP G-3.

All entries in field logbooks should be legibly recorded, and contain accurate and inclusive documentation of project activities.

MR-SOP-1

ANOMALY AVOIDANCE

Analog Detection and Removal Operations

Document No. MR-SOP-1

Reviewed and Approved by: _____ Date: 8/27/2018
Senior Client Service Manager, Munitions Response

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
01	8/27/2018	Section 3.4 Earth Moving Machinery/ A discussion was added about "high input" operations.	Lara Lugo	Melanie Costello
00		Original Publication	Bryan Hnetinka	Brian Grassmyer

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when conducting analog detection and removal operations commonly referred to as "mag & dig" or "mag & flag" surveys. This SOP provides Weston Solutions, Inc. (WESTON) employees and subcontractors with the minimum procedures and safety and health requirements applicable to the conduct of analog detection and removal operations at sites with munitions and explosives of concern (MEC).

The following operating procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with other work planning documents including site-specific work plan, Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP), applicable Federal, State, and local regulations, and contract restrictions and guidance.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel Responsibilities and Duties

All UXO personnel will meet or exceed the requirements of Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP)-18, Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities (DDESB, 2016), for their respective project functions. The following individuals will be involved in analog operations.

Senior UXO Supervisor (SUXOS) – Ensures operations related to MEC are being conducted in accordance with this SOP and applicable planning documents. Duties may include but are not limited to:

- Managing UXO Teams and Other Teams and assigning specific tasks.

- Coordinating MEC operations with other site activities.
- Inspect recovered items for the presence of energetic material.
- Maintain a log of MEC operations at the site.
- See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Safety Officer (UXOSO) – Communicates directly with WESTON's Health and Safety Lead on all matters concerning safety. Duties may include but are not limited to:

- Ensure all explosive safety procedures are performed in accordance with site-specific project plans.
- Analyze explosives operational risk, hazards, and safety requirements.
- Confirm compliance with all site-specific safety requirements for explosives operations.
- Enforce personnel limits and safety exclusion zones for MEC operations.
- Monitors all activities associated with explosives transportation, storage, and destruction.
- Position may be dual-hatted with the UXOQCS. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Quality Control Specialist (UXOQCS) – Communicates directly with WESTON's Quality Control Lead on all matters concerning quality. Duties may include but are not limited to:

- Ensure all quality procedures are performed in accordance with site-specific project plans.
- Confirm compliance with all site-specific quality requirements for explosives operations.
- Establish a site-wide seeding program and monitors recovery results.
- Position may be dual-hatted with the UXOSO. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Team Leader/ UXO Technician III – Responsible for operations of his/her team including safety and quality. Duties may include but are not limited to:

- Supervise the UXO Team to ensure safe operating practices and work is being performed at a high quality. The UXO Team Leader may work as a member of the sweep line and perform other tasks.
- Determine if work is complete at each assigned area.
- Classify recovered items and identify MEC by the specific nomenclature if possible.
- Maintain a log of UXO Team operations.
- Complete required forms or other documentation specified in the work planning documents.
- Will be able to perform the responsibilities of a UXO Technician II. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Technician II – Responsible for safely detecting and investigating anomalies. Duties may include but are not limited to:

- Operate analog geophysical equipment to detect anomalies.
- Conduct intrusive investigations and make preliminary identification and classification of recovered items.
- Supervise UXO Technician I's and conduct other duties as assigned.

CONTROLLED COPY

- Will be able to perform the responsibilities of a UXO Technician I. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Technician I – Aids in the investigation of anomalies. Duties may include but are not limited to:

- Operate analog geophysical equipment to detect anomalies.
- Conduct intrusive investigations.
- See DDESB TP-18 for additional detailed clarification on responsibilities.

2.2 Equipment and Materials

The following is a list of equipment and materials often required to perform analog operations. Consult work planning documents to revise/ modify this list to meet the specific project requirements.

- Analog geophysical instrument
- Safety gear per APP/SSHP
- Intrusive tools (e.g. shovel, pick, digging bar, hand trowel)
- Bucket
- Camera
- Radio
- Line/rope
- Pin flags
- Communication device

2.2.1 Inspection and Function Testing

Equipment functionality of all geophysical instruments will be checked daily at the instrument test strip. The operator will verify the response from known items is appropriate. Instrument settings will be confirmed. Log the test results per the site-specific planning documents.

3. Procedure and Protocols

Analog detection and removal operations can be conducted along transects in support of site characterization or individual or contiguous grids. Typically analog geophysical instruments are utilized where digital geophysical systems would be ineffective or cost prohibited. Sites where analog geophysical sensors are utilized may have vegetation or terrain challenges or at sites where anomaly density is too high to accurately analyze and interpret digital data outputs.

3.1 Safety

All analog detection and removal activities at sites containing MEC will be conducted under the supervision of UXO-qualified personnel per DDESB TP-18. Only essential personnel and UXOSO approved authorized visitors will be allowed within the exclusion zone during intrusive operations. If access is required by non-essential personnel contact the SUXOS to halt all intrusive work. During operations, WESTON personnel will strictly adhere to the APP/ SSHP and the following general safety practices:

CONTROLLED COPY

- Access to operating areas will be limited to only those personnel necessary to accomplish the specific operation.
- The exclusion zone should be monitored by the UXOSO and Team Leaders for unauthorized entry and stop intrusive work when non-essential personnel enter the area.
- MEC will only be handled by qualified UXO Technicians.
- During MEC operations the minimum separation distance (MSD) between MEC and non-MEC operations is based on the unintentional detonation fragmentation distance of the munition with the greatest fragmentation distance (MGFD), as stated in the Explosives Site Plan (ESP) or Explosives Safety Submission (ESS).
- All personnel will attend a safety briefing prior to entering the operating area.
- Anyone can stop operations for an unsafe act or situation.
- Safety violations and/or unsafe acts will be immediately reported to the SUXOS and/or UXOSO.
- Failure to comply with safety rules/procedures may result in termination of employment.

3.2 Sweep Procedures

Specific instructions for site layout and survey locations will be provided in the site specific planning documents.

3.2.1 Transect Survey Procedures

The following transect survey approach will be performed by the UXO Team:

- Any pre-planned analog transect locations will be reviewed with the UXO Team at the morning briefing.
- Each analog instrument planned to be used for transect surveys will be checked at the instrument test strip to confirm functionality.
- The first transect and starting point will be located using GPS. The transect ID will be confirmed with the instruction provided by the SUXOS.
- The pre-planned transects will be followed by the UXO Team using a GPS or equivalent navigation aid to display transect locations and/or track waypoints along the transects.
- The actual path traversed by the UXO Team will be recorded with a GPS and transferred to the project GIS daily.
- During traversal the UXO Technician moves the analog geophysical instrument back and forth from one side to the other in a manner to ensure complete coverage within a five (5)-foot-wide lane. Both forward movement and the swing of the geophysical instrument are performed at a pace that ensures the entire lane is searched and that the instrument is able to appropriately respond to subsurface anomalies.
- When an anomaly is detected, the UXO Technician halts and investigates the anomaly at that time. Anomalies detected along each transect will be investigated as they are detected.
- Visual observations will also be made by the team and recorded on dig lists as each transect is traversed.
- Throughout this operation the team leader closely monitors the team's individual performance to ensure these procedures are being performed correctly.

CONTROLLED COPY

3.2.2 Grid Survey Procedures

The following grid survey approach will be performed by the UXO Team:

- Any pre-planned analog grid locations will be reviewed with the UXO Team at the morning briefing.
- Each analog instrument planned to be used for grid surveys will be checked at the instrument test strip to confirm functionality.
- The first grid will be located using GPS. The grid ID will be confirmed with the instructions provided by the SUXOS.
- The UXO team will divide each grid into 5 feet wide lanes using rope, pin flags, cones, etc.
- Each lane will be surveyed using an analog geophysical instrument. The operation will begin at one end of each lane and move in a forward direction toward the opposing baseline.
- During traversal the UXO Technician moves the analog geophysical instrument back and forth from one side to the other in a manner to ensure complete coverage within a 5 foot wide lane. Both forward movement and the swing of the geophysical instrument are performed at a pace that ensures the entire lane is searched and that the instrument is able to appropriately respond to subsurface anomalies. The survey will be performed in such a manner that there is sufficient overlap between lanes to confirm full coverage surveys.
- When an anomaly is detected, the UXO Technician halts and investigates the anomaly at that time. Anomalies detected along each transect will be investigated as they are detected.
- Visual observations will also be made by the team and recorded on dig lists as each transect is traversed.
- Throughout this operation the team leader closely monitors the team's individual performance to ensure these procedures are being performed correctly.

3.3 Subsurface Investigations

Subsurface anomalies will be investigated by UXO Technicians as they are identified during the survey (e.g. transect or grid).

- All identified anomalies within the grid will be intrusively investigated. Excavations for individual anomalies will be conducted using an analog geophysical instrument to assist the team in determining the location of the target item.
- The UXO Technicians excavating anomalies shall initially remove no more than a 6-inch layer of soil alongside the location of the anomaly, being careful not to interact with the item.
- The UXO Technician will conduct a visual and geophysical search of the excavation to further pin point the anomaly source as needed.
- This process shall be repeated until the audible signal from the geophysical instrument indicates the object is close to the surface. Once this determination has been made, soil will be removed by hand until the source of the anomaly is located.
- Once the item is uncovered, characterize and recover the item.
- Re-check the area with the analog geophysical instrument and continue removal efforts if a signal persists.
- Backfill any excavation after completing documentation unless otherwise instructed.
- Repeat process until the assigned area is complete.

CONTROLLED COPY

3.4 Earth Moving Machinery

The UXO Team may use earth moving machinery (EMM) to assist in manual excavation of anomalies. A UXO Technician on the ground must guide excavation. Once the EMM is within 12 inches of the item, complete the excavation manually. There is no need to harden/shield the EMM to protect its operator when EMM is used to remove soil overburden to within 12 inches from the item.

Use of EMM may be required to access, excavate, inspect and process material. These operations are considered to be "Low Input" per DoD 6055.09-M. Shielding is required to protect the operator from fragmentation. The operator will be afforded protection from blast overpressure based on the K24 distance. The MSD may be reduced to the K18 distance if hearing protection is used. Refer to the ESP or ESS for approved minimum separation distances. Low Input operations are not intended to intentionally deform material including MEC but depends on the risk assessment and type of MEC that may be encountered.

"High Input" processing operations (e.g. shredders, crushers) are intended to physically deform material including any MEC being processed and certain excavations depending upon the risk assessment. Non-essential personnel shall be provided protection for intentional detonations based on the MGFD. Shielding is required to protect the operator from fragmentation. The operator will be afforded protection from blast overpressure based on the K24 distance. The MSD may be reduced to the K18 distance if hearing protection is used. Refer to the ESP or ESS for approved minimum separation distances.

3.5 Material Potentially Presenting an Explosive Hazard

Inspection of material potentially presenting an explosive hazard (MPPEH) will follow the following general procedures. Refer to site-specific planning documents for site-specific instruction:

- After initial inspection of MPPEH by a UXO Technician II, the UXO Technician III must perform a second independent inspection.
- After the second inspection document the material as material documented as safe (MDAS) in the team leader's logbook and turn MDAS over to the SUXOS for final disposition.
- Mark identified MEC for disposal and notify the SUXOS. The demolition procedure should be referenced.
- MEC acceptable to move as determined by the SUXOS and UXOSO may be relocated within the site for subsequent disposal operations. MEC unacceptable to move will be blown-in-pace.
- MEC will be safeguarded until disposal operations can take place unless otherwise directed.

4. Data Management/ Documentation

All aspects of analog detection and removal operations will be documented for reporting purposes. Follow site-specific forms provided in the work planning documents throughout the course of operations.

CONTROLLED COPY

5. Quality Control

The site-specific quality control program is documented in the work planning documents. Overarching quality control aspects that will be monitored by the UXOQCS include the following:

- Confirm all work planning documents have been read by project personnel and all practices and procedures are understood and followed.
- Test equipment functionality of geophysical instrumentation daily and document the results.
- Develop a site-wide seeding program if required by work planning documents to confirm coverage and detection capability of the UXO Team. Track and report daily by location and team.
- Assess UXO Team performance periodically to confirm project objectives are achieved.

6. Reporting

Project personnel are responsible for providing objective documentation in sufficient detail showing that they have met the requirements of this SOP and relevant project plans. Collect, retain and maintain the documentation resulting from this SOP with the project record files in accordance with the work plan.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

APP	Accident Prevention Plan
DDESB	Department of Defense Explosives Safety Board
EMM	Earth Moving Machinery
ESP	Explosives Site Plan
ESS	Explosives Safety Submission
GPS	Global Positioning System
MDAS	Material Documented as Safe
MEC	Munitions and Explosives of Concern
MGFD	Munition with the Greatest Fragmentation Distance
MPPEH	Material Potentially Presenting an Explosive Hazard
MSD	Minimum Separation Distance
SOP	Standard Operating Procedure
SUXOS	Senior UXO Supervisor
SSHP	Site Specific Health and Safety Plan
TP	Technical Paper
UXO	Unexploded Ordnance
UXOQCS	UXO Quality Control Specialist
UXOSO	UXO Safety Officer
WESTON	Weston Solutions, Inc.

CONTROLLED COPY

8. References

DoD. 2017. DoD Manual 6055.09-M. DoD Ammunition and Explosives Safety Standards: General Explosives Safety Information and Requirements.

DDESB. 2016. Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities.

USACE. 2013. EM 385-1-97, Explosives Safety and Health Requirements Manual.

USACE. 2015. EM 200-1-15, Technical Guidance for Military Munitions Response Actions.

CONTROLLED COPY

MR-SOP-2

ANALOG DETECTION AND REMOVAL OPERATIONS

Analog Detection and Removal Operations

Document No. MR-SOP-2

Reviewed and Approved by: _____ Date: 8/27/2018
Senior Client Service Manager, Munitions Response

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
01	8/27/2018	Section 3.4 Earth Moving Machinery/ A discussion was added about "high input" operations.	Lara Lugo	Melanie Costello
00		Original Publication	Bryan Hnetinka	Brian Grassmyer

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when conducting analog detection and removal operations commonly referred to as "mag & dig" or "mag & flag" surveys. This SOP provides Weston Solutions, Inc. (WESTON) employees and subcontractors with the minimum procedures and safety and health requirements applicable to the conduct of analog detection and removal operations at sites with munitions and explosives of concern (MEC).

The following operating procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with other work planning documents including site-specific work plan, Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP), applicable Federal, State, and local regulations, and contract restrictions and guidance.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel Responsibilities and Duties

All UXO personnel will meet or exceed the requirements of Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP)-18, Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities (DDESB, 2016), for their respective project functions. The following individuals will be involved in analog operations.

Senior UXO Supervisor (SUXOS) – Ensures operations related to MEC are being conducted in accordance with this SOP and applicable planning documents. Duties may include but are not limited to:

- Managing UXO Teams and Other Teams and assigning specific tasks.

- Coordinating MEC operations with other site activities.
- Inspect recovered items for the presence of energetic material.
- Maintain a log of MEC operations at the site.
- See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Safety Officer (UXOSO) – Communicates directly with WESTON's Health and Safety Lead on all matters concerning safety. Duties may include but are not limited to:

- Ensure all explosive safety procedures are performed in accordance with site-specific project plans.
- Analyze explosives operational risk, hazards, and safety requirements.
- Confirm compliance with all site-specific safety requirements for explosives operations.
- Enforce personnel limits and safety exclusion zones for MEC operations.
- Monitors all activities associated with explosives transportation, storage, and destruction.
- Position may be dual-hatted with the UXOQCS. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Quality Control Specialist (UXOQCS) – Communicates directly with WESTON's Quality Control Lead on all matters concerning quality. Duties may include but are not limited to:

- Ensure all quality procedures are performed in accordance with site-specific project plans.
- Confirm compliance with all site-specific quality requirements for explosives operations.
- Establish a site-wide seeding program and monitors recovery results.
- Position may be dual-hatted with the UXOSO. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Team Leader/ UXO Technician III – Responsible for operations of his/her team including safety and quality. Duties may include but are not limited to:

- Supervise the UXO Team to ensure safe operating practices and work is being performed at a high quality. The UXO Team Leader may work as a member of the sweep line and perform other tasks.
- Determine if work is complete at each assigned area.
- Classify recovered items and identify MEC by the specific nomenclature if possible.
- Maintain a log of UXO Team operations.
- Complete required forms or other documentation specified in the work planning documents.
- Will be able to perform the responsibilities of a UXO Technician II. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Technician II – Responsible for safely detecting and investigating anomalies. Duties may include but are not limited to:

- Operate analog geophysical equipment to detect anomalies.
- Conduct intrusive investigations and make preliminary identification and classification of recovered items.
- Supervise UXO Technician I's and conduct other duties as assigned.

CONTROLLED COPY

- Will be able to perform the responsibilities of a UXO Technician I. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Technician I – Aids in the investigation of anomalies. Duties may include but are not limited to:

- Operate analog geophysical equipment to detect anomalies.
- Conduct intrusive investigations.
- See DDESB TP-18 for additional detailed clarification on responsibilities.

2.2 Equipment and Materials

The following is a list of equipment and materials often required to perform analog operations. Consult work planning documents to revise/ modify this list to meet the specific project requirements.

- Analog geophysical instrument
- Safety gear per APP/SSHP
- Intrusive tools (e.g. shovel, pick, digging bar, hand trowel)
- Bucket
- Camera
- Radio
- Line/rope
- Pin flags
- Communication device

2.2.1 Inspection and Function Testing

Equipment functionality of all geophysical instruments will be checked daily at the instrument test strip. The operator will verify the response from known items is appropriate. Instrument settings will be confirmed. Log the test results per the site-specific planning documents.

3. Procedure and Protocols

Analog detection and removal operations can be conducted along transects in support of site characterization or individual or contiguous grids. Typically analog geophysical instruments are utilized where digital geophysical systems would be ineffective or cost prohibited. Sites where analog geophysical sensors are utilized may have vegetation or terrain challenges or at sites where anomaly density is too high to accurately analyze and interpret digital data outputs.

3.1 Safety

All analog detection and removal activities at sites containing MEC will be conducted under the supervision of UXO-qualified personnel per DDESB TP-18. Only essential personnel and UXOSO approved authorized visitors will be allowed within the exclusion zone during intrusive operations. If access is required by non-essential personnel contact the SUXOS to halt all intrusive work. During operations, WESTON personnel will strictly adhere to the APP/ SSHP and the following general safety practices:

CONTROLLED COPY

- Access to operating areas will be limited to only those personnel necessary to accomplish the specific operation.
- The exclusion zone should be monitored by the UXOSO and Team Leaders for unauthorized entry and stop intrusive work when non-essential personnel enter the area.
- MEC will only be handled by qualified UXO Technicians.
- During MEC operations the minimum separation distance (MSD) between MEC and non-MEC operations is based on the unintentional detonation fragmentation distance of the munition with the greatest fragmentation distance (MGFD), as stated in the Explosives Site Plan (ESP) or Explosives Safety Submission (ESS).
- All personnel will attend a safety briefing prior to entering the operating area.
- Anyone can stop operations for an unsafe act or situation.
- Safety violations and/or unsafe acts will be immediately reported to the SUXOS and/or UXOSO.
- Failure to comply with safety rules/procedures may result in termination of employment.

3.2 Sweep Procedures

Specific instructions for site layout and survey locations will be provided in the site specific planning documents.

3.2.1 Transect Survey Procedures

The following transect survey approach will be performed by the UXO Team:

- Any pre-planned analog transect locations will be reviewed with the UXO Team at the morning briefing.
- Each analog instrument planned to be used for transect surveys will be checked at the instrument test strip to confirm functionality.
- The first transect and starting point will be located using GPS. The transect ID will be confirmed with the instruction provided by the SUXOS.
- The pre-planned transects will be followed by the UXO Team using a GPS or equivalent navigation aid to display transect locations and/or track waypoints along the transects.
- The actual path traversed by the UXO Team will be recorded with a GPS and transferred to the project GIS daily.
- During traversal the UXO Technician moves the analog geophysical instrument back and forth from one side to the other in a manner to ensure complete coverage within a five (5)-foot-wide lane. Both forward movement and the swing of the geophysical instrument are performed at a pace that ensures the entire lane is searched and that the instrument is able to appropriately respond to subsurface anomalies.
- When an anomaly is detected, the UXO Technician halts and investigates the anomaly at that time. Anomalies detected along each transect will be investigated as they are detected.
- Visual observations will also be made by the team and recorded on dig lists as each transect is traversed.
- Throughout this operation the team leader closely monitors the team's individual performance to ensure these procedures are being performed correctly.

CONTROLLED COPY

3.2.2 Grid Survey Procedures

The following grid survey approach will be performed by the UXO Team:

- Any pre-planned analog grid locations will be reviewed with the UXO Team at the morning briefing.
- Each analog instrument planned to be used for grid surveys will be checked at the instrument test strip to confirm functionality.
- The first grid will be located using GPS. The grid ID will be confirmed with the instructions provided by the SUXOS.
- The UXO team will divide each grid into 5 feet wide lanes using rope, pin flags, cones, etc.
- Each lane will be surveyed using an analog geophysical instrument. The operation will begin at one end of each lane and move in a forward direction toward the opposing baseline.
- During traversal the UXO Technician moves the analog geophysical instrument back and forth from one side to the other in a manner to ensure complete coverage within a 5 foot wide lane. Both forward movement and the swing of the geophysical instrument are performed at a pace that ensures the entire lane is searched and that the instrument is able to appropriately respond to subsurface anomalies. The survey will be performed in such a manner that there is sufficient overlap between lanes to confirm full coverage surveys.
- When an anomaly is detected, the UXO Technician halts and investigates the anomaly at that time. Anomalies detected along each transect will be investigated as they are detected.
- Visual observations will also be made by the team and recorded on dig lists as each transect is traversed.
- Throughout this operation the team leader closely monitors the team's individual performance to ensure these procedures are being performed correctly.

3.3 Subsurface Investigations

Subsurface anomalies will be investigated by UXO Technicians as they are identified during the survey (e.g. transect or grid).

- All identified anomalies within the grid will be intrusively investigated. Excavations for individual anomalies will be conducted using an analog geophysical instrument to assist the team in determining the location of the target item.
- The UXO Technicians excavating anomalies shall initially remove no more than a 6-inch layer of soil alongside the location of the anomaly, being careful not to interact with the item.
- The UXO Technician will conduct a visual and geophysical search of the excavation to further pin point the anomaly source as needed.
- This process shall be repeated until the audible signal from the geophysical instrument indicates the object is close to the surface. Once this determination has been made, soil will be removed by hand until the source of the anomaly is located.
- Once the item is uncovered, characterize and recover the item.
- Re-check the area with the analog geophysical instrument and continue removal efforts if a signal persists.
- Backfill any excavation after completing documentation unless otherwise instructed.
- Repeat process until the assigned area is complete.

CONTROLLED COPY

3.4 Earth Moving Machinery

The UXO Team may use earth moving machinery (EMM) to assist in manual excavation of anomalies. A UXO Technician on the ground must guide excavation. Once the EMM is within 12 inches of the item, complete the excavation manually. There is no need to harden/shield the EMM to protect its operator when EMM is used to remove soil overburden to within 12 inches from the item.

Use of EMM may be required to access, excavate, inspect and process material. These operations are considered to be "Low Input" per DoD 6055.09-M. Shielding is required to protect the operator from fragmentation. The operator will be afforded protection from blast overpressure based on the K24 distance. The MSD may be reduced to the K18 distance if hearing protection is used. Refer to the ESP or ESS for approved minimum separation distances. Low Input operations are not intended to intentionally deform material including MEC but depends on the risk assessment and type of MEC that may be encountered.

"High Input" processing operations (e.g. shredders, crushers) are intended to physically deform material including any MEC being processed and certain excavations depending upon the risk assessment. Non-essential personnel shall be provided protection for intentional detonations based on the MGFD. Shielding is required to protect the operator from fragmentation. The operator will be afforded protection from blast overpressure based on the K24 distance. The MSD may be reduced to the K18 distance if hearing protection is used. Refer to the ESP or ESS for approved minimum separation distances.

3.5 Material Potentially Presenting an Explosive Hazard

Inspection of material potentially presenting an explosive hazard (MPPEH) will follow the following general procedures. Refer to site-specific planning documents for site-specific instruction:

- After initial inspection of MPPEH by a UXO Technician II, the UXO Technician III must perform a second independent inspection.
- After the second inspection document the material as material documented as safe (MDAS) in the team leader's logbook and turn MDAS over to the SUXOS for final disposition.
- Mark identified MEC for disposal and notify the SUXOS. The demolition procedure should be referenced.
- MEC acceptable to move as determined by the SUXOS and UXOSO may be relocated within the site for subsequent disposal operations. MEC unacceptable to move will be blown-in-pace.
- MEC will be safeguarded until disposal operations can take place unless otherwise directed.

4. Data Management/ Documentation

All aspects of analog detection and removal operations will be documented for reporting purposes. Follow site-specific forms provided in the work planning documents throughout the course of operations.

CONTROLLED COPY

5. Quality Control

The site-specific quality control program is documented in the work planning documents. Overarching quality control aspects that will be monitored by the UXOQCS include the following:

- Confirm all work planning documents have been read by project personnel and all practices and procedures are understood and followed.
- Test equipment functionality of geophysical instrumentation daily and document the results.
- Develop a site-wide seeding program if required by work planning documents to confirm coverage and detection capability of the UXO Team. Track and report daily by location and team.
- Assess UXO Team performance periodically to confirm project objectives are achieved.

6. Reporting

Project personnel are responsible for providing objective documentation in sufficient detail showing that they have met the requirements of this SOP and relevant project plans. Collect, retain and maintain the documentation resulting from this SOP with the project record files in accordance with the work plan.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

APP	Accident Prevention Plan
DDESB	Department of Defense Explosives Safety Board
EMM	Earth Moving Machinery
ESP	Explosives Site Plan
ESS	Explosives Safety Submission
GPS	Global Positioning System
MDAS	Material Documented as Safe
MEC	Munitions and Explosives of Concern
MGFD	Munition with the Greatest Fragmentation Distance
MPPEH	Material Potentially Presenting an Explosive Hazard
MSD	Minimum Separation Distance
SOP	Standard Operating Procedure
SUXOS	Senior UXO Supervisor
SSHP	Site Specific Health and Safety Plan
TP	Technical Paper
UXO	Unexploded Ordnance
UXOQCS	UXO Quality Control Specialist
UXOSO	UXO Safety Officer
WESTON	Weston Solutions, Inc.

CONTROLLED COPY

8. References

DoD. 2017. DoD Manual 6055.09-M. DoD Ammunition and Explosives Safety Standards: General Explosives Safety Information and Requirements.

DDESB. 2016. Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities.

USACE. 2013. EM 385-1-97, Explosives Safety and Health Requirements Manual.

USACE. 2015. EM 200-1-15, Technical Guidance for Military Munitions Response Actions.

CONTROLLED COPY

MR-SOP-3

DIGITAL ANOMALY REMOVAL OPERATIONS

Digital Anomaly Removal Operations

Document No. MR-SOP-2

Reviewed and Approved by: _____ Date: 9/2/2017
Senior Client Service Manager, Munitions Response

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
00		Original Publication	Melanie Costello	Brian Grassmyer

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when conducting removal operations following a digital geophysical mapping (DGM) survey. This SOP provides Weston Solutions, Inc. (WESTON) employees and subcontractors with the minimum procedures and safety and health requirements applicable to the conduct of intrusive operations at sites with munitions and explosives of concern (MEC).

The following operating procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with other work planning documents including site-specific work plan, Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP), applicable Federal, State, and local regulations, and contract restrictions and guidance.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel Responsibilities and Duties

All UXO personnel will meet or exceed the requirements of Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP)-18, Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities (DDESB, 2016), for their respective project functions. The following individuals will be involved in intrusive operations at detected anomaly locations.

Senior UXO Supervisor (SUXOS) – Ensures operations related to MEC are being conducted in accordance with this SOP and applicable planning documents. Duties may include but are not limited to:

- Managing UXO Teams and Other Teams and assigning specific tasks.
- Coordinating MEC operations with other site activities.
- Inspect recovered items for the presence of energetic material.
- Maintain a log of MEC operations at the site.
- See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Safety Officer (UXOSO) – Communicates directly with WESTON's Health and Safety Lead on all matters concerning safety. Duties may include but are not limited to:

- Ensure all explosive safety procedures are performed in accordance with site-specific project plans.
- Analyze explosives operational risk, hazards, and safety requirements.
- Confirm compliance with all site-specific safety requirements for explosives operations.
- Enforce personnel limits and safety exclusion zones for MEC operations.
- Monitors all activities associated with explosives transportation, storage, and destruction.
- Position may be dual-hatted with the UXOQCS. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Quality Control Specialist (UXOQCS) – Communicates directly with WESTON's Quality Control Lead on all matters concerning quality. Duties may include but are not limited to:

- Ensure all quality procedures are performed in accordance with site-specific project plans.
- Confirm compliance with all site-specific quality requirements for explosives operations.
- Position may be dual-hatted with the UXOSO. See DDESB TP-18 for additional detailed clarification on responsibilities.

Quality Control (QC) Geophysicist – Communicates directly with WESTON's Quality Control Lead on all matters concerning quality. Duties may include but are not limited to:

- Reviews and approves reacquisition list.
- Monitors intrusive investigation results with respect to the digital geophysical signature.
- Confirms QC seeds have been selected and intrusively investigated.

UXO Team Leader/ UXO Technician III – Responsible for operations of his/her team including safety and quality. Duties may include but are not limited to:

- Supervise the UXO Team to ensure safe operating practices and work is being performed at a high quality. The UXO Team Leader may work as a member of the dig team and perform other tasks.
- Determine if work is complete at each assigned area.
- Classify recovered items and identify MEC by the specific nomenclature if possible.
- Maintain a log of UXO Team operations.
- Complete required forms or other documentation specified in the work planning documents.
- Will be able to perform the responsibilities of a UXO Technician II. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Technician II – Responsible for safely detecting and investigating anomalies. Duties may include but are not limited to:

- Operate analog or geophysical equipment for anomaly avoidance and to refine the location of anomalies.

CONTROLLED COPY

- Conduct intrusive investigations and make preliminary identification and classification of recovered items.
- Supervise UXO Technician I's and conduct other duties as assigned.
- Will be able to perform the responsibilities of a UXO Technician I. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Technician I – Aids in the investigation of anomalies. Duties may include but are not limited to:

- Operate analog or digital geophysical equipment to refine the location of anomalies.
- Conduct intrusive investigations.

2.2 Equipment and Materials

The following is a list of equipment and materials often required to perform intrusive operations at anomaly locations. Consult work planning documents to revise/ modify this list to meet the specific project requirements.

- Analog geophysical instrument
- Original project-specific DGM survey equipment if required by the project plans (for example EM61-MK2)
- Safety gear per APP/SSHP
- Intrusive tools (e.g. shovel, pick, digging bar, hand trowel)
- Bucket
- Camera
- Radio
- Line/rope
- Pin flags
- Communication device

2.2.1 Inspection and Function Testing

Equipment functionality of all geophysical instruments will be checked daily at the instrument test strip. The operator will verify the response from known items is appropriate. Instrument settings will be confirmed. Log the test results per the site-specific planning documents.

3. Procedure and Protocols

Intrusive operations at anomaly locations occur following a DGM survey along a transect in support of site characterization or at individual or contiguous grids. Typically a Field Geophysicist will operate a digital sensor such as an EM61-MK2 to collect data and transfer to the geophysical Data Analyst to process and interpret the data and ultimately select anomaly locations. The anomaly locations are added to a dig list to be reacquired using a navigation system such as a global positioning system. Following reacquisition, the UXO Team will investigate the anomaly to determine if it is munitions related or non-munitions related debris. The procedures and protocols described below focus on activities that occur following anomaly reacquisition.

CONTROLLED COPY

3.1 Safety

All digital detection and removal activities at sites containing MEC will be conducted under the supervision of UXO-qualified personnel per DDESB TP-18. Only essential personnel and UXOSO approved authorized visitors will be allowed within the exclusion zone during intrusive operations. If access is required by non-essential personnel contact the SUXOS to halt all intrusive work. During operations, WESTON personnel will strictly adhere to the APP/ SSHP and the following general safety practices:

- Access to operating areas will be limited to only those personnel necessary to accomplish the specific operation.
- The exclusion zone should be monitored by the UXOSO and Team Leaders for unauthorized entry and stop intrusive work when non-essential personnel enter the area.
- MEC will only be handled by qualified UXO Technicians.
- During MEC operations the minimum separation distance (MSD) between MEC and non-MEC operations is based on the unintentional detonation fragmentation distance of the munition with the greatest fragmentation distance (MGFD), as stated in the Explosives Site Plan (ESP) or Explosives Safety Submission (ESS).
- All personnel will attend a safety briefing prior to entering the operating area.
- Anyone can stop operations for an unsafe act or situation.
- Safety violations and/or unsafe acts will be immediately reported to the SUXOS and/or UXOSO.
- Failure to comply with safety rules/procedures may result in termination of employment.

3.2 Anomaly Reacquisition

Anomalies interpreted from the DGM survey data and added to the dig list are surveyed using a navigation system (i.e. GPS, robotic total station (RTS), professional surveyor or manual measurement from grid corners). Target locations are marked in the field using non-metallic pin flags or marking paint. Each marker is labeled with a target identification number so that the status of each anomaly can be tracked and documented through reacquisition, excavation and final QC procedures. Specific instructions for anomaly reacquisition will be provided in the site specific planning documents or other SOP's.

3.3 Anomaly Location Investigation

Reacquired anomalies will be investigated by UXO Technicians as they are marked out and identified.

- All reacquired and marked anomalies will be intrusively investigated. Excavations for individual anomalies will be conducted using an analog geophysical instrument to assist the team in determining the location of the target item unless otherwise stated in work planning documents.
- The UXO Technicians excavating anomalies shall initially remove no more than a 6-inch layer of soil alongside the location of the anomaly, being careful not to interact with the item.
- The UXO Technician will conduct a visual and geophysical search of the excavation to further pin point the anomaly source as needed.

CONTROLLED COPY

- This process shall be repeated until the audible signal from the geophysical instrument indicates the object is close to the surface. Once this determination has been made, soil will be removed by hand until the source of the anomaly is located.
- Once the item is uncovered, characterize and recover the item.
- Re-check the area with the analog geophysical instrument and continue removal efforts if a signal persists.
- Backfill any excavation after completing documentation unless otherwise instructed.
- Repeat process until the assigned area is complete.

3.3.1 Earth Moving Machinery

The UXO Team may use earth moving machinery (EMM) to assist in manual excavation of anomalies. A UXO Technician on the ground must guide excavation. Once the EMM is within 12 inches of the item, complete the excavation manually. There is no need to harden/shield the EMM to protect its operator when EMM is used to remove soil overburden to within 12 inches from the item.

Use of EMM may be required to access, excavate, inspect and process material. These operations are considered to be "Low Input" per DoD 6055.9-M. Shielding is required to protect the operator from fragmentation. The operator will be afforded protection from blast overpressure based on the K24 distance. The MSD may be reduced to the K18 distance if hearing protection is used. Refer to the ESP or ESS for approved minimum separation distances.

3.3.2 Material Potentially Presenting an Explosive Hazard

Inspection of material potentially presenting an explosive hazard (MPPEH) will follow the following general procedures. Refer to site-specific planning documents for site-specific instruction:

- After initial inspection of MPPEH by a UXO Technician II, the UXO Technician III must perform a second independent inspection.
- After the second inspection document the material as material documented as safe (MDAS) in the team leader's logbook and turn MDAS over to the SUXOS for final disposition.
- Mark identified MEC for disposal and notify the SUXOS. The demolition procedure should be referenced.
- MEC acceptable to move as determined by the SUXOS and UXOSO may be relocated within the site for subsequent disposal operations. MEC unacceptable to move will be blown-in-pace.
- MEC will be safeguarded until disposal operations can take place unless otherwise directed.

3.3.3 Post-Dig Anomaly Resolution

Post-dig anomaly resolution sampling is conducted after intrusive investigation to verify that the source of the anomaly has been removed during the intrusive investigation. The original geophysical instrument used to detect anomalies, or one that performs better than the original, should be used to verify that the anomaly has been resolved. Consult work planning documents for specific instrumentation.

CONTROLLED COPY

The work planning documents should detail the number of anomalies that require post-dig verification sampling. The UXOQCS and QC Geophysicist will implement the post-dig anomaly resolution process as prescribed in the work planning documents.

4. Data Management/ Documentation

All aspects of the removal operations will be documented for reporting purposes. Follow site-specific forms provided in the work planning documents throughout the course of operations.

5. Quality Control

The site-specific quality control program is documented in the work planning documents. Overarching quality control aspects that will be monitored by the UXOQCS include the following:

- Confirm all work planning documents have been read by project personnel and all practices and procedures are understood and followed.
- Test equipment functionality of geophysical instrumentation daily and document the results.
- Track and report recovery of QC seeds daily by location and team.
- Assess UXO Team performance periodically to confirm project objectives are achieved.
- Monitor dig results to confirm item attributes match digital signatures.

6. Reporting

Project personnel are responsible for providing objective documentation in sufficient detail showing that they have met the requirements of this SOP and relevant project plans. Collect, retain and maintain the documentation resulting from this SOP with the project record files in accordance with the work plan.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

APP	Accident Prevention Plan
DDESB	Department of Defense Explosives Safety Board
DGM	Digital Geophysical Mapping
EMM	Earth Moving Machinery
ESP	Explosives Site Plan
ESS	Explosives Safety Submission
GPS	Global Positioning System
MDAS	Material Documented as Safe
MEC	Munitions and Explosives of Concern
MGFD	Munition with the Greatest Fragmentation Distance
MPPEH	Material Potentially Presenting an Explosive Hazard
MSD	Minimum Separation Distance
RTS	Robotic Total Station

CONTROLLED COPY

SOP	Standard Operating Procedure
SUXOS	Senior UXO Supervisor
SSHP	Site Specific Health and Safety Plan
TP	Technical Paper
UXO	Unexploded Ordnance
UXOQCS	UXO Quality Control Specialist
UXOSO	UXO Safety Officer
WESTON	Weston Solutions, Inc.

8. References

DoD. 2012. DoD Manual 6055.09-M. DoD Ammunition and Explosives Safety Standards: General Explosives Safety Information and Requirements.

DDESB. 2016. Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities.

USACE. 2013. EM 385-1-97, Explosives Safety and Health Requirements Manual.

USACE. 2015. EM 200-1-15, Technical Guidance for Military Munitions Response Actions.

CONTROLLED COPY

MR-SOP-4

MANAGEMENT OF MATERIAL POTENTIALLY PRESENTING AN EXPLOSIVE HAZARD

Management of Material Potentially Presenting an Explosive Hazard

Document No. MR-SOP-4

Reviewed and Approved by: _____ Date: 12/17/2018

Senior Client Service Manager, Munitions Response

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
00		Original Publication	Melanie Costello, Lara Lugo	Bruce Moe, Andrew Caldwell, Brian Grassmyer
01	Dec 2018	3.1 Certification and Verification Procedures/ Part (3) was revised to clarify that the OESS only verifies the inspection process and not MPPEH	Doug Boyd	Ryan Steigerwalt

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when certifying and verifying material potentially presenting an explosive hazard (MPPEH) as material documented as safe (MDAS). This SOP provides Weston Solutions, Inc. (WESTON) employees and subcontractors with the minimum procedures and safety and health requirements applicable to the conduct of managing MPPEH.

The following operating procedures are not all inclusive nor are they applicable in all situations. This SOP is not a stand-alone document and is to be used together with other work planning documents including site-specific work plan, Accident Prevention Plan (APP) and Site Safety and Health Plan (SSHP), applicable Federal, State, and local regulations, and contract restrictions and guidance.

2. Personnel Responsibilities and Duties

All UXO personnel will meet or exceed the requirements of Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP)-18, Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities (DDESB, 2016) and Engineering Manual (EM) 385-1-97 for their respective project functions. The following individuals will be involved in MPPEH management.

UXO Technician I:

- Tentatively identifies a located item as MPPEH with confirmation by a UXO Technician II or UXO Technician III

UXO Technician II:

- Performs a 100% inspection of each item as it is recovered and determines the following:
  - Is the item unexploded ordnance (UXO), discarded military munitions (DMM), munitions debris (MD) or range related debris (RRD)?
  - Does the item contain explosives hazards or other dangerous fillers?
  - Does the item require detonation?
  - Does the item require demilitarization or venting to expose dangerous fillers?
  - Does the item require draining of engine fluids, removal of illuminating dials and other visible liquid hazardous, toxic or radiological waste (HTRW)?
- Segregates items requiring demilitarization or venting procedures from items ready for certification.
- Processes items found to contain explosive hazards or other dangerous fillers in accordance with applicable procedures.

UXO Technician III:

- Performs a 100% re-inspection of all recovered items to determine if it is free of explosive hazards or other dangerous fillers, engine fluids, illuminating dials and other visible HTRW.
- Supervises detonation of items containing explosive hazards or other dangerous fillers and venting/ demilitarization procedures.
- Supervises the consolidation of MPPEH to be containerized and sealed, ensuring MD and RRD are segregated.

UXO Quality Control Specialist (UXOQCS):

- Conducts daily audits of the procedures used by UXO teams and individuals for processing MPPEH.
- Performs and documents random inspections by item, volume of items or by area of all MPPEH collected to ensure no items with explosive hazards, engine fluids, illuminating dials or visible liquid HTRW materials are identified as MD or RRD.
- Position may be dual-hatted with the UXOSO. See DDESB TP-18 for additional detailed clarification on responsibilities.

UXO Safety Officer (UXOSO):

- Ensures all procedures for processing MPPEH are being performed safely and consistent with the work planning documents including APP, SSHP and/or applicable regulations.
- Position may be dual-hatted with the UXOQCS. See DDESB TP-18 for additional detailed clarification on responsibilities.

Senior UXO Supervisor (SUXOS):

- Implements the work plan.
- Completes DD Form 1348-1A for all MD and RRD to be transferred for final disposition.
- Performs random checks of the material to satisfy that the MD and RRD is free of explosive hazards necessary to complete DD Form 1348-1A.

CONTROLLED COPY

- Certifies all MD and RRD as free of explosive hazards, engine fluids, illuminating dials and other visible liquid HTRW.
- Ensures inspected debris is secured in a closed, labeled and sealed container.

3. Procedures and Protocols

3.1 Certification and Verification Procedures

Assess all MPPEH to determine its explosives safety status before transferring the material within Department of Defense (DoD) facilities or releasing it from DoD control. Authorized and technically qualified personnel (see section 2.1) must certify the MPPEH as MDAS before it can be released. MPPEH procedures comply with DoDI 4140.62 and EM 385-1-97.

Follow this certification and verification procedures for material suspected or determined to be MPPEH before transporting it within or out of DoD control:

1) Obtain certification and verification that 100% inspected and an independent 100% re-inspection has been completed and that the material has been determined to be free of explosives before certifying it as MDAS.
2) The SUXOS certifies that the items are free of explosive hazards and can be classified as MDAS.
3) The United States Army Corps of Engineers (USACE) Ordnance and Explosives Safety Specialist (OESS), or similarly trained individuals, verifies the MPPEH inspection process has been followed. When an OESS is not on site, the UXOQCS may perform the verification.
4) When certified and verified as free of explosive hazards, MD/RRD collected will be placed in containers and sealed. Each container will be closed in a manner that requires that the seal be broken to gain access to the interior of the container. The containers will be labeled with a unique ID as follows:
   - USACE (or DoD organization)/Weston Solutions, Inc./Container number (e.g., 0001)/Seal number
   - Additional containers will be numbered 0002, 0003, etc.
5) Use DD Form 1348-1A as the certification/verification document with the following information:
   - Document date
   - Basic material content (type of metal – steel or mixed)
   - Total weight
   - SUXOS, OESS (or UXOQCS) names
   - Company name and DoD representatives organization and addresses, telephone numbers
   - Container seal number
   - Site name, city and state where MD and/or RRD was obtained
6) Enter the following certification/ verification on each DD Form 1348-1A for the turnover of MD. The SUXOS and OESS (or UXOQCS) must sign the form:
   - "*This certifies and verifies that the material listed has been 100 percent inspected and to the best of our knowledge and belief, is inert and/or free of explosives or related materials.*"

CONTROLLED COPY

7) Enter the following certification/ verification on each DD Form 1348-1A for MD or RRD transferred within or released from DoD control. The SUXOS and OESS (or UXOQCS) must sign the form:
   - "*This certifies that the material listed has been 100 percent properly inspected and, to the best of our knowledge and belief, is free of explosive hazards, engine fluids, illuminating dials and other visible liquid HTRW materials.*"
8) The SUXOS or designee shall ensure that the following information is obtained from the qualified recycler upon receipt of the material identified on DD Form 1348-1A"
   - Quantity of material received
   - Signature
   - Date

3.2 Maintaining Chain of Custody and Final Disposition

Release the certified and verified materials only to an organization that will perform the following:

1) Provide certification on company letterhead stating the following:
   - "*Upon receiving the unopened labeled containers each with its unique identification and unbroken seal ensuring a continued chain of custody, and after reviewing and concurring with all the provided supporting documentation, sign for having received and agreed with the provided documentation that the sealed containers contained no explosive hazards when received. The contents of these sealed containers will not be sold, traded or otherwise given to another party until the contents have been smelted and are only identifiable by their basic content.*"
2) Send notification and supporting documentation to Weston documenting that the sealed containers have been smelted and are now only identifiable by their basic content.

The following steps should then be taken:

1) Incorporate documentation in the final report.
2) If the chain of custody is broken, the affected MPPEH must undergo a second 100% inspection, a second 100% re-inspection, and be documented to verify its explosives safety status.
3) Provide documentation to the Weston resource manager to be maintained in the project file.
4) Document MDAS being transferred within or released from DoD control on a chain of custody form.
5) SUXOS or designee contacts the receiving agent/ recycler to obtain MDAS final demilitarization documentation.

4. Data Management/ Documentation

The following documentation is required:

- Two original copies of DD Form 1348-1A, completed with signatures by SUXOS, OESS (or UXOQCS), and recycler.
- Chain of custody form.
- Certification letter.

CONTROLLED COPY

5. Quality Control

All personnel involved with MPPEH inspections and management must carefully follow all safeguards and security control measures to prevent comingling of processed material. If suspicion arises that comingling has occurred, notify the SUXOS and UXOQCS immediately. Reprocess the questionable material in accordance with this SOP.

Train all UXO-qualified personnel in the recognition and safe handling of used and unused military munitions and specific types of MPPEH in accordance with DoDI 4140.62, qualify all UXO-qualified personnel in accordance with DDESB TP 18.

6. Reporting

All documentation shall be appended to the final report. Maintain copies for 3 years.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

APP	Accident Prevention Plan
DDESB	Department of Defense Explosives Safety Board
DMM	Discarded Military Munitions
DoD	Department of Defense
EM	Engineering Manual
HTRW	Hazardous, Toxic and Radiological Waste
MD	Munitions Debris
MDAS	Material Documented as Safe
MPPEH	Material Potentially Presenting an Explosive Hazard
OESS	Ordnance and Explosives Safety Officer
RRD	Range Related Debris
SOP	Standard Operating Procedure
SUXOS	Senior UXO Supervisor
SSHP	Site Specific Health and Safety Plan
TP	Technical Paper
USACE	United States Army Corps of Engineers
UXO	Unexploded Ordnance
UXOQCS	UXO Quality Control Specialist
UXOSO	UXO Safety Officer
WESTON	Weston Solutions, Inc.

8. References

DoD. 2017. DoD Instruction 4140.62, Material Potentially Presenting an Explosive Hazard.

DDESB. 2016. Technical Paper 18, Minimum Qualifications for Personnel Conducting Munitions and Explosives of Concern-Related Activities.

CONTROLLED COPY

USACE. 2013. EM 385-1-97, Explosives Safety and Health Requirements Manual.

CONTROLLED COPY

GEO-SOP-5

SETUP AND OPERATION OF THE EM31

Setup and Operation of the EM31

Document No. GEO-SOP-5

Reviewed and Approved by: _____ Date: 12/20/2019

Senior Client Service Manager, Munitions Response

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
0.0	Dec. 20, 2019	Original Publication	G. Abrams	R. Steigerwalt

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to be employed when performing dynamic surveys using a Geonics EM31 (frequency-domain electromagnetic terrain conductivity meter) for geophysical surveys.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the collection of geophysical survey data:

- Project Geophysicist
- Quality Control (QC) Geophysicist
- Field Geophysicist
- Data Analyst

2.2 Equipment

The following is a list of required equipment and materials:

- Geonics EM31-MK2 (front transmitter tube, back receiver tube, and console box)
- Data Collection Computer (e.g. Juniper Allegro)
- Data positioning software (e.g. Geonics Dat31 or Trackmaker31)
- Data contouring software (e.g. Geosoft Oasis Montaj)
- Navigational mount (Navigation equipment is usually mounted on a backpack worn by the operator)
- Navigation instrument [e.g., real-time kinematic (RTK) Global Positioning System (GPS) (see GCO-SOP-31, Setup and Operation of RTK GPS Navigation System), robotic total system (RTS) (see GCO-SOP-32, Setup and Operation of RTS Navigation System), or Differential GPS unit (GEO-SOP-3)]
- Navigation markers (if necessary, at the discretion of the Field Team Leader), (may include, but are not limited to, ropes, tapes, spray paint, or non-metallic flags).

CONTROLLED COPY

Navigational mount and instruments will not be required during line and fiducial surveys, however, survey tools will be necessary to establish grid boundaries.

3. Procedure and Guidelines

3.1 Equipment Set-Up

This section outlines the steps for setting up the EM31 system in the field for the acquisition of geophysical data using a navigational system (e.g. sub-meter GPS). Line and fiducial surveys will be completed using the same steps but will not require navigational equipment. The operating manual (Geonics, 1999) should be referenced during set-up and operation. Geometrics EM31 equipment set-up will follow these general steps:

1. Assemble EM31 according to operating manual and project configurations.

2. Interface the EM31 with a navigational system (connect serial cable from navigational system into the data collection port).

3. Perform 10-15 minute warm-up according to manufacture recommendations.

4. Ensure that the operator has removed all metallic objects from their person. Avoid use of cell phones and radios in the vicinity (less than 50 feet) from the EM31.

5. Perform spot check readings to locate an area free of noise or anomalies and representative of background to perform QC function tests. Place a non-metallic pin flag in the ground at this location to ensure the same location is used to check readings throughout the day or over multiple days.

6. Perform Pre-survey calibration checks (see EM31 manual) which usually consists of the following:
    - Adjust the inphase meter readings (set the *coarse* and *fine* compensation controls to zero),
    - Phase Check (remove change in meter readings when *coarse* is turned 1/4), and
    - Sensitivity Check (meter should read between 22 to 26 milliohms/meter). Adjust range settings for areas with background conductivity higher than 30 milliohms/meter.

7. Set-up the site-specific data collection parameters on the data collection console:
    - Set the appropriate data sampling rate to 10 Hertz (unless otherwise stated in project plan).
    - Set the data collection Com ports to interface with the EM31 and navigation equipment.
    - Set collection mode (Vertical or Horizontal) and enable Conductivity and InPhase (most applications will use Vertical mode).
    - Adjust line increments and station starts as needed according to the survey file.

CONTROLLED COPY

3.2 Function Test Measurements

Function test measurements will be performed prior to each day of data collection to confirm that all system components are operational. Function test procedures may vary based on client and project-specific requirements. Standard static QC tests will generally be performed as follows:

1. Cable Shake Test – The operator collects data for 30 seconds and moves cables and electronics to note any possible fluctuations (may indicate a broken wire or an electronic interference from some data loggers).

2. Static Background – The operator collects data for a period of 1 to 3 minutes (depending on project requirements) over a background area. The purpose is to identify any variations in the collected signal. The amplitude should remain constant, typically within 10% of standard response.

3.3 EM31-MK2 Data Collection

Dynamic survey for digital geophysical mapping (DGM) involves collecting data along lines or transects across the survey area. Dynamic data are collected along each line or transect at a spacing appropriate to the site and project needs. Data collection is controlled by the user on the data logging console, which allows the user to assign datasets, line numbers, and start positions of each transect.

Navigation along transects is performed visually with the assistance of markers, if necessary, at the discretion of the Field Team Leader. They may include, but are not limited to, ropes, tapes, spray paint, or non-metallic flags. Data positioning is captured through the use of the navigation system and/or fiducial markers. When an obstacle is encountered along a line or transect, the obstacle can be avoided by either altering the path of the line or transect or stopping data collection and resuming a new transect on the other side of the obstacle. Data gaps that are the result of obstacles should be recorded by the Field Geophysicist and submitted to the Data Analyst.

3.4 EM31-MK2 Data Processing

Initial data processing for the EM31 data will be completed using Geonics Dat31 or Trackmaker31 software to position data, and export to a .xyz file format. Data will then be imported into contouring software (e.g. Geosoft Oasis Montaj) for further data analysis and processing. Processing corrections, filters, and analysis will be up to the discretion of the Data Analyst based on specific project needs and challenges. General data processing steps that may be completed are listed as follows:

1. GPS offset and Latency corrections – These corrections account for any GPS/Sensor offsets (if applicable) and the latency experienced in positional reading during collection.

2. Gap identification – Data will be assessed to identify gaps in data coverage. Data gaps will be re-visited with EM31 if possible.

CONTROLLED COPY

3. Anomaly identification – Data will be assessed to identify features of interest. Identified features may include general areas of notable instrument response or individual point anomalies (e.g. potential burial pit or metallic items).

4. Data Management

4.1 Input Data Required

The data inputs required for performing an EM31-MK2 survey are as follows:

- A list of coordinates identifying the site boundaries
- A list of project data objectives

4.2 Output Data

The data outputs of the EM31 survey are:

- EM31 survey data over survey area(s)
- Function test measurement data
- Raw field notes (.pdf images of hand written notes and applicable field forms)
- Digital field notes [if applicable, any Excel, MS Access, or other digitally recorded table presenting data file names as delivered and rectified field notes (i.e., differences between delivered digital filenames and field notes are resolved)]
- List of identified features/targets including coordinates and response descriptions (if applicable).

5. Quality Control

The primary QC procedures to be followed during reacquisition include the following:

- Verification of the navigation equipment on a known point prior to use for data collection or grid installation.

- Static background and cable-shake tests for the EM31 on each day of data collection.

6. Reporting

Reporting of the activities associated with this SOP will consist of the digital copies of the field notes and the submittal of output data associated with this SOP.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

DGM	digital geophysical mapping
GCO	Geophysical Classification Organization

CONTROLLED COPY

GPS	global positioning system
QC	Quality Control
RTK	real-time kinetic
RTS	robotic total station
SOP	Standard Operating Procedure
WESTON®	Weston Solutions, Inc.

8. References

No references included in this SOP.

9. Attachments

None

CONTROLLED COPY

AOR-SOP-001

ANALOG GEOPHYSICAL AND INTRUSIVE OPERATIONS

Identifier:	Revision:	Effective Date:
AOR-SOP-001	**0**	**2/22/19**
Document Catalog Number: **2013/05/03**		
Author: Jason Kanski		

Standard Operating Procedures

Analog Geophysical and Intrusive Operations

AOR International

Safety, Quality and Professionalism

Merritt Island, Florida

www.aorintl.com

Document History

Document Location

This is an on-line document. Paper copies are valid only on the day they are printed. Refer to the author if you are in any doubt about the accuracy of this document.

Revision History

Date of this revision:	Date of next revision:

Revision Number	Revision Date	Summary of Changes	Author

Approvals

This document requires following approvals:

Name	Title

Distribution

This document has been distributed to

Name	Title

Table of Contents

1. Introduction 4
1.1 Purpose 4
1.2 Scope 4
1.3 Training 4
1.4 Acronyms 5
1.5 Responsibility 5
1.6 Equipment 6
2. Procedure 7
2.1 Geophysical Verification and Instrument Functionality 7
2.2 Data Collection Techniques 8
3. Relevant Supporting Documents 9
4. Reference Documents 9

1. Introduction

1.1 Purpose

The purpose of this Standard Operating Procedure (SOP) is to provide all AOR International Inc. (AOR) employee's procedures applicable to the conduct of operations involving an analog geophysical investigation using hand-held analog geophysical equipment and performing hand dig anomaly intrusive operations. Special consideration should be used for site-specific concerns for the project sites where the method is employed.

1.2 Scope

This SOP applies to all site personnel, to include contractor and subcontractor personnel, involved in the conduct of operations that require the use of analog geophysical followed by intrusive anomaly investigation. SOP may apply to either magnetometer and/or electromagnetic employed analog equipment. The SOP applies to qualified personnel as defined in this SOP. This SOP is not intended to contain all the requirements needed to ensure regulatory compliance. Consult the documents listed in Section 3.0 of this SOP for additional compliance issues.

1.3 Training

Required Training Before Arriving On-Site: AOR's field personnel on this project will have completed the training requirements listed below as required for their specific responsibilities. Additional site-specific training in accordance with Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations 1910.120 for Hazardous Waste Operations and Emergency Response (HAZWOPER), as well as Engineer Manual 385-1-1, Safety and Health Requirements, will be provided to all personnel upon their initial mobilization. Additionally, all AOR field personnel will participate in a medical surveillance program, with the latest physical exam occurring within 12 months of field operations.

AOR UXO-qualified personnel will meet the requirements set forth in the most current version of the Department of Defense Explosive Safety Board (DDESB) Technical Paper 18 (TP-18), Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel.

Site-Specific Required Training After Arriving On-Site: AOR's field personnel on this project will arrive on-site and be trained on the project-specific health and safety issues, overall project

responsibilities, and specific job training including operation of the geophysical analog detectors. **Each team member will sign documentation that they have read and understand this SOP**.

1.4 Acronyms

DDESB - Department of Defense Explosive Safety Board
EMI – Electromagnetic Induction
ITS – Instrument Test Strip
MEC – munitions of explosive concern
MPPEH – material potentially presenting an explosive hazard
SOP – Standard Operating Procedure
SUXOS – Senior UXO Supervisor
TP – Technical Paper
UFP-QAPP - Uniform Federal Policy for Quality Assurance Project Plans
UXO – Unexploded Ordnance
UXOQCS – UXO Quality Control Specialist
UXOSO – UXO Safety Officer

1.5 Responsibility

The AOR field team for Munitions of Concern (MEC) will consist of a six-man team consisting of a Dive Supervisor /UXO Technicians III, II, or I depending on the team build out. UXO Team personnel will be established in the site specific UFP-QAPP. All UXO-qualified personnel will meet the requirements set forth in the latest version of the Department of Defense Explosive Safety Board (DDESB) Technical Paper 18 (TP-18), Minimum Qualifications for Unexploded Ordnance (UXO) Technicians and Personnel.

- **PROJECT MANAGER**, The PM is responsible for the overall implementation of the AOR Project and the work performed at project sites the PM manages. The PM is responsible for ensuring the best qualified personnel are staffed to work at the site, and that the Senior UXO Team Supervisor (SUXOS), UXO Quality Control Specialist (UXOQCS), and the UXO Safety Officer (UXOSO) on-site will oversee the work to ensure its completion as outlined in approved project plans. At underwater sites, the Dive Supervisor and UXO Team Lead will oversee the use of underwater detectors along with the UXOQCS.
- **UXOQCS,** The UXOQCS will ensure that the team is properly trained and can implement the SOP for operations involving analog geophysical detection and anomaly intrusive activities. The UXOQCS ensures the UXO Technicians have demonstrated proficiency in operating the analog detectors to be used on-site. To accomplish this, the UXOQCS will be responsible for the following:
    - Conducting a review of this SOP with the team and noting any exceptions, as necessary.

- Reviewing planned site activities to identify how tasks pose any unique concerns with performing the work associated with this SOP.

- Perform training and testing as necessary and as outlined in approved project plans and manufactures manual for personnel performing the work.

- Documenting training and testing of personnel as needed in the Site Daily Operational Log.

- **UXO Technicians,** The UXO-qualified Technicians will be responsible for reviewing and understanding this SOP and any site-specific procedures outlined in the project specific documents. The UXO Technician is responsible for operating the geophysical equipment in the environment following the procedures outlined. The UXO Technician will ensure he has been trained, reviewed the project documents, understands the equipment operation, and completes the required project documentation.

1.6 Equipment

In addition to equipment required for performing safe procedures as outlined in the Accident Prevention Plan, AOR's geophysical equipment used on site will consist of an Ebinger Electromagnetic Induction (EMI) analog detector or equivalent. These instruments are proven detectors commonly used in MEC investigations and remedial actions and accepted by the industry. Other equipment may include:

- Field book,
- Shovels and hand tools,
- Ropes and buoys (water)
- Tape measure,
- Buckets or floating baskets (water),
- GPS,
- Camera,
- Data Logs, and
- Required PPE

2. Procedure

2.1 Geophysical Verification and Instrument Functionality

Determine from site-specific documents requirements for quality control and responsibilities of the geophysical analog operator to include the following

a. Verification of geophysical system requirements,
b. Detection of targets of interest to depths of interest under site conditions,
c. Other QC procedures (i.e., blind seed, instrument functionality, positioning requirements),
d. Detector is operated as outlined in Equipment Operations Manual.

2.1.1 Instrument Test Strip (ITS)

The analog detector verification step usually will require the installation of an instrument test strip (ITS). The approved UFP-QAPP for the project will outline the project specific requirements for the items included in the ITS, frequency of tests, and documentation required. The following outlines some of the key features of the ITS:

- Location of the ITS should be in an area with easy access to allow all operators to access the site daily and cleared of any metallic objects prior to installing test items.
- Underwater ITS shall be located in water in depths of between 1 and 2 feet.
- Three items shall be shallowly buried within a five wide transect line within the ITS and GPS surveyed.
- Items located within the ITS shall consist of small, medium, and large standard industry objects (ISOs) or inert munitions as specified in the UFP-QAPP.
- Items shall be buried according to the UFP-QAPP at a spacing of approximately 5 meters so to minimize the potential for interference.
- Operators will be trained at the ITS on proper sweep techniques and the UXOQCS and dive supervisor will document the operator.

2.1.2 ITS Documentation

The UXOQCS will document and record the following activities at the ITS:

- ITS construction including layout and depth and type of buried test ISOs.
- Analog detectors are operating as designed and test items are detectable with each detector used.
- UXO-Technicians are trained on the operation of the analog detector.
- Daily verification of equipment is performed as outlined in the approved UFP-QAPP.
- Any required retraining of operators.

If the UXOQCS overseeing the ITS activities believes the operator is not operating the equipment properly or suspects the detector is faulty, the activity will cease. If the equipment is determined to be faulty it will be set aside for repair and will not be used. If the operator needs to be retrained, the UXOQCS will perform the retraining until the operator is performing satisfactorily.

2.2 Data Collection Techniques

Background: Analog detection surveys performed by underwater UXO divers generally are conducted in individual search lanes 3-4 feet wide. Surveys may be performed to cover 100% of an area or designed to complete linear transects with a predetermined distance between each transect. Transect locations may be set up using a variety of techniques such as ropes tied to a buoy system, diver directed through communication with topside supervisory personnel, or using a diver board equipped with positional tracking such as ultra-short baseline (USBL), floating GPS, or doppler sonar. The procedure used will be dependent on the site-specific requirements and purpose of the work. Photographs of the lane set-up will be used if rope lanes are used and provided to the UXOQCS to verify coverage.

Procedure:
Step 1 A UXO Technician assigned will perform all required geophysical instrument and verification steps prior to performing any investigative work and ensure all equipment passes QC requirements and is documented. The UXO team understand the days objectives, grid or transect set-up and documentation requirements.

Step 2 UXO Technician detector is functional. If GPS tracking is being used, the UXO Team Lead will verify the positioning accuracy and tracking.

Step 3 The UXO Technician assigned will systematically search the assigned transect lane or grid line using an analog detector. The UXO Technician will move forward, slowly sweeping the instrument back and forth across the lane in a manner that keeps the tip of the instrument within 4 to 6 inches of the ground surface and will form a series of arcs across the lane approximately 3 to 6 inches between arcs.

Step 4 During this operation, the UXO Technician will monitor the audio indications produced by the detector and identify the location of any subsurface metallic anomaly encountered. The UXO Technician will hand excavate and identify the source of the anomaly using shovels and small hand tools. Once the item is exposed for inspection, the UXO Technician will record on the dig sheet such items as date, time, depth, description, etc. The specifics of data needed to be recorded will be established in the Final approved UFP-QAPP.
If potential MEC or MPPEH is suspected, dig operations will stop and the Team Leader will be notified confirmation of the item and the determination of whether the item is MEC, MPPEH, or other debris. Further confirmation of MEC and debris collection will be performed following the approved site documents.

Step 5 Following completion of the intrusive investigation, the UXO Technician will use the detector to check the excavation area to ensure the area is clear of any other anomalous magnetic objects.

3. Relevant Supporting Documents

It is the responsibility of the on-site AOR employees to ensure to understand this procedure before performing the outlined tasks. Contact the project quality officer if you have any questions about this procedure.

Note: Deviations from this SOP are made in accordance with the site specific UFP-QAPP, dive plan, and accident prevention plan.

4. Reference Documents

The following Occupational Safety and Health Administration (OSHA) standards and U.S. Army Corps of Engineers (USACE) requirements directly apply to the conduct of operations associated with this SOP. In the event other hazards are associated with the conduct of this SOP, consultation of other SOPs and regulatory references may be needed:

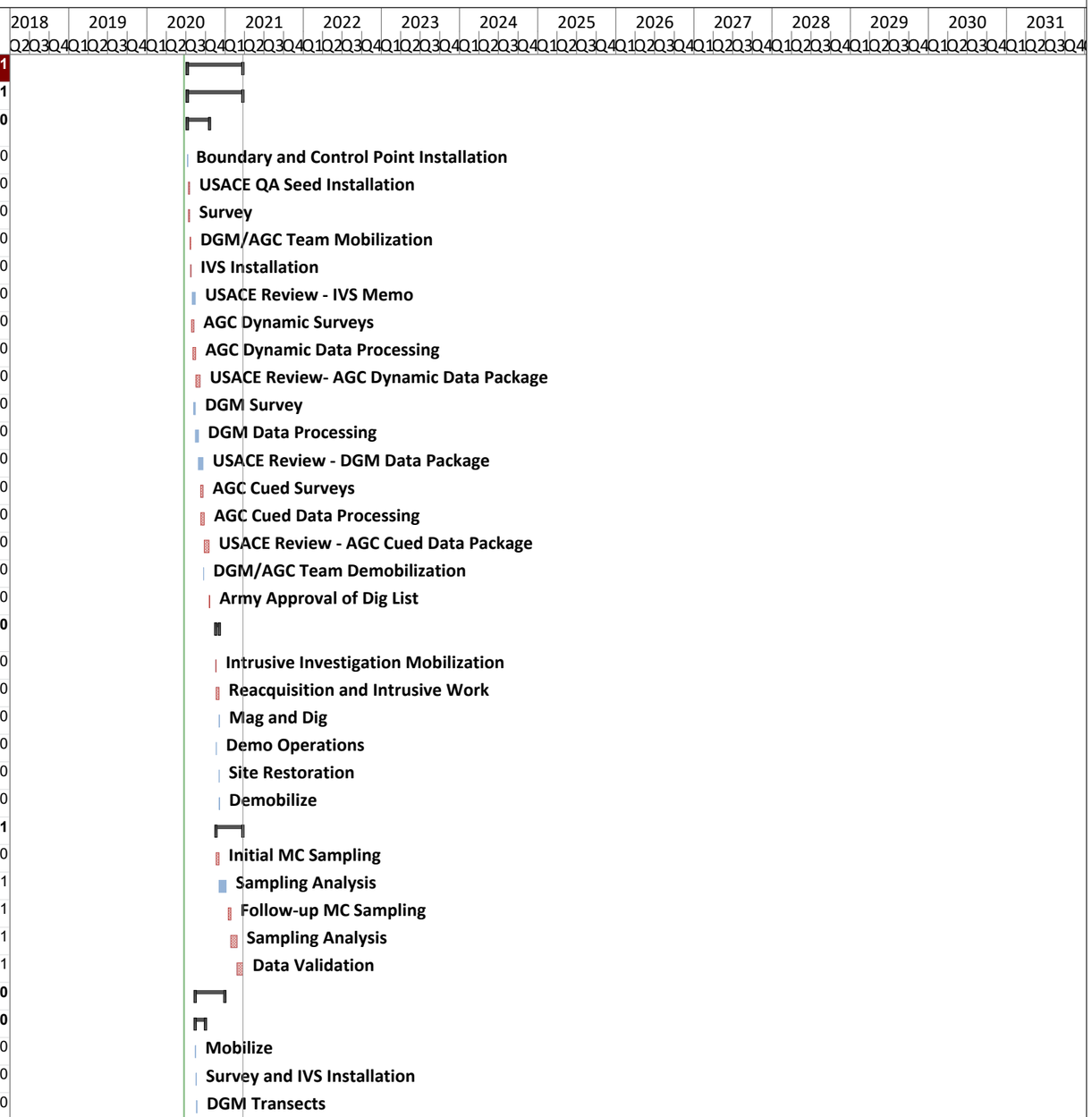
- OSHA Construction Standard 29 CFR, Part 1910, Subpart O
- OSHA General Industry Standard 29 CFR, Part 1926, Subpart I
- USACE Engineer Manual 385-1-1
- EPA QA/G-6, Guidance for Preparing Standard Operating Procedures (SOPs)

APPENDIX I

PROJECT SCHEDULE

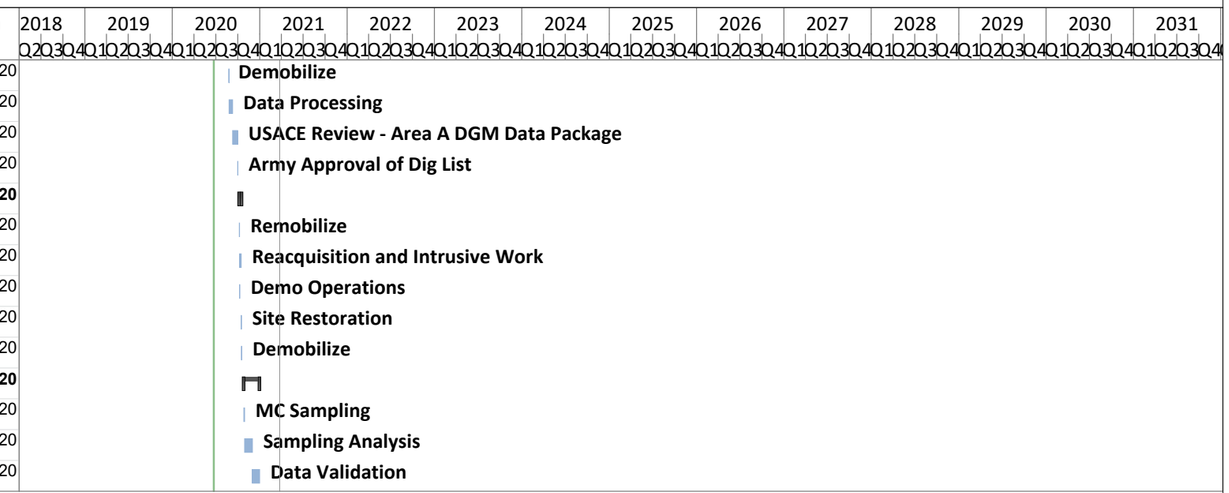
Environmental and Munitions Response Services at
Radford Army Ammunition Plant
Radford, VA

ID	CLIN	Activity ID	Task Name	Cal Day Duration	Work Day Duration	Start	Finish
1	0002		**RFI/CMS and IDD Former Gun and Trench Mortar Range**	**260 days**	**176 days**	**7/8/20**	**3/24/21**
2			**RFI Fieldwork Former Gun and Trench Mortar Range**	**260 days**	**176 days**	**7/8/20**	**3/24/21**
3			**Mobilization/Digital Geophysical Mapping Former Gun and Trench Mortar Range**	**104 days**	**72 days**	**7/8/20**	**10/19/20**
4			Boundary and Control Point Installation	2 days	2 days	7/8/20	7/9/20
5			USACE QA Seed Installation	5 days	5 days	7/13/20	7/17/20
6			Survey	5 days	5 days	7/13/20	7/17/20
7			DGM/AGC Team Mobilization	3 days	3 days	7/20/20	7/22/20
8			IVS Installation	2 days	2 days	7/23/20	7/24/20
9			USACE Review - IVS Memo	14 days	10 days	7/31/20	8/13/20
10			AGC Dynamic Surveys	11 days	9 days	7/27/20	8/6/20
11			AGC Dynamic Data Processing	12 days	10 days	8/3/20	8/14/20
12			USACE Review- AGC Dynamic Data Package	19 days	15 days	8/17/20	9/4/20
13			DGM Survey	7 days	5 days	8/7/20	8/13/20
14			DGM Data Processing	14 days	10 days	8/14/20	8/27/20
15			USACE Review - DGM Data Package	22 days	15 days	8/28/20	9/18/20
16			AGC Cued Surveys	11 days	9 days	9/8/20	9/18/20
17			AGC Cued Data Processing	16 days	12 days	9/9/20	9/24/20
18			USACE Review - AGC Cued Data Package	22 days	15 days	9/25/20	10/16/20
19			DGM/AGC Team Demobilization	1 day	1 day	9/21/20	9/21/20
20			Army Approval of Dig List	1 day	1 day	10/19/20	10/19/20
21			**Reacquisition/Intrusive Investigation - Former Gun and Trench Mortar Range**	**17 days**	**11 days**	**11/18/20**	**12/4/20**
22			Intrusive Investigation Mobilization	1 day	1 day	11/18/20	11/18/20
23			Reacquisition and Intrusive Work	14 days	8 days	11/19/20	12/2/20
24			Mag and Dig	2 days	2 days	12/3/20	12/4/20
25			Demo Operations	2 days	2 days	11/19/20	11/20/20
26			Site Restoration	1 day	1 day	12/3/20	12/3/20
27			Demobilize	1 day	1 day	12/4/20	12/4/20
28			**Sampling and Analysis - Former Gun and Trench Mortar Range**	**126 days**	**83 days**	**11/19/20**	**3/24/21**
29			Initial MC Sampling	14 days	8 days	11/19/20	12/2/20
30			Sampling Analysis	33 days	20 days	12/3/20	1/4/21
31			Follow-up MC Sampling	12 days	7 days	1/15/21	1/26/21
32			Sampling Analysis	29 days	20 days	1/27/21	2/24/21
33			Data Validation	28 days	20 days	2/25/21	3/24/21
34			**RFI Fieldwork Area A**	**139 days**	**92 days**	**8/14/20**	**12/30/20**
35			**Mobilization/Digital Geophysical Mapping Area A**	**48 days**	**33 days**	**8/14/20**	**9/30/20**
36			Mobilize	1 day	1 day	8/14/20	8/14/20
37			Survey and IVS Installation	2 days	2 days	8/17/20	8/18/20
38			DGM Transects	3 days	3 days	8/19/20	8/21/20


2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031
Q2Q3Q4Q1Q2Q3Q4Q1Q2Q3Q4Q1

Environmental and Munitions Response Services at
Radford Army Ammunition Plant
Radford, VA

ID	CLIN	Activity ID	Task Name	Cal Day Duration	Work Day Duration	Start	Finish
39			Demobilize	1 day	1 day	8/24/20	8/24/20
40			Data Processing	15 days	10 days	8/25/20	9/8/20
41			USACE Review - Area A DGM Data Package	21 days	15 days	9/9/20	9/29/20
42			Army Approval of Dig List	1 day	1 day	9/30/20	9/30/20
43			**Reacquisition/Intrusive Investigation - Area A**	**10 days**	**7 days**	**10/7/20**	**10/16/20**
44			Remobilize	1 day	1 day	10/7/20	10/7/20
45			Reacquisition and Intrusive Work	7 days	4 days	10/8/20	10/14/20
46			Demo Operations	1 day	1 day	10/8/20	10/8/20
47			Site Restoration	1 day	1 day	10/15/20	10/15/20
48			Demobilize	1 day	1 day	10/16/20	10/16/20
49			**Sampling and Analysis - Area A**	**66 days**	**43 days**	**10/26/20**	**12/30/20**
50			MC Sampling	3 days	3 days	10/26/20	10/28/20
51			Sampling Analysis	33 days	20 days	10/29/20	11/30/20
52			Data Validation	30 days	20 days	12/1/20	12/30/20



Task
Split
Milestone
Summary
Project Summary
Critical
Progress
Manual Progress

APPENDIX J

ANALYTICAL SOPS

Provided on CD.

SOP MT 007

ACID DIGESTION OF SOLIDS AND SEMI-SOLIDS FOR TOTAL METALS BY GFAA AND ICP

CT LABORATORIES

delivering more than data from your environmental analyses

STANDARD OPERATING PROCEDURE

MT 007 Acid Digestion of Solids and Semi-solids for Total Metals by GFAA and ICP

Review Date: 05/24/18

05/24/2018

Technical Review by: Date

07/05/18

Approved by: Quality Assurance Date

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table of Contents

STANDARD OPERATING PROCEDURE		1
1.	SCOPE AND APPLICATION	3
2.	METHOD SUMMARY	3
3.	DEFINITIONS	3
4.	HEALTH AND SAFETY	4
5.	CAUTIONS	4
6.	INTERFERENCES	4
7.	PERSONEL QUALIFICATIONS	5
8.	APPARATUS AND MATERIALS	5
9.	INSTRUMENT OR METHOD CALIBRATION	6
10.	SAMPLE COLLECTION, HANDLING AND PRESERVATION	7
11.	SAMPLE PREPARATION AND ANALYSIS	7
12.	TROUBLESHOOTING	10
13.	DATA ACQUISITON, CALCULATIONS AND DATA REDUCTION	11
14.	COMPUTER HARDWARE AND SOFTWARE	11
15.	DATA MANAGEMENT AND RECORD MANAGEMENT	11
16.	QUALITY CONTROL	11
17.	REFERENCES	11
18.	FIGURES	12

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

1.0 SCOPE AND APPLICATION

1.1 This method is an acid digestion procedure used to prepare soils, sediments, sludges, oils, paint chips, tissue samples, wipes and other solid waste samples for analysis by ICP, FLAA, or GFAA spectroscopy for the following metals:

Aluminum*	Calcium*	Magnesium*	Silver*
Antimony*	Chromium	Manganese*	Sodium*
Arsenic	Cobalt	Molybdenum	Strontium*
Barium*	Copper*	Nickel *	Thallium
Beryllium	Iron	Potassium*	Vanadium*
Cadmium	Lead	Selenium	Zinc*

* Cannot be used for GFAA for selected element

1.2 For analysis by ICP or FLAA both HCl and HNO_3 are used in the digestion procedure. For analysis by GFAA, HNO_3 only is used.

2.0 METHOD SUMMARY

2.1 For the digestion of samples, a representative 0.5 gram sample or 1-2g for QSM soil or 4g for tissue samples for QSM work is digested with repeated additions of nitric acid and hydrogen peroxide

2.2 For GFAA analysis, the resultant digestate is reduced in volume while heating and then diluted to a final volume of 50 ml.

2.3 For ICP (trace) or FLAA analyses, hydrochloric acid (HCl) is added to the initial digestate and the sample is refluxed. The digestate is then diluted to a final volume of 50 ml.

3.0 DEFINITIONS

3.1 Batch - A batch consists of a maximum of 20 samples of similar matrix which are prepared and analyzed in the same manner. Each batch is given a unique prep batch number for tracking purposes.

3.2 Reagent Blank **-** A solution of de-ionized water, (containing in correct proportion, all reagents required by the method), used with the calibration standards to standardize the instrument, as a calibration blank, and for sample dilution.

3.3 LCS (Laboratory Control Sample) - A mid-range standard prepared from a source different from that used for calibration standards. The LCS is used to verify the accuracy of the digestion procedure and is analyzed at the beginning of the analytical batch.

3.4 MB (Method Blank) - A reagent blank which is carried through the entire preparation and analytical method. The method blank is used to detect possible contamination that may occur prior to or during the sample preparation process. A minimum of one MB is prepared per batch and is analyzed at the beginning of an analytical batch.

3.5 MS-MSD (Matrix Spike-Matrix Spike Duplicate): - Two separate sample aliquots to which a known concentration of analyte has been added which is carried through the entire preparation and analytical procedure. The purpose of a matrix spike is to reveal any matrix effect from the sample on the recovery of the analyte by the method being used. An MS-MSD pair is prepared for every batch (see 3.1) of routine samples. An MS and a DUP are prepared for every ACOE batch. Failure to meet criteria may be due to poor recovery during the preparation method or to matrix interference within the digestate. To be considered acceptable, MSD's must meet both the same % recovery criteria as an MS, and the same % RPD as a duplicate sample. MS/MSD %RPD may be used as acceptance criteria for duplicate analysis.

3.6 Duplicate (DUP) - A separate aliquot of sample which has been carried through the entire preparation and analytical procedure the same as the original sample. One duplicate per batch is prepared for ACOE work.

4.0 HEALTH AND SAFETY

4.1 Gloves, protective eyewear, and protective clothing should be worn to protect against unnecessary exposure to hazardous chemicals and contaminants in samples. All activities performed while following this procedure should utilize appropriate laboratory safety systems.

5.0 CAUTIONS

5.1 The extracts from GFAA and FLAA/ICP are not interchangeable and should only be used with the analytical determinations outlined.

5.2 This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become “environmentally available.” By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

5.3 Reagent grade chemicals shall be used in all tests. The reagent blank must be less than the MDL in order to be used.

6.0 INTERFERENCES

6.1 Sludge samples can contain diverse matrix types, each of which may present its own analytical challenge. Spiked samples and any relevant standard reference material should be processed in accordance with the quality

control requirements to aid in determining whether Method 3050B is applicable to a given waste.

7.0 PERSONNEL QUALIFICATIONS

7.1 All personnel performing this analysis shall be instructed in the use of personal protective equipment prior to beginning analysis.

7.2 Personnel shall know how to read a meniscus and how to use a pipette correctly.

8.0 APPARATUS AND MATERIALS

8.1 Equipment Required

8.1.1 Thomas Cain DEENA Automated Sample Preparation Systems with reflux trays (DEENA I and DEENA II or equivalent)

8.1.2 Environmental Express Hotblock Digestion Apparatus: To maintain a temperature of 90-95°C.

8.1.3 50 mL Class A plastic hotblock digestion tubes, with watch glasses and storage caps. (Thomas Cain SC475 and SC505 or equivalent)

8.1.4 Qualitative filter paper and filter funnels.

8.1.5 Filtermate Teflon digestion tube filters: (Environmental Express p/n SC0401 or equivalent)

8.1.6 Thermometer: For monitoring temperature of the block at beginning and end of digestion process.

8.1.7 Balance: 0.01g capacity.

8.2 REAGENTS

8.2.1 ASTM Type II Water (ASTM D1193): Water should be monitored for impurities.

8.2.2 Concentrated Nitric Acid, trace metals grade (HNO_3): Acid is of sufficient purity and comes with a certificate of analysis. All metals levels are lower than our lowest detection limits for any given element. However, each acid lot is logged in and tracked to each individual bottle to identify potential contamination problems. If contamination is detected at any point and the problem is limited to a given bottle, the acid may be replaced with another bottle from the same lot. If the entire lot is a problem, then any remaining acid from the contaminated lot will be removed from the lab and a replacement acid from a

different lot of sufficient purity shall be obtained. All acid used to make standards is recorded in the log book when the standard is made.

8.2.3 Concentrated Hydrochloric Acid, trace metals grade (HCl): Acid is of sufficient purity and comes with a certificate of analysis. All metals levels are lower than our lowest detection limits for any given element. However, each acid lot is logged in and tracked to each individual bottle to identify potential contamination problems. If contamination is detected at any point and the problem is limited to a given bottle, the acid may be replaced with another bottle from the same lot. If the entire lot is a problem, then any remaining acid from the contaminated lot will be removed from the lab and a replacement acid from a different lot of sufficient purity shall be obtained. All acid used to make standards is recorded in the log book when the standard is made.

8.2.4 Hydrogen Peroxide, 30% (H_2O_2): Each peroxide lot is logged in and tracked to each individual bottle to identify potential contamination problems. If contamination is detected at any point and the problem is limited to a given bottle, the peroxide may be replaced with another bottle from the same lot. If the entire lot is a problem, then any remaining peroxide from the contaminated lot will be removed from the lab and a replacement hydrogen peroxide bottle from a different lot shall be obtained.

8.2.5 SPEX Certiprep Spike- SPEX catalog number SPIKE 1-500

8.2.6 Molybdenum- 1,000 mg/L standard SPEX PLMO9-2Y or equivalent

8.2.7 Potassium-10,000 mg/L standard PLK2-3X or equivalent

8.2.8 Ultra-Custom Standard – Ultra Catalog number ICUS192 or equivalent

8.2.9 Inorganic Venture Spike- Inorganic Venture catalog number SPK1 or equivalent

9.0 INSTRUMENT OR METHOD CALIBRATION

9.1 *DEENA Calibration:*

9.1.1 Prior to digesting any samples using the automated sample digester, the system needs to be calibrated.

9.1.2 After logging into the DEENA system (refer to sections 11.2.2-11.2.5), click on the “manual mode” tab at the top of the screen.

9.1.3 Click the “pump calibration” tab (figure 4).

9.1.4 Weigh out 5 digestion tubes and record their weights in the “initial weight” column for the 5 tubes.

9.1.5 Click “Go All”. The digester is dispensing water into the 5 empty tubes.

9.1.6 The tubes are then weighed again and the final weight is recorded in the “final weight” column.

9.1.7 The difference between the final weight and the initial weight is the amount of volume dispensed per “X” steps on the peristaltic pump. An average is then taken between the 5 replicates. The digester is now calibrated.

9.2 *Hot Block Calibration:*

9.2.1 Please refer to the Hot Block operator manual for instrument temperature calibration.

10.0 SAMPLE COLLECTION, HANDLING AND PRESERVATION

10.1 All sample containers must be demonstrated to be free of contamination at or below the reporting limit. Plastic and glass containers are both suitable. Note: Environmental Express provides a certificate of analysis with each tube lot.

10.2 Samples shall be refrigerated upon receipt and analyzed within 180 days.

11.0 SAMPLE PREPARATION AND ANALYSIS

11.1 *Manual Digestion:*

11.1.1 Turn on hot blocks to allow them to warm up. The switch is located on the right outer side of hood. Place a thermometer into a centrifuge tube of water and place it in the hot block to monitor the temperature of the hot block to insure the temperature is acceptable prior to use. The temperature should be 95 $\pm$ 5°C for digestion.

11.1.2 Carefully weigh on a balance and then transfer a 0.5 g representative portion (for routine work) or for QSM work 1-2g randomly or for tissue samples 4 g* of the sample to a tube, or use a known volume of a sludge sample based on the viscosity of the sample. Do not use metal spatulas. Refer to the subsampling SOP PR007 for instructions on subsampling from the original sample. For some samples it is acceptable to use a larger sample size following the guidelines below:

Wet solids:	Up to 1.0 g.
Wipes:	The entire wipe is used.

Biological tissue:	Up to 2.0 g.
"liquidly" sludges	Up to 2.0 g
*Tissue samples	Typically 4.0 g sample since the tissue homogenization only yields 2.0g of sample when Milli Q DI H2O is added @ a 1:1 ratio during preparation.

11.1.2.1 Teflon boiling stone/beads (Chemware, Item # 0919120 or equivalent) are used as the solids matrix match for MB and LCS preparation. Weigh the appropriate amount and add to the digestion tube prior to digestion.

11.1.2.2 Refer to SOP GT002 for the use of diatomaceous earth as the MB/LCS matrix for sample prepared by grinding of multi-incremental samples by Puck Mill.

11.1.3 For samples to be spiked (MS, MSD, LCS), add the appropriate amount of spiking solution to sample (see Pre-digestion Spikes-LCS & LFB chart attached).

11.1.4 Add 5 mL 1:1 HNO_3 to routine samples or 10mL of 1:1 HNO_3 for ACOE samples, mix, and cover the tube with a watch glass. Do not handle the underside of the watch glass at any time, in order to prevent contamination. Place the tubes in the hotblock and heat the samples until they reflux for 10-15 minutes. For wipe samples, add DI water to wet the entire wipe if needed.

11.1.5 Add 2.5 mL concentrated HNO_3 to all routine samples and 5mL of concentrated HNO_3 to ACOE samples.

11.1.6 Place thermometer in one block location, record temperature in the sample prep book for the initial block temperature recording. Record again at the end of the digestion process in a different spot on the block. Rotate the placement of the thermometer between digestion batches to ensure that no "hot spots" develop on the block.

11.1.7 Return to the hotblock, and reflux the samples for 30 minutes. Do not allow the samples to go dry. If samples are still generating "brown" fumes, continue to add concentrated HNO_3 in 5mL increments until no more "brown" fumes are generated.

11.1.8 Allow the solution to evaporate to 5 mL without boiling or heat at 95°C ± 5°C without boiling for 2 hours. Do not allow samples to go to dryness.

11.1.9 Remove the samples from the hotblock and let cool to avoid excessive effervescence of hydrogen peroxide. For routine samples add 1 mL of DI water and 1.5 mL of 30% hydrogen peroxide to each tube. For DoD samples add 2 mL of DI water and 3 mL of 30% hydrogen peroxide to each tube (omit this step for Tin). Return to hot block and heat gently until the effervescence subsides.

11.1.10 Repeat step 11.9 two times or until effervescence is minimal for routine samples using a maximum of 5mL of 30% hydrogen peroxide. For ACOE samples, add 30% hydrogen peroxide in 1mL increments, up to 10mL, until the sample effervescence is minimized or the sample consistency is unchanged. It will not be necessary to cool down the samples between additions if they do not react too strongly.

11.1.11 Return samples to hot block and heat until volume is reduced to 2.5mL or heat at 95°C ± 5°C without boiling for 2 hours.

11.1.12 For samples to be analyzed by ICP or FLAA, add 5 mL concentrated HCl for routine samples or for ACOE samples add 10mL of concentrated HCl and reflux for an additional 15 minutes. Omit this step for samples to be analyzed by GFAA.

11.1.13 Remove each tube from block using the tube racks provided and allow them to cool. Dilute to exactly 50 mL using the guide on the digestion tube and let sample sit to allow solids to settle out. If solids do not settle readily and remain suspended throughout sample, then it will be necessary to filter prior to analysis. Using the Environmental Express tube filters, push the filter down through the sample till it sits on the bottom. The digestion tubes are calibrated to 50mL ± 0.2mL.

11.1.14 Cap sample, taking care not to touch underside of cap or inside of container. To minimize contamination and for safety purposes appropriate gloves must be worn at any point where sample solution is being transferred. If gloves become stained and dirty, discard and replace, as the surface of the gloves themselves may also transfer contaminants.

11.1.15 If the digestate is clear and without solids distributed throughout the liquid portion, sample aliquots may be decanted for analysis. If not, then filtration will be necessary prior to analysis. Rinse a syringe filter (GF Syringe Filter, Part# SFGF025100MCU) with 2-3

ml of 10% HNO3 followed by 2-3 ml of DI H2O before filtering digestate.

11.2 *Automated Digestion (DEENA)*

11.2.1 See section 11.1.2-11.1.3 for weighing of samples.

11.2.2 Log-in to the computer associated to the DEENA automated sample preparation system.

11.2.3 Double-click on the DEENA shortcut icon on the desktop.

11.2.4 Next to “instrument selection”, select the sampler to be used. The program will open.

11.2.5 The blue light on the DEENA system will turn off, indicating that the computer is communicating with the instrument.

11.2.6 Prior to digesting samples, the automated digester needs to be calibrated. This is done before the first run of the day. See section 9.

11.2.7 Open up a template workspace. Click “file”, “new from”, “C-drive”, “program files”, “Thomas Cain”, “DEENA”. Choose the desired template for the method to be run.

11.2.8 Click the “automated mode” tab. The template that was chosen from the DEENA file is now loaded. The template will display the method steps, reagent list and tray setup.

11.2.9 Open the “method tab” and click the method to be run. Then click “ok”.

11.2.10 Click the “rack definition” tab. In the window, make sure start position is “1” and then fill in the number of samples to be digested. Click “ok” (figure 6).

11.2.11 Place the samples in the digestion block. Cover samples with reflux tray. Check to make sure all reagent bottles are at adequate volume for analysis. Click “run” on the screen.

11.2.12 Upon completion, save the workspace run log to Q-drive, DEENA I and II, run log by the date followed by rl1 or rl2 (designating a run log which instrument was used).

11.2.13 Remove digestion tubes from the system. Make sure final sample volume is accurate. Cap the digestion tubes. The samples are ready for analysis.

11.2.14 If the digestate is clear and without solids distributed throughout the liquid portion, sample aliquots may be decanted for analysis. If not, then filtration will be necessary prior to analysis. Rinse a syringe filter (GF Syringe Filter, Part# SFGF025100MCU) with 2-3 ml of 10% HNO3 followed by 2-3 ml of DI H2O before filtering digestate

11.2.15 For detailed instructions for automated digestion, see the DEENA operator's manual, rev.1.2.3.

12.0 TROUBLESHOOTING

12.1 If method blank is higher than MDL, identify source of contamination. Contamination can come from many sources including the reagents used in the procedure and samples that were digested in the batch.

12.2 Over time, hot blocks can develop "hot spots". Monitor the temperature in different block spaces ensure that temperature is consistent throughout the hot block unit.

13.0 DATA ACQUISITION, CALCULATIONS AND DATA REDUCTION

13.1 There are no calculations for this method.

14.0 COMPUTER HARDWARE AND SOFTWARE

14.1 Computer with StarLIMS

15.0 DATA MANAGEMENT AND RECORD MANAGEMENT

15.1 Batch data information is recorded in the Digestion Log book.

15.2 Prep data is entered into LIMS, and then the batch sheet is given to the metals analyst.

16.0 QUALITY CONTROL

16.1 For each batch of samples processed, a method blank should be carried throughout the entire sample preparation procedure.

16.2 By matrix, prepare one MS/MSD for routine work or one MS/DUP for ACOE work per 20 or fewer samples per matrix per digestion batch.

16.3 Prepare one LCS (lab control sample) for each digestion batch. The LCS source is carried through the entire digestion procedure. Prepare one LCS for every 20 samples per medium per day.

17.0 REFERENCES

17.1 *Test Methods for Evaluating Solid Waste*. USEPA SW-846, Rev 2 Dec 1996, Method 3050B.

17.0 CT Laboratories Quality Manual, current revision.

17.1 Department of Defense, Quality Systems Manual for Environmental Laboratories, Version 4.2, October 2010.

17.2 Department of Defense, Quality Systems Manual for Environmental Laboratories, Version 5.0, July 2013.

17.3 Department of Defense, Quality Systems Manual for Environmental Laboratories, Version 5.1, January 2017 or most recent revision.

17.4 National Environmental Laboratory Accreditation Conference (NELAC), 2003 NELAC Standard Chapters 1 to 6, EPA/600/R-04/003, June 5, 2003 or most recent version.

17.5 ISO. 2005. General requirements for the competence of testing and calibration laboratories. ISO17025.

17.6 Thomas Cain, DEENA Operation Manual, Revision 1.2.3, November 2015

17.7 Department of Defense, Quality Systems Manual for Environmental Laboratories, Version 5.1, January 2017 or most recent revision.

18.0 FIGURES

Figure 1: ICP/FLAA Table

SPIKE, & LFB ANALYSIS- ICP/FLAA Pre-digestion Spikes-LCS & LFB					
Element	**Spike Amt. mL**	**Spike Stock**	**Stock Conc. Mg/L**	**Final Vol mL**	**Expected Conc. Ug/L**
Aluminum	1	**A**	200	50	4000
Antimony	1	**A**	50	50	1000
Arsenic	1	**A**	200	50	4000
Barium	1	**A**	200	50	4000
Beryllium	1	**A**	5	50	100
Cadmium	1	**A**	5	50	100
Calcium	0.5	**C**	20,000	50	200000
Chromium	1	**A**	20	50	400
Cobalt	1	**A**	50	50	1000
Copper	1	**A**	25	50	500
Iron	1	**A**	100	50	2000
Lead	1	**A**	50	50	1000
Manganese	1	**A**	50	50	1000
Magnesium	0.5	**C**	10,000	50	100000
Molybdenum	0.1	**B**	1000	50	2000
Nickel	1	**A**	50	50	1000
Potassium	0.5	**D**	10,000	50	100000
Selenium	1	**A**	200	50	4000
Silver	1	**A**	5	50	100
Sodium	0.5	**C**	10,000	50	100000
Thallium	1	**A**	200	50	4000
Vanadium	1	**A**	50	50	1000
Zinc	1	**A**	50	50	1000

Spike Solutions		
Supplier	**Lot #/ std.**	**Stock**
SPEX Certiprep	SPIKE 1-500	**A**
Molybdenum	1000 mg/L	**B**
Ultra	ICUS 192	**C**
Potassium	10,000	**D**

Pre-Digestion Matrix Spike Prep for (GFAA)					
Element	**Spike Amt. mL**	**Spike Stock**	**Stock Conc. Mg/L**	**Final Vol mL**	**Expected Conc. Ug/L**
Antimony-GFAA	1.0	**A**	1000.0	50.0	20.0
Arsenic-GFAA	1.0	**A**	1000.0	50.0	20.0
Lead-GFAA	1.0	**A**	1000.0	50.0	20.0
Selenium-GFAA	1.0	**A**	1000.0	50.0	20.0
Thallium-GFAA	1.0	**A**	1000.0	50.0	20.0

Standard Source		
Supplier	**Dilution**	**Solution**
Inorg. Vent.-SPK1 (multi-element std.)	1/100	**A**

Figure 2: Metals Digestion Summary (FMT7-01, Example)

Analyst:		Metals Digestion Summary-CT Laboratories Baraboo								Date:	
Prep Batch#	Sample ID#	Matrix*	Prep Method**	Sample Amt gms or mls	Final Volume, mLs	Blk	Dup	MS	MSD	Spike/LCS/ LFB info	Acid ID#
Method Temperature Verification					*So,Sl,ww,gw,fish,tclp,splp,other					Review date/initials	
Block Used:		Initial Block Temp (C):			**3005,3010,3020,3050,3060					Digestion Tube Lot #:	
Cell #		Final Block Temp (C):			Comments:						

Figure 3: Metals Digestion Bench Sheet (FMT 3,7-01, Example)

FORM #: FMT3,4,5,6,7,8-01
Rev. #: 1.0
Effective Date: 05/17/2014

FMT3,4,5,6,7,8-01

Metals Digestion Bench Sheet

(Prep Methods 3010, 3020, 3005, & 3050)

Program: _____
*Matrix: _____

3010= ICP Liquids
3020= GFAA Liquids
3005= Sb Liquids
3050= ICP/GFAA Solids
7060/7740= GFAA, As & Se Liquids

Prep Batch #:	
Prep Method:	
Analyst:	
Date:	
Start Time:	

Prep Analyst: _____
Balance ID: _____

End Date: _____
End Time: _____
Digestion Tube Lot #: _____
Block Used: _____
Cell Position for Temp. Check: _____
Initial-DigestionTemp (°C): _____
Final-Digestion Temp (°C): _____

Reagent: Ref. #
Nitric Acid: _____
Hydrochloric Acid: _____
Hydrogen Peroxide: _____

Sample ID			(Solids) Sample Weight (g)	(Liquids) Sample Volume (ml)	Final Volume (ml)
	(MB)				50
	(LCS)				50
					50
	Comments:				50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
					50
	(DUP)				50
	(MS)	Parent Sample			50
	(MSD)				50
Leave >>	(DUP) if applicable				50
blank	(MS)	Parent Sample			50
if N/A	(MSD)				50

MB=Method Blank, LCS=Laboratory Control Sample, DUP=Duplicate, MS=Matrix Spike & MSD=Matrix Spike Duplicate
*Matrix: Soil, Sludge, Waste, GW=Groundwater, WW=Wastewater, Tissue, TLCP, SPLP, ASTM or other.

MS/MSD Spike Amount (ml)	Spike Ref. #

LCS Spike Amount (ml)	Spike Ref. #

Reviewed By/Date: _____

Page 1 of 1 Metals Prep Template_FMT3,4,5,6,7,8-01 03/25/1522:55

Figure 4: Calibration Window for DEENA

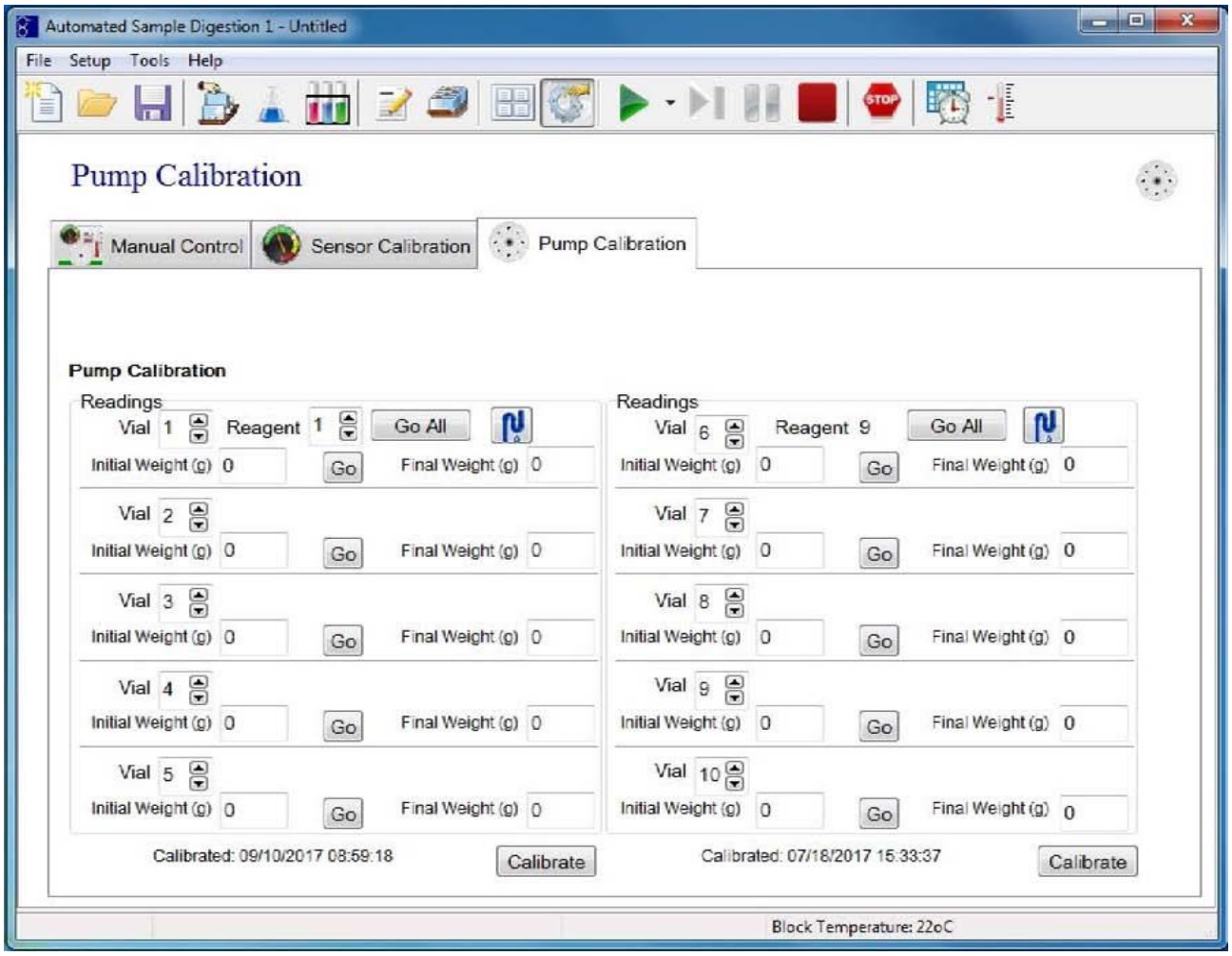


Figure 5: Digestion Method Window for DEENA (Example)

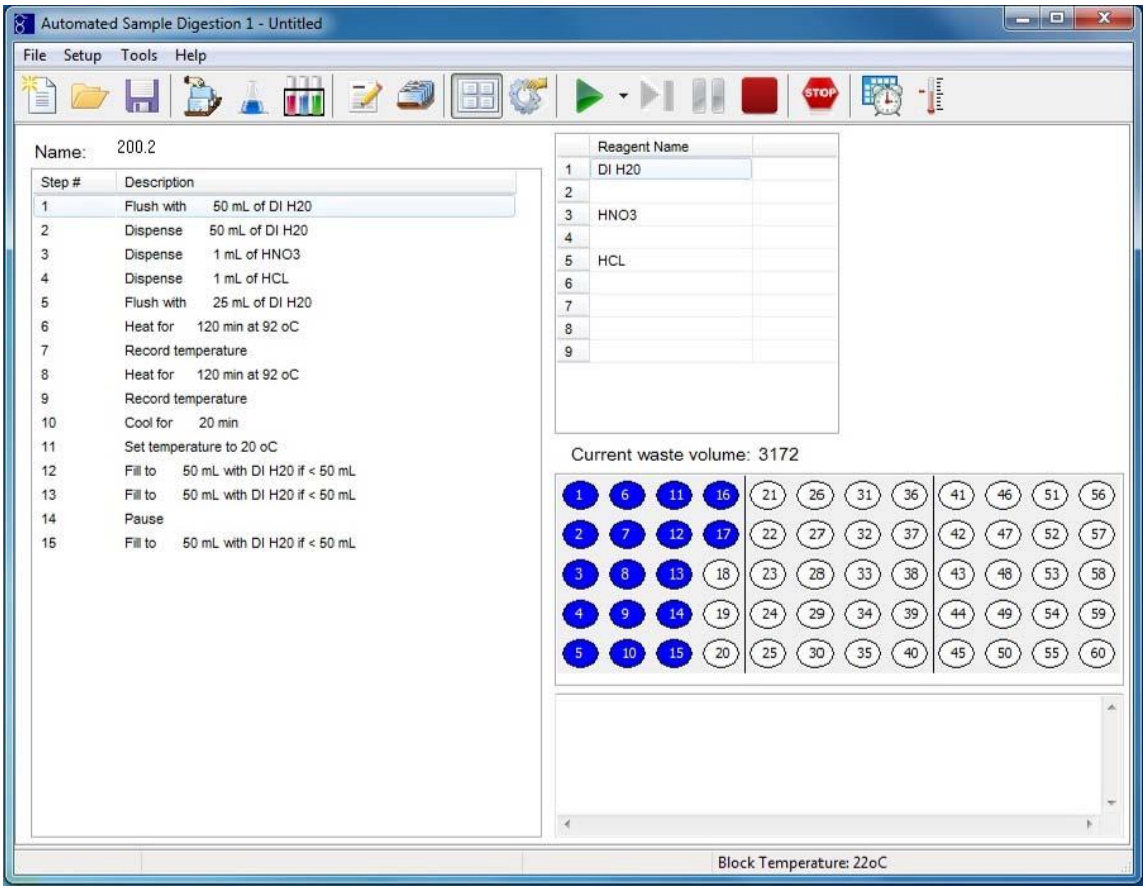
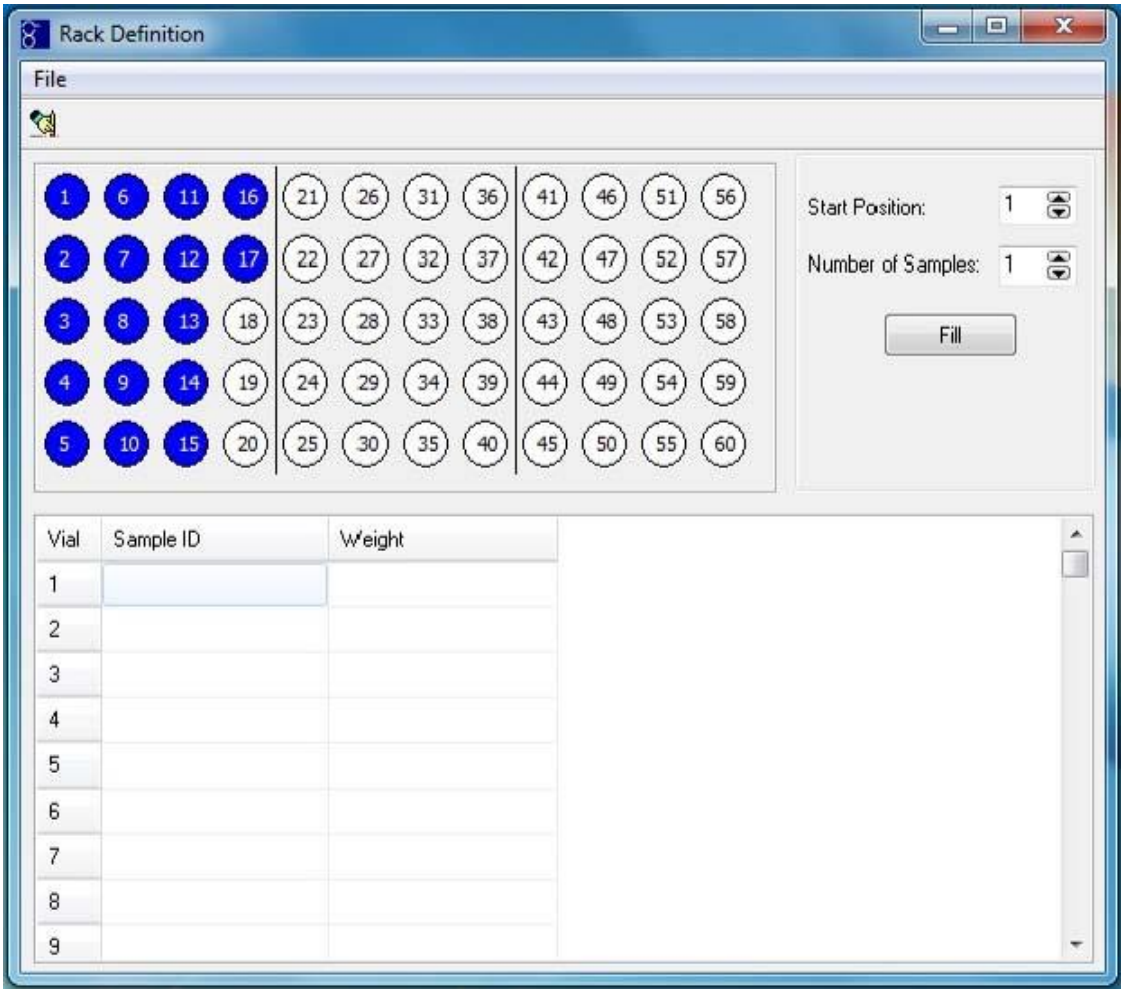


Figure 6: Digestion Rack Window for DEENA



Revision Number	Description of Changes	Date
05	Document changed to incorporated administrative requirements of ISO 17025 and QSM 5.0. Descriptions of changes have not been tracked in previous versions of this document.	03/12/2015
5.1	Modified tissue statement in section 11.2	03/31/2016
6.0	Included DEENA Automated Digester Procedure	09/15/2017
6.1	Added Teflon beads used for LCS/MB prep. (sec. 11.1.2.1) and diatomaceous earth used for homogenized sample by grinding (11.1.2.2). Added acid rinsing of filters (sec. 11.1.15 and 11.2.14). Added QSM 5.1 reference.	05/24/2018

SOP MT 009

INDUCTIVELY COUPLED PLASMA (ICP) EMISSION – ICP-OES 6000

STANDARD OPERATING PROCEDURE

MT 009 Inductively Coupled Plasma (ICP) Emission – ICP-OES 6000

Review Date: 05/22/18



05/22/2018

Technical Review by: Date



07/06/2018

Approved by: Quality Assurance Date

1.0 Identification of Test Method

1.1 This procedure is used for the analysis of trace elements (metals) following EPA SW 846 Methods 6010B and/or 6010C/ and or 6010D (Inductively Coupled Plasma –Atomic Emission Spectrometry) and Method 200.7.

2.0 Applicable Matrix or Matrixes

2.1 This method is applicable to the determination of various metals in drinking water, surface water, groundwater, sludge, soils, and industrial wastes.

3.0 Detection Limits

3.1 Method detection limits (MDLs) are determined annually and results vary from element to element. Procedures for conducting MDL studies can be found in SOP QA023.

4.0 Scope and Application

4.1 Metals in solution can be readily analyzed by atomic emission using an Inductively Coupled Plasma (ICP) spectrometer. All matrices, excluding filtered groundwater samples and drinking waters with a turbidity less than 1 NTU, will require a digestion prior to analysis.

5.0 Method Summary

5.1 If necessary, prior to analysis, samples are digested using an approved method. See SOPs MT003 and MT007for further information on sample digestion.

5.2 This method describes multi-element determinations using an ThermoScientific iCAP 6000 Series ICP-OES which use an Echelle optical design and a Charge Injection Device (CID) solid-state detector to provide elemental analysis. Most Samples are liquids that are pumped through a nebulizer to produce a fine spray. The large droplets are removed by a spray chamber and the small droplets then pass through to the plasma. The solvent is evaporated. The residual sample is decomposed to atoms and ions that become excited and emit characteristic light which is measured, giving measurement of the concentration of each element type in the original sample. Control of the spectrometer is provided by the PC based iTeva software (refer to the Thermo ICP-OES software manual). Samples are routinely analyzed using an internal standard solution of 50 mg/L Yttrium to eliminate certain matrix interference problems. Line switching is also used to extend the dynamic range of an element.

5.3 The data is exported to the LIMS system and reviewed by the analyst. Following analyst review, the data is given to a qualified reviewer for complete data review. After the data has been reviewed and it is determined that it is valid data, the reviewer sends the data to the “validated” mode in the LIMS system.

6.0 Definitions

6.1 For full definitions on all terms applicable to this method, see the Quality Assurance Manual (QAM).

6.2 For a list of common acronyms and abbreviations, see QAM.

6.3 Low-Level Calibration Check Standard (LLCCV) For DOD-QSM samples a low level standard shall be analyzed daily at or below the LOQ for the element(s) being analyzed. The acceptance criterion is +/- 20% of the expected value.

6.4 Interelement Correction Factors (IEC) – These correction factors are determined by analyzing a concentration range of known interferants solutions of (Al, Ba, Be, Cd, Ca, Ce, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Ni, Sn, SiO2, Ti, Tl V and Zn) and examining all other lines for a significant linear response. A line is considered to be significantly affected when the correlation coefficient for the interference is 0.99 or better and the correction factor multiplied by ten is greater than the MDL of the affected line. For interferents known to occur at high levels in environmental samples (Al, Ca, Cr, Cu, Fe, Mg and Zn) the interference will be considered to be significant when the correction factor multiplied by 100 is over the MDL of the affected line and the correlation coefficient in 0.99 or better. Interelement correction is used where applicable.

6.5 Linear Dynamic Range (LDR) – The upper limit of the linear dynamic range is established for each wavelength utilized by determining the signal responses from a minimum of three different concentration standards across the range. One of these will be near the upper limit of the range. The ranges used for the analysis of samples are judged by the analyst from the resulting data. The data and calculations are kept on file. The upper range limit is an observed signal no more than 10% below the level extrapolated from the lower standards. Determined analyte concentrations above the upper range limit are diluted and reanalyzed. New dynamic ranges are determined whenever there is a significant change in instrument response. For analytes that routinely approach the upper limit of the range, the range will be checked biannually. For analytes that are known interferents and exceed the dynamic range, the analyst will check that IEC's have been correctly applied. DOD-QSM requires that a LDR (or high level check standard) study be perform at least every six months.

6.6 ICS-A (Interelement Correction Standard-A): A standard containing the elements Al, Ca, Fe, and Mg at 500mg/L and Ce at 10 mg/L,. This standard may also contain other program specified elements (i.e. copper and nickel are included at 10 mg/L for the drinking water analysis of 200.7) This standard is analyzed when using method 200.7 following the ICV at the beginning of the run to determine that interelement correction factors are correctly compensating for interference from these elements on other analyte lines.

6.7 ICS-AB (Interelement Correction Standard-AB): A standard containing the elements Al, Ca, Mg, and Fe at 500mg/L and all other elements at 500ug/L. This standard is analyzed following the ICV at the beginning of each run. It is

analyzed to determine that the IEC are correctly preventing interference by these elements on the measurement of other analytes. PDS (Post Digestion Spike): When a serial dilution or matrix spike falls outside of the acceptance limits a post digestion spike is used to determine if the sample digestion matrix is interfering with the analysis of the analyte. The sample is spiked at a level similar to that of the matrix spike.

6.8 SD (Serial Dilution Analysis): A sample is diluted 5x with method blank solution and analyzed. The diluted result and the undiluted result should agree within a limit of precision defined by the program or client QAPP.

6.9 IDL (Instrument Detection Limit); A series of blanks analyzed during initial setup or after significant changes, or as per DOD-QSM requirements. The limits established shall be < LOD for any given element.

7.0 Interferences

7.1 Background emission and stray light are corrected using background correction. See ICP 6000 Series operator's manual for further instructions on background correction application.

7.2 Spectral overlaps are corrected for using interelement correction factors (IEC). When IEC are used, the interfering elements must be analyzed along with the elements of interest. The accuracy of IEC shall be verified daily by analyzing the ICSAB. All IEC factors shall be updated every six months or when an instrumentation change occurs; such as, changing a torch, nebulizer, injector, or plasma conditions.

7.3 Physical interferences such as viscosity are minimized by using an internal standard. Post digestion spike and serial dilutions help to determine if physical interferences are present.

7.4 Chemical interferences include molecular compound formation, ionization effects, and solute vaporization effects. Chemical interferences are not normally seen during ICP analysis and are highly matrix dependent.

7.5 Memory interferences occur when a sample of high analyte concentration does not thoroughly rinse prior to the analysis of the next sample. This causes elevated readings for that analyte in the subsequent sample. Memory effects can be minimized by rinsing at least 60 seconds between samples.

7.6 Switching to an alternate wavelength is also an option to solve an interferent.

8.0 Safety

8.1 Gloves and protective clothing should be worn to protect against unnecessary exposure to hazardous chemicals and contaminants in samples. All activities performed while following this procedure should utilize appropriate laboratory safety systems.

8.2 Insure that waste collection vessels contain enough room to accommodate all wastes that will be produced during the operation of the instrument.

9.0 Equipment and Supplies

9.1 ICP 6500, Cetac autosampler, computer, & network printer.

9.2 Argon (Airgas-liquid high purity or gaseous pre-purified grade or equivalent).

9.3 Class A volumetric flasks and pipettes (Chemglass or equivalent).
9.4 Disposable 15-mL polystyrene culture tubes.
9.5 100 ul pipette (Eppendorf or equivalent).
9.6 10-mL pipette (Eppendorf or equivalent).

10.0 Reagents and Materials

10.1 Reagent Single element stock metals standards (Vendors =CPI/Ultra Scientific or equivalent) at either 10,000 or 1000 ug/mL Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Ni, Pb Sb Se Tl, V ,Zn, Y, Na, Si, Ti, Sr, Sn, B, Li, K, P, S, Hg, Ce, and La.
10.2 Nitric acid, conc. (Fisher, Trace Metals grade or equivalent)
10.3 Hydrochloric acid, (Fisher, Trace Metals grade or equivalent)
10.4 Deionized water (Milli Q, > 10 mega ohm).
10.5 Interference A (SPEX Certiprep, Cat.# INT-A1 or equivalent) =5000 ug/mL Al, Ca, Mg , 2000ug/mL Fe
10.6 Custom Assurance Std 23 (SPEX Certiprep, Cat.# XCTWI-5-500 or equivalent) = 100 ug/mL Al, As, B, Ba, Ca, Co, Cr, Cu, Fe, Li, Mg, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, Ti Tl V, and Zn.
10.7 Custom Assurance Std 3(SPEX Certiprep, Cat.# XCTWI-4-500 or equivalent) = 100 ug/mL Ag, Be, and Cd
10.8 Custom Assurance Std_(SPEX Certiprep, Cat.# XCTWI-1-500 or equivalent) = 20000 ug/mL Ca, 10000ug/mL Mg, Na.
10.9 Custom Assurance Std Spike (SPEX Certiprep, Cat.# XSPIKE-1-250 or
10.10 equivalent)=200 ug/mL Al, As, Ba, Se and Tl,
100 ug/mL Fe
50 ug/mL Co, Mn, Ni, Pb, Sb ,V, Zn.
25 ug/mL Cu
20 ug/mL Cr
5 ug/mL Ag, Be, Cd

See Section 13 and Appendix A, B, C and D for instructions on making the working standards.

11.0 Sample Preservation and Storage

11.1 Samples must be preserved and analyzed within holding times stated in chart. Liquid samples are stored on shelves in the Laboratory warehouse and soil samples are stored in a walk-in refrigerator unit.

	Liquids	Solids	
Preservative:	pH <2 with HNO_3		4^oC (+/-2)
Hold Time:	180 days		180 days

12.0 Quality Control

12.1 This SOP is designed to follow a variety of different projects and programs requirements. Table 3 is designed to illustrate the control steps and

provisions required to adequately producing acceptable data.

12.2 Contract Specific Sample Analysis: For certain samples, limits are specified by the QAPP (Quality Assurance Project Plan) associated with a given project. For these samples follow the limits specified in the QAPP for that project.

12.3 New or unusual matrices: It is recommended that whenever a new or unusual sample matrix is encountered, a serial dilution and post digestion (bench) spike be performed prior to reporting results. These tests will ensure that neither positive nor negative interferences are affecting sample results.

12.3.1 Serial Dilution: If the analyte concentration is sufficiently high (minimally a factor of ten above the instrumental detection limit after dilution), an analysis of a 1:5 dilution should agree within +/- 10% of the original determination. If not, a chemical or physical interference effect should be suspected.

12.3.2 Post digestion/bench spike addition (Table 2): An analyte spike added to a portion of a prepared sample, or its dilution, should be recovered to within +/- 25% of the known value. The spike addition should produce a minimum level of 10 times and a maximum of 100 times the instrumental detection limit. If the spike recovery falls outside these limits, a matrix effect should be suspected.

13.0 Calibration and Standardization

13.1 The default calibration for TAL (Target Analyte List) plus list (excluding Na and K) of metals for DOD-QSM and routine work is a multi-point calibration method called 'DOD calibration' which uses 12 mixed standards and a calibration blank.

13.2 The default calibration for the metals Sodium and Potassium for, DOD-QSM and routine work is a multi-point calibration method called 'Sodium and Potassium' which uses 8 mixed standards and a calibration blank.

13.3 The default calibration for the metal Boron for DOD-QSM and routine work is a multi-point calibration method called 'Boron' which uses 5 standards and a calibration blank

13.4 The default calibration for the metal Lithium for DOD-QSM and routine work is a multi-point calibration method called 'Lithium' which uses 7 standards and a calibration blank. Refer to section 11.0 for further instructions on how to perform the calibration.

Note: See Appendix A for preparations of calibration standards and blank for the DOD calibration method calibration. See Appendix B for the preparation of the calibration standards and blank for the Sodium and Potassium method calibration. See Appendix C for the preparation of the calibration standards and blank for the Boron calibrations. See Appendix D for the preparation of the calibration standards and blank for the Lithium calibration. See Tables 4 (a, b, & c), 5, 6, and 7 for individual element calibration concentrations/ranges.

13.5 Calibration Blank: Into a 1 L. volumetric flask, add 750 mL of Milli-Q water

and 10mL of conc. HNO3 and 10mL HCl. Mix, dilute to volume with Milli-Q H2O. Transfer to a clean 1 L. Nalgene bottle. Prepare every 6 months or as needed.

13.6 Yttrium Internal std (Used for all methods) : Into a 2000mL volumetric flask, add 500mL of Milli-Q H2O, 10 ml 10,000 mg/L Yttrium standard dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean 2L Nalgene bottle. Prepare every 6 months or as needed. Concentration = 50 mg/L Yttrium solution.

13.7 Initial/Continuing Calibration Verification (ICV/CCV): Into a 1000mL volumetric flask, add 500mL of Milli-Q water, 10 mL of conc. HNO3 and 10mL HCl. Add the following:

10 mL Custom Assurance standard Spike or Equivalent
0.5mL Mo 1000mg/L
2 ml Interferents-A-SPEX Certiprep or equivalent
1 ml Ce 1000 std

Dilute to volume with Milli-Q water, mix and transfer to a clean 1 L Nalgene bottle. Make new every 6 months or as needed.

Concentration	Analyte
50ug/L	Cd, Be
100ug/L	Ag
200ug/L	Cr
250ug/L	Cu
500ug/L	Co, Mn, Mo, Ni, Pb, Sb, V, Zn
2000ug/L	Ba, As, Tl, Se
5,000ug/L	Fe
10,000ug/L	Ca, Mg
12,000ug/L	Al

13.8 Interference Check Solution (ICSA): Into a 500 mL volumetric flask, add 300 mL of Milli-Q H2O, 5 mL of conc. HNO3 and 5mL conc. HCl. Add the following stock solutions in the volumes listed:

50 mL Spex Certiprep Interferents A or equivalent
15 ml Fe 10,000mg/L or equivalent
5 mL Cu and Ni 1000 mg/L or equivalent
5 ml Ce 1000 mg/L or equivalent

Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean 500 mL Nalgene bottle. Prepare every 6 months or as needed.

Concentration	Analyte
500,000 ug/L	Al, Ca, Mg, Fe
10,000 ug/L	Cu, Ni
10,000 ug/L	Ce

13.9 Interference Check Solution (ICSAB): Into a 500 mL volumetric flask, add 300 mL of Milli-Q H2O, 5 mL of conc. HNO3 and 5 mL conc. HCl. Add the

following stock solutions in the volumes listed:

50 mL Spex Certiprep Interferent A or equivalent
15 ml Spex Certiprep Fe 10,000 mg/L or equivalent
2.5 ml Custom Assurance std 23 or equivalent
2.5 ml custom assurance std 3 or equivalent

Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean 500 mL Nalgene bottle. Prepare every 6 months or as needed.

Concentration	Analyte
500,000 ug/L	Al, Ca, Mg, Fe
500 ug/L	Ag, As, Ba, Be Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Se, Sb, Tl, V, Zn

13.10 CRDL/MRL/LLOQ solution: Concentrations needed depend on the CRDL/MRL/LLOQ of a given contract.

14.0 Procedure

14.1 Instrument start-up procedure:

14.1.1 Open valve at argon tank, turn on chiller and instrument. For best results, the instrument should be on and with an argon purge for at least 24 hours

14.1.2 Inspect pump tubing on instrument and on autosampler and change if necessary.

14.1.3 Fill DI rinse reservoir with DI water and preserve with HNO3 to1%.

14.1.4 Open up the ITeva software on the PC. Choose user, wait until instrument initializes.

14.1.5 Plasma startup and shutdown: Refer to the ICAP 6000 Series ICP-OES Spectrometer Operator manuals pages 11-1 thru 11-4. After plasma startup check the “Debug Wavelength Check” at the bottom of the ITeva control center. The absolute value of x and y #s should be less than 5, if not, stop and call Thermo service.

14.1.6 After a 30-minute warm-up period, check condition of nebulizer. Put pump tube into a 100mg/L solution Yttrium Std. With the lights off and after enough time has elapsed for the Yttrium standard to reach the plasma, a red cone should be noticeable in the center of the plasma. If the nebulizer is in good condition and the nebulizer gas flows are set properly, the red cone should project about 2mm beyond the coils. If not, check the settings, the pump tubes, and inspect the nebulizer under a microscope for any obstructions or breakage.

14.2 To create an autosampler sequence:

14.2.1 Refer to the ICAP 6000 Series ICP-OES Spectrometer Operator manuals pages 11-9 thru 11-11 to start an autosampler sequence.

14.2.2 Add all samples, LCS, Blanks, MS-MSD, etc. in order of program, agency or client request.

14.2.3 Print Autosampler Table: This will be used when preparing all

samples and standards.

14.2.4 Using the printed autosampler table sheet, prepare all standards, QC samples, and samples in their designated positions in the autosampler. Prepare any bench spikes and place them in autosampler. Calibration standards, CCV, ICV, CCB, ICB and ICSAB all go into 50 ml vials in the designated S-# positions of the autosampler. All others are poured into 15 ml plastic vials into the designated areas within the 60 position racks.

14.3 Calibration and Analysis.

14.3.1 Once all calibration standards have been placed in the autosampler make sure the autosampler is initialized by clicking on the autosampler icon and the sequence is saved and then press the yellow arrow icon to start the calibration and prepare the remaining samples as the calibration is being carried out.

14.4 Instrument shutdown

14.4.1 If run will not be finished during work hours, program the instrument to shut down at the end of the analytical run. When setting up on the sequence page click the “End Action (after all sequences) Box to “Shutdown Plasma”. This will shut down the plasma.

14.4.2 For manual shutdown go to the flame icon in the bottom right corner and click, and then select the plasma off icon. After the plasma is shutdown loosen the pump tubes and shut off the chiller.

15.0 Calculations

15.1 Sample Calculations:

Liquid Concentration (ug/L) = A x C

$$\text{Solid Concentrations (mg/kg)} = \frac{A \times B \times C}{D \times E}$$

Where:
A = instrument reading for sample (ug/L)
B = total volume of digestion (L)
C= dilution factor, if necessary (ex. For a 1 to 10 dilution, C = 10)
D = amount of sample used in digestion (g)
E = percent solids/100, if necessary (fraction equivalent)

15.2 Spike Recovery Calculations:

$$\text{LCS Recovery (\%)} = \frac{(\text{Result obtained}) \times 100}{(\text{Spike amount})}$$

$$\text{MS/MSD Spike Recovery (\%)} = \frac{(\text{Spiked sample conc.} - \text{Sample conc.}) \times 100}{(\text{Spike amount})}$$

$$\%\text{RPD} = \frac{(\text{MS} - \text{MSD}) \times 100}{}$$

(MS + MSD)/2

Where: MS = Matrix spike concentration obtained
MSD = Matrix spike duplicate concentration obtained

15.3 "Total Hardness" (by calculation) can be determined by using the values for calcium and magnesium obtained by this procedure. The "Total Hardness" value is calculated in the LIMS system using the following equation:

Total Hardness (mg/L) or Hardness equivalent $CaCo^3$/L =

2.497[Ca mg/L} + 4.118[Mg mg/L]

15.4 Ferric/Ferrous Iron (by calculation can be determined by using the values for Total Iron (Fe) and Dissolved Iron obtained by this procedure. The "Iron III" or Ferric Fe value is calculated in the LIMS system using the following equation:

Total Fe – Dissolved Fe = Ferric Fe (Iron III)

16.0 Method Performance

16.1 Certified standard solutions, properly used instrumentation, and analyst experience and expertise are critical elements in producing accurate results. Standards and instrument performance are continually checked by analyzing external performance test samples provided by the appropriately accredited agencies. Internal blind spikes are also utilized to check analyst performance.

16.2 Initial demonstration of capability (IDC) is another technique used to ensure acceptable method performance. An analyst must demonstrate initial precision and accuracy through the analysis of 4-5 laboratory control spikes for each matrix and sample type. After analysis, the analyst calculates the average recovery (AR) and the relative standard deviation (RSD) of the recoveries for each analyte. In the absence of specific criteria found in the EPA methods or project specific limits, the default criteria of 70-130% recovery and 20 % RSD are used until internal limits are generated. (See SOP QA-022 for specifics)

16.3 Proper instrument maintenance is another means to ensure adequate method performance.

16.3.1 Pump tubing and rollers: Ensure that the pump rollers turn freely. Inspect pump tubing daily and replace when it starts failing to retain its shape.

16.3.2 Drain line: Spray chamber drain line must flow unimpeded directly into waste jug. Make sure line is draining properly.

16.3.3 Spray Chamber: If the spray chamber becomes dirty, the sample waste may not drain properly. Remove and wash with hot soapy water, then rinse with DI H_2O.

16.3.4 Torch and O-rings: The O-rings surrounding the torch may need to be replaced if the plasma becomes unstable or internal standard emission counts fall off. See ICP6000 manual for technique. Torch needs to be cleaned occasionally with aqua regia followed by sonication. See sections 5 and 6 in the "ICAP 6000 Series ICP-OES Spectrometer Operating Manuals" for further assistance if needed.

17.0 Pollution Prevention

17.1 See QAM.

18.0 Data Assessment and Acceptance Criteria for QC Measures

18.1 When the analysis of an analytical batch or sequence has been completed, the data is processed and prepared for reporting. The analyst will review the data to ensure QC is acceptable and that exceedances are addressed. Acceptable data is then captured into the LIMS system (See SOP MT-010 Data Capture for instructions on data capture).

18.2 All manual integrations will be reviewed for validity (See SOP QA-016 Manual Integrations for specifics).

18.3 After data has been captured by LIMS, it is reviewed by the analyst for accuracy and completeness. See checklist (FMT9-01) for data review guidance.

18.4 Once analyst has reviewed and approved the data, it is given to a peer or supervisor for review.

18.5 After the second reviewer approves the data, the reviewer sends the data to "validated" status in LIMS.

18.6 A paper copy of the data is then filed or archived. The package includes the checklist, the sequence run log, and a copy of the bench sheet (if applicable), the LIMS run log, and verification of calibration data.

19.0 Corrective Measures for Out-of-Control Data

19.1 See QAM.

20.0 Contingencies for Handling Out-of-Control or Unacceptable Data

20.1 See QAM

21.0 Waste Management

21.1 Samples are routinely held for up to six weeks from analysis date before they enter the waste stream. Waste disposal of samples and standards follows the procedures documented in the Laboratory Waste Disposal SOP (WS-001).

22.0 REFERENCES

22.1 Test Methods for Evaluating Solid Waste, EPA, SW-846, Method 6010B, rev. 2, December 1996.

22.2 Test Methods for Evaluating Solid Waste, EPA, SW-846, Method 6010B, rev.

3, February, 2000.
22.3 Test Methods for Evaluating Solid Waste, EPA, SW-846, Method 6010C, rev. 3, February, 2007.
22.4 Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91/010, Method 200.7, rev. 4.4, 1991.
22.5 USEPA - Contract Laboratory Program, Statement of Work for Inorganic Analysis, ILM04.0.
22.6 ICAP 6000 Series ICP-OES Spectrometer Operator's Manual, Thermo Electron (registration number 441506).
22.7 Thermo Electron Corporation Training Manual iCAP 6000 Series.
22.8 Standard Methods For the Examination of Water and Wastewater, 21st Edition, 2340B-Hardness by Calculation, 2005.
22.9 CT Laboratories Quality Manual, current revision.
22.10 Department of Defense, Quality Systems Manual for Environmental Laboratories, Version 5.0, July 2013 or most recent revision.
22.11 Department of Defense, Quality Systems Manual for Environmental
22.12 National Environmental Laboratory Accreditation Conference (NELAC), 2003 NELAC Standard Chapters 1 to 6, EPA/600/R-04/003, June 5, 2003 or most recent version.
22.13 ISO. 2005. General requirements for the competence of testing and calibration laboratories. ISO17025.
22.14 Department of Defense, Quality Systems Manual for Environmental Laboratories, Version 4.2, October 2010.
22.15 Test Methods for Evaluating Solid Waste, EPA, SW-846, Method 6010D, rev 4, July, 2014.

23.0 Appendices

Table1: Spike, LCS, & LFB Analysis- ICP
Pre-digestion Spikes

Element	Spike Amt. mL of	Spike Stock A, B, C	Stock Conc. mg/L	Final Vol. mL	Expected Conc. ug/L
Aluminum	1	**A**	200	50	4000
Antimony	1	**A**	50	50	1000
Arsenic	1	**A**	200	50	4000
Barium	1	**A**	200	50	4000
Beryllium	1	**A**	5	50	100
Cadmium	1	**A**	5	50	100
Calcium	0.5	**C**	20,000	50	200000
Chromium	1	**A**	20	50	400
Cobalt	1	**A**	50	50	1000
Copper	1	**A**	25	50	500
Iron	1	**A**	100	50	2000
Lead	1	**A**	50	50	1000
Manganese	1	**A**	50	50	1000
Magnesium	0.5	**C**	10,000	50	100000
Molybdenum*	0.1	**B**	1000	50	2000
Nickel	1	**A**	50	50	1000
Selenium	1	**A**	200	50	4000
Silver	1	**A**	5	50	100
Thallium	1	**A**	200	50	4000
Vanadium	1	**A**	50	50	1000
Zinc	1	**A**	50	50	1000

Spike Solutions ***		
Supplier	**Lot #/ std**	**Stock**
SPEX Certiprep or equiv.	SPIKE 1-500	**A**
Molybdenum * or equiv.	1000 mg/L	**B**
Custom Std***	SPEX	**C**

- * Addition of Boron, Lithium, Silicon, Tin, Strontium, Titanium, and Tungsten at 0.1 ml each of a 1000 mg/L solution from SPEX Certiprep or equivalent.
- ** Addition of Potassium at 0.5 ml of a 10,000 mg/L solution from SPEX Certiprep or equivalent.
- *** Sodium is also included in this standard at 10,000 mg/L

Table 2: Bench Spike Analysis-ICP
Post Digestion/ Bench Spikes

Element	Spike Amt. ML of	Spike Soln.	Stock Conc. mg/L	Final Vol. mL	Expected Conc. ug/L
Aluminum	0.2	**A**	200	10	4000
Antimony	0.2	**A**	50	10	1000
Arsenic	0.2	**A**	200	10	4000
Barium	0.2	**A**	200	10	4000
Beryllium	0.2	**A**	5	10	100
Cadmium	0.2	**A**	5	10	100
Calcium	0.2	**B**	20,000	10	400000
Chromium	0.2	**A**	20	10	400
Cobalt	0.2	**A**	50	10	1000
Copper	0.2	**A**	25	10	500
Iron	0.2	**A**	100	10	2000
Lead	0.2	**A**	50	10	1000
Manganese	0.2	**A**	50	10	1000
Magnesium	0.2	**B**	10,000	10	200000
Molybdenum	0.02	**C***	1000	10	2000
Nickel	0.2	**A**	50	10	1000
Selenium	0.2	**A**	200	10	4000
Silver	0.2	**A**	5	10	10
Thallium	0.2	**A**	200	10	4000
Vanadium	0.2	**A**	50	10	1000
Zinc	0.2	**A**	50	10	1000

Standard Source * **	
Supplier	
SPEX	**A**
SPEX Custom Std	**B**
Molybdenum-1,000 mg/L Std*	**C***

- * Addition of Boron, Lithium, Silicon, Tin, Strontium, Titanium, and Tungsten at 0.02 ml each of a 1000 mg/L solution from SPEX Certiprep or equivalent.
- ** Addition of Potassium and Sodium at 0.1 ml of a 10,000 mg/L solution from SPEX Certiprep or equivalent.

Table 3: Summary of Quality Control Requirements

QC Type	Frequency	Conc. Level	1. *Acceptance Criteria*	2. *Corrective Action*
Linear Dynamic Range(LDR) or high level check standard	At initial set up and checked every 6 months with a high standard at the upper limit of the range	High point of calibration curve	Recovery (Rec.) within ± 10% of true value.	Data cannot be reported above the high calibration range without an a established/passing high level check standard
Initial Calibration (ICAL) for all analytes	Daily ICAL prior to sample analyst	Table. 4a.	If more than one calibration standard used, r2 ≥ 0.99.	Minimum one high standard and a calibration blank. No samples shall be analyzed until ICAL has passed.
Initial Calibration Verification (ICV)	1 per calibration	Mid. Calib. Range	EPA 200.7 Rec.: 95-105% SW846:90-110% Or Project/Program Specific	Terminate run. Correct the problem before proceeding
Initial Calibration Blank (ICB)	Immediately after the ICV	<MDL	SW846: < 3x IDL EPA 200.7: < MDL DOD-QSM < MDL or Project / Program Specific	Terminate analysis and correct the problem before proceeding.
Method Blank (MB)	1 per batch of 20 samples	<MDL	200.7: < MDL SW846: < 2x MDL DOD-QSM: <1/2 MRL or Project / Program Specific	Access data and reanalyze/re-prepare the MB and affected data or flag “B” analyte detected in Method Blank when insufficient sample remains
Laboratory Control Sample (LCS)	1 per batch of 20 samples	Mid. Calib. Range	In-house limits or, default Rec.: 80-120% EPA200.7 ; 85-115% or Project / Program Specific	Terminate analysis: correct problem before proceeding.
Continuing Calibration Verification (CCV)	1 after every 10th sample	Mid. Calib. Range	SW846: Rec.: 90-110% EPA 200.7: 90-110% CLP:90-110%	Rerun once if fail Recalibrate and reanalyze all samples back to the last acceptable CCV or ICV

Low Level Continuing Calibration Verification (LLCCV)	Daily	LLCCV should be less than or equal to the LOQ.	All reported analytes within ± 20% rec. of the true value.	No samples shall be analyzed without a valid Low-Level Calibration Check Standard (LLCCV). If the concentration of the lowest calibration standard is less than or equal to the LOQ, the lowest standard may be re-quantified against the calibration curve as a LLCCV. Otherwise, a separate standard must be analyzed as the LLCCV prior to the analysis of any samples.
Continuing Calibration Blank (CCB)	Immediately following each CCV	<MDL	SW846: < 3x IDL EPA 200.7: < MDL DOD-QSM < MDL or Project / Program Specific	Reanalyze all samples back to the last acceptable CCB or flag "B" analytes detected
Interference Check Solution A (ICSA)	Immediately After LCS (& before final CCV if required by program / project specific QAPP)	500mg/L Al, CA,FE, Mg, or program specific	Rec.: 80-120% for Interference Elements ABS of analytes not included must be < 2X MRL or Project / Program Specific	Terminate analysis, correct problem & reanalyze all samples back to last good ICSA/ICSAB
Interference Check Solution AB (ICSAB)	Immediately After ICSA (& before final CCV if required by program / project specific QAPP)	500mg/L Al, CA, FE,MG Other elements 500ug/L	Rec.: 80-120% for All Elements	Terminate analysis, correct problem & reanalyze all samples back to last good ICSA/ICSAB

MS	One per batch (20 samples) per matrix EPA 200.7-one per 10 samples	See Table 1 spike chart	1. In-house limits: default 70-130 % Rec. 2. DOD-QSM: Use specified LCS limits. 3. LCG: 75-125 % Rec. when [matrix] is <4x[spike] 4. EPA 200.7 default 70-130% Rec. or in-house generated limits.	1. Reanalyze an alternative sample or perform a PDS, if MS and PDS fail qualify data as to matrix effect. 2. DOD-QSM: Used for matrix evaluation only. Determine source of difference (i.e. serial dilution/PDS). Reanalyze or qualify data as per client/ project requirement. 3. LCG: If MS fails and sample results are < 5x the MRL run a PDS. If sample results are > 5x the MRL perform a serial dilution.
MSD or Matrix Dup. (MD)	1. In-house & QSM-DOD: one MSD or MD per batch or matrix. 2. EPA 200.7-one per 10 samples	See Table 1 spike chart	1. In-house limits: default 70-130 % Rec. RPD = 20% 2. DOD-QSM: Use specified LCS limits for MSD. RPD = 20 % for MS/MSD or MD.	1. Perform PDS, if MSD and PDS fail qualify data as to matrix effect. 2. DOD-QSM: Used for matrix evaluation only. Determine source of difference (i.e. serial dilution/PDS). Reanalyze or qualify data as per client/ project requirement.
Serial Dilution Analysis (SD)	1. In-house: Analyzed on the sample with a PDS failure. 2. DOD-QSM: Analyzed with each batch of samples. .	5 fold dilution of chosen sample	RPD within 10% of value of diluted and undiluted sample, but only if sample conc. 1. In-house: > 10x LOQ 2. DOD-QSM: > 50x the MDL	1. In-house: Qualify data only if sample result is > 10x the LOQ. 2. Analyze a PDS if sample result is > 50x the MDL.

Post Digestion Spike (PDS)	1. In-house: Upon failure of MS or MSD. 2. DOD-QSM: When the SD test fails or all sample results < 50x the MDL and there is an MS or MSD failure.	Between 10 and 100 times the MDL	1. In-house: 80-120% Rec. 2. DOD-QSM : 80-120% Rec.	1. In-house: Qualify for matrix interference or if requested analyze by MSA. 2. DOD-QSM: Run samples by MSA or ISA or qualify data using program/project specified criteria.
Method of Standard Additions (MSA) or Internal Standard Calibration (ISA)	1. In-house: When requested. 2. DOD-QSM: After the failure of a PDS.	Minimum of 3 standard levels and the unspiked sample	N/A	Document the use of an MSA or ISA

Table 4a. TAL list Concentrations/Ranges for ICP ug/L

Element, Wavelength and Order	Calibration Standards																											
	Blank		CalStd1=0.25		CalStd2=0.5		CalStd3=1		CalStd4=5		CalStd5=10		CalStd6=20		CalStd7=50		CalStd8=100		Ca									
	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?									
Ag 328.068 {103}	☒	0	☐		☐		☒	1	☐		☒	10	☐		☐		☒	100	☐									
Ag 338.289 {100}	☒		☐		☐		☒		☐		☒		☐		☐		☒		☒									
Al 167.079 {501}	☒	0	☐		☐		☐		☐		☒	10	☐		☐		☒	100	☒									
Al 308.215 {109}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Al 396.152 { 85}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
As 193.759 {474}	☒	0	☐		☐		☐		☐		☒	10	☐		☒	50	☒	100	☒									
As 197.262 {471}	☒		☐		☐		☐		☐		☒		☐		☐		☐		☒									
Ba 233.527 {445}	☒	0	☐		☐		☒	1	☒	5	☒	10	☒	20	☒	50	☒	100	☒									
Ba 455.403 { 74}	☒		☐		☐		☒		☒		☒		☒		☒		☐		☒									
Ba 493.409 { 68}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Be 313.042 {108}	☒	0	☒	0.25	☒	0.5	☒	1	☒	5	☒	10	☐		☐	50	☒	100	☒									
Be 234.861 {144}	☒		☐		☐		☐		☐		☐		☐		☒		☒		☒									
Ca 315.887 {107}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐	100	☒									
Ca 317.933 {106}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Ca 393.366 { 86}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Ca 396.847 { 85}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Cd 226.502 {449}	☒	0	☐		☒	0.5	☒	1	☒	5	☒	10	☐		☒	50	☒	100	☒									
Cd 228.802 {447}	☒		☐		☒		☒		☒		☒		☐		☒		☒		☒									
Cd 228.802 {448}	☒		☐		☒		☒		☒		☒		☐		☒		☒		☒									
Co 228.616 {447}	☒	0	☐		☐		☒	1	☒	5	☒	10	☐		☒	50	☒	100	☒									
Co 238.892 {141}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Cr 205.560 {464}	☒	0	☐		☐		☒	1	☒	5	☒	10	☐		☒	50	☒	100	☒									
Cr 267.716 {126}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Cu 224.700 {450}	☒	0	☐		☐		☒	1	☒	5	☒	10	☒	20	☒	50	☒	100	☒									
Cu 324.754 {104}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Cu 327.396 {103}	☒		☐		☐		☐		☐		☐		☒		☒		☒		☒									
Fe 234.349 {144}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐		☒									
Fe 239.562 {140}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Fe 259.940 {129}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Mg 202.582 {466}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐	100	☒									
Mg 279.079 {121}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Mg 280.270 {120}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Mn 257.610 {131}	☒	0	☐		☐		☐		☒	5	☒	10	☒	20	☒	50	☒	100	☒									
Mn 259.373 {130}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Mo 202.030 {466}	☒	0	☐		☐		☐		☒	5	☒	10	☒	20	☒	50	☒	100	☒									
Mo 203.844 {465}	☒		☐		☐		☐		☒		☒		☐		☒		☒		☒									
Mo 204.598 {464}	☒		☐		☐		☐		☒		☒		☒		☒		☒		☒									
Ni 221.647 {452}	☒	0	☐		☐		☐	1	☒	5	☒	10	☐		☐	50	☒	100	☒									
Ni 231.604 {445}	☒		☐		☐		☒		☒		☒		☐		☐		☒		☒									
Pb 216.999 {455}	☒	0	☐		☐		☐		☒	5	☒	10	☐		☐		☒	100	☒									
Pb 220.353 {453}	☒		☐		☐		☐		☒		☒		☐		☐		☒		☒									
Pb 220.353 {153}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒									
Sb 206.833 {463}	☒	0	☐		☐		☐		☒	5	☒	10	☐	20	☒	50	☒	100	☒									
Sb 217.581 {455}	☒		☐		☐		☐		☒		☒		☒		☐		☒		☒									

Table 4b. TAL list Concentrations/Ranges for ICP ug/L cont.

Element, Wavelength and Order	lStd9=1000		CalStd10=10000		CalStd12=100K		CalStd13=10000		CalStd14=50000		CalibStd15=100	
	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	
Ag 328.068 {103}	1000											
Ag 338.289 {100}												
Al 167.079 {501}	1000		10000				100000		500000		1e+006	
Al 308.215 {109}		X				X				X		
Al 396.152 { 85}		X				X		X		X		
As 193.759 {474}	1000		10000									
As 197.262 {471}		X										
Ba 233.527 {445}	1000		10000									
Ba 455.403 { 74}		X										
Ba 493.409 { 68}		X										
Be 313.042 {108}	1000											
Be 234.861 {144}												
Ca 315.887 {107}	1000	X	10000			X	100000	X	500000	X	1e+006	
Ca 317.933 {106}		X				X		X		X		
Ca 393.366 { 86}												
Ca 396.847 { 85}		X										
Cd 226.502 {449}	1000											
Cd 228.802 {447}												
Cd 228.802 {448}												
Co 228.616 {447}	1000	X	10000									
Co 238.892 {141}		X										
Cr 205.560 {464}	1000	X	10000	X	100000							
Cr 267.716 {126}		X										
Cu 224.700 {450}	1000	X	10000		100000							
Cu 324.754 {104}		X		X								
Cu 327.396 {103}		X		X								
Fe 234.349 {144}	1000	X	10000			X	100000	X	500000	X	1e+006	
Fe 239.562 {140}		X				X		X		X		
Fe 259.940 {129}		X				X				X		
Mg 202.582 {466}	1000	X	10000			X	100000	X	500000	X	1e+006	
Mg 279.079 {121}		X				X		X		X		
Mg 280.270 {120}		X										
Mn 257.610 {131}	1000	X	10000		100000							
Mn 259.373 {130}		X		X								
Mo 202.030 {466}	1000		10000									
Mo 203.844 {465}												
Mo 204.598 {464}		X										
Ni 221.647 {452}	1000	X	10000									
Ni 231.604 {445}		X										
Pb 216.999 {455}	1000	X	10000	X	100000							
Pb 220.353 {453}												
Pb 220.353 {153}		X		X								
Sb 206.833 {463}	1000	X	10000									
Sb 217.581 {455}		X										

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table 4c. TAL list Concentrations/Ranges for ICP ug/L cont.

Element, Wavelength and Order	Calibration Standards																					
	Blank		CalStd1=0.25		CalStd2=0.5		CalStd3=1		CalStd4=5		CalStd5=10		CalStd6=20		CalStd7=50		CalStd8=100		Ca	
	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?
Se 196.090 {472}	☒	0	☐		☐		☐		☐		☒	10	☐		☒	50	☒	100	☒
Se 206.279 {463}	☒		☐		☐		☐		☐		☐		☐		☐		☐		☒
Tl 190.856 {476}	☒	0	☐		☐		☐		☐		☒	10	☐		☐		☒	100	☒
Tl 190.856 {477}	☒		☐		☐		☐		☐		☒		☐		☐		☒		☒
V 290.882 {116}	☒	0	☐		☐		☐		☐		☐	10	☐	20	☐	50	☒	100	☒
V 292.402 {115}	☒		☐		☐		☐		☐		☒		☒		☒		☒		☒
Zn 202.548 {466}	☒	0	☐		☐		☐		☐		☒	10	☐		☐		☒	100	☒
Zn 206.200 {463}	☒		☐		☐		☐		☐		☒		☐		☐		☒		☒
Zn 213.856 {457}	☒		☐		☐		☐		☐		☒		☐		☐		☒		☒
Y 324.228 {104}*	☒	0	☐		☐		☐		☐		☐		☐		☐		☐		☐
Y 371.030 { 91}*	☒		☐		☐		☐		☐		☐		☐		☐		☐		☐
Y 224.306 {451}*	☒		☐		☐		☐		☐		☐		☐		☐		☐		☐
Na 588.995 { 57}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐		☒
Si 251.611 {134}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐		☒
Ti 323.452 {104}	☒	0	☐		☐		☐		☒	5	☒	10	☐		☒	50	☒	100	☒
Ti 334.941 {101}	☒		☐		☐		☐		☒		☒		☐		☒		☒		☒
Sr 407.771 { 83}	☒	0	☐		☐		☒	1	☒	5	☒	10	☐		☐		☒	100	☒
Sr 421.552 { 80}	☒		☐		☐		☒		☒		☒		☐		☐		☒		☒
Sn 189.989 {477}	☒	0	☐		☐		☐		☐		☒	10	☐		☐		☒	100	☒
B 249.678 {135}	☒	0	☐		☐		☐		☐		☒	10	☐		☐		☒	100	☒
B 249.773 {135}	☒		☐		☐		☐		☐		☒		☐		☐		☒		☒
Li 670.784 { 50}	☒	0	☐		☐		☐		☐		☒	10	☐		☐		☒	100	☒
K 766.490 { 44}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐		☒
P 213.618 {457}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐		☐
S 182.034 {485}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐		☒
Hg 184.950 {482}	☒	0	☐		☐		☐		☐		☐		☐		☐		☒	100	☒
Ce 404.076 { 83}	☒	0	☐		☐		☐		☐		☐		☐		☐		☐		☒

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table 4d. TAL list Concentrations/Ranges for ICP ug/L cont.

Element, Wavelength and Order	alStd9=1000		CalStd10=10000		CalStd12=100K		CalStd13=10000		CalStd14=50000		CalibStd15=100	
	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	
Se 196.090 {472}	1000	☒	10000	☐		☐		☐		☐		
Se 206.279 {463}		☒		☐		☐		☐		☐		
Tl 190.856 {476}	1000	☒	10000	☐		☐		☐		☐		
Tl 190.856 {477}		☒		☐		☐		☐		☐		
V 290.882 {116}	1000	☒	10000	☐		☐		☐		☐		
V 292.402 {115}		☒		☐		☐		☐		☐		
Zn 202.548 {466}	1000	☒	10000	☒	100000	☐		☐		☐		
Zn 206.200 {463}		☒		☒		☐		☐		☐		
Zn 213.856 {457}		☐		☐		☐		☐		☐		
Y 324.228 {104}*		☐		☐		☐		☐		☐		
Y 371.030 { 91}*		☐		☐		☐		☐		☐		
Y 224.306 {451}*		☐		☐		☐		☐		☐		
Na 588.995 { 57}	1000	☒	10000	☐		☐		☐		☐	☒	1e+006
Si 251.611 {134}	1000	☒	10000	☒	100000	☐		☐		☐		
Ti 323.452 {104}	1000	☒	10000	☐		☐		☐		☐		
Ti 334.941 {101}		☒		☐		☐		☐		☐		
Sr 407.771 { 83}	1000	☒	10000	☐		☐		☐		☐		
Sr 421.552 { 80}		☒		☐		☐		☐		☐		
Sn 189.989 {477}	1000	☒	10000	☐		☐		☐		☐		
B 249.678 {135}	1000	☒	10000	☐		☐		☐		☐		
B 249.773 {135}		☒		☐		☐		☐		☐		
Li 670.784 { 50}	1000	☒	10000	☐		☐		☐		☐		
K 766.490 { 44}	1000	☒	10000	☐		☐		☐		☐	☒	1e+006
P 213.618 {457}		☒	10000	☐		☐		☐		☐		
S 182.034 {485}	1000	☒	10000	☐		☐		☐		☐	☒	1e+006
Hg 184.950 {482}	1000	☐		☐		☐		☐		☐		
Ce 404.076 { 83}	1000	☐		☐		☐		☐		☐		

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Note: These metals are calibrated using a blank and minimum of three standards. It is not allowable to remove any mid-levels to obtain an acceptable calibration; all points must be used. Multi-level calibrations must be sequential.

Appendix A.

Element specific standard prep for multipoint calibration of ICP.

A1 Calibration Standard 0.25 (Be, & Cd): Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 0.25 ul of SPEX Quality Assurance l Standard 3 and 0.25 ul of SPEX Quality Assurance Standard 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 0.25 ug/L.

A2 Calibration Standard 0.50 (Be & Cd): Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 50uL of SPEX Quality Assurance Standard 3 and 50uL of SPEX Quality Assurance Standard 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 0.50 ug/L.

A3 Calibration Standard 1.0 (Ag, Ba, Be, Cd, Co, Cr, Mn, Mo, Ni, Pb, Se, Sb, Tl, V, & Zn): Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1 ml of conc. HNO3 and 1mL conc. HCl. Add 1.0 ul of SPEX Quality Assurance Standard 3 and 1.0 ul of SPEX Quality Assurance Standard 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 1 ug/L

A4 Calibration Standard 5.0 (Ag, As, Ba, Be, Cd, Co, Cr, Cu, Mn, Sb, Tl, V, & Zn): Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 5 ul of SPEX Quality Assurance Standard 3 and 5 ul of SPEX Quality Control Standard 21. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 5 ug/L

A5 Calibration Standard 10.0 (Ag, As, B Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Li, Mo, Ni, Pb, Se, Sb, Tl, V, Sr, Sn, Ti & Zn): Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 10 ul of SPEX Quality Assurance Standard 3 and 10 ul of SPEX Quality Assurance Standard 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 10 ug/L

A6 Calibration Standard 20 (Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe Mn, Mo, Ni, Pb, Sb, Tl, & V): Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 20uL of SPEX Quality Assurance Standard 3 and 20uL of SPEX Quality Assurance Standard 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 20 ug/L

A7 Calibration Standard 50 (Ag, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, Pb, Se, Tl, V & Zn): Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 50uL of SPEX Quality Assurance Standard 3 and 50uL of SPEX Quality Assurance Standard 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 50 ug/L

A8 Calibration Standard 100(Ag, As, B Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Li,Mo, Ni, Pb, Se, Sb, Tl, V, Sr, Sn, Ti & Zn (: Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 100 ul of SPEX Quality Assurance Standard 3 and 100 ul of SPEX Quality Assurance Standard 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 100 ug/L

A9 Calibration Standard 1000 (Ag, Al, As, Ba, Be, Ca, Cd Ce Co, Cr, Cu, Fe, Hg, K Mg, Mn, Mo, Ni, Na Pb, Se, Si, S Tl, V & Zn): Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 1000uL of SPEX Quality Assurance Standard 3 and 1000uL of SPEX Quality Assurance Standard 23 and add 0.1 ml from single element standards 1000ug/mL Ce, Hg, K, Na Si and S . Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 1000 ug/L

A10 Calibration Standard 10000(Ag, As, B Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Li, Mo, Ni, Pb, Se, Sb, Tl, V, Sr, Sn, Ti & Zn and add 1.0 ml from single element standards 1000ug/mL Ce, Hg, K, Na Si and S): Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 10000uL of SPEX Quality Assurance Standard 3 and 10000uL of SPEX Quality Assurance Standard 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 10,000 ug/L

A11 Calibration Standard 100000 (Al, Ca, Fe, & Mg): Into a 100mL volumetric flask, add 5mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL of HCl. Add 1mL of 10,000 mg/L Al, 1mL of 10,000 mg/L Ca, 1mL of 10,000 mg/L Fe and 1mL of 10,000 mg/L Mg . Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 100,000 ug/L Al, Ca, Fe, Mn, and Mg.

A12 Calibration Standard 100K (Cr, Cu, Mn, & Pb): Into a 100mL volumetric flask, add 5mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL of HCl and add 10 ml of Cr 1000 mg/L, 10 mls Cu 1000 mg/L, 10 mls Pb 1000 mg/L, 10 mls and 10 ml of Mn 1000 mg/L and mix by inverting several times. Transfer to a clean Nalgene bottle.

Prepare every 6 months or as needed. Concentration:100,000 ug/L , Cr, Cu, , Mn, and Pb.

A13 Calibration Standard 500000 (Al, Ca, Fe, & Mg): Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL of HCl. Add 5mL of 10,000 mg/L Al, 5mL of 10,000 mg/L Ca, 5mL of 10,000 mg/L Fe and 5mL of 10,000 mg/L Mg. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500,000 ug/L Al, Ca, Fe and Mg

A14 Calibration Standard 1000000 (Al, Ca, Fe, K, Na, S & Mg): Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL of HCl. Add 10mL of 10,000 mg/L Al, 10mL of 10,000 mg/L Ca, 10mL of 10,000 mg/L Fe 10mL of 10,000 mg/L Mg, 10mls of 10,000 mg/L K, 10mls of 10,000 mg/L Na, and 10mls of 10,000 mg/L S. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 1,000,000ug/L Al, Ca, Fe and Mg

A17 Calibration Blank: Into a 1 L. volumetric flask, add 750 mL of Milli-Q water and 10 mL of conc. HNO3 and 10mL HCl. Mix, dilute to volume with Milli-Q H2O. Transfer to a clean 1 L. Nalgene bottle. Prepare every 6 months or as needed.

A18 ICV/CCV: Into a 1000mL volumetric flask, add 10mL Milli-Q water, 1mL of conc. HNO3 and 10mL of conc. HCl. Add 10.0mL Spex Certiprep Spike Sample Standard 1 or equivalent and 2.0mL Interference A or equivalent, 0.5 mls of 1000 ug/L Mo, 0.5 mls of 1000ug/ L Si,0.5 mls 1000ug/ L Li, 0.5 mls of 1000ug/ L Sn. 0.5mls of 1000ug/ L Sr 1000ug/ L Ti and 0.5 mls 10000 ug/L standards Na, K, and S . Dilute to volume with Milli-Q water and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentrations listed in LIMS.

A19 ICSAB: Into a 500mL volumetric flask, add 300mL Milli-Q water, 5mL of conc. HNO3 and 5mL of conc. HCl. Add 50 ml of SPEX Interferents A or equivalent, 15.0mLs of 10,000 mg/L Fe, 2.5mL Spex Certiprep QA 3 and 2.5 ml Spex Certiprep-QA 23 or equivalent. Dilute to volume with Milli-Q water and mix by inverting several times.

A20 ICSA: Into a 500mL volumetric flask, add 300mL Milli-Q water, 5mL of conc. HNO3 and 5mL of conc. HCl. Add 50 ml of SPEX Interferents A or equivalent, 15.0mLs of 10,000 mg/L Fe, 2.5mL Dilute to volume with Milli-Q water and mix by inverting several times.

A21 ICSA Cu and Ni 10,000 ug/L: Into a 500mL volumetric flask, add 300mL Milli-Q water, 5mL of conc. HNO3 and 5mL of conc. HCL 0.5mls 10,000 mg/l Cu and 5 mls of 1000 mg/L Ni. Dilute to volume with Milli-Q water and mix by inverting several times.

Table 5. Sodium and Potassium Concentrations/Ranges for ICP (mg/L)

Element, Wavelength and Order	Calibration Standards																	
	Blank		CalibStd-0.5		CalibStd-1.0		CalibStd-5.0		CalibStd-10.0		CalibStd-50.0		CalibStd-100		CalibStd-200		CalibStd-500000	
	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc
K 766.490 (44)	☒	0	☒	0.5	☒	1	☒	5	☒	10	☒	50	☒	100	☒	200	☐	
Na 330.237 (102)	☒	0	☐	0.5	☐	1	☐	5	☐	10	☒	50	☒	100	☒	200	☐	
Na 589.592 (57)	☒		☒		☒		☒		☒		☐		☐		☐		☐	
Al 309.271 (109)	☒	0	☐		☐		☐		☐		☐		☐		☐		☒	500
Ca 317.933 (106)	☒	0	☐		☐		☐		☐		☐		☐		☐		☒	500
Fe 259.940 (130)	☒	0	☐		☐		☐		☐		☐		☐		☐		☒	500
Mg 279.079 (121)	☒	0	☐		☐		☐		☐		☐		☐		☐		☒	500
Y 360.073 (94)*	☒	0	☐		☐		☐		☐		☐		☐		☐		☐	

Note: These metals are calibrated using a blank and minimum of three standards. It is not allowable to remove any mid-levels to obtain an acceptable calibration; all points must be used. Multi-level calibrations must be sequential.

Appendix B

Standard Prep for Sodium and Potassium analysis.

B1 Calibration Standard 0.5: Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 2mL of conc. HNO3 and 2mL conc. HCl. Add 0.05mL Sodium 1000mg/L and 0.05mL Potassium 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 0.5 mg/L Na, K.

B2 Calibration Standard 1.0: Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 0.1mL Sodium 1000mg/L and 0.1mL Potassium 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 1 mg/L Na, K.

B3. Calibration Standard 5.0: Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 0.5mL Sodium 1000mg/L and 0.5mL Potassium 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 5 mg/L Na, K.

B4. Calibration Standard 10: Into a 100mL volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 1mL Sodium 1000mg/L and 5mL Potassium 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 10 mg/L Na, K.

B5. Calibration Standard 50: Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 5mL Sodium 1000mg/L and 5mL

Potassium 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 50 mg/L Na, K.

B6. Calibration Standard 100: Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 10mL Sodium 1000mg/L and 10mL Potassium 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 100 mg/L Na, K.

B7. Calibration Standard 200: Into a 100mL volumetric flask, add H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 50mL Sodium 1000mg/L and 50mL Potassium 1000mg/L. Mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500 mg/L Na, K.

B8. Calibration Standard 500 high std: Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 5mL Aluminum 10,000mg/L, 5mL, Calcium 10,000mg/L, 5mL, Magnesium 10,000mg/L and 5mL Iron 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500 mg/L Al, Ca, Mg, and Fe.

B9. ICV/CCV: Into a 100mL volumetric flask, add 50mL Milli-Q water, 1mL of conc. HNO3 and 1mL of conc. HCl. Add 1.0mL 10,000mg/L Na and 1.0mL 10,000 K. Dilute to volume with Milli-Q water and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 100 mg/L Na an K.

B8. ICSAB: Into a 100mL volumetric flask, add 10mL Milli-Q water, 1mL of conc. HNO3 and 1mL of conc. HCl. Add 10 ml of SPEX Interferents A or equivalent, 3.0mLs of 10,000 mg/L Fe, 1.0mL 10,000mg/L Na and 1.0mL 10,000 K. Dilute to volume with Milli-Q water and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 100mg/L Na and K, 500,000ug/L Al, Ca, Fe and Mg.

Table 6. Boron and Silicon Concentrations/Ranges for ICP (ug/L)

Element, Wavelength and Order	Calibration Standards													
	Blank		CalibStd-50		CalibStd=50 &10		CalibStd=500 &1		CalibStd=1000&2		CalibStd=5000&1		CalibStd=500000	
	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc
B 249.773 {135}	☒	0	☒	50	☒	100	☒	1000	☒	2000	☒	10000	☐	
Si 251.611 {134}	☒	0	☐		☒	50	☒	500	☒	1000	☒	5000	☐	
Al 308.215 {109}	☒	0	☐		☐		☐		☐		☐		☒	500000
Ca 317.933 {106}	☒	0	☐		☐		☐		☐		☐		☒	500000
Fe 234.349 {144}	☒	0	☐		☐		☐		☐		☐		☒	500000
Mg 279.079 {121}	☒	0	☐		☐		☐		☐		☐		☒	500000
Y 360.073 {94}*	☒	0	☐		☐		☐		☐		☐		☐	

Note: Boron and Silicon are calibrated using a blank and a minimum three standards. It is not allowable to remove any mid-levels to obtain an acceptable calibration; all points must be used. Multi-level calibrations must be sequential.

Appendix C

Standard Prep for Boron and Silicon Analysis

C1. Calibration Standard 50 ug/L B: Into a 100mL **plastic** volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 0.05 ml Spex Certiprep QA std. 23 or equivalent. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 50 ug/L B

C2. Calibration Standard 50 ug/L Si & 100 B ug/L: Into a 100mL **plastic** volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 0.1 ml Spex Certiprep QA std. 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 50 ug/L Si & 100 ug/L B

C3. Calibration Standard 500 ug/L Si & 1000 B ug/L: Into a 100mL **plastic** volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 1.0 ml Spex Certiprep QA std. 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500 ug/L Si &1000 ug/L B.

C4. Calibration Standard 1000 ug/L Si & 2000 B ug/L: Into a 100mL **plastic** volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 1.0 ml Spex Certiprep QA std. 23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration:1000 ug/L Si &5000 ug/L B.

C5. Calibration Standard 5000 ug/L Si & 10000 B ug/L: Into a 100mL **plastic** volumetric flask, add 50mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 1.0 ml Spex Certiprep Q std23. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 5000 ug/L Si &10000 ug/L B.

C6. Calibration Standard 500 high std: Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 1mL of conc. HNO3 and 1mL conc. HCl. Add 5mL Aluminum 10,000mg/L, 5mL, Calcium 10,000mg/L, 5mL, Magnesium 10,000mg/L and 5mL Iron 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500 mg/L Al, Ca, Mg, and Fe.

C7. ICV/CCV: Into a 100mL **plastic** volumetric flask, add 50mL of Milli-Q water, 1 mL of conc. HNO3 and 1mL conc. HCl. Add 0.1mL of 1000mg/L Boron and 0.1mL of 1000mg/L Silicon (alternate sources from calibration source). Dilute to volume with Milli-Q water and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 1000 ug/L Boron and Silicon.

C8. ICSAB: Into a 100mL volumetric flask, add 10mL Milli-Q water, 1mL of conc. HNO3 and 1mL of conc. HCl. Add 10 ml of SPEX Interferents A or equivalent, 3.0mLs of 10,000 mg/L Fe, 0.05 ml 1000 mg/L B and 0.5 ml 1000 mg /L Si. Dilute to volume with Milli-Q water and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500 ug/L B and Si, 500,000 ug/L Al, Ca, Fe and Mg.

Table 7. Lithium, Tin, Strontium, and Titanium Concentrations/Ranges for ICP ug/L

Element, Wavelength and Order	Calibration Standards													
	Blank		1		10		100		1000		10000		500000	
	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc	?	Conc
Li 670.784 (50)	☒	0	☒	1	☒	10	☒	200	☒	1000	☒	10000	☐	
Sn 189.989 (477)	☒	0	☐		☐	10	☐	100	☐	1000	☒	10000	☐	
Sn 189.989 (478)	☒		☐		☐		☐		☐		☐		☐	
Sr 407.771 (83)	☒	0	☒	1	☒	10	☒	100	☒	1000	☐	10000	☐	
Sr 421.552 (80)	☒		☐		☐		☐		☐		☐		☐	
Ti 334.941 (101)	☒	0	☐	1	☒	10	☒	100	☒	1000	☒	10000	☐	
Ti 337.280 (100)	☒		☒		☐		☐		☐		☐		☐	
W 224.875 (450)	☒	0	☐		☒	10	☒	100	☒	1000	☒	10000	☐	
W 239.709 (141)	☒		☐		☐		☐		☐		☐		☐	
Al 309.271 (109)	☒	0	☐		☐		☐		☐		☐		☒	500000
Ca 317.933 (106)	☒	0	☐		☐		☐		☐		☐		☒	500000
Fe 259.940 (130)	☒	0	☐		☐		☐		☐		☐		☒	500000
Mg 279.553 (121)	☒	0	☐		☐		☐		☐		☐		☒	500000
Y 360.073 (94)*	☒	0	☐		☐		☐		☐		☐		☐	

Appendix D

Standard prep for Lithium, Tin, Titanium, Strontium, and Tungsten

D1. Calibration Standard 1: Into a 1000mLvolumetric flask, add 50mL of Milli-Q H2O, 10mL of conc. HNO3 and 10mL conc. HCl. Add 0.01 ml Spex Certiprep QA standard 23 or equivalent and 0.001 1000mg/L Sn. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 1 ug/L

D2. Calibration Standard 10: Into a 1000mLvolumetric flask, add 50mL of Milli-Q H2O, 10mL of conc. HNO3 and 10mL conc. HCl. Add 0.1 ml Spex Certiprep QA std. 23 or equivalent and .01 1000mg/L Sn. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 10 ug/L Li, Sr, Sn, and Ti.

D3. Calibration Standard 100: Into a 1000mLvolumetric flask, add 50mL of Milli-Q H2O, 10mL of conc. HNO3 and 10mL conc. HCl. Add 1.0 ml Spex Certiprep QA std. 23 or equivalent and 0.1 1000mg/L Sn. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 100 ug/L Li, Sr, Sn, and Ti.

D4. Calibration Standard 1000: Into a 1000mLvolumetric flask, add 50mL of Milli-Q H2O, 10mL of conc. HNO3 and 10mL conc. HCl. Add 10.0 ml Spex Certiprep 23 or equivalent and 1.0 1000mg/L Sn. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 1000 ug/L Li, Sr, Sn, and Ti.

D5. Calibration Standard 10000: Into a 1000mLvolumetric flask, add 50mL of Milli-Q H2O, 10mL of conc. HNO3 and 10mL conc. HCl. Add 100.0 ml Spex Certiprep QA std. 23 or equivalent and 10.0 1000mg/L Sn. Dilute to volume with Milli-Q H2O and

mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 10000 ug/L Li, Sr, Sn, and Ti.

D6. Calibration Standard 500000 high std: Into a 100mL volumetric flask, add 10mL of Milli-Q H2O, 10mL of conc. HNO3 and 10mL conc. HCl. Add 5mL Aluminum 10,000mg/L, 5mL, Calcium 10,000mg/L, 5mL, Magnesium 10,000mg/L and 5mL Iron 1000mg/L. Dilute to volume with Milli-Q H2O and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500 mg/L Al, Ca, Mg, and Fe.

D7. ICV/CCV: Into a 1000mL volumetric flask, add 50mL of Milli-Q water, 10 ml of conc. HNO3 and 10mL conc. HCl. Add 0.5mL of 1000mg/L Li, 0.5mL of 1000ug/L Sn, 0.5mL of 1000ug/L Sr, 0.5 ml of 1000mg/L Silicon and 0.5 ml of 1000mg/L Titanium. (all alternate sources from calibration source). Dilute to volume with Milli-Q water and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500 ug/L Li, Sr, Sn, Ti, and W.

D8. ICSAB: Into a 100mL volumetric flask, add 10mL Milli-Q water, 1mL of conc. HNO3 and 1mL of conc. HCl. Add 10 ml of SPEX Interferents A or equivalent, 3.0mLs of 10,000 mg/L Fe, 0.05 ml of 1000 mg/L Sr, 0.05 ml 1000 mg /L of Li, 0.05 ml 1000 mg /L of Sn, 0.05 ml 1000 mg /L of Ti, 0.05 ml. Dilute to volume with Milli-Q water and mix by inverting several times. Transfer to a clean Nalgene bottle. Prepare every 6 months or as needed. Concentration: 500 ug/L Li, Sr, Sn, Ti, and W and 500,000ug/L Al, Ca, Fe and Mg.

Note: For DOD-QSM data the lowest level (Calib. Level # 1) on a multi-point curve is prepared at concentrations equal to or less than the MRL /LLOQ for any given project and these levels are subject to change.

FMT9-01 iCAP 6000/6500 Data Review Checklist (Example)

iCAP 6000 / 6500 Data Review Checklist	Analysis Date:		Data File:		Date of review:
Cal Std ID: LIMS # :	Analyst:		Reviewer:		Approved? Yes / No
Is Audit Trail turned on or Manual Manipulations addressed? Yes / No (If no, any manual manipulations must be initialed, dated, and reason(s) stated for change)					
QC Parameters : 6010 / 200.7 / QSM / Other	**YES**	**NO**	**YES**	**NO**	**Comments:**
1) Calibration linearity: r > 0.995 / r > 0.998					
2) ICV: 90-110% / 95-105%					
3) ICB: < 3X IDL / <LOD / <LOQ					
4) ICSA: < ABS LOD					
5) ICSAB: 80-120%					
6) MRL: 70-130% / 80-120%					
7) MDL Check: >LOD					
8) CCV1/CCB1 (CCV: 90-110%)					
9) CCV2/CCB2 (CCB: < 3X IDL / <LOD / <LOQ)					
10) CCV3/CCB3					
11) CCV4/CCB4					
12) CCV5/CCB5					
13) CCV6/CCB6					
Preparation Batch Parameters	**YES**	**NO**	**YES**	**NO**	
Prep Batch ID#:_____ Dig. Meth._____					
LCS - generated limits or project specific limits					
MB - <LOD or ≤ ½ RL					
Spiked samples in batch:					
a)_____ matrix = _____					
b)_____ matrix = _____					
c)_____ matrix = _____					
PDS: ±15% / 20% / 25% Sample#:_____					
Prep Batch ID#:_____ Dig. Meth._____					
LCS - generated limits or project specific limits					
MB - <LOD or ≤ ½ RL					
Spiked samples in batch:					
a)_____ matrix = _____					
b)_____ matrix = _____					
c)_____ matrix = _____					
PDS: ±15% / 20% / 25% Sample#:_____					
Prep Batch ID#:_____ Dig. Meth._____					
LCS - generated limits or project specific limits					
MB - <LOD or ≤ ½ RL					
Spiked samples in batch:					
a)_____ matrix = _____					
b)_____ matrix = _____					
c)_____ matrix = _____					
PDS: ±15% / 20% / 25% Sample#:_____					
Prep Batch ID#:_____ Dig. Meth._____					
LCS - generated limits or project specific limits					
MB - <LOD or ≤ ½ RL					
Spiked samples in batch:					
a)_____ matrix = _____					
b)_____ matrix = _____					
c)_____ matrix = _____					

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Revision Number	Description of Changes	Date
02	Document changed to incorporated administrative requirements of ISO 17025 and QSM 5.0. Descriptions of changes have not been tracked in previous versions of this document.	03/12/2014
03	Added 4.2 QSM reference	3-9-2015
03	Added LDR and ICAL QC requirements to table 3	3-9-2015
04	Updated RSD requirement in section 12.3.1 from 5% to 3%.	03/02/2016
05	Added LLOQ standard reference at 6.2, 6.10,12.5.3,13.9, 13.10, 22.0 and D.8	4/11/17
5.1	Added frequency and criteria for spikes following EPA Method 200.7, Included WI 200.7 drinking water interference requirements.	09/15/17
5.2	Added ferric iron calculation (15.3). Updated LLCCV definition (6.4). Added LLCCV criteria to Table 3. Added Standard vendors (sec. 10.0). And added QSM 5.1 reference.	05/22/2018

SOP SV 010

EXPLOSIVES BY MODIFIED METHOD 8330B

CT LABORATORIES

delivering more than data from your environmental analyses

STANDARD OPERATING PROCEDURE

SV 010 Explosives by Modified Method 8330B

Review Date: 05/23/2018

05/23/2018

Technical Review by: Date

05/24/18

Approved by: Quality Assurance Date

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table of Contents

Section Title	Page Number
Semi-Volatile 8330B Explosives Analysis with Extended Analyte List	3
Table 1: Explosives Target Analyte List	4
Table 2.0: Secondary Column Pump Program Solvent Usage	6
Table 2.1: NQ Secondary Column Pump Program Solvent Usage	6
Table 3.0: Explosives Intermediate Working Standard Concentration	9
Table 3.1: Explosives Intermediate Working Standard Concentration (Second Source for ICV)	10
Table 3.2: Nitroguanidine (NQ) Intermediate Working Standard Concentration	10
Table 3.3: Nitroguanidine (NQ) Intermediate Working Standard Concentration (Second Source for ICV)	10
Table 3.4: Surrogate (12-DNB) Intermediate Working Standard Concentration	10
Table 3.5: Calibration Points for 8330B Explosives Linearity	11
Table 3.6: Calibration Points for Nitroguanidine	11
Table 3.7: Explosives ICV Working Standard	12
Table 3.8: Nitroguanidine ICV Working Standard	12
Table 3.9: Explosives CCV Working Standard	13
Table 3.10: Nitroguanidine CCV Working Standard	13
Table 4: Summary of Method Objectives for Method 8330B	27
Table 5: 8330B Explosives Analysis Data Review Checklist	31
Table 6: 8330A/8330B Bench Sheet	34

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

1.0 Identification of the Test Method

This method is designed to follow procedures and QC requirements found in EPA SW-846 methods 8330B, 3535, and 8332 for the quantitation of various explosive compounds in extracts from a variety of different solid and aqueous matrices. The method also incorporates USACCREL nitroguanidine (NQ) sample preparation guidelines for determination of NQ in solid and aqueous sample matrices.

2.0 Applicable Matrix or Matrices

Explosives are quantitated from a variety of matrices. This method is applicable to many types of samples, including ground water, surface water, wastewater, soils and sediments.

3.0 Detection Limits

Method detection limits (MDLs) vary from compound to compound. Water MDLs for samples prepped by normal solid phase extraction (SPE) methods (Method 3535) typically fall in the range of 0.1 ug/L to 4.0 ug/L (excluding NQ). Water MDLs for MDLs prepped using low level SPE methods are usually between 0.01 ug/L and 0.4 ug/L. NQ water MDLs are prepped by a high level method and fall in the range of 20 ug/L to 30 ug/L. Soil MDLs for all compounds are between 0.05 mg/kg and 0.55 mg/kg. Procedures for conducting MDL studies can be found in CT Laboratories Initial Method Performance and Reporting SOP.

4.0 Scope and Application

4.1 Method SW-846 8330B-extended analyte list is used to determine the quantitation of various explosive compounds in extracts from solid and aqueous matrices. High Performance Liquid Chromatography (HPLC) is employed with two columns and a dual wavelength UV detector. Target compounds determined by this method are listed in Table 1.

4.2 This method is a dual column analysis. The secondary chromatographic column is used to confirm or report final results in conjunction with the primary column. Each column uses the same QC criteria for the reporting of analytical results. The order of elution of the target analytes is different for the primary column as compared to the secondary column. Times of elution are reflected in the analytical method.

Table 1
Explosives Target Analyte List

Analytes
HMX
RDX
1,2-dinitrobenzene (1,2-DNB) (SSTD)
1,3,5-trinitrobenzene (135-TNB)
1,3-dinitrobenzene (13-DNB)
Tetryl
Nitrobenzene (NB)
2,4,6-trinitrotoluene (246-TNT)
4-amino-2,6-dinitrotoluene (4-AM-26-DNT)
2-amino-4,6-dinitrotoluene (2-AM-46-DNT)
2,6-dinitrotoluene (26-DNT)
2,4-dinitrotoluene (24-DNT)
2-nitrotoluene (2-NT)
3-nitrotoluene (3-NT)
4-nitrotoluene (4-NT)
Nitroglycerin (NG)
PETN
3,5-dinitroaniline (35-DNA)
Nitroguanidine (NQ)

5.0 Method Summary

5.1 This method describes procedures for isolating nitroaromatic and nitroamine compounds through sample preparation from aqueous and solid matrices (reference methods SW846-3535, 8330B, and USACCREL nitroguanidine sample preparation).

5.2 A sample of a known volume or weight is extracted or diluted with solvent. The resulting solution is filtered and analyzed on an HPLC that is equipped with a dual wavelength UV detector and employs a dual column technique.

5.3 The procedures contained within this method are restricted to use by or under the supervision of trained analysts. Each analyst must demonstrate the ability to generate acceptable results.

6.0 Definitions

6.1 Triplicate soil sample (TSS): For QSM, three subsamples are taken from a sample expected to contain the highest levels of explosives within the quantitation range of the method. The RSD for the results above the reporting limit must not exceed 20%. There will be one triplicate per batch of 20 samples. If explosives levels are unknown, a sample will be chosen at random for triplicate analysis. If the client has designated a sample to be used for matrix spike/matrix spike duplicate analysis, and there is no historical information about the samples, then the client designated QC sample shall be used for triplicate analysis.

6.2 For standard laboratory definitions, see QAM Appendix 10.

6.3 For a list of common acronyms and abbreviations, see QAM Appendix 7.

7.0 Interferences

7.1 Solvents, reagents, glassware, and other sample processing hardware can yield artifacts and /or interferences to sample analysis. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by analyzing method blanks. Specific selection of reagents and purification of solvents by distillation in all-glass systems can be necessary. Refer to each method for specific guidance on quality control procedures.

7.2 Tetryl is an unstable compound that decomposes rapidly, especially in water/methanol solutions and in the presence of heat. In addition, the degradation products of tetryl interfere with the quantitation of other compounds. Water samples or sample extracts suspected of containing tetryl can be acidified to pH<3 to help stabilize the sample. Also, samples containing tetryl will not be exposed to temperatures above room temperature.

8.0 Safety

8.1 Gloves and protective clothing will be worn to protect against unnecessary exposure to hazardous chemicals and contaminants in samples. All activities performed while following this procedure will utilize appropriate laboratory safety systems.

8.2 The toxicity of chemicals used in this method has not been precisely defined. Each chemical will be treated as a potential health hazard, and exposure to these chemicals will be minimized.

8.3 Because of the explosive nature of some of the target analytes and their derivatives, special care will be taken when handling standard neat materials and in the infrequent cases where water and soil samples are highly contaminated. Do not dry standards and samples at oven temperatures, and do not grind suspected highly contaminated soils. Visual inspection of solid samples is very important and any samples having a chemical appearance or that appear as a finely ground grayish-white material shall be treated as highly contaminated.

9.0 Equipment and Supplies

9.1 A complete High Performance Liquid Chromatography (HPLC) analytical system with auto-injection and all required accessories including syringes, analytical columns, dual wavelength UV detector, column heater, and EZ Chrom Elite data acquiring system.

9.1.1. Shimadzu System Controller (Model SCL-10A)

9.1.2. Two Shimadzu Liquid Chromatograph pump units (Model LC-10AS) with pump program settings that vary according to analytical column being used and analysis being performed.

9.1.2.1. Primary column: Restek Pinnacle II C18, 5 um, 250x4.6 mm, catalog #9214575 in conjunction with a Restek Pinnacle II C18 pre-column, 5 um, 20x4.0 mm, catalog #921450220.

9.1.2.2. Primary column pump parameters (excluding NQ analysis):

Mobile phase = 57.5% MeOH/42.5% H2O
Run time = 16.1 minutes (isocratic)

Flow rate = 1.0 mL/min

9.1.2.3. Primary column pump parameters for NQ:

Mobile phase = 55% MeOH/45% H2O
Run time = 7 minutes (isocratic)
Flow rate = 1.2 mL/min

9.1.2.4. Secondary column: Restek Ultra II Aromax, 5um, 250x4.6mm, catalog #9607575 in conjunction with a Restek Ultra II Aromax pre-column, 5 um, 20x4.0 mm, catalog #960750220.

9.1.2.5. Secondary column pump parameters (excluding NQ analysis):

Flow rate = 1.2 mL/min

Table 2.0
Secondary Column Pump Program Solvent Usage

Time (min)	%MeOH/%H2O
0	64/36
25	64/36
26	85/15
37.5	85/15
38	64/36
41	stop

9.1.2.6. Secondary column pump parameters for NQ:

Flow rate = 1.2 mL/min

Table 2.1
NQ Secondary Column Pump Program Solvent Usage

Time (min)	%MeOH/%H2O
0	50
1	70
2	70
12	70
12.1	50
15	stop

9.1.3. Shimadzu Column Oven (Model CTO-10ASvp) set at 26°C.

9.1.4. Shimadzu Auto Injection System (Model SIL-10A), injection volume = 100 uL.

9.1.5. Shimadzu UV-Vis Detector (Model SPD-10AV) set to the following parameters:

For NQ analysis, wavelength = 254 nm and 263 nm
For all other analytes, wavelength = 210 nm and 254 nm

9.1.6. HP Desktop PC with Windows XP Professional Operating System (Version 2002; service pack 3).

9.1.7. EZChrom Elite software for data management (Version 3.1; Build 3.1.0.2384).

9.1.8. Instrument operating parameters and mobile phase composition are subject to change to improve overall chromatography (note changes in the Instrument Maintenance Logbook).

9.2 12-port Solid Phase Extraction (SPE) Manifold (Visiprep DL, Supelco #57044 or equivalent)

9.2.1. Disposable valve liners, PTFE (Supelco #57059)

9.2.2. 12 - PTFE large volume samplers for 6 mL SPE cartridges (Supelco #57275)

9.3 1-2000 mL PyrexPlus plastic-coated, heavy wall, graduated side arm filtering flask (VWR #29410-996, or equivalent)

9.4 15 mL glass centrifuge tubes with graduations, 17 x 120mm (Pyrex, Fisher #05-507-5B, or equivalent)

9.5 SPE extraction cartridges (Phenomenex, Strata SDB-L, #8B-S014-HCH, 6 mL, 500 mg or equivalent).

9.6 Syringes (disposable) B-D #301604, 10-mL plastic syringe or equivalent.

9.7 Filtration discs (disposable) Restek 0.22 um PTFE, 25 mm, #26144, or equivalent.

9.8 Analytical balances (Fisher, #XD-2200) -capable of accurately weighing to 0.0001 grams (for standard preparation) and to the nearest 0.01 gram (for sample preparation).

9.9 Analytical balance (Denver Instruments APX 6001 or equivalent) capable of weighing the drying pan and sample to the nearest 0.1 gram (for determination when a soil sample is dry).

9.10 Spatulas- stainless steel. (VWR #57952-253 or equivalent)

9.11 Eberbach Reciprocal Mechanical Shaker (Eberbach Model 6000, or equivalent)

9.12 Mortar and pestle (Fisher #12990).

9.13 Ultrasonic bath (Fisher, #FS-28)-modified for temperature control (<30 C) by constant flow through of cold tap water during the entire sonication process.

9.14 Graduated cylinders –1000 mL (Pyrex, VWR #24709-771, or equivalent).

9.15 20 mL Repipet Dispenser, glass and Teflon (VWR #53528-190, or equivalent).

9.16 Beakers - 250 mL (Pyrex, VWR #13912-207, or equivalent) and 600 mL (Pyrex, VWR #13912-240, or equivalent).

9.17 Erlenmeyer flasks – 500 mL (Pyrex, VWR #29136-081, or equivalent)

9.18 Rubber stoppers, No. 7 (VWR #59580-262, or equivalent).

9.19 Vials - 2 mL (NSC, # 4000-186w) and 15 mL (Supelco, #27003) amber screw cap vials with Teflon lined caps, 20 mL (Fisher, #033374) vials (glass), 60 mL screw cap vials with Teflon lined caps (C&G #LX64-A030-A01A) or equivalents.

9.20 Pasteur Pipettes (VWR, #53283-911).(Used whole for sample transfers, etc. or with tips removed for soil subsampling)

9.21 Syringes (glass) 10 uL (Hamilton #24557 or equivalent), 100 uL (Hamilton #24563 or equivalent), 1.0 mL (Hamilton #24575 or equivalent), and 5.0 mL (Hamilton#201780 or equivalent).

9.22 Volumetric flask - Class A Volumetric flask – 5 mL (VWR #29619-98, or equivalent), 10 mL (VWR #29620-084, or equivalent), 25 mL (VWR #29620-109, or equivalent), 50 mL (VWR #29620-120, or equivalent), 100 mL (VWR #29620-142, or equivalent), and 200 mL (VWR #29620-164, or equivalent).

9.23 Vortex tubes (Pyrex, # 264828)-15 mL, glass or equivalent.

9.24 Kuderna-Danish (K-D) apparatus:

9.24.1. Concentrator tube, 10.0 mL, graduated. (Fisher # K570051-1025).

9.24.2. Evaporation flask- 500 mL or 250 ml (Fisher # K570035-0250).

9.24.3. Snyder column- Three-ball macro (Fisher # K503000-0121).

9.24.4. Polyacetal 19/22 clamps (VWR #KT675300-0019).

9.25 Funnels – glass. (VWR #154-08 or equivalent)

10.0 Reagents and Materials

10.1 Deionized water (In-house MilliQ processed reagent water).

10.2 Silica sand or soil- analyte free. Purify by heating at 400^{o}C for 4 hours in a shallow glass tray. Mesh size 4020 (80% will pass through a #60 sieve) or equivalent. Will be stored in air tight glass jars located in a cupboard under the counter in the soil grinding lab or in the extractions lab and used within 5 years of purifying.

10.3 50:50 methanol:Millipore water. Prepared by mixing 1 L HPLC grade methanol with 1 L Millipore water. Mix well and allow bubbles to subside. Expires 6 months after preparation, not to exceed expiration date of methanol.

10.4 Acetonitrile, HPLC grade. Stored under the extractions lab hood and used within one year of opening or before the manufacturer's expiration date.

10.5 Methanol, HPLC grade. Stored under the extractions lab hood and used within one year of opening or before the manufacturer's expiration date.

10.6 Methylene chloride, HPLC grade. Stored under the extractions lab hood and used within one year of opening or before the manufacturers expiration date. Or stored in large carboy tank provided by manufacturer and used by the manufacturer's expiration date.

10.7 Formic Acid, 98% or equivalent. Stored under the prep lab hood and used within one year of opening or before the manufacturer's expiration date.

10.8 Sodium sulfate (granular, anhydrous 60/120 mesh, JT Baker # 3375-05) or equivalent. If sodium sulfate passes in house lot check, it can be used as is. Otherwise condition sodium sulfate by heating to 400^{o}C for 4

hours in a shallow glass tray loosely covered with foil and recheck for purity. Sodium sulfate will be stored in airtight glass jars at room temperature in the extractions lab and used within one year of opening or before the manufacturer's expiration date.

10.9 Boiling chips, carborundum, approximately 10/40 mesh (methylene chloride rinsed) (Fisher # 09-191-12) equivalent. Stored in extractions lab.

10.10 Filter- Glass Microfiber 12.5 cm (Ahlstrom, MG # F136-1250, or equivalent).

10.11 Stock Standards -Stock Standards are purchased from vendors who provide certified solutions. Standards are stored at -10ºC to -20°C in a freezer reserved for standard solutions. Unopened standards shall have the manufactures suggested expiration date. Stock standards, once opened, expire within one year or sooner if routine QC indicates a problem and are not to exceed the manufactures expiration date. Stock standards are saved in a capped vial in the original box in the freezer (-10°C to -20°C). The following list of stock standards are commercially prepared certified standards, such as:

8330 Calibration Standard: Restek #33905 at 1000 ug/ml
8330 Calibration Mix 1: Cerilliant #ERE-011 at 100 ug/ml
8330 Calibration Mix 2: Cerilliant #ERE-012 at 100 ug/ml
3,5-Dinitroaniline: Restek #31661 at 1000 ug/ml
3,5-Dinitroaniline: AccuStandard #M-8330-ADD-4 at 100 ug/ml
1,2-Dinitrobenzene (surrogate): Restek #31453 at 1000 ug/ml
1,2-Dinitrobenzene(surrogate): Cerilliant#ERD-110S at 1000 ug/ml
PETN standard: Restek #31600 at 1000 ug/ml
PETN standard: Cerilliant #P-037 at 1000 ug/ml
Nitroglycerin standard: Restek #31498 at 1000 ug/ml
Nitroglycerin standard: Cerilliant #T-002 at 1000 ug/ml
Nitroguanidine standard: Restek #31602 at 1000 ug/ml
Nitroguanidine standard: AccuStandard #M-8330-ADD-6 at 100 ug/ml

10.12 Preparation of intermediate and calibration standards is documented in the explosives standards logbook. Each standard is labeled with a unique standard number to allow for tracking.

10.13 Intermediate Working Stock Standards (Spiking Solutions):

10.13.1. These standards are diluted stock standards so that the concentration levels are manageable for the working range of the HPLC. They expire within six months of preparation, or sooner if routine QC indicates a problem. The expiration date of the intermediate standards shall not exceed the expiration date of the stock standard from which they were made.

10.13.2. The intermediate working standards are prepared at an optimum level from the stock standard. (Table 3.0, Table 3.1, Table 3.2, Table 3.3, and Table 3.4). These standards are used for making the calibration curves and for spiking QC samples.

Table 3.0
Explosives Intermediate Working Standard Concentration

Stock Standard Name	Stock Standard	Stock Standard	Final Volume	Final Concentration

	Concentration (ug/ml)	Volume (ml)	(ml)	(ug/ml)
8330 Calibration Standard	1000	0.100	10	10.0
Nitroglycerin	1000	0.400	10	40.0
PETN	1000	0.400	10	40.0
3,5-Dinitroaniline	1000	0.100	10	10.0
Surrogate (12-DNB)	1000	0.100	10	10.0

Table 3.1
Explosives Intermediate Working Standard Concentration (second source for ICV)

Stock Standard Name	Stock Standard Concentration (ug/ml)	Stock Standard Volume (ml)	Final Volume (ml)	Final Concentration (ug/ml)
8330 Mix A	100	1.00	10	10.0
8330 Mix B	100	1.00	10	10.0
Nitroglycerin	1000	0.400	10	40.0
PETN	1000	0.400	10	40.0
3,5-Dinitroaniline	100	1.00	10	10.0
Surrogate (12-DNB)	1000	0.100	10	10.0

Table 3.2
Nitroguanidine (NQ) Intermediate Working Standard Concentration

Stock Standard Name	Stock Standard Concentration (ug/ml)	Stock Standard Volume (ml)	Final Volume (ml)	Final Concentration (ug/ml)
Nitroguanidine	1000	0.100	10	10.0
Surrogate (12-DNB)	1000	0.100	10	10.0

Table 3.3
Nitroguanidine (NQ) Intermediate Working Standard Concentration (second source for ICV)

Stock Standard Name	Stock Standard Concentration (ug/ml)	Stock Standard Volume (ml)	Final Volume (ml)	Final Concentration (ug/ml)
Nitroguanidine	1000	0.100	10	10.0
Surrogate (12-DNB)	1000	0.100	10	10.0

Table 3.4
Surrogate (12-DNB) Intermediate Working Standard Concentration

Stock Standard Name	Stock Standard Concentration (ug/ml)	Stock Standard Volume (ml)	Final Volume (ml)	Final Concentration (ug/ml)
Surrogate (12-DNB)	1000	0.100	10	10.0

10.14 Calibration standards: An initial calibration of the listed explosive compounds in Table 1 is performed using a minimum of 5 calibration points. Such standards will be used to demonstrate the linearity of the UV detector corresponding to the expected concentrations found in real samples (Table 3.5 and Table 3.6 below).

10.14.1. The calibration standards are made by taking known aliquots of the intermediate standard (Table 3.0 and Table 3.2) and diluting them to volume in a 1:1 solution of acetonitrile: 0.1% formic acid in water, or for NQ analysis, in a 1:1 solution of methanol: water.

10.14.2. The calibration standards are stored in the refrigerator (0°-6°C) and must be used within one day of preparation (excluding NQ). NQ standards may be stored for up to 6 months, with their expiration date not to exceed that of the stock standard from which they were made. Alternative standard concentrations for the calibration curve can be prepared to meet client or program specified criteria.

Table 3.5
Calibration Points for 8330B Explosives Linearity

Linearity Points	Intermediate Working Standard Component	Intermediate Working Standard Component Concentration (ug/mL)	Intermediate Working Standard Volume (ml)	Final Volume (ml)	Final Component Concentration (ug/ml)
1	8330 Cal. Std. NG PETN 35-DNA 12-DNB	10.0 40.0 40.0 10.0 10.0	0.005	1.00	0.05 0.20 0.20 0.05 0.05
2	8330 Cal. Std. NG PETN 35-DNA 12-DNB	10.0 40.0 40.0 10.0 10.0	0.010	1.00	0.10 0.40 0.40 0.10 0.10
3	8330 Cal. Std. NG PETN 35-DNA 12-DNB	10.0 40.0 40.0 10.0 10.0	0.025	1.00	0.25 1.00 1.00 0.25 0.25
4	8330 Cal. Std. NG PETN 35-DNA 12-DNB	10.0 40.0 40.0 10.0 10.0	0.050	1.00	0.50 2.00 2.00 0.50 0.50
5	8330 Cal. Std. NG PETN 35-DNA 12-DNB	10.0 40.0 40.0 10.0 10.0	0.100	1.00	1.00 4.00 4.00 1.00 1.00
6	8330 Cal. Std. NG PETN 35-DNA 12-DNB	10.0 40.0 40.0 10.0 10.0	0.200	1.00	2.00 8.00 8.00 2.00 2.00
7	8330 Cal. Std. NG PETN 35-DNA 12-DNB	10.0 40.0 40.0 10.0 10.0	0.300	1.00	3.00 12.00 12.00 3.00 3.00

Table 3.6
Calibration Points for Nitroguanidine

Linearity Points	Intermediate Working Standard	Intermediate Working Standard	Intermediate Working Standard	Final Volume (ml)	Final Concentration (ug/ml)

		Concentration (ug/mL)	Volume (ml)		
1	NQ intermediate 12-DNB	10.0 10.0	0.004 0.004	1.0	0.04 0.08
2	NQ intermediate 12-DNB	10.0 10.0	0.008 0.008	1.0	0.08 0.16
3	NQ intermediate 12-DNB	10.0 10.0	0.020 0.020	1.0	0.20 0.40
4	NQ intermediate	10.0	0.050	1.0	0.50
5	NQ intermediate	10.0	0.100	1.0	1.00
6	NQ intermediate	10.0	0.200	1.0	2.00
7	NQ intermediate	10.0	0.300	1.0	3.00

10.15 Initial Calibration Verification (ICV): The initial calibration verification standard (different manufacturer or lot number from the initial calibration standard) shall verify the initial calibration curve.

10.15.1. The ICV standard involves the analysis of all the target compounds each time the initial calibration is performed and must meet specified recovery criteria for all components prior to sample analysis.

10.15.2. The ICV is prepared from intermediate standards (Table 3.1 and Table 3.3) diluted in 1:1 acetonitrile: 0.1% formic acid in water (or 1:1 methanol: water for NQ) at the same concentration as calibration point 4 of the standard curve. See Table 3.7 and Table 3.8 for ICV preparation details.

Table 3.7
Explosives ICV Working Standard

ICV Standard Component	Intermediate Standard Concentration (ug/ml)	Standard Volume (ml)	Final Volume (ml)	Final Concentration (ug/ml)
8330 Mix A	10.0	0.050	1.0	0.50
8330 Mix B	10.0			0.50
NG	40.0			2.00
PETN	40.0			2.00
35-DNA	10.0			0.50
12-DNB	10.0			0.50

Table 3.8
Nitroguanidine ICV Working Standard

ICV Standard Component	Intermediate Standard Concentration (ug/ml)	Standard Volume (ml)	Final Volume (ml)	Final Concentration (ug/ml)

NQ 12-DNB	10.0 10.0	0.050	1.0	0.50 0.50

10.16 Continuing Calibration Verification (CCV) Standard (Table 3.9 and Table 3.10): A working standard solution used to check the validity of a calibration curve on a daily basis. The CCV is prepared the same way and at the same concentration as the calibration point 4 of the calibration curve.

Table 3.9
Explosives CCV Working Standard

CCV Standard Component	Intermediate Standard Concentration (ug/ml)	Standard Volume (ml)	Final Volume (ml)	Final Concentration (ug/ml)
8330 Cal. Std. NG PETN 35-DNA 12-DNB	10.0 40.0 40.0 10.0 10.0	0.250	5.0	0.50 2.00 2.00 0.50 0.50

Table 3.10
Nitroguanidine CCV Working Standard

CCV Standard Component	Intermediate Standard Concentration (ug/ml)	Standard Volume (ml)	Final Volume (ml)	Final Concentration (ug/ml)
NQ 12-DNB	10.0 10.0	0.250	5.0	0.50 0.50

10.17 0.1% formic acid solution preparation - Add 4.0 mL formic acid to 4.0 L Millipore water. Mix well.

11.0 Sample Collection, Preservation, and Storage

11.1 Aqueous samples are collected in 1-L amber glass containers with Teflon lined lids. Aqueous samples are to be collected in duplicate for high-level analysis or regular SPE analysis and in triplicate for low-level SPE analysis. Solid samples are collected in 250-mL wide mouth glass containers with Teflon-lined lids. All samples are preserved by cooling to 4ºC. The solid samples must be extracted within 14 days and water samples must be extracted within 7 days of the date of collection.

11.2 Sample extracts are stored in the refrigerator and analyzed within 40 days of extraction.

12.0 Quality Control

12.1 This SOP is designed to follow a variety of different projects and programs requirements. Table 4 is designed to illustrate the control steps and provisions required to adequately produce acceptable data.

12.2 Contract Specific Sample Analysis: For certain samples, limits are specified by the QAPP (Quality Assurance Project Plan) associated with a given project. For these samples follow the limits specified in the QAPP for that project.

12.3 Program Specific Limits: Samples analyzed under the guidance of certain programs; such as the Department of Defense Quality Systems Manual (DoD/QSM) or Louisville Chemistry Guidance (LCG), require their own specified limits. For these samples follow the limits specified in the manuals for that program.

13.0 Calibration and Standardization

13.1 Calibration

13.1.1. The initial calibration for SW-846-8330B chromatographic method involves the analysis of standards containing the target compounds at a minimum of five different concentrations covering the working range of the instrument across two dissimilar analytical columns. Each column must meet the initial calibration and continuing calibration criteria found in Table 4.

13.1.2. The identification of analytes such as explosives is performed by retention times. Retention time windows are crucial to the identification of target compounds.

13.1.3. Compare the retention time of each analyte in the calibration standard with the absolute retention time windows established in accordance with Method 8000 Section 11.6.

13.1.4. Make three injections of the target analyte standards over a course of 72-hour period.

13.1.5. Each retention time must be to three decimal places. Calculate the mean and standard deviation of the target analytes. The width is 3x the standard deviation of the mean absolute retention time during the 72 hour period or 0.03 minutes, which ever is higher. If the standard deviation is 0.000, the laboratory will include more data points or use the default value of 0.01 minutes.

13.1.6. Each analyte in each standard must fall within its respective retention time window. The retention time shall be set using the midpoint standard of the initial calibration curve or the value in the continuing calibration verification standard at the beginning of the analytical shift.

13.1.7. If the analytes fall outside the established retention time window, the HPLC system must either be adjusted so that a second analysis of the standard target analytes fall within their retention time windows, or a new initial calibration must be performed and new retention time windows established.

13.1.8. For each compound of interest, prepare calibration standards at a minimum of five different concentrations as described above in section 10.15. Note: QSM requires that the LOQ or the lowest point in the curve, which ever is greater, be used for the reporting limit.

13.1.8.1. Calibration standards are injected directly into the high pressure liquid chromatograph. An external calibration technique is employed. One of the external standards will be at a concentration near, but above the method detection limit. If the RSD $\leq$ 20% (15% for QSM), the correlation of $r \geq 0.995$, or $r^2 \geq 0.990$ is obtained then the calibration is deemed acceptable.

13.1.8.2. The lowest concentration calibration standard that is analyzed during an initial calibration curve, establishes the method's quantitation limit based on the final volume of the sample extract described in the preparative method or employed by the laboratory.

13.1.8.3. External standard calibration involves comparison of instrument response from the target compounds in the calibration standards. Sample peak areas are compared to peak areas of the standards. The ratio of the detector response to the amount of analyte in the calibration standard is defined as the calibration factor (CF).

13.1.8.4. Linear calibration using the average calibration or response factor: When calculating, both calibration factors and response factors are a measure of the calibration relationship and assume that the curve passed through the origin. If the relative standard deviation (RSD), is less than or equal to 20% (less than or equal to 15% for QSM), the use of the linear model is generally appropriate, and the calibration curve can be assumed to be linear and to pass through the origin.

13.1.8.5. Linear calibration using a least squared regression: When the RSD of the calibration or response factors is greater than 20% (15% for QSM) over the calibration range, linearity through the origin

cannot be assumed. The approach is to employ a regression equation that does not pass through the origin. This approach can also be employed based on past experience of the instrument response.

13.1.8.6. Non-linear calibration: Non-linear calibration is not allowed by EPA method 8330B.

13.1.8.7. A minimum of five calibration points must be analyzed (six points if using a quadratic or second order model). If more calibration points are analyzed, points from the upper end of the calibration curve may be dropped if necessary, but no calibration point may be dropped from the middle of the calibration curve. (For example: If seven calibration points are analyzed, then the seventh point may be dropped, or the seventh and sixth points may be dropped, but the sixth point or any lower numbered point alone may not be dropped from the middle of the curve.)

13.1.8.8. Check the validity of the calibration by analyzing an ICV. The variance of any given compound shall not be more than +/- 15% difference (20% for QSM). This standard must be prior to sample analysis. If the percent drift or the percent difference criteria are not met then the subsequent sample analysis for that analyte is not acceptable.

13.1.8.9. For QSM projects, the lowest standard must be re-analyzed (re-calculated) and meet +/-20% recovery criteria prior to the analysis of samples

13.1.8.10. Continuous checking of the validity of the calibration is done by analyzing CCVs. The variance of any given compound shall not be more than +/- 15% difference (20% for QSM). This standard must be ran at the beginning, every 20 samples or every 12-hour interval (which ever comes first), and at the end of the analysis run. (Note: QSM samples must have CCVs injected every ten field samples.)

13.2 **Calibration Calculations**

13.2.1. When determining explosives by the external standard technique, calculate the calibration factor (CF) for each peak in each of the initial calibration standards using the equation below.

$$CF = \frac{\text{Peak Area (or Height) in the Standard}}{\text{Total Mass of the Standard Injected (in Nanograms)}}$$

13.2.2. The calibration factors from the initial calibration are used to evaluate the linearity of the initial calibration. This involves the calculation of the mean calibration factor, the standard deviation, and the relative standard deviation (RSD) for each multi-component peak.

$$\text{Mean CF} = \overline{CF} = \frac{\sum_{i=1}^{n} CF_i}{n}$$

$$SD = \sqrt{\left(\frac{\sum_{n}(CF_I - \overline{CF})^2}{n-1}\right)}$$

$$RSD = \frac{SD}{\text{Mean CF}} \times 100$$

13.2.3 Linear Calibration: If the RSD of the calibration factor is greater than 20% over the calibration range (15% for QSM), then linearity though the origin cannot be assumed. If this is the case, the analyst can employ a regression equation that does not pass through the origin. This approach can also be employed based on the past experience of the instrument response. The regression will produce the slope and intercept terms for a linear equation in the form:

$$y = mx + b$$

y = instrument response (peak area or height)
m = Slope of the line
x = Concentration of the calibration standard
b = y-intercept

13.2.4 The analyst will not force the line through the origin, but have the intercept calculated from the five data points. The use of origin (0,0) as a calibration point: the use of linear regression will not be used as a rationale for reporting results below the calibration range.

13.2.5 A linear least squares regression attempts to construct a linear equation of the form: $y= mx + b$, by minimizing the differences between the observed results (y_i, the response calculated from the constructed equation). The regression equation is:

$$y_i' = ax_i + b$$

where:

a = Regression coefficient or the slope of the line
b = y-intercept
y_i' = Predicted (or calculated) response for the i^{th} calibration standard.
x_i = Mass of analyte in the i^{th} calibration standard aliquot introduced into the instrument.

The sum of the squares of the differences is minimized to obtain a and b:

$$\sum_{i=1}^{n} (y_i - y_i')^2$$

where n is the total number of calibration points. The regression calculations attempt to minimize the sum of squares, hence the name "least squares regression."

Weighting the sum of the squares of the differences can significantly improve the ability of the least squares regression to fit the linear model to the data. The general form of the sum of the squares of the differences containing the weighting factor is:

$$\sum_{i=1}^{n} w_i (y_i - y_i')^2$$

where:

w_i = Weighting factor for the calibration standard (w=1 for unweighted least squares regression.
y_i = Observed instrument response (area or height) for the i^{th} calibration standard.

y_i' = Predicted (or calculated) response for the i^{th} calibration standard.
n = Total number of calibration standards.

13.2.6 Least Squares Equation (LSQ) weighting method to be used for calculation of least squares regression fits, either 1/x or $1/x^2$, gives increased importance to smaller concentrations and areas. LSQ Weight can be applied to linear, quadratic, and cubic fits only.

14.0 Procedure

14.1 Explosives Water Extraction by SPE (Method 3535)

14.1.1. Pre-rinse all glassware to be used in the extraction with Acetonitrile (HPLC Grade).

14.1.2. Water samples may be prepared using either the high-level, regular SPE or low-level SPE methods. Regular and low-level SPE sample preparation is described below, starting with 14.1.3. To analyze water samples by the high level method, combine 5.0 mL of sample with appropriate volumes of surrogate and/or spiking solutions in a 10 mL volumetric flask. Add acetonitrile to reach a final volume of 10 mL. Mix well and filter the sample through a 0.22-micron filter. Discard the first three mL of filtrate and transfer a portion to a 2.0 mL amber vial for analysis.

14.1.3. For regular SPE analysis, quantitatively measure 500 mL of sample to be extracted. In low-level SPE analysis, a full liter of sample is extracted. Mark the meniscus on the 1 L amber glass collection jar so that the sample volume can be measured after sample extraction. All initial sample volumes need to be noted on the extraction bench sheet.

14.1.4. Clean and rinse (with acetonitrile and purified water) the extraction manifold, its valves, and Teflon samplers, and any other equipment used in the extraction process that can come into contact with the sample.

14.1.5. One method blank (MB) and laboratory control spike (LCS) must be prepared with each batch of 20 samples or less. Prepare by measuring 500 mL of Milli-Q water into a 1 L amber jar for regular SPE analysis and 1 L of Milli-Q water for low-level SPE analysis.

14.1.6. One sample from each batch of 20 samples or less will be selected for use in the preparation of a matrix spike (MS) and a matrix spike duplicate (MSD). For regular SPE analysis, select the sample and from the glass sample collection jar, quantitatively measure 500 mL of sample to a 1 L amber jar to be spiked and extracted. For low-level SPE analysis, mark the meniscus on the jars selected for the MS/MSD and spike and extract the entire jar.

14.1.7. To the method blank and all samples being tested for explosives, add 0.5 mL of the surrogate standard (Table 3.4) at 10.0 ug/mL for regular SPE preparation and 0.2 mL surrogate standard for low-level SPE preparation.

14.1.8. To the control spike and the matrix spike/matrix spike duplicate pair add 0.5ml of intermediate (spiking) standard described in Table 3.0 above for regular SPE and 0.2 mL spiking standard for low-level SPE.

14.1.9. Assemble the SPE extraction manifold by inserting the disposable Teflon liners into the flow control valves and then close valves. Connect the manifold to the waste collection vessel, which is then connected to the in-house vacuum system.

14.1.10. Mount the SPE extraction cartridges onto the flow control valves and rinse them with 3-4 volumes of methylene chloride to remove phthalate contamination. Do this by opening the valves and turning on

the house vacuum. Condition the cartridges using 10-15 mLs of acetonitrile at a flow rate of approximately 10 mL/minute (To obtain the 10 mL /minute flow turn on the house vacuum and set the regulator on the manifold to around 4-5 mm/Hg. Fine adjustments will be necessary). Be careful not to let the cartridge go dry.

14.1.11. Follow up the acetonitrile conditioning by rinsing the cartridges with 10-15 mL DI H2O at a flow rate of approximately 10 mL/minute. Label each cartridge with the ID of the sample, blank, or spike that is to be extracted. Be careful not to let the cartridge go dry.

14.1.12. Attach the appropriate end of the clean Teflon samplers to the SPE cartridges while placing the weighted end into the sample. When all needed lines are attached, pull the sample, spike, and/or blank through the cartridges by applying the vacuum at a rate of approximately 10 mL/minute. Waste will be collected into the manifold's basin and into the waste vessel and must be monitored and emptied as needed so the liquid does not get into the vacuum line. If all the positions on the manifold are not being used be sure to close the valves at those positions.

14.1.13. When a sample is completely drawn through a particular cartridge close the valve to that cartridge. When all samples are drawn through their cartridges shut off the vacuum and close all valves. Remove the Teflon samplers from the cartridges and the samples. Fill each cartridge with DI water, open the valves and draw the water through under low vacuum. This will remove the water droplets on the inside wall of the cartridge. Allow the cartridges to dry under vacuum for approximately 5 minutes to remove as much water as possible. Shut off the vacuum and close the valves again. Empty the manifold basin and the waste vessel.

14.1.14. Remove the lid to the manifold and place inside the basin a sample tray containing the, appropriately labeled, 15 mL graduated centrifuge (or equivalent) tubes for collection of the eluted extract. Alternatively, use screw cap culture tubes for collection.

14.1.15. Elute the samples and their associated QC samples by passing a 5.0 mL aliquot of acetonitrile through the extraction cartridges at about 1 mL/minute. Collect the eluate in the collection tubes. Bring the final sample volume to 5 mL with acetonitrile. If using culture tubes, the sample will need to be transferred with a Pasteur pipette to a class A 5 mL volumetric flask and brought to volume with acetonitrile. Record the eluate volume on the extraction bench sheet.

14.1.15.1. Note: If per client specification, the samples are to undergo gel-permeation chromatography (GPC) clean-up, it is necessary for them to be eluted from the SPE cartridges using a 5.0 mL aliquot of methylene chloride rather than acetonitrile. The eluate is collected into a 13mm x 100mm disposable glass culture tube. The collected eluate may contain a small layer of water on the top that will need to be removed using a disposable glass Pasteur pipet.

14.1.15.2. The procedure for GPC clean-up is described in the SOP SV-014.

14.1.15.3. Following the GPC clean-up, samples will need to be concentrated and exchanged back to acetonitrile. This procedure is described in section 14.2 below.

14.1.16. For regular SPE, bring the final sample volume to 5 mL with acetonitrile.

14.1.17. Prior to analysis, dilute the final extract 50 %(v/v) with 0.1% formic acid in water. Store the final extract in an amber vial and refrigerate until analysis. Mix well and filter the sample through a 0.22-micron filter. Discard the first 1-2 mL of filtrate (for low level samples, only discard the first few drops as sample volume is very limited) and transfer a portion to a 2.0 mL amber vial for analysis.

14.2 **Concentration (for samples that have undergone GPC cleanup only)**

14.2.1. Place glass microfiber filter paper into a glass funnel. Fill the filter paper two-thirds full with sodium sulfate. Rinse filter paper, sodium sulfate, funnel, K-D apparatus, and concentrator tube with methylene chloride.

14.2.2. Quantitatively pour the extract taken from the GPC instrument through the filter and funnel seated on a 250mL Kuderna-Danish (K-D) apparatus complete with concentrator tube. Rinse the glass collection tube three times with methylene chloride. Add these rinses through the filter and funnel into the K-D apparatus. Add a boiling chip to the K-D flask prior to placing it on the heated water bath. Wet a three ball Snyder column with approximately 2-mL of methylene chloride. Attach the Snyder column.

14.2.3. Place the K-D in the heated water bath so the concentrator tube is immersed in the water and the lower rounded surface of the K-D is bathed in steam. At the proper rate of distillation the balls of the column will actively chatter, but the chambers will not flood (set the knob of the temperature control to 5~6). It is critical that the analyst watches the extract as it distills. THE EXTRACT CANNOT GO TO DRYNESS.

14.2.4. When the extract volume reaches approximately 5-7 mL, remove the K-D from the bath. Slightly tilt the apparatus and rotate to aid in solvent drainage from the Snyder column. Allow it to cool.

14.2.5. Pour 30 mL of acetonitrile through the top of the Snyder column and allow solvent to completely empty from the Snyder column into the KD. Turn the knob of the temperature control of the water bath heater to 8~9. Mix the contents of the KD by slightly tilting and placing it upright several times using care so that the content does not spill out of the Snyder column. Concentrate the extract to approximately 4-mL. Remove the K-D apparatus from the bath. As above, slightly tilt the apparatus and rotate to aid in solvent drainage. Allow it to cool completely.

14.2.6. Remove the Snyder column, wipe off the water from the bottom of the K-D flask and the concentration tube with a paper towel and then remove the K-D flask.

14.2.7. Turn on the heating unit for the Organomation and adjust the temperature control so that the water bath is about 35ºC. Place sample concentrator tube into the nitrogen blow down apparatus. Allow a gentle stream of nitrogen to interact with the extract. There shall be no splashing or excessive movement upon the surface of the extract. Allow the extract to evaporate down to approximately 0.8 ml. Remove concentrator tube from water bath and use a Pasteur pipet to bring sample extract up to a 1.0-ml volume with acetonitrile. Highly contaminated samples may not adequately concentrate down to 1mL. Such samples shall be transferred to an appropriate volume volumetric flask and brought to volume with acetonitrile. Transfer 1-mL of the extract to an amber labeled screw-cap injection vial. Record the final extract volume on the extraction bench sheet.

14.3 **Explosives Solid Extraction by Sonication**

14.3.1. Prepare solid samples for extraction by first examining the sample matrix for physical presence of contamination (see Safety, 8.0). Remove by gloved hand any extraneous, obvious non-soil components (paper, plant material, etc).

14.3.2. See the Grinding of Multi-incremental Samples by Puck Mill SOP (GT-002) for procedures regarding soil sample homogenization by the puck mill.

14.3.2.1. For QSM, a 100 g laboratory control sample (LCS), spiked with all target analytes of interest, is prepared and taken through all grinding steps. To the LCS - add 10.0 mL of methylene chloride containing the following: 0.2 mL of 8330 stock standard at 1000 ug/mL,

0.2 mL 3,5-dinitroaniline stock standard at 1000 ug/mL, and 0.2 mL 1,2-DNB surrogate stock standard at 1000 ug/mL, 0.4 mL NG stock standard at 1000 ug/mL, and 0.4 mL PETN stock standard at 1000 ug/mL.

14.3.2.2. This is best done by placing the 100g of soil to be spiked into a glass baking dish and gently shaking the dish back and forth to level out the soil.

14.3.2.3. Using a glass disposable Pasteur pipet, drizzle the methylene chloride and standard solution in a spiral pattern onto the soil.

14.3.2.4. Using a metal spatula or equivalent device, work the solution into the soil manually so that no moisture is visible before placing the soil into the metal puck mill bowl for grinding. (Note: A certified reference material / LCS may be purchased from either ERA or Wibby Environmental).

14.3.3. The MS/MSD samples for both QSM and non-QSM work and the LCS for non-QSM work are not taken through the puck mill grinding portion of the procedure after spiking. The MS/MSD samples for QSM work are for matrix evaluation only and are taken and spiked post-grinding from the same ground sample as the parent subsample is taken.

14.3.4. Per client or project specifications, samples may not undergo the puck mill grinding procedure described above, but will be ground by mortar and pestle instead (if deemed safe to do so).

14.3.4.1. Air dry samples at room temperature and in the dark.

14.3.4.2. Rinse the mortar and pestle with acetonitrile and allow to dry thoroughly.

14.3.4.3. Place approximately 50 grams of dried sample into the mortar and grind sample so that it will pass through a 10-mesh sieve.

14.3.4.4. Place the ground sample into a sealed 4 ounce amber jar and label the jar with the appropriate sample number.

14.3.4.5. Wash the mortar and pestle with warm soapy water and dry thoroughly with a towel or allow to air dry.

14.3.5. Weigh 10 grams of sample, grinding blank (or grinding blank composite), method blank (purified sand or soil), matrix spike, matrix spike duplicate and LCS (non-homogenized: purified sand or soil; homogenized: spiked and homogenized LCS) to the nearest 0.01 g into a 40 mL vial.

14.3.5.1. Use the trimmed down glass Pasteur pipet sampling tubes to transfer homogenized soil samples in small quantities into the 60 mL vial. (For small samples that have not undergone puck mill homogenization a metal spatula may be used for sample transfer.)

(Note: QSM V 4.2 requires the following: Entire ground sample is mixed, spread out on a large flat surface (e.g. baking tray), and 30 or more randomly located increments are removed from the entire depth to create a subsample of ~10g.)

14.3.5.2. For homogenized soil samples, the grinding blank may be used as the method blank also, since it is taken through all steps of the prep procedure.

14.3.5.3. For QSM, all homogenized soil samples are required to have one sample per batch prepped and analyzed in triplicate. If there is any information on which sample may contain the

highest concentrations of analytes then that sample should be chosen. Otherwise, use the client-designated QC sample. If the client did not designate a QC sample, then choose a sample at random for triplicate analysis.

14.3.6. Add 2.00 mL 12-DNB surrogate solution at 10 ug/mL to all client samples and the method blank and/or grinding blank only (spiking solution added to LCS/MS/MSD samples already contains the appropriate amount of surrogate).

14.3.7. To the MS/MSD samples, add 2.0 mL of standard spiking solution described in Table 3.0 above.

14.3.8. Add acetonitrile to each sample to reach a total final volume of 20 mL (be sure to account for any volume added by surrogate or spike).

14.3.9. Mix samples with acetonitrile well by first shaking vigorously for 10-20 seconds or until all soil is visibly wet and not stuck to the bottom of the vial. Place samples on the mechanical shaker on the highest setting and allow to shake for 10 minutes.

14.3.10. Sonicate samples for 18 hours in the temperature controlled (< 30° C) ultrasonic bath.

14.3.11. Wipe samples are directly added to the 40 ml amber sample vial (no sample weight), 2.00 mL surrogate is added, and they are brought to 20 mL final volume with acetonitrile. Mix well by shaking vigorously for 10 seconds. Place the sample(s) into a temperature controlled ultrasonic bath (<30 C) and sonicate for 18 hours.

14.3.12. After sonication, allow the sample to settle for at least 30 minutes. Remove 2.0 mL of the supernatant and combine it with 2.0 mL of 0.1 % formic acid solution. Alternatively, shake the sample and remove 2.0 mL. Add 18 mL 0.1% formic acid solution to the extraction vial and allow settling for at least 30 minutes.

14.3.13. Place the supernatant in a disposable syringe, attach a 0.22-micron filter disc, and filter it into the 15 mL amber vials (or directly into 2 mL amber vials used in analysis). Discard the first 1-2 mL of supernatant before adding to the vials. Store the final extract in the refrigerator (0°-6°C) until analysis.

14.4 **Water Sample Preparation of Nitroguanidine (NQ) by High Level Prep**

14.4.1. Pre-rinse all glassware to be used in the preparation with acetonitrile (HPLC Grade).

14.4.2. Nitroguanidine water samples are prepared using the high-level method. For the method blank and client samples, combine 5.0 mL of sample with 0.5 mL surrogate at 10.0 ug/mL in a 10 mL volumetric flask. For LCS,, MS, and MSD samples, combine 5.0 mL sample with 0.5 mL NQ intermediate at 10.0 ug/mL. Add methanol to reach a final volume of 10 mL. Mix well by corking and inverting the flask several times. Filter the sample through a 0.22-micron filter. Discard the first 1-2 mL of filtrate and transfer a portion to a 2.0 mL amber vial for analysis.

14.5 **Soil Extraction of Nitroguanidine (NQ) by Sonication**

14.5.1. Prepare solid samples for extraction by first examining the sample matrix for a physical presence of contamination (see Safety, 8.0). Samples will be allowed to air dry at room temperature. Per client or project specifications, the samples will undergo either mortar and pestle or puck mill homogenization as described above.

14.5.2. See the Grinding of Multi-incremental Samples by Puck Mill SOP (GT-002) for procedures regarding soil sample homogenization by the puck mill.

14.5.3. Weigh 5 grams of sample to the nearest 0.1 g into a 40-mL vial and label the vials with the sample numbers. As noted in section 14.3.5.1 above, QSM V 4.2 requires that samples homogenized by the puck mill be spread out on a baking sheet and that 30 or more randomly chosen aliquots of soil be used to create the 5 gram subsample. With client approval, the trimmed down glass Pasteur pipet sampling tubes may be used to transfer the soil to the vials.

14.5.4. One method blank and control spike must be prepared with each batch of 20 samples or less. Prepare by adding 5 grams of organic free silica sand or soil that has previously been determined to be clean to a 40-mL vial. For homogenized samples, the grinding blank may be used as the method blank.

14.5.5. One sample from each batch of 20 samples or less must be used in the preparation of a MS and a MSD. Weigh 5 grams of the parent sample into each of two 40-mL vials for the MS/MSD pair.

14.5.6. Prior to extraction, add to the method blank and all field samples, 1.0 mL of surrogate spiking solution at 10.0 ug/mL. To the matrix spike/matrix spike duplicate and control spike add 1.0 mL NQ intermediate solution described in Table 3.2.

14.5.7. For homogenized samples, a homogenized NQ LCS shall be prepared and taken through all grinding steps.

14.5.7.1. Prepare an LCS spiking solution by placing 0.200 mL NQ stock standard at 1000 ug/mL and 0.200 mL surrogate stock standard at 1000 ug/mL into a 10 mL volumetric flask containing methanol. Bring to volume with methanol, cap, and invert to mix.

14.5.7.2. Place 100g of soil to be spiked into a glass baking dish and gently shake the dish back and forth to level out the soil.

14.5.7.3. Using a glass disposable Pasteur pipette, drizzle the prepared standard solution in a spiral pattern onto the soil.

14.5.7.4. Using a metal spatula or equivalent device, work the solution into the soil manually so that no moisture is visible before placing the soil into the metal puck mill bowl for grinding. (Note: A certified reference material / LCS may be purchased from either ERA or Wibby Environmental).

14.5.8. To all client and QC samples, add 50:50 Millipore water: methanol to reach a final total volume of 20 mL. Shake well for 10-20 seconds until all soil is wet and none remains stuck to the bottom of the vial. Place on the mechanical shaker for 10 minutes at the highest setting. Place the sample(s) into a temperature controlled ultrasonic bath <30 C) and sonicate for 2 hours. Remove from sonicator and allow samples to settle for 30 minutes.

14.5.9. Finally, place the supernatant in a disposable syringe, attach a 0.22-micron filter disc, and filter it into the 2 mL amber vials used in analysis. Discard the first 1-2 mL of supernatant before adding to the vials. Store the final extract in the refrigerator (0°-6°C) until analysis.

15.0 Data Analysis and Calculations

15.1 Sample Sequence

15.1.1. Before initial calibration or sample analysis, an instrument blank must be analyzed to determine baseline characteristics.

15.1.2. If instrument calibration is required, the calibration points shall come after the instrument blank and be immediately followed by the ICV injection. The calibration must be verified by a passing ICV before sample analysis can occur. The variance of any given compound in the ICV shall not be more than +/- 15% difference (20% for QSM). See Table 4 for acceptance criteria and corrective actions.

15.1.3. Verify calibration each twelve-hour shift by injecting a Continuing Calibration Verification standard (CCV), prior to conducting any sample analysis. A CCV must be injected at the beginning of the sequence (or following the ICV when calibrating) and at intervals of no less than one per 20 sample injections or twelve hours (whichever comes first) and at the end of each sequence (every 10 samples for QSM). The variance of any given compound shall not be more than +/- 15% difference (20% for QSM). See Table 4 for acceptance criteria and corrective actions.

15.1.4. Before sample analysis, inject a method blank to demonstrate that the instrument, as well as the extraction procedure, is free from contamination. All compounds must be below the method detection limit (< ½ the reporting limit and <1/10 the amount measured in any sample for QSM). See Table 4 for acceptance criteria and corrective actions.

15.1.5. Samples can be directly injected after the successful analyses of the calibration curve, ICV, CCV, and method blank. There can be up to 20 samples in an analytical batch. A matrix spike/matrix spike duplicate and laboratory control spike must be analyzed with every analytical batch. Recoveries must be within laboratory generated QC limits or client specified limits for all surrogate, matrix spike/matrix spike duplicate and laboratory control spike injections. See Table 4 for acceptance criteria and corrective actions.

15.1.6. All detects in the associated sample must be confirmed with a second column. Detects are identified and quantitated on the primary column. Results must be confirmed or reported at +/- 40 % on the secondary column. If no anomalies are noted, review the chromatographic conditions. If there is no evidence of chromatographic problems, then it is appropriate to report the lower result (method 8000C). Specific projects and/or programs will require that the higher result or both of the results be reported. See Table 4 for guidance and corrective actions.

15.1.7. Each sample analysis must be bracketed with passing continuing calibration verification standards. If the continuing calibration verification standard fails to meet QC criteria, all samples that were injected after the last standard that met QC criteria must be re-analyzed.

15.2 **Sample Calculations**

15.2.1. The computer software determines the concentration of each analyte in the sample. It calculates the amount of compound from the peak area, using the calibration curve. Linear regression of standard responses (R) against their known concentration (C in ug/ml), derives the following equation:

$$C = mR + b$$

15.2.2. Using the slope (m) and the intercept (b) from this equation, the concentration of the sample (ug/ml) is calculated and appears on the report page following the chromatogram.

Water samples:

$$C_S = [(C_C)(V_E)(D)]/V_S$$

Soil samples:

$$C_S = [(C_c)(V_E)(D)]/(W)$$

Wipe samples:

$C=[(C_c)(V_E)(D)]$

Where: C_S = Concentration of sample in ug/L for waters and mg/kg on a dry weight basis for soils

C_c = Concentration from the curve (ug/ml)

C = Concentration in total ug

V_E = Total volume of sample extract (after concentration) in ml

V_S= Volume of water sample in liters

D = Dilution factor if extract was diluted

W = Weight of dried soil sample in grams

16.0 Method Performance

16.1 Certified standard solutions, properly maintained instrumentation, and analyst experience and expertise are critical elements in producing accurate results. Standards and instrument performance are continually checked by analyzing external performance test samples provided by the appropriately accredited agencies. Internal blind spikes are also utilized to check analyst performance.

16.2 Initial demonstration of capability (IDC) is another technique used to ensure acceptable method performance. An analyst must demonstrate initial precision and accuracy through the analysis of 4-5 laboratory control spikes for each matrix and sample type. After analysis, the analyst calculates the average recovery (x) and the relative standard deviation (RSD) of the recoveries for each analyte. In the absence of specific criteria found in the SW-846 methods or project or program specific limits, the default criteria of 70-130% recovery and 20 % RSD are used until internal limits are generated (Method 8000B, sec. 8.4.9).

16.3 The LOD check sample is analyzed quarterly (or with each prep batch if it is determined that samples are received less frequently than once per quarter) to confirm instrument sensitivity (e.g. to verify that the method detection limits are still achievable). The LOD check samples are taken through all preparation and extraction steps used for actual samples. The recovery criteria for LOD check samples are the ability to detect all compounds. If any given compound is not detected, the LOD check is spiked at a higher level and analyzed again. Detection limits for those compounds not detected on the initial LOD check analysis need to be raised to match the LOD check analysis at which they were detected.

16.4 The LOQ check sample is analyzed quarterly (or with each prep batch if it is determined that samples are received less frequently than once per quarter). The LOQ check samples are taken through all preparation and extraction steps used for actual samples. The recovery criteria for LOQ check samples are the same as LCS acceptance ranges established in the QSM manual. If any given compound does not meet the recovery criteria, the LOQ check is spiked at a higher level and analyzed again. The reporting limit for those compounds that did not meet the initial recovery criteria must be raised to match the LOQ check analysis level at which the recovery criteria were met.

16.5 Creating and monitoring control charts is also important for maintaining and improving method performance. Currently all SSTD, MS, MSD, and LCS recoveries are monitored with the use of the LIMS system. The data collected is used to recognize trends in recovery performance, as well as for generating new in-house QC limits. Default accuracy limits of 70-130 % recovery and a precision limit 20 % RSD are used until enough data points are generated to provide usable internal limits. Client and/or Project specific limits are also used frequently in sample analyses.

17.0 Pollution Prevention

See QAM Appendix 9

18.0 Data Assessment and Acceptance Criteria for Quality Control Measures

18.1 If the initial analysis of a sample or a dilution of the sample has a concentration of a particular explosive compound that exceeds the calibration range, the sample must be re-analyzed at a dilution.

18.2 The qualitative identification of each explosive determined by this method is based on retention time. This method employs a dual column comparison on dissimilar phases. The retention time is updated with the midpoint of each new calibration and is continually updated with the continuing calibration verification standards (CCVs). A new method ID is provided for each new method with updated retention times or alteration to the operating initial calibration method. If an alteration occurs (other than daily retention time updates), project management and the QA officer will be notified. A description of the alteration will be addressed in the client notes or case narrative.

18.3 **Reporting Quantitative Analysis**

18.3.1. When the analysis of an analytical batch or sequence has been completed, the data is processed and prepared for reporting. Once the standard retention times have been compared with the sample retention times, the sample data can be reported. Assessments of all spiked, calibration control samples, and standards will also be finalized before reporting the data.

18.3.2. When the analyst has finished processing the analytical batch, the results are electronically transferred to the LIMS system where weight to volume corrections, dilution factors, and percent solids adjustments are made. Once the final results have been verified, a checklist (Table 5) is filled out and signed confirming that all the data has been thoroughly scrutinized. At this point, the data is turned over to another qualified analyst for final validation. The second analyst confirms the results, electronically marks them validated, and signs his or her portion of the checklist (the checklist is included in this SOP). Finally, the validated results are made available to the client services personnel in order for the data to be given to the client or appropriate agencies.

18.3.3. An electronic copy of the data is then filed and archived. The package includes; the sequence run log, a copy of the bench sheet, the LIMS run log, LIMS prep sheet, verification of calibration data, and each sample, the chromatogram. All the data is to be initialed and dated by the analyst. Each sequence file header will be labeled by the date of sequence.

19.0 Corrective Measures for Out-of-Control Data

See QAM Appendix 9

20.0 Contingencies for Handling Out-of-Control or Unacceptable Data

See QAM Appendix 9

21.0 Waste Management

See WS-001

22.0 Equipment/Instrument Maintenance, Computer Hardware and Software & Troubleshooting

See QAM Appendix 9

23.0 References

22.1 USEPA, SW-846, 3rd Ed. "Determinative Chromatographic Separations", Method 8000C. March 2003.

22.2 USEPA, SW-846 Method 8330B. October, 2006.

22.3 USEPA, SW-846 Method 8332. December, 1996.

22.4 USACE, Methods Manual for Detection of PEP Compounds, EPA Method 8330, May 19, 1999.

22.5 USACE/CRREL, Methods for Determining Nitroguanidine in Soil and Water, Special Report 89-35, November 1989.

22.6 USACE/CRREL, Stability of Nitroguanidine in Moist, Unsaturated Soils, Special Report ERDC/CRREL TR-05-2, February 2005.

22.7 USEPA, SW-846, "Organic Extraction and Sample Preparation", Method 3500B Revision 2. December 1996.

22.8 CT Laboratories Quality Assurance Manual current revision.

23.0 Tables, Diagrams, Flowcharts, and Validation Data

Table 4
Summary of Method Quality Objectives for Method 8330B- Explosives

Quality Control Element	Frequency of Implementation	Acceptance Criteria	Corrective Action
Initial Calibration (ICAL)	Initial Calibration prior to sample analysis. Minimum of 5 calibration standards with the lowest standard at or below the RL. For QSM, once the curve or line is generated, the lowest calibration point must be re-analyzed.	1. RSD for each analyte ≤ 15% 2. Linear – least squares regression r ≥ 0.995. 3. Non-linear regression is not acceptable for method 8330B analyses. 4. Apparent signal-to-noise ratio at the RL must be at least 5:1 for QSM.	Linearity must fit one of acceptance criteria, or the curve must be reanalyzed. No samples can be run without a valid ICAL. This applies to all analytes and both analytical columns. For QSM, the reanalysis of the first point after calibration is complete must generate results for all analytes that are within ± 20% of the true value. If all analytes do not pass, it will be necessary to correct any problems and to repeat the initial calibration.
Initial Calibration Verification (ICV)	After initial calibration (ICAL)	Difference ≤15% QSM difference ≤20%	If ICV falls outside QC criteria, reanalysis must take place. If ICV still fails, it will be necessary to correct the problem, or it will be appropriate to repeat the initial calibration curve. QSM: No samples will be analyzed until the problem has been corrected and a passing ICV is obtained.
Continuing Calibration Verification (CCV)	Every twelve hours or every twenty samples (which ever comes first) QSM: Prior to sample analysis, after every 10 field samples, and at the end of the analysis sequence.	Difference ≤15% QSM difference ≤20%	If CCV falls outside QC criteria, reanalysis must take place. If CCV still fails, it will be necessary to correct to problem, or it will be appropriate to repeat the initial calibration curve or to qualify the analyte with "Z". Exception to the above, if the acceptance limits are exceeded high and the analyte is not detected in the sample the verification standard has passed (analyte would have been detected if present). QSM: When a CCV fails, all samples analyzed after the last passing CCV will need to be re-analyzed. No samples will be analyzed until the problem has been corrected. Flagging is only appropriate in cases where the samples cannot be re-analyzed.
Retention Time Window (RTW)	Retention Times will be set using the midpoint standard in the ICAL or the RT in the CCV run at the beginning of each analytical shift.	Shift less than ± 3 times the absolute Standard Deviation from the 72 hour RTW study, with a minimum width of 0.03 minutes	No samples shall be analyzed without a verified retention time window. If a retention time shift occurs, th problem shall be corrected and the samples re-analyzed. It may be appropriate to recalibrate as well.

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table 4
Summary of Method Quality Objectives for Method 8330B- Explosives

Quality Control Element	Frequency of Implementation	Acceptance Criteria	Corrective Action
MDL/study/LOD/LOQ verification check	MDL study shall be performed at initial setup and then at a frequency in accordance with program specifications. LOD and LOQ Verification Checks shall be performed quarterly for QSM or with each prep batch if it is determined that samples are received less often than quarterly.	LOD checks must produce a signal at least 5 times the instrument's noise level. LOQ check recoveries must pass the established LCS control limits for each analyte.	Samples can not be analyzed without a valid MDL. QSM: If LOD/LOQ checks fail, re-analyze at the same level. If second analysis fails, re-prep at a higher spike level. If not analyzed quarterly, must be prepped and analyzed with each batch.
Method Blank (MB)	1 per sample batch ≤ 20 samples of the same matrix	Analytes must not he higher than the highest of the following: 1/2 MRL, or 5% of the associated sample concentration. QSM = ½ MRL or 10% of the associated sample concentration	If sample is available and within holding times, samples associated with method blank need to be re-prepped. If no sample is available, qualify the data with a "B" to all associated positives when less than 20X blank concentration or less than 10X blank concentration for QSM. QSM: Apply "B" to all results for the specific analytes in all samples in the associated preparatory batch.
Soil Grinding Blank	QSM - Between each sample. With client permission, may be generated after every 10 samples and/or composited into one final grinding blank sample.	Can be analyzed individually or composited. No target analytes detected greater than ½ the RL	If the composite grinding blank exceeds the acceptance criteria B-flag ALL the associated samples. If any individual grinding blank exceeds acceptance criteria B-flag ONLY the sample following that blank.
Laboratory Control Sample (LCS)	1 per sample batch ≤ 20 samples of the same matrix QSM - a 250 g solid reference material must be spiked with all analytes of interest and taken through all grinding, prep and analytical steps.	In-house limits, or program or client specified limits	Correct problem, then re-analyze the LCS. If LCS recoveries are still outside QC control limits, then re-pep and reanalyze the LCS and all samples in the associated batch for the failed analytes in the samples, if sample is available. Qualify the failing analytes in all samples with a "Q" qualifier. Flagging is only appropriate in cases where samples can not be re-prepped or re-analyzed.
Matrix Spike (MS)	1 per sample batch ≤ 20 samples of the same matrix	1.) Client specified limits. 2.) QSM – use LCS criteria 3.) In-house limits. For QSM: For matrix evaluation only, therefore is taken post grinding from same ground sample as parent subsample is taken.	No action is taken based on MS recovery alone, use of professional judgment. For recoveries outside QC criteria, qualify out lying compound with "M" in the parent sample. QSM: Contact the client as to additional measures to be taken.

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table 4
Summary of Method Quality Objectives for Method 8330B- Explosives

Quality Control Element	Frequency of Implementation	Acceptance Criteria	Corrective Action
Matrix Spike Duplicate (MSD)	1 per sample batch ≤ 20 samples of the same matrix	1.) Client specified limits. 2.) QSM – use LCS criteria 3.) In-house limits. For QSM: For matrix evaluation only, therefore is taken post grinding from same ground sample as parent subsample is taken. Relative percent difference (RPD) < 30%.	No action is taken based on MSD results alone, use of professional judgment. . For recoveries outside QC criteria, qualify out lying compound with "M" in the parent sample. If RPD is outside QC criteria, then qualify the out lying compounds with "Y" in the parent sample. QSM: Contact the client as to additional measures to be taken.
Triplicate soil sample	QSM - 1 per sample batch ≤ 20 samples of the same matrix. Can not be performed on any type of blank sample.	The RSD for results above the RL must not exceed 20%	Corrective action must be taken if this criterion is not met (e.g., the grinding process should be investigated to ensure samples are being reduced to a sufficiently small particle size) Apply a 'J' flag if the corrective action does not solve the problem and no sample available.
Surrogates	Every sample and QC	In-house Limits, or program or client specified limits	Rerun sample. If no apparent matrix interference noticed re-extract sample. If no sample is available, qualify the surrogate with "S". QSM: For QC and field samples; correct problem, re-analyze, if no apparent interference, re-prep and re-analyze all failed samples or failed surrogates in the associated batch, if sample material is available. If no sample available, apply "S" to the specific sample.
Target Analyte Confirmation	Whenever a positive is detected on one column, analyzed on a 2nd column.	If present: RPD ≤ 40%	**If not present**, Do not report value. **If present and RPD ≤40%** QSM: Report data from the primary analytical column as appropriate. Non-QSM: Reporting the lower of the two values may be appropriate unless otherwise specified. **If present and RPD >40%** QSM: Report data from both columns with a "P" qualifier. Non-QSM: Report lower of the two values, may be appropriate, with a "P" qualifier. Certain projects/clients/programs may require reporting the higher of the two values.

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Revision Number	Description of Changes	Date
05	Document changed to incorporated administrative requirements of ISO 17025 and QSM 5.0. Descriptions of changes have not been tracked in previous versions of this document.	03/12/2014

Table 5
FSV10-01 8330B Analysis Data Review Checklist (Example)

Sequence Date	Analyst / Data Interpreter	Independent Reviewer	Date of Review	Approved
				Yes or No

Instructions: Complete one checklist per *analytical run*. Enter the appropriate response for each question. Each "No" response requires an explanation in the Comments section and may require the initiation of a Nonconformance Report.

Requirement:	**Acceptance Criteria**	**Analyst Review**		**Independent Review**		**Comments:** (indicate reference to an attachment if necessary)
		Yes	**No**	**Yes**	**No**	
1. INITIAL CALIBRATION (ICAL)						
a. Was the Explosive initial calibration performed using a minimum of five varying standard concentration levels?	Lowest standard at or near MRL					
b. Is the variation between calibration response factors for all concentration levels <15% RSD, is r^2 >.990, or r > 0.995 for the regression line?	RSD <15%, r^2 >.990, r>0.995					
c. Was each ICAL uniquely identified (i.e. Standard Number)?						
d. Was an initial calibration blank (ICB) analyzed?						
2. INITIAL CALIBRATION VERIFICATION (ICV)						
a. Was there a second source ICV for all target analytes analyzed after the initial calibration and prior to analysis of any samples?	Second source					
c. Were the recoveries for the ICV between 85-115% (80-120% for QSM).	% Recovery					
d. Was the ICV uniquely identified (i.e. Standard Number)?						
3. CONTINUING CALIBRATION VERIFICATION (CCV)						
a. Were CCVs analyzed at the beginning of the sequence, after every 12 hours or every 20 samples (which ever comes first) (every 10 field samples for QSM) and at the end of the analytical run?						
b. Were the recoveries for the CCVs between 85-115% (80-120% for QSM)?	%Recovery					
c. Was each CCV uniquely identified (i.e. Standard Number)?						

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table 5
8330B Analysis Data Review Checklist Continued

Requirement:	Acceptance Criteria	Analyst Review		Independent Review		Comments: (indicate reference to an attachment if necessary)
		Yes	No	Yes	No	
4. BLANKS						
a. Was a method blank (MB) analyzed prior to the analysis of samples?						
b. Was the MB result less than ½ the reporting limit (RL) or 5% of the sample amount (QSM: less than ½ the RL and <10% of the sample amount)?						
c. Was a MB prepped and analyzed at a frequency of one per Prep Batch?	Batch ≤20 samples					
5. LABORATORY CONTROL SAMPLE (LCS)						
a. Was a LCS analyzed at a frequency of one per Prep Batch?	Batch ≤20 samples					
b. Were the LCS recoveries in each LCS within the acceptance criteria?	Per program					
6. MATRIX SPIKES						
a. Was a matrix spiked (MS) sample analyzed at a frequency one per Prep Batch?	Batch ≤20 samples					
b. Were MS recoveries in each MS within the acceptance criteria?	Per program					
7. MATRIX SPIKE DUPLICATE						
a. Was a duplicate matrix spike sample analyzed at a frequency one per Prep Batch?	Batch ≤20 samples					
b. Were MSD recoveries within the acceptance criteria?	Per program					
c. Is the relative percent difference (RPD) between a matrix spike (MS) and its duplicate (MSD) within the acceptance criteria?	Per program QSM: 30%RPD					

Table 5
8330B Analysis Data Review Checklist Continued

Requirement:	Acceptance Criteria	Analyst Review		Independent Review		Comments: (indicate reference to an attachment if necessary)
		Yes	No	Yes	No	

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

8. SAMPLES (INCLUDING BLANKS, STANDARDS, AND QC SAMPLES)						
a. Are chromatogram characteristics, including peak shapes and areas, consistent with those of the CCV?						
b. Are surrogate recoveries for all samples, blanks, standards, and QC samples within acceptance criteria?						
c. Were all samples having analytes detected in amounts exceeding the calibration range diluted and reanalyzed?						
d. Were all samples extracted within holding times and analyzed within 40 days of extracting?	Analysis within 40 days of extraction					
e. Was there a acetonitrile:H2O injection preformed prior to sample analysis?						
f. If any analytes were detected in the soil grinding blanks were the associated samples B-flagged?	< ½ RL					
g. Was the batch soil triplicate results RSD within acceptance criteria?	< 20%					
9. RECORDS AND REPORTING						
a. Are Run, Prep Batch and Extraction sheets, Summary sheets, Sequence file, initial and rerun raw and process data present in the PDF file?						
b. Are all chromatograms dated and initialed?						
c. Are reported results whose amounts exceeded the acceptance criteria flagged with an appropriate qualifier and, if needed, a NCR completed?						
d. Do all values, dilution factors and qualifiers listed on the raw reports match the LIMS data?						
e. Is the ICAL method referenced on the Raw Data?						

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

Table 6
FSV10-02 8330A/8330B Bench Sheet (Example)

Explosives or Nitroguanidine Prep Bench Sheet
(SOP Reference #'s 8330A & 8330B)

Prep Batch #:	
Prep Method:	
Analyst:	
Date:	
Start Time:	
End Time:	

8330A,8330B, or 8330M >>
Extraction>>
Extraction>>
Extraction>>
Extraction>>

Reagent: Lot #
Methylene Chloride
Acetonitrile
Methanol
0.1% Formic Acid

Matrix:
Balance:

GPC By:
GPC Start Date:
GPC Start Time:
GPC Stop Date:
GPC Stop Time:

8330A = Explosives (liquids/solids)
8330B = Explosives (liquids/solids)
8330M = Nitroguanidine (liquids/solids)

Concentrated By:
Concentration Date:

Sample ID #		(Solids) Sample Weight (g)	(Liquids) Sample Volume (L)	Extract Volume (ml)	Diluted (Yes/No)	Dilution Volume (ml)
	(MB)					
	(LCS)					
	Comments:					
	(Dup)					
	(Trip)					
	(MS) Parent Sample					
	(MSD)					

MB=Method Blank, LCS=Laboratory Control Sample, Dup=Duplicate, Trip=Triplicate, MS=Matrix Spike & MSD=Matrix Spike Duplicate

MS/MSD/ LCS Spike Amount (ml):
Spike Concentration (ug/mL):
Spike Reference #:

Surrogate Spike Amount (ml):
Surrogate Spike Conc. (ug/mL):
Surrogate Spike Reference #:

Relinquished to:
Date:

Reviewed By:
Date:

Explosives Prep 3/3/201210:47 AM

THIS DOCUMENT IS UNCONTROLLED WHEN PRINTED

EPA METHOD 6200

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATION IN SOIL AND SEDIMENT

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT

SW-846 is not intended to be an analytical training manual. Therefore, method procedures are written based on the assumption that they will be performed by analysts who are formally trained in at least the basic principles of chemical analysis and in the use of the subject technology.

In addition, SW-846 methods, with the exception of required method use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique which a laboratory can use as a basic starting point for generating its own detailed Standard Operating Procedure (SOP), either for its own general use or for a specific project application. The performance data included in this method are for guidance purposes only, and are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to the in situ and intrusive analysis of the 26 analytes listed below for soil and sediment samples. Some common elements are not listed in this method because they are considered "light" elements that cannot be detected by field portable x-ray fluorescence (FPXRF). These light elements are: lithium, beryllium, sodium, magnesium, aluminum, silicon, and phosphorus. Most of the analytes listed below are of environmental concern, while a few others have interference effects or change the elemental composition of the matrix, affecting quantitation of the analytes of interest. Generally elements of atomic number 16 or greater can be detected and quantitated by FPXRF. The following RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Antimony (Sb)	7440-36-0
Arsenic (As)	7440-38-0
Barium (Ba)	7440-39-3
Cadmium (Cd)	7440-43-9
Chromium (Cr)	7440-47-3
Cobalt (Co)	7440-48-4
Copper (Cu)	7440-50-8
Lead (Pb)	7439-92-1
Mercury (Hg)	7439-97-6
Nickel (Ni)	7440-02-0
Selenium (Se)	7782-49-2
Silver (Ag)	7440-22-4
Thallium (Tl)	7440-28-0
Tin (Sn)	7440-31-5

Analytes	CAS Registry No.
Vanadium (V)	7440-62-2
Zinc (Zn)	7440-66-6

In addition, the following non-RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Calcium (Ca)	7440-70-2
Iron (Fe)	7439-89-6
Manganese (Mn)	7439-96-5
Molybdenum (Mo)	7439-93-7
Potassium (K)	7440-09-7
Rubidium (Rb)	7440-17-7
Strontium (Sr)	7440-24-6
Thorium (Th)	7440-29-1
Titanium (Ti)	7440-32-6
Zirconium (Zr)	7440-67-7

1.2 This method is a screening method to be used with confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnance atomic absorption spectrometry (GFAA), inductively coupled plasma-atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)). This method's main strength is that it is a rapid field screening procedure. The method's lower limits of detection are typically above the toxicity characteristic regulatory level for most RCRA analytes. However, when the obtainable values for precision, accuracy, and laboratory-established sensitivity of this method meet project-specific data quality objectives (DQOs), FPXRF is a fast, powerful, cost effective technology for site characterization.

1.3 The method sensitivity or lower limit of detection depends on several factors, including the analyte of interest, the type of detector used, the type of excitation source, the strength of the excitation source, count times used to irradiate the sample, physical matrix effects, chemical matrix effects, and interelement spectral interferences. Example lower limits of detection for analytes of interest in environmental applications are shown in Table 1. These limits apply to a clean spiked matrix of quartz sand (silicon dioxide) free of interelement spectral interferences using long (100 -600 second) count times. These sensitivity values are given for guidance only and may not always be achievable, since they will vary depending on the sample matrix, which instrument is used, and operating conditions. A discussion of performance-based sensitivity is presented in Sec. 9.6.

1.4 Analysts should consult the disclaimer statement at the front of the manual and the information in Chapter Two for guidance on the intended flexibility in the choice of methods, apparatus, materials, reagents, and supplies, and on the responsibilities of the analyst for demonstrating that the techniques employed are appropriate for the analytes of interest, in the matrix of interest, and at the levels of concern.

In addition, analysts and data users are advised that, except where explicitly specified in a regulation, the use of SW-846 methods is *not* mandatory in response to Federal testing requirements. The information contained in this method is provided by EPA as guidance to be used by the analyst and the regulated community in making judgments necessary to generate results that meet the data quality objectives for the intended application.

1.5 Use of this method is restricted to use by, or under supervision of, personnel appropriately experienced and trained in the use and operation of an XRF instrument. Each analyst must demonstrate the ability to generate acceptable results with this method.

2.0 SUMMARY OF METHOD

2.1 The FPXRF technologies described in this method use either sealed radioisotope sources or x-ray tubes to irradiate samples with x-rays. When a sample is irradiated with x-rays, the source x-rays may undergo either scattering or absorption by sample atoms. This latter process is known as the photoelectric effect. When an atom absorbs the source x-rays, the incident radiation dislodges electrons from the innermost shells of the atom, creating vacancies. The electron vacancies are filled by electrons cascading in from outer electron shells. Electrons in outer shells have higher energy states than inner shell electrons, and the outer shell electrons give off energy as they cascade down into the inner shell vacancies. This rearrangement of electrons results in emission of x-rays characteristic of the given atom. The emission of x-rays, in this manner, is termed x-ray fluorescence.

Three electron shells are generally involved in emission of x-rays during FPXRF analysis of environmental samples. The three electron shells include the K, L, and M shells. A typical emission pattern, also called an emission spectrum, for a given metal has multiple intensity peaks generated from the emission of K, L, or M shell electrons. The most commonly measured x-ray emissions are from the K and L shells; only metals with an atomic number greater than 57 have measurable M shell emissions.

Each characteristic x-ray line is defined with the letter K, L, or M, which signifies which shell had the original vacancy and by a subscript alpha (α), beta (β), or gamma (γ) etc., which indicates the higher shell from which electrons fell to fill the vacancy and produce the x-ray. For example, a K_α line is produced by a vacancy in the K shell filled by an L shell electron, whereas a K_β line is produced by a vacancy in the K shell filled by an M shell electron. The K_α transition is on average 6 to 7 times more probable than the K_β transition; therefore, the K_α line is approximately 7 times more intense than the K_β line for a given element, making the K_α line the choice for quantitation purposes.

The K lines for a given element are the most energetic lines and are the preferred lines for analysis. For a given atom, the x-rays emitted from L transitions are always less energetic than those emitted from K transitions. Unlike the K lines, the main L emission lines (L_α and L_β) for an element are of nearly equal intensity. The choice of one or the other depends on what interfering element lines might be present. The L emission lines are useful for analyses involving elements of atomic number (Z) 58 (cerium) through 92 (uranium).

An x-ray source can excite characteristic x-rays from an element only if the source energy is greater than the absorption edge energy for the particular line group of the element, that is, the K absorption edge, L absorption edge, or M absorption edge energy. The absorption edge energy is somewhat greater than the corresponding line energy. Actually, the K absorption edge energy is approximately the sum of the K, L, and M line energies of the particular element, and the L absorption edge energy is approximately the sum of the L and M line energies. FPXRF is more sensitive to an element with an absorption edge energy close to but less than

the excitation energy of the source. For example, when using a cadmium-109 source, which has an excitation energy of 22.1 kiloelectron volts (keV), FPXRF would exhibit better sensitivity for zirconium which has a K line energy of 15.77 keV than to chromium, which has a K line energy of 5.41 keV.

2.2 Under this method, inorganic analytes of interest are identified and quantitated using a field portable energy-dispersive x-ray fluorescence spectrometer. Radiation from one or more radioisotope sources or an electrically excited x-ray tube is used to generate characteristic x-ray emissions from elements in a sample. Up to three sources may be used to irradiate a sample. Each source emits a specific set of primary x-rays that excite a corresponding range of elements in a sample. When more than one source can excite the element of interest, the source is selected according to its excitation efficiency for the element of interest.

For measurement, the sample is positioned in front of the probe window. This can be done in two manners using FPXRF instruments, specifically, in situ or intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. The sample cup is then placed on top of the window inside a protective cover for analysis.

Sample analysis is then initiated by exposing the sample to primary radiation from the source. Fluorescent and backscattered x-rays from the sample enter through the detector window and are converted into electric pulses in the detector. The detector in FPXRF instruments is usually either a solid-state detector or a gas-filled proportional counter. Within the detector, energies of the characteristic x-rays are converted into a train of electric pulses, the amplitudes of which are linearly proportional to the energy of the x-rays. An electronic multichannel analyzer (MCA) measures the pulse amplitudes, which is the basis of qualitative x-ray analysis. The number of counts at a given energy per unit of time is representative of the element concentration in a sample and is the basis for quantitative analysis. Most FPXRF instruments are menu-driven from software built into the units or from personal computers (PC).

The measurement time of each source is user-selectable. Shorter source measurement times (30 seconds) are generally used for initial screening and hot spot delineation, and longer measurement times (up to 300 seconds) are typically used to meet higher precision and accuracy requirements.

FPXRF instruments can be calibrated using the following methods: internally using fundamental parameters determined by the manufacturer, empirically based on site-specific calibration standards (SSCS), or based on Compton peak ratios. The Compton peak is produced by backscattering of the source radiation. Some FPXRF instruments can be calibrated using multiple methods.

3.0 DEFINITIONS

3.1 FPXRF -- Field portable x-ray fluorescence.

3.2 MCA -- Multichannel analyzer for measuring pulse amplitude.

3.3 SSCS -- Site-specific calibration standards.

3.4 FP -- Fundamental parameter.

3.5 ROI -- Region of interest.

3.6 SRM -- Standard reference material; a standard containing certified amounts of metals in soil or sediment.

3.7 eV -- Electron volt; a unit of energy equivalent to the amount of energy gained by an electron passing through a potential difference of one volt.

3.8 Refer to Chapter One, Chapter Three, and the manufacturer's instructions for other definitions that may be relevant to this procedure.

4.0 INTERFERENCES

4.1 The total method error for FPXRF analysis is defined as the square root of the sum of squares of both instrument precision and user- or application-related error. Generally, instrument precision is the least significant source of error in FPXRF analysis. User- or application-related error is generally more significant and varies with each site and method used. Some sources of interference can be minimized or controlled by the instrument operator, but others cannot. Common sources of user- or application-related error are discussed below.

4.2 Physical matrix effects result from variations in the physical character of the sample. These variations may include such parameters as particle size, uniformity, homogeneity, and surface condition. For example, if any analyte exists in the form of very fine particles in a coarser-grained matrix, the analyte’s concentration measured by the FPXRF will vary depending on how fine particles are distributed within the coarser-grained matrix. If the fine particles "settle" to the bottom of the sample cup (i.e., against the cup window), the analyte concentration measurement will be higher than if the fine particles are not mixed in well and stay on top of the coarser-grained particles in the sample cup. One way to reduce such error is to grind and sieve all soil samples to a uniform particle size thus reducing sample-to-sample particle size variability. Homogeneity is always a concern when dealing with soil samples. Every effort should be made to thoroughly mix and homogenize soil samples before analysis. Field studies have shown heterogeneity of the sample generally has the largest impact on comparability with confirmatory samples.

4.3 Moisture content may affect the accuracy of analysis of soil and sediment sample analyses. When the moisture content is between 5 and 20 percent, the overall error from moisture may be minimal. However, moisture content may be a major source of error when analyzing samples of surface soil or sediment that are saturated with water. This error can be minimized by drying the samples in a convection or toaster oven. Microwave drying is not recommended because field studies have shown that microwave drying can increase variability between FPXRF data and confirmatory analysis and because metal fragments in the sample can cause arcing to occur in a microwave.

4.4 Inconsistent positioning of samples in front of the probe window is a potential source of error because the x-ray signal decreases as the distance from the radioactive source increases. This error is minimized by maintaining the same distance between the window and each sample. For the best results, the window of the probe should be in direct contact with the sample, which means that the sample should be flat and smooth to provide a good contact surface.

4.5 Chemical matrix effects result from differences in the concentrations of interfering elements. These effects occur as either spectral interferences (peak overlaps) or as x-ray absorption and enhancement phenomena. Both effects are common in soils contaminated with heavy metals. As examples of absorption and enhancement effects; iron (Fe) tends to absorb copper (Cu) x-rays, reducing the intensity of the Cu measured by the detector, while chromium (Cr) will be enhanced at the expense of Fe because the absorption edge of Cr is slightly lower in energy than the fluorescent peak of iron. The effects can be corrected mathematically through the use of fundamental parameter (FP) coefficients. The effects also can be compensated for using SSCS, which contain all the elements present on site that can interfere with one another.

4.6 When present in a sample, certain x-ray lines from different elements can be very close in energy and, therefore, can cause interference by producing a severely overlapped spectrum. The degree to which a detector can resolve the two different peaks depends on the energy resolution of the detector. If the energy difference between the two peaks in electron volts is less than the resolution of the detector in electron volts, then the detector will not be able to fully resolve the peaks.

The most common spectrum overlaps involve the K_β line of element Z-1 with the K_α line of element Z. This is called the K_α/K_β interference. Because the K_α:K_β intensity ratio for a given element usually is about 7:1, the interfering element, Z-1, must be present at large concentrations to cause a problem. Two examples of this type of spectral interference involve the presence of large concentrations of vanadium (V) when attempting to measure Cr or the presence of large concentrations of Fe when attempting to measure cobalt (Co). The V K_α and K_β energies are 4.95 and 5.43 keV, respectively, and the Cr K_α energy is 5.41 keV. The Fe K_α and K_β energies are 6.40 and 7.06 keV, respectively, and the Co K_α energy is 6.92 keV. The difference between the V K_β and Cr K_α energies is 20 eV, and the difference between the Fe K_β and the Co K_α energies is 140 eV. The resolution of the highest-resolution detectors in FPXRF instruments is 170 eV. Therefore, large amounts of V and Fe will interfere with quantitation of Cr or Co, respectively. The presence of Fe is a frequent problem because it is often found in soils at tens of thousands of parts per million (ppm).

4.7 Other interferences can arise from K/L, K/M, and L/M line overlaps, although these overlaps are less common. Examples of such overlap involve arsenic (As) K_α/lead (Pb) L_α and sulfur (S) K_α/Pb M_α. In the As/Pb case, Pb can be measured from the Pb L_β line, and As can be measured from either the As K_α or the As $K_ß$ line; in this way the interference can be corrected. If the As K_β line is used, sensitivity will be decreased by a factor of two to five times because it is a less intense line than the As K_α line. If the As K_α line is used in the presence of Pb, mathematical corrections within the instrument software can be used to subtract out the Pb interference. However, because of the limits of mathematical corrections, As concentrations cannot be efficiently calculated for samples with Pb:As ratios of 10:1 or more. This high ratio of Pb to As may result in reporting of a "nondetect" or a "less than" value (e.g., <300 ppm) for As, regardless of the actual concentration present.

No instrument can fully compensate for this interference. It is important for an operator to understand this limitation of FPXRF instruments and consult with the manufacturer of the FPXRF instrument to evaluate options to minimize this limitation. The operator’s decision will be based on action levels for metals in soil established for the site, matrix effects, capabilities of the instrument, data quality objectives, and the ratio of lead to arsenic known to be present at the site. If a site is encountered that contains lead at concentrations greater than ten times the concentration of arsenic it is advisable that all critical soil samples be sent off site for confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnance atomic absorption spectrometry (GFAA), inductively coupled plasma-

atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)).

4.8 If SSCS are used to calibrate an FPXRF instrument, the samples collected must be representative of the site under investigation. Representative soil sampling ensures that a sample or group of samples accurately reflects the concentrations of the contaminants of concern at a given time and location. Analytical results for representative samples reflect variations in the presence and concentration ranges of contaminants throughout a site. Variables affecting sample representativeness include differences in soil type, contaminant concentration variability, sample collection and preparation variability, and analytical variability, all of which should be minimized as much as possible.

4.9 Soil physical and chemical effects may be corrected using SSCS that have been analyzed by inductively coupled plasma (ICP) or atomic absorption (AA) methods. However, a major source of error can be introduced if these samples are not representative of the site or if the analytical error is large. Another concern is the type of digestion procedure used to prepare the soil samples for the reference analysis. Analytical results for the confirmatory method will vary depending on whether a partial digestion procedure, such as Method 3050, or a total digestion procedure, such as Method 3052, is used. It is known that depending on the nature of the soil or sediment, Method 3050 will achieve differing extraction efficiencies for different analytes of interest. The confirmatory method should meet the project-specific data quality objectives (DQOs).

XRF measures the total concentration of an element; therefore, to achieve the greatest comparability of this method with the reference method (reduced bias), a total digestion procedure should be used for sample preparation. However, in the study used to generate the performance data for this method (see Table 8), the confirmatory method used was Method 3050, and the FPXRF data compared very well with regression correlation coefficients (r often exceeding 0.95, except for barium and chromium). The critical factor is that the digestion procedure and analytical reference method used should meet the DQOs of the project and match the method used for confirmation analysis.

4.10 Ambient temperature changes can affect the gain of the amplifiers producing instrument drift. Gain or drift is primarily a function of the electronics (amplifier or preamplifier) and not the detector as most instrument detectors are cooled to a constant temperature. Most FPXRF instruments have a built-in automatic gain control. If the automatic gain control is allowed to make periodic adjustments, the instrument will compensate for the influence of temperature changes on its energy scale. If the FPXRF instrument has an automatic gain control function, the operator will not have to adjust the instrument's gain unless an error message appears. If an error message appears, the operator should follow the manufacturer's procedures for troubleshooting the problem. Often, this involves performing a new energy calibration. The performance of an energy calibration check to assess drift is a quality control measure discussed in Sec. 9.2.

If the operator is instructed by the manufacturer to manually conduct a gain check because of increasing or decreasing ambient temperature, it is standard to perform a gain check after every 10 to 20 sample measurements or once an hour whichever is more frequent. It is also suggested that a gain check be performed if the temperature fluctuates more than 10° F. The operator should follow the manufacturer's recommendations for gain check frequency.

5.0 SAFETY

5.1 This method does not address all safety issues associated with its use. The user is responsible for maintaining a safe work environment and a current awareness file of OSHA regulations regarding the safe handling of the chemicals listed in this method. A reference file of material safety data sheets (MSDSs) should be available to all personnel involved in these analyses.

NOTE: No MSDS applies directly to the radiation-producing instrument because that is covered under the Nuclear Regulatory Commission (NRC) or applicable state regulations.

5.2 Proper training for the safe operation of the instrument and radiation training should be completed by the analyst prior to analysis. Radiation safety for each specific instrument can be found in the operator's manual. Protective shielding should never be removed by the analyst or any personnel other than the manufacturer. The analyst should be aware of the local state and national regulations that pertain to the use of radiation-producing equipment and radioactive materials with which compliance is required. There should be a person appointed within the organization that is solely responsible for properly instructing all personnel, maintaining inspection records, and monitoring x-ray equipment at regular intervals.

Licenses for radioactive materials are of two types, specifically: (1) a general license which is usually initiated by the manufacturer for receiving, acquiring, owning, possessing, using, and transferring radioactive material incorporated in a device or equipment, and (2) a specific license which is issued to named persons for the operation of radioactive instruments as required by local, state, or federal agencies. A copy of the radioactive material license (for specific licenses only) and leak tests should be present with the instrument at all times and available to local and national authorities upon request.

X-ray tubes do not require radioactive material licenses or leak tests, but do require approvals and licenses which vary from state to state. In addition, fail-safe x-ray warning lights should be illuminated whenever an x-ray tube is energized. Provisions listed above concerning radiation safety regulations, shielding, training, and responsible personnel apply to x-ray tubes just as to radioactive sources. In addition, a log of the times and operating conditions should be kept whenever an x-ray tube is energized. An additional hazard present with x-ray tubes is the danger of electric shock from the high voltage supply, however, if the tube is properly positioned within the instrument, this is only a negligible risk. Any instrument (x-ray tube or radioisotope based) is capable of delivering an electric shock from the basic circuitry when the system is inappropriately opened.

5.3 Radiation monitoring equipment should be used with the handling and operation of the instrument. The operator and the surrounding environment should be monitored continually for analyst exposure to radiation. Thermal luminescent detectors (TLD) in the form of badges and rings are used to monitor operator radiation exposure. The TLDs or badges should be worn in the area of maximum exposure. The maximum permissible whole-body dose from occupational exposure is 5 Roentgen Equivalent Man (REM) per year. Possible exposure pathways for radiation to enter the body are ingestion, inhaling, and absorption. The best precaution to prevent radiation exposure is distance and shielding.

6.0 EQUIPMENT AND SUPPLIES

The mention of trade names or commercial products in this manual is for illustrative purposes only, and does not constitute an EPA endorsement or exclusive recommendation for

use. The products and instrument settings cited in SW-846 methods represent those products and settings used during method development or subsequently evaluated by the Agency. Glassware, reagents, supplies, equipment, and settings other than those listed in this manual may be employed provided that method performance appropriate for the intended application has been demonstrated and documented.

6.1 FPXRF spectrometer -- An FPXRF spectrometer consists of four major components: (1) a source that provides x-rays; (2) a sample presentation device; (3) a detector that converts x-ray-generated photons emitted from the sample into measurable electronic signals; and (4) a data processing unit that contains an emission or fluorescence energy analyzer, such as an MCA, that processes the signals into an x-ray energy spectrum from which elemental concentrations in the sample may be calculated, and a data display and storage system. These components and additional, optional items, are discussed below.

6.1.1 Excitation sources -- FPXRF instruments use either a sealed radioisotope source or an x-ray tube to provide the excitation source. Many FPXRF instruments use sealed radioisotope sources to produce x-rays in order to irradiate samples. The FPXRF instrument may contain between one and three radioisotope sources. Common radioisotope sources used for analysis for metals in soils are iron Fe-55 (^{55}Fe), cadmium Cd-109 (^{109}Cd), americium Am-241 (^{241}Am), and curium Cm-244 (^{244}Cm). These sources may be contained in a probe along with a window and the detector; the probe may be connected to a data reduction and handling system by means of a flexible cable. Alternatively, the sources, window, and detector may be included in the same unit as the data reduction and handling system.

The relative strength of the radioisotope sources is measured in units of millicuries (mCi). All other components of the FPXRF system being equal, the stronger the source, the greater the sensitivity and precision of a given instrument. Radioisotope sources undergo constant decay. In fact, it is this decay process that emits the primary x-rays used to excite samples for FPXRF analysis. The decay of radioisotopes is measured in "half-lives." The half-life of a radioisotope is defined as the length of time required to reduce the radioisotopes strength or activity by half. Developers of FPXRF technologies recommend source replacement at regular intervals based on the source's half-life. This is due to the ever increasing time required for the analysis rather than a decrease in instrument performance. The characteristic x-rays emitted from each of the different sources have energies capable of exciting a certain range of analytes in a sample. Table 2 summarizes the characteristics of four common radioisotope sources.

X-ray tubes have higher radiation output, no intrinsic lifetime limit, produce constant output over their lifetime, and do not have the disposal problems of radioactive sources but are just now appearing in FPXRF instruments. An electrically-excited x-ray tube operates by bombarding an anode with electrons accelerated by a high voltage. The electrons gain an energy in electron volts equal to the accelerating voltage and can excite atomic transitions in the anode, which then produces characteristic x-rays. These characteristic x-rays are emitted through a window which contains the vacuum necessary for the electron acceleration. An important difference between x-ray tubes and radioactive sources is that the electrons which bombard the anode also produce a continuum of x-rays across a broad range of energies in addition to the characteristic x-rays. This continuum is weak compared to the characteristic x-rays but can provide substantial excitation since it covers a broad energy range. It has the undesired property of producing background in the spectrum near the analyte x-ray lines when it is scattered by the sample. For this reason a filter is often used between the x-ray tube and the sample to suppress the continuum radiation while passing the characteristic x-rays from the anode. This filter is sometimes incorporated into the window of the x-ray tube. The choice of

accelerating voltage is governed both by the anode material, since the electrons must have sufficient energy to excite the anode, which requires a voltage greater than the absorption edge of the anode material and by the instrument's ability to cool the x-ray tube. The anode is most efficiently excited by voltages 2 to 2.5 times the edge energy (most x-rays per unit power to the tube), although voltages as low as 1.5 times the absorption edge energy will work. The characteristic x-rays emitted by the anode are capable of exciting a range of elements in the sample just as with a radioactive source. Table 3 gives the recommended operating voltages and the sample elements excited for some common anodes.

6.1.2 Sample presentation device -- FPXRF instruments can be operated in two modes: in situ and intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. For FPXRF instruments operated in the intrusive mode, the probe may be rotated so that the window faces either upward or downward. A protective sample cover is placed over the window, and the sample cup is placed on top of the window inside the protective sample cover for analysis.

6.1.3 Detectors -- The detectors in the FPXRF instruments can be either solid-state detectors or gas-filled, proportional counter detectors. Common solid-state detectors include mercuric iodide (HgI_2), silicon pin diode and lithium-drifted silicon Si(Li). The HgI_2 detector is operated at a moderately subambient temperature controlled by a low power thermoelectric cooler. The silicon pin diode detector also is cooled via the thermoelectric Peltier effect. The Si(Li) detector must be cooled to at least -90 °C either with liquid nitrogen or by thermoelectric cooling via the Peltier effect. Instruments with a Si(Li) detector have an internal liquid nitrogen dewar with a capacity of 0.5 to 1.0 L. Proportional counter detectors are rugged and lightweight, which are important features of a field portable detector. However, the resolution of a proportional counter detector is not as good as that of a solid-state detector. The energy resolution of a detector for characteristic x-rays is usually expressed in terms of full width at half-maximum (FWHM) height of the manganese K_α peak at 5.89 keV. The typical resolutions of the above mentioned detectors are as follows: HgI_2-270 eV; silicon pin diode-250 eV; Si(Li)–170 eV; and gas-filled, proportional counter-750 eV.

During operation of a solid-state detector, an x-ray photon strikes a biased, solid-state crystal and loses energy in the crystal by producing electron-hole pairs. The electric charge produced is collected and provides a current pulse that is directly proportional to the energy of the x-ray photon absorbed by the crystal of the detector. A gas-filled, proportional counter detector is an ionization chamber filled with a mixture of noble and other gases. An x-ray photon entering the chamber ionizes the gas atoms. The electric charge produced is collected and provides an electric signal that is directly proportional to the energy of the x-ray photon absorbed by the gas in the detector.

6.1.4 Data processing units -- The key component in the data processing unit of an FPXRF instrument is the MCA. The MCA receives pulses from the detector and sorts them by their amplitudes (energy level). The MCA counts pulses per second to determine the height of the peak in a spectrum, which is indicative of the target analyte's concentration. The spectrum of element peaks are built on the MCA. The MCAs in FPXRF instruments have from 256 to 2,048 channels. The concentrations of target analytes are usually shown in ppm on a liquid crystal display (LCD) in the instrument. FPXRF instruments can store both spectra and from 3,000 to 5,000 sets of numerical analytical results. Most FPXRF instruments are menu-driven from software built into the

units or from PCs. Once the data–storage memory of an FPXRF unit is full or at any other time, data can be downloaded by means of an RS-232 port and cable to a PC.

6.2 Spare battery and battery charger.

6.3 Polyethylene sample cups -- 31 to 40 mm in diameter with collar, or equivalent (appropriate for FPXRF instrument).

6.4 X-ray window film -- Mylar™, Kapton™, Spectrolene™, polypropylene, or equivalent; 2.5 to 6.0 µm thick.

6.5 Mortar and pestle -- Glass, agate, or aluminum oxide; for grinding soil and sediment samples.

6.6 Containers -- Glass or plastic to store samples.

6.7 Sieves -- 60-mesh (0.25 mm), stainless-steel, Nylon, or equivalent for preparing soil and sediment samples.

6.8 Trowels -- For smoothing soil surfaces and collecting soil samples.

6.9 Plastic bags -- Used for collection and homogenization of soil samples.

6.10 Drying oven -- Standard convection or toaster oven, for soil and sediment samples that require drying.

7.0 REAGENTS AND STANDARDS

7.1 Reagent grade chemicals must be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 Pure element standards -- Each pure, single-element standard is intended to produce strong characteristic x-ray peaks of the element of interest only. Other elements present must not contribute to the fluorescence spectrum. A set of pure element standards for commonly sought analytes is supplied by the instrument manufacturer, if designated for the instrument; not all instruments require the pure element standards. The standards are used to set the region of interest (ROI) for each element. They also can be used as energy calibration and resolution check samples.

7.3 Site-specific calibration standards -- Instruments that employ fundamental parameters (FP) or similar mathematical models in minimizing matrix effects may not require SSCS. If the FP calibration model is to be optimized or if empirical calibration is necessary, then SSCSs must be collected, prepared, and analyzed.

7.3.1 The SSCS must be representative of the matrix to be analyzed by FPXRF. These samples must be well homogenized. A minimum of 10 samples spanning the concentration ranges of the analytes of interest and of the interfering elements must be obtained from the site. A sample size of 4 to 8 ounces is recommended, and standard glass sampling jars should be used.

7.3.2 Each sample should be oven-dried for 2 to 4 hr at a temperature of less than 150 °C. If mercury is to be analyzed, a separate sample portion should be dried at ambient temperature as heating may volatilize the mercury. When the sample is dry, all large, organic debris and nonrepresentative material, such as twigs, leaves, roots, insects, asphalt, and rock should be removed. The sample should be homogenized (see Sec. 7.3.3) and then a representative portion ground with a mortar and pestle or other mechanical means, prior to passing through a 60-mesh sieve. Only the coarse rock fraction should remain on the screen.

7.3.3 The sample should be homogenized by using a riffle splitter or by placing 150 to 200 g of the dried, sieved sample on a piece of kraft or butcher paper about 1.5 by 1.5 feet in size. Each corner of the paper should be lifted alternately, rolling the soil over on itself and toward the opposite corner. The soil should be rolled on itself 20 times. Approximately 5 g of the sample should then be removed and placed in a sample cup for FPXRF analysis. The rest of the prepared sample should be sent off site for ICP or AA analysis. The method use for confirmatory analysis should meet the data quality objectives of the project.

7.4 Blank samples -- The blank samples should be from a "clean" quartz or silicon dioxide matrix that is free of any analytes at concentrations above the established lower limit of detection. These samples are used to monitor for cross-contamination and laboratory-induced contaminants or interferences.

7.5 Standard reference materials -- Standard reference materials (SRMs) are standards containing certified amounts of metals in soil or sediment. These standards are used for accuracy and performance checks of FPXRF analyses. SRMs can be obtained from the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), the Canadian National Research Council, and the national bureau of standards in foreign nations. Pertinent NIST SRMs for FPXRF analysis include 2704, Buffalo River Sediment; 2709, San Joaquin Soil; and 2710 and 2711, Montana Soil. These SRMs contain soil or sediment from actual sites that has been analyzed using independent inorganic analytical methods by many different laboratories. When these SRMs are unavailable, alternate standards may be used (e.g., NIST 2702).

8.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

Sample handling and preservation procedures used in FPXRF analyses should follow the guidelines in Chapter Three, "Inorganic Analytes."

9.0 QUALITY CONTROL

9.1 Follow the manufacturer’s instructions for the quality control procedures specific to use of the testing product. Refer to Chapter One for additional guidance on quality assurance (QA) and quality control (QC) protocols. Any effort involving the collection of analytical data should include development of a structured and systematic planning document, such as a Quality Assurance Project Plan (QAPP) or a Sampling and Analysis Plan (SAP), which translates project objectives and specifications into directions for those that will implement the project and assess the results.

9.2 Energy calibration check -- To determine whether an FPXRF instrument is operating within resolution and stability tolerances, an energy calibration check should be run. The energy calibration check determines whether the characteristic x-ray lines are shifting,

which would indicate drift within the instrument. As discussed in Sec. 4.10, this check also serves as a gain check in the event that ambient temperatures are fluctuating greatly (more than 10 °F).

9.2.1 The energy calibration check should be run at a frequency consistent with manufacturer's recommendations. Generally, this would be at the beginning of each working day, after the batteries are changed or the instrument is shut off, at the end of each working day, and at any other time when the instrument operator believes that drift is occurring during analysis. A pure element such as iron, manganese, copper, or lead is often used for the energy calibration check. A manufacturer-recommended count time per source should be used for the check.

9.2.2 The instrument manufacturer's manual specifies the channel or kiloelectron volt level at which a pure element peak should appear and the expected intensity of the peak. The intensity and channel number of the pure element as measured using the source should be checked and compared to the manufacturer's recommendation. If the energy calibration check does not meet the manufacturer's criteria, then the pure element sample should be repositioned and reanalyzed. If the criteria are still not met, then an energy calibration should be performed as described in the manufacturer's manual. With some FPXRF instruments, once a spectrum is acquired from the energy calibration check, the peak can be optimized and realigned to the manufacturer's specifications using their software.

9.3 Blank samples -- Two types of blank samples should be analyzed for FPXRF analysis, specifically, instrument blanks and method blanks.

9.3.1 An instrument blank is used to verify that no contamination exists in the spectrometer or on the probe window. The instrument blank can be silicon dioxide, a polytetraflurorethylene (PTFE) block, a quartz block, "clean" sand, or lithium carbonate. This instrument blank should be analyzed on each working day before and after analyses are conducted and once per every twenty samples. An instrument blank should also be analyzed whenever contamination is suspected by the analyst. The frequency of analysis will vary with the data quality objectives of the project. A manufacturer-recommended count time per source should be used for the blank analysis. No element concentrations above the established lower limit of detection should be found in the instrument blank. If concentrations exceed these limits, then the probe window and the check sample should be checked for contamination. If contamination is not a problem, then the instrument must be "zeroed" by following the manufacturer's instructions.

9.3.2 A method blank is used to monitor for laboratory-induced contaminants or interferences. The method blank can be "clean" silica sand or lithium carbonate that undergoes the same preparation procedure as the samples. A method blank must be analyzed at least daily. The frequency of analysis will depend on the data quality objectives of the project. If the method blank does not contain the target analyte at a level that interferes with the project-specific data quality objectives then the method blank would be considered acceptable. In the absence of project-specific data quality objectives, if the blank is less than the lowest level of detection or less than 10% of the lowest sample concentration for the analyte, whichever is greater, then the method blank would be considered acceptable. If the method blank cannot be considered acceptable, the cause of the problem must be identified, and all samples analyzed with the method blank must be reanalyzed.

9.4 Calibration verification checks -- A calibration verification check sample is used to check the accuracy of the instrument and to assess the stability and consistency of the analysis for the analytes of interest. A check sample should be analyzed at the beginning of each working day, during active sample analyses, and at the end of each working day. The frequency of calibration checks during active analysis will depend on the data quality objectives of the project. The check sample should be a well characterized soil sample from the site that is representative of site samples in terms of particle size and degree of homogeneity and that contains contaminants at concentrations near the action levels. If a site-specific sample is not available, then an NIST or other SRM that contains the analytes of interest can be used to verify the accuracy of the instrument. The measured value for each target analyte should be within ±20 percent (%D) of the true value for the calibration verification check to be acceptable. If a measured value falls outside this range, then the check sample should be reanalyzed. If the value continues to fall outside the acceptance range, the instrument should be recalibrated, and the batch of samples analyzed before the unacceptable calibration verification check must be reanalyzed.

9.5 Precision measurements -- The precision of the method is monitored by analyzing a sample with low, moderate, or high concentrations of target analytes. The frequency of precision measurements will depend on the data quality objectives for the data. A minimum of one precision sample should be run per day. Each precision sample should be analyzed 7 times in replicate. It is recommended that precision measurements be obtained for samples with varying concentration ranges to assess the effect of concentration on method precision. Determining method precision for analytes at concentrations near the site action levels can be extremely important if the FPXRF results are to be used in an enforcement action; therefore, selection of at least one sample with target analyte concentrations at or near the site action levels or levels of concern is recommended. A precision sample is analyzed by the instrument for the same field analysis time as used for other project samples. The relative standard deviation (RSD) of the sample mean is used to assess method precision. For FPXRF data to be considered adequately precise, the RSD should not be greater than 20 percent with the exception of chromium. RSD values for chromium should not be greater than 30 percent. If both in situ and intrusive analytical techniques are used during the course of one day, it is recommended that separate precision calculations be performed for each analysis type.

The equation for calculating RSD is as follows:

$$RSD = (SD/Mean\ Concentration) \times 100$$

where:

RSD = Relative standard deviation for the precision measurement for the analyte
SD = Standard deviation of the concentration for the analyte
Mean concentration = Mean concentration for the analyte

The precision or reproducibility of a measurement will improve with increasing count time, however, increasing the count time by a factor of 4 will provide only 2 times better precision, so there is a point of diminishing return. Increasing the count time also improves the sensitivity, but decreases sample throughput.

9.6 The lower limits of detection should be established from actual measured performance based on spike recoveries in the matrix of concern or from acceptable method performance on a certified reference material of the appropriate matrix and within the appropriate calibration range for the application. This is considered the best estimate of the true method sensitivity as opposed to a statistical determination based on the standard deviation of

replicate analyses of a low-concentration sample. While the statistical approach demonstrates the potential data variability for a given sample matrix at one point in time, it does not represent what can be detected or most importantly the lowest concentration that can be calibrated. For this reason the sensitivity should be established as the lowest point of detection based on acceptable target analyte recovery in the desired sample matrix.

9.7 Confirmatory samples -- The comparability of the FPXRF analysis is determined by submitting FPXRF-analyzed samples for analysis at a laboratory. The method of confirmatory analysis must meet the project and XRF measurement data quality objectives. The confirmatory samples must be splits of the well homogenized sample material. In some cases the prepared sample cups can be submitted. A minimum of 1 sample for each 20 FPXRF-analyzed samples should be submitted for confirmatory analysis. This frequency will depend on project-specific data quality objectives. The confirmatory analyses can also be used to verify the quality of the FPXRF data. The confirmatory samples should be selected from the lower, middle, and upper range of concentrations measured by the FPXRF. They should also include samples with analyte concentrations at or near the site action levels. The results of the confirmatory analysis and FPXRF analyses should be evaluated with a least squares linear regression analysis. If the measured concentrations span more than one order of magnitude, the data should be log-transformed to standardize variance which is proportional to the magnitude of measurement. The correlation coefficient (r) for the results should be 0.7 or greater for the FPXRF data to be considered screening level data. If the r is 0.9 or greater and inferential statistics indicate the FPXRF data and the confirmatory data are statistically equivalent at a 99 percent confidence level, the data could potentially meet definitive level data criteria.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Instrument calibration -- Instrument calibration procedures vary among FPXRF instruments. Users of this method should follow the calibration procedures outlined in the operator's manual for each specific FPXRF instrument. Generally, however, three types of calibration procedures exist for FPXRF instruments, namely: FP calibration, empirical calibration, and the Compton peak ratio or normalization method. These three types of calibration are discussed below.

10.2 Fundamental parameters calibration -- FP calibration procedures are extremely variable. An FP calibration provides the analyst with a "standardless" calibration. The advantages of FP calibrations over empirical calibrations include the following:

- No previously collected site-specific samples are necessary, although site-specific samples with confirmed and validated analytical results for all elements present could be used.

- Cost is reduced because fewer confirmatory laboratory results or calibration standards are necessary.

However, the analyst should be aware of the limitations imposed on FP calibration by particle size and matrix effects. These limitations can be minimized by adhering to the preparation procedure described in Sec. 7.3. The two FP calibration processes discussed below are based on an effective energy FP routine and a back scatter with FP (BFP) routine. Each FPXRF FP calibration process is based on a different iterative algorithmic method. The calibration procedure for each routine is explained in detail in the manufacturer's user manual for each FPXRF instrument; in addition, training courses are offered for each instrument.

10.2.1 Effective energy FP calibration -- The effective energy FP calibration is performed by the manufacturer before an instrument is sent to the analyst. Although SSCS can be used, the calibration relies on pure element standards or SRMs such as those obtained from NIST for the FP calibration. The effective energy routine relies on the spectrometer response to pure elements and FP iterative algorithms to compensate for various matrix effects.

Alpha coefficients are calculated using a variation of the Sherman equation, which calculates theoretical intensities from the measurement of pure element samples. These coefficients indicate the quantitative effect of each matrix element on an analyte's measured x-ray intensity. Next, the Lachance Traill algorithm is solved as a set of simultaneous equations based on the theoretical intensities. The alpha coefficients are then downloaded into the specific instrument.

The working effective energy FP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of sampling. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. A manufacturer-recommended count time per source should be used for the calibration check. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A percent difference (%D) is then calculated for each target analyte. The %D should be within ±20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line or the y-intercept value for the analyte. The SRM or SSCS is reanalyzed until the %D falls within ±20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

The equation to calibrate %D is as follows:

$$\%D = ((C_s - C_k) / C_k) \times 100$$

where:

%D = Percent difference
C_k = Certified concentration of standard sample
C_s = Measured concentration of standard sample

10.2.2 BFP calibration -- BFP calibration relies on the ability of the liquid nitrogen-cooled, Si(Li) solid-state detector to separate the coherent (Compton) and incoherent (Rayleigh) backscatter peaks of primary radiation. These peak intensities are known to be a function of sample composition, and the ratio of the Compton to Rayleigh peak is a function of the mass absorption of the sample. The calibration procedure is explained in detail in the instrument manufacturer's manual. Following is a general description of the BFP calibration procedure.

The concentrations of all detected and quantified elements are entered into the computer software system. Certified element results for an NIST SRM or confirmed and validated results for an SSCS can be used. In addition, the concentrations of oxygen and silicon must be entered; these two concentrations are not found in standard metals analyses. The manufacturer provides silicon and oxygen concentrations for typical soil types. Pure element standards are then analyzed using a manufacturer-recommended

count time per source. The results are used to calculate correction factors in order to adjust for spectrum overlap of elements.

The working BFP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of the analysis. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. The standard sample is analyzed using a manufacturer-recommended count time per source to check the calibration curve. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A %D is then calculated for each target analyte. The %D should fall within ±20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line the y-intercept value for the analyte. The standard sample is reanalyzed until the %D falls within ±20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

10.3 Empirical calibration -- An empirical calibration can be performed with SSCS, site-typical standards, or standards prepared from metal oxides. A discussion of SSCS is included in Sec. 7.3; if no previously characterized samples exist for a specific site, site-typical standards can be used. Site-typical standards may be selected from commercially available characterized soils or from SSCS prepared for another site. The site-typical standards should closely approximate the site's soil matrix with respect to particle size distribution, mineralogy, and contaminant analytes. If neither SSCS nor site-typical standards are available, it is possible to make gravimetric standards by adding metal oxides to a "clean" sand or silicon dioxide matrix that simulates soil. Metal oxides can be purchased from various chemical vendors. If standards are made on site, a balance capable of weighing items to at least two decimal places is necessary. Concentrated ICP or AA standard solutions can also be used to make standards. These solutions are available in concentrations of 10,000 parts per million, thus only small volumes have to be added to the soil.

An empirical calibration using SSCS involves analysis of SSCS by the FPXRF instrument and by a conventional analytical method such as ICP or AA. A total acid digestion procedure should be used by the laboratory for sample preparation. Generally, a minimum of 10 and a maximum of 30 well characterized SSCS, site-typical standards, or prepared metal oxide standards are necessary to perform an adequate empirical calibration. The exact number of standards depends on the number of analytes of interest and interfering elements. Theoretically, an empirical calibration with SSCS should provide the most accurate data for a site because the calibration compensates for site-specific matrix effects.

The first step in an empirical calibration is to analyze the pure element standards for the elements of interest. This enables the instrument to set channel limits for each element for spectral deconvolution. Next the SSCS, site-typical standards, or prepared metal oxide standards are analyzed using a count time of 200 seconds per source or a count time recommended by the manufacturer. This will produce a spectrum and net intensity of each analyte in each standard. The analyte concentrations for each standard are then entered into the instrument software; these concentrations are those obtained from the laboratory, the certified results, or the gravimetrically determined concentrations of the prepared standards. This gives the instrument analyte values to regress against corresponding intensities during the modeling stage. The regression equation correlates the concentrations of an analyte with its net intensity.

The calibration equation is developed using a least squares fit regression analysis. After the regression terms to be used in the equation are defined, a mathematical equation can be developed to calculate the analyte concentration in an unknown sample. In some FPXRF instruments, the software of the instrument calculates the regression equation. The software uses calculated intercept and slope values to form a multiterm equation. In conjunction with the software in the instrument, the operator can adjust the multiterm equation to minimize interelement interferences and optimize the intensity calibration curve.

It is possible to define up to six linear or nonlinear terms in the regression equation. Terms can be added and deleted to optimize the equation. The goal is to produce an equation with the smallest regression error and the highest correlation coefficient. These values are automatically computed by the software as the regression terms are added, deleted, or modified. It is also possible to delete data points from the regression line if these points are significant outliers or if they are heavily weighing the data. Once the regression equation has been selected for an analyte, the equation can be entered into the software for quantitation of analytes in subsequent samples. For an empirical calibration to be acceptable, the regression equation for a specific analyte should have a correlation coefficient of 0.98 or greater or meet the DQOs of the project.

In an empirical calibration, one must apply the DQOs of the project and ascertain critical or action levels for the analytes of interest. It is within these concentration ranges or around these action levels that the FPXRF instrument should be calibrated most accurately. It may not be possible to develop a good regression equation over several orders of analyte concentration.

10.4 Compton normalization method -- The Compton normalization method is based on analysis of a single, certified standard and normalization for the Compton peak. The Compton peak is produced from incoherent backscattering of x-ray radiation from the excitation source and is present in the spectrum of every sample. The Compton peak intensity changes with differing matrices. Generally, matrices dominated by lighter elements produce a larger Compton peak, and those dominated by heavier elements produce a smaller Compton peak. Normalizing to the Compton peak can reduce problems with varying matrix effects among samples. Compton normalization is similar to the use of internal standards in organics analysis. The Compton normalization method may not be effective when analyte concentrations exceed a few percent.

The certified standard used for this type of calibration could be an NIST SRM such as 2710 or 2711. The SRM must be a matrix similar to the samples and must contain the analytes of interests at concentrations near those expected in the samples. First, a response factor has to be determined for each analyte. This factor is calculated by dividing the net peak intensity by the analyte concentration. The net peak intensity is gross intensity corrected for baseline reading. Concentrations of analytes in samples are then determined by multiplying the baseline corrected analyte signal intensity by the normalization factor and by the response factor. The normalization factor is the quotient of the baseline corrected Compton K_{α} peak intensity of the SRM divided by that of the samples. Depending on the FPXRF instrument used, these calculations may be done manually or by the instrument software.

11.0 PROCEDURE

11.1 Operation of the various FPXRF instruments will vary according to the manufacturers' protocols. Before operating any FPXRF instrument, one should consult the manufacturer's manual. Most manufacturers recommend that their instruments be allowed to warm up for 15 to 30 minutes before analysis of samples. This will help alleviate drift or energy calibration problems later during analysis.

11.2 Each FPXRF instrument should be operated according to the manufacturer's recommendations. There are two modes in which FPXRF instruments can be operated: in situ and intrusive. The in situ mode involves analysis of an undisturbed soil sediment or sample. Intrusive analysis involves collection and preparation of a soil or sediment sample before analysis. Some FPXRF instruments can operate in both modes of analysis, while others are designed to operate in only one mode. The two modes of analysis are discussed below.

11.3 For in situ analysis, remove any large or nonrepresentative debris from the soil surface before analysis. This debris includes rocks, pebbles, leaves, vegetation, roots, and concrete. Also, the soil surface must be as smooth as possible so that the probe window will have good contact with the surface. This may require some leveling of the surface with a stainless-steel trowel. During the study conducted to provide example performance data for this method, this modest amount of sample preparation was found to take less than 5 min per sample location. The last requirement is that the soil or sediment not be saturated with water. Manufacturers state that their FPXRF instruments will perform adequately for soils with moisture contents of 5 to 20 percent but will not perform well for saturated soils, especially if ponded water exists on the surface. Another recommended technique for in situ analysis is to tamp the soil to increase soil density and compactness for better repeatability and representativeness. This condition is especially important for heavy element analysis, such as barium. Source count times for in situ analysis usually range from 30 to 120 seconds, but source count times will vary among instruments and depending on the desired method sensitivity. Due to the heterogeneous nature of the soil sample, in situ analysis can provide only “screening” type data.

11.4 For intrusive analysis of surface or sediment, it is recommended that a sample be collected from a 4- by 4-inch square that is 1 inch deep. This will produce a soil sample of approximately 375 g or 250 cm^3, which is enough soil to fill an 8-ounce jar. However, the exact dimensions and sample depth should take into consideration the heterogeneous deposition of contaminants and will ultimately depend on the desired project-specific data quality objectives. The sample should be homogenized, dried, and ground before analysis. The sample can be homogenized before or after drying. The homogenization technique to be used after drying is discussed in Sec. 4.2. If the sample is homogenized before drying, it should be thoroughly mixed in a beaker or similar container, or if the sample is moist and has a high clay content, it can be kneaded in a plastic bag. One way to monitor homogenization when the sample is kneaded in a plastic bag is to add sodium fluorescein dye to the sample. After the moist sample has been homogenized, it is examined under an ultraviolet light to assess the distribution of sodium fluorescein throughout the sample. If the fluorescent dye is evenly distributed in the sample, homogenization is considered complete; if the dye is not evenly distributed, mixing should continue until the sample has been thoroughly homogenized. During the study conducted to provide data for this method, the time necessary for homogenization procedure using the fluorescein dye ranged from 3 to 5 min per sample. As demonstrated in Secs. 13.5 and 13.7, homogenization has the greatest impact on the reduction of sampling variability. It produces little or no contamination. Often, the direct analysis through the plastic bag is possible without the more labor intensive steps of drying, grinding, and sieving given in Secs. 11.5 and 11.6. Of course, to achieve the best data quality possible all four steps should be followed.

11.5 Once the soil or sediment sample has been homogenized, it should be dried. This can be accomplished with a toaster oven or convection oven. A small aliquot of the sample (20 to 50 g) is placed in a suitable container for drying. The sample should be dried for 2 to 4 hr in the convection or toaster oven at a temperature not greater than 150 °C. Samples may also be air dried under ambient temperature conditions using a 10- to 20-g portion. Regardless of what drying mechanism is used, the drying process is considered complete when a constant sample weight can be obtained. Care should be taken to avoid sample cross-contamination and these measures can be evaluated by including an appropriate method blank sample along with any sample preparation process.

CAUTION: Microwave drying is not a recommended procedure. Field studies have shown that microwave drying can increase variability between the FPXRF data and confirmatory analysis. High levels of metals in a sample can cause arcing in the microwave oven, and sometimes slag forms in the sample. Microwave oven drying can also melt plastic containers used to hold the sample.

11.6 The homogenized dried sample material should be ground with a mortar and pestle and passed through a 60-mesh sieve to achieve a uniform particle size. Sample grinding should continue until at least 90 percent of the original sample passes through the sieve. The grinding step normally takes an average of 10 min per sample. An aliquot of the sieved sample should then be placed in a 31.0-mm polyethylene sample cup (or equivalent) for analysis. The sample cup should be one-half to three-quarters full at a minimum. The sample cup should be covered with a 2.5 µm Mylar (or equivalent) film for analysis. The rest of the soil sample should be placed in a jar, labeled, and archived for possible confirmation analysis. All equipment including the mortar, pestle, and sieves must be thoroughly cleaned so that any cross-contamination is below the established lower limit of detection of the procedure or DQOs of the analysis. If all recommended sample preparation steps are followed, there is a high probability the desired laboratory data quality may be obtained.

12.0 DATA ANALYSIS AND CALCULATIONS

Most FPXRF instruments have software capable of storing all analytical results and spectra. The results are displayed in ppm and can be downloaded to a personal computer, which can be used to provide a hard copy printout. Individual measurements that are smaller than three times their associated SD should not be used for quantitation. See the manufacturer's instructions regarding data analysis and calculations.

13.0 METHOD PERFORMANCE

13.1 Performance data and related information are provided in SW-846 methods only as examples and guidance. The data do not represent required performance criteria for users of the methods. Instead, performance criteria should be developed on a project-specific basis, and the laboratory should establish in-house QC performance criteria for the application of this method. These performance data are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

13.2 The sections to follow discuss three performance evaluation factors; namely, precision, accuracy, and comparability. The example data presented in Tables 4 through 8 were generated from results obtained from six FPXRF instruments (see Sec. 13.3). The soil samples analyzed by the six FPXRF instruments were collected from two sites in the United States. The soil samples contained several of the target analytes at concentrations ranging from "nondetect" to tens of thousands of mg/kg. These data are provided for guidance purposes only.

13.3 The six FPXRF instruments included the TN 9000 and TN Lead Analyzer manufactured by TN Spectrace; the X-MET 920 with a SiLi detector and X-MET 920 with a gas-filled proportional detector manufactured by Metorex, Inc.; the XL Spectrum Analyzer manufactured by Niton; and the MAP Spectrum Analyzer manufactured by Scitec. The TN 9000 and TN Lead Analyzer both have a HgI_2 detector. The TN 9000 utilized an Fe-55, Cd-109, and Am-241 source. The TN Lead Analyzer had only a Cd-109 source. The X-Met 920 with the SiLi detector had a Cd-109 and Am-241 source. The X-MET 920 with the gas-filled proportional detector had only a Cd-109 source. The XL Spectrum Analyzer utilized a silicon pin-diode

detector and a Cd-109 source. The MAP Spectrum Analyzer utilized a solid-state silicon detector and a Cd-109 source.

13.4 All example data presented in Tables 4 through 8 were generated using the following calibrations and source count times. The TN 9000 and TN Lead Analyzer were calibrated using fundamental parameters using NIST SRM 2710 as a calibration check sample. The TN 9000 was operated using 100, 60, and 60 second count times for the Cd-109, Fe-55, and Am-241 sources, respectively. The TN Lead analyzer was operated using a 60 second count time for the Cd-109 source. The X-MET 920 with the Si(Li) detector was calibrated using fundamental parameters and one well characterized site-specific soil standard as a calibration check. It used 140 and 100 second count times for the Cd-109 and Am-241 sources, respectively. The X-MET 920 with the gas-filled proportional detector was calibrated empirically using between 10 and 20 well characterized site-specific soil standards. It used 120 second times for the Cd-109 source. The XL Spectrum Analyzer utilized NIST SRM 2710 for calibration and the Compton peak normalization procedure for quantitation based on 60 second count times for the Cd-109 source. The MAP Spectrum Analyzer was internally calibrated by the manufacturer. The calibration was checked using a well-characterized site-specific soil standard. It used 240 second times for the Cd-109 source.

13.5 Precision measurements -- The example precision data are presented in Table 4. These data are provided for guidance purposes only. Each of the six FPXRF instruments performed 10 replicate measurements on 12 soil samples that had analyte concentrations ranging from "nondetects" to thousands of mg/kg. Each of the 12 soil samples underwent 4 different preparation techniques from in situ (no preparation) to dried and ground in a sample cup. Therefore, there were 48 precision data points for five of the instruments and 24 precision points for the MAP Spectrum Analyzer. The replicate measurements were taken using the source count times discussed at the beginning of this section.

For each detectable analyte in each precision sample a mean concentration, standard deviation, and RSD was calculated for each analyte. The data presented in Table 4 is an average RSD for the precision samples that had analyte concentrations at 5 to 10 times the lower limit of detection for that analyte for each instrument. Some analytes such as mercury, selenium, silver, and thorium were not detected in any of the precision samples so these analytes are not listed in Table 4. Some analytes such as cadmium, nickel, and tin were only detected at concentrations near the lower limit of detection so that an RSD value calculated at 5 to 10 times this limit was not possible.

One FPXRF instrument collected replicate measurements on an additional nine soil samples to provide a better assessment of the effect of sample preparation on precision. Table 5 shows these results. These data are provided for guidance purposes only. The additional nine soil samples were comprised of three from each texture and had analyte concentrations ranging from near the lower limit of detection for the FPXRF analyzer to thousands of mg/kg. The FPXRF analyzer only collected replicate measurements from three of the preparation methods; no measurements were collected from the in situ homogenized samples. The FPXRF analyzer conducted five replicate measurements of the in situ field samples by taking measurements at five different points within the 4-inch by 4-inch sample square. Ten replicate measurements were collected for both the intrusive undried and unground and intrusive dried and ground samples contained in cups. The cups were shaken between each replicate measurement.

Table 5 shows that the precision dramatically improved from the in situ to the intrusive measurements. In general there was a slight improvement in precision when the sample was dried and ground. Two factors caused the precision for the in situ measurements to be poorer. The major factor is soil heterogeneity. By moving the probe within the 4-inch by 4-inch square,

measurements of different soil samples were actually taking place within the square. Table 5 illustrates the dominant effect of soil heterogeneity. It overwhelmed instrument precision when the FPXRF analyzer was used in this mode. The second factor that caused the RSD values to be higher for the in situ measurements is the fact that only five instead of ten replicates were taken. A lesser number of measurements caused the standard deviation to be larger which in turn elevated the RSD values.

13.6 Accuracy measurements -- Five of the FPXRF instruments (not including the MAP Spectrum Analyzer) analyzed 18 SRMs using the source count times and calibration methods given at the beginning of this section. The 18 SRMs included 9 soil SRMs, 4 stream or river sediment SRMs, 2 sludge SRMs, and 3 ash SRMs. Each of the SRMs contained known concentrations of certain target analytes. A percent recovery was calculated for each analyte in each SRM for each FPXRF instrument. Table 6 presents a summary of this data. With the exception of cadmium, chromium, and nickel, the values presented in Table 6 were generated from the 13 soil and sediment SRMs only. The 2 sludge and 3 ash SRMs were included for cadmium, chromium, and nickel because of the low or nondetectable concentrations of these three analytes in the soil and sediment SRMs.

Only 12 analytes are presented in Table 6. These are the analytes that are of environmental concern and provided a significant number of detections in the SRMs for an accuracy assessment. No data is presented for the X-MET 920 with the gas-filled proportional detector. This FPXRF instrument was calibrated empirically using site-specific soil samples. The percent recovery values from this instrument were very sporadic and the data did not lend itself to presentation in Table 6.

Table 7 provides a more detailed summary of accuracy data for one particular FPXRF instrument (TN 9000) for the 9 soil SRMs and 4 sediment SRMs. These data are provided for guidance purposes only. Table 7 shows the certified value, measured value, and percent recovery for five analytes. These analytes were chosen because they are of environmental concern and were most prevalently certified for in the SRM and detected by the FPXRF instrument. The first nine SRMs are soil and the last 4 SRMs are sediment. Percent recoveries for the four NIST SRMs were often between 90 and 110 percent for all analytes.

13.7 Comparability -- Comparability refers to the confidence with which one data set can be compared to another. In this case, FPXRF data generated from a large study of six FPXRF instruments was compared to SW-846 Methods 3050 and 6010 which are the standard soil extraction for metals and analysis by inductively coupled plasma. An evaluation of comparability was conducted by using linear regression analysis. Three factors were determined using the linear regression. These factors were the y-intercept, the slope of the line, and the coefficient of determination (r^2).

As part of the comparability assessment, the effects of soil type and preparation methods were studied. Three soil types (textures) and four preparation methods were examined during the study. The preparation methods evaluated the cumulative effect of particle size, moisture, and homogenization on comparability. Due to the large volume of data produced during this study, linear regression data for six analytes from only one FPXRF instrument is presented in Table 8. Similar trends in the data were seen for all instruments. These data are provided for guidance purposes only.

Table 8 shows the regression parameters for the whole data set, broken out by soil type, and by preparation method. These data are provided for guidance purposes only. The soil types are as follows: soil 1--sand; soil 2--loam; and soil 3--silty clay. The preparation methods are as follows: preparation 1--in situ in the field; preparation 2--intrusive, sample collected and homogenized; preparation 3--intrusive, with sample in a sample cup but sample still wet and not

ground; and preparation 4–intrusive, with sample dried, ground, passed through a 40-mesh sieve, and placed in sample cup.

For arsenic, copper, lead, and zinc, the comparability to the confirmatory laboratory was excellent with r^2 values ranging from 0.80 to 0.99 for all six FPXRF instruments. The slopes of the regression lines for arsenic, copper, lead, and zinc, were generally between 0.90 and 1.00 indicating the data would need to be corrected very little or not at all to match the confirmatory laboratory data. The r^2 values and slopes of the regression lines for barium and chromium were not as good as for the other for analytes, indicating the data would have to be corrected to match the confirmatory laboratory.

Table 8 demonstrates that there was little effect of soil type on the regression parameters for any of the six analytes. The only exceptions were for barium in soil 1 and copper in soil 3. In both of these cases, however, it is actually a concentration effect and not a soil effect causing the poorer comparability. All barium and copper concentrations in soil 1 and 3, respectively, were less than 350 mg/kg.

Table 8 shows there was a preparation effect on the regression parameters for all six analytes. With the exception of chromium, the regression parameters were primarily improved going from preparation 1 to preparation 2. In this step, the sample was removed from the soil surface, all large debris was removed, and the sample was thoroughly homogenized. The additional two preparation methods did little to improve the regression parameters. This data indicates that homogenization is the most critical factor when comparing the results. It is essential that the sample sent to the confirmatory laboratory match the FPXRF sample as closely as possible.

Sec. 11.0 of this method discusses the time necessary for each of the sample preparation techniques. Based on the data quality objectives for the project, an analyst must decide if it is worth the extra time necessary to dry and grind the sample for small improvements in comparability. Homogenization requires 3 to 5 min. Drying the sample requires one to two hours. Grinding and sieving requires another 10 to 15 min per sample. Lastly, when grinding and sieving is conducted, time has to be allotted to decontaminate the mortars, pestles, and sieves. Drying and grinding the samples and decontamination procedures will often dictate that an extra person be on site so that the analyst can keep up with the sample collection crew. The cost of requiring an extra person on site to prepare samples must be balanced with the gain in data quality and sample throughput.

13.8 The following documents may provide additional guidance and insight on this method and technique:

13.8.1 A. D. Hewitt, "Screening for Metals by X-ray Fluorescence Spectrometry/Response Factor/Compton K_α Peak Normalization Analysis," American Environmental Laboratory, pp 24-32, 1994.

13.8.2 S. Piorek and J. R. Pasmore, "Standardless, In Situ Analysis of Metallic Contaminants in the Natural Environment With a PC-Based, High Resolution Portable X-Ray Analyzer," Third International Symposium on Field Screening Methods for Hazardous Waste and Toxic Chemicals, Las Vegas, Nevada, February 24-26, 1993, Vol 2, pp 1135-1151, 1993.

13.8.3 S. Shefsky, "Sample Handling Strategies for Accurate Lead-in-soil Measurements in the Field and Laboratory," *International Symposium of Field Screening Methods for Hazardous Waste and Toxic Chemicals*, Las Vegas, NV, January 29-31, 1997.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity and/or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

14.2 For information about pollution prevention that may be applicable to laboratories and research institutions consult *Less is Better: Laboratory Chemical Management for Waste Reduction* available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th St., N.W. Washington, D.C. 20036, http://www.acs.org.

15.0 WASTE MANAGEMENT

The Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any sewer discharge permits and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management, consult *The Waste Management Manual for Laboratory Personnel* available from the American Chemical Society at the address listed in Sec. 14.2.

16.0 REFERENCES

1. Metorex, X-MET 920 User's Manual.

2. Spectrace Instruments, "Energy Dispersive X-ray Fluorescence Spectrometry: An Introduction," 1994.

3. TN Spectrace, Spectrace 9000 Field Portable/Benchtop XRF Training and Applications Manual.

4. Unpublished SITE data, received from PRC Environment Management, Inc.

17.0 TABLES, DIAGRAMS, FLOWCHARTS, AND VALIDATION DATA

The following pages contain the tables referenced by this method. A flow diagram of the procedure follows the tables.

TABLE 1

EXAMPLE INTERFERENCE FREE LOWER LIMITS OF DETECTION

Analyte	Chemical Abstract Series Number	Lower Limit of Detection in Quartz Sand (milligrams per kilogram)
Antimony (Sb)	7440-36-0	40
Arsenic (As)	7440-38-0	40
Barium (Ba)	7440-39-3	20
Cadmium (Cd)	7440-43-9	100
Calcium (Ca)	7440-70-2	70
Chromium (Cr)	7440-47-3	150
Cobalt (Co)	7440-48-4	60
Copper (Cu)	7440-50-8	50
Iron (Fe)	7439-89-6	60
Lead (Pb)	7439-92-1	20
Manganese (Mn)	7439-96-5	70
Mercury (Hg)	7439-97-6	30
Molybdenum (Mo)	7439-93-7	10
Nickel (Ni)	7440-02-0	50
Potassium (K)	7440-09-7	200
Rubidium (Rb)	7440-17-7	10
Selenium (Se)	7782-49-2	40
Silver (Ag)	7440-22-4	70
Strontium (Sr)	7440-24-6	10
Thallium (Tl)	7440-28-0	20
Thorium (Th)	7440-29-1	10
Tin (Sn)	7440-31-5	60
Titanium (Ti)	7440-32-6	50
Vanadium (V)	7440-62-2	50
Zinc (Zn)	7440-66-6	50
Zirconium (Zr)	7440-67-7	10

Source: Refs. 1, 2, and 3
These data are provided for guidance purposes only.

TABLE 2

SUMMARY OF RADIOISOTOPE SOURCE CHARACTERISTICS

Source	Activity (mCi)	Half-Life (Years)	Excitation Energy (keV)	Elemental Analysis Range	
Fe-55	20-50	2.7	5.9	Sulfur to Chromium Molybdenum to Barium	K Lines L Lines
Cd-109	5-30	1.3	22.1 and 87.9	Calcium to Rhodium Tantalum to Lead Barium to Uranium	K Lines K Lines L Lines
Am-241	5-30	432	26.4 and 59.6	Copper to Thulium Tungsten to Uranium	K Lines L Lines
Cm-244	60-100	17.8	14.2	Titanium to Selenium Lanthanum to Lead	K Lines L Lines

Source: Refs. 1, 2, and 3

TABLE 3

SUMMARY OF X-RAY TUBE SOURCE CHARACTERISTICS

Anode Material	Recommended Voltage Range (kV)	K-alpha Emission (keV)	Elemental Analysis Range	
Cu	18-22	8.04	Potassium to Cobalt Silver to Gadolinium	K Lines L Lines
Mo	40-50	17.4	Cobalt to Yttrium Europium to Radon	K Lines L Lines
Ag	50-65	22.1	Zinc to Technicium Ytterbium to Neptunium	K Lines L Lines

Source: Ref. 4

Notes: The sample elements excited are chosen by taking as the lower limit the same ratio of excitation line energy to element absorption edge as in Table 2 (approximately 0.45) and the requirement that the excitation line energy be above the element absorption edge as the upper limit (L2 edges used for L lines). K-beta excitation lines were ignored.

TABLE 4

EXAMPLE PRECISION VALUES

Analyte	Average Relative Standard Deviation for Each Instrument at 5 to 10 Times the Lower Limit of Detection					
	TN 9000	TN Lead Analyzer	X-MET 920 (SiLi Detector)	X-MET 920 (Gas-Filled Detector)	XL Spectrum Analyzer	MAP Spectrum Analyzer
Antimony	6.54	NR	NR	NR	NR	NR
Arsenic	5.33	4.11	3.23	1.91	12.47	6.68
Barium	4.02	NR	3.31	5.91	NR	NR
Cadmium	29.84[a]	NR	24.80[a]	NR	NR	NR
Calcium	2.16	NR	NR	NR	NR	NR
Chromium	22.25	25.78	22.72	3.91	30.25	NR
Cobalt	33.90	NR	NR	NR	NR	NR
Copper	7.03	9.11	8.49	9.12	12.77	14.86
Iron	1.78	1.67	1.55	NR	2.30	NR
Lead	6.45	5.93	5.05	7.56	6.97	12.16
Manganese	27.04	24.75	NR	NR	NR	NR
Molybdenum	6.95	NR	NR	NR	12.60	NR
Nickel	30.85[a]	NR	24.92[a]	20.92[a]	NA	NR
Potassium	3.90	NR	NR	NR	NR	NR
Rubidium	13.06	NR	NR	NR	32.69[a]	NR
Strontium	4.28	NR	NR	NR	8.86	NR
Tin	24.32[a]	NR	NR	NR	NR	NR
Titanium	4.87	NR	NR	NR	NR	NR
Zinc	7.27	7.48	4.26	2.28	10.95	0.83
Zirconium	3.58	NR	NR	NR	6.49	NR

These data are provided for guidance purposes only.
Source: Ref. 4

[a] These values are biased high because the concentration of these analytes in the soil samples was near the lower limit of detection for that particular FPXRF instrument.

NR Not reported.

NA Not applicable; analyte was reported but was below the established lower limit detection.

TABLE 5

EXAMPLES OF PRECISION AS AFFECTED BY SAMPLE PREPARATION

Analyte	Average Relative Standard Deviation for Each Preparation Method		
	In Situ-Field	Intrusive-Undried and Unground	Intrusive-Dried and Ground
Antimony	30.1	15.0	14.4
Arsenic	22.5	5.36	3.76
Barium	17.3	3.38	2.90
Cadmium[a]	41.2	30.8	28.3
Calcium	17.5	1.68	1.24
Chromium	17.6	28.5	21.9
Cobalt	28.4	31.1	28.4
Copper	26.4	10.2	7.90
Iron	10.3	1.67	1.57
Lead	25.1	8.55	6.03
Manganese	40.5	12.3	13.0
Mercury	ND	ND	ND
Molybdenum	21.6	20.1	19.2
Nickel[a]	29.8	20.4	18.2
Potassium	18.6	3.04	2.57
Rubidium	29.8	16.2	18.9
Selenium	ND	20.2	19.5
Silver[a]	31.9	31.0	29.2
Strontium	15.2	3.38	3.98
Thallium	39.0	16.0	19.5
Thorium	NR	NR	NR
Tin	ND	14.1	15.3
Titanium	13.3	4.15	3.74
Vanadium	NR	NR	NR
Zinc	26.6	13.3	11.1
Zirconium	20.2	5.63	5.18

These data are provided for guidance purposes only.
Source: Ref. 4
[a] These values may be biased high because the concentration of these analytes in the soil samples was near the lower limit of detection.
ND Not detected.
NR Not reported.

TABLE 6

EXAMPLE ACCURACY VALUES

Analyte	Instrument															
	TN 9000				TN Lead Analyzer				X-MET 920 (SiLi Detector)				XL Spectrum Analyzer			
	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec	SD	n	Range of % Rec.	Mean % Rec.	SD
Sb	2	100-149	124.3	NA	--	--	--	--	--	--	--	--	--	--	--	--
As	5	68-115	92.8	17.3	5	44-105	83.4	23.2	4	9.7-91	47.7	39.7	5	38-535	189.8	206
Ba	9	98-198	135.3	36.9	--	--	--	--	9	18-848	168.2	262	--	--	--	--
Cd	2	99-129	114.3	NA	--	--	--	--	6	81-202	110.5	45.7	--	--	--	--
Cr	2	99-178	138.4	NA	--	--	--	--	7	22-273	143.1	93.8	3	98-625	279.2	300
Cu	8	61-140	95.0	28.8	6	38-107	79.1	27.0	11	10-210	111.8	72.1	8	95-480	203.0	147
Fe	6	78-155	103.7	26.1	6	89-159	102.3	28.6	6	48-94	80.4	16.2	6	26-187	108.6	52.9
Pb	11	66-138	98.9	19.2	11	68-131	97.4	18.4	12	23-94	72.7	20.9	13	80-234	107.3	39.9
Mn	4	81-104	93.1	9.70	3	92-152	113.1	33.8	--	--	--	--	--	--	--	--
Ni	3	99-122	109.8	12.0	--	--	--	--	--	--	--	--	3	57-123	87.5	33.5
Sr	8	110-178	132.6	23.8	--	--	--	--	--	--	--	--	7	86-209	125.1	39.5
Zn	11	41-130	94.3	24.0	10	81-133	100.0	19.7	12	46-181	106.6	34.7	11	31-199	94.6	42.5

Source: Ref. 4. These data are provided for guidance purposes only.
n: Number of samples that contained a certified value for the analyte and produced a detectable concentration from the FPXRF instrument.
SD: Standard deviation; NA: Not applicable; only two data points, therefore, a SD was not calculated.
%Rec.: Percent recovery.
-- No data.

TABLE 7

EXAMPLE ACCURACY FOR TN 9000[a]

Standard Reference Material	Arsenic			Barium			Copper			Lead			Zinc		
	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.
RTC CRM-021	24.8	ND	NA	586	1135	193.5	4792	2908	60.7	144742	149947	103.6	546	224	40.9
RTC CRM-020	397	429	92.5	22.3	ND	NA	753	583	77.4	5195	3444	66.3	3022	3916	129.6
BCR CRM 143R	--	--	--	--	--	--	131	105	80.5	180	206	114.8	1055	1043	99.0
BCR CRM 141	--	--	--	--	--	--	32.6	ND	NA	29.4	ND	NA	81.3	ND	NA
USGS GXR-2	25.0	ND	NA	2240	2946	131.5	76.0	106	140.2	690	742	107.6	530	596	112.4
USGS GXR-6	330	294	88.9	1300	2581	198.5	66.0	ND	NA	101	80.9	80.1	118	ND	NA
NIST 2711	105	104	99.3	726	801	110.3	114	ND	NA	1162	1172	100.9	350	333	94.9
NIST 2710	626	722	115.4	707	782	110.6	2950	2834	96.1	5532	5420	98.0	6952	6476	93.2
NIST 2709	17.7	ND	NA	968	950	98.1	34.6	ND	NA	18.9	ND	NA	106	98.5	93.0
NIST 2704	23.4	ND	NA	414	443	107.0	98.6	105	106.2	161	167	103.5	438	427	97.4
CNRC PACS-1	211	143	67.7	--	772	NA	452	302	66.9	404	332	82.3	824	611	74.2
SARM-51	--	--	--	335	466	139.1	268	373	139.2	5200	7199	138.4	2200	2676	121.6
SARM-52	--	--	--	410	527	128.5	219	193	88.1	1200	1107	92.2	264	215	81.4

Source: Ref. 4. These data are provided for guidance purposes only.
[a] All concentrations in milligrams per kilogram.
%Rec.: Percent recovery; ND: Not detected; NA: Not applicable.
-- No data.

TABLE 8

EXAMPLE REGRESSION PARAMETERS FOR COMPARABILITY[1]

	Arsenic				Barium				Copper			
	n	r^2	Int.	Slope	n	r^2	Int.	Slope	n	r^2	Int.	Slope
All Data	824	0.94	1.62	0.94	1255	0.71	60.3	0.54	984	0.93	2.19	0.93
Soil 1	368	0.96	1.41	0.95	393	0.05	42.6	0.11	385	0.94	1.26	0.99
Soil 2	453	0.94	1.51	0.96	462	0.56	30.2	0.66	463	0.92	2.09	0.95
Soil 3	—	—	—	—	400	0.85	44.7	0.59	136	0.46	16.60	0.57
Prep 1	207	0.87	2.69	0.85	312	0.64	53.7	0.55	256	0.87	3.89	0.87
Prep 2	208	0.97	1.38	0.95	315	0.67	64.6	0.52	246	0.96	2.04	0.93
Prep 3	204	0.96	1.20	0.99	315	0.78	64.6	0.53	236	0.97	1.45	0.99
Prep 4	205	0.96	1.45	0.98	313	0.81	58.9	0.55	246	0.96	1.99	0.96

	Lead				Zinc				Chromium			
	n	r^2	Int.	Slope	n	r^2	Int.	Slope	n	r^2	Int.	Slope
All Data	1205	0.92	1.66	0.95	1103	0.89	1.86	0.95	280	0.70	64.6	0.42
Soil 1	357	0.94	1.41	0.96	329	0.93	1.78	0.93	—	—	—	—
Soil 2	451	0.93	1.62	0.97	423	0.85	2.57	0.90	—	—	—	—
Soil 3	397	0.90	2.40	0.90	351	0.90	1.70	0.98	186	0.66	38.9	0.50
Prep 1	305	0.80	2.88	0.86	286	0.79	3.16	0.87	105	0.80	66.1	0.43
Prep 2	298	0.97	1.41	0.96	272	0.95	1.86	0.93	77	0.51	81.3	0.36
Prep 3	302	0.98	1.26	0.99	274	0.93	1.32	1.00	49	0.73	53.7	0.45
Prep 4	300	0.96	1.38	1.00	271	0.94	1.41	1.01	49	0.75	31.6	0.56

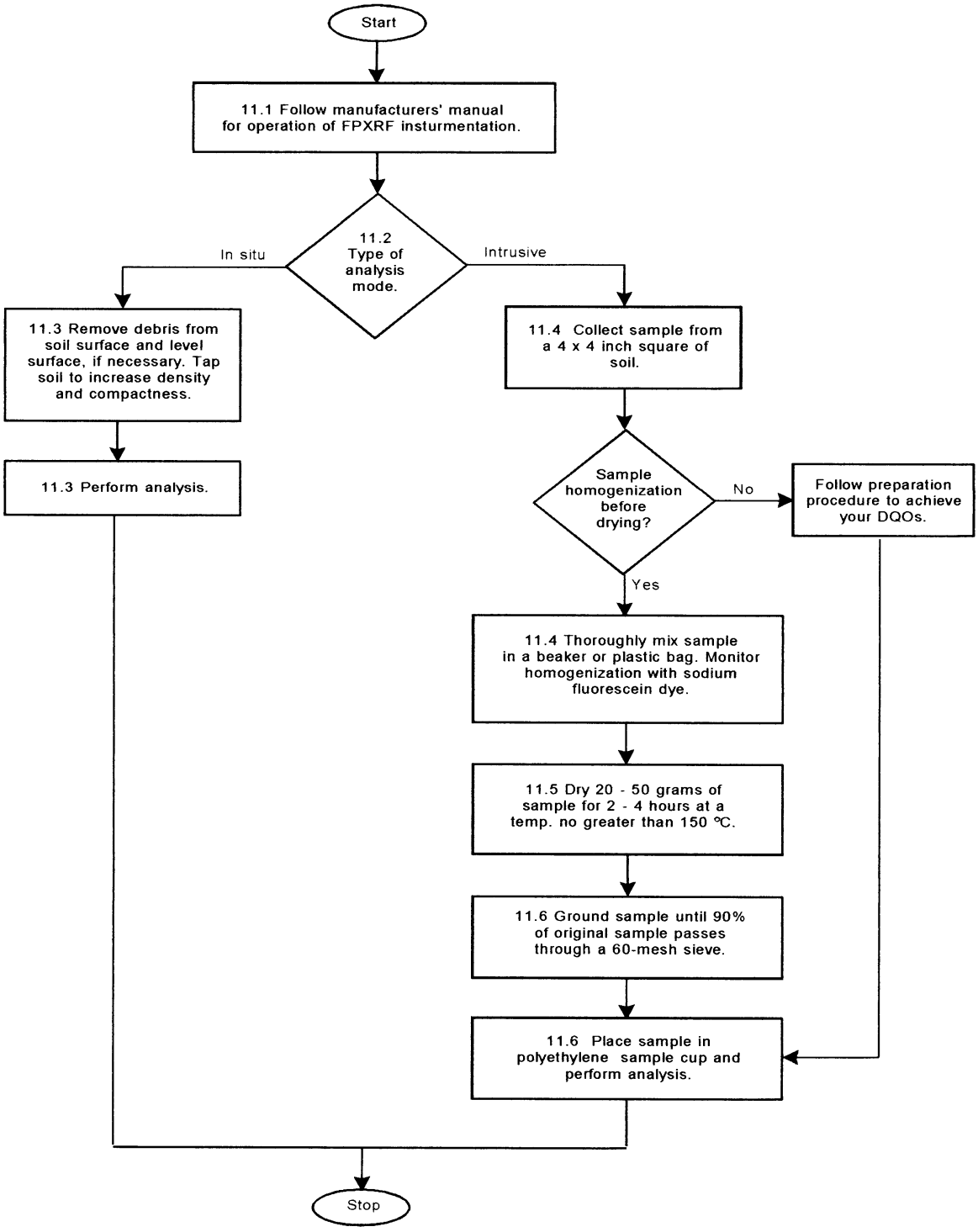
Source: Ref. 4. These data are provided for guidance purposes only.

[1] Log-transformed data

n: Number of data points; r^2: Coefficient of determination; Int.: Y-intercept

— No applicable data

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT



APPENDIX K

QUALITY CONTROL PLAN

QUALITY CONTROL PLAN

The Quality Control Plan (QCP) identifies quality requirements to be implemented to ensure that overall project activities are accomplished using internal controls and review procedures. The intent of such controls is to eliminate conflicts, errors, and omissions and to ensure the technical accuracy of deliverables. The QCP is applicable to the Radford Army Ammunition Plant (RFAAP) project activities that will be performed by WESTON and its subcontractors, as described in the UFP-QAPP.

QC requirements for specific technical tasks, such as the AGC and DGM work and MC sampling and laboratory analysis, are presented in the UFP-QAPP.

1. QUALITY MANAGEMENT STRUCTURE

WESTON's staff of experienced technical professionals and subcontractors will execute the project. Project personnel will be responsible for ensuring that quality methods and procedures are implemented. The specific responsibilities of the quality management personnel are detailed in the following subsections**.**

1.1 PROJECT MANAGER

The Project Manager is responsible for project activities and for ensuring that contractual requirements are met and the project is performed in an efficient, safe, and quality manner. Additional responsibilities include implementing project QC procedures, analyzing QC failures with the SUXOS, UXOQCS, UXOSO, and Geophysics QC Manager, and ensuring that corrective actions are implemented and lessons learned are documented.

1.2 MUNITIONS AND EXPLOSIVES OF CONCERN QUALITY CONTROL MANAGER

The MEC QC Manager is responsible for providing corporate QC oversight of MEC activities on the project. His responsibilities include providing technical support as needed and performing scheduled and unscheduled audits of the project. The MEC QC Manager will provide technical assistance to the PM and guidance to the SUXOS. The UXOQCS will communicate directly with the MEC QC Manager on quality issues, findings, and recommendations.

1.3 SENIOR UNEXPLODED ORDNANCE SUPERVISOR

The SUXOS is responsible for managing, overseeing, and guiding MEC operations and UXO teams. The SUXOS is responsible for ensuring that field personnel are properly trained and indoctrinated, and that they have the necessary experience and skills to perform the assigned task. The SUXOS will ensure that the RFI activities are in compliance with DoD directives and federal, state, and local statutes and codes. Additionally, the SUXOS is responsible for providing subject matter expertise and leadership to ensure the team's safety and the quality of the project.

1.4 UNEXPLODED ORDNANCE QUALITY CONTROL SPECIALIST

The UXOQCS reports independently to the MEC QC Manager on quality-related matters. The UXOQCS is responsible for monitoring site activities affecting quality and for ensuring these activities are being carried out in accordance with the established requirements and protocols in this QCP. The UXOQCS is responsible for conducting QC inspections of intrusive and explosives operations for compliance with the established procedures. The UXOQCS will perform daily surveillance of the work activities and issue corrective actions as necessary. The UXOQCS will prepare daily QC reports documenting QC processes and results and will execute the three-inspection process.

1.5 GEOPHYSICS QUALITY CONTROL MANAGER

The Geophysics QC Manager is responsible for the quality of the digital geophysical data. His responsibilities include performing reviews of raw and processed geophysical data and audits of geophysical team procedures, and recommending actions to be taken in the event of geophysical data QC nonconformance. The Geophysics QC Manager will recommend and provide solutions to quality problems.

1.6 CHEMICAL QUALITY CONTROL MANAGER

The Chemical QC Manager is responsible for ensuring the implementation of the MC sampling QC program in accordance with project requirements, as specified in the UFP-QAPP. In addition,

the Chemical QC Manager is responsible for reviewing the technical quality of the analytical data, the data validation, and the reports, as identified in the UFP-QAPP.

2. PERSONNEL QUALIFICATIONS AND TRAINING

Project staff will be qualified to perform the specific tasks they are assigned on the project, as discussed in the UFP-QAPP. The H&S training requirements for on-site personnel and visitors are discussed in the Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP). The UXO-qualified personnel and/or UXO technicians will meet the requirements of Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP) - 18, Minimum Qualifications for Unexploded Ordnance Technicians and Personnel (DoD, 2004).

At the beginning of the project, personnel will provide their training and qualification records to the PM for approval. These records will also be maintained on-site by the UXOQCS and will be reviewed periodically to ensure they are current. Prior to beginning field work and/or any new phases of work, the UXOQCS will review the work processes with project personnel to ensure they are adequately trained/refreshed in the phase of work requirements, standards, and procedures.

Prior to allowing any visitors on-site, the UXOQCS will review their training and qualifications and determine appropriate visitation access based on the APP/SSHP and the daily site activities. Visitors will be given a project and safety briefing by the SUXOS/Site Manager or designee, will sign off on the briefing, and will be accompanied by site personnel during their visit as appropriate.

3. THREE PHASE INSPECTION PROCESS

A three phase inspection (TPI) process will be used to ensure that project activities comply with approved procedures and methods and that opportunities for improving processes are documented and changes (if approved) are implemented. The UXOQCS or designee is responsible for implementing this process. The TPI process includes a preparatory, initial, and follow-up/final phase inspection for each project definable feature of work (DFW) as described in the following sections. A final inspection will be performed at the completion of a DFW. The DFWs, inspection descriptions, responsible personnel, and potential failure actions are provided in **Table 1**. Specific geophysical inspection methods and failure criteria are presented in **Table 2**.

3.1 DEFINABLE FEATURES OF WORK

DFWs have been developed for each aspect of the project from planning to implementation to reporting. The primary DFWs are as follows:

- DFW 1: MOBILIZATION
- DFW 2: SITE PREPARATION
- DFW 3: VEGETATION CLEARANCE
- DFW 4: PROFESSIONAL LAND SURVEY AND GRID ESTABLISHMENT
- DFW 5: INSTRUMENT-ASSISTED SURFACE CLEARANCE
- DFW 6: GEOPHYSICAL SYSTEM VERIFICATION
- DFW 7: DGM (EM-31) SURVEY
- DFW 8: DYNAMIC DETECTION SURVEY (AGC METALMAPPER 2X2)
- DFW 9: CUED SURVEY (AGC METALMAPPER 2X2)
- DFW 10: INTRUSIVE INVESTIGATION, ANALOG MAG AND DIG, AND MECHANICAL TRENCHING
- DFW 11: G-858 SURVEY OF AREA A (NEW RIVER)
- DFW 12: DIVE OPERATIONS OF AREA A (NEW RIVER)
- DFW 13: MPPEH/MEC AND MDAS HANDLING, CERTIFICATION, AND DISPOSAL
- DFW 14: MC SAMPLING
- DFW 15: SITE RESTORATION
- DFW 16: DEMOBILIZATION

The DFWs, inspection descriptions, responsible personnel, and potential failure actions are provided in **Table 1**. The QC requirements for MC sampling are presented in the UFP-QAPP.

Table 1 Definable Features of Work and Inspection Checklist

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
1. MOBILIZATION			
Verify planning documents have been approved and are available on-site and that substantive permit requirements are met.	Once at mobilization and as required if new documents are generated or revised.	SSHO/UXOQCS	Do not proceed with field activities until approval has been granted.
Verify work personnel are available and are qualified to perform the work.	Once prior to mobilization and follow-up as new employees mobilize.	Project Manager, SUXOS, SSHO, UXOQCS	Do not allow personnel on-site until training and qualifications are confirmed.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
Verify all personnel have read and understand the planning documents.	Once at mobilization and follow-up as new employees mobilize.	SSHO, UXOQCS	Do not proceed with field activities until inspection is passed.
Confirm all personnel have signed the UFP-QAPP and APP acknowledgement forms.	Once at mobilization and follow-up as new employees mobilize.	SSHO, UXOQCS	Do not proceed with field activities until inspection is passed.
2. SITE PREPARATION			
Calibrate and test equipment initially to confirm it is functional.	Once as equipment arrive on-site.	SSHO, UXOQCS, Geophysicist	Do not proceed with field activities until inspection is passed.
3. VEGETATION CLEARANCE			
Verify team has appropriate qualifications including safety/training.	Once at onset of field work.	SSHO	Do not proceed with field activities until inspection is passed.
PPE is properly worn and maintained.	Daily	SSHO	Do not proceed with field activities until inspection is passed.
Confirm brush is sufficiently thinned so that digital and analog surveys can be conducted while ensuring that compliance with the EPP is maintained.	Once following clearance of a grid or area. Follow up as needed.	SSHO, Geophysicist	Return to location and clear vegetation as necessary to pass inspection.
4. PROFESSIONAL LAND SURVEY AND GRID ESTABLISHMENT			
Verify survey team has appropriate qualifications, including safety/training and state licensing.	Once at start of survey activity.	Project Manager, Geophysicist	Surveyor must provide qualifications, training certificates and licensing prior to starting work or change surveyor.
Confirm location of established control points are suitable for use (located in proximity to work area, no tree canopy) with the RTK base station.	As control points are being established.	Geophysicist	Move control to improved location and resurvey.
Corner points for DGM grids requiring professional survey have been located and marked as described in the Work Plan.	As grid points are being surveyed.	Geophysicist	Resurvey and mark corner points.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
Each DGM grid has at least one seed item as described in the UFP-QAPP (location, depth, orientation and seed type are recorded).	As grid points are being surveyed.	UXOQCS or UXO escort	Return to grid, place seed item, and survey.
Grid corners and control points are of suitable quantity and location to be used during line and fiducial data positioning if necessary.	As grid points are being surveyed.	Geophysicist	Add additional control.
5. INSTRUMENT-AIDED SURFACE CLEARANCE			
Confirm all personnel have the appropriate PPE and supplies.	Daily	SUXOS, UXOQCS, UXOSO	Stop activities until PPE and supplies are in place.
Confirm UXO teams are recording/logging all required parameters during item recovery.	Daily	UXOQCS, Geophysicist	Retrain or replace personnel.
Conduct anomaly/area verification sampling when clearance activities are complete in a grid or area.	At completion of grid/ area.	UXOQCS	Resurvey grid/area and resubmit for QC.
Verify the determination of acceptable to move MEC/MPPEH for consolidation is appropriate.	Each MEC/MPPEH item, as required.	UXOQCS	MEC/MPPEH item will be BIP. Retrain or replace personnel.
Ensure appropriate notifications and procedures are in place to transport MEC/MPPEH and the designated consolidation point is used for demolition.	Each MEC/MPPEH item, as required.	UXOQCS	Do not move MEC/MPPEH item until inspection passes. Retrain or replace personnel.
Verify disposal procedures are being conducted in accordance with the UFP-QAPP.	Each MEC item, as required.	UXOQCS	Stop activities until UFP-QAPP procedures are being followed and any activities not performed in compliance with procedures are reevaluated and re-performed if necessary.
6. GEOPHYSICAL SYSTEM VERIFICATION			
Instrument verification strip (IVS) was constructed in accordance with the UFP-QAPP (type and number of seed items, depth, and separation).	Once during IVS construction.	Geophysicist	Re-seed and re-survey seed items.
Confirm geophysical sensors (digital and analog) selected for the project are capable of achieving detection performance requirements based on noise levels and depths of items to be encountered.	Once after initial IVS surveys.	UXOQCS, Geophysicist	Repair sensors or recommend changing instrumentation/method. Rerun IVS.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
Positioning systems are capable of achieving accuracy requirements documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Repair equipment or recommend changing positioning system. Rerun IVS.
Responses for seed items fall on or above the least favorable orientation sensor response curves within the appropriate tolerance as documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Repair sensors or recommend changing instrumentation/method. Rerun IVS.
Noise levels, anomaly selection thresholds, and appropriate processes are documented and approved by the USACE geophysicist prior to performing production surveys.	Once after initial IVS surveys.	Project Manager, UXOQCS, Geophysicist	Do not allow production surveys to commence before approval.
Confirm digital functionality tests are performed before and after surveys and results are verified against metrics established in the Work Plan.	Daily and following repair or maintenance.	Geophysicist	Re-collect data between tests where discrepancies were observed if a resolution cannot be determined.
The IVS procedures documented in the UFP-QAPP are being performed by each DGM team before and after surveys.	Daily.	Geophysicist	If data quality is poor and IVS data are not available to support a resolution, data may need to be re-collected for the time period in question.
Analog instruments are tested on the IVS to confirm functionality before transect and grid activities.	Daily and following repair or maintenance.	UXOQCS	Replace/repair instrument if functionality is questionable.
7. DGM (EM-31) SURVEY			
Verify survey team has appropriate qualifications, including safety/training and state licensing.	Once at start of survey activity.	Project Manager, Geophysicist	Surveyor must provide qualifications, training certificates, and licensing prior to starting work or change surveyor.
Confirm location of established control points are suitable for use (located in proximity to work area, no tree canopy) with the RTK base station.	As control points are being established.	Geophysicist	Move control to improved location and resurvey.
Corner points for DGM grids requiring survey have been located and marked as described in the UFP-QAPP.	As grid points are being surveyed.	Geophysicist	Resurvey and mark corner points.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
Each DGM grid has at least one seed item as described in the UFP-QAPP (location, depth, orientation and seed type are recorded).	As grid points are being surveyed.	UXO escort	Return to grid, place seed item and survey.
IVS was constructed in accordance with the UFP-QAPP (type and number of seed items, depth, and separation).	Once during IVS construction.	Geophysicist	Reseed and resurvey seed items.
Confirm geophysical sensors (digital and analog) selected for the project are capable of achieving detection performance requirements based on noise levels and depths to be encountered.	Once after initial IVS surveys.	Geophysicist	Repair sensors or recommend changing instrumentation/method. Rerun IVS.
Positioning systems are capable of achieving accuracy requirements documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Repair equipment or recommend changing positioning system. Rerun IVS.
Responses for seed items fall on or above the least favorable orientation sensor response curves within the appropriate tolerance as documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Rerun IVS.
Noise levels, anomaly selection thresholds, and appropriate processes are documented and approved by the USACE Geophysicist prior to performing production surveys.	Once after initial IVS surveys.	Project Manager, Geophysicist	Do not allow production surveys to commence before approval.
Confirm digital functionality tests are performed before and after surveys and results are verified against metrics established in the UFP-QAPP.	Daily and following repair or maintenance.	Geophysicist	Re-collect data between tests where discrepancies were observed if a resolution cannot be determined.
The IVS procedures documented in the UFP-QAPP are being performed by each DGM team before and after surveys.	Daily.	Geophysicist	If data quality is poor and IVS data are not available to support a resolution, data may need to be recollected for the time period in question.
Analog instruments are tested on the IVS to confirm functionality before transect and grid mag and dig activities.	Daily and following repair or maintenance.	UXOQCS	Replace/repair instrument if functionality is questionable.
Confirm DGM processes detailed in the UFP-QAPP are being performed and metrics are being achieved.	Daily during DGM.	Geophysicist	Data may need to be repackaged, reprocessed, or recollected.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
Confirm digital data packages are submitted for USACE review.	Weekly and as needed.	Project Manager, Geophysicist	Data may need to be repackaged, reprocessed, or recollected based on results from USACE review.
8. DYNAMIC DETECTION SURVEY (AGC METALMAPPER 2X2)			
Verify survey team has appropriate qualifications including safety/training and state licensing.	Once at start of survey activity.	Project Manager, Geophysicist	Surveyor must provide qualifications, training certificates, and licensing prior to starting work or change surveyor.
Confirm location of established control points are suitable for use (located in proximity to work area, no tree canopy) with the RTK base station.	As control points are being established.	Geophysicist	Move control to improved location and resurvey.
Corner points for AGC grids requiring survey have been located and marked as described in the UFP-QAPP.	As grid points are being surveyed.	Geophysicist	Resurvey and mark corner points.
Each AGC grid has at least one seed item as described in the UFP-QAPP (location, depth, orientation and seed type are recorded).	As grid points are being surveyed.	UXO escort	Return to grid, place seed item, and survey.
IVS was constructed in accordance with the UFP-QAPP (type and number of seed items, depth, and separation).	Once during IVS construction.	Geophysicist	Reseed and resurvey seed items.
Positioning systems are capable of achieving accuracy requirements documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Repair equipment or recommend changing positioning system. Rerun IVS.
Responses for seed items fall on or above the least favorable orientation sensor response curves within the appropriate tolerance as documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Rerun IVS.
Noise levels, anomaly selection thresholds, and appropriate processes are documented and approved by the USACE Geophysicist prior to performing production surveys.	Once after initial IVS surveys.	Project Manager, Geophysicist	Do not allow production surveys to commence before approval.
Confirm functionality tests are performed before and after surveys and results are verified against metrics established in the UFP-QAPP.	Daily and following repair or maintenance.	Geophysicist	Re-collect data between tests where discrepancies were observed if a resolution cannot be determined.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
The IVS procedures documented in the UFP-QAPP are being performed by each AGC team before and after surveys.	Daily	Geophysicist	If data quality is poor and IVS data are not available to support a resolution, data may need to be recollected for the time period in question.
Confirm AGC processes detailed in the UFP-QAPP are being performed and metrics are being achieved.	Daily during DGM.	Geophysicist	Data may need to be repackaged, reprocessed, or recollected.
Confirm digital data packages are submitted for USACE review.	Weekly and as needed.	Project Manager, Geophysicist	Data may need to be repackaged, reprocessed, or recollected based on results from USACE review.
9. CUED SURVEY (AGC METALMAPPER 2X2)			
Positioning systems are capable of achieving accuracy requirements documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Repair equipment or recommend changing positioning system. Rerun IVS.
Noise levels, anomaly selection thresholds, and appropriate processes are documented and approved by the USACE Geophysicist prior to performing production surveys.	Once after initial IVS surveys.	Project Manager, Geophysicist	Do not allow production surveys to commence before approval.
Confirm functionality tests are performed before and after surveys and results are verified against metrics established in the UFP-QAPP.	Daily and following repair or maintenance.	Geophysicist	Re-collect data between tests where discrepancies were observed if a resolution cannot be determined.
The IVS procedures documented in the UFP-QAPP are being performed by each AGC team before and after surveys.	Daily	Geophysicist	If data quality is poor and IVS data are not available to support a resolution, data may need to be recollected for the time period in question.
Confirm AGC processes detailed in the UFP-QAPP are being performed and metrics are being achieved.	Daily during DGM.	Geophysicist	Data may need to be repackaged, reprocessed, or recollected.
Confirm digital data packages are submitted for USACE review.	Weekly and as needed.	Project Manager, Geophysicist	Data may need to be repackaged, reprocessed, or recollected based on results from USACE review.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
10 INTRUSIVE INVESTIGATION, ANALOG MAG AND DIG, AND MECHANICAL TRENCHING			
Ensure the appropriate exclusion zones are established and maintained in active work areas based on the ESP.	Daily.	SUXOS, UXOQCS, UXOSO	Stop activities until the appropriate exclusion zones have been established and maintained.
Verify team separation distances.	Daily.	SUXOS, UXOQCS, UXOSO	Stop activities until the appropriate separation distance is being followed.
Confirm all personnel have the appropriate PPE and supplies.	Daily.	SUXOS, UXOQCS, UXOSO	Stop activities until PPE and supplies are in place.
Observe anomaly reacquisition/ intrusive work accuracy and completeness.	Daily and as required.	UXOQCS	Stop activities until Work Plan procedures are being followed and any activities not performed within compliance are reevaluated and re-performed if necessary.
Observe mag and dig operations for accuracy and completeness.	Daily and as required.	UXOQCS	Stop activities until Work Plan procedures are being followed and any activities not performed within compliance are reevaluated and re-performed if necessary.
Confirm UXO teams are recording/ logging all required parameters during item recovery.	Daily.	UXOQCS, Geophysicist	Retrain or replace personnel.
Verify all seed items have been recovered within a specific grid or area.	At completion of grid.	UXOQCS, Geophysicist	Resurvey grid and resubmit for QC.
Conduct anomaly/area verification sampling when removal activities are complete in a grid or area.	At completion of grid/ area.	UXOQCS	Resurvey grid/ area and resubmit for QC.
Verify excavations/trenches have been backfilled and properly restored.	Daily.	UXOQCS	Return to excavation to perform necessary restoration.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
11. G-858 SURVEY OF AREA A (NEW RIVER)			
Verify survey team has appropriate qualifications including safety/training and state licensing.	Once at start of survey activity.	Project Manager, Geophysicist	Surveyor must provide qualifications, training certificates, and licensing prior to starting work or change surveyor.
Start points for DGM transects requiring survey have been located and marked as described in the UFP-QAPP.	As transect endpoints are being surveyed.	Geophysicist	Resurvey and mark points.
Area A has at least six seed items as described in the UFP-QAPP (location, depth, orientation, and seed type are recorded).	As endpoints are being surveyed.	UXO escort	Return to Area A, place seed item and survey.
IVS was constructed in accordance with the UFP-QAPP (type and number of seed items, depth, and separation).	Once during IVS construction.	Geophysicist	Reseed and resurvey seed items.
Confirm geophysical sensors (digital and analog) selected for the project are capable of achieving detection performance requirements based on noise levels and depths to be encountered.	Once after initial IVS surveys.	Geophysicist	Repair sensors or recommend changing instrumentation/method. Rerun IVS.
Positioning systems are capable of achieving accuracy requirements documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Repair equipment or recommend changing positioning system. Rerun IVS.
Responses for seed items fall on or above the least favorable orientation sensor response curves within the appropriate tolerance as documented in the UFP-QAPP.	Once after initial IVS surveys.	Geophysicist	Rerun IVS.
Noise levels, anomaly selection thresholds, and appropriate processes are documented and approved by the USACE Geophysicist prior to performing production surveys.	Once after initial IVS surveys.	Project Manager, Geophysicist	Do not allow production surveys to commence before approval.
Confirm digital functionality tests are performed before and after surveys and results are verified against metrics established in the UFP-QAPP.	Daily and following repair or maintenance.	Geophysicist	Re-collect data between tests where discrepancies were observed if a resolution cannot be determined.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
The IVS procedures documented in the UFP-QAPP are being performed by each DGM team before and after surveys.	Daily	Geophysicist	If data quality is poor and IVS data are not available to support a resolution, data may need to be recollected for the time period in question.
Confirm DGM processes detailed in the UFP-QAPP are being performed and metrics are being achieved.	Daily during DGM.	Geophysicist	Data may need to be repackaged, reprocessed, or recollected.
Confirm digital data packages are submitted for USACE review.	Weekly and as needed.	Project Manager, Geophysicist	Data may need to be repackaged, reprocessed, or recollected based on results from USACE review.
12. DIVE OPERATIONS OF AREA A (NEW RIVER)			
Verify dive team has appropriate qualifications including safety/training and state licensing and equipment.	Once at start of survey activity and daily for equipment.	Project Manager, SUXOS, Dive Coordinator	Team must provide qualifications, training certificates and licensing prior to starting work.
Instruments checked to confirm functionality before mag and dig activities.	Daily and following repair or maintenance.	AOR Dive Supervisor	Replace/repair instrument if functionality is questionable.
Confirm all personnel have the appropriate PPE and supplies.	Daily	AOR Dive Supervisor	Stop activities until PPE and supplies are in place.
Verify all QC items have been recovered within a specific transect using pingers (or other means)	As required, prior to start of transect.	AOR Dive Supervisor	Re-inspect equipment, recalibrate, and/or re-perform.
Observe mag and dig operations for accuracy and completeness.	Daily and as required.	UXOQCS and AOR Dive Supervisor	Stop activities until Work Plan procedures are being followed and any activities not performed within compliance are reevaluated and re-performed if necessary.
Confirm UXO dive teams are recording/logging all required parameters during item recovery.	Daily	UXOQCS	Retrain or replace personnel.
Verify procedures and equipment in place to transport and/or BIP MEC/ MPPEH.	Each anomaly.	UXOQCS	Retrain or replace personnel.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
Verify disposal procedures are being conducted in accordance with the UFP-QAPP/Dive Plan.	Each MEC item, as required.	UXOQCS	Stop activities until Work Plan procedures are being followed and any activities not performed within compliance are reevaluated and re-performed if necessary.
13. MPPEH/MEC AND MDAS HANDLING, CERTIFICATION, AND DISPOSAL			
Verify the determination if acceptable to move MEC/MPPEH for consolidation is appropriate.	Each MEC/MPPEH item, as required.	UXOQCS	MEC/MPPEH item will be BIP. Retrain or replace personnel.
Ensure appropriate notifications and procedures are in place to transport MEC/MPPEH and the designated consolidation point is used for demolition.	Each MEC/MPPEH item, as required.	UXOQCS	Do not move MEC/MPPEH item until it has passed inspection. Retrain or replace personnel.
Verify disposal procedures are being conducted in accordance with the Work Plan.	Each MEC item, as required.	UXOQCS	Stop activities until Work Plan procedures are being followed and any activities not performed within compliance are reevaluated and re-performed if necessary.
Verify personnel qualifications.	Once.	UXOQCS	Replace unqualified personnel with qualified personnel.
Perform inspections on accumulated MDAS.	Daily as accumulated.	UXOQCS	Stop activities until Work Plan procedures are being followed and any activities not performed within compliance are reevaluated and re-performed if necessary.
14. MUNITIONS CONSTITUENTS SAMPLING			
Confirm all personnel have the appropriate PPE and supplies.	Daily	SSHO	Stop activities until PPE and supplies are in place.
Personal protective equipment is properly worn and maintained.	Daily	SSHO	Do not proceed with field activities until inspection is passed.

Inspection Description	Frequency of Inspection	Inspection Responsibility	Possible Action if Failure Occurs
Ensure field screening equipment is available, properly operated, maintained, and calibrated.	Once and follow up through duration of activities.	Sampling Leader	Do not proceed with field activities until inspection is passed.
Confirm sampling teams are recording/ logging all required parameters during field work.	Daily	Sampling Leader	Retrain or replace personnel.
Confirm all sample locations and sampling requirements conducted in accordance with UFP-QAPP.	Daily, end of sampling phase	Sampling Leader	Identify sampling issues and collect samples
15. SITE RESTORATION			
Confirm all work locations are restored as documented in the UFP-QAPP.	Completion of project.	Project Manager, SUXOS, UXOQCS, Geophysicist	Perform inspection following completion of definable feature of work.
16. DEMOBILIZATION			
Confirm all site features, equipment, supplies, and personnel are removed.	Completion of project.	Project Manager, SUXOS, UXOQCS, Geophysicist	Perform inspection following completion of definable feature of work.

3.2 PREPARATORY PHASE INSPECTION

The preparatory phase inspection comprises the planning and design process leading up to the field activities. The preparatory phase inspection will be performed prior to initiating each DFW. The UXOQCS or designee will review the appropriate documentation to ensure the requirements to carry out each DFW are in place and compliant.

The UXOQCS will verify that required planning documentation, including the UFP-QAPP and appendices, have been approved and are available for site personnel. Equipment, sensors, and materials delivered to the site will be inspected to ensure they are calibrated, functional, and all required components are inventoried. Personnel certifications will be reviewed to ensure that appropriate training, medical clearance, licenses, and instruction has been performed based on assigned responsibilities and site-specific requirements. The UXOQCS or designee will determine if the personnel needed to carry out the DFW are identified, available, meet the qualifications of the position, and those positions are filled accordingly.

Where site conditions or constraints prohibit carrying out a specific DFW, the UXOQCS will designate personnel to correct or resolve discrepancies. UFP-QAPP discrepancies will be corrected and subsequently verified by the UXOQCS or designee before beginning the DFW.

3.2.1 Initial Phase Inspection

The initial phase inspection will begin at the startup of a DFW. The work performed as part of the DFW will be inspected for compliance with established procedures so that a high level of quality can be obtained from task commencement to completion. The UXOQCS will document the inspection results in the QC logbook that will be transcribed daily to the QC Report. The QC Report will list the DFW(s), QC requirements, and inspection processes performed that day based on the DFW checklist (**Table 1**).

If the inspection results identify discrepancies between the approved plans and site practices, a discrepancy resolution process will be implemented. The appropriate expert based on discipline (DGM, chemistry, safety, munitions) will be engaged to support the PM and project team in resolving discrepancies immediately after they are identified. The ultimate resolution will be made by the PM. If the discrepancy cannot be resolved, the nonconformance will be documented in a Corrective Action Request (CAR) as described in Subsection 1.3.4. When an unresolved discrepancy is identified as potentially causing a nonconformance, the work activities will be stopped until a resolution can be documented and approved.

3.2.2 Follow-Up Phase Inspection (Surveillance)

Scheduled and unscheduled inspections will be performed as part of the follow-up phase. The purpose of these inspections is to ensure a high level of quality is maintained throughout the work activity by monitoring compliance to the project plans and procedures on an ongoing basis. The UXOQCS has primary responsibility for on-site verification of the work practices in relation to the DFW inspection requirements. However, the SUXOS and Geophysicist are also responsible for monitoring performance. The following will be performed for each DFW:

- Inspections and surveillance to ensure compliance with project plans.
- Inspections and surveillance to ensure a high level of workmanship is maintained.
- Inspections and surveillance to ensure logbooks are complete.

- Inspections and surveillance to ensure compliance with the inspection frequency and requirements documented in **Table 1**.

Results of the follow-up phase inspections will be documented in the UXOQCS logbook and summarized in the QC Report.

3.2.3 Final Phase Inspection

At the completion of all work associated with a DFW, the UXOQCS will conduct an inspection of the work. The work will be inspected for conformance to plans, specifications, quality, workmanship, and completeness. An itemized list will be compiled that includes a summary of work not properly completed, inferior workmanship, and work not conforming to plans and specifications. The list will be documented as a nonconformance in the QC Report with an estimated date for correction of each discrepancy. If the discrepancy cannot be reconciled, a CAR will be prepared.

Following correction of work, a second inspection will be conducted by the UXOQCS to ensure that all deficiencies have been corrected. The inspections and resolutions will be completed within the schedule stated for completion of the entire work, or any particular increment thereof if the project is divided into increments by separate completion dates.

3.2.4 Geophysical Inspection Methods and Failure Criteria

In addition to the inspection criteria described above for each DFW, there are operation-specific inspection methods and failure criteria for the geophysical inspections. These inspection methods and failure criteria are presented in **Table 2**.

Table 2 Follow-Up Phase Inspection Methods and Failure Criteria

Activity	Inspection Method	Failure Criteria
Equipment and instrument checks	▪ Inspect equipment and instrumentation at IVS. ▪ Observe operation by personnel. ▪ Record results on appropriate forms.	▪ Equipment is not operational. ▪ Personnel are not proficient with operation.
Process and procedure inspections	▪ Visual observations of personnel and accuracy of methods being employed. ▪ Part of the follow-up inspection phase.	▪ Any discrepancies identified will need to be resolved as discussed in the QCP.

Activity	Inspection Method	Failure Criteria
	▪ Confirm the requirements of the UFP-QAPP, and that inspections for DFWs, regulations, and industry standards comply with project objectives.	▪ Unresolved discrepancies or nonconformance will require a Corrective Action Request (CAR). ▪ If the same discrepancy is reoccurring, prepare a CAR.
Mag and dig for transects	▪ Visual observations during operations to confirm procedures documented in the UFP-QAPP are being properly executed. ▪ Conduct random inspections of at least 10% of the grid or transect with the same type of instrumentation used for mag and dig to determine whether metallic anomalies remain in the grid or along the transect. ▪ Evaluate whether MEC/MPPEH, MD, and non-MD (size of a 37 mm or greater) were completely removed within a 3.25-ft radius of dig locations. ▪ Verify seed items were recovered, as applicable.	▪ Failure to investigate subsurface anomalies. ▪ MEC/MPPEH, MD, and non-MD (size of a 37 mm or greater) were found within 3.25 ft of dig location. ▪ One seed item is missed. ▪ MEC/MPPEH of the same or greater size of what was anticipated remains in grids or along transects.
AGC/DGM operations	Discussed in the UFP-QAPP.	Discussed in the UFP-QAPP.
Anomaly reacquisition and investigation	▪ Respond to grid or transect following excavation for inspection. ▪ Inspect at least 10% of anomaly locations to confirm metal has been removed from a 2-ft radius. ▪ Confirm excavations have been restored to UFP-QAPP specified conditions. ▪ Verify seed items were recovered, as applicable.	▪ Failure to reacquire all anomalies on dig list. ▪ Failure to investigate subsurface anomalies that were reacquired. ▪ MEC/MPPEH, MD, and non-MD (size of a 37 mm or greater) were found within 2 ft of dig location. ▪ One seed item is missed. ▪ MEC/MPPEH of the same or greater size of what was anticipated remains in grids or along transects. ▪ Restoration not performed or incomplete.

3.3 AUDITS

The Geophysics QC Manager and MEC QC Manager will periodically conduct on-site audits of the field work and QC documentation. Procedures for auditing activities will be identified prior to implementation of the audits. The audit process involves identifying, documenting and reporting non-conformances or deficiencies, initiating corrective actions through appropriate channels, and

conducting a compliance review. Auditing tasks and findings will be documented in an audit report and provided to USACE as an attachment to the QC Report.

3.4 DOCUMENTING DEFICIENCIES AND CORRECTIVE ACTIONS

The UXOQCS is responsible for verifying compliance with this QCP through daily inspections, documenting deficiencies in the QC Report, and ensuring appropriate corrective actions. The Geophysics QC Manager and MEC QC Manager are responsible for verifying compliance with the QCP through periodic on-site audits, documenting deficiencies in audit reports, and ensuring appropriate corrective actions. The PM will coordinate with all QC personnel as deemed necessary following reviews, audits, and inspections at the project level to confirm that work is progressing in accordance with the UFP-QAPP.

3.4.1 Corrective Action Process

The PM and UXOQCS are responsible for ensuring that the procedures for reporting, evaluating, and correcting nonconformance are addressed through the planned QC procedures. The determination of any nonconforming conditions must be supported with objective evidence. The nonconforming conditions will be evaluated and corrected and may be considered as opportunities to improve the process during the project.

3.4.2 Continuous Improvement

Personnel are encouraged to continuously review their processes and to suggest changes that improve the process; provide benefits; or improve project efficiency, safety, and quality. These suggestions can be submitted formally through a written memorandum to the SUXOS or UXOQCS or submitted informally through verbal discussions at project meetings.

3.4.3 Deficiency Identification and Resolution

Personnel have the responsibility to identify and report conditions adverse to quality. The deficiencies will be identified, documented, investigated, and corrected appropriately. The PM and UXOQCS are responsible for evaluating the causes of the deficiencies or the nonconformance and for recommending solutions to correct the deficiency identified. The UXOQCS will be responsible for verifying implementation of the corrective action and for monitoring the effectiveness of the corrective action for each DFW.

3.4.4 Corrective Action Request

A CAR can be issued by any member of the project team, including subcontractor personnel. The CAR is also issued by the UXOQCS when a discrepancy is identified that cannot be resolved following the DFW inspection (at any phase). The CAR will be provided to the PM, who will evaluate the request based on input from the UXOQCS and subject matter experts. If the CAR is accepted, the PM will develop a corrective strategy, assign resources, and specify a schedule for corrective actions. The UXOQCS will verify the effectiveness of the corrective action once it has been implemented and completed. Reoccurring reviews of the CAR will be performed to ensure that the established protocols for corrective actions are being implemented properly and the desired intent is being achieved.

As part of the CAR, a root cause analysis will be conducted to identify the factors that led to the problem. Criteria to be considered in the analysis will include personnel qualifications, training, adequacy of procedures, adequacy of equipment, and adequacy of QC inspections and measures. Input will be obtained from field personnel as necessary and technical experts to support the analysis. The nonconformance will be traced back to the problem using reverse engineering as applicable.

At a minimum, the nonconformance will be documented on the CAR within 24 hours of occurrence. The date when the corrective action will need to be completed and integrated will be discussed with the project team and documented on the CAR and QC Report.

3.4.5 Corrective Action Tracking

Each CAR will be tracked with a unique identifier for the duration of the field activities. The review, approval, implementation, and completion dates will be tracked in a tabular format in the project file.

3.4.6 Lessons Learned

The CARs will be attached to the QC Reports. The intent is to transparently document discrepancies and corrective actions to share lessons learned with the project team. The CARs will also be made topics of daily tailgate meetings as appropriate to ensure that field staff are aware of the situation and the corrective strategy.

The lessons learned that might aid other projects will be shared through WESTON's internal systems.

3.5 PROJECT COMMUNICATION AND SUBMITTALS

3.5.1 Daily Project Briefings

Daily briefings will be held with the field personnel to review the project activities and to discuss technical and safety issues. The SUXOS and UXOQCS will conduct the meetings and document that they are attended by the field personnel. The UXOQCS may schedule additional meetings to discuss technical and quality issues at any time. The SUXOS will maintain communications with the project management team and report any significant problems or decisions to the PM for assistance. The project QC aspects will also be documented in the UXOQCS Log and QC Report for specific DFWs.

3.5.2 Bi-Weekly Project Meeting

During execution of this DO, a project team meeting (via teleconference) will be held biweekly with project management personnel. During active field activities, the field operations team will be invited to participate to discuss project progress and QC-related issues. An agenda will be distributed prior to the meeting. Notes from the meeting will be captured and distributed for review and approval.

3.5.3 Field Documentation

The UXOQCS and Geophysicist will monitor and track the field documentation to ensure that the daily reports, QC logs, forms, and documents are prepared, submitted, and approved as described in this QCP. The UXOQCS will delegate reviews to the appropriate quality management staff based on the document type, the content, and DFW. Copies will be maintained in the project file and digital records will be kept on the project's TeamLink website for secure access of authorized users. **Table 3** lists the field documents required for each DFW. **Table 4** identifies the responsible preparer and minimum required content for each field document.

Any comments received during documentation review will be tracked in the project file and disseminated to the project team to ensure that corrective actions are incorporated for the life of the project.

3.5.4 Contract Submittals

The PM will control project submittals to ensure that the documents are prepared and approved in accordance with the PWS. The PM will monitor and track the submission of the project documentation and delegate reviews to the appropriate quality management and technical staff based on the document type and content. Comments received during documentation review will be tracked in the project file and disseminated to the appropriate project team members to ensure that corrective actions are incorporated for the life of the project.

Table 3 Field Documentation Schedule for Each Definable Feature of Work

DFW	Primary Documentation Associated with the DFW
DFW 1: Mobilization DFW 2: Site Preparation DFW 3: Vegetation Clearance DFW 4: Land Survey and Grid Establishment DFW 16: Mobilization	Daily Summary Report UFP-QAPP acknowledgement APP/SSHP acknowledgement QC Report SUXOS logbook UXOQCS logbook Weekly report (as required)
DFW 5: Instrument-Assisted Surface Clearance DFW 6: System Verification DFW 7: DGM (EM-31 Survey) DFW 8: Dynamic Survey (AGC Metalmapper 2x2) DGW 9: Cued Survey (AGC Metamapper 2x2) DGW 11: G-858 Survey of Area A	Daily Summary Report APP/SSHP acknowledgement QC Report DGM processing form SUXOS logbook UXOQCS logbook Dig list Weekly report
DFW 10: Intrusive Investigation, Analog Mag and Dig, and Mechanical Trenching DFW 12: Dive Operations of Area A	Daily Summary Report APP/SSHP acknowledgement QC Report SUXOS logbook UXOQCS logbook Dig list Weekly report

Table 3 Field Documentation Schedule for Each Definable Feature of Work (Continued)

DFW	Primary Documentation Associated with the DFW
DFW 14: MC Sampling	Daily Summary Report APP/SSHP acknowledgement QC Report Field screen equipment checkout SUXOS logbook UXOQCS logbook Weekly report (as required)
DFW 13: MPPEH/MEC and MDAS Handling, Certification, and Disposal	Daily Summary Report APP/SSHP acknowledgement QC Report SUXOS logbook UXOQCS logbook Weekly report (as required) DD Form 1348

Table 4 Field Documentation Preparer and Minimum Content Requirement

Report/Form/Log Name	Description and Minimum Requirements
UFP-QAPP acknowledgement Manager: UXOQCS	All WESTON employees and applicable subcontractors will read and acknowledge by signature they have read and understand the UFP-QAPP.
APP/SSHP acknowledgement Manager: UXOQCS/UXOSO	All WESTON employees and subcontractors will read and acknowledge by signature they have read and understand the APP/SSHP. This form will be used as the daily sign-in sheet and tailgate safety brief acknowledgement.
Daily Summary Report Manager: SUXOS, UXOQCS/ UXOSO, Geophysicist	This report will summarize the day's activities and tasks performed for any and all DFWs and may include the following as required: ▪ QC findings ▪ Safety and health findings ▪ DGM progress and activities ▪ SUXOS activity summary ▪ MEC recovery information ▪ MC recovery information ▪ Records of site work and progress
QC Report Manager: UXOQCS	The QC Report will provide inspection results for each activity that was monitored. It will document and summarize the information recorded in the UXOQCS log. The QC Report includes: ▪ Each DFW undergoing inspection ▪ Phase of inspection ▪ Results of inspection ▪ Summary of discrepancies ▪ Summary of nonconformance ▪ Resulting actions
SUXOS log Manager: SUXOS	This log is maintained by the SUXOS and records at a minimum: ▪ Activities started and completed ▪ Work stoppage ▪ Official correspondence ▪ Personnel list ▪ Team location and assigned activities ▪ Demolition activity ▪ Visitors
UXOQCS log Manager: UXOQCS	This log is maintained by the UXOQCS and records at a minimum: ▪ Equipment testing and results ▪ Quality control inspections and documentation as required by the QC Report ▪ Work stoppage due to QC issues ▪ Date and personnel observed/checked

Table 4 Field Documentation Preparer and Minimum Content Requirements (Continued)

Report/Form/Log Name	Description and Minimum Requirements
Analog equipment checkout Manager: UXOQCS	Analog instrument testing results at the IVS will be documented daily. Instruments will be taken out of service until repaired and functionality can be demonstrated. Serial numbers, date of test, and operability will be recorded.
DGM processing form Manager: Geophysicist	The DGM processing parameters and results will be recorded. The form also includes IVS results and descriptions of field conditions, dates of survey, instrument type, and results of the QC function tests.
Dig list Manager: UXOQCS and Geophysicist	Dig lists will be generated by the geophysicist or as anomalies are investigated during intrusive operations. Dig results will be logged using the WESTON RespondFast system. Records include: ▪ Date of intrusive activity ▪ Grid/transect location and ID ▪ Anomaly ID ▪ Waypoint coordinates ▪ Depth of item ▪ Appropriate offsets ▪ Item classification, type and description ▪ Dig team ID ▪ Disposition
Demolition notification list Manager: UXOQCS	The demolition notification list is provided in Section 3 of the UFP-QAPP. All parties will be notified prior to performing demolition.
DoD Form 1348-1A Manager: SUXOS	Form will be completed when MD is transferred for flashing and recycling as required. Process and instructions for the form are provided in Section 3 of the UFP-QAPP.

APPENDIX L

ENVIRONMENTAL PROTECTION PLAN

ENVIRONMENTAL PROTECTION PLAN

1. GENERAL

This Environmental Protection Plan (EPP) has been prepared in accordance with DID MR-005-12 (Environmental Protection Plan) (USACE, 2003). The objective of this EPP is to provide adequate procedures during site activities to safeguard against detrimental impacts to the surrounding environment and its natural resources, to correct any damage done to the environment as a result of site activities, and to control noise and dust on-site within reasonable limits. This EPP addresses the known environmental concerns/issues associated with this project; however, during operations, unforeseen concerns/issues may arise. In this event, operations in the affected area will be suspended until the full potential environmental impact is understood and appropriate safeguards can be implemented.

2. IDENTIFICATION OF ARARS

Applicable or relevant and appropriate requirements (ARARs) are those cleanup standards, standards of control, and other substantive environmental or facility siting regulations and protection requirements, criteria, or limitations promulgated under Federal or State law. ARARs are identified on a general and site-specific basis and involve a two-part analysis: first, it is determined whether a given requirement is applicable; if not applicable, it is determined whether the requirement is nevertheless both relevant and appropriate. When a requirement is found to be both relevant and appropriate, that requirement must be complied with to the same degree as if it were applicable. Non-promulgated advisories or guidance documents issued by federal or state governments do not have the status of potential ARARs. However, these to be considered (TBC) criteria may be used in determining the necessary level of cleanup for human safety and protection of the environment.

An initial evaluation of ARARs has been performed. Evaluation of ARARs is an iterative process that will continue throughout the life of the project. **Table 1** lists action-specific, location-specific, and chemical-specific ARARs. Other TBC criteria are also evaluated.

Table 1 Potential ARARs and TBCs

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comment
Action-Specific			
National Environmental Policy Act (NEPA)	40 Code of Federal Regulations (CFR) 1500	NEPA is the national charter for the protection of the environment. It establishes policy, sets goals, and provides means for carrying out the policy.	NEPA procedures must ensure that information is available to public officials and citizens before decisions are made and before actions are taken.
National Contingency Plan (NCP)	40 CFR 300	Provides the organizational structure and procedures for preparing for, and responding to, discharges or releases of hazardous substances, pollutants, and contaminants.	
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) cleanup standards	42 United States Code (USC) 9621	CERCLA cleanup standards.	
Department of Transportation (DOT) – shipping containers	49 CFR 178	Prescribes the manufacturing and testing specifications for packaging and containers used for the transportation of hazardous materials in commerce.	
Environmental Protection and Enhancement	Army Regulation (AR) 200-1, DA PAM 200-1	Requires Army compliance with all environmental statutes and regulations and consultation with federal, state, and local regulatory agencies.	
Dept. of Army Ammunition and Explosive Safety Standards	AR 385-64, DA PAM 385-64	Requires that safety measures be taken for the handling of explosive ordnance.	Army Regulation that establishes Army standards for the storage, handling, transportation, and disposing of munitions.
United States Department of Defense (DoD) Ammunition and Explosives Safety Standards	DoD 6055.09-M	Requires that specialized personnel be employed to detect, remove, and dispose of munitions. This standard also defines the safety precautions and procedures for the detonation or disposal of munitions.	Establishes DoD ammunition and explosives safety standards.
Military Munitions Rule	40 CFR Part 266, Subpart M	Regulates unused munitions, munitions used for intended purposes, and used or fired munitions.	To be considered.

Table 1 Potential ARARs and TBCs (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comment
National Ambient Air Quality Standards (NAAQS)	40 CFR Part 50	Establishes primary and secondary NAAQS for ambient air quality to protect public health and welfare, for sulfur dioxide, nitrogen oxide, carbon monoxide, ozone, lead, and particulate matter.	Applicable to alternatives that have the potential to impact ambient air quality from soil excavation/grading.
Environment and Explosives Safety Management	DoD Directive (DoDD) 4715.11	Establishes policy for management of active and inactive military ranges. Includes guidelines for range clearance operations, hazard assessment, and recycling/ disposal.	
Resource Conservation and Recovery Act (RCRA)	40 CFR 236 – 259 for solid waste management, 40 CFR 260 – 279 for hazardous waste management, and VHWMR 9 Virginia Administrative Code (VAC) 20-80-60	As promulgated by the Virginia Waste Management Board under federal RCRA requirements, Virginia has an approved RCRA program, and Virginia Hazardous Waste Management Regulations (VHWMR) will govern instead of RCRA. However, Virginia does not yet have primacy for Land Disposal Restrictions. Disposal of the contaminated soils or treatment residuals at an off-site facility would trigger the RCRA land disposal restrictions of 40 CFR Part 268.	
Virginia Solid Waste Management Regulations	9 VAC 20-80-10 to 760	As promulgated by the Virginia Waste Management Board under federal RCRA requirements, this regulation will govern the generation, transport, treatment, and disposal of solid wastes.	Solid Waste Management Regulations will be an applicable ARAR if contaminated soil is excavated and removed from the site for treatment and/or disposal.

Table 1 Potential ARARs and TBCs (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comment
Air Pollution Control Board, Ambient Air Quality Standards, Standards of Performance for Visible Emissions and Fugitive Dust/Emissions [Rule 5-1], and Environmental Protection Agency National Emission Standards for Hazardous Air Pollutants [Rule 6-1]	Va. Code Ann. §§ 10.1-1300 to 1328 (2010); 9 VAC 5-30-10 to 80; 9 VAC 5-50-60 to 120; and 9 VAC 5-60-60 to 80	Promulgated by the Virginia Air Pollution Control Board under the requirements of the federal Clean Air Act, these regulations set policies and procedures to limit airborne particulate matter produced by construction activities and regulate all other types of potential air impacts.	Applicable for all active remedies that include dust generation or the generation of any air contaminants from the remedial action alternatives considered.
Stormwater Management Act, Stormwater Management Program Permit Regulations, Erosion and Sediment Control Law, and Erosion and Sediment Control Regulations	Va. Code Ann. §§ 10.1-603.2 to 603.15 (2001); 4 VAC 50-60-10 to 1240; Va. Code Ann. §§ 10.1-560 to 571 (2003); and 4 VAC 50-30-10 to 110.	Promulgated by the Virginia Water Control Board pursuant to the requirements of the Clean Water Act, these regulations describe the procedures and requirements to be followed in connection with the Virginia Stormwater Management Program (VSMP) permits.	An Erosion and Sediment Control Plan must be prepared prior to any land-disturbing activity. Applicable due to the potential for implementation of an active remedial action whose components could impact surface waters.
Location-Specific			
Endangered Species Act of 1973	16 USC 1531 et seq. 50 CFR 402	Establishes requirements to protect species threatened by extinction and habitats critical to their survival.	
Wild and Scenic Rivers Act	16 USC 1271	Establishes the Wild and Scenic River (WSR) System to protect rivers designated for their wild and scenic values from activities that may adversely affect those values.	No Wild and Scenic Rivers are currently listed within the Commonwealth of Virginia.
Fish and Wildlife Coordination Act	16 USC 661-666; 40 CFR 6.302 [g]	Require consultation when a federal department or agency proposes or authorizes any modification of any stream or other water body; requires adequate provisions for protection of fish and wildlife resources. It also establishes policy for Executive Order 11990, "Protection of Wetlands."	

Table 1 Potential ARARs and TBCs (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comment
Virginia Wetlands Mitigation Compensation Policy and Virginia Wetlands Regulations	4 VAC 20-390-10 to 50) and 9 VAC 25-380-10 to 30)	The Virginia Wetlands Mitigation Compensation Policy as promulgated by the Virginia Marine Resources Commission and the Virginia Wetland Regulations as promulgated by the State Water Control Board Virginia in support of the Wetlands Act and the Federal Water Pollution Control Act in 1972 identify situations in which wetland impacts must be mitigated/compensated.	Both are applicable because of the presence of wetlands in the potential remediation area and the construction activities associated with various remedies could potentially impact the wetlands. If wetlands are impacted, the compensation policy presents specific mitigation procedures to be followed.
Protection of Wetlands	Executive Order 11990	This policy includes requirements to avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. This rule was promulgated pursuant to the Water Resources Planning Act of 1965, section 402, Pub. L. 89–90, 79 Stat. 245 (42 USC 1962d–1).	This Order requires federal agencies to take action to avoid adversely affecting wetlands wherever possible under federally undertaken, financed, or assisted construction. These activities may be implemented as part of the remedial actions for the site. The requirements of this Executive Order are considered applicable to the site because of the potential for impacts to adjacent wetlands through stormwater runoff that could carry additional particulates or contaminated particulates to those wetlands during a remedial action.

Table 1 Potential ARARs and TBCs (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comment
Floodplain Management	Executive Order 11988	This policy includes requirements to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy or modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative. This rule was promulgated pursuant to the Water Resources Planning Act of 1965, section 402, Pub. L. 89–90, 79 Stat. 245 (42 USC 1962d–1).	This Order requires federal agencies to take actions to minimize the long-term and short-term adverse effects associated with modification of floodplains. Each agency is to determine whether an action will occur in a floodplain. The requirements of this Executive Order are considered applicable to the site because of the potential for impacts (e.g., through impacts of runoff from site construction activities that are associated with each remedy or altering elevations that impact flood management) to the floodplain during a remedial action.
Virginia Water Protection Permit Regulations	9 VAC 25-210-10 to 260	Promulgated by the State Water Control Board pursuant to the requirements of the Clean Water Act (33 USC §1251 et seq.) as amended 1987, describes the procedures and requirements to be followed when an activity may impact the physical, chemical, or biological properties of surface waters.	Applicable because the potential remediation area is adjacent to the surface waters, which could alter the elevations of wetlands and floodplains through particulate runoff during remedial action construction activities.
Chemical-Specific			
United States Environmental Protection Agency (EPA) Region 3 Regional Screening Levels (RSLs)	EPA Region 3 website	Media cleanup targets based on human exposure for industrial and residential use scenarios. For a single contaminant in a single medium, under standard default exposure assumptions, the TBC corresponds to the target risk or hazard quotient. However, the RSLs for non-carcinogens are adjusted by a factor or 0.1 to account for the cumulative effects of multiple contaminants.	

Table 1 Potential ARARs and TBCs (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comment
Site Specific Reference Values	Radford Army Ammunition Plant (RFAAP)	Establishes site-specific reference values that are 95% upper prediction limit of RFAAP background data.	
EPA Ecological Soil Screening Levels	EPA website	May aid in determining soil cleanup criteria by calculating ecological receptor exposures to contaminated soil using Biological Technical Assistance Group (BTAG) screening levels.	
EPA Region 3 freshwater sediment screening benchmarks	EPA Region 3 website	May aid in determining sediment cleanup criteria by calculating ecological receptor exposures to contaminated sediment using BTAG screening levels.	
Other			
DoD Contractors Safety Manual for Ammunition and Explosives	DoD 4145.26M	Manual provides safety requirements for contractual work involving ammunition and explosives.	
Discharges of Dredged or Fill Material into Waters of the U.S.	33 CFR Part 323	Establishes permit requirements for actions that involve dredging or filling in of a navigable waterway or wetland.	

3. IDENTIFICATION OF ENVIRONMENTAL RESOURCES AND EFFECTS

3.1 THREATENED/ENDANGERED SPECIES

The United States Fish and Wildlife Service (USFWS) does not list any critical habitat for threatened or endangered species within the boundaries of, or in the nearby vicinity of, the Munitions Response Site (MRS). The USFWS Environmental Conservation Online System lists the following species as present in Pulaski and/or Montgomery Counties based on published historical range and population (USFWS, 2014). However, previous biological surveys conducted at RFAAP and within the MRS have not documented the presence of any of these species (URS, 2003).

- Indiana bat
- Virginia big-eared bat
- Cumberland bean
- Roanoke logperch
- Virginia fringed mountain snail
- James spinymussel
- Smooth coneflower

3.2 SURFACE WATER RESOURCES

Surface water is located within the Area A (New River) portion of the investigation area. On-site sheet flow and drainage swale flow is expected to move to the New River through overland flow.

Water used on RFAAP is taken from the New River. Intake 1 is located upstream of the mouth of Stroubles Creek, and Intake 2 is located downstream of the mouth of Stroubles Creek. RFAAP Intake 1 is located just upstream from the MRS, on the opposite side of the New River. Intake 2 is located downstream of the MRS. The towns of Blacksburg and Christiansburg also draw drinking water from the New River, but this occurs upstream from RFAAP (URS, 2003).

Groundwater at RFAAP exists in alluvial aquifers, located within the floodplain of the New River, and in fractured bedrock. The hydrogeology of fractured bedrock aquifers is dominated by karst features. The hydraulic gradient underlying RFAAP generally trends toward the New River and away from the higher areas of RFAAP, with evidence of communication between groundwater and the New River (URS, 2003).

No known jurisdictional wetlands have been identified within the boundaries of the MRS; therefore, no wetland impacts are anticipated.

The nature of the investigation activities described in this QAPP is not expected to adversely impact these surface water resources. Project activities will comply with stormwater best management practices (BMPs). Additionally, project activities will be conducted in a manner that prevents the discharge of pollutants into adjacent surface water resources. If project activities occur in proximity to locations where the surface waters could potentially be impacted, Weston Solutions, Inc. (WESTON) will consult the Army to determine and implement appropriate measures of protection.

3.3 VEGETATION REMOVAL

Limited vegetation removal will be necessary at the MRS to aid survey and investigation activities. Wherever possible and where access permits, brush will be removed from the site and chipped. In some locations, where removal is not permitted, or in cases where the location is inaccessible, brush will be slashed so that it lies close to the ground. Additionally, the brush will be cut as low to the ground as possible. Woody plants with stems greater than 2 inches in diameter will not be treated as brush. Pruning will be considered if necessary to gain access to areas. Removal of trees larger than 2 inches in diameter is not anticipated.

3.4 CULTURAL, ARCHAEOLOGICAL, AND HISTORICAL RESOURCES

Cultural and archaeological resources have not been evaluated on a facility wide basis at RFAAP. No facilities on RFAAP are currently listed in the National Register of Historic Places (NRHP, 2015), although it is possible that some of RFAAP may be eligible based on the long history of operation of the plant. It is not anticipated that any of the infrastructure located on the MRS is eligible for inclusion in the NRHP (BSEn, 2018).

4. MITIGATION PROCEDURES

4.1 MANIFESTING, TRANSPORTING, AND DISPOSING OF WASTES

4.1.1 Non-Hazardous Wastes

All generated waste will be properly characterized and disposed of under the direction of the RFAAP Environmental Office and in accordance with all applicable requirements. It is expected that only non-hazardous material will be generated as a result of this project. All personal protective equipment (PPE) and disposable sampling equipment are considered non-hazardous. PPE and sampling equipment will be placed in a plastic bag and disposed in an appropriate refuse container.

Although munitions and explosives of concern (MEC) are potentially hazardous, once detonated in place or at the designated demolition area, the only remaining material requiring disposal will be scrap metal. WESTON intends to arrange for recycling of all scrap metal. In accordance with 40 CFR 261.6(a)(3), scrap metal, if recycled, is not subject to parts 262-266, or 268, 270, or 124. WESTON will recycle all scrap metal generated as a result of the RCRA Facility Investigation (RFI) and maintain records of all recycling.

Transportation of all wastes and materials will be conducted in accordance with applicable U.S. Department of Transportation (DOT) regulations, including labeling, use of placards, and documentation of transportation.

4.1.2 Hazardous Wastes

WESTON does not anticipate generating or encountering hazardous wastes during this project. If WESTON encounters any signs of hazardous materials/waste, WESTON will make appropriate attempts to avoid those areas, and the Program Health and Safety Manager and RFAAP Environmental Office will be notified. Appropriately trained individuals will be tasked with waste removal.

However, in the unlikely event that hazardous materials and wastes are encountered, they will be stored in authorized containers; labeled in accordance with applicable regulations; appropriately manifested; and transported to a permitted disposal facility in accordance with applicable Virginia

Department of Environmental Quality (VDEQ), DOT, and EPA regulations. Accumulation, transportation, and disposal of all hazardous waste will be coordinated with the RFAAP Environmental Office.

4.2 SECURITY OF HAZARDOUS MATERIALS

WESTON personnel will provide security to control the work area. All hazardous materials associated with the project (primarily explosives) will be secured as discussed in the Explosives Management Plan.

4.3 BURNING ACTIVITIES

Burning activities are not planned for this project. Potential ignition around the detonation of MEC or other possible ignition sources will be mitigated in accordance with the safety measures presented in the Accident Prevention Plan (APP). Open fires, such as campfires or fires to dispose of cut brush, will not be permitted during the performance of this project.

Smoking will be restricted to designated areas or within closed automobiles. Smoking areas will be designated by the Site Safety and Health Officer (SSHO) or Unexploded Ordnance Safety Officer (UXOSO). In all cases, cigarettes butts and matches must be disposed of either in an automobile ashtray or in a metal can. Cigarette butts and matches may not be tossed from car windows or discarded on the ground surface.

4.4 DUST AND EMISSION CONTROL

EPA has established National Ambient Air Quality Standards (NAAQS) pursuant to Sections 109 and 301(a) of the Clean Air Act (CAA). These standards, expressed in micrograms per cubic meter, establish safe concentration levels for each criteria pollutant. NAAQS have been set for six pollutants: particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and lead.

Because MEC demolition activities, intrusive investigations, and normal vehicle use are considered minor mobile sources of air emissions, it is not anticipated that project activities will have any significant effect on air quality. All vehicles and equipment will be in good working order and will meet applicable vehicle emissions requirements.

Although MEC detonation and intrusive investigations may result in a brief suspension of particulates, they will rapidly settle out of the air. Therefore, the activity is not expected to adversely affect air quality.

4.5 NOISE CONTROL AND PREVENTION

It is expected that this project will generate two primary sources of noise: noise from mechanical equipment (i.e., trucks and excavators), and noise from demolition activities. WESTON will control the noise emissions from mechanical equipment by ensuring that the manufacturer's noise control equipment is in place and functioning (i.e., mufflers). To minimize nuisance noise, equipment will be powered off when it is not in use.

The second source of noise will be pulse noises resulting from demolition activities. Both tamping the demolition shot with earth and observing weather conditions on the day of the shot will control this noise. For example, a day with a low cloud ceiling will transmit the nuisance noise more effectively than a clear day. To reduce the nuisance noise on a cloudy day, various options, including possibilities such as not conducting the demolition shot, waiting for a shift in the prevailing winds, reducing the net explosive weight of the shot, or some combination of controls, will be assessed. The SUXOS and the Demolition Supervisor will determine the applicable method of noise control.

Because noise generated by project activities will be limited to infrequent pulses that are short in duration, WESTON does not anticipate adverse impacts to resident fauna. It is expected that fauna will temporarily avoid areas where noise is being generated until the activities have ceased.

4.6 SPILL CONTROL AND PREVENTION

WESTON anticipates that unleaded gasoline, diesel fuel No.2, and motor oil will be the only substances with hazardous constituents that may be stored on-site and these will be stored in quantities less than 5 gallons. To decrease the amount of pollutants to be stored on-site WESTON plans to conduct all fueling and repair of vehicles off-site, to the greatest extent possible.

Hazardous liquids that are necessary to conduct the project investigations will be stored in the smallest quantities possible. Should the storage of hazardous waste or materials with hazardous

constituents be necessary, a storage tank constructed primarily of non-earthen materials or a stationary device designed to contain an accumulation of hazardous waste would be placed within an approved secondary containment of adequate size to contain a spill (110% of storage tank size). The tank would be managed in accordance with the APP and 40 CFR Subpart I.

Because of the nature of the operations, the potential for a spill of pollutants during operations is low. The highest probability for a spill will occur during re-fueling operations of equipment (i.e., filling a chainsaw's gas and oil tanks). In the event of a spill, WESTON will notify appropriate emergency personnel. The RFAAP Environmental Office would complete any required notifications to VDEQ. Additionally, WESTON will be equipped with spill kits on-site for immediate cleanup if a petroleum product is inadvertently spilled. Any spills originating from small containers (e.g., gasoline cans) would be contained using absorbent materials.

If fuel or oil is spilled, the following measures will be taken:

- The spill area will be isolated and contained.
- RFAAP Environmental Office will be notified during a spill response.
- The liquid and affected soil will be shoveled into a plastic bag and subsequently placed into a DOT-approved shipping container.
- Each container will be labeled to identify its contents.
- The container(s) will be shipped off-site and disposed of at a permitted facility in accordance with the Code of Federal Regulations 260 – 270 and 9 VAC 20-80.

4.7 STORAGE AREAS AND TEMPORARY FACILITIES

Storage of materials will be in a designated on-site area approved by the RFAAP Environmental Office. Scrap metal will be containerized and stored in locked 55-gallon drums. Drums will be disposed of off-site at the conclusion of the project. WESTON does not anticipate the construction or use of a temporary storage area for hazardous materials. Temporary storage of fuel containers will be in vehicles. Unless directed by the United States Army Corps of Engineers (USACE) Project Manager (PM) to do otherwise, all temporary facilities erected by WESTON to execute the project will be removed during demobilization.

4.8 ACCESS ROUTES

WESTON will use establish roads to gain access to various portions of the MRS. If access to areas of the MRS is not available through use of a road, WESTON will utilize areas that will result in no environmental impact. No environmental impact is anticipated from the use of existing roads.

4.9 VEGETATION PROTECTION AND RESTORATION

WESTON shall take all actions necessary to protect and prevent unnecessary damage to vegetation. WESTON personnel will disturb only the vegetation necessary for safe and effective access for investigation activities. WESTON will work in close coordination with the RFAAP Environmental Office to ensure that impacts on all rare and protected floral and faunal species will be avoided and minimized to the greatest extent practicable. Because of the limited vegetation removal activities planned in the MRS, no tree or shrub restoration is planned after investigation activities are completed.

4.10 SITE WATER RUN-ON AND RUNOFF

Run-on and runoff water controls are not necessary because there is no expectation that contaminated soils, water, or waste are present on-site, or that such materials will be generated while activities are conducted. Project activities will comply with stormwater management BMPs. Additionally, project activities will be conducted in a manner that prevents the discharge of pollutants into adjacent waterways; waste disposal will be at an off-site facility. WESTON will consult the RFAAP Environmental Office to determine and implement appropriate measures of protection for any areas where there are adjacent waterways (i.e., sandbags or other barrier devices could be used to prevent the spread of potentially contaminated soil or water).

4.11 DECONTAMINATION PROCEDURES

All investigation activities of this project within the MRS will be conducted in Level D PPE. No decontamination of personnel is anticipated to be performed. All PPE are considered non-hazardous. As such, PPE will be placed in a plastic bag, disposed of in an appropriate refuse container, and transported off-site for disposal through the municipal waste system. Although the use of disposable equipment (e.g., plastic scoops, disposable pans) is planned, if non-disposal equipment is used for MC sampling, they will require decontamination in accordance with the

UFP QAPP. Equipment and vehicles used for other aspects of the RFI field efforts described in the QAPP are not expected to require decontamination.

4.12 MINIMIZING AREAS OF DISTURBANCE

To the greatest extent practicable, all activities associated with this project will be conducted in a manner that will avoid and minimize impacts to land resources both within and outside of the project boundaries. The area of soil that will be disturbed on this project is not anticipated to be above the threshold that requires an erosion and sediment control plan and provisions.

5. POST-ACTIVITY SITE RESTORATION

All wastes will be removed from the site immediately upon completion of each day's field activities. Therefore, no post–activity cleanup should be required. A post–activity inspection will be conducted by the Field Leader to ensure the location is left clean.

Restoration activities will be approved prior to releasing WESTON from the contract. This will be accomplished by obtaining USACE PM approval. This will be coordinated by the RFAAP Environmental Office and USACE, and the restored areas will be visually inspected immediately after completing site restoration.

5.1 AIR AND EFFECTS MONITORING

Air monitoring is not necessary for the activities planned during this investigation. There is minimal intrusive activity and WESTON does not anticipate finding hazardous, toxic, or radioactive waste (HTRW)-related contamination that would require air sampling. If conditions change and it is deemed necessary, WESTON would perform required monitoring to evaluate airborne contamination.

The use of engineering controls (e.g., soil cover and/or sandbags for mitigation of fragmentation, blast, and noise effects resulting from intentional detonation of munitions) will be required for all demolition shots conducted. The quantity of MEC to be destroyed will be kept to a minimum to reduce overpressure and noise travel into residential areas. Additionally, MEC/MPPEH that is acceptable to move will be relocated to remote areas within the MRS prior to demolition, thereby reducing overpressure and noise levels in more populated areas.

6. REFERENCES

Bering Sea Environmental, LLC (BSEn), 2018. Final Site Investigation Report. Former Gun and Mortar Range Munitions Response Site (RFAAP-002-R-01). September.

NRHP (National Register of Historic Places). 2015. National Register of Historic Places. Retrieved August 2015, from National Park Service, U.S. Department of the Interior: http://www.nps.gov/nr/research/index.htm

URS (URS Corporation). 2003. Final Master Work Plan, Quality Assurance Plan, Health and Safety Plan. Radford Army Ammunition Plant, Radford, VA. August 2003.

USACE (U.S. Army Corps of Engineers). 2003. DID MR-005-12, Environmental Protection Plan.

USFWS (U.S. Fish and Wildlife Service. 2014. Environmental Conservation Online System. Retrieved from U.S. Fish & Wildlife Service: http://www.fws.gov/endangered/

APPENDIX M

ADVANCED GEOPHYSICAL CLASSIFICATION SOPS

Provided on CD

GCO SOP-11

2X2 SENSOR SYSTEM ASSEMBLY AND CORRECT OPERATION VERIFICATION

2x2 Sensor System Assembly and Correct Operation Verification

Document No. GCO-SOP-11

Reviewed and Approved by: _____ Date: Sept. 9, 2019
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by: _____ Date: Sept. 9, 2019
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
3.0	Sept. 9, 2019	Referenced the use of a serialized industry standard object and revised MetalMapper 2.x2 manual and/or need to use the manufacturers operating manual throughout the document. Section 3.7, clarified pass/ fail notifications for cued surveys.	G. Abrams	M. Costello
2.0	Sept. 14, 2017	The first paragraph of Section 3.1 has been revised as follows, "All assembly operations are described in the TEMTADS 2x2 user guide (NRL, 2014). The current version of the TEMTADS 2X2 user guide will be used as a reference during sensor assembly and verification.	G. Abrams	M. Costello
1.0	August 22, 2017	GCO-SOP-11 has been revised to remove reference to the Manual as Attachment 2, and the NRL TEMTADS 2x2 is now listed and controlled separately as a Reference Document on GCO-List-1, Master List of Documents. A bullet has been added to the Section 2 list of required equipment and materials to include an appropriate WESTON GCO SOP pertaining to use of navigation equipment; GCO-SOP-31, Setup and Operation of RTK GPS Navigation System, or GCO-SOP-32, Setup and Operation of RTS Navigation System. A note has been added to the 4th bullet in Section 2 to clarify that if use of digital cameras on site is prohibited, the GCO will follow site procedures for obtaining photos, if available. Step 2 of Section 3.1 has been revised to state, "Attach the handle and then attach the wheels or sled."	M. Costello	G. Abrams

Controlled Copy

		The second paragraph of Section 5 has been deleted from the SOP.		
0.0	July 12, 2017	Original Publication	M. Costello	T. King

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when assembling the 2x2 sensor system for data collection and verifying that all components are correctly assembled, operating normally, and capable of acquiring data of sufficient quality.

This SOP has been prepared in accordance with SOP 1T, provided in Appendix A of the Intergovernmental Data Quality Task Force (IDQTF) *Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP)* (IDQTF, 2016).

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into Advanced Geophysical Classification Projects (AGC).

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following is a list of required equipment and materials:

- 2x2 sensor coupled with a real-time kinematic (RTK) Global Positioning System (GPS) or robotic total station (RTS).
- Inertial Measurement Unit (IMU) for orientation measurements used to measure yaw, pitch, and roll of the 2x2 sensor.
- A serialized Industry Standard Object (ISO) for operational testing.
- Digital camera or cell phone to take photographs of the 2x2 sensor. (Note: if use of digital cameras on site is prohibited, the GCO will follow site procedures for obtaining photos if available). Personnel should not carry cell phones when operating the sensor.
- Appropriate WESTON GCO SOP pertaining to use of navigation equipment; GCO-SOP-31, Setup and Operation of RTK GPS Navigation System, or GCO-SOP-32, Setup and Operation of RTS Navigation System.
- Preparatory 2x2 Sensor System Assembly Quality Control (QC) Checklist, included as **Attachment 1** to this SOP.
- Time-domain electromagnetic multi-sensor tower array detection system (TEMTADS) 2x2 User's Guide [US Naval Research Laboratory (NRL), 2014] (if using TEMTADS 2x2 sensor).
- MetalMapper 2x2 Operations Manual (Geometrics, Rev 1.01) (if using MetalMapper 2x2 sensor).

CONTROLLED COPY

The following individuals will be involved in the assembly and verification of the 2x2:

- Project or Field Geophysicist – Confirms that sensor was assembled correctly either in person or through notes, photographs, and 2x2 Sensor System Assembly QC Checklist.
- QC Geophysicist – Reviews QC testing and verifies results are documented in the QC database.
- Field Team Leader – Operates 2x2 sensor during data collection.
- Data Processor – Processes collected data and documents QC results in the project QC database.

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability (DOC), and project-required documentation of qualifications will be provided in the project-specific AGC-QAPP (Worksheets #4, 7, and 8).

3. Procedure and Protocols

The 2x2 system is an advanced electromagnetic induction sensor designed for the detection and classification of buried metal objects. The sensor consists of four sensor elements arranged on 40-centimeter (cm) centers in a 2x2 array. Each sensor element consists of a 35-cm square transmit coil for target illumination with an 8-cm three-axis receive cube centered in the transmit coil. The transmitters are energized in sequence and the decay curve is recoded up to 25 milliseconds (ms) after the transmitters are turned off for each of the 12 (4 cubes with 3 axes each) receive channels. A schematic of the sensor coil configuration is shown on **Figure 3-1**.

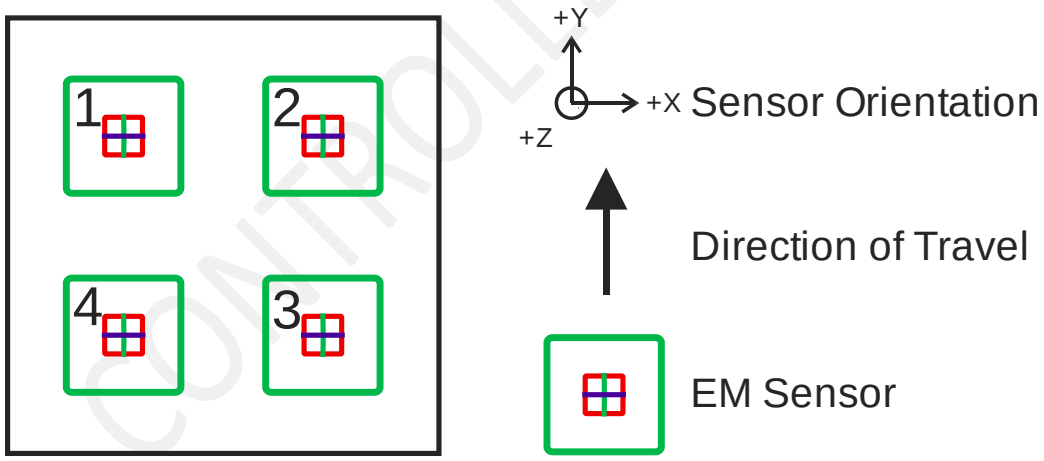


Figure 3-1 Orientation of the Four 2x2 Sensor Elements (Top View)

Positioning of the 2x2 sensor is accomplished using an RTK GPS or RTS. The 2x2 orientation is measured using a six-degree-of-freedom IMU. For proper functioning it is important to verify that the IMU has been mounted to the 2x2 in the correct orientation.

CONTROLLED COPY

3.1 Assemble the 2x2

All assembly operations are described in the TEMTADS 2x2 user guide (NRL, 2014) or the MetalMapper 2x2 Operations Manual (Geometrics, Rev 1.01). The current version of the TEMTADS 2X2 user guide or MetalMapper 2x2 operations manual will be used as a reference during sensor assembly and verification. The assembly steps are briefly described below:

1. Remove the sensor assembly from the packing crate following the instructions in the unpacking guide.

2. Attach the handle and then attach the wheels or sled.

3. Securely attach the GPS or RTS antenna to the top of the mounting platform. If GPS is not being used, move to Step 4.

4. Set the IMU onto its position below the GPS/RTS. The attachment will be secured after correct IMU orientation is verified.

5. Connect the sensor cable bundle to the sensor. This includes the sensor Tx and Rx cables and the cables to the GPS/RTS and IMU.

6. Attach the Tx, Rx, and IMU cables to the electronics box. The GPS/RTS cable will be attached after booting the computer.

3.2 Turn On and Initialize the Data Acquisition Computers

Following the instructions provided in the operating manuals start the data acquisition system. After the main computer in the electronics housing boots, plug the GPS/RTS cable into the electronics housing. The last step involves observing the IMU output. Leave the system in this state for the next operation.

3.3 Verify IMU Orientation

The procedure to verify the correct orientation of the IMU is shown in **Figure 3-2** and instructions for this test follow:

CONTROLLED COPY

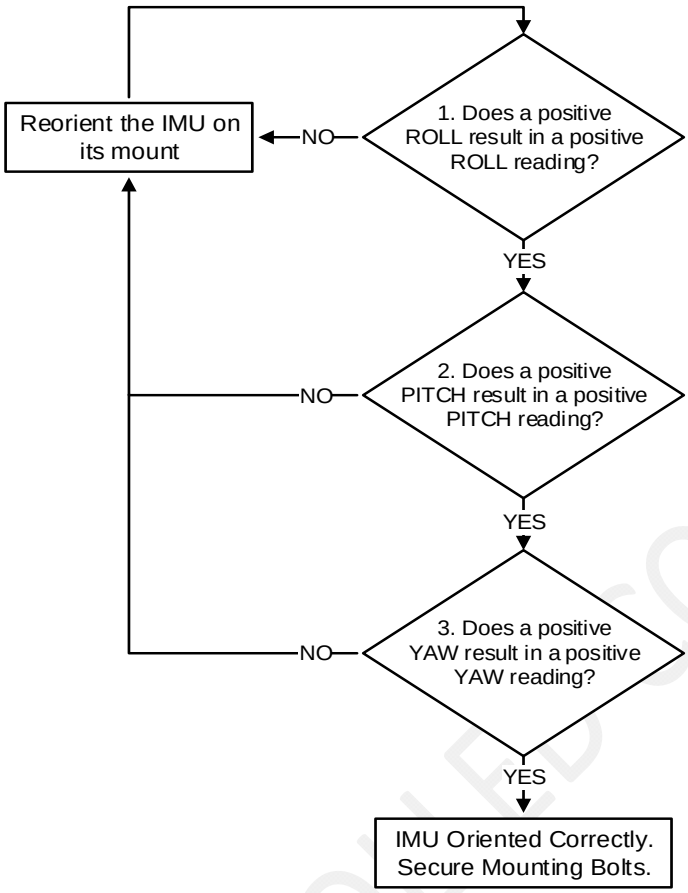


Figure 3-2 Procedure for Verifying IMU Orientation

1. Facing the direction of travel, rotate the IMU around the along-track axis to produce a positive ROLL as shown in **Figure 3-3**. Verify that the data acquisition system records a positive ROLL, as shown in **Figure 3-4**. If it does not, reorient the IMU on its mount and test again.

2. Standing on the side of the sensor with the direction of travel to your right, rotate the IMU around the cross-track axis to produce a positive PITCH as shown in **Figure 3-3**. Verify that the data acquisition system records a positive PITCH. If it does not, reorient the IMU on its mount and return to Step 1.

3. Looking down on the sensor from above, rotate the IMU around the vertical axis to produce a positive YAW as shown in **Figure 3-3**. Verify that the data acquisition system records a positive YAW. If it does not, reorient the IMU on its mount and return to Step 1.

CONTROLLED COPY

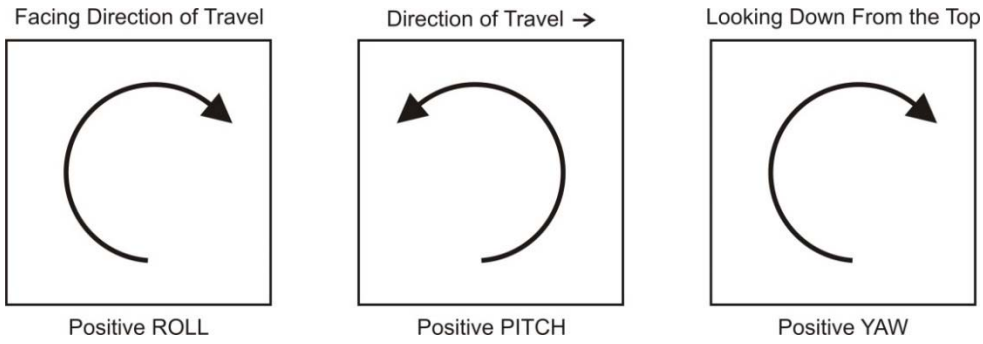
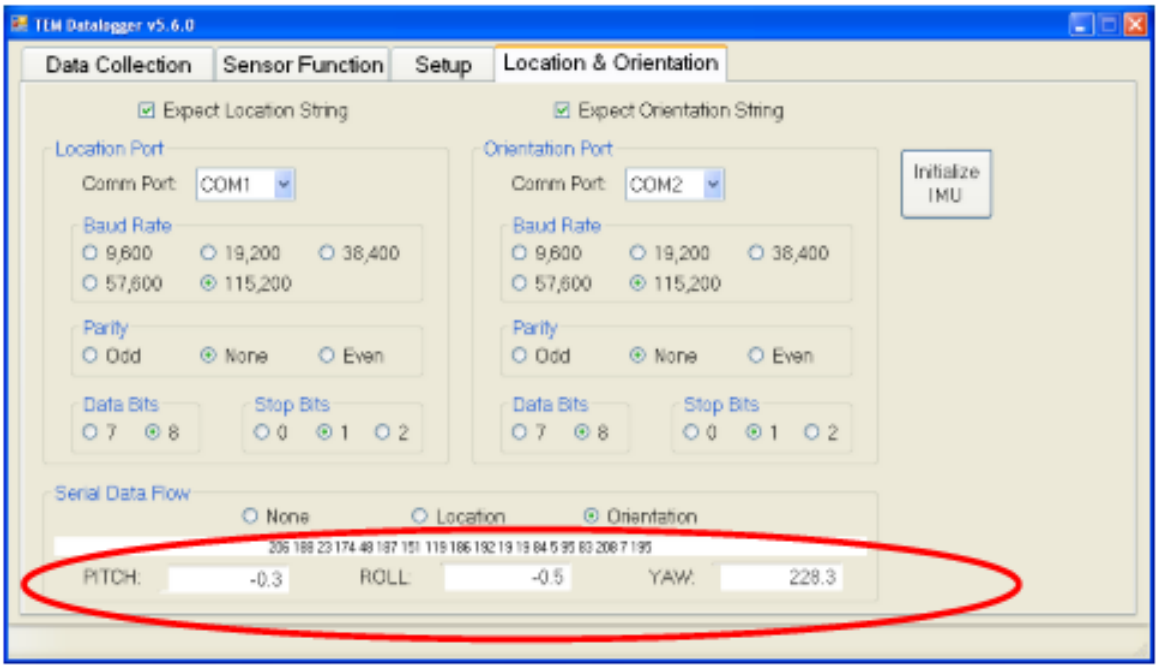
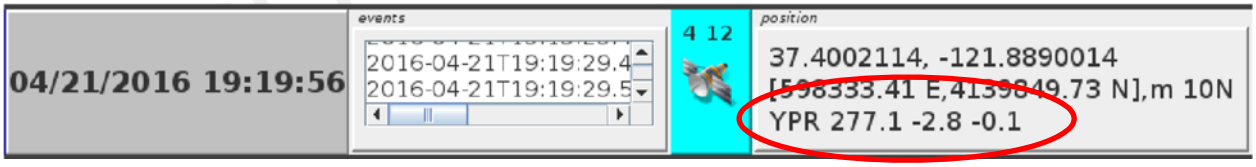


Figure 3-3 Positive ROLL, PITCH, and YAW Rotations of the IMU



A) TEMTADS



B) MetalMapper 2x2

Figure 3-4 Electronics Box Screen Showing Orientation Inputs for TEMTADS (A) and MetalMapper 2x2 (B)

3.4 Verify GPS Operation

Turn on the GPS/RTS receiver and allow it time to lock onto a position. Verify that GPS/RTS readings are being received at the data acquisition computer.

3.5 Photograph the Sensor

Using a cell phone or other digital camera, photograph the installed sensor. Verify that the photograph(s) show the locations and orientations of the GPS/RTS and IMU sensors.

3.6 Set Up the Data Acquisition Parameters

Data acquisition parameters will be entered in accordance with the manufacture operating manual. For the TEMTADS use the [Setup] tab in TEMDataLogger or TEMTablet to set the correct data acquisition parameters for the dynamic or cued survey. The easiest way to set the parameters is to use [Standard Dynamic] or [Standard Cued] button, **Figure 3-5**. The standard parameters are listed in **Table 3-1**.

Table 3-1 Standard Data Acquisition Parameters

Parameter	Cued Survey	Dynamic Survey
Acq Mode	Decimated	Decimated
Gate Width	5%	20%
Stacks	18	1
Repeats	9	3
Stack Period	0.9	0.033

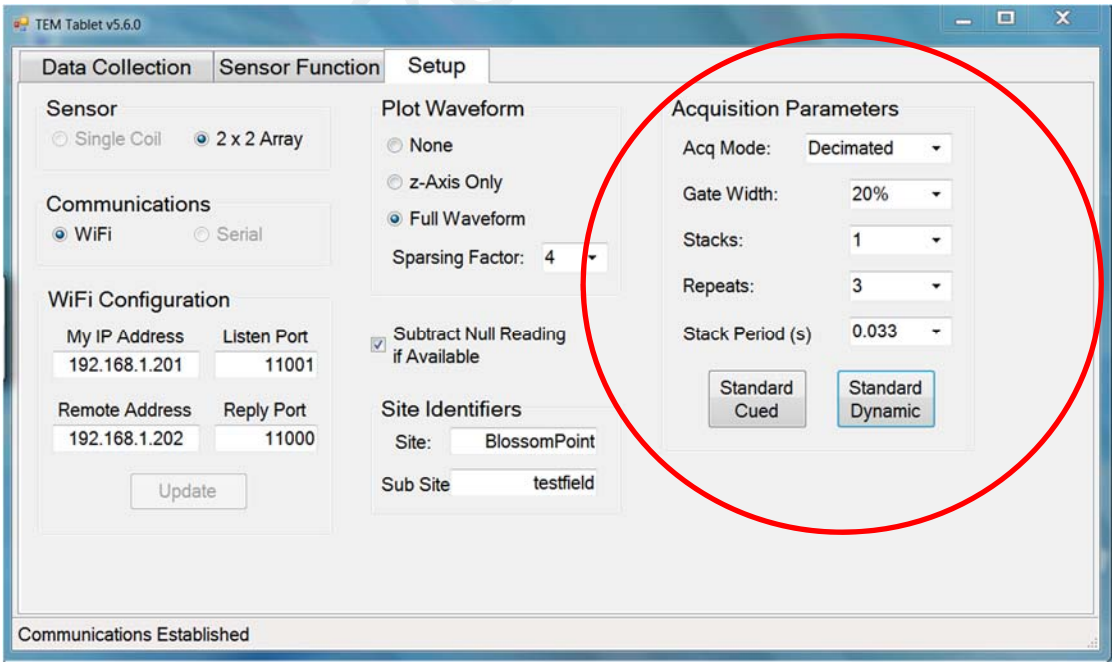


Figure 3-5 Standard Acquisition Parameters for Dynamic Surveys

3.7 Perform a Sensor Function Test

The sensor function test will be performed using cued mode acquisition parameters. If there is a reference response for the combination of hardware and data acquisition parameters you are using, the [Sensor Function] tab will be available on the data acquisition computer. Access that tab to perform a sensor function test as illustrated in **Figure 3-6** and described in the following steps.

1. Position the sensor in a spot known to be clear of buried metal. Often the clear position in the Instrument Verification Strip (IVS) will be the best choice. Collect a background measurement from [Sensor Function] tab of the data acquisition software.

2. Without moving the sensor, mount the serialized ISO test item in the hole on the top of the sensor housing.

3. Collect sensor function data. If the results agree with the reference values, a green light-emitting diode (LED) is displayed or a message of sensor function test passed will appear. If they do not agree, a red LED or a message of sensor function test failed is displayed along with a summary of the incorrect results.

4. Transfer the background and sensor function data files to the QC Geophysicist for archiving in accordance with GCO-SOP-7, Control of Records.

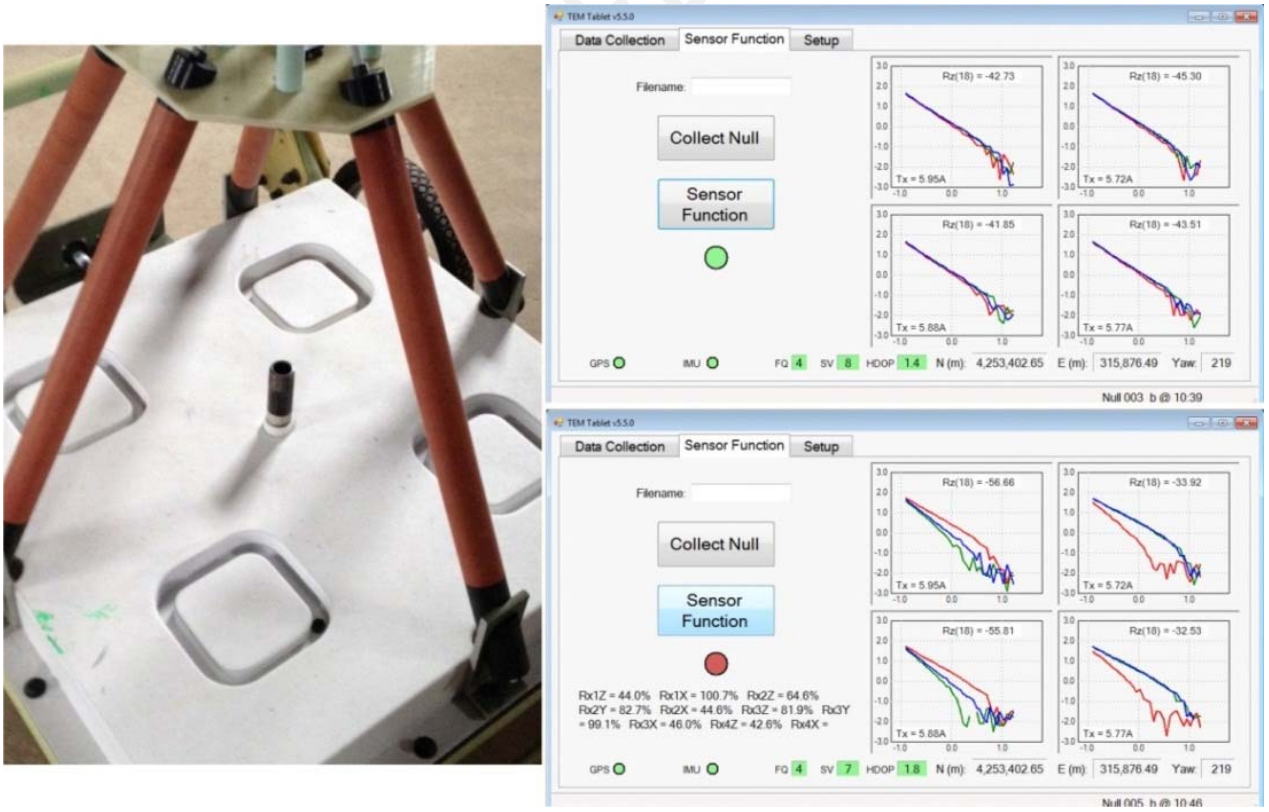


Figure 3-6 TEMTADS Left Panel

4. Data Management

The following sections describe the input data that are needed to perform this SOP and the resulting output data.

4.1 Input Data Required

Input data consist of the assembly and operation instructions for the 2x2 sensor in the unpacking instructions and user guides referenced within this SOP.

4.2 Output Data

The results of the sensor function test described in Section 3.6 will be saved in the project-specific data file. The QC checklist in **Attachment 1** of this SOP will be completed, signed, and filed with the assembly photograph(s) as proof of correct assembly.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

Work in accordance with this SOP will be a definable feature of work to be accomplished only during the preparatory phase of geophysical projects specified within a site-specific AGC-QAPP. As a result, only preparatory QC checks will be performed (i.e., the inspections on the Preparatory 2x2 Sensor Assembly QC Checklist, included as **Attachment 1**). This checklist will be completed by the Field or Project Geophysicist and will be reviewed by the QC Geophysicist who will document the implementation of this SOP in a Geophysics Daily QC Report.

6. Reporting

Achievement of the Sensor Assembly MQOs (as specified in Worksheet #22 of the project-specific AGC-QAPP) will be documented by the Field or Project Geophysicist by completion of the Preparatory 2x2 Sensor System Assembly QC Checklist (**Attachment 1**) and will be verified by the QC Geophysicist in a Geophysics Daily QC Report.

The delivered data package for the assembled and tested 2x2 sensor will be included in the IVS Letter Report in accordance with GCO-SOP-12, Testing of Sensor and System at the Instrument Verification Strip (IVS), and will include the following information:

- A brief description of the assembly and test process along with the photograph(s) required by Section 3.4 of this SOP.
- The completed Preparatory QC Checklist signed by the Project or Field Geophysicist and checked by the QC Geophysicist verifying the assembly and orientation tests described above.
- The sensor Function Test results.

6.1 Terms, Definitions and Abbreviations

6.2 Definitions/Terms

No terms or definitions are included in this SOP.

CONTROLLED COPY

6.3 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
DOC	Demonstration of Capability
cm	centimeter
GCO	Geophysical Classification Organization
GPS	global positioning system
IDQTF	Intergovernmental Data Quality Task Force
IMU	Inertial Measurement Unit
ISO	Industry Standard Object
IVS	Instrument Verification Strip
LED	light-enhanced diode
MQO	measurement quality objective
ms	millisecond
NRL	US Naval Research Laboratory
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RTK	real-time kinetic
RTS	robotic total station
SOP	Standard Operating Procedure
TEMTADS	time-domain electromagnetic multi-sensor tower array detection system
WESTON®	Weston Solutions, Inc.

7. References

IDQTF (Intergovernmental Data Quality Task Force). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

CONTROLLED COPY

Geometrics, Inc. 2017. MetalMapper 2x2 Operations Manual, Rev 1.01.

NRL (US Naval Research Laboratory). 2014. TEMTADS MP 2x2 Cart User's Guide, v2.00, MTADS Program, US Naval Research Laboratory, Chemistry Division, Washington, DC. May 2014.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-12, Testing of Sensor and System at the Instrument Verification Strip (IVS) (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-31, Setup and Operation of RTK GPS Navigation System (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-32, Setup and Operation of RTS Navigation System (current version). West Chester, PA.

8. Attachments

CONTROLLED COPY

Attachment 1 Preparatory 2x2 Sensor System Assembly QC Checklist

This checklist is to be completed by the Field or Project Geophysicist and checked by the QC Geophysicist during assembly and initial testing of the system.

QC Step	QC Process and Guidance Reference	Yes/ No	Initial
1. Qualifications	Are the qualifications of the Project and Field Geophysicists and the Data Analyst in accordance with GCO-SOP-23 and with the AGC-QAPP Worksheets 4, 7, and 8?		
2. Assembly	Is the 2x2 sensor assembled in accordance with the published instructions and in the sequence specified in Section 3.1 of this SOP?		
3. Testing: IMU orientation verification	Have the procedure and tests for verification of the IMU orientation been completed in accordance with Section 3.3 of this SOP?		
4. Testing: GPS	Was the GPS warmed up and allowed time to lock onto position in accordance with Section 3.4 of this SOP?		
5. Photograph the installation	Was a photograph of the 2x2 showing the placement and orientation of the GPS and IMU taken in accordance with Section 3.5 of this SOP?		
6. 2x2 sensor function test	Was the 2x2 sensor function test performed in accordance with Section 3.7 of this SOP and were the results saved in the project-specific database?		

Project or Field Geophysicist: _____ Date: _____

CONTROLLED COPY

GCO-SOP-12

ADVANCED CLASSIFICATION INSTRUMENT VERIFICATION STRIP

Advanced Classification Instrument Verification Strip (IVS)

Document No. GCO-SOP-12

Reviewed and Approved by: _____ Date: Sept. 9, 2019
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by: _____ Date: Sept. 9, 2019
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
4.0	Sept. 9, 2019	Section 3.2.1, Added reference to instrument specific owners manual. Section 3.2.2, Added reference to HDF5 files. Attachment 1, Deleted reference to a duplicate data collection check.	B. Guthrie	G. Abrams
3.0	Sept. 4, 2018	Section 3.2, this statement has been added to the first sentence, "using the same collection method(s) used on that day." The full sentence now reads as follows, "Prior to collecting production data each morning and in the evening after completing field operations, the advanced EMI sensor will be used to collect IVS data using the same collection method(s) used on that day to ensure equipment is functioning properly.	G. Abrams	R. Steigerwalt
2.0	Sept. 14, 2017	Section 3.2, the following sentence has been removed from the first paragraph, "Initial IVS testing will follow the same procedures as daily tests but will be repeated 5 times to be used as a baseline assessment of instrument functionality." Section 3.2.3, the following statement has been removed from the 4th bullet, "The initial location will be determined by averaging the results of the five surveys of the IVS performed during initial testing."	G. Abrams	M. Costello
1.0	August 22, 2017	Revision 1.0 of this SOP includes editorial and substantive changes. The following substantive changes has been made to this SOP: Section 3 of the SOP has been reorganized into subsections 3.1, Instrument Verification Strip Construction, and 3.2, IVS Data Collection and Processing. Section 3.2 has been reorganized to address data collection and processing activities	G. Abrams	R. Steigerwalt

		independently as subsections 3.2.1, Instrument Function Test, 3.2.2, Cued IVS Processing, 3.2.3, Dynamic IVS Processing, and 3.2.4, IVS Data Assessment. Additional detail has been incorporated into subsections 3.2.1 through 3.2.4 to further illustrate each activity. An additional bullet has been included in Section 2 to that states, "UXO Technicians – provide anomaly avoidance for intrusive activities during IVS construction if within munitions site boundaries." Additional text has been included in section 3.1.3, Step 3 to state that photographs will be taken of each seed item prior to burial to record seed condition, depth, and orientation. An additional bullet has been added to the list of materials and equipment in Section 2 to include a digital camera or cell phone for photographing seed items, along with a note which states if use of digital cameras on site is prohibited, the GCO will follow site procedures for obtaining photos if available. The second paragraph of section 3.1.3, Step 3 has been revised to clarify that coordinates of each item will be recorded using acceptable survey equipment. Measurements of the item depths will be to the center of mass of each item measured from the average surrounding elevation of the ground using a straight edge for measurement control. The last bullet in Section 3.2.2, Cued IVS Processing, has been revised to state, "Verify that offset between the IVS ground truth and the modeled position for each seed is within the MQO specified in the project-specific QAPP and that library matching provided the appropriate results." The last bullet in Section 3.2.3, Dynamic IVS Processing have been revised to state, "Verify that the offset between the selected target locations and the initial location measured for each seed is within the MQO specified in the project-specific QAPP. The initial location will be determined by averaging the results of the five surveys of the IVS performed during initial testing." Section 3.1.3, IVS Procedures, Step 3, has been revised to include the following text, "A blank space will be established within the IVS to be used as a background location and will be validated using the procedures described in GCO-SOP-18, Collection		

CONTROLLED COPY

		of Static Background Measurements. A reference to GCO-SOP-18 has been included in Section 8, References. Former Steps 9 and 10, have been removed from the IVS Construction and Initial Demonstration QC Checklist, and Step 9, Data analysis now states, "Do the processed IVS results match the expected locations and library values in accordance with this SOP?" Former Step 12 is now Step 10 on the QC Checklist, and remains otherwise unchanged.		
0.0	July 12, 2017	Original Publication	M. Costello	T. King

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to be employed when verifying the operation of an advanced digital geophysical mapping system prior to and during site surveys. The Instrument Verification Strip (IVS) is constructed of a series of buried inert munitions or industry standard objects (ISO). During the IVS process the advanced electromagnetic induction sensor system measures the response of each item in the IVS and these responses are compared to a library of expected responses to ensure and document proper functioning of the system.

This SOP has been prepared in accordance with SOP 2, provided within Appendix A of the Intergovernmental Data Quality Task Force (IDQTF) *Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP)* (IDQTF, 2016).

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following is a list of required equipment and materials:

- Advanced electromagnetic induction (EMI) sensor coupled with a real-time kinematic (RTK) Global Positioning System (GPS) and/or robotic total station (RTS) and Inertial Measurement Unit (IMU) for orientation measurements.
- Transport vehicle (skid steer, tractor, extended reach forklift) used to move the sensor (if required) during data collection.
- Quality Control (QC) seed items as specified in the site-specific AGC-QAPP [Industry Standard Objects (ISOs) or inert munitions]to construct the IVS.
- Measuring tape and non-metallic markers (pin flags, stakes, tent pegs, spray paint, etc.) to mark the positions of the test items and the beginning and end of the IVS.
- Hand tools including shovels, pick axes, breaker bars, etc. to construct the IVS.

CONTROLLED COPY

- Analog instrument, such as a Schonstedt or EM sensor used to search for burial metal or confirm there are no significant metallic items in a specific location.
- Digital camera or cell phone for photographing seed items (see section 3.1.3). (Note: if use of digital cameras on site is prohibited, the GCO will follow site procedures for obtaining photos if available).
- IVS Construction and Initial Demonstration Quality Control (QC) Checklist, included as **Attachment 1** to this SOP.

The following individuals will be involved in establishing and verifying correct operation of the sensor systems at the IVS:

- Project Geophysicist – Designs IVS and reviews IVS testing results; responsible for production of IVS Technical Memorandum.
- QC Geophysicist – Reviews IVS testing results and verifies IVS results are documented in the QC database.
- Field Team Leader – Documents IVS seed data (position, depth, type) and operates geophysical and positioning equipment over the IVS and noise strip.
- Data Analyst – Processes IVS data and documents results in the QC database.
- Note: multiple roles may be performed by a single individual (e.g., the Project Geophysicist may also perform the roles of the Field Geophysicist or Data Analyst).UXO Technicians – provide anomaly avoidance for intrusive activities during IVS construction if within munitions site boundaries.

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the in the project-specific AGC-QAPP (Worksheets #4, 7 & 8).

3. Procedure and Guidelines

3.1 Instrument Verification Strip Construction

Verification of the advanced EMI system is accomplished using an IVS. Multiple IVS locations may be constructed during the project for convenience (for example, to avoid long travel times to reach the IVS on large sites). The constructions details and verification procedures described in this document apply to each IVS location.

3.1.1 Location and Configuration of the IVS

IVS locations will be determined during initial site reconnaissance by the DGM field team. The IVS should be established in an area that is easily accessible, not prone to flooding and other weather-related phenomena, geologically representative of the MRS, and is determined to be relatively free of subsurface metal objects. The IVS is constructed as one or more survey transects.

3.1.2 IVS Objects

Seed objects for the IVS can be either actual inert munitions or ISOs. ISOs, if used, should approximate the size of the MEC expected to be found on the site and more than one type of ISO

CONTROLLED COPY

should be used if MEC of various sizes are expected. Small, medium, or large ISOs, singly or in combination, can be selected. **Table 3-1** shows the specifications for the three possible ISO and **Figure 3-1** is a photograph of the three ISOs.

Table 3-1 Industry Standard Objects Characterized for use as Munitions Surrogates

Item	Nominal Pipe Size	Outside Diameter	Length	Part Number[1]	Schedule
Small ISO80	1"	1.315" (33 millimeter (mm))	4" (102 mm)	4550K226	80
Medium ISO40	2"	2.375" (60 mm)	8" (204 mm)	44615K529	40
Large ISO40	4"	4.500" (115 mm)	12" (306 mm)	44615K137	40

[1] Part number from the McMaster-Carr catalog (http://www.mcmaster.com/).



Figure 3-1 Small, Medium, and Large ISO

3.1.3 IVS Procedures

Figure 3-2 illustrates the overall IVS process and the procedures to be followed during the siting, emplacement of the IVS. The process is described as follows:

1. An IVS location will be selected with preference for the following (although none of the conditions are vital for IVS success):

    - Terrain, geology, and vegetation similar to that of a majority of the DGM survey area
    - Geophysical noise conditions similar to those expected across the survey area
    - Large enough site to accommodate all necessary IVS tests and equipment and for adequate spacing (at least 3-m separation and preferably greater) of the ISO items to avoid ambiguities in data evaluation

- Readily accessible to project personnel
- Close proximity to the actual survey site (if not within the site)

2. The Field Team Leader will perform a background DGM survey with the advanced EMI sensor or other DGM instrument. The purpose of this step is to document the appropriateness of the location (e.g. few existing anomalies), and will verify that IVS targets are not seeded near existing anomalies. The data from this IVS pre-survey will be processed and provided to the Project, and QC Geophysicists for evaluation before any seeding is performed.

3. Once the IVS area is cleared in accordance with the project-specific AGC-QAPP, and deemed suitable for use, (i.e. free of significant subsurface anomalies or containing anomalies that are clearly identified so that they can be avoided during seeding), targets will be buried horizontally at depths below ground surface of approximately 3 and 7 times their diameter. These depths are intended to provide adequate signal to noise ratio for detecting the targets. A blank space will be established within the IVS to be used as a background location and will be validated using the procedures described in GCO-SOP-18, Collection of Static Background Measurements. The generalized diagram of the seeded IVS transect is presented as **Figure 3-3**. In this example, only one target is shown. This is the minimum requirement for an IVS. Local custom, stakeholder comfort, or other similar reasons may lead to larger number of items in the IVS. Rarely will more than three or four items be required.

   Coordinates of each item will be recorded using acceptable survey equipment. Measurements of the item depths will be to the center of mass of each item measured from the average surrounding elevation of the ground using a straight edge for measurement control. On-site personnel will bury the IVS targets using shovels to dig the holes to the appropriate depths for burial of the seed items in coordination with the QC Geophysicist. UXO personnel will implement MEC avoidance procedures using analog instruments during installation. The background survey data and anomaly avoidance techniques will be reviewed so that transect start and end stakes and the seed items are not placed on top of or near existing anomalies. Photos will be taken of each seed item prior to burial to record seed condition, depth, and orientation. IVS construction personnel will bury the ISOs and record the following information:

   - transect endpoints
   - test item description (e.g. Small ISO80)
   - test item emplacement coordinates
   - test item emplacement depth (to the center of mass)
   - target emplacement orientation (azimuth and inclination)
   - photos of each seed item (if allowed on site)

4. The holes will then be backfilled with soil and a wooden survey stake or other suitable non-metallic marker will be placed at each buried item location as well as the start and end location of the IVS. The marker will not extend more than 3 inches above the ground

CONTROLLED COPY

surface to prevent interference with the advanced EMI sensor when passing over them. (Note: no physical marking of seed locations is necessary once GPS measurements of the seed locations have been recorded. Data may be collected at/over the seeds using the GPS locations displayed on the advanced EMI sensor screen).

3.2 IVS Data Collection and Processing

Prior to collecting production data each morning and in the evening after completing field operations, the advanced EMI sensor will be used to collect IVS data using the same collection method(s) used on that day to ensure equipment is functioning properly. IVS procedures will be completed as follows:

3.2.1 Instrument Function Test

Perform instrument function test in accordance with instrument-specific owner's manual and GCO-SOP-11.

3.2.2 Cued IVS Processing

Cued data will be collected over each of the positions in the IVS including the background location (blank space). The raw .tem files and converted .csv files or the HDF5 file for each measurement will be passed to the Data Analyst who will perform the following steps:

- Import cued data over IVS items and Background location(s) separately.
- Calculate IVS item QC statistics and identify flagged readings.
- Review IVS item decay plots
- Calculate Background QC stats and identify flagged readings.
- Review Background decay plots
- Level sensor data using background files
- Process IVS data using the Process IVS data tool
- Perform a Library Match and create polarization plots for each item.
- Verify that offset between the IVS ground truth and the modeled positon for each seed is within the MQO specified in the project-specific QAPP and that library matching provided the appropriate results.

3.2.3 Dynamic IVS Processing

Dynamic data will be collected along the IVS and noise lines. The raw .tem files and converted .csv files for both measurements will be passed to the Data Analyst, who will perform the following steps:

- Import dynamic IVS data
- Process Dynamic IVS data using the Dynamic IVS Bundle tool.
- Perform a Library Match and create polarization plots for each item.
- Verify that the offset between the selected target locations and the initial location measured for each seed is within the MQO specified in the project-specific QAPP.

CONTROLLED COPY

3.2.4 IVS Data Assessment

If the measurement performance criteria (MPCs)/ measurement quality objectives (MQOs) have not been met, the Project or QC Geophysicist will initiate a root-cause analysis (RCA) to determine the source of the discrepancies (in accordance with GCO-SOP-5, Corrective Action). If modifications to the instrument or procedures can be made so that the MPCs/MQOs can be met, these modifications will be made. If the MPCs/MQOs cannot be met, for example if the initial background decay amplitudes are too large, the Project and QC Geophysicist will meet with the project team to discuss potential resolutions. Once the initial (or modified) MPCs/MQOs have been met, the IVS survey will be complete and the system and operators verified for field data collection.

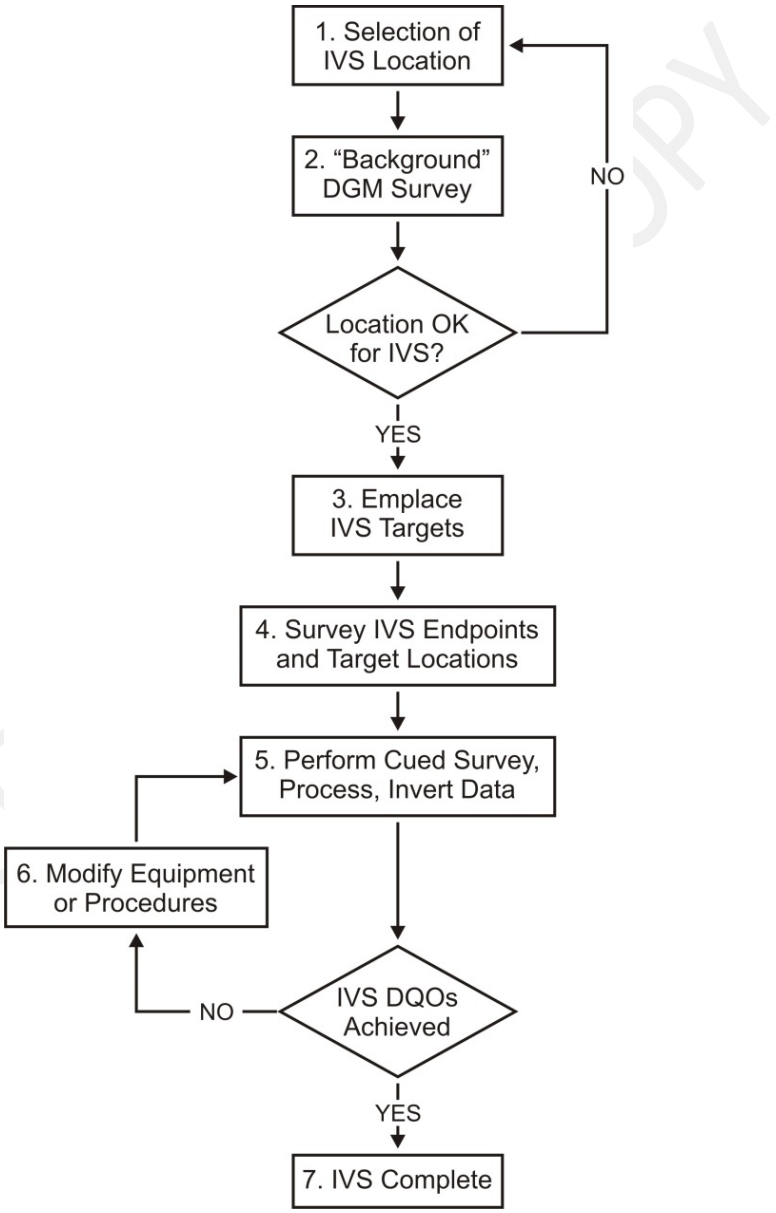


Figure 3-2 IVS Siting, Emplacement, and Use

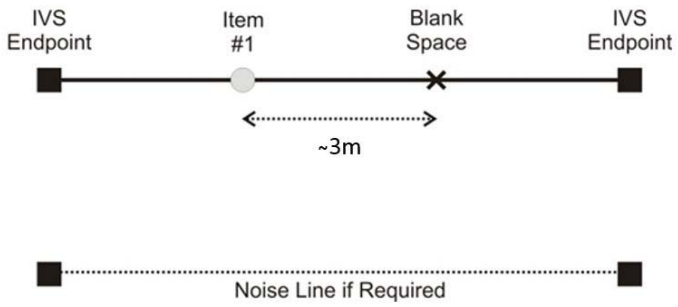


Figure 3-3 Example Layout of the IVS

4. Data Management

4.1 Input Data Required

Input data required for this SOP are the ongoing function baseline test results, locations and identities of the IVS items, and the library polarizabilities for each.

4.2 Output Data

Performance and acceptability of the initial IVS data will be documented in an IVS Letter Report. The test measurements over the IVS items described in Section 3.2will be saved in the project-specific QC database file. Inversion results and library match metric for each of the measurements will be recorded and saved in daily QC databases.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

This SOP is performed throughout the project to ensure proper functionality of equipment and methods.

The Project and/or QC Geophysicist will be notified of any sudden changes identified on the cued IVS data QC database even if the confidence does not drop below the MQO. Any such changes will require a thorough examination of the initial decays for the failing points(s) to identify any obvious transmitter/receiver problems. The QC Geophysicist may also request preliminary classification results for all points collected on the day of the change to compare against QC seeds.

Performance of the IVS installation and initial QC checks will be documented by the Field or Project Geophysicist and checked by the QC Geophysicist on the IVS Construction and Initial Demonstration QC Checklist included as **Attachment 1** to this SOP. The QC Geophysicist will verify and document Follow-on IVS performance in the daily QC reports.

The MQOs for the IVS are presented in Worksheet #22 of each project-specific AGC-QAPP. The advanced EMI sensor of choice for the project will not be used for field data collection until it is able to meet these MQOs or until the project team agrees on modifications to these MQOs.

CONTROLLED COPY

6. Reporting

This procedure will be documented through the completion of the IVS Construction and Initial Demonstration QC Checklist (**Attachment 1)** and daily QC reports

The IVS construction and implementation will be documented in an IVS Letter Report. A copy of the completed IVS Construction and Initial Demonstration QC Checklist (**Attachment 1**) of this SOP, along with copies of the completed Start-up Checklist (GCO-SOP-11) will be included as attachments to the IVS Letter Report.

Results from Follow-on QC tests defined in this SOP will be recorded in project databases and presented in daily QC Reports.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
cm	centimeter
DGM	digital geophysical mapping
DoD	Department of Defense
EMI	electromagnetic induction
GCO	Geophysical Classification Organization
GPS	global positioning system
IDQTF	Intergovernmental Data Quality Task Force
IMU	Inertial Measurement Unit
ISO	Industry Standard Object
IVS	Instrument Verification Strip
m	meter
mm	millimeter
MPC	measurement performance criteria
MQO	measurement quality objective

CONTROLLED COPY

ms	millisecond
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RCA	root-cause analysis
RMS	root-mean-square
RTK	real-time kinetic
Small ISO80	Schedule 80 small Industry Standard Object
SOP	Standard Operating Procedure
WESTON	Weston Solutions, Inc.

8. References

WESTON (Weston Solutions, Inc.). GCO-SOP-5, Corrective Action (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-11, 2x2 Sensor System Assembly and Correct Operation Verification (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-18, Collection of Static Background Measurements (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

Intergovernmental Data Quality Task Force (IDQTF). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

9. Attachments

CONTROLLED COPY

Attachment 1

IVS Construction and Initial Demonstration QC Checklist

This checklist is to be completed by the Field or Project Geophysicist during construction and initial demonstration of the IVS. Construction and initial demonstration of the IVS and completion of this checklist will be verified by the QC Geophysicist and recorded in the IVS Letter Report.

QC Step	QC Process	Yes/No	Initial
1. Qualifications	Are the qualifications of the Project and Field Geophysicists and the Data Analyst in accordance with this SOP?		
2. IVS Construction	Has an appropriate location for the IVS been selected in accordance with this SOP?		
3. IVS Construction	Has the background geophysical survey been performed in accordance with this SOP?		
4. IVS Construction	Were the target seeds buried appropriately, backfilled and marked in accordance with this SOP?		
5. IVS Construction	Was the required data on the IVS construction recorded for inclusion in the IVS Letter Report in accordance with this SOP?		
6. Data collection	Was the initial IVS data collected in accordance with all relevant SOPs?		
7. Data processing	Did the Data Analyst process the IVS in accordance with this SOP?		
8. Data analysis	Was the data collected on the blank space suitable for use as background in accordance with this SOP?		
9. Data analysis	Do the processed IVS results match the expected locations and library values in accordance with this SOP?		
10. MQO Documentation	Have the appropriate MQOs from Worksheet #22 of the project-specific AGC-QAPP been achieved?		

Project or Field Geophysicist: _____ Date:_____

Data Analyst: _____ Date:_____

CONTROLLED COPY

GCO SOP-13

PRODUCTION AREA SEEDING

Production Area Seeding

Document No. GCO-SOP-13

Reviewed and Approved by:_____ Date: Sept 9, 2019
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by:_____ Date: Sept 9, 2019
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
3.0	Sept. 9, 2019	Sections 2.2 and 3/ Clarifies the need for a production area QC seed plan that is prepared by the QC geophysicist.	G. Abrams	R. Steigerwalt
2.0	Feb. 23, 2018	A notation has been added to Section 2.1 to specify that the Field Geophysicist must be separate from the data collection team.	M. Costello	R. Steigerwalt
1.0	August 22, 2017	A bullet has been added to section 2.1, Personnel, to include UXO Technician (minimum Tech 2). The first bullet has been revised to clarify Field Geophysicist or surveyor. The first bullet following the third paragraph in section 3.2 has been revised to state, "The x, y, and z coordinates for the center of the seed, with coordinates reported in the approved project coordinate system. Section 5 has been revised to state, "The QC Geophysicist will be responsible for ensuring that blind seeding activities are completed in accordance with this SOP. No field work will be performed until this verification has been documented as described in Section 6."	G. Abrams	R. Steigerwalt
0.0	May 19, 2017	Original Publication	M. Costello	T. King

1. Purpose and Scope

The purpose of this Standard Operating procedure (SOP) is to identify the methods to be employed when emplacing quality control (QC) or validation seeds in the production area.

This SOP has been prepared in accordance with SOP 3, provided within Appendix A of the Intergovernmental Data Quality Task Force (IDQTF) *Uniform Federal Policy for Quality*

Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) (IDQTF, 2016).

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in production area seeding:

- Field Geophysicist (must be separate from the data collection team) or surveyor
- UXO Technician (minimum Tech 2)
- QC Geophysicist

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the project-specific AGC-QAPP (Worksheets #4, 7, & 8).

2.2 Equipment

The following is a list of required equipment and materials:

- Site-specific Production Area Seed Plan.
- Inert munitions and/or Industry Standard Objects (ISOs) to emplace the seeds, consistent in size with the target of interest (TOI).
- Hand-held geophysical sensor (typically a Schonstedt magnetic locator or White's all-metal detector).
- Hand tools including shovels, pick axes, breaker bars, etc., to emplace the seeds.
- Excavators if required by the production seed plan.
- Real-time kinetic (RTK) or robotic total station (RTS) Global Positioning System (GPS) unit to record the location of seed items.
- Meter stick and straight edge to measure the depth of the seeded items.
- Level or inclinometer and compass to measure the inclination and orientation of the seeded items.
- Preparatory Production Area Seeding QC Checklist, included as **Attachment 1** to this SOP.

3. Procedure and Guidelines

The production area seed plan is developed by the QC Geophysicist and provides a list of seed identities, locations, depths, and orientations. When emplacing the seeds, the emplacement team should employ anomaly avoidance techniques as described in Section 3.1 and use the emplacement procedure described in Section 3.2. All production area seeding operations will be blind to data

CONTROLLED COPY

collectors and data processors. All data outputs generated from this SOP will be kept and controlled by the QC Geophysicist.

3.1 Anomaly Avoidance

It is likely that the demonstration area will contain some metallic items or electromagnetically active geology. These will produce anomalies in data collected with a magnetometer or electromagnetic induction instrument. The emplacement team should avoid emplacing seeds in the immediate vicinity of any strong anomalies. **Figure 3-1** describes the process that should be used to avoid strong anomalies when emplacing a seed. First, the emplacement team should acquire the seed's intended location. Then, the team should use a hand-held instrument to survey within the immediate vicinity (30 to 40 centimeter [cm] radius) of the intended location. If there are no strong anomalies in the immediate vicinity, then the team should emplace the seed at the intended location. If, however, the intended location is in the immediate vicinity of any strong anomaly, then the team should select a new location for the seed, as close as safety allows. The new location should ***not*** be in the immediate vicinity of any strong anomaly and should ***not*** be within 60 cm of another seed.

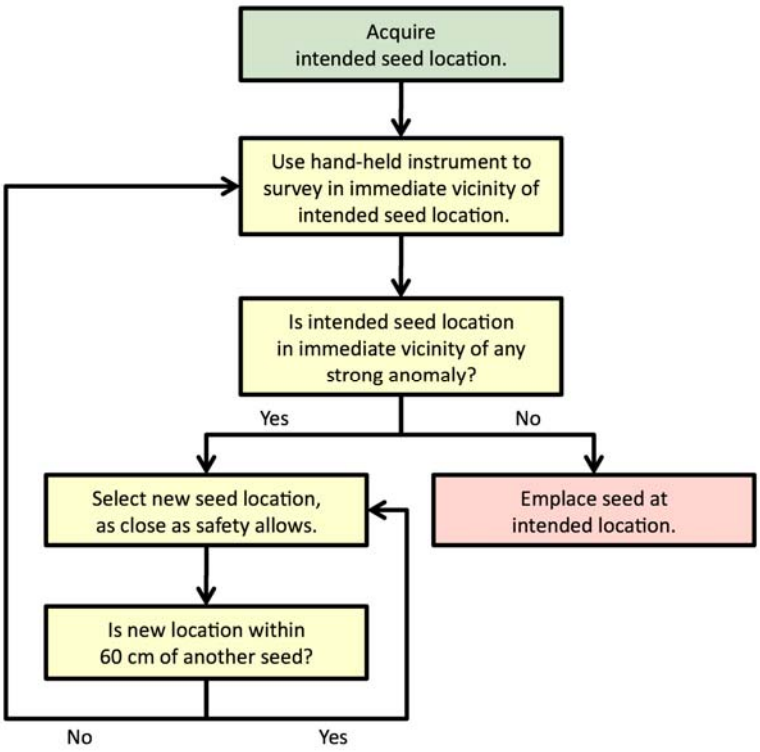


Figure 3-1 Anomaly Avoidance During Seed Emplacement

3.2 Seed Emplacement

The study will attempt to reconstruct the physical parameters of the buried targets such as location, depth, inclination, azimuth, and size. Therefore it is critical for the success of the study that the

actual locations of the buried seeds are surveyed as accurately and precisely as possible. To that end, the emplacement team should dig in a fashion to minimize seed migration (e.g., settling) after burial.

The production area seed plan specifies the intended burial parameters of the seeds. The intended locations are given to 1-cm precision, with the intended depths to 2-cm precision and the intended inclinations and azimuths to 15-degree precision. All locations should be acquired as accurately and precisely as possible before digging begins, because this accuracy ensures anomaly avoidance. Locations should be surveyed relative to a cm-level control point.

This plan is merely a ***guide*** for seed emplacement. The emplacement team may allow small deviations from the intended burial parameters as listed in the production seed plan. This variation is desired and the exact parameters should be recorded by survey. For example, the inclinations are specified to within 45 degrees of horizontal or vertical down. Therefore, the emplacement team should avoid burying the seeds exactly horizontally or exactly vertically down. In addition, the emplacement team should adjust the inclination angles of the seeds to ensure 5 cm of overburden.

After emplacing a seed in the ground, but before covering it with dirt, the following information should be carefully recorded:

- The x, y, and z coordinates for the center of the seed, with coordinates reported in the approved project coordinate system.
- The depth of the seed, measured as the vertical distance from the bottom of a straight edge placed across the opening of the hole down to the center of the seed.
- A photograph of the seed, showing its serial number. A ruler or similar scale should also be included in the photograph.

For each seed, the emplacement team should also use the following procedures:

- Ensure any inert munition seeds (if used) are marked with blue paint and/or otherwise marked as inert. Note: ISO seeds may be marked with a seed identification number to be based on the requirements of each project-specific AGC-QAPP.
- Replace dirt in the hole as completely as possible.
- Level the burial location.
- Replace the grass plug over the burial location (if possible).

4. Data Management

The following sections describe the data that are needed to perform this SOP and the resulting data.

4.1 Input Data Required

The production area seed plan which includes a table of seed items, initial locations, and depths and orientations, is required for this SOP.

CONTROLLED COPY

4.2 Output Data

The output data from this SOP consist of the final production area seed report. This report comprises a brief narrative describing the seed emplacement and a discussion of significant deviations from the seed plan. The bulk of the report consists of a seed location table that includes the "as emplaced" identity, location, depth, and orientation of each of the emplaced seeds accompanied by a photograph of the item in the ground before being covered.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP. All production area seeding operations will be blind to data collectors and data processors. All data outputs generated from this SOP will be kept and controlled by the QC Geophysicist.

5. Quality Control

The QC Geophysicist will be responsible for ensuring that blind seeding activities are completed in accordance with this SOP. No field work will be performed until this verification has been documented as described in Section 6.

6. Reporting

This procedure will be documented through the completion of the Production Area Seed Report as described in Section 4.2.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
cm	centimeter
GCO	Geophysical Classification Organization
GPS	global positioning system
IDQTF	Intergovernmental Data Quality Task Force
ISO	Industry Standard Object
MQO	measurement quality objective
NAD	North American Datum
QAPP	Quality Assurance Project Plan
QC	Quality Control

CONTROLLED COPY

QMS	Quality Management System
RTK	real-time kinetic
RTS	robotic total station
SOP	Standard Operating Procedure
TOI	target of interest
UTM	Universal Transverse Mercator
WESTON®	Weston Solutions, Inc.

8. References

Intergovernmental Data Quality Task Force (IDQTF). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

9. Attachments

None.

CONTROLLED COPY

GCO SOP-18

COLLECTING STATIC BACKGROUND MEASUREMENTS

Collecting Static Background Measurements

Document No. GCO-SOP-18

Reviewed and Approved by: _____ Date: Sept 28, 2018
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by: _____ Date: Sept 28, 2018
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
5.0	Sept. 28, 2018	Section 3.2 has been revised to add the following additional step to the procedure for taking background measurements, "2) If the Metal Mapper 2x2 is being used, warm up the instrument until readings are stable which may be for up to 10 minutes by firing in dynamic mode even though cued data are being collected."	S. Takata	R. Steigerwalt
4.0	Sept. 4, 2018	Section 2.1 has been revised to allow the Field Geophysicist perform the functions assigned to the Field Team Leader in this SOP. Section 2.2 has been revised to include UXOLAB V2.0 in the list of approved software. Section 3.1, 3) has been revised to allow for use of approved software in addition to Geosoft (i.e., UXOLab). Section 3.2. 3) has been revised to read, "Inspect background receiver responses in data acquisition software to ensure reasonable background responses." Attachment 1 has been revised to include Instrument ID and Date at the top of the checklist. The checklist has also been revised to allow either/or the Field or Project Geophysicist to sign the completed checklist, instead of both personnel.	G. Abrams	R. Steigerwalt
3.0	Sept. 28, 2017	An Attitude and Heading Reference System (AHRS) has been included in the list of equipment that could be used as an alternative to an IMU to measure yaw, pitch, and roll of the sensor. References to GCMR-QAPP have been revised to AGC-QAPP **Attachment 1** has been revised to "Initial Background Collection QC Checklist" Step 7 has been eliminated, and the former Step 8 is now Step 7. References to GCO-SOP-11, have been removed from the document and references have been replaced with "appropriate SOPs for assembly of the sensor".	G. Abrams	M. Costello

CONTROLLED COPY

		Section 3.1, last bullet has been revised to read, "Initial measurement of the production area background locations should be collected as five background measurements; one centered at the flag and four measurements offset approximately 40 centimeters (cm) from the cart (e.x. cardinal directions)." Section 3.4, 2), 3), and 4) have been revised as follows: 2) Collect a background measurement and ensure that the GPS, IMU or Attitude and Heading Reference System (AHRS), and transmit coils are operating during collection. 3) Inspect background receiver responses in TEM Tablet software to ensure reasonable background responses. Note – receiver responses will typically be around 25mV/A on the Rz(18) time gate. 4) If background readings result in questionable results, the field team should document any environmental changes that may have led to this deviation in the field notes, and submit data for approval by the Data Analyst before proceeding with the background location in question.		
2.0	Sept. 14, 2017	Section 3.1, the last bullet in the first paragraph has been revised as follows, "Initial measurement of the production area background locations should be collected as five background measurements; one centered at the flag and one four measurements offset 40 centimeters (cm) from the cart (e.x. in each cardinal directions). All measurements should be below the project background threshold."	G. Abrams	M. Costello
1.0	Aug. 24, 2017	The first bullet of section 2.2 has been revised as follows: "An advanced EMI sensor (type/brand selected on a project-specific basis) coupled with a real-time kinematic (RTK) GPS (see GCO-SOP-31, Setup and Operation of RTK GPS Navigation System) or robotic total station (RTS) (see GCO-SOP-32, Setup and Operation of RTS Navigation System) and orientation sensor." The section 2.2 bullet discussing ISOs/IVS items has been removed from this SOP. The last bullet in section 2.2 has been revised to clarify "Software used for geophysical data processing that is validated and accepted per the DENIX DAGCAP webpage, such as Geosoft Oasis Montaj with UX-Analyze, Version 9.2." The first sentence of section 3 has been revised to state, "Background measurements will be recorded at a frequency of every two hours, minimum, and at one or more geographic locations as required to document the EMI signatures of near-surface soils present at the site." The following sentence has been added following the first sentence in section 3.1, "As part of the IVS installation (GCO-SOP-12), a background location will be placed on the IVS. This location can be chosen by referring to the dynamic background survey collected prior to installing the seeds. The background location will be placed at a sufficient distance from the nearest seed, approximately 3 meters, along the seeded line to prevent signal influence into the background area."	B. Guthrie	G. Abrams

CONTROLLED COPY

		The 2nd bullet in section 3.1, has been revised as follows: "The background measurements should be collected at locations devoid of buried metal objects. If a suitable object free area cannot be identified, UXO intrusive procedures will be put in place to create a "clear" 2-meter (m) square area by surveying and removing all metal objects. Once cleaned, the background measurements should be re-collected in the "clear" area." Section 3.1, subsection 2)b. has been revised to include, "Decay thresholds are dependent on site soil response and will be determined by the Data Analyst and approved by the QC Geophysicist during initial IVS testing. The last sentence of subsection 2)b. has been revised as follows: "The client will be consulted prior to any change in background threshold." Section 5, Step 1 has been revised as follows: "Field notes will be maintained either digitally or in logbooks and will record the responsible geophysicist's identification collecting each data file. By logging the background data, and thereby taking responsibility for it, the geophysicist logging the data is certifying that they have complied with the requirements of this SOP." Step 6, Preparation was included in error in the Attachment 1 QC Checklist and has been deleted.		
0.0	May 19, 2017	Original Publication	M. Costello	T. King

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to be employed when selecting the positions for background measurements using an advanced digital geophysical mapping (DGM) system and verifying the usability of the resulting background data. The observed signal in a cued measurement using advanced sensors is composed of 1) the electromagnetic induction (EMI) response of the buried target, 2) the self-signature of the sensor system, and 3) any response from the ambient environment in which the target is buried.

The objective of taking background measurements is to independently measure the last two contributors to the overall EMI response. These "non-target" values can then be subtracted from the overall signal response to determine the signal response from only the unknown buried object being evaluated. For this to be successful, the background measurements must be collected in an area without any buried targets and with geology representative of where the unknown items are located. They must also be taken throughout the survey day because environmental changes such as large changes in ambient temperature, significant changes in background moisture (morning dew evaporating, rain showers passing through, etc.), or significant changes to the sensor itself [cable replacement, new global positioning system (GPS) antenna, etc.] will cause the sensor or environmental contribution to the background reading to change.

This SOP has been prepared in accordance with SOP 6, provided within Appendix A of the Intergovernmental Data Quality Task Force (IDQTF) *Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP)* (IDQTF, 2016).

CONTROLLED COPY

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the collection of background data:

- Project Geophysicist – Confirms selected background locations are acceptable; reviews results for initial background collections at each location surveyed.
- Quality Control (QC) Geophysicist – Reviews QC testing results and verified results are documented in the QC database.
- Field Team Leader/Field Geophysicist – Operates geophysical sensor during data collection.
- Data Analyst – Identifies preliminary locations for background points by reviewing detection data; processes collected data and documents QC results in the project QC database.

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the in the project-specific AGC-QAPP (Worksheets #4, 7 & 8).

2.2 Equipment

The required equipment is as follows:

- An advanced EMI sensor (type/brand selected on a project-specific basis) coupled with a real-time kinematic (RTK) GPS (see GCO-SOP-31, Setup and Operation of RTK GPS Navigation System) or robotic total station (RTS) (see GCO-SOP-32, Setup and Operation of RTS Navigation System) and orientation sensor.
- Transport vehicle (skid steer, tractor, extended reach forklift) used to move the advanced EMI sensor (if required based on type of sensor selected for project) during data collection.
- GPS unit used to record location of collected geophysical data.
- Inertial Measurement Unit (IMU) or Attitude and Heading Reference System (AHRS) used to measure yaw, pitch, and roll of sensor. Data used to correct position measured by the GPS.
- Personal computer used to manage geophysical data and software.
- Software used for geophysical data processing that is validated and accepted per the DENIX DAGCAP webpage (e.g. Geosoft Oasis Montaj with UX-Analyze, Version 9.2, UXOLab V2.0.)

Also required is the Initial Background Collection QC Checklist, included as **Attachment 1** to this SOP.

CONTROLLED COPY

3. Procedure and Guidelines

Background measurements will be recorded at a frequency of every two hours, minimum, and at one or more geographic locations as required to document the EMI signatures of near-surface soils present at the site. Background measurements involve positioning the sensor and collecting static measurements over a pre-identified set of background locations. In combination with appropriate SOPs for assembly of the EMI sensor, and testing at the Instrument Verification Strip (IVS) (GCO-SOP-12), background data are collected that are used to correct the static data described in this SOP.

Prior to cued data collection, the correct operation of the geophysical sensor and navigation and orientation systems must be verified by completion of the QC checklist included as Attachment 1 of the GCO-SOP-12, Advanced Classification IVS.

3.1 Choose Locations for the Background Measurements and Verify their Suitability

One or more locations for background measurements will be planned at each site. As part of the IVS installation (GCO-SOP-12), a background location will be positioned on the IVS. This location can be chosen by referring to the dynamic background survey collected prior to installing the seeds. The background location will be placed at a sufficient distance from the nearest seed, approximately 3 meters, along the seeded line to prevent signal influence into the background area. The number and location of the background measurements will be influenced by the following considerations:

- The background measurements should be collected at locations that are similar to that of the production survey area with regard to geophysical noise, terrain, geology, and vegetation. If these factors change appreciably, additional background measurements, taken at a more representative location, will be required.
- The background measurements should be collected at locations devoid of buried metal objects. If a suitable object free area cannot be identified, UXO intrusive procedures will be put in place to create a “clear” 2-meter (m) square area by surveying and removing all metal objects. Once cleaned, the background measurements should be re-collected in the “clear” area.
- For efficiency, background measurements in production areas should be collected in areas that are close to the survey area(s) to minimize travel time.
- Initial measurement of the production area background locations should be collected as five background measurements; one centered at the flag and four measurements offset approximately 40 centimeters (cm) from the cart (e.g. cardinal directions).

Once the IVS background location and/or background locations within the survey area have been identified, an initial measurement should be collected over each of the background locations in turn as illustrated in **Figure 3-1** and summarized below.

1) Initial locations for the background measurement are chosen most easily by referring to the dynamic survey data. These data can be used to guide the geophysicist to suitable locations that satisfy the considerations noted above.

CONTROLLED COPY

2) Once background locations have been identified, an initial measurement should be collected over each background location as follows:

    a. Center the sensor over the location chosen as a background point. Mark the edges of the sensor with non-metallic pin flags (or similar) to allow this same location to be found again for future background readings.

    b. Record the stationary geophysical data at this location, and at the four locations offset by ½ sensor spacing in four orthogonal offset directions. If high amplitude decays are observed, the location should be inspected and any metal contamination found should be removed. If an apparent subsurface source cannot be cleared quickly, another nearby location can be chosen. If no metal contamination is present, the applicability of the selected point should be considered with regard to local background conditions. If local background conditions (i.e. increased geological response over a wide area) suggest that the measured background accurately reflects local background, the default background thresholds may need to be revised.

3) Continue this process at each of the chosen locations and submit raw files to the Data Analyst to verify their suitability for background measurements using validated Background Location Validation Test. Instrument specific default threshold values (e.x. background amplitude threshold, TOI Metric Match, measurement distances) will be used for background verification unless the Data Analyst determines a need to make adjustments based on site-specific conditions. Any deviations will be noted in a Geophysics Daily QC Report.

4) Once this process is complete, the Data Analyst will provide the Field Team Leader with a list of validated background locations that have been verified and approved to be used during the survey.

CONTROLLED COPY

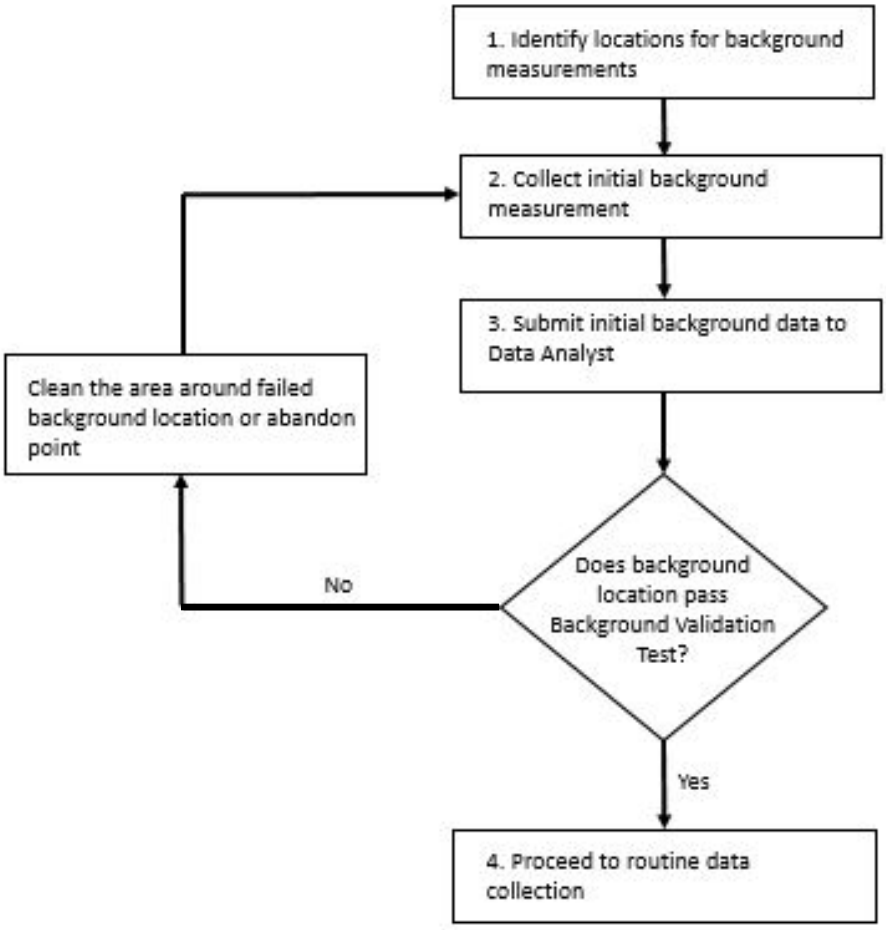


Figure 3-1 Choosing and Verifying Locations for Background Measurements

3.2 Collect Background Measurements Throughout the Survey Day

Background measurements should be collected with a maximum duration of two hours throughout the survey day. Additional background measurements can be taken if the Project Geophysicist or Field Team Leader determines that changes made to the sensor or natural environmental changes may have caused the sensor or environmental contribution to the background reading to change. Careful field notes should be made to document the reasons for extra background readings to guide the Data Analyst in choosing the correct background for each cued data set.

The procedure for taking background measurements is as follows:

1) Return the sensor to one of the previously verified background measurement locations taking care to position the sensor as closely as possible to the initial location and orientation.

2) If the Metal Mapper 2x2 is being used, warm up the instrument until readings are stable which may be for up to 10 minutes by firing in dynamic mode even though cued data are being collected.
3) Collect a background measurement and ensure that the GPS, IMU or Attitude and Heading Reference System (AHRS), and transmit coils are operating during collection.

4) Inspect background receiver responses in data acquisition software to ensure reasonable background responses.

5) If background readings result in questionable results, the field team should document any environmental changes that may have led to this deviation in the field notes, and submit data for approval by the Data Analyst before proceeding with the background location in question.

4. Data Management

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 Input Data Required

An initial list of suitable background locations, identified from the survey data, is required to begin this SOP. After the locations have been verified, they become the final background location list.

4.2 Output Data

The background data collected at each background location will be saved in the project database.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific ACG-QAPP.

5. Quality Control

This procedure ensures that the sensor is working properly and that the field geophysical team is collecting data of adequate quality. Therefore, for routine background measurements, this procedure requires QC inspections which are documented through completion of the Initial Background Collection Checklist (**Attachment 1**) through the following steps:

1) Field notes will be maintained either digitally or in logbooks and will record the responsible geophysicist's identification collecting each data file. By logging the background data, and thereby taking responsibility for it, the geophysicist logging the data is certifying that they have complied with the requirements of this SOP.

2) The QC Geophysicist will review background data collection from each morning and afternoon of data collection activities and document results in a Geophysics Daily QC Report.

3) Achievement of the background collection measurement quality objectives (MQOs) will be documented by the Field or Project Geophysicist and verified by the QC Geophysicist in a Geophysics Daily QC Report.

CONTROLLED COPY

4) During review of each background measurement, the Data Analyst will overlay the measured decays from all measurements at that location to observe any variation. Should variations be observed that are not the result of changing environmental conditions documented by the field team, a comprehensive root-cause analysis (RCA) will be performed and a corrective action (CA) determined in accordance with GCO-SOP-5, Corrective Action.

The MQOs for background measurements are presented in Worksheet #22 of the project-specific AGC-QAPP. Measured backgrounds will not be used to correct field data until these MQOs are met or until the project team agrees on modifications to these MQOs.

6. Reporting

This procedure will be documented through the completion of the Initial Background Collection QC Checklist provided as **Attachment 1** by the Field or Project Geophysicist. The completed checklist will be used to document the selection and preparation of the background areas, the initial background readings taken at each selected area, and the routine once every two hours (at a minimum) background readings taken during the production survey. The QC Geophysicist will verify the background collection process, verify background results, and will document completion of all checklists in a Geophysics Daily QC Report and copies of the completed checklists will be attached to the report. Decay plots comparing initial backgrounds at new points and daily measurements to a reference threshold will be delivered with their applicable data sets. Rejected background and the consequences of rejection (i.e. points to be re-collected) will be recorded in the project QC database.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
AHRS	Attitude and Heading Reference System
CA	corrective action
cm	centimeter
DGM	digital geophysical mapping
EMI	electromagnetic induction
GCO	Geophysical Classification Organization
GPS	global positioning system

CONTROLLED COPY

IDQTF	Intergovernmental Data Quality Task Force
IMU	Inertial Measurement Unit
ISO	Industry Standard Object
IVS	Instrument Verification Strip
m	meter
mm	millimeter
MQO	measurement quality objective
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RCA	root cause analysis
RTK	real-time kinetic
SOP	Standard Operating Procedure
TOI	target of interest
WESTON	Weston Solutions, Inc.

8. References

Intergovernmental Data Quality Task Force (IDQTF). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

WESTON (Weston Solutions, Inc.). GCO-SOP-5, Correction Action (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-12 Advanced Classification Instrument Verification Strip (IVS) (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

CONTROLLED COPY

WESTON (Weston Solutions, Inc.). GCO-SOP-31, Setup and Operation of RTK GPS Navigation System (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-32, Setup and Operation of RTS Navigation System (current version). West Chester, PA. Attachments

CONTROLLED COPY

Attachment 1
Initial Background Collection QC Checklist

This checklist is to be completed by the Field or Project Geophysicist during initial data collection at each background area. Successful completion of this process will be verified by the QC Geophysicist in a Geophysics Daily QC Report.

Instrument ID: _____ Date:_____

QC Step	QC Process	Yes/No	Initial
1. Qualifications	Are the same geophysical personnel being used as in the assembly SOP for the EMI sensor? If not, are the qualifications of the new personnel in compliance with the requirements of Worksheets 4, 7, and 8 and GCO-SOP-23?		
2. Preparation	Have the instrument start-up procedures and pre-operation checklist from the sensor assembly SOP been successfully completed?		
3. Background area selection and preparation	Are the selected background areas devoid of buried metal objects or has a 2 m square area been "cleaned" in accordance with this SOP?		
4. Background area selection	Do the selected background areas have similar geophysical noise, terrain, geology and vegetation as the production survey area they represent in accordance with this SOP?		
5. Background area selection	Are the selected background areas sufficiently close to the production area to minimize travel in accordance with this SOP?		
6. Data collection	Is the instrument properly centered on the background location and are the 4 offset points marked with non-metallic pin flags (or equivalent) in accordance with this SOP?		
7. Data collection	Is background data recorded at the center point and at the 4 offset points for each background location in accordance with this SOP?		

Field or Project Geophysicist: _____ Date:_____

CONTROLLED COPY

GCO SOP-19

COLLECTING CUED TARGET MEASUREMENTS

Collecting Cued Target Measurements

Document No. GCO-SOP-19

Reviewed and Approved by:_____ Date: Feb 12, 2020
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by:_____ Date: Feb 12, 2020
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
5.0	Feb. 5, 2020	Section 3, Paragraph 3: "Verify the reference file is correct for the system configuration being used." Attachment 1: Dynamic Data Collection QC Check Sheet has entry added "Confirm correct reference file is loaded."	S. Takata	G. Abrams
4.0	Sept. 9, 2019	The following statement has been removed from Section 3, Step 2/ "If the Metal Mapper 2x2 is being used, prior to collecting the first anomaly's cued data, warm up the instrument until readings are stable which may be for up to 10 minutes by firing in dynamic mode. This is performed even though cued data are being collected." Attachment 1/ Attachment was revised to, "The following steps must be completed after end of day function, spin (MPV only), and IVS testing with the MPV/Metal Mapper."	S. Stout	G. Abrams
3.0	Sep 28, 2018	Section 3, Step 2 has been revised to include the following statement when collecting a set of static sensor measurements. "If the Metal Mapper 2x2 is being used, prior to collecting the first anomaly's cued data, warm up the instrument until readings are stable which may be for up to 10 minutes by firing in dynamic mode. This is performed even though cued data are being collected." Section 3, The last sentence of Step 3 has been revised for clarity as follows: "If inversion results through data processing by the Data Analyst indicate that any target source is greater than 40 cm from the sensor location, target locations will be re-acquired and re-shots will be collected directly over the inverted source location."	S. Takata	R. Steigerwalt
2.0	Sep 4, 2018	Section 2.1 has been revised to show that duties assigned to the Field Team Leader may also be	G. Abrams	R. Steigerwalt

CONTROLLED COPY

		performed by the Field Geophysicist during performance of this SOP. Section 3.1, 1) has been revised to remove specification of RTK GPS. The statement "within 15 centimeters (cm)" has been removed from the second paragraph of this subsection. Section 5, 4th bullet has been revised as follows, "Cued sensor data will be import into processing software and data quality will be assessed using the validated QC function tests. Section 6, Reporting, has been revised as follows, "Reporting of the activities associated with this SOP will consist of the digital copies of the field notes, the project QC database, and completion of the Cued Data Collection QC Checklist provided in Attachment 1." The SOP has been revised to include reference to GCO-SOP-35, MPV System Assembly and Verification. Attachment 1, Cued Data Collection QC Checklist has been added to this SOP.		
1.0	August 24, 2017	Sections 2.2 and 8 have been revised to include references to GCO-SOP-31, Setup and Operation of RTK GPS Navigation System, and GCO-SOP-32, Setup and Operation of RTS Navigation System. The third paragraph of section 3, Step 1 has been deleted. A statement has been added to the end of Step 2 which states, "Any metal associated with the sensor and deployment mechanism (e.g, console, support structures) that cannot be reasonably distanced from the sensor must be kept in the same physical relation to the sensor as was maintained during background measurements. Step 3 has been revised as follows, "Immediately after data acquisition, the integrity and quality of the data will be verified by the operator to ensure that the data acquisition cycle completed properly and that the target is a suitable distance from the center of the sensor. The distance between inverted source locations and the sensor location will be determined during in-field inversions and/or data processing. If the in-field inversion results from the initial measurement location indicate that the source is greater than 30 cm from the sensor location, the sensor will be immediately repositioned over the inverted source location and a second measurement will be collected. If inversion results through data processing indicate that any target source is greater than 40 cm from the sensor location, target locations will be re-acquired and re-shots will be collected directly over the inverted source location." The first sentence of section 4.2 has been revised to state, "The output data from this SOP will consist of	G. Abrams	R. Steigerwalt

CONTROLLED COPY

		raw sensor data files (.tem and .gps or .hdf5) per anomaly interrogated." The text of section 5 has been revised to clarify the procedures for conducting QC checks during cued data collection as follows: "The Preparatory and Initial QC checks for this SOP are performed during the implementation of GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) and GCO-SOP-18, Collecting Static Background Measurements. GCO-SOP-12 ensures that the instrument is working properly and that the field geophysical team is collecting data of adequate quality. GCO-SOP-18 ensures that background data has been collected and validated properly. Therefore, this procedure requires only follow-on QC inspections which are documented through the following steps: • Field team composition and roles will be documented during field activities. By logging the data, and thereby taking responsibility for it, the geophysicist logging the data is certifying compliance with the requirements of this SOP. • Field Team Lead will perform and observe data collection throughout the project to ensure proper data collection and document any non-conformities to the project plan. • Cued sensor data will be import into Geosoft Oasis Montaj and data quality will be assessed using the Calculate Survey Database QC Stats .GX. • The QC Geophysicist will review data flagged for removal, assess its usability, and document the observations in a Daily Geophysics QC Report."		
0.0	July 12, 2017	Original Publication	M. Costello	T. King

CONTROLLED COPY

1. Purpose and Scope

The purpose of this standard operating procedure (SOP) is to identify the means and methods to be employed when collecting cued measurements using an advanced electromagnetic induction (EMI) sensor for target classification. Cued data collection involves navigating the sensor to the precise anomaly location; collecting static, advanced electromagnetic sensor data at this location; and verifying the integrity and validity of the collected data. Verification includes using the sensor data to derive an estimate of the target position relative to the center of the sensor. If this position estimate falls outside a predetermined threshold, the sensor will be repositioned and a second data collection event will be performed.

This SOP has been prepared in accordance with SOP 7, provided in Appendix A of the Intergovernmental Data Quality Task Force (IDQTF) *Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP)* (IDQTF, 2016).

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the collection of cued target data:

- Project Geophysicist – Designs the geophysical approach for the project and monitors advanced sensor data acquisition.
- Quality Control (QC) Geophysicist – Reviews QC testing results and verifies results are documented in the QC database.
- Field Team Leader/Field Geophysicist – Acquires geophysical data and documents obstructions to collecting geophysical data.
- Data Analyst – Processes collected data and documents testing results in the QC database.

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the project-specific AGC-QAPP (Worksheets #4, 7, & 8).

2.2 Equipment

The following is a list of required equipment and materials:

- Advanced EMI sensor as selected for the project.
- Transport vehicle (skid steer, tractor, extended reach forklift) if required based on selection of EMI sensor for project.
- Navigation instrument [(e.g. real-time kinematic (RTK) global positioning system (GPS) (see GCO-SOP-31) and/or robotic total station (RTS) (see GCO-SOP-32)]
- Inertial Measurement Unit (IMU) for orientation measurements.
- Cued Data Collection QC Checklist, included as **Attachment 1** to this SOP.

3. Procedure and Guidelines

Cued investigation for target classification involves positioning the sensor and collecting static measurements over a pre-identified set of anomalies, in combination with the following SOPs:

- GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification (if applicable)
- GCO-SOP-35, MPV System Assembly and Verification (if applicable)
- GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS)
- GCO-SOP-18, Collecting Background Measurements

At each anomaly the data acquisition will be performed using the steps shown in **Figure 3-1**.

CONTROLLED COPY

Prior to cued data collection, the correct operation of the geophysical sensor and navigation and orientation systems must be verified at the IVS as described in GCO-SOP-12. Verify the reference file is correct for the system configuration being used. This will be verified by completion of the QC checklist attached to GCO-SOP-12.

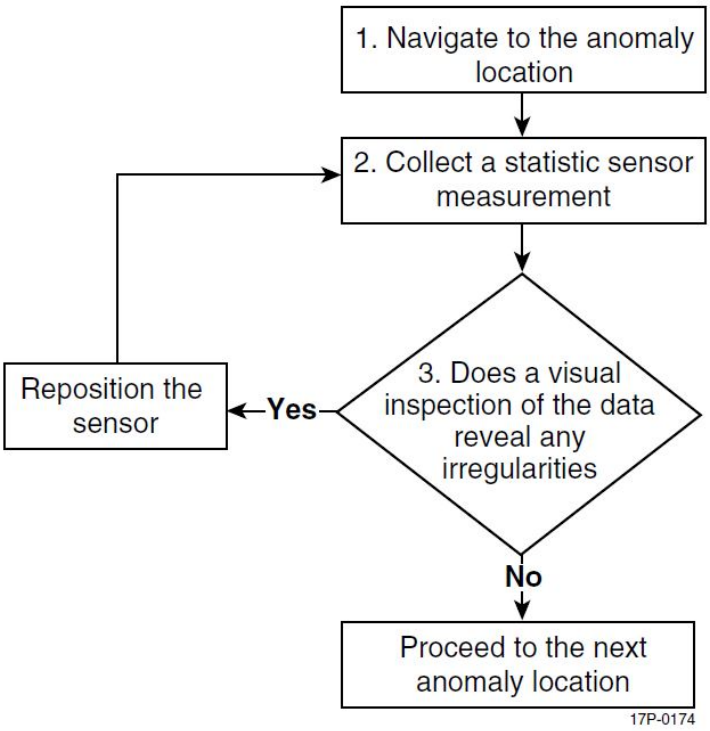


Figure 3-1 Procedure to Collect a Cued Target Measurement

The following is a description of each of the steps shown in **Figure 3-1**:

1) **Navigate to the Anomaly Location**. Navigation to the anomaly location may be performed visually or through the use of the positioning system. Visual navigation requires marking the anomalies (usually with survey pin flags) in advance. Although some sensors may have the ability to direct the operator to an anomaly location based on the geophysical signal received, the first measurement will be taken at the predetermined anomaly location as indicated by visual alignment with the pin flag or the predetermined survey position within the acquisition software.

   To implement this step, the sensor will be transported to the anomaly location and the center of the sensor precisely positioned over the provided anomaly location.

2) **Collect a set of static sensor measurements**. Initiate the collection of a set of measurements. During this measurement, care will be taken to ensure that the sensor does not move, and all external sources of electromagnetic (EM) signals (i.e., metal) are kept away from the sensor. Any metal associated with the sensor and deployment mechanism (e.g., console, support structures) that cannot be reasonably distanced from the sensor must

be kept in the same physical relation to the sensor as was maintained during background measurements.

3) **Verify the integrity and quality of the collected data.** Immediately after data acquisition, the integrity and quality of the data will be verified by the operator to ensure that the data acquisition cycle completed properly and that the target is a suitable distance from the center of the sensor.

   The distance between inverted source locations and the sensor location will be determined during in-field inversions and/or data processing. If the in-field inversion results from the initial measurement location indicate that the source is greater than 30 cm from the sensor location, the sensor will be immediately repositioned over the inverted source location and a second measurement will be collected. If inversion results through data processing by the Data Analyst indicate that any target source is greater than 40 cm from the sensor location, target locations will be re-acquired and re-shots will be collected directly over the inverted source location.

4. Data Management

The following sections describe the input data that are needed to perform this SOP and the resulting output data.

4.1 Input Data Required

The required input data consist of an anomaly list with anomaly identifiers (IDs) and Universal Transverse Mercator (UTM) Northing and Easting coordinates in meters (m).

4.2 Output Data

The output data from this SOP will consist of raw sensor data files (.tem and .gps or .hdf5) per anomaly interrogated. These data files will be transferred daily (or as dictated by the project-specific AGC-QAPP) to the Data Analyst.

Also, the Cued Data Collection QC Checklist in **Attachment 1** of this SOP will be completed, signed, and filed as proof of performance.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

The Preparatory and Initial QC checks for this SOP are performed during the implementation of GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) and GCO-SOP-18, Collecting Static Background Measurements. GCO-SOP-12 ensures that the instrument is working properly and that the field geophysical team is collecting data of adequate quality. GCO-SOP-18 ensures that background data has been collected and validated properly. Therefore, this procedure requires only follow-on QC inspections which are documented through the following steps:

CONTROLLED COPY

- Field team composition and roles will be documented during field activities. By logging the data, and thereby taking responsibility for it, the geophysicist logging the data is certifying compliance with the requirements of this SOP.
- Field team will complete the Cued Data Collection QC Checklist in **Attachment 1** of this SOP.
- Field Team Lead will perform and observe data collection throughout the project to ensure proper data collection and document any non-conformities to the project plan.
- Cued sensor data will be imported into processing software and data quality will be assessed using validated QC function tests.
- The QC Geophysicist will review data flagged for removal, assess its usability, and document the observations in a Daily Geophysics QC Report.

Daily data packages, containing the geophysical data from that day, will be reviewed by the QC Geophysicist to ensure that the Measurement Quality Objectives (MQOs) are being achieved. A comprehensive root-cause analysis (RCA) will be performed and a corrective action (CA) (in accordance with GCO-SOP-5, Corrective Action, will be determined if the QC Geophysicist determines that the MQOs are not being met or if a trend toward the MQO limits is observed.

The MQOs for cued target measurements are presented in Worksheet #22 of the project-specific AGC-QAPP. Cued data will not be used to classify targets until these MQOs are met or until the project team agrees on modifications to these MQOs.

6. Reporting

Reporting of the activities associated with this SOP will consist of the digital copies of the field notes, the project QC database, and completion of the Cued Data Collection QC Checklist provided in **Attachment 1**.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
CA	corrective action
cm	centimeter
EM	electromagnetic
EMI	electromagnetic induction
GCO	Geophysical Classification Organization
GPS	global positioning system

CONTROLLED COPY

ID	identifier
IDQTF	Intergovernmental Data Quality Task Force
IVS	Instrument Verification Strip
m	meter
MQO	measurement quality objective
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RCA	root-cause analysis
RTK	real-time kinetic
RTS	robotic total station
SOP	Standard Operating Procedure
UTM	Universal Transverse Mercator
WESTON®	Weston Solutions, Inc.

8. References

Intergovernmental Data Quality Task Force (IDQTF). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

WESTON (Weston Solutions, Inc.). GCO-SOP-5, Correction Action (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-18, Collecting Static Background Measurements (current version). West Chester, PA.

CONTROLLED COPY

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-31, Setup and Operation of RTK GPS Navigation System (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-32, Setup and Operation of RTS Navigation System (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-35, MPV System Assembly and Verification (current version). West Chester, PA.

9. Attachments

CONTROLLED COPY

Attachment 1

Cued Data Collection QC Checklist

The following checks must be completed each day before morning function, and IVS testing during cued data collection.

Instrument ID: _____ Date:_____

QC Step	QC Process	Yes/No	Initial
Hardware Setup	Handle correctly assembled, aligned, and bolts tight		
	IMU Box aligned and secure		
	GPS/RTS mast secure		
	RTK or RTS corrections on		
	Batteries secure in backpack		
	Data acquisition hardware secure in backpack		
	Receiver and transmitter cables connected correctly		
	Transmitter cables to horizontal coils connected correctly (MPV only)		
	Cable strain relief ok for backpack and IMU box		
Software Setup	GPS stream ok		
	IMU stream ok		
	Navigation test: GPS/RTS positions updating on map		
	Correct job loaded		
	Output filename updated		
	Confirm correct reference file is loaded		

The following steps must be completed after end of day function, spin (MPV only), and IVS testing with the MPV or Metal Mapper.

QC Step	QC Process	Yes/No	Initial
Hardware	Shut down the instrument		
	Turn off the GPS		
	Put all batteries on charge (sensor, GPS, monitor, tablet)		
Data	Save data on an external hard drive		
	Scan/photograph field notes and save on an external hard drive		

Field or Project Geophysicist: _____ Date: _____

CONTROLLED COPY

GCO-SOP-20

PROCESSING CUES ADVANCED EMI DATA

Processing Cued Advanced EMI Data

Document No. GCO-SOP-20

Reviewed and Approved by: 
Ryan Steigerwalt, *Quality* Manager Date: Oct. 31, 2019

Reviewed and Approved by: 
Greg Abrams, Technical Manager Date: Oct. 30, 2019

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
6.0	Oct. 31, 2019	Section 2.2 revised to be inclusive of the DENIX approved version of UX-Analyze as specified in the project-specific AGC-QAPP.	G. Abrams	M. Costello
5.0	Sept. 9, 2019	Section 3.2 Clarified the data import requirements.	G. Abrams	R. Steigerwalt
4.0	Nov. 13, 2017	Section 3.4 has been revised to state that the approved library database may be reduced to better represent the CSM on a project specific basis, however, any reduction of the approved Library database must be coordinated with and approved by the project delivery team as described in the following paragraph. During AGC-QAPP preparation and through the Systematic Project Planning process, the Project Geophysicist will propose/present modifications to the TOI Library based on site specific considerations. The modified TOI Library will be reviewed and approved as part of the AGC-QAPP. During the course of project delivery, it may become necessary for the TOI Library to be further modified based on findings or events. In this situation, the Data Analyst will recommend TOI Library revisions with sufficient justification to the Project Geophysicist and QC Geophysicist. The Project Geophysicist and QC Geophysicist will review and concur with the recommendations or return to the Data Analyst with comments. Upon concurrence by the Project Geophysicist and QC Geophysicist, the recommended TOI Library modifications will be distributed to the DoD project delivery team per instructions in the AGC-QAPP. TOI Library modifications will be approved by the project delivery team prior to implementation. Polarization plots will be overlaid with library results using the Create Library Overlay tool and a scatterplot will be generated to assist with a self-clutter analysis using the interactive Scatter Analysis Tool.	M. Costello	R. Steigerwalt

CONTROLLED COPY

3.0	Oct. 20, 2017	Section 5. The last sentence has been revised to read, "Typically, selected results that do not pass an MQO are chosen to represent a target because they are a much closer match to a TOI than another result for that target which did pass all of the MQOs."	T. King	M. Costello
2.0	Sept. 28, 2017	Section 3.4. A sentence has been added to the first paragraph which states, "At the discretion of the GCO, the approved library database may be reduced to remove items that are unlikely to be encountered and better represent the CSM." Section 3.5. A sentence has been added to the first paragraph which states, "The Data Analyst will visually review library matches and polarization plots to ensure that items have been correctly classified. At the discretion of the GCO, items with poor visual polarization fit characteristics may be removed from the final prioritized dig list."	G. Abrams	M. Costello
1.0	August 24, 2017	Section 2 list of equipment and materials has been revised to include the following: • Personal computer to manage geophysical data and processing software • Approved version of Oasis Montaj with UX-Analyze module as indicated by the DENIX DAGCAP webpage (e.x. Version 9.2) • Raw data files provided by cued survey • Preparatory Geosoft training materials, UX-Analyze Workshop, Version 9.2 (Geosoft, 2017). Section 3 has been revised to specify that cued processing will follow the steps provided in UX Analyze Workshop, Version 9.2 (Geosoft, 2017). The subsections within section 3 have been revised to summarize processing the cued production data including positioning and leveling of the data, processing/assessing the QC activities related to cued data collection, and generating a prioritized dig list. Section 4.2. Output data has been revised to align with relevant Geosoft QC outputs. Section 6, Reporting requirements have been revised to align with relevant Geosoft QC outputs.	T. King	G. Abrams
0.0	May 19, 2017	Original Publication	M. Costello	T. King

1. Purpose and Scope

The purpose of this Standard Operating procedure (SOP) is to identify the means and methods to be employed when processing cued measurements collected using an advanced electromagnetic induction (EMI) sensor for target classification. Cued surveys include the collection of cued data over predetermined target locations and background locations. Cued measurements are also performed over instrument verification strip (IVS) targets for quality control (QC) purposes. This

CONTROLLED COPY

SOP details the steps required to verify the quality of these measurements, process these measurements to derive features related to the physical characteristic of the target, and use these features to classify the targets.

This SOP has been prepared in accordance with SOP 8, provided within Appendix A of the Intergovernmental Data Quality Task Force (IDQTF) *Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP)* (IDQTF, 2016).

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the processing of cued target data:

- Project Geophysicist – Designs geophysical approach for the project; monitors advanced sensor data acquisition; reviews compiled ranked dig lists.
- QC Geophysicist – Reviews QC testing results and verifies results are documented in the QC database; confirms that QC seeds have been correctly classified as targets of interest (TOI).
- Data Analyst – Processes collected data and documents testing results in the QC database; makes classification decisions based on data results.

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the in the project-specific AGC-QAPP (Worksheets #4, 7 & 8).

2.2 Equipment

The following is a list of equipment and materials required to implement this SOP:

- Personal computer to manage geophysical data and processing software
- Approved version of data processing software as indicated by the DENIX DAGCAP webpage (e.g. UX-Analyze Version 9.6), as specified within the project-specific AGC-QAPP
- Raw data files provided by cued survey
- Preparatory training materials (e.g. UX-Analyze Oasis Montaj Version 9.6)

3. Procedure and Guidelines

This section describes the procedures used to process the cued production data including positioning and leveling of the data, processing/assessing the QC activities related to cued data

CONTROLLED COPY

collection, and generating a prioritized dig list. Cued processing will follow the steps provided in the Geosoft UX-Analyze training material referenced within this SOP. The following sections provide a summary of the cued data processing steps.

The processing of Cued AGC data is achieved in the following general steps:

1) Static function tests
2) Data import and initial QC
3) Background removal and data positioning
4) Library validation
5) Classification and Ranking

Each of these steps are described in the following subsections.

3.1 Static Function Tests

Static function test data will be imported and processed separately from production data. Static test item and background files will be import into separate .gdb files. The Sensor Function Test UX-Analyze tool will be used to verify that the sensor function test data passes and the instrument is suitable for data collection.

3.2 Data Import and Initial QC

Raw HDF5 or CSV data will be imported into a Geosoft Database (*.gdb) using a purpose-built utility in UX-Analyze. Cued target list data is then incorporated into data files using the Master Flag Database. Once imported, the Calculate Survey Database QC Stats and Decay Display tools are run and results are assessed against the measurement quality objectives (MQOs) provided in Worksheet #22 of the project-specific AGC-QAPP. Data measurements that do not pass the MQOs are automatically identified using the Decay Display - QA tool. This maintains the chronologic integrity of the EMI data but prevents the out-of-specification data from being mapped and used for detection.

3.3 Background Removal and Data Positioning

Validated Background locations will be used to correct cued data files. The Level Sensor Data tool will be used to apply background corrections to cued data files based on time of collection and proximity to background locations.

3.4 Library Validation

Library matching will be completed using an approved Library database and the Validate Library UX-Analyze tool. The approved library database may be reduced on a project-specific basis to remove items that are unlikely to be encountered and better represent the CSM. Any reduction of the approved Library database must be coordinated with and approved by the project delivery team as described in the following paragraph.

During AGC-QAPP preparation and through the Systematic Project Planning process, the Project Geophysicist will propose/present modifications to the TOI Library based on site specific considerations. The modified TOI Library will be reviewed and approved as part of the AGC-

CONTROLLED COPY

QAPP. During the course of project delivery, it may become necessary for the TOI Library to be further modified based on findings or events. In this situation, the Data Analyst will recommend TOI Library revisions with sufficient justification to the Project Geophysicist and QC Geophysicist. The Project Geophysicist and QC Geophysicist will review and concur with the recommendations or return to the Data Analyst with comments. Upon concurrence by the Project Geophysicist and QC Geophysicist, the recommended TOI Library modifications will be distributed to the DoD project delivery team per instructions in the AGC-QAPP. TOI Library modifications will be approved by the project delivery team prior to implementation.

Polarization plots will be overlaid with library results using the Create Library Overlay tool and a scatterplot will be generated to assist with a self-clutter analysis using the interactive Scatter Analysis Tool.

3.5 Classification and Ranking

The Classify and Rank Tool in UX-Analyze will be used to assess modeling, library matches, self matches, and creates a prioritized dig list and final QC environment with graphics. The resulting products will return a prioritized dig list ranking anomalies into three categories. The Data Analyst will visually review library matches and polarization plots to ensure that items have been correctly classified. At the discretion of the GCO, items with poor visual polarization fit characteristics may be removed from the final prioritized dig list.

Training and verification digs may be requested to compare against data results and ensure all anomalies are correctly classified and no TOIs are excluded from the dig list. Additional validation and verification digs, as specified in the project-specific AGC-QAPP Worksheet #22 and as discussed in GCO-SOP-22, Validation of Classification Process will reveal ground truth information for sources beyond the stop dig point.

4. Data Management

The following sections describe the input data that is needed to perform this SOP and the resulting output data.

4.1 Input Data Required

The data inputs required for performing a cued advanced analysis data acquisition are:

- A list of target anomalies including identifier (ID) and position (X, Y)
- A list of Background locations (ID, X, Y)
- A list of IVS locations (ID, X, Y)
- Advanced EMI measurement data including those for target anomalies, daily IVS, backgrounds, and function tests
- Digital field notes for all data collection activities
- Site specific and comprehensive library signatures

CONTROLLED COPY

4.2 Output Data

The data outputs of the cued advanced analysis data processing for each delivered survey unit (contiguous subset of the survey site) are:

- Geosoft QC reports summarizing daily QC measurement and data results
- Target measurement data, background measurement data, and target feature databases
- Supporting documents for classification (PNG, JPG, or PDF images)
- Cued survey data usability assessment
- Prioritized target list

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

The MQOs for cued target measurements are presented in Worksheet #22 of the project-specific AGC-QAPP. Performance relative to the MQOs will be assessed during the processing of the collected data. Cued data will not be used to classify targets until these MQOs are met or until the project team agrees on modifications to these MQOs.

Every effort will be made to ensure that the selected result(s) for each target either passes the MQOs specified in Worksheet #22 or that there is an adequate explanation for why the selected result does not pass an MQO. Typically, selected results that do not pass an MQO are chosen to represent a target because they are a much closer match to a TOI than another result for that target which did pass all of the MQOs.

6. Reporting

Reporting of the activities associated with this SOP will consist of:

- Digital field notes.
- Relevant Geosoft QC outputs file (e.x. .map, .gdb, .csv)
- QC Report detailing the system performance against the MQOs identified on the project-specific AGC-QAPP Worksheet #22 (including MQOs for daily IVS and Function Test performance as well as for individual measurement metrics)
- Final data archive (gdb or xyz format) for delivered area subset
- Final classified and ranked target dig list
- A Classification Report detailing specific approach to classification and final results

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

CONTROLLED COPY

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
β	beta
CSM	conceptual site model
EMI	electromagnetic induction
ESTCP	Environmental Security and Technology Certification Program
GCO	Geophysical Classification Organization
GPS	global positioning system
ID	identifier
IDQTF	Intergovernmental Data Quality Task Force
IMU	Inertial Measurement Unit
IVS	Instrument Verification Strip
MQO	measurement quality objective
NRL	Naval Research Lab
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QMS	Quality Management System
SOP	Standard Operating Procedure
TOI	target of interest
Tx	transmit
UXA	UXAnalyze-Advanced
UXO	unexploded ordnance
WESTON	Weston Solutions, Inc.

CONTROLLED COPY

8. References

Intergovernmental Data Quality Task Force (IDQTF). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-22, Validation of Classification Process (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

CONTROLLED COPY

GCO SOP-21

VERIFYING RECOVERED OBJECTS ARE COMPATIBLE WITH PREDICTIONS

Verifying Recovered Objects are Compatible with Predictions

Document No. GCO-SOP-21

Reviewed and Approved by: _____ Date: March 2, 2020
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by: _____ Date: March 2, 2020
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
2.0	March 2, 2020	Revised SOP to be inclusive of all DAGCAP approved AGC processing software. Section 3.1, revised to reference MQO stated in the project-specific AGC-QAPP Section 4.2 and 6, revised to clarify that intrusive discrepancies would be submitted with final intrusive results.	Shawn MacMillan	G. Abrams
1.0	Oct. 20, 2017	Section 2.1, last sentence has been revised to delete "in the", which was repeated.	T. King	M. Costello
0.0	May 19, 2017	Original Publication	M. Costello	T. King

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to be employed when comparing the results of an intrusive investigation against the target parameters resulting from analysis of advanced sensor data.

This SOP has been prepared in accordance with SOP 9, provided within Appendix A of the Intergovernmental Data Quality Task Force (IDQTF) *Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP)* (IDQTF, 2016).

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

CONTROLLED COPY

2.1 Personnel

The following individuals will be involved in the performance of this SOP:

- Project Geophysicist – Compares intrusive results to classification decisions; recommends additional intrusive activity if necessary.
- Quality Control (QC) Geophysicist – Reviews data to confirm results.

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the project-specific AGC-QAPP (Worksheets #4, 7 & 8).

2.2 Equipment

The following is a list of required equipment and materials required to implement this SOP:

- Personal computer to manage geophysical data and processing software
- DAGCAP approved AGC processing software (e.g. Oasis Montaj UX-Analyze)
- Results of the intrusive investigation to include recovery depths, photographs and descriptions to be checked against the sources predicted during classification.

3. Procedure and Guidelines

Each item recovered during the intrusive investigation of an anomaly should be compared to the results of the data analysis. Specific parameters to compare include burial depth, rough size, and item shape. Any significant deviations will require a re-examination of the anomaly and/or a re-analysis of the advanced sensor data.

3.1 Compare Recovered Items(s) Against Predictions

In the case where only a single item is predicted to be the source of the anomaly, this comparison is relatively straightforward.

1) Compare predicted depth to actual burial depth and ensure that they are within the MQO stated in the project-specific AGC-QAPP.

2) Compare recovered item size to predicted size band. The AGC database will contain a predicted size for the item within three bands. Items defined as small will be the size of a 37-milimeter (mm) projectile and smaller. Items defined as medium will be larger than a 37-mm projectile and smaller than a 105-mm projectile. Items defined as large will be the size of a 105-mm projectile and larger.

3) Compare the shape of the recovered item to the predicted shape. The predicted shape is inferred from the polarizability decay curves in the project database. Three examples of symmetric (or near-symmetric) items are shown in **Figure 3-1**. If all three curves are different, then the object is predicted to be non-symmetric.

   The curves in plot (a) (**Figure 3-1**) depict a cylindrical object with one large response and two smaller, but equal responses. In addition, the polarizabilities decay slowly indicating a

CONTROLLED COPY

thick-walled object. The curves in (b) result from a plate-like object with two large and nearly equal, responses and one smaller response. These polarizabilities decay quickly indicating a thin-walled object. The object in plot (c) is also plate-like but thicker walled as indicated by the slowly decaying polarizabilities.

If the analysis indicates the anomaly results from multiple items, then a comparison will be required for each item recovered.

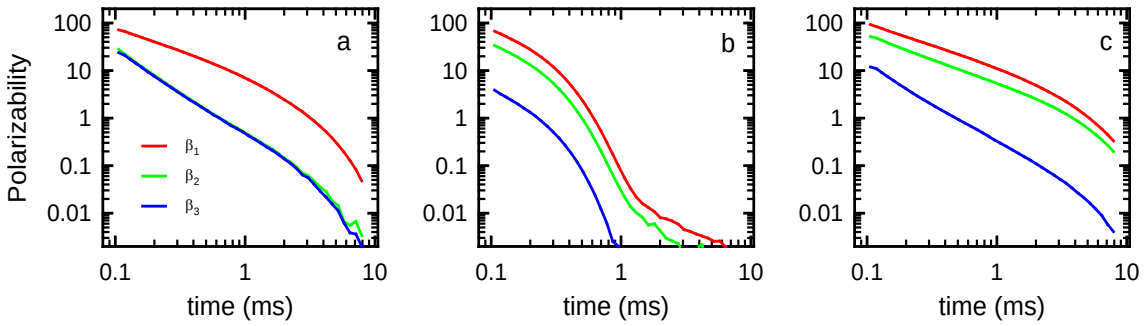


Figure 3-1 Examples of the Polarizability Decay Curves for a Variety of Symmetric (or Near-symmetric) Objects

3.2 Resolution of a Discrepancy

There are two common causes for a discrepancy between the recovered object and the analysis predictions. The resolution of these cases is straightforward.

1) A small item is recovered from a shallow depth when the prediction is for a larger item more deeply buried. This often results from a failure of the intrusive crew to clear the hole after recovering a shallow frag item.

2) A small item (or no item) is recovered when the prediction is for a very deeply buried large item. This often results when the anomaly resulted from geologic interference. In attempting to reproduce the measured anomaly, the inversion routine is driven toward a very deep large anomaly.

Any other discrepancy between prediction and observations will require an examination of the anomaly location or the analysis or both.

4. Data Management

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 Input Data Required

The analysis predictions for depth, size, and shape are contained in the AGC database. The parameters of the recovered items are contained in the intrusive results file.

4.2 Output Data

The resolution of any discrepancies between the recovered items and analysis predictions will be documented and submitted with the final intrusive results.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

QC consists of performing the inspections for Recovered Item Verification by the by the Project Geophysicist and verified by the QC Geophysicist. The QC Geophysicist will document the implementation of this SOP in a Geophysics Daily QC Report.

Successful performance of this SOP will be based on achievement of the Recovered Object Verification measurement quality objectives (MQOs), presented in Worksheet #22 of the project-specific AGC-QAPP.

6. Reporting

As stated in Section 4.2, the resolution of any discrepancies between the recovered items and analysis predictions will be documented and submitted with the final intrusive results.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
cm	centimeter
GCO	Geophysical Classification Organization
IDQTF	Intergovernmental Data Quality Task Force
MQO	measurement quality objective
mm	millimeter
ms	millisecond
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System

CONTROLLED COPY

SOP	Standard Operating Procedure
WESTON	Weston Solutions, Inc.

8. References

Intergovernmental Data Quality Task Force (IDQTF). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

CONTROLLED COPY

GCO SOP-22

VALIDATING THE CLASSIFICATION PROCESS

Validating the Classification Process

Document No. GCO-SOP-22

Reviewed and Approved by:  Date: Oct. 31, 2019

Ryan Steigerwalt, *Quality* Manager

Reviewed and Approved by:  Date: Oct. 30, 2019

Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
2.0	October 31, 2019	Section 2.2 revised to be inclusive of the DENIX approved AGC processing software as specified in the project-specific AGC-QAPP.	G. Abrams	M. Costello
1.0	August 24, 2017	The second bullet of section 2.2 has been revised to specify an approved version of Oasis Montaj with UX-Analyze module as indicated by the DENIX DAGCAP webpage (e.x. Version 9.2). The first sentence of section 5 has been revised to read, "The QC Geophysicist will document the implementation of this SOP in a daily QC Report and the daily summary report of field activities."	T. King	G. Abrams
0.0	May 19, 2017	Original Publication	M. Costello	T. King

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to be employed when validating the classification process at the completion of a munitions response. The items dug as targets of interest (TOI) have validated the ability of the analyst to correctly classify unexploded ordnance (UXO). This procedure is intended to validate the remaining question: was the analyst able to classify non-TOI correctly. To accomplish this validation, the site team will randomly select a number of anomalies classified as due to non-TOI. The analyst will provide the rationale for classifying these items as non-TOI. The items will be excavated and compared to this rationale.

This SOP has been prepared in accordance with SOP 10, provided within Appendix A of the Intergovernmental Data Quality Task Force (IDQTF) *Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP)* (IDQTF, 2016).

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the performance of this SOP:

- Project Geophysicist – Reviews validation dig data to confirm results; responsible for root-cause analysis (RCA)/corrective action (CA) implementation for failure.
- QC Geophysicist – Compares intrusive results to Data Analyst's reasoning for non-target of interest (TOI) decision.
- Data Analyst – Provides rationale for non-TOI decision for validation targets.

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the in the project-specific AGC-QAPP (Worksheets #4, 7 & 8).

2.2 Equipment

The following is a list of required equipment and materials required to implement this SOP:

- Personal computer to manage geophysical data and processing software
- Approved version of processing software as indicated by the DENIX DAGCAP webpage (e.g. UX-Analyze Version 9.6) as specified in the project-specific AGC-QAPP
- Results of the intrusive investigation to include recovery depths, photographs and descriptions. These will be checked against the sources predicted during classification

3. Procedure and Guidelines

The project team will choose a number of items (to be specified in Worksheet # 22 of the project-specific AGC-QAPP) for validation digs. In many cases, these items will be chosen randomly from the list of anomalies classified as non-TOI. It is possible that some of these validation items may be chosen based on particular characteristics of the item (e.g. a large "cluster" of items with similar polarizabilities that have not been investigated). This list will be provided to the Data Analyst and intrusive team.

3.1 Provide Rationale for Classification Decision

For each item on the validation list, the analyst will provide a brief rationale for the classification decision. In many cases, this will be a simple statement such as "item too small to be TOI," "thin-walled plate like object," or "item recognized as a baseplate." If a more detailed narrative is required, the analyst will provide it.

CONTROLLED COPY

3.2 Excavate the Anomaly

In parallel with the Data Analyst's work, the intrusive team will return to the listed anomalies and excavate them using standard procedures. The excavated items should be saved for examination by the QC Geophysicist. If this is not possible, a series of photographs should be recorded.

3.3 Compare Excavated Item to Prediction

Each excavated item will be compared by the QC Geophysicist to the prediction generated by the Data Analyst. Each recovered item should qualitatively support the rationale provided for the classification decision. For a single-source inversion this comparison is straightforward. For a multi-source inversion with several realizations, the comparison may be more involved but the principle remains the same.

In the unlikely event a TOI is recovered during this validation effort, all work should stop and the site manager notified of this serious systemic failure. Otherwise, the QC Geophysicist will prepare a Validation Report documenting the analyst's predictions and the actual recoveries from the intrusive investigation.

4. Data Management

The following sections describe the data that is needed to perform this SOP and the resulting data.

4.1 Input Data Required

The list of validation anomalies chosen by the site team is the input to this SOP.

4.2 Output Data

Validation dig results are recorded in the project database. The comparison of the recovered items and analysis predictions will be documented in a Validation Report to be submitted by the Project Geophysicist.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

The QC Geophysicist will document the implementation of this SOP in a daily QC Report and the daily summary report of field activities.

Successful performance of this SOP will be based on achievement of the Recovered Object Verification measurement quality objectives (MQOs), presented in Worksheet #22 of the project-specific AGC-QAPP.

6. Reporting

Per Section 4.2, the comparison of the recovered items and analysis predictions will be documented in a Validation Report to be submitted by the Project Geophysicist.

CONTROLLED COPY

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Accreditation
CA	corrective action
GCO	Geophysical Classification Organization
IDQTF	Intergovernmental Data Quality Task Force
MQO	measurement quality objective
QAPP	Quality Assurance Project Plan
QC	quality control
QMS	Quality Management System
RCA	root-cause analysis
SOP	Standard Operating Procedure
TOI	target of interest
UXO	Unexploded Ordnance
WESTON	Weston Solutions, Inc.

8. References

Intergovernmental Data Quality Task Force (IDQTF). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

CONTROLLED COPY

GCO SOP-27

ESTIMATING MEASUREMENT UNCERTAINTY

Estimating Measurement Uncertainty

Document No. GCO-SOP-27

Reviewed and Approved by: _____ Date: Oct. 20, 2017
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by: _____ Date: Oct. 20, 2017
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
1.0	Oct. 20, 2017	Section 3.1.1, the third sentence has been revised to remove "in" which was repeated.	T. King	M. Costello
0.0	July 12, 2017	Original Publication	M. Costello	T. King

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to recognize and appropriately manage potential sources of uncertainty to ensure data are representative of the population of interest and test results can be used as intended with an acceptable level of confidence.

This SOP has been prepared in accordance with the guidance provided in the Department of Defense (DoD) Quality System Requirements (QSR), Appendix F: Factors Affecting Measurement Uncertainty (DoD, 2015).

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS) and is applicable for use and incorporation into Advanced Geophysical Classification (AGC) projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment, and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the performance of this SOP:

- Project Geophysicist
- Quality Control (QC) Geophysicist

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the project-specific Geophysical Classification for Munitions Response (GCMR) Quality Assurance Project Plan (QAPP) (Worksheets #4, 7 & 8).

2.2 Equipment

None listed.

3. Procedure and Guidelines

Uncertainty components are to be considered when making the primary decision of whether or not to dig a detected item. These uncertainty components vary according to the conditions specific to each site.

Uncertainties of most concern are in the estimated polarizabilities for the unknown item. Of lesser concern are uncertainties in positioning, which impact the time required for excavation and the likelihood of recovering the correct item.

3.1 Factors Affecting Measurement Uncertainty

Many factors can affect the measurement uncertainty and must be considered. Some example factors are provided in the following subsections.

3.1.1 Recovered Polarizabilities

Analyses starting with a high signal-to-noise measurement routinely yield precise polarizabilities. As the signal-to-noise ratio (SNR) degrades, the uncertainties in the recovered polarizabilities increase until the results are too poor to use as inputs to classification. In the case of this limit, the item is marked for excavation (DoD, 2015). The two contributors to low SNR, incorrect background subtraction and weak or contaminated signal from the unknown item, are described in the following subsections.

3.1.1.1 Background Uncertainties

For large targets with high amplitude signals, minor variations in background are negligible. For the smallest targets of interest (TOIs) at their deepest depths of concern; however, signal amplitudes are low and minor variations in background result in large variation in the input to the geophysical inversion routine that is used to estimate polarizabilities. Common causes of background variation in decreasing importance include the following:

- Short spatial scale variability in the soil response with the result that a nearby background measurement is not representative of the soil response at the site of the unknown measurement.
- The presence of small pieces of metal at the site of the background measurement resulting in a background that is the sum of the soil response and the signal from the metal contamination.
- Rapid change in soil conductivity due to moisture changes associated with dew burn off or a passing rainstorm.

CONTROLLED COPY

- Long spatial scale variability in soil response making a background collected on one side of the field unsuitable for use correcting an unknown measurement on the other side of the field.

3.1.1.2 Weak or Contaminated Signal

Selecting anomalies too deeply into the noise in an attempt to stretch the detection depth of the instruments can lead to measured data with insufficient amplitude for analysis. Even for stronger signals, external noise sources, such as nearby radars and transmission towers, high-power overhead transmission lines, and even faulty electric fences, can add noise to the measurement and compromise the SNR. Even those sources in very different frequency bands (radar and radio) can leak sufficient energy into the measurement band to impact the SNR.

3.1.1.3 Diagnosing Uncertainty in Recovered Polarizabilities

The best diagnosis of uncertainty in recovered polarizabilities is to compare the results for the QC and validation seeds. If a large number of the seeds are identical items, such as Industry Standard Objects (ISOs) the measured variation in the recovered polarizabilities will be a direct measure of the uncertainties in polarizabilities (DoD, 2015).

3.1.2 Location Uncertainties

A Global Positioning System (GPS) can be used for sensor geolocation in areas with good sky view for centimeter-level GPS. Use of this procedure, coupled with an accurate orientation measurement, can result in a location estimate uncertainty that is negligible for the purposes of classification. There is a continuing check of this result from comparison of the derived position of the blind and Instrument Verification Strip (IVS) seeds against their known emplaced positions.

For other positioning systems, such as robotic total station (RTS) or fiducial methods that must be employed in GPS-compromised environments, the location uncertainties can be great (decimeters to meters), which can impact the ability of the intrusive team to efficiently return to the intended excavation target and even the recovery of incorrect items. These uncertainties will be evaluated on a case-by-case basis depending on the particular conditions encountered at the site.

4. Data Management

The Project Geophysicist documents factors affecting measurement uncertainty on the daily reports.

All data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific GCMR-QAPP.

5. Quality Control

The QC Geophysicist documents factors affecting measurement uncertainty on a Geophysics Daily QC Report.

CONTROLLED COPY

6. Reporting

Measurement uncertainty is reported with method records on the project-specific GCMR-QAPP Worksheet #37, Data Usability Assessment (DUA).

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
DoD	Department of Defense
DUA	Data Usability Assessment
GCMR	Geophysical Classification for Munitions Response
GCO	Geophysical Classification Organization
GPS	Global Positioning System
ISO	Industry Standard Object
IVS	Instrument Verification Strip
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
QSR	Quality System Requirements
RTS	robotic total station
SNR	signal-to-noise ratio
SOP	Standard Operating Procedure
TOI	Target of Interest
WESTON®	Weston Solutions, Inc.

8. References

Department of Defense (DoD), 2015. Department of Defense Quality Systems Requirements for Advanced Geophysical Classification. Version 1.0. November 2015.

CONTROLLED COPY

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

9. Attachments

None provided.

CONTROLLED COPY

GCO-SOP-28

2X2 SENSOR SYSTEM DISASSEMBLY AND PACKING

2x2 Sensor System Disassembly and Packing

Document No. GCO-SOP-28

Reviewed and Approved by: _____ Date: Sept.14, 2017
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by: _____ Date: Sept. 14, 2017
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
2.0	Sept. 14, 2017	The first sentence of Section 3.2 has been revised to read as follows, "Using a cell phone or other digital camera, photograph the sensor prior to disassembly in order to document any physical damage that may have occurred during field operations."	G. Abrams	M. Costello
1.0	August 24, 2017	The SOP has been revised to remove the Reference to the NRL TEMTADS 2x2 User's Guide (NRL, 2014) as Attachment 2. The NRL TEMTADS 2x2 User's Guide is now listed on the Master Document List and is controlled separately as a WESTON GCO Reference Document. A note has been added to the 4th bullet in Section 2, and to Section 3.2 to clarify that if use of digital cameras on site is prohibited, the GCO will follow site procedures for obtaining photos, if available. Sections 2 and 7 have been updated to include references to the Geometrics, Inc. MetalMapper 2.2 Operations Manual, Rev 1.01.	M. Costello	G. Abrams
0.0	July 12, 2017	Original Publication	G. Abrams	M. Costello

Controlled Copy

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when disassembling the 2x2 sensor system for storage/shipping and verifying that all components are correctly disassembled, and packed following fieldwork.

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into Advanced Geophysical Classification (AGC) Projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following is a list of required equipment and materials:

- 2x2 sensor coupled with a real-time kinematic (RTK) Global Positioning System (GPS) or robotic total station (RTS).
- Inertial Measurement Unit (IMU) for orientation measurements used to measure yaw, pitch, and roll of the 2x2 sensor.
- A schedule 80 small Industry Standard Object (small ISO80).
- Digital camera or cell phone to take photographs of the 2x2 sensor following packing. Note: If use of digital cameras on site is prohibited, the GCO will follow site procedures for obtaining photos, if available.
- 2X2 Sensor Disassembly Quality Control (QC) Checklist, included as **Attachment 1** to this SOP.
- Time-domain electromagnetic multi-sensor tower array detection system (TEMTADS) 2x2 User's Guide (NRL, 2014) or MetalMapper 2x2 Operations Manual (Geometrics, Rev 1.01).

The following individuals will be involved in the disassembly of the 2x2:

- QC Geophysicist – Confirms that sensor was disassembled correctly either in person or through notes, and photographs.
- Field Team Leader or Field Geophysicist – Disassembles and oversees disassembly of 2x2 sensor.

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability (DOC), and project-required documentation of qualifications will be provided in the project-specific Geophysical Classification for Munitions Response Quality Assurance Project Plan (GCMR-QAPP) (Worksheets #4, 7, and 8).

3. Procedure and Protocols

3.1 2x2 Disassembly and Packing

The disassembly operations for the 2X2 Sensor System are described below. These detailed instructions should be followed precisely using the TEMTADS 2x2 User Guide (NRL, 2014) or the MetalMapper 2x2 Operations Manual (Geometrics, Rev 1.01) as a reference if necessary. The disassembly and packing steps are briefly described below:

1. Remove all batteries and return them to shipping containers.

2. Cut all zip-ties that bundle cables and secure cables to equipment.

3. Disconnect the Tx, Rx, GPS/RTS, and IMU cables from the equipment and electronics box.

CONTROLLED COPY

4. Remove GPS or RTS antenna from the top of the mounting platform. If GPS is not being used, move to Step 5.

5. Remove sensor, GPS/RTS, and IMU cables individually and return to their appropriate cases and boxes.

6. Remove the electronic housing from the backpack and return it to its shipping container.

7. Remove wheels and handle.

8. Return the sensor assembly to the packing crate.

3.2 Photograph the Sensor

Using a cell phone or other digital camera, photograph the sensor prior to disassembly in order to document any physical damage that may have occurred during field operations.

Photograph the packed content of each case prior to shipping.

Note: If use of digital cameras on site is prohibited, the GCO will follow site procedures for obtaining photos, if available.

4. Quality Control

Work in accordance with this SOP will be included within a definable feature of work to be accomplished only at the completion of geophysical projects as specified within a site-specific GCMR-QAPP. As a result, only final QC checks will be performed (i.e., the inspections on the 2x2 Sensor Disassembly QC Checklist, included as **Attachment 1**). This checklist will be completed by the Field or Project Geophysicist and documented in the Daily QC Report..

5. Reporting

Achievement of the this SOP will be documented by the Team Lead or Field Geophysicist by completion of the 2x2 Sensor System Disassembly QC Checklist (**Attachment 1**) and will be documented in the Daily QC Report.

6. Terms, Definitions and Abbreviations

6.1 Definitions/Terms

No terms or definitions are included in this SOP.

6.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
DOC	Demonstration of Capability
GCMR	Geophysical Classification for Munitions Response
GCO	Geophysical Classification Organization

CONTROLLED COPY

GPS	global positioning system
IMU	Inertial Measurement Unit
ISO	Industry Standard Object
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RTK	real-time kinetic
RTS	robotic total station
small ISO80	Schedule 80 small Industry Standard Object
SOP	Standard Operating Procedure
TEMTADS	time-domain electromagnetic multi-sensor tower array detection system
WESTON®	Weston Solutions, Inc.

7. References

Geometrics, Inc. MetalMapper 2.2 Operations Manual, Rev 1.01, P/N 0071740-01.

NRL (US Naval Research Laboratory). 2014. TEMTADS MP 2x2 Cart User's Guide, v2.00, MTADS Program, US Naval Research Laboratory, Chemistry Division, Washington, DC. May 2014.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-12, Testing of Sensor and System at the Instrument Verification Strip (IVS) (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

8. Attachments

CONTROLLED COPY

Attachment 1 2x2 Sensor System Disassembly QC Checklist

This checklist is to be completed by the Field or Project Geophysicist during disassembly and packing of the system.

QC Step	QC Process and Guidance Reference	Yes/ No	Initial
1. Qualifications	Are the qualifications of the Project and Field Geophysicists in accordance with GCO-SOP-23 and with the GCMR-QAPP Worksheets 4, 7, and 8?		
2. Disassembly	Is the 2x2 sensor disassembled in accordance with the published instructions and in the sequence specified in Section 3.1 of this SOP?		
3. Packing	Have all system components been packed in their original cases and placed into shipping boxes?		
4. Photograph the Disassembly	If applicable, Have photos been taken to show physical damage that may have occurred during this project?		
5. Photograph the Disassembly	Have photos been taken to show each of the packed shipping containers prior to shipping?		

Project or Field Geophysicist: _____ Date: _____

CONTROLLED COPY

GCO-SOP-29

PERFORMING DYNAMIC SURVEYS WITH METALMAPPER 2X2

Performing Dynamic Surveys with METALMAPPER 2x2

Document No. GCO-SOP-29

Reviewed and Approved by:_____ Date: Feb 28, 2018
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by:_____ Date: Feb 28, 2018
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
2.0	Feb 28, 2018	Section 1, 4th paragraph, corrected small typo "he user" to "the user".	M. Costello	R. Steigerwalt
1.0	Sept. 6, 2017	Section 3.1, Survey Grid Preparation, has been removed from this SOP. The subsequent sections have been renumbered.	M. Costello	G. Abrams
0.0	August 24, 2017	Original Publication	M. Costello	G. Abrams

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating procedure (SOP) is to identify the means and methods to be employed when performing dynamic surveys using a MetalMapper 2x2 advanced electromagnetic induction (EMI) sensor for target detection.

Dynamic data collection involves navigating the sensor along transects at a transect spacing designed to meet the project objectives with respect to detection performance of suspected targets of interest (TOI) in the subsurface. The detection objectives and resultant transect spacing are identified in the project-specific Geophysical Classification for Munitions Response-Quality Assurance Project Plan (GCMR-QAPP).

The system uses time domain electromagnetic (TDEM) principles to induce electrical currents in buried metallic objects and then measures the effects of those currents in receivers on the surface. It has four (4) co-planar transmitter coils placed in a 2 by 2 square. Each transmitter coil is approximately 35 centimeter (cm) by 35cm in size. Located in the center of each transmitter coil is a 10cm by 10cm by 10cm receiver cube, each one containing three (3) orthogonal coils to measure the fields resulting in 12 different receiver coils. The receiver coils are oriented in 3-dimensions. The transmitter coils are powered using a bi-polar half duty cycle and the time decay of the subsurface currents (transients) are measured during time off of the transmitter coils.

The MetalMapper 2x2 can be used in two collection modes; dynamic or static. Dynamic mode is collected by pushing the cart over targets in a series of closely spaced parallel lines. Navigation

features in the software direct the user to stay on the correct path. Static mode is collected by moving the instrument over predefined targets from an anomaly list. Data is collected and stored in a HDF5 file format. Details of the data processing and analysis of dynamic data are covered in GCO-SOP-30, Processing Dynamic Survey Data with MetalMapper 2x2.

This SOP has been prepared in accordance with Rev 1.01 of the MetalMapper 2x2 Operations Manual prepared by Geometrics, Inc.

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the collection of dynamic survey data:

- Project Geophysicist
- Quality Control (QC) Geophysicist
- Field Team Leader
- Field Geophysicist
- Data Analyst

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the project-specific GCMR-QAPP (Worksheets #4, 7 & 8).

2.2 Equipment

The following is a list of required equipment and materials:

- MetalMapper 2x2 sensor
- Navigation instrument [e.g., real-time kinematic (RTK) Global Positioning System (GPS) (see GCO-SOP-31, Setup and Operation of RTK GPS Navigation System) or robotic total system (RTS) (see GCO-SOP-32, Setup and Operation of RTS Navigation System)]
- Inertial Measurement Unit (IMU) for orientation measurements
- Remote desktop tablet (such as Motion Computing)
- Field survey-grade tape measure
- Traffic cones or equivalent for lane marking or marking paint
- Dynamic MetalMapper 2x2 Data Collection QC Checklist, included as **Attachment 1** to this SOP
- Geometrics MetalMapper 2x2 Operations Manual, Rev 1.01, included as **Attachment 2** to this SOP
- Skid steer (if required)

CONTROLLED COPY

- MetalMapper skid-steer attachment (if using a skid steer)

3. Procedure and Guidelines

3.1 Function Test Measurements

Function test measurements (described in GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification and the Geometrics MetalMapper 2x2 Operations Manual, Rev 1.01), will be performed prior to each day of collection to confirm that all transmit and receive components of the MetalMapper 2x2 sensor are operational.

3.2 Daily IVS Survey

Prior to the start and at the end of each day of data collection, measurements of the set of Instrument Verification System (IVS) targets will be performed as described in GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS).

3.3 Dynamic Data Collection

Dynamic survey for digital geophysical mapping (DGM) involves collecting data along transects across the survey area. In combination with SOPs for sensor assembly (GCO-SOP-11) and testing at the IVS (GCO-SOP-12), in-motion data are collected along each transect at a spacing appropriate to the site and project needs, as defined in the project-specific GCMR-QAPP. Data collection is controlled by the user with the ATEM software, which allows the user to assign a numerical identification (ID) to each transect line and start/stop data collection at the beginning/end of each transect. When an obstacle is encountered along a transect, the obstacle can be avoided by either altering the path of the transect or stopping data collection and resuming a new ID transect on the other side of the obstacle. Data gaps that are the result of obstacles should be recorded by the Field Geophysicist and submitted to the Data Analyst. Data gaps that are the result of line spacing over the defined acceptable spacing will be determined by the Data Analyst and provided to the Field Geophysicist for re-collection. Data acquisition will be performed using the following steps:

1) **Start-up and test the MetalMapper 2x2.** The geophysical and navigation systems are started and a function test is performed prior to every data collection sortie. In addition the data acquisition software is monitored to ensure that all data streams (EMI, GPS, and IMU) are valid and being recorded.

2) **Navigate and collect data along transects.** Navigation along transects is performed at a slow walking speed (1.5 miles per hour or less). Planned transects will be loaded into the survey map using a .csv file so specific planned lines can be selected and navigated during data collection. Data collection may be completed with the assistance of visual markers, which are determined at the discretion of the Field Geophysicist. They may include, but are not limited to, ropes, tapes, spray paint, or flags. Positioning in the data is captured through the use of the RTK/RTS GPS system and the IMU.

CONTROLLED COPY

3) **Verify the integrity and quality of the collected data.** During data acquisition, the integrity and quality of the data will be verified by the operator by inspection of the MetalMapper 2x2 data collection screen to ensure that the following:

    - The data collection starts and stops in coordination with the beginning and end of each transect.
    - Each transect is assigned a unique numerical ID, in sequential order.
    - The amplitude responses measured by each receiver coil appear reasonable (i.e., not 'flat-lined').
    - The GPS and IMU data streams are updating with values consistent with the orientation and location of the sensor.

4) **Verify complete coverage of survey area.** 100% coverage surveys will require appropriate line spacing (presented in the site-specific GCMR-QAPP Worksheet #12). Data gaps resulting from obstacles or inaccessible terrain will be marked and verified by the Field Geophysicist. Data gaps exceeding the Measurement Quality Objectives (MQOs) identified in site-specific GCMR-QAPP Worksheet #22 will be reacquired using RTK/RTS GPS and re-collected.

4. Data Management

4.1 Input Data Required

The data inputs required for performing a dynamic advanced analysis data acquisition are as follows:

- A list of coordinates identifying the site boundaries
- A list of IVS transect start and end points
- A list of survey transect start and end points

4.2 Output Data

The data outputs of the dynamic advanced analysis data acquisition are:

- Dynamic MetalMapper 2x2 transect data over the IVS line and survey area
- Function test measurement data
- Raw field notes (pdf images of hand written notes)
- Digital field notes (an Excel, MS Access, or other digitally recorded table presenting data file names as delivered and rectified field notes [i.e., differences between delivered digital filenames and field notes are resolved])

Also, the Dynamic MetalMapper 2x2 Data Collection QC Checklist in **Attachment 1** of this SOP will be completed, signed, and filed as proof of performance.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific GCMR-QAPP.

CONTROLLED COPY

5. Quality Control

Practical considerations limit the real-time QC of the dynamic data acquisition activities to qualitative assessments. Quantitative QC and assessment of the collected data will be performed as part of GCO-SOP-30, Processing Dynamic Survey Data with MetalMapper 2x2.

The Dynamic MetalMapper 2x2 Data Collection QC Checklist in **Attachment 1** of this SOP will be filled out and delivered as part of the reporting requirement (Section 6) of this SOP.

The MQOs for dynamic data acquisition are presented in Worksheet #22 of the project-specific GCMR-QAPP. Performance relative to the MQOs will be assessed during the processing of the collected data (GCO-SOP-30). Dynamic MetalMapper 2x2 data will not be used to detect targets until these MQOs are met or until the project team agrees on modifications to these MQOs.

6. Reporting

Reporting of the activities associated with this SOP will consist of the digital copies of the field notes and completion of the Dynamic MetalMapper 2x2 Data Collection QC Checklist provided in **Attachment 1**.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
cm	centimeter
DGM	digital geophysical mapping
EMI	electromagnetic induction
GCMR	Geophysical Classification for Munitions Response
GCO	Geophysical Classification Organization
GPS	global positioning system
ID	identification
IDQTF	Intergovernmental Data Quality Task Force
IMU	Inertial Measurement Unit
IVS	Instrument Verification Strip

CONTROLLED COPY

MQO	measurement quality objective
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RTK	real-time kinetic
RTS	robotic total station
SOP	Standard Operating Procedure
TDEM	time domain electromagnetic
TOI	target of interest
WESTON®	Weston Solutions, Inc.

8. References

Geometrics, Inc. MetalMapper 2.2 Operations Manual, Rev 1.01, P/N 0071740-01.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-30, Processing Dynamic Survey Data with MetalMapper 2x2 (current version). West Chester, PA.

9. Attachments

CONTROLLED COPY

Attachment 1

Dynamic MetalMapper 2x2 Data Collection QC Checklist

This checklist is to be completed by the Field or Project Geophysicist each day MetalMapper 2x2 data are collected.

QC Step	QC Process	Yes/No	Initial
1. Preparation	Has the GCO-SOP-11 checklist detailing the proper assembly and operation of the MetalMapper 2X2 sensor for dynamic detection surveys been completed (or recompleted as required due to equipment modifications)?		
2. AM Function Tests	Were AM function tests performed and did all function tests pass using the real-time assessment?		
3. AM IVS Tests	Were AM transect surveys conducted over the IVS items or have exceptions been noted in the field notes?		
4. Sensor Navigation	Were valid data collected along the intended transects with any exceptions or gaps in coverage noted in the field notes?		
5. Data Measurements	For the dynamic data collection (including IVS measurements), was the system monitored with regard to transmit current and receiver decay curves and any exceptions noted in the field notes?		
6. PM Function Tests	Were PM function tests performed and did all function tests pass using the real-time assessment?		
7. PM IVS Tests	Were PM transect surveys conducted over the IVS items or have exceptions been noted in the field notes?		
8. Reporting	Were the field notes correctly recorded and checked for completeness?		

Field or Project Geophysicist: _____ Date: _____

CONTROLLED COPY

GCO-SOP-30

PROCESSING DYNAMIC SURVEY DATA - METALMAPPER 2X2

Processing Dynamic Survey Data – MetalMapper 2x2

Document No. GCO-SOP-30

Reviewed and Approved by:_____ Date: Oct. 31, 2019
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by:_____ Date: Oct. 30, 2019
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
1.0	Oct 31, 2019	Section 2.2 revised to be inclusive of any DENIX approved version of UX-Analyze, as specified within the project-specific AGC-QAPP Section 3 was revised to align with updated processing guide	G. Abrams	M. Costello
0.0	August 24, 2017	Original Publication	M. Costello	G. Abrams

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to be employed when processing dynamic survey data collected using a MetalMapper 2x2 advanced electromagnetic induction (EMI) sensor for target detection.

Dynamic MetalMapper 2x2 data collection involves navigating the sensor along transects at a transect spacing designed to meet the project objectives with respect to detection performance of suspected targets of interest (TOI) in the subsurface. The detection objectives and resultant transect spacing are identified in the site-specific Advanced Geophysical Classification (AGC)-Quality Assurance Project Plan (QAPP). Processing the dynamic data involves processing and assessing all quality control (QC) tests (including daily function tests and instrument verification strip [IVS] surveys), leveling the raw data to remove EMI signal due to the self-signature of the sensor systems and the ambient EMI soil response, and target selection.

A set of QC measurements are conducted upon initial commissioning of the system and on a daily basis to validate the operation of the various components of the MetalMapper 2x2 dynamic survey system.

In the dynamic survey data, the observed signal measured by the MetalMapper 2x2 is composed of 1) the EMI response of potential buried metallic objects, 2) the self-signature of the sensor system, and 3) any response from the ambient environment in which the target is buried. To isolate

responses associated with buried discrete metal objects, a background model comprising the latter two contributing signals must be derived and removed from the raw data. The resulting 'leveled' signal data (raw data – background model) are used as inputs into a detection algorithm where anomalous responses due to potential TOI are mapped and selected for further investigation.

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the analysis of dynamic survey data:

- Project Geophysicist
- QC Geophysicist
- Data Analyst

The qualifications of the personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the project-specific GCMR-QAPP (Worksheets #4, 7 & 8).

2.2 Equipment

The following is a list of equipment and materials required to implement this SOP:

- Personal computer to manage geophysical data and processing software
- Approved version of Oasis Montaj with UX-Analyze module as indicated by the DENIX DAGCAP webpage (e.g. UX-Analyze Oasis Montaj Version 9.6), as specified in the project-specific AGC-QAPP
- Raw data files provided by dynamic survey
- Preparatory Geosoft training materials, (e.g. UX-Analyze Oasis Montaj Version 9.6)

3. Procedure and Guidelines

This section describes the procedures used to process the dynamic production data including positioning and leveling of the data, processing/assessing the QC activities related to dynamic data collection, and selecting target anomalies from the final processed data. Dynamic processing will follow steps provided in the appropriate UX-Analyze Workshop guide. The following sections provide a summary of the dynamic data processing and target selection steps.

3.1 Processing of Dynamic MetalMapper 2x2 Data

The processing of dynamic MetalMapper 2x2 data is achieved in the following general steps:

1) Static function tests

CONTROLLED COPY

2) Data import and initial Processing
3) Background removal and data positioning
4) Data QA/QC
5) Determination of anomaly thresholds and Target Selection
6) Invert and filter target sources

3.1.1 Static Sensor Function Tests

Static sensor function test data will be imported and processed separately from production data. Static test item and background files will be import into separate .gdb files. The Sensor Function Test UX-Analyze tool will be used to verify that the sensor function test data passes and the instrument is suitable for data collection.

3.1.2 Data Import/Initial Processing

The raw HDF5 data files are imported into a Geosoft Database (*.gdb) using a purpose-built utility in UX-Analyze. Once imported, the data are inspected and assessed against the measurement quality objectives (MQOs) provided in Worksheet #22 of the project-specific GCMR-QAPP for:

- Transmit (Tx) current within limits
- Global Positioning System (GPS) fit quality
- Valid inertial measurement unit (IMU) data
- EMI response signal not saturated

Data measurements that do not pass the MQOs are automatically identified using the Dynamic Data QA tool that is used to identify data where the MQOs are not met. This maintains the chronologic integrity of the EMI data but prevents the out-of-specification data from being mapped and used for detection.

3.1.3 Background Removal and Data Positioning

The Dynamic Data Filtering tool will be used to derive an estimate of the background model from the dataset. This model is subtracted from the raw data to provide a background removed or 'leveled' dataset. **Figure 3-1** shows an example of raw data (top panel, red trace), the background model derived from these data (top panel, green trace), and the resulting background removed data. The Create Located Database tool will be used to automatically assign positions to the monostatic, Z-component EMI measurements based on the GPS antenna location, platform geometry, and platform attitude (IMU) data.

The leveled monostatic data are gridded and mapped using conventional Geosoft tools.

The gridded and mapped monostatic Z-component data are suitable for use to select background locations that may be verified for use during follow-on cued investigations.

CONTROLLED COPY

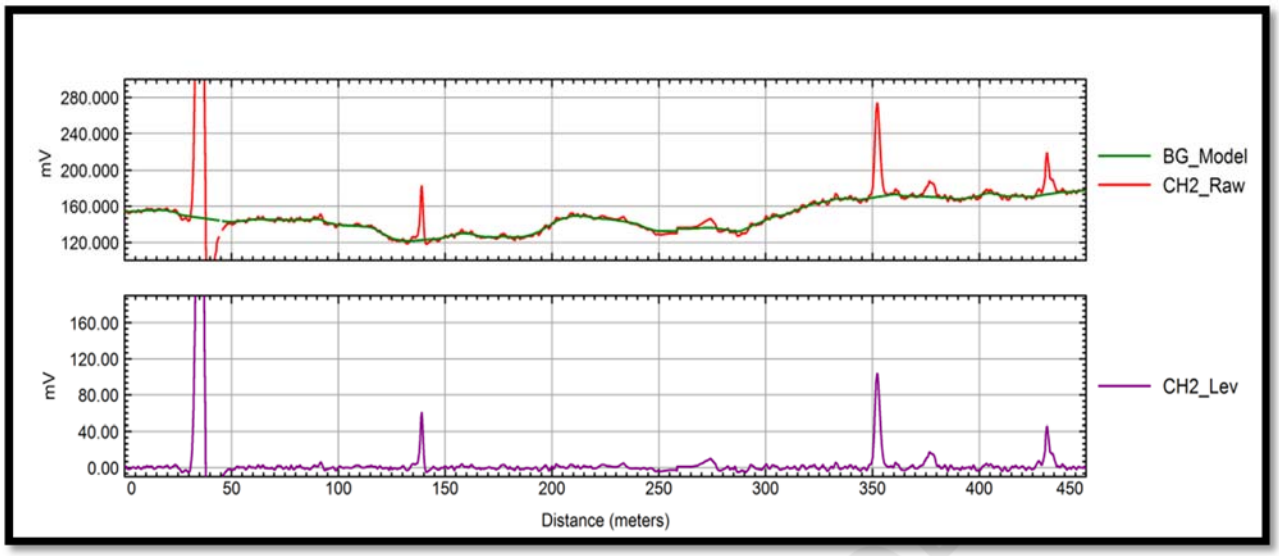


Figure 3-1 Example of Raw and Leveled Data

3.1.4 Determination of Anomaly Threshold and Target Selection

Target selection using AGC data will be performed based on an anomaly amplitude threshold and a model coherence threshold. The Determine Model Coherence Anomalies tool will be run to calculate single dipole models throughout the dataset based on a probable source depth. A grid of the model coherence is generated and will then be used to identify potential target locations based on a coherence threshold. The Determine Coherence Anomaly Threshold tool is used to generate a depth response scatter plot based on a representative library item. Appropriate amplitude and cohesion thresholds will be determined by the GCO based on these results. The Pick Target Locations tool will be used to select targets based using the selected amplitude and coherence thresholds selected for their respective grids. Invert and Filter Target Locations

3.1.5 Invert and Filter Target Sources

The Invert for Sources tool will be used to determine the potential sources parameters at the identified target locations. At each target location the data is modeled using a three dipole model to determine the sources. Individual sources identified will be inverted again and a complete list of individual sources will be created. The Filter Dynamic Sources tool will be used to filter the source results based on size, decay, and other source parameters. Potential sources in close proximity will be merged and a final flag database will be generated for follow-on cued investigations. This Flag database will be reviewed by the Project Geophysicist and manual additions and deletions may be made to this list. The final list is reviewed by the QC Geophysicist prior to finalization of the target list.

3.2 Assessment of Quality Control of Dynamic Survey Data

During the course of a dynamic survey, QC measurements are performed on a daily basis to verify the operation of the sensor and associated components. These tests comprised function tests (described in GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification) and transects along the IVS (described in GCO-SOP-12, Advanced Classification Instrument

Verification Strip [IVS]). The successful completion of these tests on a daily basis is required to validate the survey data collected on that day.

3.2.1 Function Test Measurement Processing

Function test measurements (described in Section 3.1.1 and GCO-SOP-11) are performed prior to each day to confirm that all transmit and receive components of the MetalMapper sensor are operational. The data from each function test are assessed relative to the MQOs presented in Worksheet #22 of the project-specific GCMR-QAPP, compiled, and presented in graphical form for review. Results that do not pass the MQOs are identified and the appropriate action specified in Worksheet #22 is taken.

3.2.2 Daily IVS Survey Processing

Prior to the start and at the end of each day of data collection, measurements of the set of IVS targets are performed (described in GCO-SOP-12). These data are processed in the same manner as the production survey data with regard to positioning and background removal. The data from each IVS test are assessed relative to the MQOs presented in Worksheet #22 of the project-specific GCMR-QAPP, compiled and presented in graphical form for review. Results that do not pass the MQOs are identified and the appropriate action specified in Worksheet #22 of the project-specific GCMR-QAPP is taken. Root cause analysis (RCA) and/or corrective action (CA) are taken in accordance with GCO-SOP-5, Corrective Action. Depending on the findings of the RCA, the survey data associated with the IVS MQO failure may need to be re-collected.

3.2.3 Data QA/QC inspections

The production data is inspected to ensure that all production data meets the MQOs presented in Worksheet #22 of the project-specific GCMR-QAPP. QC inspections will be performed using the purpose built UX-Analyze tools to inspect coverage, and data separation, Results that do not pass the MQOs are identified and the appropriate action specified in Worksheet #22 is taken.

3.2.4 QC Seed Detection

The location of QC Seeds will be blind to the data analysis and data collection teams during the course of the project. All seeds will be emplaced according to GCO-SOP-13, Production Area Seeding and the QC Geophysicist will be responsible for retaining blind seed locations and information. During the course of a dynamic survey the QC Geophysicist will ensure that seed items are apparent in the DGM data and present on cued target lists.

4. Data Management

4.1 Input Data Required

The data inputs required for processing dynamic MetalMapper 2x2 data are as follows:

- A list of coordinates identifying the site boundaries
- Raw dynamic MetalMapper 2x2 data files

CONTROLLED COPY

4.2 Output Data

The data outputs of the processing of dynamic MetalMapper 2x2 data are as follows:

- Geosoft QC reports summarizing daily QC measurement and data results
- Processed data files (e.x. .GDB, .GRD, .MAP, .CSV)
- Target anomaly list
- Letter report detailing processing approach, including leveling and target selection procedures

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific GCMR-QAPP.

5. Quality Control

The MQOs for processing dynamic MetalMapper 2x2 data are presented in Worksheet #22 of the project-specific GCMR-QAPP. Performance relative to the MQOs will be assessed during the processing of the data. Dynamic MetalMapper 2x2 data will not be used to select targets until these MQOs are met or until the project team agrees on modifications to these MQOs.

6. Reporting

Reporting of the activities associated with this SOP will consist of the following:

- Digital field notes
- Relevant Geosoft QD outputs detailing the following for each sortie and/or grid:
    - Survey date
    - % Invalid data with regard to transmit (Tx) current, GPS fix quality, IMU data quality, EMI response within range
    - Standard QC checks performance:
        - Correct coordinates for grids
        - Coverage
        - Line gaps
        - Background response
        - Dropouts
        - Downline density
        - Appropriate anomaly selection
    - Associated Function Test filename
    - Associated IVS Test filename(s)
    - Area subset (grid ID)
- A QC Report detailing the system performance against the MQOs identified on the project-specific GCMR-QAPP Worksheet #22 (including MQOs for daily IVS and Function Test performance as well as for individual measurement metrics)
- Cued Target list – final list of identified anomalies for delivered area subset
- Final data archive (gdb or xyz format) for delivered area subset
- Final grids of monostatic Z-component amplitude response for delivered area subset
- Final grids of detection metric for delivered area subset

CONTROLLED COPY

- Processing/data selection letter report

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
CA	corrective action
cm	centimeter
EMI	electromagnetic induction
GCO	Geophysical Classification Organization
GPS	global positioning system
ID	identifier
IDQTF	Intergovernmental Data Quality Task Force
IMU	Inertial Measurement Unit
IVS	Instrument Verification Strip
MQO	measurement quality objective
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RCA	root cause analysis
Rx	receive
SOP	Standard Operating Procedure
TOI	target of interest
Tx	transmit
WESTON®	Weston Solutions, Inc.

CONTROLLED COPY

8. References

Intergovernmental Data Quality Task Force (IDQTF). 2016. Uniform Federal Policy for Quality Assurance Project Plans, Advanced Geophysical Classification for Munitions Response (AGC-QAPP) Version 1.0. March, 2016).

WESTON (Weston Solutions, Inc.). GCO-SOP-5, Correction Action (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-11, 2x2 System Assembly and Correct Operation Verification (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

9. Attachments

None.

CONTROLLED COPY

GCO-SOP-31

SET-UP AND OPERATION OF RTK GPS NAVIGATION SYSTEM

Set-Up and Operation of RTK GPS Navigation System

Document No. GCO-SOP-31

Reviewed and Approved by: 
Ryan Steigerwalt, Quality Manager

Date: Jan. 2, 2020

Reviewed and Approved by: 
Greg Abrams, Technical Manager

Date: Jan. 2, 2020

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
4.0	Jan. 2 2020	Revised SOP to define GGA, GSA, and GLONASS within the text and in the list of acronyms.	M. Costello	G. Abrams
3.0	Sep. 10, 2019	Section 3.1, The following text has been removed "In most cases the system will be configured prior to shipping. Prior to setup, remove the packing list that is provided with the equipment and verify that all components that are in the boxes match the packing list. Document in a field logbook the serial numbers of the specific equipment used (i.e. antennas, radio)" Section 3.1, the following text has been added "Ensure the job settings are represent the correct instrument configuration that is being used (e.g. base and 1 radio, base with 2 radios)." Section 3.2, the following text has been added "When using the Metal Mapper ensure, that the GLONASS satellite is turned off and the station index is set to either station index 2 (primary) or 19."	S. Stout	R. Steigerwalt
2.0	Sep. 4, 2018	Section 3.2.1.c has been revised as follows, "Enter survey control points into your existing project by selecting Key In or loading a CSV file." Section 3.2.3, second sentenced has been revised as follows, "The rover will identify a base station then click to accept." Section 3.3.1 has been revised as follows, "Tap on Stakeout icon, and select from list the desired point to check. Place the staff tip on the control point and level the bubble." Section 3.3.2, first sentence has been revised as follows, "Hold the staff steady, enter proper point ID, and tap record." The following sentence has been removed from Section 3.4, "Most systems have a "monitor GPS"	G. Abrams	R. Steigerwalt

CONTROLLED COPY

		or an indicator warning whether GPS RTK quality is locked or no GPS reading are being received at all." Section 4.1 has been revised to remove "by a licensed surveyor" from the paragraph.		
1.0	Oct. 20, 2017	The last sentence of Section 2 has been revised to delete "in the", which was repeated.	T. King	M. Costello
0.0	August 28, 2017	Original Publication	B. Guthrie	G. Abrams

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when assembling the Trimble Navigation, Limited (Trimble) Global Navigation Satellite System (GNSS) Real-Time Kinematic (RTK) Global Positioning System (GPS) for geophysical data collection, target reacquisition, and verifying that all components are correctly assembled, operating normally, and capable of acquiring data of sufficient quality.

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into Advanced Geophysical Classification Projects (AGC) as well as for all non-AGC work.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following equipment and materials may include:

- RTK GPS System. System components will likely include, multiple GPS antennas (Base and Rover), Trimble Data Collector, tripods, bipods, and a survey staff.
- Materials for marking out control points to check RTK positioning (such as survey nails, stakes, or pin flags, and flagging tape).
- Digital camera or cell phone to take photographs (if desired) of the RTK base station setup and location. Note: Photographic documentation is a desired best practice, but are not a requirement of this SOP. If use of digital cameras on site is prohibited the GCO will follow site procedures for obtaining photos (if available).
- Surveyor data in project coordinate system (if available) to setup the RTK base station and perform positioning checks.

The following individuals will be involved in the assembly and verification of the RTK GPS:

- Project or Field Geophysicist – Confirms that the RTK GPS was assembled correctly either in person or through notes, or photographs.
- Quality Control (QC) Geophysicist – Reviews QC testing and verifies results are documented in the QC database.
- Field Team Leader or Field Geophysicist – Operates the RTK GPS in conjunction with the geophysical equipment or during anomaly reacquisition.

CONTROLLED COPY

- Data Analyst – Processes collected data and documents QC results in the project QC database. Verifies the positioning of the data.

The qualifications of the personnel implementing this SOP during AGC projects will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the project-specific AGC-QAPP (Worksheets #4, 7 & 8).

3. Procedure and Protocols

Procedures for assembly, positioning, and operational verification are included in the following subsections.

3.1 Assemble the RTK GPS

WESTON rents the RTK GPS from outside vendors, in accordance with GCO-SOP-6, Purchasing. Depending on the vendor, manuals may or may not be included with the equipment. The March 2015, Trimble R10 GNSS Receiver User Guide V1.10 Rev C (Trimble, 2015) and/or the February 2016, Trimble R8s GNSS Receiver User Guide V1.00 Rev C (Trimble, 2016) may be used as a reference to this SOP. These reference documents are maintained and controlled as WESTON GCO Quality System Documents and are readily available within the WESTON GCO Reference Documents folder in accordance with GCO-SOP-3, Document Control.

The general assembly steps for Trimble RTK GPS equipment are briefly described below:

1. Set up the base unit tripod over a control point and ensure that the tripod is level. A minimum of two control points will be established before starting an RTK survey, one to establish the base station and an additional point to confirm the equipment accuracy.

2. Place the base receiver on the tripod. Install a battery in the receiver and connect the power cable to Port 1 on the receiver by lining up the key/notch on the cable with the port. Failure to do so will result in bent pins and damaged cables. Ensure the unit is turned on and confirm that the satellite light-emitting diode (LED) on the front display is blinking yellow at 1-second intervals.

3. If the RTK GPS base station will be at great distance from the survey area, a radio antenna may be necessary. If applicable, set up the second tripod and assemble the radio antenna and connect it to the tripod. Connect the coaxial cable to the back of the radio and connect the power cable to an external battery. Ensure Radio settings correspond to applicable base station setting and that data is transmitting. Ensure the job settings are represent the correct instrument configuration that is being used (e.g. base and 1 radio, base with 2 radios).

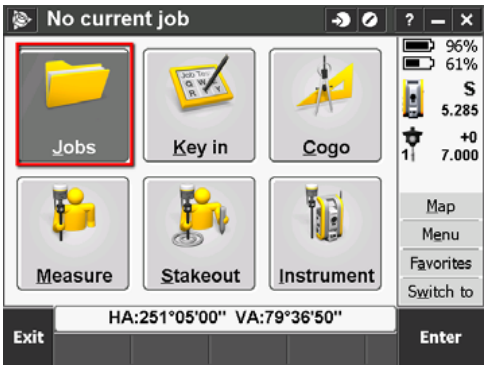
3.2 Setup the RTK GPS Parameters and Initialize for Survey

The following steps describe the general process for starting up the RTK Base survey and Rover surveys. Note that time-domain electromagnetic multi-sensor towed array detection system (TEMTADS) 2x2, MetalMapper 2x2 and EM61 sensors require different NMEA output options and will need to be adjusted accordingly. In most cases the RTK GPS has been configured ahead of time.

CONTROLLED COPY

1. Turn on the Trimble datalogger and open Survey Controller software.

    a. Tap on General Survey then click on Jobs to create a new job.



    b. Enter the project coordinate information (Datum, units). Once complete, hit enter and store to return to Menu screen.

    c. Enter survey control points into your existing project by selecting Key In or loading a CSV file.

2. Verify that you are connected to the base antenna, tap on Instrument icon, select Base Mode and Start Survey. In the start base receiver menus, add from list the control point being used for the base station. Enter in the base station height and store. At this point the satellite and transmit beacon LED lights should both be flashing at a slow rate.

3. Verify that you are connected to the rover antenna, tap on Instrument icon, Select Rover Mode, and Start Survey. Click on RTK survey. The rover will identify a base station then click to accept. The RTK base and rover setup should be complete.

4. Check the NMEA output by tapping on the Instrument icon, and selecting Survey Styles. Scroll to the bottom of the list to NMEA output. Check the settings for advanced geophysical surveys with the advanced electromagnetic induction (EMI) sensor (i.e, TEMTADS 2x2 or MetalMapper 2x2), check that the legacy is turned off. Verify that the fix information (GGA) is on for advanced EMI sensor surveys, and the GGA and overall satellite data (GSA) are on for EM61 surveys. When using the MetalMapper ensure, that the Global Navigation Satellite System (GLONASS) satellite is turned off and the station index is set to either station index 2 (primary) or 19.

3.3 Perform Navigational/Positioning QC Check

Prior to any digital geophysical surveying or anomaly reacquisition, positional accuracy checks must be performed daily. This is accomplished by performing a stake-out mode of surveying to a known control point and recording the position to the nearest 0.01 meters. Allow the GPS time to lock onto a position prior to starting the stakeout procedure or for data collection.

1. Tap on Stakeout icon, and select from list the desired point to check. Place the staff tip on the control point and level the bubble.

CONTROLLED COPY

2. Hold the staff steady, enter proper point ID, and tap record. Note the position offset and identify if it is within project metrics. Store the results and return to the menus screen. If the offset is not within project metrics, determine cause of failure and redo the checks.

3.4 Verify GPS Stream in Geophysical Equipment

After the RTK GPS base station has been started and position checks performed, verify that the GPS readings are being received in the data acquisition computer. If GPS is not streaming, ensure that the baud rates on the geophysical systems and on the RTK GPS are set to the same number. Verify on the geophysical systems the sampling frequency is set according to manufacturer recommendations and project requirements.

4. Data Management

The following sections describe the input data that are needed to perform this SOP and the resulting output data.

4.1 Input Data Required

Input data consist of the assembly and operation instructions for the RTK GPS in the R10 User Guide (Trimble, 2015) or R8s User Guide (Trimble, 2016). Additional inputs may include control point information and project files including boundaries and targets for reacquisition.

4.2 Output Data

The results of the position checks described in Section 3.3 will be saved in the project-specific data files. All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

Achievement of the RTK GPS assembly and operation will be verified by the QC Geophysicist in a daily QC Report.

6. Reporting

Achievement of the RTK GPS assembly and operation will be documented by the Field Team Leader, Field or Project Geophysicist by completion of the position checks described in Section 3.3 and will be documented by the QC Geophysicist in a daily QC Report.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
cm	centimeters

CONTROLLED COPY

CSV	comma separated values
GCO	Geophysical Classification Organization
GGA	fix information
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Position System
GSA	overall satellite data
LED	light-enhance diode
NMEA	National Marine Electronics Association
QC	quality control
QMS	Quality Management System
RTK	Real-Time kinematic
SOP	standard operating procedures
TEMTADS	time-domain electromagnetic multi-sensor towed array detection system
Trimble	Trimble Navigation Limited
UHF	ultra high frequency
USB	universal serial bus
WESTON	Weston Solutions, Inc.

8. References

Trimble, 2015. Trimble R10 User Guide V1.10 Rev C. March 2015.

Trimble, 2016. Trimble R8s User Guide V1.00 Rev C. February 2016.

WESTON (Weston Solutions, Inc.). GCO-SOP-3, Document Control (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-6, Purchasing (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

CONTROLLED COPY

GCO SOP-32

SET-UP AND OPERATION OF RTS NAVIGATION SYSTEM

Set-Up and Operation of RTS Navigation System

Document No. GCO-SOP-32

Reviewed and Approved by: _____ Date: July 25, 2019
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by: _____ Date: July 25, 2019
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Rev. Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
3.0	July 25, 2019	Section 3.1, third bullet has been revised to simplify instruction for connection of the RTS unit battery. Section 3.2, first paragraph has been revised to replace references to specific sensors (TEMTADS, MetalMapper, etc.) with "various geophysical sensors". Section 3.2 Step 1.b, first sentence has been revised to "Enter the appropriate job coordinate system, units, and job files". Section 3.2. Step 3, last sentence has been removed ~~"Scroll to next screen and verify that GPS search is on and Auxillary GPS is in the box under "select data source." Select Accept.~~ Section 3.2, Step 4 text has been removed, ~~"Standing at least 10 feet away from robot, turn the prism on to the channel that was set in prism settings and ensure instrument lock."~~ And remaining steps have been renumbered concurrently. Section 3.2, Step 5, has been revised to include, "If using an active prism, ensure prism is powered on and set to the proper channel." Section 3.3, Step 2, first sentence has been revised to state, "Enter proper point ID, ensure the staff is steady and tap "Measure". Section 3.4 has been revised as follows, "3.4 Verify RTS Stream in Geophysical Equipment After the RTS station has been started and position checks performed, verify that the RTS pseudo NMEA stream readings are being received in the data acquisition computer. If data is not streaming, determine the cause of failure and redo the checks. Prior to data collection, set the prism height to desired survey height by clicking on the RTS prism	K. Yarmush	R. Steigerwalt

CONTROLLED COPY

		icon in the home screen. If height corrections are applied during data processing the survey prism height should be set to zero. Section 5 has been revised as follows, "Achievement of the RTS operation will be verified by the QC Geophysicist and recorded in a project database. Section 6 has been revised as follows, "Achievement of the RTS assembly and operation will be documented by the Field Team Leader or Field Geophysicist by completion of the position checks described in Section 3.3 and will be verified by the QC Geophysicist and recorded in a project database.		
2.0	Sep. 4, 2018	The following bullet has been removed from Section 2, "Cell phones loaded with a weather app is also recommended for corrections information in the RTS setup." Section 3.1 has been revised as follows, "All assembly operations are described in the November 2015, Trimble Quick Start Guide for Trimble S5, S7, S9, S9HP Total Station (Trimble, 2015). The current version of the Trimble Quick Start Guide will be used as a reference during sensor assembly and verification. The Assembly steps are briefly described below: 1. Place the RTS unit onto the tripod and center at the desired location. 2. Level the station by centering the bubble using the dials on the unit. 3. Place batteries into the cradle and attach the cables to the unit and battery cradle. 4. Assemble prism staff and insert prism battery" The following sentence has been added to the beginning of Section 3.2, "A minimum of three established control points must be established before starting an RTS survey." The following statement has been removed from Section 3.2.1.b, "For AGC work, this should always be in meters." Section 3.2.1.c has been revised as follows, "Enter survey control points into your existing project by selecting Key In or loading a CSV file." Section 3.2.2 has been revised as follows, "Adjust the height and make Tracking mode active if necessary." Section 3.2.4 has been revised as follows, "Standing at least 10-15 feet away from robot, turn the prism on to the channel that was set in prism settings and ensure instrument lock." The following text has been removed from Section 3.2.5, "This allows the robot station to be setup anywhere as long as the angle between two known	G. Abrams	R. Steigerwalt

CONTROLLED COPY

		points is greater than 30 degrees and less than 150 degrees. Enter the corrections for pressure and temperature. The parts per million (ppm) error will automatically be calculated." Section 3.2.6 has been revised as follows, "Complete instrument set-up using desired method (back-site or resection)." Section 3.2.7, has been revised as follows, "Check the NMEA output by tapping on the Instrument icon in the status bar, and select TRK icon. A "T" should show in the status bar next to the robot station icon. Section 3.2.8 has been revised as follows, "Verify the ouputs for the data collector by clicking on the Instrument icon and Data output and ensuring correct settings." Section 3.3.1 has been revised as follows, "Tap on Stakeout icon, and select from list the desired point to check. Start stakeout and follow the arrows to the point. Place the staff tip on the control point and level the bubble." The following sentence has been removed from Section 3.4, "Most systems have a "monitor GPS" or an indicator warning whether GPS RTK quality is locked or no GPS reading are being received at all." Section 4.1 has been revised to remove "by a licensed surveyor" from the paragraph.		
1.0	Oct. 20, 2017	The last sentence of Section 2 has been revised to delete "in the" which was repeated. Section 3.1 – Steps 1 and 2 were the same. Step 2 has been deleted, and the remaining steps have been renumbered accordingly.	T. King	M. Costello
0.0	August 28, 2017	Original Publication	B. Guthrie	G. Abrams

CONTROLLED COPY

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the methods to be employed when assembling the Trimble Navigation Limited (Trimble) Robotic Total Station (RTS) for geophysical data collection, target reacquisition, and verifying that all components are correctly assembled, operating normally, and capable of acquiring data of sufficient quality.

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into Advanced Geophysical Classification Projects (AGC) as well as for all non-AGC work.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following list of equipment and materials may include:

- Trimble RTS System. System components will likely include a total station, a prism "receiver", Trimble Data Collector, tripods, bipods, and a survey staff.
- The November 2015, Trimble Quick Start Guide for Trimble S5, S7, S9, S9HP Total Station (Trimble, 2015).
- Trimble RTS with Trimble Access controller setup information included in **Attachment 1** to this SOP.
- Materials for marking out control points to check RTS positioning (such as survey nails, stakes, or pin flags, and flagging tape).
- Digital camera or cell phone to take photographs (if desired) of the RTS setup and location. Note: Photographic documentation is a desired best practice, but are not a requirement of this SOP. If use of digital cameras on site is prohibited the GCO will follow site procedures for obtaining photos (if available).
- Surveyor data in project coordinate system (if available) to setup the RTS and to perform positioning checks.

The following individuals will be involved in the assembly and verification of the RTS:

- Project or Field Geophysicist – Confirms that the RTS was assembled correctly either in person or through notes, or photographs.
- Quality Control (QC) Geophysicist – Reviews QC testing and verifies results are documented in the QC database.
- Field Team Leader or Field Geophysicist – Operates the RTS in conjunction with the geophysical equipment or during anomaly reacquisition.
- Data Analyst – Processes collected data and documents QC results in the project QC database. Verifies the positioning of the data.

The qualifications of the personnel implementing this SOP during AGC projects will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the project-specific AGC-Quality Assurance Project Plan (QAPP) (Worksheets #4, 7 & 8).

3. Procedure and Protocols

Procedures for assembly, positioning, and operational verification are included in the following subsections.

3.1 Assemble the RTS

All assembly operations are described in the November 2015, Trimble Quick Start Guide for Trimble S5, S7, S9, S9HP Total Station (Trimble, 2015). The current version of the Trimble Quick Start Guide will be used as a reference during sensor assembly and verification. The Assembly steps are briefly described below:

- Place the RTS unit onto the tripod and center at the desired location.
- Level the station by centering the bubble using the dials on the unit.

CONTROLLED COPY

- Install/Connect RTS unit battery.
- Assemble prism staff and insert prism battery

3.2 Setup the RTS Parameters and initialize for Survey

A minimum of three established control points must be established before starting an RTS survey. The following steps describe the process for starting up the RTS survey. Note that various geophysical sensors require different NMEA output options and will need to adjust accordingly. **Attachment 1** presents the step by step process for RTS setup in the Trimble Survey Controller. The datalogger setup is briefly described below.

1. Turn on the Trimble datalogger and open Trimble Access/General Survey, and wait for General survey to connect to the instrument.

    a. Tap on General Survey then click on Jobs to create a new job. **Figure 3-1** is a screen shot of the menus.

    b. Enter the appropriate job coordinate system, units, and job files (**Figure 3-1**). Once complete, hit enter and accept to save changes to return to Menu screen.



Figure 3-1
Screen Shots of Initial Setup

    c. Enter survey control points into your existing project by selecting Key In or loading a CSV file.

2. Verify the prism and target settings by clicking on the Prism Icon in the status bar located on the right side of the screen. Adjust the height and Tracking mode if necessary.

3. Tap on Instrument icon and Select Target Controls and set target lock to “Autolock,” and check “snap to target”, and “autosearch”.

CONTROLLED COPY

4. Start Station Setup by selecting the Measure icon and clicking on VX S Series. Select Station Setup if you plan to set the RTS on a known control point, and use a known back-sight point with one additional control point to perform a control check. Select Resection if you plan to set the RTS at an unknown location and use two known back-site points with one additional control point to perform a control check.

5. If using an active prism, ensure prism is powered on and set to the proper channel. Complete instrument set-up using desired method (back-site or resection).

6. Check the NMEA output by tapping on the Instrument icon in the status bar, and select TRK icon. A "T" should show in the status bar next to the robot station icon.

7. Verify the outputs for the data collector by clicking on the Instrument icon and Data output and ensuring correct settings.

3.3 Perform Navigational/Positioning QC Check

Prior to any digital geophysical surveying or anomaly reacquisition, positional accuracy checks must be performed daily or after each time the station is moved. This is accomplished by performing a stake-out mode of surveying to a known control point and recording the position to the nearest 0.01 meters.

1. Tap on Stakeout icon, and select from list the desired point to check. Place the staff tip on the control point and level the bubble.

2. Enter proper point ID, ensure the staff is steady and tap "Measure". Note the position offset and identify if it is within project metrics. Store the results and return to the menus screen. If the offset is not within project data quality objective (DQO) metrics, determine the cause of failure and redo the checks.

3.4 Verify RTS Stream in Geophysical Equipment

After the RTS station has been started and position checks performed, verify that the RTS pseudo NMEA stream readings are being received in the data acquisition computer. If data is not streaming, determine the cause of failure and redo the checks. Prior to data collection, set the prism height to desired survey height by clicking on the RTS prism icon in the home screen. If height corrections are applied during data processing the survey prism height should be set to zero.

4. Data Management

The following sections describe the input data that are needed to perform this SOP and the resulting output data.

4.1 Input Data Required

Input data consist of the assembly and operation instructions for the RTS in the Quick Start Guide (Trimble, 2015) and Trimble RTS with Trimble Access controller setup information included in

CONTROLLED COPY

Attachment 1 of this SOP. Additional inputs include control point information and project files including boundaries and targets for reacquisition.

4.2 Output Data

The results of the position checks described in Section 3.3 will be saved in the project-specific data files. All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

Achievement of the RTS operation will be verified by the QC Geophysicist and recorded in a project database.

6. Reporting

Achievement of the RTS assembly and operation will be documented by the Field Team Leader or Field Geophysicist by completion of the position checks described in Section 3.3 and will be verified by the QC Geophysicist and recorded in a project database.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
CSV	comma separated values
DGM	digital geophysical mapping
DQO	Data Quality Objectives
EDM	electronic distance meter
EM61-Mk2	time-domain electromagnetic sensor detection system
GCO	Geophysical Classification Organization
GPS	Global Position System
mm	millimeter
NMEA	National Marine Electronics Association
ppm	parts per million
QAPP	quality assurance project plan
QC	quality control
QMS	Quality Management System
RTS	Robotic Total Station

CONTROLLED COPY

SOP	standard operating procedures
Trimble	Trimble Navigation Limited
USB	universal serial bus
WESTON	Weston Solutions, Inc.

8. References

Trimble, 2015. Trimble Quick Start Guide for Trimble S5, S7, S9, S9HP Total Station. November 2015.

WESTON (Weston Solutions, Inc.). GCO-SOP-3, Document Control (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-6, Purchasing (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

9. Attachments

CONTROLLED COPY

Attachment 1 Trimble RTS with Trimble Access Setup and Data Streaming

CONTROLLED COPY

GCO SOP-33

ANOMALY REACQUISITION

Anomaly Reacquisition

Document No. GCO-SOP-33

Reviewed and Approved by: 
Name, Quality Manager

Date: Sep. 4, 2018

Reviewed and Approved by: 
Name, Technical Manager

Date: Sep 4, 2018

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
1.0	Sep 4, 2018	Section 3.1 has been revised to add the following bullet, "With the AGC Sensor, using the preloaded cued target locations into the data acquisition software and navigate to each point during cued data collection (see GCO-SOP-19)."	G. Abrams	R. Steigerwalt
0.0	August 24, 2017	Original Publication	G. Abrams	R. Steigerwalt

1. Purpose and Scope

Accurate reacquisition and marking of targets selected for intrusive investigation is critical to the success of a Military Munitions Response Program (MMRP) project. The purpose of this Standard Operating Procedure (SOP) is to outline the general procedures for reacquisition of anomaly locations (targets) on a dig list discovered by digital geophysical mapping (DGM) prior to intrusive investigation of these targets.

Target reacquisition consists of two primary elements:

- Locating and marking the interpreted x,y target locations from the cued or dig list.
- Adjusting marked locations to improve their precision with the geophysical instrument used in the DGM survey.

Note that DGM surveys conducted with Advanced Geophysical Classification (AGC) instruments such as the time-domain electromagnetic multi-sensor towed-array detection system (TEMTADS) or Man-Portable Vector (MPV), this adjustment is not necessary because positions will be adjusted through the cued survey process.

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into AGC projects.

CONTROLLED COPY

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

For MMRP projects, target reacquisition and intrusive operations are considered separate steps. However, they can be performed concurrently with the reacquisition team embedded in the intrusive operations team. Target reacquisition can be accomplished by either geophysical teams and/or UXO teams. A target reacquisition team is comprised of personnel who are trained in the use of both survey and detection instruments, and are familiar with DGM procedures.

2.1 Personnel

The following individuals may be involved in the reacquisition of targets:

- Data Analyst – identifies anomalies for reacquisition
- Quality Control (QC) Geophysicist – Reviews and approves reacquisition list
- Field Team Leader – leads reacquisition efforts
- Field Geophysicist – reacquires locations
- UXO Personnel – Provides UXO support during reacquisition (if required)

UXO personnel will be responsible for overall daily site access and safety aspects of the project, compiling subcontractor health and safety documents, conducting daily safety briefings, and performing anomaly avoidance, as needed, in the field. Information on the specific qualifications for various UXO personnel support roles can be found in the project-specific Health and Safety Plan.

The qualifications of the geophysical personnel implementing this SOP will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required documentation of qualifications will be provided in the in the project-specific Geophysical Classification for Munitions Response (GCMR)-Quality Assurance Project Plan (QAPP) (Worksheets #4, 7 & 8).

2.2 Equipment

The following is a list of equipment and materials that may be required for reacquisition:

- Reacquire target list
- Real-time kinetic (RTK) global positioning system (GPS) Navigation System or Robotic Total Station (RTS) Navigation System
- Original project-specific survey equipment (for example: EM61-MK2 or Magnetometer G-858)
- Tape Measures
- Logbook
- Color-coded sensor map
- Dig Sheet
- Non-metallic pin flags, marking paint, or other means of demarcation

CONTROLLED COPY

3. Procedure and Guidelines

3.1 Marking Interpreted Target Locations

The first step in successfully reacquiring targets for excavation is to survey and mark the locations as interpreted from the geophysical survey data. This may be accomplished in one of four ways (in order of efficiency):

- With the AGC Sensor, using the preloaded cued target locations into the data acquisition software and navigate to each point during cued data collection (see GCO-SOP-19).
- With RTK GPS, with a base station set up on a control point and a rover used to navigate to within 5 centimeters (cm) of the mapped target location (see GCO-SOP-31, Setup and Operation of RTK Navigation System)
- With RTS, where a base is set up within or near the targets to be flagged and its location fixed by resection on two control points using the rover prism (see GCO-SOP-32, Setup and Operation of RTS Navigation System).
- If the GPS signal is not achievable and RTS is not available, target locations may be flagged using calculated distances measured from adjacent grid corner stakes.

Target locations are marked in the field using non-metallic pin flags or marking paint. Each marker is labeled with a target identification number so that the status of each anomaly can be tracked and documented through reacquisition, excavation, and final QC procedures.

Note that for DGM surveys conducted with AGC instruments such as the TEMTADS or MPV, no further adjustment of target locations is necessary.

3.2 Re-locating Targets

This section is not relevant for AGC surveys.

During reacquisition operations the original DGM instrument will be used to identify targets in the field in order to compare the reacquired target amplitude to the original amplitude. By comparing amplitudes the team can verify that the correct target has indeed been reacquired. Lower amplitude anomalies (below the selected threshold) may exist in close proximity to the target.

3.3 Adjustment of Target Locations

This section is not relevant for AGC surveys.

In the event that the reacquisition team encounters an anomaly that offset from the original target location greater than the site-specific measurement quality objective (MQO), both the original location and the new location will be flagged. Both locations will be noted and provided to the GCO team for review.

4. DATA MANAGEMENT

The following sections describe the data that is needed to perform this SOP and the resulting data that is produced.

CONTROLLED COPY

4.1 Input Data Required

The primary input data for reacquisition is the approved cued or dig list, consisting of the target identifier, the sensor reading from the initial DGM survey for the target (e.g. milliVolts for EM61-MK2, nanoTesla/meter for G-858), and coordinates of the target. Typically the dig list is digitally loaded into the control unit of the RTK GPS or RTS.

4.2 Output Data

Output data consists of new flag locations with peak instrument amplitudes for the original DGM targets on the dig sheet, which are transferred to the dig team prior to intrusive investigation.

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific GCMR-QAPP.

5. QUALITY CONTROL

The primary QC procedures to be followed during reacquisition include the following:

1. Verification of the RTK GPS or RTS rover on a control point prior to use for flagging targets.
2. Static background, cable-shake, and spike tests if a geophysical instrument is used for reacquisition, both before and after all reacquisition is accomplished on a given day. If an instrument is only used for reacquisition during a day, no dynamic data [on an Instrument Verification Strip (IVS)] is required.

6. Reporting

Performance of this SOP will be documented in the project-specific database, dig sheets and daily reports. The project-specific database will contain a list of all targets that require reacquisition throughout the project. The dig sheets and daily reports will indicate which targets have been reacquired and investigated.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
cm	centimeter
DGM	digital geophysical mapping
GCMR	Geophysical Classification for Munitions Response
GCO	Geophysical Classification Organization

CONTROLLED COPY

GPS	global positioning system
IVS	Instrument Verification Strip
MEC	munitions and explosives of concern
MMRP	Military Munitions Response Program
MPV	Man-Portable Vector
MQO	measurement quality objective
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RCA	root-cause analysis
RTK	real-time kinetic
RTS	robotic total station
SOP	Standard Operating Procedure
TEMTADS	time-domain electromagnetic multi-sensor towed-array detection system
UXO	unexploded ordnance
WESTON	Weston Solutions, Inc.

8. References

WESTON (Weston Solutions, Inc.). GCO-SOP-5, Correction Action (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-31, Setup and Operation of RTK GPS Navigation System (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-32, Setup and Operation of RTS Navigation System (current version). West Chester, PA.

CONTROLLED COPY

GCO SOP-37

SET-UP AND OPERATION OF THE G-858 MAGNETOMETER

Setup and Operation of the G-858 Magnetometer

Document No. GCO-SOP-37

Reviewed and Approved by:  Date: Oct. 3, 2017
Ryan Steigerwalt, Quality Manager

Reviewed and Approved by:  Date: Oct. 3, 2017
Greg Abrams, Technical Manager

The "Controlled Copy" watermark indicates this is a controlled document. Absence of Controlled Copy watermark indicates this copy is not controlled and will not receive revision updates.

Document Revisions History

Rev. No.	Date	Section Affected/Description	Prepared/ Revised By	Reviewed By
0.0	Oct. 3, 2017	Original Publication	G. Abrams	R. Steigerwalt

1. Purpose and Scope

The purpose of this Standard Operating Procedure (SOP) is to identify the means and methods to be employed when performing dynamic surveys using a Geometrics G-858 Magnetometer for geophysical surveys.

This SOP serves as a supporting document as part of the Weston Solutions, Inc. (WESTON®) Geophysical Classification Organization (GCO) Quality Management System (QMS), and is applicable for use and incorporation into Advanced Geophysical Classification Projects (AGC) as well as for all non-AGC work.

2. Personnel, Equipment, and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

2.1 Personnel

The following individuals will be involved in the collection of dynamic survey data:

- Project Geophysicist
- Quality Control (QC) Geophysicist
- Field Team Leader
- Field Geophysicist
- Data Analyst

The qualifications of the personnel implementing this SOP during AGC projects will be verified in accordance with GCO-SOP-23, Demonstrations of Capability, and project-required

CONTROLLED COPY

documentation of qualifications will be provided in the project-specific AGC-Quality Assurance Project Plan (QAPP) (Worksheets #4, 7 & 8).

2.2 Equipment

The following is a list of required equipment and materials:

- Geometrics G-858-Sensor (additional sensors may be used for Gradiometer or towed configurations)
- Collection and deployment accessories (Standard systems will include Geometrics data logging console, battery pack, and aluminum pieces to assemble standard data collection staff)
- Navigational mount (Navigation equipment is usually mounted on a backpack worn by the operator)
- Navigation instrument [e.g., real-time kinematic (RTK) Global Positioning System (GPS) (see GCO-SOP-31, Setup and Operation of RTK GPS Navigation System), robotic total system (RTS) (see GCO-SOP-32, Setup and Operation of RTS Navigation System), or Differential GPS unit]

Navigational mount and instruments will not be required during line and fiducial surveys, however, survey tools will be necessary to establish grid boundaries.

3. Procedure and Guidelines

3.1 Equipment Set-Up

This section outlines the steps for setting up the G-858 Magnetometer system in the field for the acquisition of geophysical data using a navigational system (e.x. GPS, RTS). Line and fiducial surveys will be completed using the same steps but will not require navigational equipment. Operating manuals should be referenced during set-up and operation. Geometrics G-858 equipment set-up will follow these general steps:

1. Assemble G-858 Magnetometer according to operating manuals and project configurations. When using multiple sensors, measure the distance between sensors to ensure proper site-specific configuration.

2. Interface the G-858 with a navigational system (connect serial cable from navigational system into the RS-232 Port).

3. Perform warm-up according to manufacture recommendations and ensure system have reached operational values by ensuring:

    - RF should be below 60% (optimum is 35%)
    - Brightness should always be 50% (+/- 2%)
    - COLD should always be 50% (+/- 2%)
    - Signal usually is about 25% but is dependent on the environment

CONTROLLED COPY

4. Ensure that the operator has removed all metallic objects from their person. Avoid use of cell phones and radios in the vicinity (less than 100 feet) from the G-858.

5. Perform spot check readings to locate an area free of noise or anomalies and representative of background to perform QC function tests.

6. Set-up the site-specific data collection parameters on the data collection console:

    - Set the appropriate data collection rate (sampling rate, i.e. 10 Hertz for munitions and explosives of concern (MEC) detection projects).
    - The G-858 utilizes five (5) "Datasets" to store data. All QC data should be stored in Dataset 1 and survey files will be stored in Datasets 2-5.
    - Adjust line increments and station starts as needed according to the survey file.

3.2 Function Test Measurements

Function test measurements will be performed prior to each day of data collection to confirm that all system components are operational. Function test procedures may vary based on client and project-specific requirements. Standard static QC tests will generally be performed as follows:

1. Personnel Test – Operators of the equipment should check themselves for influence on the sensor readings by approaching the sensors and noting the readings before and after use (operators should remove all metal from their person before running this test). The test results should be digitally recorded for 15 to 30 seconds, and should be run every day to ensure the operator does not have any metallic items that may interfere with the survey (i.e., steel toed boots and cell phones).

2. Cable Shake Test – The operator collects data for 30 seconds and moves cables and electronics to note any possible fluctuations (may indicate a broken wire or an electronic interference from some data loggers).

3. Static Background – The operator collects data for a period of 1 to 3 minutes (depending on project requirements) over a background area. The purpose is to identify any variations in the collected signal. The amplitude should remain constant, typically within 10% of standard response.

4. Static Spike – The operator collects data for a period of 1 to 3 minutes (depending on project requirements) over a spike object [usually a small or medium industry standard object (ISO)]. The purpose is to identify any variations in the collected signal. The amplitude should remain constant, typically within 10% of standard item response.

Additional non-standard tests may be completed at the start of the project and may include:

1. Height Optimization Test – This test is performed at the beginning of the project to determine the optimal operating height of the data collection instrument. The test is performed by measuring the response of a calibration object (usually the smallest item of interest at the site) and varying the depth of this object to determine the instrument height

CONTROLLED COPY

that yields the highest signal-to-noise quality.

2. Azimuth Test – The test is performed if using the line and fiducial method. It is performed by placing the sensor over a background area and rotating around a fixed point, recording the results in eight cardinal directions. The results are entered in a heading table and used to correct heading errors usually associated with the direction of survey.

3. Octant Test – The test is performed when the instrument is interfaced with a navigational system. A background spot is marked on the ground and the operator traverses in all cardinal directions (at least 10 feet on either side of the spot). The database is then analyzed and a heading correction table is automatically generated from the data.

4. Diurnal Test – This test is usually performed with a single sensor configuration using a Base Station (G-856) to collect data to monitor the daily natural magnetic background fluctuations. Diurnal data may also be available from online sources (e.x. NOAA). The data are used to apply a correction to the collected total field data with the G-858 sensors. The correction removes the daily diurnal effects from the data and is applied during the export process of the magnetometer data. Note: Prior to any data acquisition both the G-858 Survey Mag and G-856 Base Station Mag internal clocks must be synchronized to the second.

3.3 Daily IVS Survey

If an Instrument Verification Strip (IVS) is required on a project, measurements will be collected over the IVS prior to surveying and after surveying each day of data collection. The IVS is used to demonstrate the instrumentation repeatability and accuracy and to determine latency. The peak response and locations from the IVS seed items would be plotted to assess instrument repeatability. IVS results will be checked throughout the project to ensure that all project specific Measurement Quality Objectives (MQOs) are met. IVS construction will be completed in accordance with GCO-SOP-12. IVS data collection will be completed using project-specific configurations and survey methods over the IVS lane in order to demonstrate instrument functionality.

3.4 G-858 Data Collection

Dynamic survey for digital geophysical mapping (DGM) involves collecting data along lines or transects across the survey area. Dynamic data are collected along each line or transect at a spacing appropriate to the site and project needs. Data collection is controlled by the user on the data logging console, which allows the user to assign datasets, line numbers, and start positions of each transect. Navigation along transects is performed visually with the assistance of markers, if necessary, at the discretion of the Field Team Leader. They may include, but are not limited to, ropes, tapes, spray paint, or flags. Data positioning is captured through the use of the RTK/RTS GPS system and/or fiducial markers. When an obstacle is encountered along a line or transect, the obstacle can be avoided by either altering the path of the line or transect or stopping data collection and resuming a new transect on the other side of the obstacle. Data gaps that are the result of obstacles should be recorded by the Field Geophysicist and submitted to the Data Analyst.

CONTROLLED COPY

3.5 G-858 Data Processing

Initial data processing for the G-858 data will be completed using magmap software to position data, perform diurnal correction (if applicable), and export to a .xyz file format. Data will then be imported into contouring software (e.x. Geosoft Oasis Montaj) for further data analysis and processing. Processing corrections, filters, and analysis will be up to the discretion of the Data Analyst based on specific project needs and challenges. General data processing steps that may be completed are listed as follows:

1. GPS offset and Latency corrections – These corrections account for the inherent GPS/Sensor offset in mag systems and the latency experienced in positional reading during collection.

2. Diurnal Corrections – This correction removes the daily diurnal effects from the data and is applied during the export process of the magnetometer data. Multi-sensor gradiometer configurations do not require diurnal corrections.

3. Data Filters – High-pass and Low-pass filters will be used to smooth noisy data and remove data trends caused by external sources. If applicable, a specific 60 Hertz (Hz) noise filters may be applied to reduce caused by power lines.

4. Calculate Analytic Signal – the analytic signal is derived from the X and Y signal derivatives to generate the Analytic Signal based on instrument response to refine anomaly locations.

5. Anomaly identification – Data will be assessed to identify features of interest. Identified features may include general areas of notable instrument response or individual point anomalies [e.x. underground storage tank (UST) or MEC]. If site-specific thresholds are required to identify anomalies within a site, the IVS will be used to assess data quality and determine instrument thresholds prior to anomaly identification.

4. Data Management

4.1 Input Data Required

The data inputs required for performing a G-858 survey are as follows:

- A list of coordinates identifying the site boundaries
- A list of project data objectives

4.2 Output Data

The data outputs of the G-858 survey are:

- G-858 survey data over survey area(s)
- Function test measurement data

CONTROLLED COPY

- Raw field notes (.pdf images of hand written notes)
- Digital field notes [if applicable, any Excel, MS Access, or other digitally recorded table presenting data file names as delivered and rectified field notes (i.e., differences between delivered digital filenames and field notes are resolved) .
- List of identified features/targets including coordinates and response descriptions (if applicable).

All output data will be managed in accordance with GCO-SOP-7, Control of Records, along with the requirements specified in the project-specific AGC-QAPP.

5. Quality Control

The primary QC procedures to be followed during reacquisition include the following:

1. Verification of the RTK GPS or RTS rover on a control point prior to use for data collection or grid installation.

2. Static background, cable-shake, and spike tests for the G-858 both before and after all data collection is completed on a given day.

3. IVS verification and analysis (if required) both before and after all data collection is completed on a given day.

6. Reporting

Reporting of the activities associated with this SOP will consist of the digital copies of the field notes and the submittal of output data associate with this SOP.

7. Terms, Definitions and Abbreviations

7.1 Definitions/Terms

No terms or definitions are included in this SOP.

7.2 Acronyms/Abbreviations

AGC	Advanced Geophysical Classification
DGM	digital geophysical mapping
GCO	Geophysical Classification Organization
GPS	global positioning system
Hz	Hertz
IVS	Instrument Verification Strip
ISO	Industry Standard Object

CONTROLLED COPY

MEC	munitions and explosives of concern
MQO	measurement quality objective
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMS	Quality Management System
RTK	real-time kinetic
RTS	robotic total station
SOP	Standard Operating Procedure
UST	underground storage tank
WESTON®	Weston Solutions, Inc.

8. References

WESTON (Weston Solutions, Inc.). GCO-SOP-7, Control of Records (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-12, Advanced Classification Instrument Verification Strip (IVS) (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-23, Demonstrations of Capability (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-31, Setup and Operation of RTK GPS (current version). West Chester, PA.

WESTON (Weston Solutions, Inc.). GCO-SOP-32, Setup and Operation of RTS (current version). West Chester, PA.

9. Attachments

None

CONTROLLED COPY

APPENDIX N

VERIFICATION AND VALIDATION PLAN

VERIFICATION AND VALIDATION PLAN
MILITARY MUNITIONS RESPONSE PROGRAM (MMRP)
RCRA FACILITY INVESTIGATION
FORMER GUN AND TRENCH MORTAR RANGE MUNITIONS RESPONSE SITE (RFAAP-002-R-01)
RADFORD ARMY AMMUNITION PLANT
RADFORD, VIRGINIA

Contract No.: W912DR-15-D-0022

Delivery Order No.: W912DR18F0492

Prepared For:

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
2 Hopkins Place
Baltimore, MD 21201

and

RADFORD ARMY AMMUNITION PLANT
Radford, Virginia

Prepared By:

WESTON SOLUTIONS, INC.
2 Eaton Street, Suite 603
Hampton, Virginia 23669

MAY 2019

This Page Intentionally Left Blank

TABLE OF CONTENTS

Section **Page**

1. INTRODUCTION....1

2. BACKGROUND....1

3. TARGET SELECTION VERIFICATION....2

4. LIBRARY-MATCH THRESHOLD VERIFICATION....3

5. NON-TOI VALIDATION....4

5.1 CLUSTER ANALYSIS....5

5.2 FEATURE SPACE ANALYSIS....5

5.3 RANDOM SELECTION....5

LIST OF ACRONYMS AND ABBREVIATIONS

β	polarizability
AGC	Advanced Geophysical Classification
CA	corrective action
CENAB	U.S. Army Corps of Engineers, Baltimore District
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DO	Delivery Order
FUDS	Formerly Used Defense Site
ID	identifier
MAMMS II	Multiple Award Military Munitions Services II
mm	millimeter
MMRP	Military Munitions Response Program
PWS	Performance Work Statement
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RA	Remedial Action
RCA	root-cause analysis
ROC	receiver operating characteristic
Rx	receive
SOP	standard operating procedure
SVFUDS	Spring Valley Formerly Used Defense Site
TOI	target of interest
Tx	transmit
USACE	United States Army Corps of Engineers

1. INTRODUCTION

This Verification and Validation Plan has been developed as an appendix to the Advanced Geophysical Classification (AGC)-Quality Assurance Project Plan (QAPP), prepared for the Military Munitions Response Program (MMRP) Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at the Former Gun and Trench Mortar Range Munitions Response Site (MRS) located at the Radford Army Ammunition Plant (RFAAP) near Radford, Virginia.

The intent of this Verification and Validation Plan is to provide assurance that there are no native targets of interest (TOI) classified as non-TOI during the RFI. The validation process will be performed by selection of a number of "validation digs" designed to test the assumptions inherent in the classification approach.

This Verification and Validation Plan describes the validation rationale, a description of the initial validation approach, and procedures for verifying the classification results of the RFI. The final number and distribution of validation digs required will be dependent upon a number of factors including, but not limited to, the details of the classification approach and the performance against the quality control (QC) and validation seeds. It is anticipated that this plan will be amended prior to implementation based upon the above factors for each property.

2. BACKGROUND

The RFI has two main components; an initial dynamic detection survey, followed by a cued classification survey. The initial dynamic detection survey is essentially the first step in classification where potential anomalies are rejected based upon the detection threshold. Once an anomaly is identified using advanced classification, there are three ways for a target to be classified as a TOI:

1. Match any of the candidate TOI items in the library.

2. Be a member of a cluster or group of similar polarizabilities (βs) that are identified as TOI through the duration of the project.

3. Have features that are typical of TOI expected at the site (axial symmetry, amplitude response, size, depth).

Because the goal of the validation process is to demonstrate that no TOI were classified as non-TOI, it is instructive to restate the above in terms of how anomalies are classified as non-TOI. From this perspective, anomalies are classified as non-TOI as follows:

1. The target selection process (anomalies below a response threshold and attribute filter thresholds [e.g., size, shape, depth, decay] are non-TOI).

2. Not matching any of the candidate TOI in the library.

3. Not belonging to an identified cluster of anomalies with similar βs that are subsequently found to be TOI.

4. Not having βs that indicate the item is axially symmetric and of reasonable amplitude response, size, or depth.

The following sections present an initial approach to classification validation for each mode of classification (including initial selection), with emphasis on describing what thresholds will be tested and the rationale for these tests. Any validation failures will require a root-cause analysis (RCA) and appropriate corrective action (CA) developed and implemented in consultation with the United States Army Corps of Engineers (USACE).

3. TARGET SELECTION VERIFICATION

Anomaly selection will be performed using a traditional “response amplitude” metric. AGC dynamic target selection will be followed by an attribute filter for further screening and/or informed source selection. It is often additionally advantageous to screen anomaly sizes to prevent numerous unnecessary small nonhazardous metallic objects from making it onto the cued target list. Informed source selection uses the observed datafit value obtained from the dynamic production data survey. If the observed datafit is above a specified value, thus reflecting a quality dipole fit, quantified characteristics are compared, such as magnitude and decay, to those of the

TOI. If the values are well below the TOI, they are deemed non-TOI and excluded from the cued survey.

The anomaly selection threshold(s) (i.e., the amplitude response threshold) and informed source selection (i.e., attribute filter thresholds) will be established after site-specific noise levels have been measured and several days of digital geophysical mapping (DGM) data have been collected. An evaluation of whether to use a filter for additional screening along with the details of the determination of the threshold(s) will be reported in the Target Selection Technical Memorandum.

To verify our AGC target selection methods, 10% of the overall rejected targets closest to the screening threshold used for target selection will be re-added to the cued target list to verify that threshold (approximately 2 to 3 per grid). A verification failure will result if any TOI are found at or shallower than their maximum detection depth when those verification targets are intrusively investigated.

4. LIBRARY-MATCH THRESHOLD VERIFICATION

Classification will be based primarily on the decision statistic generated by comparing the β values estimated for each surveyed target and the β valued in the project-specific TOI library. The decision statistic indicates the fit correlation between a target and the best fit in the library, with higher metrics indicating a better fit between the target and the corresponding item in the library.

This library matching process will be performed for each single-solver model and every target model in each of the multi-solver candidate realizations. For each cued record, the highest value decision metric (i.e., most likely TOI) from the combined set of single-solver and multi-solver models will be used as the decision statistic for that position. A stop-dig decision statistic threshold will be established as described in Standard Operating Procedure (SOP) GCO-SOP-39, Processing Cued Survey Data - MPV.

The stop-dig threshold will be verified by intrusively investigating anomalies beyond the threshold. The number of digs required to achieve this confirmation will depend to a large degree on the dig results – particularly the results for anomalies that were ranged just prior to the stop-

dig threshold. Ten percent (%) (not to exceed 200) of the project-wide anomalies will be investigated beyond the last TOI on the ranked dig list. A verification failure will result if any TOI are found at anomalies with decision statistics below the stop-dig threshold. Existing data will be used for library-match threshold verification if 10% (not to exceed 200) of anomalies beyond the last TOI (stop dig point) have already been investigated.

5. NON-TOI VALIDATION

In addition to the verification targets investigated as described above, 10% (not to exceed 200) of the anomalies classified as non-TOI across the project site will be selected for validation and will be investigated as Non-TOI validation digs. Rather than selecting the targets based on ranking on the dig lists, specific targets classified as non-TOI will be chosen by the project team and may include anomalies below the stop dig threshold.

For each selected validation target, the Data Analyst will be required to provide a short rationale for why that target was classified as non-TOI. Examples of acceptable rationales include, but are not limited to, the following:

- Too small to be TOI.
- Decays too quickly to be TOI.
- Wrong shape to be TOI (asymmetric or plate-like).
- Geologic response.
- Detection anomaly due to instrument noise.

All validation targets will be excavated and the resulting sources, or lack of a source, will be qualitatively compared to the stated rationale for the non-TOI classification. Recovery of a TOI from one of these targets will stop work and require a thorough re-examination of the classification process. A qualitative mismatch between a recovered source and the non-TOI rationale will require a RCA and possible CA.

The method(s) used for selecting the validation targets will be ultimately determined by the project team. Three possible methods of identifying these targets are described in the following subsections.

5.1 CLUSTER ANALYSIS

Cluster analysis identifies groups of items with similar polarizabilities, with the underlying assumption that within a cluster the items will all be very similar in size, shape, and composition. Identified clusters in which most or all items have been classified as non-TOI may represent a group of TOI that were not expected at the site and for which library entries did not exist during the classification process.

5.2 FEATURE SPACE ANALYSIS

Feature space analysis involves examining the target specific features such as size and decay, which are also involved in cluster analysis. In this case, rather than requiring that a group of items all resemble each other, there may be a single trait specific to a single target classified as non-TOI that suggests it is worth examining. Examples include targets with large sizes or very slow decays that stand out in a size/decay plot, but do not match any library examples, and were classified as non-TOI.

5.3 RANDOM SELECTION

Random selection involves random selection of validation targets throughout the list of non-TOI. Random selection can be performed using random number generators in programs such as Microsoft Excel that can be used to re-sort the non-TOI target identifiers (IDs) on the ranked dig list, selecting 1 out of every X non-TOI targets on the ranked dig list, with X determined based on the total number of non-TOI targets. Random selection can also be performed by simply picking out non-TOI anomaly IDs while proceeding down the ranked dig list.

APPENDIX O

EXPLOSIVES SITE PLAN

Provided on CD.

DEPARTMENT OF DEFENSE EXPLOSIVES SAFETY BOARD
4800 MARK CENTER DRIVE, SUITE 16E12
ALEXANDRIA VIRGINIA, 22350

JUL 03 2019

DDESB-PE

MEMORANDUM FOR DIRECTOR, U.S. ARMY DEFENSE AMMUNITION CENTER
ATTENTION: ATCL-ACE

SUBJECT: DDESB Approval of Explosives Site Plan, Remedial Investigation Former Gun and Mortar Range, Radford Army Ammunition Plant, Radford, VA [USATCES MEC File Number 7786]

References: (a) DAC ATCL-ACE Memorandum of 26 June 2019, Subject: Explosives Site Plan, Remedial Investigation, MRS Former Gun and Mortar Range, Radford Army Ammunition Plant, Radford, VA, June 2019 [USATCES 7786].

(b) Defense Explosives Safety Regulation 6055.09, Edition 1, 13 January 2019

(c) DDESB Technical Paper 15 (TP-15), Current Revision, "Approved Protective Construction"

(d) DA PAM 385-64, 24 May 2011/RAR 10 October 2013

The Department of Defense Explosives Safety Board (DDESB) Staff has reviewed the subject explosives site plan (ESP) forwarded by reference (a) against the requirements of reference (b). Based on the information provided, approval is granted for removal and destruction of material potentially presenting an explosive hazard (MPPEH) and munitions and explosives of concern (MEC) at Radford Army Ammunition Plant, Radford, VA. This approval is based on the following:

a. The efforts addressed in this ESP involve manual unintentional detonation operations and intentional detonations supporting munitions response actions within Munitions Response Site (MRS) Former Gun and Mortar Range (FGMR).

b. The DDESB acknowledges that reference (b) currently does not provide criteria to establish the minimum separation distance (MSD) for personnel in/under the water from intrusive (i.e., unintentional and intentional detonation) explosive operations conducted underwater. Consequently, the DDESB is unable to approve intrusive underwater explosive operations. The Army, per reference (a), will establish criteria addressing intrusive underwater explosive operations within MRS FGMR and will make an informed risk decision associated with those operations in accordance with Army policy.

c. The property will remain under Army control.

d. The results of this ESP will be used to prepare an explosives safety submission per reference (b).

e. The munition with the greatest fragmentation distance (MGFD) for the terrestrial portions of the MRS FGMR is the 81mm M43A1 Mortar; the minimum separation distance (MSD) for teams for manual unintentional detonation operations is 66 feet (ft) based on K40 of the 81mm M45 Mortar; the MSD for nonessential personnel from manual unintentional detonation operations is 242 ft based on the hazardous fragment distance of the 81mm M45 Mortar; and the MSD for all personnel from intentional detonations is 1,579 ft based on the maximum fragment distance of the MGFD.

f. Collection points and consolidated shots are authorized provided the Army ensures usage of reference (c), paragraph C6.2.7.5.

g. The use of sandbags and earth tamping is authorized as an engineering control for intentional detonations involving the MEC identified in reference (a) provided the Army ensures usage per reference (c), paragraph C6.2.7.5.

h. Demolition materials, per reference (a), will be delivered as needed. Handling of commercial explosives must comply with reference (d).

i. Prior to initiation and through completion of on-site explosives operations, all nonessential personnel will be evacuated and prevented from entering any area/facility encumbered by the MSD required for the operation being conducted, or explosives operations will be suspended if nonessential personnel enter the MSD.

j. MPPEH will be inspected and classified as material documented as safe prior to release to the public.

If changes occur during or after completion of this effort that could increase explosive hazards to site workers or the public due to the presence of military munitions at the site, an amendment to this ESP must be submitted to DDESB for review and approval.

The point of contact for this action is Ms. Kristene Bigej, (571) 372-6705, DSN 372-6705, E-mail address: kristene.a.bigej.civ@mail.mil.

THIERRY L. CHIAPELLO
Executive Director

DEPARTMENT OF THE ARMY
US ARMY DEFENSE AMMUNITION CENTER
1 C TREE ROAD
MCALESTER OK 74501-9053

ATCL-ACE 3 July 2019

MEMORANDUM FOR Military Munitions Center of Expertise, (CEHNC-EMM/Mr. Zange/Mr. Barker), P.O. Box 1600, Huntsville, AL 35807-4301

SUBJECT: Army and DDESB Approval of Explosives Site Plan (ESP), Remedial Investigation Former Gun and Mortar Range, Radford Army Ammunition Plant, Radford, VA [USATCES MEC File Number 7786]

1. References:

a. Memorandum, DDESB-PE, 3 July 2019, Subject DDESB Approval of Explosives Site Plan, Remedial Investigation Former Gun and Mortar Range, Radford Army Ammunition Plant, Radford, VA [MEC File Number 7786]

b. DoDM 6055.09, DoD Ammunition and Explosives Safety Standards, date varies by Volume, Administratively Reissued 4 August 2010. (Defense Explosives Safety Regulation (DESR) 6055.09, Edition 1, 13 January 2019.)

c. Department of the Army Pamphlet 385-64, Ammunition and Explosives Safety Standards, 10 October 2013, Rapid Action Revision

2. This memorandum with enclosed reference 1.a, provides U.S. Army and Department of Defense Explosives Safety Board (DDESB) approval of subject ESP.

3. Any changes that modify the approved ESP or increases risk or hazard will require additional approval. All conditions stipulated in this memorandum and reference 1.a must be adhered to for this approval to be valid. This approval and the approved ESP Site Plan will be made part of the administrative record for the site.

4. The Primary USATCES POC is Mr. Calvin Smith, (918) 420-8869 (DSN 956), calvin.b.smith.civ@mail.mil, alternate POC is. Mr. Chad Williams, (918) 420-8044 (DSN 956), chad.t.williams7.civ@mail.mil.

Encl

CARL A. THOMAS
Director, U.S. Army
Technical Center for Explosives Safety

CF:
DACS-SF/Mr. Patton

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, ENGINEERING AND SUPPORT CENTER, HUNTSVILLE
P.O. BOX 1600
HUNTSVILLE, ALABAMA 35807-4301

REPLY TO ATTENTION OF

CEHNC-EMM 21 June 2019

MEMORANDUM FOR US Army Technical Center for Explosives Safety, Explosives Safety Knowledge, OE and Chemical Division, (ATCL-ACE/ Ms. Robin Jett), Building 35, 1C Tree Road, McAlester, OK 74501-9053

SUBJECT: Explosives Site Plan (ESP), Remedial Investigation, MRS Former Gun and Mortar Range, Radford Army Ammunition Plant, Radford, VA, June 2019

1. References:

a. ER 385-1-95, Safety and Health Concerns for Munitions and Explosives of Concern (MEC) Projects, March 2007.

b. Defense Explosives Safety Regulations (DESR) 6055.09, Edition 1, January 2019.

c. Memorandum from Department of the Army Radford Army Ammunition Plant dated 18 June 2019.

2. This ESP has been reviewed for technical adequacy and to insure compliance with US Army Corps of Engineers (USACE), Department of the Army and Department of Defense requirements. USACE participation is approved.

3. The installation request USACE to submit on their behalf IAW reference c.

4. If you have any questions, please contact Mr. Walt Zange at (256) 895-1586 or Mr. Jeff Barker at (256) 895-1513.

Encl

John D. Nebelsick
Director, Environmental and
Munitions Center of Expertise

CF: electronically w/o encl

REMEDIAL INVESTIGATION (RI)
EXPLOSIVES SITE PLAN (ESP)

Radford Army Ammunition Plant (RFAAP)

MRS - Former Gun and Mortar Range

Radford, Virginia

June 2019

PREPARED BY
EMDC BALTIMORE DISTRICT, USACE

TABLE OF CONTENTS

Section Page

1.0 SITE **1**

2.0 ANTICIPATED DATES **1**

3.0 PURPOSE **1**

4.0 SITE BACKGROUND AND CURRENT CONDITIONS **1**

5.0 EXECUTING AGENCIES **1**

6.0 SCOPE OF INVESTIGATIVE ACTION **1**

7.0 SAFETY CRITERIA **1**

8.0 METHODS OF DISPOSAL **2**

APPENDIX A: FIGURES……..A-1

APPENDIX B: FRAGMENTATION DATA REVIEW FORMS ……..…….B-1

1. **Site:**
   a. Name: Radford Army Ammunition Plant (RFAAP), Former Gun and Mortar Range
   b. State: Radford, VA

2. **Anticipated Dates:**
   a. Start: August 2019

3. **Purpose:**
   A manual Remedial Investigation is required at this location based on the historic ordnance activities and the Site Investigation (SI) findings in order to further characterize the Former gun and mortar range (RFAAP-002-R-01)

4. **Site Background and Current Conditions:**
   The Former Gun and Mortar Range (RFAAP-002-R-01) MRS comprises two adjacent ranges: the Former Gun Range (20 acres), the Former Trench Mortar Range (87 acres) and the New River (31 acres) which borders the ranges. The primary mission of RFAAP, the manufacturing of propellants, began in 1941 and continues today. Since 1968, RFAAP has also produced Trinitrotoluene (TNT) on an intermittent basis. Both ranges were operational during World War II.
   The Former Mortar Range, was used to test-fire various mortar rounds to verify the quality of propellants manufactured at the facility.
   The Former Gun Range was historically used to test projectile propellant by test-firing projectiles into tunnels dug into the hillside.
   Current Land Use - Government-owned/contractor-operated (GOCO) facility.

5. **Executing Agencies:**
   a. US Army Corps of Engineers (USACE) – Baltimore District
   b. Army Environmental Command (AEC)

6. **Scope of Investigative Action:**
   A manual remedial investigation (RI) is required to investigate the nature and extent of MEC at the Former Gun and Mortar Range to include underwater investigations in portions of New River that border the MRS

7. **Safety Criteria:**
   a. The munition with the greatest fragmentation distance (MGFD) at the Munitions Response Area (MRA) is identified in Table 7-1 per Munition Response Site (MRS). During the course of this removal action if MEC with a greater fragmentation distance is

encountered, the MSD will be adjusted in accordance with DDESB Technical Paper 16 and the Fragmentation Database. QD arcs will be adjusted accordingly.

b. See Appendix B for Fragmentation Data Calculation Sheets.

c. See Table 7-1 for Minimum Separation Distances.

d. Any occupied buildings or public roadways in the MSD areas during MEC operations will be evacuated and/or roadways blocked to prevent non-essential personnel from entering during the conduct of MEC operations. In the event that roadways cannot be blocked, guards will be posted and work halted if non-essential personnel enter the MSD. MEC operations will not resume until non-essential personnel have exited the MSD.

e. The Army will establish underwater QD criteria.

f. Only one team will be working in the underwater portion of the MRS during field investigations.

Table 7-1
Minimum Separation Distances

Munitions Response Site (MRS)	Munitions with the Greatest Fragmentation Distance (MGFD)	MSD (ft)[1]			
		Unintentional Detonations		Intentional Detonations	
		Hazardous Fragment Distance (HFD)	Team Separation Distance (K40)	Without Engineering Controls (MFD)	Using Engineering Controls
Former Gun/Mortar Range	81mm	242[1]	66[1]	1579[2]	200[3]

Note: 1-M45
2-M43A1
3-The EC distance is 125 ft., however a 200 ft. distance around the demolition operation will be secured for safety

8. Methods of Disposal:

a. The contractor will not maintain any explosives on site. Explosives will be delivered to the project location on an "as needed" basis and will be guarded by the contractor until use.

b. The MSD for intentional detonation when conducting disposal operation is identified in Table 7-1. The Senior UXO Supervisor (SUXOS) and UXO Safety Officer (UXOSO) are authorized to jointly approve movement of "acceptable to move" items within the MRS for the purpose of activity efficiency and protection of personnel, property, and/or critical assets.

c. All recovered MEC and material presenting an explosive hazard (MPPEH) identified as material documented as an explosive hazard (MEDH) will be destroyed on the same day found. In the event this cannot occur due to weather or delay in explosive delivery items will be guarded until disposal.

d. Inspection and Certification: All material potentially presenting an explosive hazard (MPPEH) procedures will be in accordance with DoDI 4140.62 and EM 385-1-97. All MPPEH will be assessed and its explosive safety status determined and documented prior to transfer within Department of Defense (DoD) or release from DoD control. Prior to release to the public, MPPEH will be documented by authorized and technically qualified personnel as Material Documented as Safe (MDAS) after 100% inspection and an independent 100% re-inspection to determine that it is safe from an explosives safety perspective.

e. Collection points are those areas used to temporarily accumulate MEC which are determined acceptable to move by the SUXOS and UXOSO pending destruction at the end of the day using consolidated shots. MEC items at collection points must be laid out as shown in "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Ordnance and Explosives (OE) Sites, August 1998 (terminology update March 2000)." The maximum net explosive weight (NEW) at a collection point will be limited such that the K40 overpressure distance for the total NEW does not exceed the HFD for the area. Consolidating multiple MEC is anticipated for this project.

f. Consolidating multiple MEC may be anticipated for this project and will be performed in accordance with "Approval of Minimum Separation Distance to Non-Essential Personnel when using DDESB-Approved Consolidated Shot Method" (DDESB, 2015) and US Army Engineering and Support Center, Huntsville (CEHNC) publication "Procedures for Demolition of Multiple Rounds (Consolidated Shots) on Ordnance and Explosives (OE) Sites," dated March 2000, will be followed and a copy of this report will be available on site. The maximum NEW for a consolidated shot will be limited such that the K328 overpressure distance for the total NEW (including donor charges) does not exceed the MSD for intentional detonation.

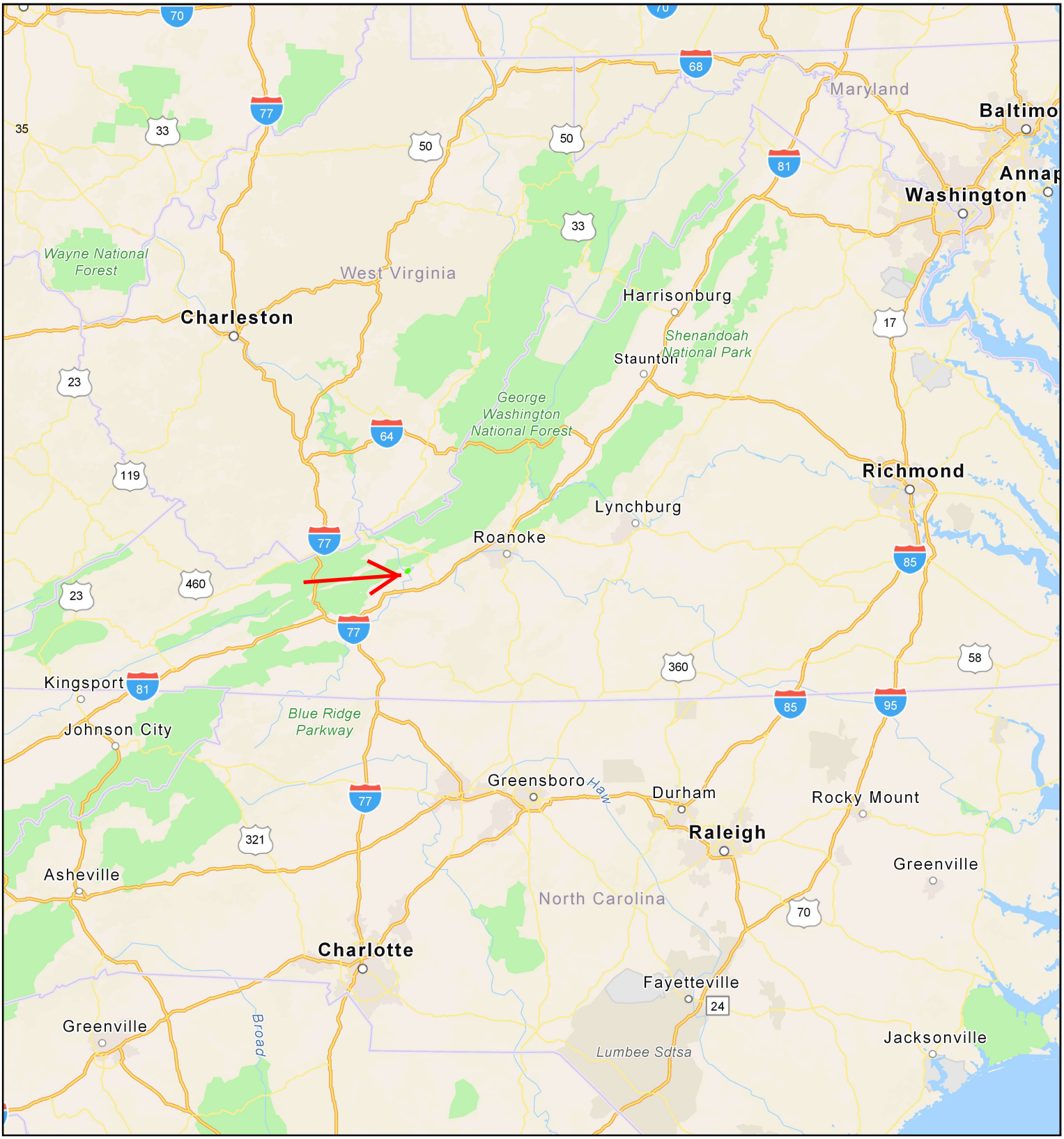
g. Engineering Controls (EC): For intentional detonations, the UXO Team may use earth tamp as an engineering control in accordance with DDESB Buried Explosion Module, latest version, and DDESB TP 16.

Sandbag mitigation may be used as engineering controls to reduce the intentional detonation MSD. The sandbag controls will be used in accordance with HNC-ED-CS-98-7, Use of Sandbags for Mitigation of Fragmentation and Blast Effects Due to Intentional Detonation of Munitions, August 1998, its Amendment 1, February 2011, and its Amendment 2, Nov 2014; CEHNC-EMM Memorandum, Safety Advisory: Use of Jet Perforator During Intentional Detonation While Using Sandbag Mitigation for Engineering Controls, 7 November 2011; and DDESB-PD memorandum of 22 May

2014, Subject: Revision of DDESB Approval for Use of Sandbags for Mitigation of Fragmentation and Blast Effects Resulting From Intentional Detonation of Munitions

APPENDIX A
Figures

- Figure 1 – Regional Map
- Figure 2 – MRS Former Gun/Mortar Range Boundary
- Figure 3 – Former Gun/Mortar Range Exclusion Zones

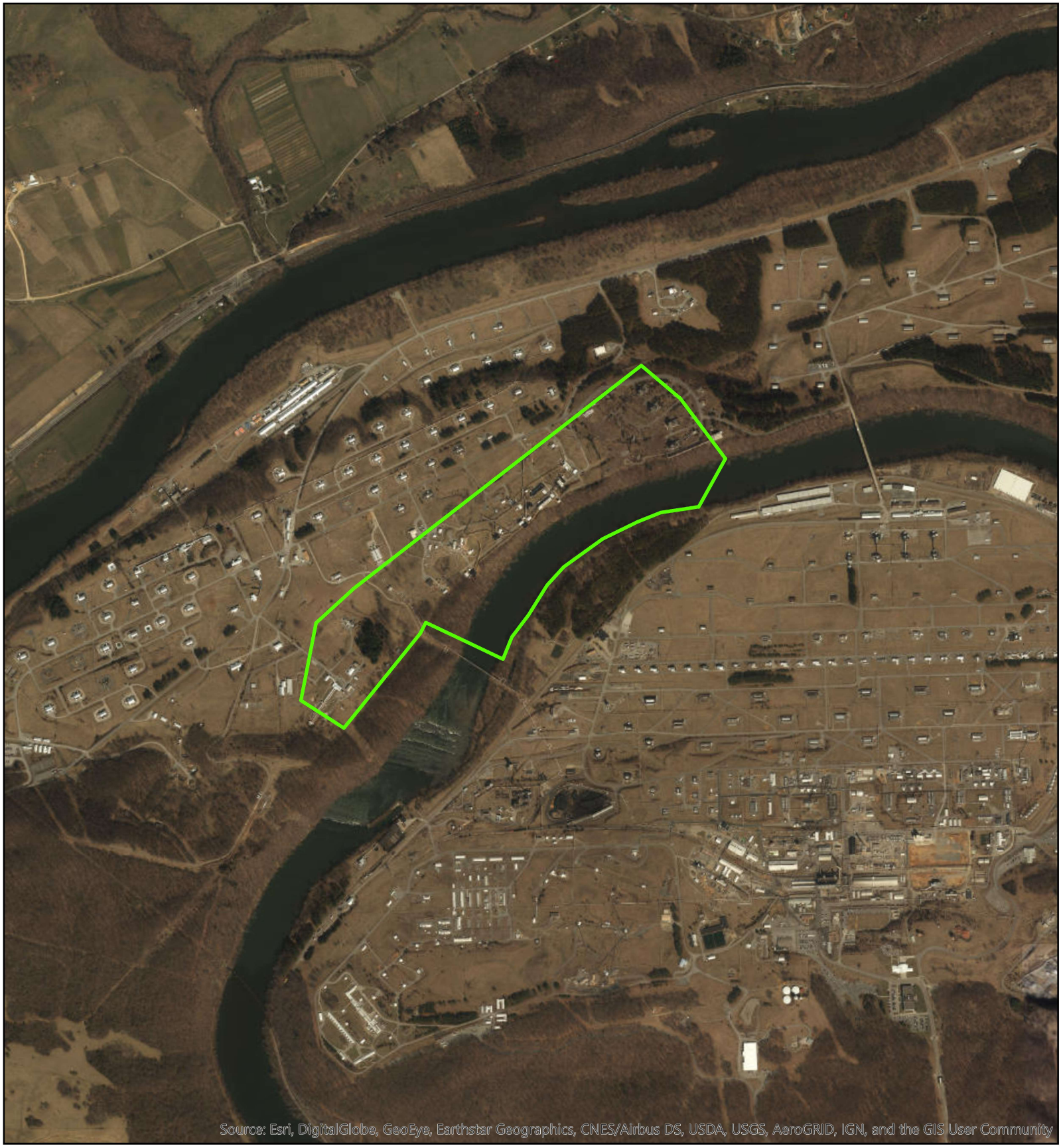


Legend

MRS Former Gun/Mortar Range

N

Figure 1

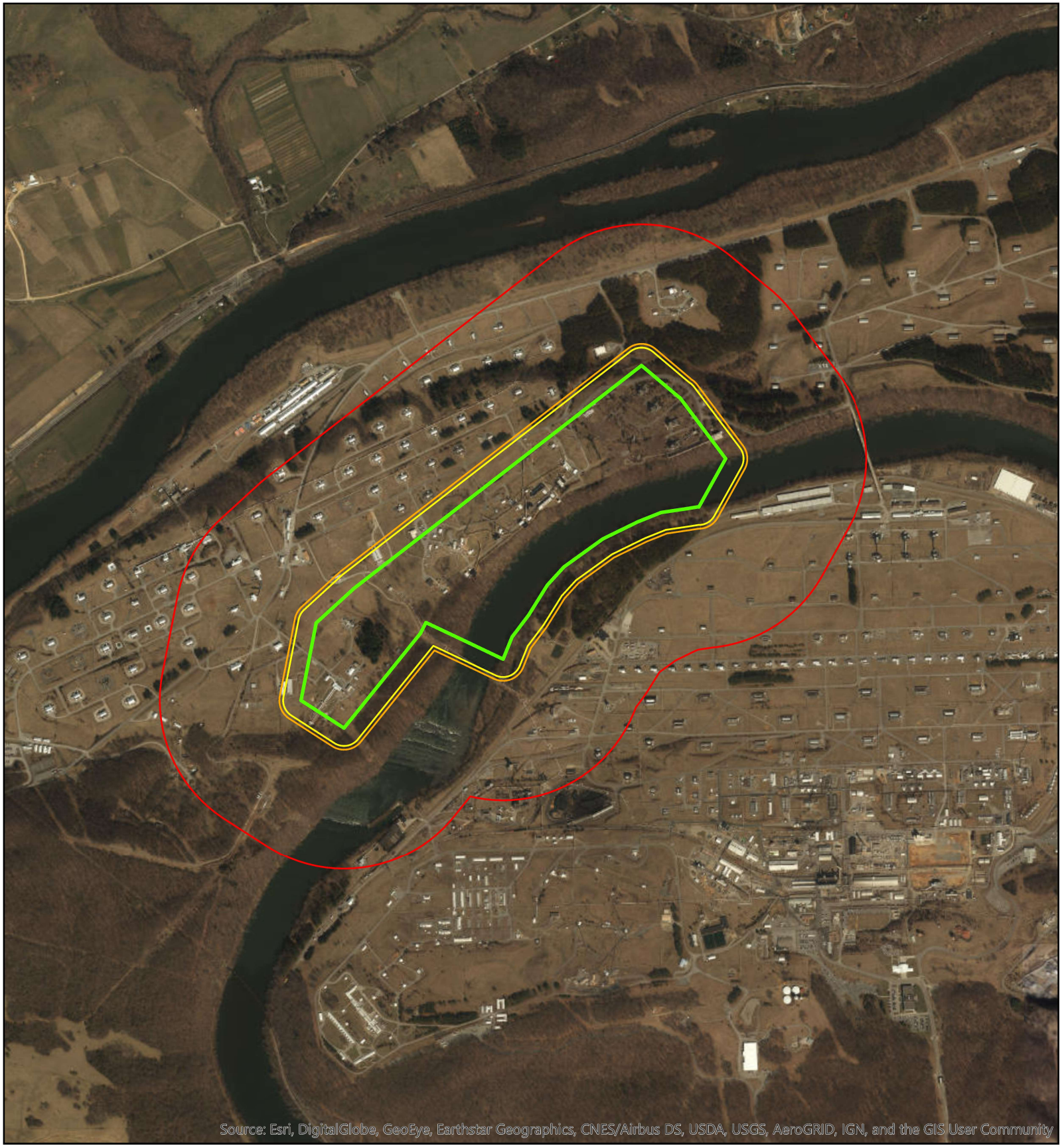


MRS Former Gun/Mortar Range

N

0 1,250 2,500 5,000 Feet

Figure 2



Legend

- MRS Former Gun/Mortar Range
- EC 200 ft
- HFD 242 ft
- MFD 1579 ft

N

0 1,250 2,500 5,000 Feet

Figure 3

APPENDIX B
FRAGMENTATION DATA CALCULATION SHEETS

Fragmentation Data Review Form

Database Revision Date 5/3/2018

Category:	Surface-Launched HE Rounds
Munition:	81 mm M45
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Non-Robust

DODIC:	
Date Record Created:	9/21/2004
Record Created By:	MMC
Last Date Record Updated:	5/3/2018
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	4.48
Diameter (in):	3.1890
Cylindrical Case Weight (lb):	3.89812
Maximum Fragment Weight (Intentional) (lb):	0.0265
Design Fragment Weight (95%) (Unintentional) (lb):	0.0034
Critical Fragment Velocity (fps):	7384

Sandbag and Water Mitigation Options

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	4.480
Kinetic Energy 10^6 (lb-ft²/s²):	0.7227

Single Sandbag Mitigation

Required Wall & Roof Thickness (in)	24
Expected Max. Throw Distance (ft):	125
Minimum Separation Distance (ft):	125

Double Sandbag Mitigation

Required Wall & Roof Thickness (in)	Not Permitted
Expected Max. Throw Distance (ft):	Not Permitted
Minimum Separation Distance (ft):	Not Permitted

Water Mitigation

Minimum Separation Distance (ft):	200
Water Containment System:	1100 gal tank

Note: Use Sandbag and Water Mitigation in accordance with all applicable documents and guidance. If a donor charge larger than 32 grams is utilized, the above mitigation options are no longer applicable. Subject matter experts may be contacted to develop site specific mitigation options.

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	242
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1199
MFD-V [Maximum Fragment Distance, Vertical] (ft):	963

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	4.480
3.5 psi, K18 Distance (ft):	30
2.3 psi; K24 Distance (ft):	40
1.2 psi, K40 Distance (ft):	66
0.0655 psi, K328 Distance (ft):	541

"NOTE: Values shown within this section only address overpressure hazards and do not account for applicable distance values for fragments and debris as required per DoD 6055.09-M."

Minimum Thickness to Prevent Perforation (in)

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	8.05	3.43
Mild Steel:	1.41	0.63
Hard Steel:	1.16	0.51
Aluminum:	2.93	1.37
LEXAN:	6.71	4.06
Plexi-glass:	5.06	2.60
Bullet Resist Glass:	4.21	2.01

Item Notes

Distribution Statement D. Distribution authorized to the Department of Defense and U.S. DoD contractors only for Administrative-Operational Use (3 May 2018). Other requests shall be referred to the Department of Defense Explosives Safety Board, 4800 Mark Center Drive, Suite 16E12, Alexandria, VA 22350.

Fragmentation Data Review Form

Database Revision Date 5/3/2018

Category:	Surface-Launched HE Rounds
Munition:	81 mm M43A1
Case Material:	Steel, Mild
Fragmentation Method:	Naturally Fragmenting
Secondary Database Category:	Mortar
Munition Case Classification:	Robust

DODIC:	C225
Date Record Created:	9/21/2004
Record Created By:	MMC
Last Date Record Updated:	5/3/2018
Individual Last Updated Record:	SDH
Date Record Retired:	

Munition Information and Fragmentation Characteristics

Explosive Type:	TNT
Explosive Weight (lb):	1.23
Diameter (in):	3.1890
Cylindrical Case Weight (lb):	4.22038
Maximum Fragment Weight (Intentional) (lb):	0.1096
Design Fragment Weight (95%) (Unintentional) (lb):	0.0377
Critical Fragment Velocity (fps):	3776

Sandbag and Water Mitigation Options

TNT Equivalent (Impulse):	1
TNT Equivalent Weight - Impulse (lbs):	1.230
Kinetic Energy 10^6 (lb-ft²/s²):	0.7808

Single Sandbag Mitigation

Required Wall & Roof Thickness (in)	24
Expected Max. Throw Distance (ft):	125
Minimum Separation Distance (ft):	125

Double Sandbag Mitigation

Required Wall & Roof Thickness (in)	48
Expected Max. Throw Distance (ft):	10
Minimum Separation Distance (ft):	12.5

Water Mitigation

Minimum Separation Distance (ft):	200
Water Containment System:	1100 gal tank

Note: Use Sandbag and Water Mitigation in accordance with all applicable documents and guidance. If a donor charge larger than 32 grams is utilized, the above mitigation options are no longer applicable. Subject matter experts may be contacted to develop site specific mitigation options.

Theoretical Calculated Fragment Distances

HFD [Hazardous Fragment Distance: distance to no more than 1 hazardous fragment per 600 square feet] (ft):	209
MFD-H [Maximum Fragment Distance, Horizontal] (ft):	1579
MFD-V [Maximum Fragment Distance, Vertical] (ft):	1215

Overpressure Distances

TNT Equivalent (Pressure):	1
TNT Equivalent Weight - Pressure (lbs):	1.230
3.5 psi, K18 Distance (ft):	19
2.3 psi; K24 Distance (ft):	26
1.2 psi, K40 Distance (ft):	43
0.0655 psi, K328 Distance (ft):	351

"NOTE: Values shown within this section only address overpressure hazards and do not account for applicable distance values for fragments and debris as required per DoD 6055.09-M."

Minimum Thickness to Prevent Perforation (in)

	Intentional	Unintentional
4000 psi Concrete (Prevent Spall):	6.61	3.98
Mild Steel:	1.27	0.77
Hard Steel:	1.04	0.63
Aluminum:	2.59	1.60
LEXAN:	6.62	5.05
Plexi-glass:	4.99	3.49
Bullet Resist Glass:	4.22	2.87

Item Notes

Distribution Statement D. Distribution authorized to the Department of Defense and U.S. DoD contractors only for Administrative-Operational Use (3 May 2018). Other requests shall be referred to the Department of Defense Explosives Safety Board, 4800 Mark Center Drive, Suite 16E12, Alexandria, VA 22350.

APPENDIX P

EXPLOSIVES MANAGEMENT PLAN

.

EXPLOSIVES MANAGEMENT PLAN

1. GENERAL

This Explosives Management Plan outlines the procedures to be used by unexploded ordnance (UXO) personnel to acquire, receive, store, transport, and issue explosives, and to report the loss of explosives used during the RFI. All personnel involved with explosives will comply with all federal, state, and local laws as required.

2. LICENSES/PERMITS

WESTON has a Type 33-User of High Explosives Permit from the Department of the Treasury – Bureau of Alcohol Tobacco, Firearms, and Explosives (ATF) and will secure a Virginia permit to use explosives as required by local regulations. A copy of all licenses and permits will be maintained on-site and available to any local, state, or federal authority.

3. ACQUISITION

WESTON will purchase explosives on an as-needed basis from a licensed commercial vendor for same-day delivery. If same-day delivery is not possible, on-site security will be provided for those munitions and explosives of concern (MEC) items that cannot be demolished the same day as identified. Vendor information will be provided as required. Prior to bringing the explosives on-site to private property, the Senior Unexploded Ordnance Supervisor (SUXOS) will coordinate with the USACE Ordnance and Explosives Safety Specialist (OESS), Radford Army Ammunition Plant (RFAAP) Point of Contact (POC), RFAAP security, and local law enforcement.

4. INITIAL RECEIPT OF EXPLOSIVES

For this field effort, a magazine will not be established on-site. Explosives that are delivered to the site will be placed in a Day Box mounted in the bed of a truck and used the same day. The following procedures will be adhered to upon initial receipt of explosive materials (see **Figure 1-1**):

- Upon arrival at the site, the SUXOS will escort the vendor/supplier to a designated area for loading/unloading.
- An individual authorized to receive the explosives will compare the explosives delivery record to the actual quantity delivered prior to accepting custody for the explosives.
- Once the quantity has been confirmed, the explosive delivery record will be signed and the explosives transferred to and stored in the approved Day Box mounted on the trucks. Explosives will be recorded on a magazine data card, such as DA Form 3020.

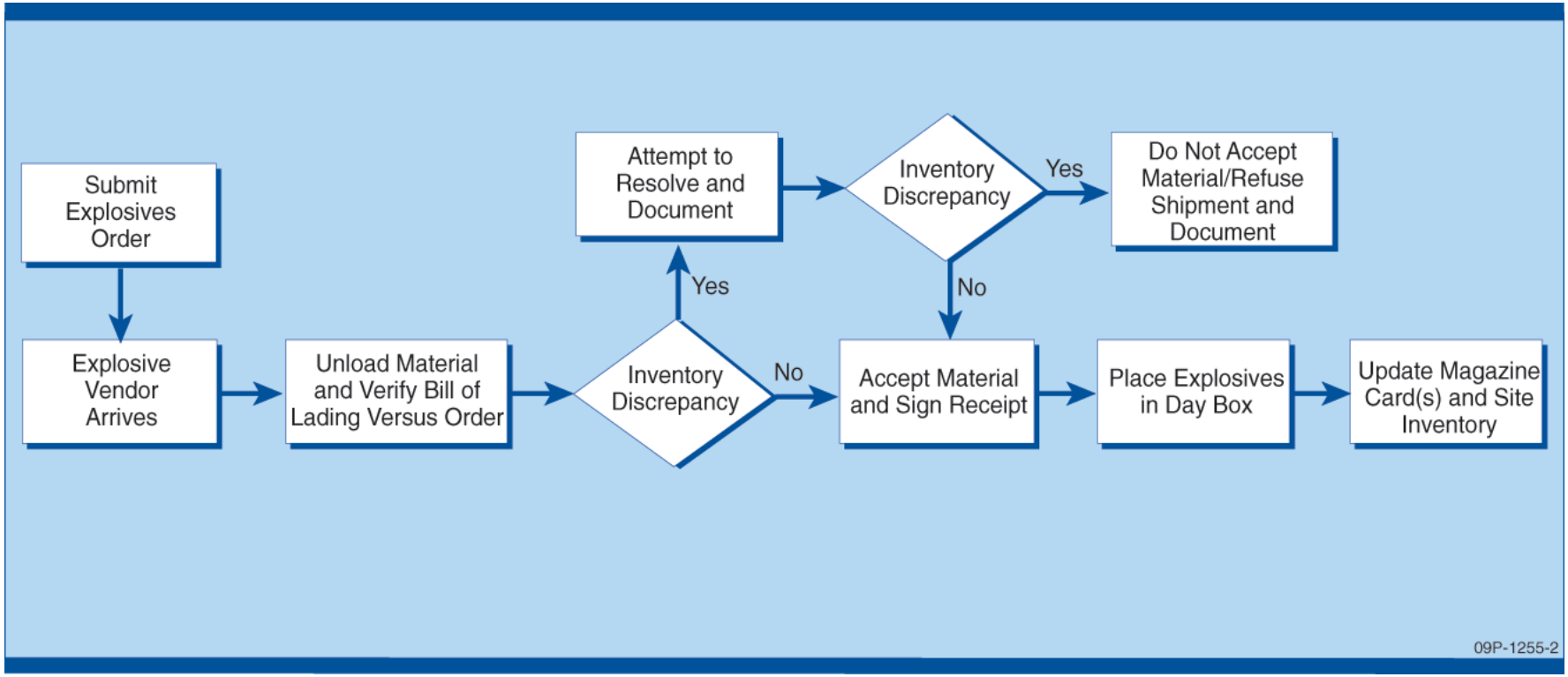


Figure 1-1 Receipt of Explosive Materials Process

- All material introduced or removed from the Day Boxes will be entered on stack cards and explosive records will be updated.
- If it is determined that there is a discrepancy between the quantity delivered and the quantity shipped, the following will occur:
  - The Unexploded Ordnance Safety Officer (UXOSO) will be notified.
  - The shipment will not be accepted.
  - The shipper will be contacted immediately to resolve the discrepancy.

Note: If the discrepancy cannot be resolved within 24 hours, the local law enforcement agency, ATF, the WESTON Program Health and Safety (H&S) Manager, the WESTON MEC Quality Control (QC) Manager, and the WESTON Project Manager (PM) will be notified.

All original receipts, shipping documents, or invoices will be retained on-site as part of records management. Copies of the documentation will be provided in the final report as an appendix.

5. EXPLOSIVES STORAGE MAGAZINE

No explosives magazine will be established on-site. All explosives will be consumed the same day received.

6. TRANSPORTATION

The transportation of explosives to locations requiring demolition operations will be conducted in the following manner:

- Vehicles will be operated by a qualified driver.
- Vehicles transporting explosives to locations requiring demolition operations will stay on roads either improved or unimproved.
- Speeds will be kept to 20 miles per hour or less, depending on road conditions.
- Radio communications will be maintained with the UXOSO.
- Vehicles will have a safety inspection performed prior to loading explosives.

- Vehicles will be equipped with a first aid kit and fire extinguisher.
- Vehicles will be placarded during the transport of explosives.

7. RECEIPT PROCEDURES

Prior to accepting any explosives, the procedures outlined above in the initial receipt procedures section will be followed.

The WESTON SUXOS is authorized to purchase, receive, access, issue, transport, and use explosives for this project. Other project personnel who will have access, issue, transportation, and use authority for explosives on this project will be annotated on the approved user list, which will be maintained in the explosive management records.

Upon completion of each demolition operation, an ammunition consumption report will be completed. Upon expenditure of all explosives, the authorized person will certify in writing that the explosives were used for their intended purpose.

8. INVENTORY

A physical inventory of all explosives will be accomplished in accordance with ATF guidelines.

9. REPORTING LOST OR STOLEN EXPLOSIVES

Loss or theft of explosives will be reported as stated in 27 CFR on Commerce in Explosives. **Table 1** lists the individuals or organizations to be notified upon the discovery of theft or loss of explosives.

Table 1 Reporting Lost or Stolen Explosives

Title	Name	Telephone Number
WESTON SUXOS	Brian Grassmyer	(757) 650-3607
WESTON UXO Safety Officer	Bruce Moe	(920) 636-6494
WESTON PM	Tony Pace	(757) 362-2461
WESTON MEC QC Manager	Ryan Steigerwalt	(267) 258-2672
USACE Explosives Safety Chief	Paul Greene	(410) 962-6741
RFAAP POC	Jim McKenna	(540) 731-5782
Local Authorities as directed	Department of Emergency Services	911
ATF		(800) 461-8841

10. RETURN TO STORAGE OF NONEXPLODED EXPLOSIVES

All explosives ordered on an as-needed basis will be consumed on the same day received.

11. DISPOSAL OF REMAINING EXPLOSIVES

All explosives ordered and received will be consumed on the same day received.

APPENDIX Q

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT METHODOLOGY

APPENDIX Q - HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT METHODOLOGY

This project includes conducting human health and ecological risk assessments for the Former Gun and Trench Mortar Range MRS and Area A (section of the adjacent New River) at Radford Army Ammunition Plant (RFAAP) to determine whether respective site contaminants pose a current or potential risk to human health and the environment in the absence of any remedial action.

1. HUMAN HEALTH RISK ASSESSMENT

A baseline human health risk assessment (BHHRA) will be conducted to assess potential health impacts to humans, considering both the current and future uses at the MRS and within Area A. Although this MRS is covered under Resource Conservation and Recovery Act (RCRA), it is not expected that the Virginia Unified Risk Assessment Model (VURAM) will be used because it is set up primarily with default parameters, and WESTON anticipates the use of more appropriate site-specific parameters to calculate site risk for human receptors. Therefore, the BHHRA will be conducted in accordance with guidance provided in the U.S. Army Corps of Engineers (USACE) *Risk Assessment Handbook, Volume I: Human Health Evaluation* (USACE, 1999) and the U.S. Environmental Protection Agency (USEPA) Risk Assessment Guidance for Superfund (RAGS), as well as other appropriate USEPA and Virginia Department of Environmental Quality (VDEQ) guidelines for risk assessment. The objectives of the BHHRA are to estimate potential risk to people contacting site-related chemicals of potential concern (COPCs) under scenarios of current and plausible future land uses, provide an analysis of risks and help determine the need for remedial action(s) at the site, and identify specific media and areas associated with unacceptable risk as applicable. The BHHRA will consist of five main sections: Hazard Identification, Toxicity Assessment, Exposure Assessment, Risk Characterization, and Uncertainty Analysis.

1.1 HAZARD IDENTIFICATION

The hazard identification will involve the review of available site data, the evaluation of data usability and data validation, establishment of guidelines for data reduction, the evaluation of data for use in the risk assessment, and selection of COPCs. The following guidelines for data reduction will be used to produce the data summaries for each medium of concern for the BHHRA:

- If a chemical is reported in both a field sample and a method or field blank, it will be considered to be a positive identification if the chemical is present in the field sample at a concentration greater than 10 times (for common laboratory contaminants), or 5 times (for all other substances) the maximum concentration reported in the blank for that data set.

- If a chemical is not positively identified in any sample for a given medium, because it is reported as a non-detect (indicated by a "U" qualifier), or because it is rejected by the data validator (indicated by an "R" qualifier), it will not be addressed for that medium. No data containing an "R" flag will be used in the BHHRA.

- Data with "J" qualifiers will be assumed to be positive identifications. "J" values are estimated chemical concentrations reported below the minimum confident quantitation limit or the sample quantitation limit (SQL). All data with "J" qualifiers will be assumed to be positive identifications for that medium and the corresponding reported concentrations will be used.

- Duplicate samples from the same sampling location will be considered as one data point. If a sample duplicate(s) is collected and analyzed, the average of the reported concentrations will be used for subsequent calculations unless there is a greater than 50% difference in soil and sediment concentrations and a 30% difference in water concentrations, in which case the higher of the two concentrations will be used. In the case of a detected sample and a non-detect duplicate, the detected concentration will be carried through subsequent calculations.

For all sample locations where soils will be sampled at multiple depths for a single location, the results from the various depths will be treated as individual data points in summarizing the data.

COPCs will be identified by comparing the maximum detected chemical concentration for each chemical by medium. In general, the list of chemical COPCs to be evaluated in the BHHRA includes the following:

- Positively detected in at least one sample in a given medium, including (a) chemicals with no qualifiers attached (excluding samples with unusually high detection limits) and (b) chemicals with qualifiers attached that indicate known identities but unknown or estimated concentrations (e.g., J-qualified data).

- A chemical will be excluded as a COPC for a medium if it is not detected in any samples from that medium.

- Frequency of detection (i.e., less than 5%) will be considered in the exclusion of a chemical as a COPC in conjunction with toxicity screening.

- Not normally considered as being toxic to humans. Calcium, magnesium, potassium, and sodium are considered to be essential nutrients and are toxic only at very high doses. These chemicals will not be retained as COPCs.

- Chemicals detected in media at concentrations in excess of risk-based concentrations (RBCs) which are associated with a cancer risk of 1E-06 (one-in-one-million) and a systemic HQ of 1. The USEPA has a national screening database found at: http://epa-prgs.ornl.gov/chemicals/index.shtml. These regional screening levels (RSLs) will be used for chemical comparison.

- Soil COPCs will be identified by comparing the maximum detected concentration of each chemical with the residential RSL. For COPC screening purposes, noncarcinogenic RSLs will be adjusted to correspond to a target hazard quotient (THQ) of 0.1 rather than 1. This will be done to ensure that chemicals with additive effects are not prematurely eliminated during screening. Where RSLs are available for carcinogenic and noncarcinogenic endpoints and both ingestion and inhalation exposure routes, the lower (i.e., most stringent) value will be used for the screening comparison.

- Currently, there are no RSLs for sediment exposure. Therefore, in order to select sediment COPCs, the maximum detected concentrations in sediment will be compared to the residential soil RSLs multiplied by a factor of 10 (TR – 1.0E-05; THQ – 1.0). VDEQ guidance states, "VRP Tier II screening values for sediment were obtained by multiplying residential soil RSL values by a factor of 10 to account for decreased exposure to sediments. For non-carcinogens, however, the target hazard quotient has been adjusted to 0.1 (the RSL has been divided by 10) so that additive toxicity will not result in a hazard index (HI) greater than one for multiple contaminants."

- If a risk-based screening level cannot be obtained or calculated for a chemical, that chemical will be carried forward and discussed qualitatively in the uncertainty analysis. However, when a chemical does not have a screening value available, efforts will be made to identify a suitable surrogate to use in the COPC selection process.

- USEPA has not assigned verified or provisional toxicity values (i.e., cancer slope factors [CSFs] and reference doses [RfDs]) to lead because the toxicity data available to date are inadequate for evaluation by current methodology. Therefore, lead risk will not be evaluated using the conventional risk assessment approach. USEPA's Integrated Exposure Uptake Biokinetic model (IEUBK) (USEPA, 2010) will be used to characterize lead risk to children aged 1 to 6 years. The Adult Lead Model (USEPA, 2003a) will be used to characterize lead risk to unborn infants based on environmental exposure of the mother to lead-contaminated media.

- Soil data will also be compared to existing the 95% upper tolerance limit (UTL) background level from Facility-Wide Background Study Report (IT Corporation, 2001). Chemicals that are above risk-based screening levels and background levels are identified as site-related COPCs and will be evaluated in the risk assessment. Chemicals that are above risk-based screening levels but below background levels are identified as non-site related COPCs and will be discussed in the Uncertainty Analysis (Tri-Service Environmental Risk Assessment Working Group [TSERAWG], 2011).

Upon identification of the COPCs, summary tables will be prepared by medium and will present the following information:

- List of COPCs.
- Arithmetic mean concentration of data.
- Median concentration of data.
- Distribution of data (normal, lognormal, neither).
- 95 percent upper confidence limit (95% UCL) of the arithmetic mean.
- Exposure point concentration (EPC).

1.2 TOXICITY ASSESSMENT

This section of the BHHRA will present a discussion of carcinogenic and noncarcinogenic toxicity characteristics of the COPCs and summarize the carcinogenic and noncarcinogenic toxicity criteria to be used in the risk characterization step. The toxicity criteria will be obtained using the following hierarchy:

- Tier 1 – USEPA's Integrated Risk Information System (IRIS) computerized database found at www.epa.gov/iris (USEPA, 2019b).
- Tier 2 – USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs) developed by the Office of Research and Development/National Center for Environmental Assessment (NCEA)/Superfund Health Risk Technical Support Center (STSC).
- Tier 3 – Other Toxicity Values (can include, for example, NCEA values as presented on the USEPA RSLs Table (USEPA, 2019a), the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), and toxicity values developed by state agencies such as California EPA.

Only chronic RfDs will be used in estimating non-carcinogenic HQs and HIs.

Toxicity criteria have not been developed for the dermal exposure route. Dermal RfDs will be derived for each chemical by multiplying the value used as the oral RfD by an appropriate gastrointestinal absorption value (ABS_{GI}). The ABS_{GI} is also known as the oral to dermal adjustment factor. Chemical-specific ABS_{GI} factors will be obtained from Exhibit 4-1 of USEPA RAGS Part E (USEPA, 2004). For organic chemicals in which chemical-specific ABS_{GI} factors are not available, the ABS_{GI} factor will be assumed to be 100%, indicating that organic chemicals are generally well absorbed (i.e., >50% across the gastrointestinal [GI] tract). Similarly, for inorganics in which chemical-specific ABS_{GI} factors are not available, the ABS_{GI} factor will also be assumed to be 100%.

Summary tables will be included that present the toxicity values for each of the COPCs and will include the source, the USEPA weight-of-evidence (for carcinogens), the route of administration, and the critical noncarcinogenic health effect.

When toxicity criteria are not available for some of the chemicals detected at the site, a surrogate (substitute) chemical will be selected to evaluate the potential impacts of a COPC lacking toxicity criteria. For instance, vanadium pentoxide will be used as a surrogate chemical for vanadium. Use of surrogate toxicity data will be documented in the BHHRA text.

1.3 EXPOSURE ASSESSMENT

The objective of the exposure assessment is to estimate the nature, extent, and magnitude of potential exposure of human receptors to COPCs considering the current and reasonably anticipated future uses of the site. The exposure assessment includes an evaluation of the likelihood of such exposures occurring and provides the basis for development of acceptable exposure concentrations. The reasonable maximum exposure (RME) scenario will be evaluated for each receptor group. The exposure assessment involves several key steps:

- Evaluation of the exposure setting includes describing the local land and water uses and identifying the potentially exposed human populations.
- Development of the conceptual site model (CSM) includes identifying the source(s) of contamination, the transport and release mechanisms, the exposure media, the exposure routes, and the potentially exposed populations (both current and future), provided in **Figure 1**.
- EPCs will be calculated for the COPC, the exposure scenario, and medium. EPCs are the concentrations to which a receptor may come in contact with at an area. The EPC will be either the 95% UCL of the mean or the maximum detected concentration, whichever is lower. The 95% UCLs will be calculated following the most recent USEPA guidance and USEPA's ProUCL statistical software program (Version 5.1, USEPA 2015). Note that ProUCL Version 5.1 restricts the use of ProUCL for samples of a size of at least 5. For data sets with less than 5 samples, no decision statistics will be computed when not more than one detected observation is present in the data set. The maximum detected concentration will be used as the EPC for sample sizes smaller than 5 or for data sets with only one detected observation.
- Algorithms for calculating the exposure doses through exposure pathways to receptors will be presented in the risk assessment and will be consistent with USEPA and USACE risk assessment guidance and recommendations from USEPA Region 3.

- Exposure parameters with which to calculate the exposure doses will be identified for each scenario and exposure routes. Guidance documents such as the following will be used to identify exposure parameters:
  - RAGS Volume I, Human Health Evaluation Manual, Part A, Interim Final (USEPA, 1989).
  - The Exposure Factors Handbook and updates (USEPA, 1997a, 2011, 2017).
  - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002).
  - Human Health Toxicity Values in Superfund Risk Assessments (USEPA, 2003b).
  - RAGS Vol. I, Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004).
  - RAGS Vol. I, Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009).
  - Specific guidance from USEPA Region 3, VDEQ, and USACE.
  - Site-specific information and professional judgment.
- Exposure doses for both carcinogenic and noncarcinogenic effects will be calculated and presented in tabular format.

1.4 RISK CHARACTERIZATION

Carcinogenic risk and noncarcinogenic health effects in susceptible populations will be determined by combining chemical-specific toxicity criteria with quantitative information from the exposure assessment. These comparisons will determine whether site contamination may affect human health.

The objective of the risk characterization is to evaluate the carcinogenic risks and adverse noncarcinogenic health effects occurring as a result of exposure to COPCs. The potential for cancer risks and noncarcinogenic health effects of COPCs will be evaluated separately because of differences in the processes by which these health effects are believed to occur. Cancer risks will be calculated for those COPCs with evidence of carcinogenicity and for which cancer toxicity values are available. Noncarcinogenic health effects will be evaluated for the COPCs for which noncarcinogenic toxicity values are available.

USEPA has developed exposure algorithms for calculating contaminant intakes through the relevant exposure pathways and routes for a site. These algorithms are mathematical models that use a variety of parameters to quantify the intake of a contaminant. The development of chemical intakes is based on USEPA methodology presented in RAGS Parts A, B, E, and F (USEPA, 1989, 1991a, 2004, 2009) and Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-03 (USEPA, 1991b). To evaluate direct contact exposure to COPCs in site soil and sediment (i.e., ingestion and dermal absorption), the exposure algorithms combine chemical concentrations with pathway- and route-specific parameters to produce daily chemical intakes in terms of the milligrams of chemical taken into the body per kilogram of body weight per day (mg/kg-day). The generic direct contact exposure algorithm is as follows:

$$I = EPC \times CR \times ET \times EF \times ED / (BW \times AT)$$

Where:

I = intake; the amount of chemical at the exchange boundary (mg/kg body weight/day).

EPC = exposure point concentration in specific media (e.g., milligrams of contaminant per kilogram of soil).

CR = contact rate; the amount of contaminated medium contacted per unit time or event (e.g., mg/day).

ET = exposure time; describes how long exposure occurs (hrs/day).

EF = exposure frequency; describes how often exposure occurs (days/year).

ED = exposure duration; describes how long exposure occurs (years).

BW = body weight; the average body weight over the exposure period (kilograms).

AT = averaging time; period over which exposure is averaged, which is equal to a 70-year lifetime when evaluating carcinogens (25,550 days), or averaged over the actual exposure duration for noncarcinogens.

For the inhalation exposure route, the concentration of the chemical in air is used as the exposure metric (e.g., milligrams per cubic meter [mg/m^3]), as follows (USEPA, 2009):

$$EC = (CA \times ET \times EF \times ED)/AT$$

Where:

EC = exposure concentration (mg/m^3)

CA = contaminant concentration in air (mg/m^3)

ET = exposure time (hours/day)

EF = exposure frequency (days/year)

ED = exposure duration (years)

AT = averaging time (carcinogens: 70 years x 365 days/year x 24 hours/day; non-carcinogens: ED x 365 days/years x 24 hours/day)

The estimated intake for each COPC will be based on the EPC for the COPC and on site-specific exposure factors developed using USEPA Exposure Factors OSWER directive (USEPA, 2014), USEPA's *Exposure Factors Handbook: 2011 Edition* (USEPA, 2011), and those references previously cited in this section.

1.5 IDENTIFICATION OF LIMITATIONS/UNCERTAINTIES

The section will identify critical assumptions and uncertainties. The goal of the uncertainty analysis in a risk assessment is to provide to the appropriate decision makers (i.e., risk managers) information about the key assumptions, their inherent uncertainty and variability, and the impact of this uncertainty and variability on the estimates of risk. The primary sources of uncertainty in this risk assessment will be identified and the potential impacts to the risks (over- or under-estimate) will be described.

1.5.1 Potentially Exposed Populations

As identified in the Site Inspection (SI) report, potential human receptors include RFAAP workers, construction workers, and trespassers/visitors. Recreational users of Area A are also considered potential human receptors who will have the same exposure parameters as the trespasser/visitor.

The current activities at the MRS and Area A include visitors touring the MRS, work performed on the MRS by site workers, construction activities on the MRS by construction workers, trespassers who may illegally enter or hunt on the MRS, and recreational boaters who float within Area A portion of the New River. No residential housing exists nearby; therefore, it is unlikely that residential exposure to chemicals of potential concern occurs at the site. Receptors to be evaluated in the risk assessment could include site and construction workers, and visitors/trespassers (adults and children) of the New River that could be exposed to soil at the MRS and sediment within the New River. Additional personnel and areas of the site that could introduce risk will be evaluated. Future uses of the MRS and Area A are expected to include the current uses.

Potential human exposure pathways for soil and sediment exist at the site. A summary for each medium is discussed as follows:

- Soil: Surface soil exposure pathways at the MRS could include incidental ingestion, dermal absorption, and inhalation of dust for current and future site and construction workers, and current and future trespassers/visitors. Based on the assumption that subsurface soil may be excavated to the ground surface as a result of construction activities, the construction worker may also be exposed to subsurface soil inhalation of fugitive dust.

- Sediment within MRS: Surface sediment (intermittent drainage ditches) exposure pathways at the site could include incidental ingestion and dermal absorption for current and future site and construction workers, and current and future trespassers/visitors. Fugitive dust exposure may also be of concern to construction workers during development/excavation activities. Subsurface sediment exposure pathways could be evaluated for the same receptors previously mentioned for surface sediment, based on the assumption that subsurface sediment may be excavated to the ground surface as a result of construction activities.

- Sediment within Area A portion of the New River: Surface sediment exposure pathways could include incidental ingestion and dermal absorption for current and future trespassers/visitors. Subsurface sediment exposure is unlikely.

- Surface water within the MRS: Based on the intermittent nature of surface water within the MRS, typically only present in drainage ditches for short periods of time, impacts to surface water quality from site activities are not anticipated; however, incidental ingestion and dermal contact for any receptors that have the potential to be exposed to any flowing or standing water will be included in the BHHRA.

- Surface water within Area A portion of the New River: Surface water exposure pathways could include incidental ingestion and dermal contact for any receptors that have the potential to be exposed to any flowing water; therefore, this pathway will be included in the BHHRA.

- Groundwater: Based on the anticipated depth to groundwater, greater than 60 feet below ground surface, impacts to groundwater quality from site activities is not anticipated and there are no current of anticipated future uses of site groundwater; therefore, no exposure to groundwater is anticipated at the MRS.

Based on the above information, the following exposure pathways and routes could be included in the human health risk assessment of the MRS and Area A:

Surface and Subsurface Soil and Sediment within MRS:

- Current/future incidental ingestion and dermal absorption of surface soil by site workers.

- Current/future incidental ingestion and dermal absorption of surface soil by construction workers.
- Current/future incidental ingestion and dermal absorption of surface soil by visitors/trespassers.
- Future inhalation of fugitive dust by construction workers during excavation activities (from surface soil).

Sediment (within Area A):

- Current and future incidental ingestion and dermal absorption by visitors/trespassers.

2. SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment (ERA) for the MRS and Area A will follow guidance provided in USEPA's *Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments,* USEPA/540-R-97-006 (USEPA, 1997b) and USACE's *Environmental Quality Risk Assessment Handbook, Volume II, Environmental Evaluation* (USACE, 2010). The general approach for conducting an ERA under this guidance follows the federal eight-step guidance document *Framework for Ecological Risk Assessment* (USEPA, 1992) process as discussed below.

- STEP 1: Screening-level problem formulation and ecological effects evaluation.
- STEP 2: Screening-level exposure estimate and risk calculation.
- STEP 3: Baseline risk assessment problem formulation.
- STEP 4: Study design and data quality objective process.
- STEP 5: Field verification of sampling design.
- STEP 6: Site investigation and analysis phase.
- STEP 7: Risk characterization.
- STEP 8: Risk management.

In addition, the SLERA will follow applicable guidance from the Biological Technical Assistance Group (BTAG) of USEPA Region 3, which has posted suggested screening benchmarks on its website.

The objective of the SLERA is to conservatively evaluate if there is a possibility of potential adverse ecological impacts at the site and to determine whether there is a need to go forward with a baseline ecological risk assessment (BERA). It should be noted that, like SLERAs, BERAs are

incapable of producing risk estimates. Thus, HQs produced in both report types do not result in probabilities of toxicological effects arising.

SLERA Steps 1 through 3a are described in the following sections.

2.1 STEP 1 - SCREENING LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

For the screening-level problem formulation, the developed ecological CSM will be refined for the sites and will address the following five issues:

- Characterization of the environmental setting and known or suspected contaminants.
- Fate and transport mechanisms that might exist at the site.
- Mechanisms of ecotoxicity associated with chemical and likely categories of receptors that could be affected.
- Complete exposure pathways.
- Selection of appropriate endpoints to screen for potential adverse ecological impact.

The basis for ecological conceptual site model will be the CSM developed for the RCRA Facility Investigation (RFI) with additional information on potential ecological receptors present that may pose complete exposure pathways for environmental contamination.

2.1.1 Potential Ecological Receptors

As previously mentioned in Section 10.5.7 of the QAPP, the U.S. Fish and Wildlife Service (USFWS) does not list any critical habitat for threatened or endangered species within the boundaries of, or in the nearby vicinity of, the Former Gun and Mortar Range MRS (RFAAP-002-R-01). The MRS is highly developed and is not likely to provide viable ecological habitat.

Table 1 presents the potentially present ecological receptors that were identified in a previous SLERA performed at the RFAAP for the Virginia Department of Environmental Quality (VDEQ) (Franklin Engineering Group, 2001).

Table 1 Common Ecological Receptors Present at Radford Army Ammunition Plant

Receptor Category	Receptor Species	Critical Ecological Attributes	Exposure Scenario
Soil Invertebrates	Arachnida, Diplopoda, Insecta, Chilopoda	Soil invertebrates provide an important food source for many higher trophic level species. As decomposers/detritivores, they play a critical role in nutrient cycling. They also aid in soil aeration and infiltration by increasing macro and micro porosity.	Uptake and burrowing in contaminated soil. Bioaccumulation of MC from contaminated soil.
Herbivorous Mammals	Meadow vole, white-tailed deer, eastern fox squirrel, eastern chipmunk, eastern gray squirrel, woodchuck, meadow jumping mouse	Herbivorous mammals are an important prey item for many higher trophic level predators. They provide an important link for energy transfer between primary producers and higher trophic level consumers. In addition, these organisms generally comprise the majority of the terrestrial tissue biomass, and are important in seed dispersal and pollination for many plant species.	Burrowing in MC contaminated soil. Consumption of plants that have absorbed and bioaccumulated MC from contaminated soil.
Herbivorous Birds	Mourning dove, Canada goose, wild turkey, chipping sparrow, northern cardinal	Herbivorous birds are an important prey item for many higher trophic level predators. They are important in seed dispersal for many plants in both terrestrial and aquatic ecosystems. Aquatic herbivorous birds may also play an important role in egg dispersion for fish and invertebrate species.	Consumption of plant seeds that have absorbed and bioaccumulated MC from contaminated soil.
Carnivorous Mammals	Red fox, swift fox, river otter, bobcat, long-tailed weasel, American badger, grey fox, American mink	Carnivorous mammals provide an important functional role to the environment by regulating lower trophic level prey populations.	Incidental ingestion of MC from contaminated soil while feeding. Consumption of animals that have bioaccumulated MC from soil.
Carnivorous Birds	Red-tailed hawk, American kestrel, great-horned owl, barn owl, burrowing owl, white-tailed hawk, golden eagle, Mississippi kite, prairie hawk	Carnivorous birds provide an important functional role to the environment by regulating lower trophic level prey populations.	Incidental ingestion of MC from contaminated soil while feeding. Consumption of animals that have bioaccumulated MC from contaminated soil.
Omnivorous Mammals	Least shrew, Virginia opossum, striped skunk, northern short-tailed shrew	Omnivorous mammals are an important prey item for higher trophic level predators, and influence lower trophic level populations through predation. They play an important role in seed dispersal for many types of terrestrial vegetation and aquatic plants.	Burrowing in MC contaminated soil. Consumption of plants and animals that have absorbed and bioaccumulated MC from contaminated soil.
Omnivorous Birds	American robin, mallard, Carolina wren, blue jay, American crow, yellow warbler, pileated woodpecker	Omnivorous birds are an important prey item for higher trophic level predators. They play an important role in seed dispersal and pollination for many types of terrestrial vegetation and aquatic plants. In addition, aquatic species provide egg dispersal for some fish and invertebrate species.	Consumption of plants and animals that have absorbed and bioaccumulated MC from contaminated soil.

The species identified in **Table 1** have the potential to come into contact with MC-contaminated surface soil and sediment. Because metals were previously detected in surface soil and sediment above ecological screening levels, surface soil/sediment dermal contact, incidental ingestion, and inhalation exposure pathways are considered complete.

The soil invertebrate group is known to spend the majority of its time burrowing in the ground, and the mammals listed in **Table 1** either dig their own burrows or inhabit dens abandoned by other animals. Additional exposure for mammals and birds could come from the consumption of MC bioaccumulated in plants, insects, or other animals.

2.1.2 Selection of Receptor Species

To assess the potential effects of contaminants released on the ecological resources of the Site, a conceptual site model (CSM) of the potential exposure to ecological receptors is provided (**Figure 1**). Receptor species were identified through an evaluation of the previous SLERAs conducted at various RFAAP sites.

Receptors have been selected based on their ecological relevance, exposure potential, sensitivity, social or economic importance, and the availability of natural history information. The ecological receptors described in the following subsections will be evaluated through food-chain modeling in the SLERA.

2.1.2.1 Red-Tailed Hawk

The red-tailed hawk (*Buteo jamaicensis*) was chosen as a representative avian carnivorous species in terrestrial habitats. The Red-tailed hawk is the most common and widespread American bird of prey (Bull and Farrand, 1977). Their habitat is variable although they are commonly found in wooded areas near open land. They are also found in other habitats including plains, prairie groves, and deserts in the western United States (National Geographic Society [NGS], 1987). The Red-tailed hawk is an opportunistic feeder which hunts from a perch or on the wing for food items such as small mammals (e.g., mice, chipmunks, and rabbits), birds (usually ground-dwelling species), reptiles, insects, and occasionally larger prey items (Burton, 1989).

2.1.2.2 Red Fox

The red fox (*Vulpes vulpes*) was selected to represent the carnivorous mammal guild in the terrestrial habitats. The red fox inhabits brushy successional areas such as old fields, borders of pastures, and rolling farmlands (Merritt, 1987). The red fox is mainly nocturnal, although it does forage at dawn and dusk. It uses earthen dens commonly situated on sunny, well-drained slopes. The fox will also nest in hollow logs, rocky caverns, and sometimes deserted outbuildings (Merritt,1987). The red fox is an opportunist and preys upon small mammals (e.g., rabbits, meadow voles, and white-footed mice), birds (including eggs), invertebrates, frogs, snakes, vegetable matter, and carrion. Seasonal preferences reflect the availability of food items; the common food items in autumn include berries, fruits, insects, and spiders, and in the winter small mammals and rabbits are hunted (Merritt, 1987).

2.1.2.3 Meadow Vole

The meadow vole (*Microtus pennsylvanicus*) will be selected as a surrogate species for assessment of potential food-chain bioaccumulation from soils into an herbivorous mammal. The meadow vole inhabits grassy areas (upland and wetland) and obtains a significant portion of its herbivorous diet from the site. The vole resides in every area of the United States and Canada where there is good grass cover, ranges in size from about 9 to 13 centimeters (cm) in length, and weighs between 17 and 52 grams (USEPA, 1993). The meadow vole has a limited foraging range, which increases its potential to be exposed (directly or indirectly) to contaminants of potential ecological concern (COPECs) in on-site surface soil. The vole has an average home range of 0.026 acre, with summer ranges larger than winter ranges. The vole does not hibernate and is active year-round. Population densities can range up to several hundred per hectare (USEPA, 1993).

2.1.2.4 Mourning Dove

The mourning dove (*Zenaida macroura*), will be selected as a surrogate species for assessment of potential food-chain bioaccumulation from soils into an herbivorous passerine bird. Mourning doves are common at the site and regularly ingest grit in their diet. Mourning doves are highly adaptable birds and are found in a wide variety of habitats. They are more common in open woodlands and forest edges near grasslands and fields. The average mass of a dove ranges from 96.0 to 170.0 grams (3.38 to 5.99 ounces). The average lifespan is 1 year. Mourning doves range

over areas of up to 5 miles each day, but usually less. The mourning dove diet consists of primarily plant material (99% or more; almost all of which is seeds), with just a trace of animal matter, including small insects (http://www.dof.virginia.gov/manage/hunt/mourning-dove.htm). Grass seeds, from both native and cultivated plants, are preferred dove foods. Doves get their food from the surface of the ground. With weak feet and poor scratching ability, foods need to be on open ground and plainly visible. Doves require a small amount of grit (small pieces of sand or gravel) and water to aid in digestion.

2.1.2.5 American Robin

The American robin (*Turdus migratorius*) will be selected to represent the omnivorous bird guild in the terrestrial habitats. The American robin is a member of the thrush family, and inhabits forests, wetlands, swamps, and habitat edges where forested areas meet agricultural and range land (USEPA, 1993). The American robin requires access to freshwater, protected nesting sites, and productive forage in areas for breeding. Breeding habitats include moist forests, swamps, open woodlands, orchards, parks, and lawns. Robins may forage on the ground, along habitat edges, stream edges, or above ground in shrubs and the lower branches of trees (USEPA, 1993). Robins eat invertebrates, seeds, and fruit (USEPA, 1993). Directly preceding and during the breeding season, robins' diet consists of greater than 90% (by volume) invertebrates and some fruit. During the rest of the year, their diet consists of 80-99% (by volume) of fruits. Fruits commonly eaten include plums, dogwood, sumac, hackberries, blackberries, cherries, greenbriers, raspberries, and juniper. Invertebrates commonly taken include beetles, caterpillars, moths, grasshoppers, spiders, millipedes, and earthworms (USEPA, 1993).

2.1.2.6 Northern Short-Tailed Shrew

The northern short-tailed shrew (*Blarina brevicauda*) will be selected to represent the omnivorous mammal guild in the habitats. The short-tailed shrew may be found in a variety of habitats with a well-developed layer of leaf litter and humus, including grasslands, brushy thickets, meadows, old fields, and deciduous, coniferous, and mixed forest (Merritt, 1987). The short-tailed shrew's diet includes invertebrates (e.g., spiders, centipedes, slugs, snails, and earthworms), salamanders, mice, voles, and occasionally birds. It has a preference for animal food, but also eats fungi and plant material such as roots, nuts, fruits, and berries. In winter, insect larvae and pupae serve as important

food sources (Merritt, 1987). A short-tailed shrew is considered as a conservative surrogate receptor for omnivorous mammals in the SLERA because it eats up to three times its body weight daily and because of its small home range. Though primarily insectivorous, shrews do eat some plant material and they incidentally ingest soil while foraging and digging underground nests or runways.

2.2 STEP 2 - SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CALCULATION

Step 2 will consist of evaluating soil and sediment data against ecological screening benchmarks. In Step 2, chemical exposure levels to screen for potential adverse ecological impact will be estimated. For all complete exposure pathways, the maximum detected site-related chemical concentration will be used as the exposure point concentration used to compare with ecological benchmarks. Results of the screening will be used to identify COPECs.

All bioaccumulative compounds will be assessed in the food chain exposure evaluation. Compounds listed on Table 4-2 in *Bioaccumulative Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs* (EPA-823-R-00-001, February 2000) will be carried through to the food chain exposure evaluation.

Soil screening benchmarks will be used to screen soil for potential adverse ecological impact to plants and soil-dwelling organisms and food chain risk for birds and mammals. The following includes a hierarchy of sources that will be used to obtain soil screening benchmarks:

- USEPA 2003-2008 Ecological Soil Screening Levels (Eco-SSLs); the lowest of plant, soil invertebrate, avian, and mammalian values (USEPA, last updated 10/22/2016; https://www.epa.gov/chemical-research/ecological-soil-screening-level).
- Los Alamos National Laboratory (LANL) ECORISK Database, Release 4.1. (LANL, 2017; https://www.lanl.gov/environment/protection/eco-risk-assessment.php).

Sediment screening benchmarks will be used to screen sediment for adverse ecological impacts to benthic organisms. The following includes a list of sources that will be used to obtain sediment screening benchmarks:

- USEPA Region 3 Biological Technical Assistance Group (BTAG) Freshwater Sediment Screening Benchmarks (USEPA, 2006; https://www.epa.gov/sites/production/files/2015-09/documents/r3_btag_fw_sediment_benchmarks_8-06.pdf).

- LANL ECORISK Database, Release 4.1. (LANL, 2017; https://www.lanl.gov/environment/protection/eco-risk-assessment.php).

The LANL ecological screening levels (ESLs) for sediment (avian and mammalian aerial insectivores) and soil (birds and mammals), and the USEPA Eco-SSLs (birds and mammals) will be used to determine food chain COPECs.

2.3 STEP 3A - REFINEMENT OF COPECs

Based on USEPA guidance (USEPA, 2001, 1998, 1997b), USEPA Step 3a provides for iteration of hazard estimates by applying additional site-specific information to further refine the COPECs to those requiring remedial evaluation and/or additional evaluation by conducting a BERA. Step 3A (refinement of COPECs) incorporates elements of a baseline risk assessment (USEPA Step 3) and is the final outcome of the SLERA, which represents a scientific management decision point (SMDP). In most cases, the Step 3A refined hazard estimate provides the basis for defining potential site risk drivers with the overall goal of identifying and prioritizing additional data needs (i.e., BERA and/or early remedial action decisions for the site).

2.4 SCIENTIFIC/MANAGEMENT DECISION POINT

A summary will be written of the SLERA, including the range of chemical concentrations detected, the number of chemicals exceeding their benchmarks, the degree of the exceedance of the benchmark (or benchmarks), the appropriateness of the benchmarks themselves, and the refinement of COPECs. The results will be evaluated to ensure that the information provided assists the risk manager in making one of the following decisions:

- That there is adequate information to conclude that the potential adverse ecological impacts are negligible; therefore, there is no need for remediation on the basis of ecological adverse effects.

- That the information is not adequate to make a decision at this point, and the ecological risk assessment process will continue to Step 3 (a BERA).

- That the information points to a potential for adverse ecological effects and a more thorough assessment is warranted.

The USEPA guidance, *Ecological Risk Assessment and Risk Management Principles for Superfund Sites* (USEPA, 1999), will be consulted to assist in this aspect. The SLERA will incorporate background data from each medium, but consistent with USEPA Region 3 policy, the background data will not be used to eliminate COPECs. Instead, all constituents will be evaluated against ecological screening guidelines to determine total site risk. Comparisons with the background data will provide useful comparisons to determine whether overall site risks are primarily associated with DoD-related contamination or other sources. In making risk management decisions, DoD funding cannot be used to address contamination that is unrelated to former DoD activities.

The result of the SLERA will be a deliverable that identifies COPECs for different media discussed. The SLERA will also include a description of available ecological habitat at the site, an evaluation of exposure pathways, and identification of potential receptors. The SMDP to be addressed at the end of the SLERA will be whether sufficient risk attributable to former DoD activities (as opposed to non-point sources or other regional contamination) is identified to warrant proceeding with a BERA.

After the completion of Step 3a, the risk managers at USEPA and VDEQ will be consulted to determine whether the SLERA is sufficient to conclude there are no adverse ecological impacts, or if a more detailed BERA must be completed (Steps 3-7), or that there is a potential for adverse ecological effects and a more detailed ecological risk assessment is needed that will incorporate more site-specific information.

The QAPP assumes that a SLERA will be conducted for the MRS and Area A. If a BERA is deemed necessary, an amended QAPP will be submitted at a later date.

3. REFERENCES

Bull, J. and J. Farrand, Jr. 1977. *The Audubon Society Field Guide to North American Birds: Eastern Region*. Alfred A. Knopf, NY.

Franklin Engineering Group. 2001. *Radford Army Ammunition Plant Screening Level Ecological Risk Assessment.* Virginia. http://deq.state.va.us/Programs/LandProtectionRevitalization/RemediationProgram/VoluntaryRemediationProgram/VRPRiskAssessmentGuidance/Guidance.aspx.

IT (IT Corporation). 2001. *Facility-Wide Background Study Report, Radford Army Ammunition Plant, Virginia*. December 2001.

LANL (Los Alamos National Laboratory). 2017. ECORISK Database (Release 4.1), LA-UR-17-26376, Los Alamos National Laboratory, Los Alamos, NM (LANL 2017, 602538).

Merritt, J.F. 1987. *Guide to the Mammals of Pennsylvania*. University of Pittsburgh Press. Pittsburgh, PA.

TSERAWG (Tri-Service Environmental Risk Assessment Working Group). 2011. Tri-Service Position Paper on Background Levels in Risk Assessment. Prepared by U.S. Army Corps of Engineers, Environmental and Munitions Center of Expertise, Omaha, NE. October 2011.

USACE (U.S. Army Corps of Engineers). 1999. *Risk Assessment Handbook Volume I: Human Health Evaluation.* EM 200-1-4 http://www.dtic.mil/dtic/tr/fulltext/u2/a402016.pdf. 31 January 1999.

USACE. 2010. *Environmental Quality Risk Assessment Handbook, Volume II, Environmental Evaluation*. EM 200-1-4. December 2010.

USEPA (U.S. Environmental Protection Agency). 1989. *USEPA Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A).* Interim Final. Office of Emergency and Remedial Response, Washington, D.C. 1989.USEPA. 1991a. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (HHEM), Part B, Development of Risk-Based Preliminary Remediation Goals.* Office of Emergency and Remedial Response, Washington, DC. OERR 9285.7-01B. NTIS PB92-963333. December 1991.

USEPA. 1991b. *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors*. OSWER Directive: 9285.6-03. Interim Final. 25 March 1991.

USEPA. 1992. *Framework for Ecological Risk Assessment*. EPA/630/R-92/001. February 1992.

USEPA. 1993. *Wildlife Exposure Factors Handbook*. Volume I of II. Office of Research and Development. Washington, DC. EPA/600/R-93/187a and 187b.

USEPA. 1997a. *Exposure Factors Handbook*. Final. National Center for Environmental Assessment Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC. August 1997.

USEPA. 1997b. *Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments*. USEPA/540-R-97-006.

USEPA. 2000. *Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment: Status and Needs*. EPA-823-R-00-001. February 2000.

USEPA. 2002. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*. OSWER 9355.4-24. Office of Solid Waste and Emergency Response, Washington, DC. December.

USEPA. 2003a. *Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil*. [EPA-540-R-03-001, OSWER Dir #9285.7-54] December 1996 update (January)—The Adult Lead Methodology.

USEPA. 2003b. *Human Health Toxicity Values in Superfund Risk Assessments.* Office of Solid Waste and Emergency Response. OSWER 9285.7-53. December 5.

USEPA. 2004. *Risk Assessment Guidance for Superfund (RAGS). Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)*. Final. EPA/540/R/99/005. NTIS No. PB99-963312. Office of Emergency and Remedial Response, Washington, DC. December 2004.

USEPA. 2006. EPA Region 3 BTAG Freshwater Sediment Screening Benchmarks. https://www.epa.gov/sites/production/files/2015-09/documents/r3_btag_fw_sediment_benchmarks_8-06.pdf. August 2006.

USEPA. 2009. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment)*. OSWER Directive 9285.7-82. Office of Superfund Remediation and Technology Innovation, U.S. Environmental Protection Agency, Washington, D.C. January 2009.

USEPA. 2010. Integrated Exposure Uptake Biokinetic Model for Lead in Children, Windows® version (IEUBKwin32 v1.1 build 11) 32-bit version. Office of Solid Waste and Emergency Response, Washington, DC. June 2010.

USEPA. 2011. *Exposure Factors Handbook: 2011 Edition.* National Center for Environmental Assessment Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC. EPA/600/R-09/052F. September 2011.

USEPA. 2014. Memorandum: Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. February 6, 2014. Office of Solid Waste and Emergency Response. OSWER Directive 9200.1-120.

USEPA. 2015. ProUCL, Version 5.1. Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. Available online at: https://www.epa.gov/land-research/proucl-software.

USEPA. 2017. Update for Chapter 5 of the *Exposure Factors Handbook*: Soil and Dust Ingestion. National Center for Environmental Assessment Office of Research and Development, U.S. Environmental Protection Agency, Washington, DC. EPA/600/R-17/384F. September 2017.

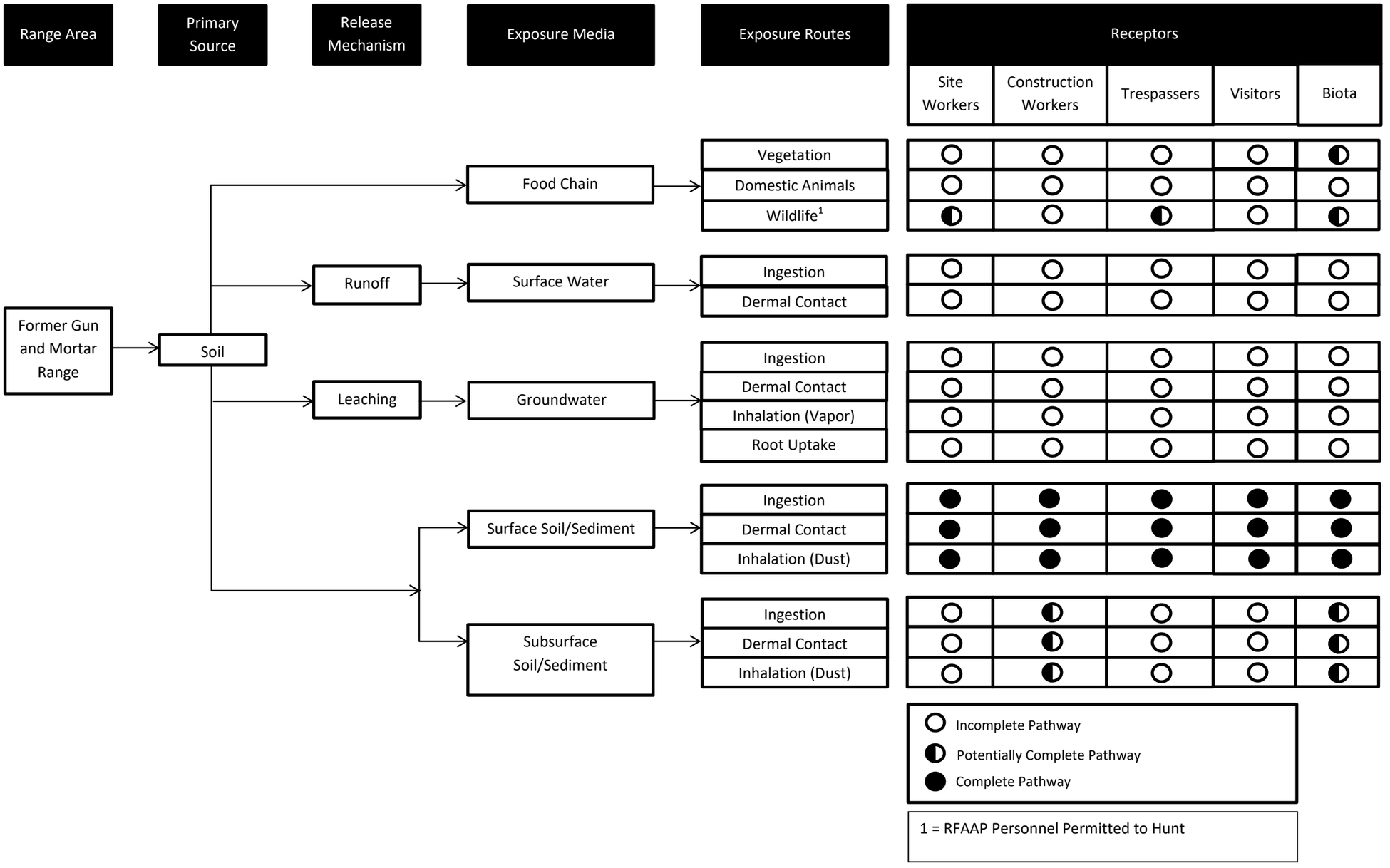
USEPA. 2019a. Screening Tools for Chemical Contaminants – RSL Calculator. https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search. Accessed July 2019.

USEPA. 2019b. Integrated Risk Information System (IRIS). https://www.epa.gov/iris. Accessed July 2019.

VDEQ (Virginia Department of Environmental Quality). 2017. *Voluntary Remediation Program Risk Assessment Guidance.*

VURAM (Virginia Unified Risk Assessment Model). 2019. – VURAM User Guide. Updated July 2019.

Figure 1. Conceptual Site Model for Munitions Constituents Exposure at the Former Gun and Mortar Range MRS



APPENDIX R

MEC RISK MANAGEMENT METHODOLOGY

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS 441 G STREET NW
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF

FEB 07 2019

CEMP-CED

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Trial Period Extension for Risk Management Methodology (RMM) at Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP) Projects

REFERENCES:

a. Memorandum dated 3 January 2017, signed by Karen Baker, Subject: Trial Period for Risk Management Methodology at Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP) Projects

1. PURPOSE: This memorandum establishes a one year extension of the process described in Study Paper: Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites (MRS), (Enclosure 1). The original two-year trial began by Memorandum signed 3 January 2017 (Reference A).

2. TRIAL RESULTS: Input provided from multiple project teams in all Military Munitions Design Centers to date has resulted in the following findings:

a. The tool promotes communication within the PDT and supports more robust development of data quality objectives during preparation of the Uniform Federal Policy Quality Assurance Project Plan (UFP QAPP).

b. The process relies on real data, using anomaly distributions and other findings that were useful for defining the "Amount of MEC" input factor.

c. The process provides a simple standard procedure that is useful for a variety of site conditions and assists the project team in differentiating and justifying acceptable vs. unacceptable conditions. This decision logic supports the definition of RAOs for the project.

d. There was minimal to no cost difference in implementation. The minimal increase was related to learning the tool use.

e. The tool allows the potential for a No Further Action (NFA) end point to remain as a reasonable result of the remedial process, where decision logic can support this

determination.

f. Although the tool was generally successful, there are some areas where development of terminology and additional guidance will be useful. An extension of the RMM trial will allow continued use, while allowing time to develop FUDS guidance to improve the tool and assist in providing additional structure for continued use. Specifically, during this one year extension, the RMM will be updated to include:

(1) Discussion of standard terminology and examples, such as "MD Indicative of MEC" and "Evidence of MEC," and "Likelihood to Impart Energy."

(2) Standardization for munitions static characteristics as they relate to the Sensitivity and Severity, and other conditions of the munition with examples for table selection.

(3) Establishment of a process to consider factors and conditions that result in frequency of access selection.

(4) Establishment of factors in consideration of institutional controls that result in reduction of access or activities that may impart energy, and provide examples.

3. APPLICABILITY: This guidance is applicable to all USACE elements engaged in FUDS MMRP projects.

4. REQUIREMENTS: In accordance with 40 CFR Part 300.175(d)(4), *"...the Lead Agency shall conduct a site specific baseline risk assessment to characterize the current and potential threats to human health and the environment..."* For unacceptable risks, and in accordance with 40 CFR Part 300.430(e)(i), the Lead Agency shall *"Establish Remedial Action Objectives (RAOs) specifying contaminants and media of concern, potential exposure pathways, and remediation goals."* The methodology in Enclosure 1 is intended to satisfy the requirement for a risk assessment for FUDS MMRP projects. RAOs are established to define the acceptable end state for a MRS.

5. IMPLEMENTATION: Although application of this risk method is first intended for use at the end of Remedial Investigations, it is also intended to support remedy selection and the post Remedial Action data assessment.

a. The method will continue to be used to:

(1) Provide information to support risk management decisions upon completion of characterization:

(2) Develop remedial action objectives: and

(3) Provide basis for assessing achievement of remedial actions relative to acceptable end states.

b. Implementation will avoid disruption of service contracts, where possible. For circumstances where ongoing work is not able to transition to the new methodology and be conducted in compliance with this Memorandum, efforts will be made to include consideration of the risk criteria discussed in Enclosure 1 and provide feedback to address how other approaches compare to the process described in the Study Paper. This information will be submitted to the EM CX in lieu of Enclosure 2 information.

6. DATA MANAGEMENT: Information regarding use for this methodology during the one year trial will be collected by the EM CX. Project teams will submit the attached Feedback Form (Enclosure 2), at the time draft reports are submitted for EM CX review. The methodology will be assessed at the end of one year from the date of this memorandum. HQUSACE, at the end of the extension, will provide FUDS guidance for continued use and implementation. Project teams are encouraged to contact the EM CX if questions arise during the use.

7. TRAINING: Project teams are encouraged to enroll in the FUDS training course #428 to learn how to use the methodology, or engage the EM CX to assist in project-specific application.

8. EFFECTIVE DATES: The requirements and procedures set forth in this interim guidance are effective immediately. They will remain in effect for one year, unless superseded by other policy or regulation.

9. POINT OF CONTACT: For additional information, please contact Ms. Nancy Flaherty, FUDS MMRP Program Manager, at 202-761-1503.

KAREN J. BAKER
Chief, Environmental Division
Directorate of Military Programs

ENCLOSURES:
1. Final Study Paper: Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites, 29 September 2016
2. New Risk Management Methodology Feedback Form

CEMP-CED
SUBJECT: Trial Period Extension for Risk Management Methodology at Formerly Used Defense Sites (FUDS) Military Munitions Response Program (MMRP) Projects

DISTRIBUTION:
Commander, Great Lakes and Ohio River Division
Commander, North Atlantic Division
Commander, Northwestern Division
Commander, Pacific Ocean Division
Commander, South Atlantic Division
Commander, South Pacific Division
Commander, Southwestern Division
Chief Counsel
Director, Environmental and Munitions Center of Expertise

7 December 2016

Final
Study Paper:
Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites

Abstract

A framework of logic is presented to evaluate hazards at Munitions Response Sites (MRS) such that a systematic assessment of the associated site specific human health risks can be determined, and remedial action objectives (RAOs) can be established. This paper is presented as a consistent methodology for these determinations which depend on site-specific characterization data and specific land use conditions at each MRS. These data are processed similar to the Department of Army Pamphlet for Risk Management (DA Pam 385-30), but the framework utilizes MRS characteristics of Accessibility, Sensitivity and Severity to illustrate site specific conditions, and assign acceptable versus unacceptable scenarios at an MRS. Acceptable end states as presented in Figure A3-1 achieve negligible risk scenarios for an MRS and can be A) Acceptable, where unlimited use unrestricted exposure (UU/UE) is supported, B) Acceptable without additional land use controls (LUCs), where UU/UE may not be supported, or C) Acceptable with LUCs, where UU/UE is not supported.

1 Purpose

The purpose of this paper is to provide U.S. Army Corps of Engineers (USACE) Formerly Used Defense Sites (FUDS) Project Delivery Teams (PDT) with decision logic to differentiate acceptable versus unacceptable site conditions at Munitions Response Sites (MRSs), to establish a systematic approach for developing remedial action objectives (RAOs), and to assist in developing acceptable response alternatives to meet the RAOs. This paper establishes a parallel to the Department of the Army Pamphlet defining the process of Risk Management (DA Pam 385-30), by defining factors more appropriate for Military Munitions Response Program (MMRP), to include specific site conditions and munitions sensitivities. The strength in the Army risk assessment approach is that it is intended to address potentially acute hazard scenarios by factoring real site conditions to establish risk.

- Section 2 provides the applicability of this paper.
- Section 3 introduces CERCLA regulatory requirements for risk assessment and defining remedial action objectives, and limitations to available tools.
- Section 4 addresses the requirement for risk assessment at Munitions Response Sites (MRSs) by providing considerations for site characterization and a framework that allows PDTs to define the current state of an MRS as acceptable or unacceptable based on specific site conditions and information gathered through characterization.
- Section 5 addresses the requirements for developing the RAO by utilizing the framework for MRS risk assessment in Section 4 to identify one or more site scenarios that are

considered acceptable and therefore would constitute a protective end state. These scenarios provide the basis for determining the RAO(s) for the MRS.

- Section 6 presents an exit strategy using post remedy data assessments to evaluate confidence in the remedial action and support achievement of the RAOs for an acceptable end state.

2 Applicability

This study paper methodology may be applied by all USACE organizations conducting FUDS MMRP CERCLA response actions.

3 Background

3.1 NCP Requirement for a Risk Assessment

In accordance with 40 CFR Part 300.175(d)(4), *"...the Lead Agency shall conduct a site specific baseline risk assessment to characterize the current and potential threats to human health and the environment..."* The methodology described in this paper is intended to meet the NCP requirement for a risk assessment, and be consistent with the risk management decision process described in DA Pam 385–30, which establishes a framework for risk management in accordance with Department of Defense Instruction (DODI) 6055.1 and Army Regulation (AR) 385–10.

3.2 NCP Requirement for Remedial Action Objectives

For unacceptable risks, and in accordance with 40 CFR Part 300.430(e)(i), the Lead Agency shall *"Establish Remedial Action Objectives (RAOs) specifying contaminants and media of concern, potential exposure pathways, and remediation goals."*

Similar to a chemical contaminant, defining a measureable and achievable RAO for munitions response sites will be dependent upon a defensible characterization[1] to result in clear identification of the munitions and explosives of concern (MEC), as well as the exposure pathways to receptors. Identification of MEC for a munitions project must first be supported by the nature of the specific munitions known or suspected to exist at a MRS. The specific nature of the munitions present is a significant consideration in defining the presence of a hazard.[2]

[1] Although there are different goals for cleanup of munitions than for HTRW, CERCLA is generally the regulatory framework that DoD has determined will be used for the MMRP. The term "characterization" is used broadly to foster the iterative development of a robust, high quality Conceptual Site Model (CSM) through investigative response actions, such as the CERCLA Preliminary Assessment (PA), Site Inspection (SI) and Remedial Investigation (RI) phases collectively, but generally irrespective of the regulatory framework under which a project is being conducted. At the end of the RI under CERCLA, the site is "characterized" and data is used for assessment of risk.

[2] Variability in explosive nature (sensitivity) of specific munitions, and variance in the anticipated result of an incident (severity) is acknowledged in determining an acceptable versus unacceptable risk on an MRS (e.g., small spotting charge vs. high explosive, fuzed munitions).

With these considerations applied to the 40 CFR Part 300 requirement for developing a measureable RAO, development of measureable and achievable RAO for a MRS requires:

A	a. Identification of specific munitions and explosives of concern (MEC) and media of concern. b. Identification of exposure pathways to receptors, and c. Identification of acceptable remediation goal.

3.3 Current Tools for Assessment of Explosive Hazards

Currently, there are tools available to assist in prioritization, and qualitative assessment of hazard reduction for MRSs. These tools have specific programmatic functions, but have limitations at the project level regarding initial determination of acceptable versus unacceptable risk at an MRS. Without this initial assessment of risk supported by the conceptual site model (CSM), it is difficult to establish RAOs for a MRS. A summary of these tools and how they were assessed in support of the approach described in this paper is provided at Attachment 1.

4 Assessing Risk at Munitions Response Sites

The following section is intended to assist project teams to initially define and defend determinations of acceptable versus unacceptable risk at munitions response sites. Section 5 builds on this logic to identify acceptable site scenarios as RAOs that will achieve one of the acceptable end states.

4.1 Defining Risk after MRS Characterization

Characterization is critical to define the presence of MEC hazards and exposure pathways to receptors that are used to create the baseline risk determination.[3] At the completion of successful characterization, the project team must be able to determine whether the conditions at the site are "acceptable" or "unacceptable," such that only unacceptable risks require remedial action. *For determination of an unacceptable risk and to develop the RAO, the likely presence of MEC with a reasonably anticipated current or future exposure scenario must be clearly supported by MRS specific information.*

B	Presence of Site Munitions with a Specific Explosive Nature and Site Specific Receptor and Exposure Pathway → Determination of Risk

[3] See Attachment 4.

The general expression for risk, shown in block B, is derived from items a and b in block A, and is directly related to the CSM[4] resulting from characterization. The determination of an explosive risk must include a) likely presence of *specific munitions* having an explosive nature at the MRS; it cannot be solely dependent on historical suspicion or general observance of uncharacterized munitions debris (MD). The known explosive component characteristics of the specific munitions present are a critical consideration in assessing and defining the sensitivity and severity of site risks.[5] Additionally, the determination of unacceptable risk in block B must also be supported by accessibility, specifically b) site-specific current or reasonably anticipated future land use scenarios, defining receptors and a pathway that would result in a likelihood of exposure.

C "Unacceptable Explosive Risk" is determined if the CSM indicates presence of munitions having a specific explosive nature, as well as the accessibility supported by the specific land use, such that the likelihood of encounter, sensitivity of the munitions items, and severity of a potential incident are collectively unacceptable.

Multiple lines of evidence are required to define the presence and nature of specific munitions, receptors and pathways that will support a qualitative risk assessment and development of the RAO. As these data typically rely heavily on observation, geophysical data, and qualified experts to determine likely presence and nature of explosive munitions, additional lines of evidence that need to be considered whenever available are historical records identifying type of ordnance used and operational context (nature of operations, when, where, how much, etc.). Additionally, details such as the horizontal and vertical spatial distribution information resulting from characterization, as well as topography and terrain, vegetation, and geology are the types of information collectively used to support a determination of the potential of an explosive risk based on current and future land use.

In section 4.3, information from the CSM is used to assess the accessibility, severity and sensitivity of the site scenario. The section provides decision logic that supports a determination of whether there is an ***unacceptable explosive risk***.[6]

4.2 MRSs with Undefined Risk

Similar to response for chemical contamination, a remedial action that results in "zero risk" remaining on the site is ***not*** possible or required. A Feasibility Study (FS) is only conducted to

[4] See Engineer Manual 200-1-12 for CSM development. Additional assistance with development of the CSM (lateral and vertical) is available through the EM CX.

[5] For HTRW, without definition of the specific chemical, concentration, toxicity, and an assessment of exposure, it is impossible to define (even relatively) the severity of risk or to assess an appropriate response. Similarly in MMRP, without defining the specific munition, the scale to the explosive nature of specific munitions, and assessment of site specific exposure pathways, it is impossible to assess and define risk at a MRS (See footnote 12).

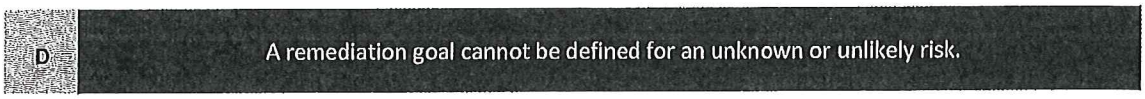
[6] This is consistent with HTRW response process, conducting the risk assessment subsequent to defining hazards resulting from RI site characterization. It is also consistent with the Department of the Army Pamphlet 385-30, Safety: Risk Management, such that the CSM conditions define the presence of a hazard.

address an unacceptable risk. It is critical to note that a RAO cannot be developed for an unknown or unlikely risk.

- If there is an "unknown" risk, then characterization is not complete.

- If there is a determination that a site risk is so small (often seen in reports described as "unlikely" or "negligible") that response would result in a residual risk equal to the initial risk, then there is no further reduction possible such that a more acceptable level of protectiveness can be defined.[3]

Therefore, it is not appropriate to conduct a FS, nor can a remedial action be conducted to reduce an "unknown," "negligible," or "unlikely" risk.



4.3 Approach to Assessing Acceptable versus Unacceptable Risk at MRSs

For each MRS, the project team is encouraged to develop data and structure for differentiating an acceptable versus unacceptable risk. By defining unacceptable versus acceptable using site specific characteristics of severity, accessibility, and sensitivity, a project team can more effectively communicate the risks and associated requirements for remedial action, develop a RAO, and facilitate the achievement of response complete (RC) for the Site.

A simple approach for this logic is to employ matrices using site-specific CSM data to relate accessibility, munitions sensitivity, and severity of an explosive event if it were to occur, to determine baseline risks.[7] The purpose of each matrix is introduced here, and then presented in detail in section 4.4 to support unacceptable risk determinations for a site.

- ***Matrix 1,*** *the Likelihood of Encounter,* relates the site characterization data for amount of MEC potentially present to site use, including *accessibility,* in order to determine the likelihood of encountering MEC at a specific site.

- ***Matrix 2,*** *the Severity of an Incident,* assesses the likelihood of encounter from Matrix 1 as related to the *severity* of an unintentional detonation.

- ***Matrix 3,*** *the Likelihood of Detonation,* relates *sensitivity* of the MEC items to the likelihood for energy to be imparted on an item during an encounter by specific land users.

- ***Matrix 4*** combines the results of the above categories to differentiate *Acceptable and Unacceptable Site Conditions.* A site which results in an unacceptable initial condition will

[7] Accessibility, Sensitivity and Severity are the same factors used in the MEC HA. This methodology requires that data elements for these hazard components result from the site specific characterization data. It is anticipated that individual site circumstances will require different levels of the severity, accessibility, or sensitivity determinations. Decision logic used to select particular levels in the matrices must be justified and well-supported by facts presented in the CSM.

proceed to the next phase of the CERCLA response process. This matrix identifies acceptable conditions, which become possible remedial action goals that are ultimately achievable (via remedial response actions) for all portions of the MRS. Section 5 discusses these acceptable conditions as RAOs.

4.4 The Risk Matrices

4.4.1 *Matrix 1.* In Matrix 1, below, the "Likelihood of Encounter" is dependent on two factors, the amount of MEC items known or suspected to exist, and access conditions (e.g., accessibility and frequency of use). Either or both of these factors can be modified as a result of the selected remedial action to reduce or eliminate the likelihood of encounter.

"Amount of MEC" is determined using site specific characterization data or anticipated or completed results of a remedial action.[8] Although the scale emphasizes the results of distribution, the selection may also include consideration of available historical information, such as development history.[9] "Access Conditions" are selected based on considerations of the access and frequency of use for the MRS.

The selection considers "Accessibility" as similarly defined by the MEC Hazard Assessment (MEC HA); but also considers other relevant conditions, such as topography, terrain, specific land use, and specific potential receptors via defined pathways to establish access conditions as a frequency of use.[10] As such, site specific circumstances may result in different access conditions, which should be supported and documented by the CSM.

[8] The "Amount of MEC" selection in Matrix 1 differs from the MEC HA's input factor for "Amount of MEC" which is based solely on the MRS "type" historically identified. Instead, the "Amount of MEC" in Matrix 1 is initially dependent on the results of characterization data regarding MEC and MD distribution. The Matrix is then used to assess anticipated or completed results of a remedial action (physical removal of MEC) to a "reduced" amount.

[9] For example, historical information indicating an area has been extensively developed and used for years with no MEC encounters, in many cases, will be evidence to support a low determination for "Amount of MEC" in the table, and therefore support a lower "Likelihood of Encounter."

[10] A site may be accessible but may have relatively low frequency of use due to the difficult terrain, which results in lower possible contact hours or "access" for the MRS. This scale of "access conditions" may include several factors, including number of visitors or receptor hours per year, nearby population, or residential versus industrial use. Each of these factors may have different justifications depending on the facts at the site. The concept of calculation of "receptor hours per year" is provided in the MEC HA document.

Matrix 1. Likelihood of Encounter

Likelihood of Encounter, Matrix 1: Amount of MEC vs. Access Conditions		Access Conditions (frequency of use)[10]			
		Regular (e.g., daily use, open access)	Often (e.g., less regular or periodic use, some access)	Intermittent (e.g., some irregular use, or access limited)	Rare (e.g., very limited use, access prevented)
Amount of MEC[8,9]	• MEC is visible on the surface and detected in the subsurface.	Frequent	Frequent	Likely	Occasional
	• The area is identified as a Concentrated Munitions Use Area (CMUA) where MEC is known or suspected (e.g., MD indicative of MEC is identified) to be present in surface and subsurface.	Frequent	Likely	Occasional	Seldom
	• MEC presence based on physical evidence (e.g., MD indicative of MEC), although the area is not a CMUA, or • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 1.0/acre at 95% confidence).	Likely	Occasional	Seldom	Unlikely
	• MEC presence is based on isolated historical discoveries (e.g., EOD report) prior to investigation, or • A DERP response action has been conducted to physically remove MEC and known or suspected hazard remains to support this selection, (e.g., surface removal where subsurface not addressed) or • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 0.5/acre at 95% confidence).	Occasional	Seldom	Unlikely	Unlikely
	• MEC presence is suspected based on historical evidence of munitions use only, or • A DERP response action has been conducted to physically remove surface and subsurface MEC (evidence that some residual hazard remains to support this selection), or • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 0.25/acre at 95% confidence).	Seldom	Seldom	Unlikely	Unlikely
	• Investigation of the MRS did not identify evidence of MEC presence, or • A DERP response action has been conducted that will achieve UU/UE.	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2. Severity of Incident

Severity of Explosive Incident, Matrix 2: Severity vs. Likelihood of Encounter		Likelihood of Encounter[11]				
		Frequent: Regular, or inevitable occurrences	Likely: Several or numerous occurrences	Occasional: Sporadic or intermittent occurrences	Seldom: Infrequent, rare occurrences	Unlikely: Not probable
Severity Associated with Specific Munitions items[12]	**Catastrophic/Critical:** May result in 1 or more deaths, permanent total or partial disability, or hospitalization	A	A	B	B	D
	Modest: May result in 1 (or more) injury resulting in emergency medical treatment, without hospitalization	B	B	B	C	D
	Minor: May result in 1 or more injuries requiring first aid or medical treatment	B	C	C	C	D
	Improbable: No injury is anticipated	D	D	D	D	D

"A" indicates conditions most likely to result in determination of an unacceptable risk.
"D" indicates conditions most likely to result in determination of an acceptable risk.

4.4.2 *Matrix 2.* Matrix 2, "The Severity of Incident," relates "Likelihood of Encounter" from Matrix 1 to the severity of an unintentional detonation. Unlike the two factors affecting the likelihood of encounter in Matrix 1, the "Severity" factor in Matrix 2 is a static characteristic of each of the munitions known or suspected to exist at the property. This is consistent with the MEC HA application for munitions identified for the property. Therefore, in order to improve the Category in Matrix 2, either the items are physically treated and/or removed (reducing the amount of MEC), land use or conditions are altered, or both of these factors are improved in Matrix 1.[11]

[11]Note that with data collected from physical remediation, it is possible to support an unlikely determination for Matrix 1 and 2, (Attachment 3).
[12] This paper recognizes there is currently no scale for ranking the explosive nature of munitions, and it therefore requires coordination with qualified UXO professionals, per TP-18 requirements (reference 15), on the project team. Initiatives are underway to evaluate these considerations of scale. There must be a defined munitions item having an explosive nature and a defined exposure scenario. Additionally, the degrees of hazards differentiate between intact UXO and munitions components such as rocket motors, fuzes, discarded military munitions (DMM), and explosive soils. Decision logic to support the selection on this scale must be supported by the CSM, and documented in the project reports. Additional research in this subject area in the future may allow for additional refinement within these categories so site specific conditions will be the primary factor for project team determination once MEC types on site have been determined.

Matrix 3. Likelihood of Detonation

Likelihood of Detonation, Matrix 3: Munitions Sensitivity vs. Likelihood of Energy to be Imparted		Likelihood to Impart Energy on an Item[14]		
		High e.g., areas planned for development, or seasonally tilled	***Modest*** e.g., undeveloped, wildlife refuge, parks	***Inconsequential*** e.g., not anticipated, prevented, mitigated
Sensitivity:[13] Susceptibility to Detonation	***High*** (e.g., classified as sensitive)	1	1	3
	Moderate (e.g., high explosive (HE) or pyrotechnics)	1	2	3
	Low (e.g., propellant or bulk secondary explosives)	1	3	3
	Not Sensitive	2	3	3

4.4.3 *Matrix 3.* Matrix 3, "The Likelihood of Detonation," relates the sensitivity of site specific munitions items to the likelihood for energy to be imparted on an item, such that the interaction results in detonation (incident). MEC sensitivity and the likelihood for energy imparted during an encounter are both specific to the site CSM. The "sensitivity" of a munitions item is alone a static component, inherent to the known or suspected munitions present at the site. The selection for sensitivity is similar to the sensitivity scale in Table 1 of the Military Munitions Response Site Prioritization Protocol (MRSPP).[13] The "Likelihood to Impart Energy" is selected from the known activities at the site that may cause an interaction that results in energy being imparted on a munitions item by human activity.[14] The "Likelihood to Impart Energy" can be affected by behavioral modifications or by altering land use, specifically to prevent accessibility or particular activities to reduce the likelihood or ability of imparting energy on a munitions item.

[13] The Sensitivity categories are scaled highest to lowest, similar to the MRSPP Table 1: Munitions Type Data Elements Table. While the scale of sensitivity in Matrix 3 is similar to MRSPP Table 1, the matrix must have the flexibility to consider the inclusion of unlisted or undefined items, such as fuzes having small amounts of primary charge and not attached to a booster charge, which may be less sensitive than fuzes with large amounts of primary charge or any fuze connected to a booster charge. Therefore, the PDT should build from this baseline structure in Matrix 3 to include additional considerations, and provide justification for the sensitivity selection for the specific item. Selections must be supported by identifying the specific munitions on the MRS (listed with correct nomenclature).

[14] The likelihood to impart energy on an item can be high for farmed land that is regularly tilled, or areas where development is planned. Moderate areas may include parks or areas where digging is manual or limited. Areas that are inconsequential will include areas where digging is not anticipated, or otherwise mitigated to prevent imparting energy on an item. The project team will consider land use, specifically types and amount of energy imparted at the site that will result in an interaction with a munitions item. The project team will document the justification for selection on the scale.

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result From Matrix 2			
		A	B	C	D
Result from Matrix 3	1	Unacceptable	Unacceptable	Unacceptable	Acceptable
	2	Unacceptable	Unacceptable	Acceptable	Acceptable
	3	Unacceptable	Acceptable	Acceptable	Acceptable

Note: Multiple conditions may exist within an MRS, such that unique baselines risks can be established for the multiple explosive hazards that are present within the same property. Acceptable conditions indicate input factors are collectively determined to support a negligible risk. Project teams shall consider the nature of the specific item within the MRS and the probability to encounter in order to support the selection on the scale.

4.4.4 *Matrix 4.* Matrix 4 represents the overall risk for the site, and differentiates "acceptable" from "unacceptable" conditions. This is determined based on the likelihood of an encounter (Matrix 1), with consideration given to the severity of the incident (Matrix 2), combined with the likelihood of an interaction that results in detonation (Matrix 3). For example: The result of A-3 in Matrix 4 indicates "unacceptable" as depicted above. The overall risk for the selection is driven by the "frequent" or "likely" encounter (Matrix 1) with a potentially catastrophic munitions item (Matrix 2), even though the likelihood of a detonation (Matrix 3) is low (3) based on sensitivity and likelihood to impart energy on the item.

At the end of characterization, the result of Matrix 4 is used to differentiate unacceptable from acceptable conditions. Where an unacceptable scenario is identified, this matrix is then used during the feasibility study to identify acceptable conditions that are ultimately achievable via remedial response actions for all portions of the MRS. Finally, the matrices are used in a post remedy data assessment to evaluate the achievement of risk reduction for a given remedy (Attachment 3).

4.5 Addressing Multiple Risk Scenarios

The risk management matrices will be applied to all portions of an MRS. Multiple conditions may exist within an MRS, such that unique baseline risks can be established for the multiple explosive hazard scenarios that are present within the same MRS. If separate remedial actions for different locations of an MRS are anticipated, the matrices may be applied separately to support the risk management decisions in each location. Multiple entries (or multiple matrices) should be used when:

1) accessibility or land use conditions vary across the MRS (e.g. industrial vs. camping or hiking vs. residential),

2) when munitions types and and/or MEC characteristics vary within an MRS, and /or

3) when the distribution of MEC differs across the MRS (e.g., target center, identified as a concentrated munitions use area (CMUA) vs. buffer or safety zones, identified as non-concentrated munitions use areas (NCMUAs)).

Therefore, multiple RAOs may be required where multiple site conditions exist. These multiple conditions may be illustrated in a tabular form. An example of multiple risk scenarios is provided in Attachment 2.

5 Defining the RAO

A RAO must establish the acceptable condition(s) for the MRS which no longer poses an unacceptable risk.[15] Project teams must carefully consider available data and logic to support assessment of any remedial action against the RAO, such that remedial actions can be developed to feasibly take a site which currently poses an unacceptable risk to one which no longer poses an unacceptable risk.

5.1 Planning Risk Reduction to the RAO

After an unacceptable risk has been defined for an MRS, teams can identify conditions that are acceptable in Matrix 4 as RAOs, where remedial actions can be identified that will result in reduction of an unacceptable risk to one of these acceptable conditions.

Once Matrix 4 establishes the unacceptable baseline risk condition, the RAO can then be developed to achieve one of the acceptable conditions of Matrix 4. ***The Remedial Action Objective(s)*** can be written *"to reduce the unacceptable risk due to presence of [name specific munitions of explosive nature or components using appropriate nomenclature] within [specified horizontal MRS boundary] to a depth of [defined depth related to current and future land use, or depth of MEC determined during characterization if less than land use] below surface to address likelihood of exposure to [receptors] via [pathway] such that an acceptable condition (as defined by Matrix 4) is achieved."*

> "The **Remedial Action Objective(s)** can be written *"to reduce the unacceptable risk due to presence of [name specific munitions of explosive nature or components using appropriate nomenclature] within [specified horizontal MRS boundary] to a depth of [defined depth related to current and future land use, or depth of MEC determined during characterization if less than land use] below surface to address likelihood of exposure to [receptors] via [pathway] such that an acceptable condition of negligible risk (as defined by Matrix 4) is achieved."*

Multiple RAOs may be required where multiple site conditions exist, for example, for different MEC characteristics or components within an MRS, for different land uses within the MRS, and/or for areas having different distribution characteristics, (e.g. target area and buffer area).

[15] For many traditional chemical analyte targets, there is either an established acceptable level on which the RAOs are based, or where there are no levels, there are standard processes used to establish project acceptable limits. For explosive hazard, however, there is no promulgated standard, nor are there standard processes to establish acceptable limits. This paper provides general guidelines as a process for defining an acceptable state for a MRS.

These multiple conditions may be illustrated in a tabular form. An example is provided in Attachment 2.

5.2 Achieving the RAO

The RAO is met by changing the unacceptable baseline risk conditions to one of the possible acceptable conditions in Matrix 4. This is achieved by moving to the right within Matrix 2, Matrix 3, or both.

- ***Moving to the right in Matrix 2.*** Risk is reduced by establishing remedial alternatives that reduce the "Likelihood of Encounter" which results in moving to the right on Matrix 2. This is accomplished either by reducing the amount of MEC, altering the frequency of access, or both in Matrix 1.

- ***Moving to the right in Matrix 3.*** Risk is reduced by establishing remedial alternatives to address likelihood of energy imparted to a munitions item as a result of specific activities at the MRS, which will result in moving to the right on Matrix 3. This can be accomplished by implementation of land use controls.

For example, if an MRS baseline is unacceptable, resulting from a "B" category of Matrix 2 and a "2" category from Matrix 3, the remedial alternatives can be established to reduce "B" in Matrix 2 to a "C" or "D", reduce "2" in Matrix 3 to a "3", or affect both matrices to reach any of the "Acceptable" risk levels.

Where multiple site conditions are present on a MRS, e.g., multiple accessibility parameters based on differing land use, or when locations of multiple explosive types and sensitivities can be differentiated from one another, different hazard matrices for these areas may be required. An example presenting multiple acceptable conditions where differing site scenarios are present is included at Attachment 3.

6 Exit Strategy Using Post Remediation Data Assessments

6.1 Defining an Acceptable End State for a MRS

The achievement of one of the "Acceptable" scenarios in Matrix 4 can result in one of the following "end states" to support a Response Complete (RC) determination, as illustrated in Attachment 3 (Figure A3-1):

a. Acceptable, where UU/UE is supported[16], or

[16] DODM 4715.20, Enclosure 3, 4.b.(5)(b)1. The assessment of remedial alternatives to meet the remediation goal must include an action to remediate the site to a condition that provides for a UU/UE alternative, and an alternative that achieves protectiveness with LUCs. Upon achievement of the RAO, information should be developed which supports achievement of the acceptable hazard level and an assessment of a UU/UE determination. Project teams must keep in mind that after any site remedy is complete, if the contamination left behind does not allow for UU/UE, 5- year reviews will be required.

b. Acceptable without LUCs, where UU/UE is not supported[17], or

c. Acceptable with LUCs, where UU/UE is not supported.

6.2 Supporting the Acceptable End State Using Post Remedy Data Assessment

Where a physical removal is a component of the selected alternative, the data collected during the physical removal supplements the CSM such that one of the three exit conditions for RC above can be confidently supported. The project team is encouraged to develop "if-then" statements within the proposed plan and decision document that provide the decision logic for these conditions.

Data assessment at the completion of any physical remediation can be used to support the achievement of the RAO, to support the RC determination, and to provide additional confidence in decisions at the site. This includes determination of whether additional actions, such as LUCs, are necessary. It separately includes the determination of whether UU/UE is supported. Teams must plan for data acquisition during the response action to support this decision logic. An example of a post remedy data assessment is included at Attachment 3.

7 Summary and Considerations of Exit Strategy at MRSs

This paper provides decision logic to define and defend decisions on acceptable versus unacceptable conditions at an MRS such that remedial action objectives can be established. These RAOs must be established so the remedial action will mitigate an unacceptable risk to an acceptable one. Furthermore, a RAO cannot be established to reduce an unknown or unlikely risk.

The following recommendations are made to differentiate acceptable and unacceptable risk conditions for each site based on magnitude of evidence collected through site characterization and/or during collection of data during implementation of physical response actions to support achievement of an acceptable end state, shown in Figure A3-1.

1) The project team is encouraged to utilize the matrices presented in this paper as a site-specific risk assessment structure to differentiate acceptable and unacceptable conditions at an MRS.

    a. The likelihood of encounter must account for the characterized distribution, and specific land use scenario. Together, these data reflect the likelihood of encounter, shown in Matrix 1. The matrix may be used pre and post remedy to assess changes to the likelihood of encounter.

[17] LUCs are additional components of a remedy that further reduce risk where the RAO is not achieved by physical remedy alone. Although UU/UE is not supported, this does not specifically necessitate LUCs. It does, however, necessitate 5-year reviews. Pre-existing site conditions may impose restrictions that are not part of the remedy and will be considered in making the remedial decision, but a site might not achieve UU/UE after RC.

b. Through the assessment of Severity and Sensitivity Matrices 2 and 3, acceptable conditions may be differentiated from unacceptable ones, thereby supporting the development of a site specific RAO.

2) At completion of characterization (or post remedy) where likelihood of exposure is not reasonably anticipated and has been described, based on combined magnitude of evidence, as "negligible" or "unlikely," then an acceptable condition already exists for which no additional remedial response is required.

3) Project teams performing physical response actions to reduce risk levels, must plan to acquire data needed to describe the residual risk post response to evaluate achievement of the RAO. These data are used to determine if an additional remedial action (such as implementation of LUCs or additional treatment or removal) is necessary to achieve the RAO.

4) Furthermore, data acquired during a remedial action in which a physical removal is conducted may be of quality to support a UU/UE determination, if data gathering is planned and the necessary data is acquired during implementation of the remedy. Project teams are encouraged to include "if-then" statements when assessing remedial alternatives that consider potentially different results of remedial data as applicable to the determination of UU/UE.

5) Where multiple site scenarios are present on a site, (for example, multiple accessibility parameters based on differing land use, or when locations of multiple explosive types and sensitivities can be differentiated from one another), different hazard matrices for these areas may be required.

8 References

1) National Oil and Hazardous Substances Pollution Contingency Plan, (NCP). 40 CFR Part 300, Sections 1-7 and 400-525 March, 1990.

2) DoD Ammunition and Explosives Safety Standards: Criteria for Unexploded Ordnance, Munitions Response, Waste Military Munitions, and Material Potentially Presenting an Explosive Hazard (Department of Defense MANUAL NUMBER 6055.09-M, Volume 7, February 29, 2008. Administratively Reissued August 4, 2010).

3) Defense Environmental Response Program (DERP), Department of Defense Instruction Number 4715.07

4) USEPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final. EPA/540/G-89/004. OSWER Directive 9355.3-01. October.

5) Technical Guidance for Military Munitions Response Actions, Environmental and Munitions Center of Expertise Interim Guidance Document (IGD) 14-01, 20 December 2013. EM 200-1-15.

6) ESTCP studies. https://www.serdp-estcp.org/Featured-Initiatives/Munitions-Response-Initiatives/Classification-Applied-to-Munitions-Response

7) USEPA, 2001. Comprehensive Five Year Review Guidance, EPA-540-R-01-007, OSWER Number 9355.7-03B-P, June.

8) USEPA, 2007. Interim guidance for Munitions of Explosive Concern Hazard Assessment (MEC HA).

9) Office of the Secretary of Defense (OSD) Munitions Response Site Prioritization Protocol (MRSPP) Primer, 32 CFR Part 179, April 2007.

10) Office of the Secretary of Defense (OSD). DoD Evaluation of MEC HA. November 2014.

11) USACE Munitions Safety, Engineer Manual (EM) 385-1-97. Chapter III Probability Assessments

12) Department of the Army, Safety: Risk Management, DA PAM 385-30, 2 December 2014.

13) USACE Engineer Manual (EM) 200-1-12.

14) USACE Memorandum dated January 2007, RE: UFP QAPP Implementation

15) DDESB Technical Paper 18: Minimum qualification standards for personnel who support MEC related activities, 16 July 2015.

Attachment 1: Current Tools for Assessment of Hazard

A1.1 Consideration of the MEC Hazard Assessment (MEC HA)

The MEC HA is intended to provide a qualitative assessment of alternatives given a baseline MRS condition. The output for the MEC HA (baseline and alternatives) is hazard levels 1 through 4, with 1 having the highest hazard, and 4 being the lowest. Each remedial alternative receives a reduced score relative to the baseline score. The score is calculated by additive characteristics of the CSM, specifically the "accessibility" to the explosive items at the MRS, "sensitivity" of the items to function, and the "severity" of an incident, should it occur.

In consideration of MEC HA tool, the "munitions classification", "type", and "energetic material" components of the score are, understandably, static characteristics. These components (accounting for ~32% of the baseline) are never reduced, no matter what remedy is selected. However, because the MEC HA score is an additive calculation, where these factors are not changed, the score cannot efficiently account for a reduced "probability of encounter", which should be a multiplicative determination founded on the "amount of MEC" and "accessibility" conditions.

Other limitations identified by the DoD memorandum, dated November 2014, are related to the rigid selection factors of the tool which do not lend flexibility for the multitude of scenarios of site specific CSMs in the MMRP. For instance, the "Amount of MEC" selection for the MEC HA tool relies on the area category, similar to the type of range that is known or suspected, rather than the period and frequency of use, or actual anomaly distribution resulting from characterization.[18] Understanding or estimating the "Amount of MEC" should be more representative of the findings of the CSM and have direct relation to the calculation of the likelihood of encounter. By selecting a "type" of use as currently provided in the MEC HA tool, the resulting score is in no way reflective of the actual distribution data resulting from the completed characterization, and therefore cannot adequately represent differences between a highly used target areas of several years versus sites with limited use having very little findings to support presence as a result of characterization.

Based on the multiple findings of the DoD (reference 10 in Section 8 above), the probability of encounter cannot be appropriately represented by the current MEC HA tool. In this way, there are limitations to the qualitative value presented by the MEC HA score, and thus is not helpful in establishing the acceptable level of risk or in communicating a likelihood of encounter with a munitions item. It is therefore not an appropriate tool to help a project team in differentiating acceptable from unacceptable risk, or in developing a RAO. A project team is left to make these

[18] Note the use of "anomaly" here is a general representation of information resulting from characterization. The "hazard" is the result of the explosive nature of specific munitions that may remain partially or fully intact, not the clutter or debris that may be included in this anomaly distribution. The potential for some of those anomalies to present an explosive concern for specific site receptors is the basis of the unacceptable risk determination. It is those specific items presenting an explosive concern that are the "targets of interest" at the MRS, and for which the RAO is focused to reduce risk by implementing a remedial action.

assumptions and considerations outside of the tool in order to support development of a site specific RAO.

Therefore, while utilizing MEC HA to assess different remedial alternatives could be useful for sites where an unacceptable risk is clearly evident, it is not recommended for use to establish an acceptable site scenario or to define an acceptable amount of reduction for an MRS.

A1.2 Consideration of the Munitions Response Site Prioritization Protocol (MRSPP)

The Munitions Response Site Prioritization Protocol (MRSPP) is specifically used as a funding prioritization, not a hazard or risk assessment. However, data acquired during the project life cycle is used to develop sensitivity, accessibility and severity components of the MRSPP score. Therefore, it may be useful to look at the structure of MRSPP when identifying the MRS hazards, specifically the structured scale for the munitions explosive nature, Tables 1-3 of the MRSPP. The information in the MRSPP tables may be pertinent, and should ultimately be comparable to the methods established in this paper, such that the accessibility, sensitivity, and severity components are reflected similarly. Although the MRSPP is completed annually for each MRS, or as new information is available, it is important to recognize that once a remedial process has been completed, the MRSPP score becomes "no longer required" indicating funding is no longer planned. As a result, the MRSPP is not used to determine the reduction of risk once a remedy has been implemented.

A1.3 MEC Probability Assessment

The Engineer Manual (EM) 385-1-97, Safety and Health Requirements Manual, provides planning requirements for military construction projects having a current scale of "no," "low," and "moderate to high" probability determinations of an explosive hazard defined in a Probability Assessment. Though most of EM 385-1-97 does not apply to FUDS, this Probability Assessment is instructive as to how other programs assess explosives safety. Both "low" and "moderate to high" determinations require planning for MEC construction support (MEC standby or onsite support, respectively) on military installation construction projects.

Prior to Errata sheet No 1, dated 12 April 13 for this EM, "negligible probability" was included as the lowest probability, rather than the current word "no". In consideration of defining a similar scale for an MRS, rather than a construction site, though, the change in this terminology is significant. The word "no" constitutes a zero probability, which ***cannot*** be supported by any characterization effort; however the term "negligible" can be supported, with a specified degree of confidence. Conceptually, by this scale historically in EM 385-1-97, either "no" or "negligible" would support an "acceptable" condition, as no construction support would be required for sites where "negligible" (now "no") probability of encounter is determined.

Further, there is ambiguity in the relative definition of "low" probability, and there is no definition to the former term "negligible". While these general terms can provide a qualitative scale to establish the baseline probability of a hazard that may be found at a site, based on

historic use and observation, there is no established logic in these terms that supports the determination of acceptable versus unacceptable risk at a site for purposes of CERCLA response.

In considering these terms for MMRP, this team recommends the term "negligible" probability because it can be defined using this RAO methodology such that an acceptable risk for an MRS can be established. In the absence of generally accepted definitions for acceptable risk levels for munitions response sites, project teams are currently encouraged to define "negligible" or "low" as acceptable risk levels, depending on specific physical and land use conditions at a MRS. This paper provides a framework of logic to support these determinations of probability, or "likelihood of encounter", relative to acceptability.

A1.4 Army Risk Management

Department of Army Pamphlet for Risk Management (DA Pam 385-30) is used to identify mission-related hazards and conduct a risk assessment for these conditions. It is generally tailored for active military missions. It does not clearly relate to environmental hazards related to MMRP; however, it focuses generally on probability and severity as key input factors for the evaluation of risk. This paper establishes a parallel to this Army process of Risk Management, using more appropriate matrix categories and factors pertinent to MMRP, to include specific site conditions and munitions sensitivities, while incorporating appropriate elements of the MEC HA, MRSPP, and the Probability Assessment. The strength in the Army risk assessment approach is that it is intended to address potentially acute hazard scenarios by assessing real site conditions to establish risk.

Attachment 2. Example RAO Acceptable Conditions

The table below gives examples of unacceptable baseline conditions and resultant acceptable conditions the remedial alternatives can seek to achieve.

MRS Scenario	Horizontal Boundary	Receptors	Pathways	Required remedial response depth[19]	UXO and DMM	Baseline Risk Condition (from Matrix 4)	Acceptable Condition(s) (from Matrix 4)	Baseline Acceptable or Unacceptable? U→FS required A→no action
Target Area	Trails plus 15m buffer that are within Target Area	Recreational users	Interaction during hiking, camping, hunting	0.5 meter	M7 155mm intact UXO	A-1	D-1 or D-3	U
				0.5 meter	M7 155mm low-order UXO	B-2	C-2, D-2, C-3 or D-3	U
				0.2 meter	M48 Fuze	B-2	C-2, D-2, C-3, D-3	U
	All other portions of Target Area	Recreational users	Interaction during hiking, camping, hunting	0.5 meter	M7 155mm intact UXO	B-1	D-1 or D-3	U
				0.5 meter	M7 155mm low-order UXO	B-2	C-2, D-2, C-3, or D-3	U
				0.2 meter	M48 Fuze	C-2	C-2, D-2, C-3, or D-3	A
Buffer Zone	Remaining Buffer Zone Area	Recreational users	Interaction during hiking, camping, hunting	0.5 meter	M7 155mm intact UXO	B-1	D-1 or D-3	U
				0.5 meter	M7 155mm low-order UXO	B-2	C-2, C-3, D-2 or D-3	U
				0.2 meter	M48 Fuze	C-2	C-2, C-3, D-2 or D-3	A

[19] Characterization must provide data to suggest a horizontal as well as depth distribution of the TOI (with indication of confidence). The response depth is built from that distribution, with relative consideration of land use and instrument detection capabilities. See Attachment 3 to illustrate the significance of this data and how the post removal assessment is used to determine need for additional response (LUCs) or whether UU/UE can be supported.

Attachment 3: Example Post Remedy Data Assessment

This attachment illustrates the decision logic that may be performed post-remedy, using data collected during the remedial action to support the decision. Decision logic for this type of assessment is provided in the decision tree at Figure A3-1. The example is based on the tabulated RAO for acceptable conditions, which was developed using the matrices presented in this document:

EXAMPLE: Acceptable Conditions that Achieve the RAO

MRS Scenario	Horizontal Boundary	Receptors	Pathways	Required remedial response depth	UXO and DMM	Baseline Risk Condition	Acceptable Condition(s)= RAOs
Target Area	MRS01 boundary	Recreational users	Interaction during hiking, camping, hunting	0. 65 meter	81mm Mortar	A-1	B-3, D-1 D-2, or D-3
				0.3 meter	37mm projectile	A-1	B-3, D-1 D-2, or D-3

37mm and 81mm mortars are the targets of interest (TOI) based on historic use and confirmed presence of explosives use during characterization. Assumptions resulting from characterization are that:

- *37mm exist from the surface to 30cm*
- *81mm exist from the surface to 65cm*
- *These items are easy to detect and classify in any orientation within those depth intervals.*
- *Items can be detected and recovered at deeper depths when a signal-to-noise ratio is predicted for a given depth and orientation that is equal or greater than the project-specific detection threshold required to detect a horizontal 37mm at 30cm or a horizontal 81mm at 65cm.*

Details of the remedial action will be specified and executed in accordance with the site specific Uniform Federal Policy for Quality Assurance Project Plan (UFP QAPP).[20] *Once the remedial action is complete, post remedy data is used at the Post Remedy Decision Points, indicated at Figure A3-1.*

In this example, data were collected during remedy implementation to support post remedy evaluation of the residual risk, confirm the CSM and achievement of the RAO, to determine

[20] The Office of the Under Secretary of Defense Memorandum of April 11, 2006, first recommended use of UFP QAPP for DoD. USACE echoed recommendation in Memo dated January 2007. UFP QAPP, has since been implemented into the EM 200-1-15, 30 October 2015. *The DoD Environment, Safety, and Occupational Health Network and Information Exchange* provides the UFP QAPP worksheets at: http://www.denix.osd.mil/edqw/Documents.cfm

whether UU/UE can be supported, and/or to determine whether additional response, such as LUCs, may be required. If the RAO is satisfied, then RC is achieved.

POST-REMEDY DECISION POINTS: Confidence in the CSM and achievement of the RAO is supported when:

- All quality control criteria as specified in the site specific UFP QAPP for the remedial action are met,
- The CSM resulting from the characterization is still true, to include:
    - Identities of the items recovered were anticipated as a result of the characterization CSM.
    - The vertical distribution resulting from characterization reflects the actual vertical distribution of UXO recovered during the remedial response; and
    - All areas within the MRS Scenario (lateral and vertical boundary specifications of the RAO) have been searched for TOI.
        - Partial search (e.g., due to areas of difficult terrain, lack of ROE or other access issues) may result in considerations for additional response at the MRS (such as LUCs), or delineation of the unsearched area for further response while the searched area remedy is considered complete.

Post Remedy Decision Point 1: The Remedial Action work plan (UFP QAPP) defines the data quality objectives (to support achievement of the RAO). The Post Remedy Decision Point 1 assesses whether the conditions of response action met the requirements of the RAO as planned.

NO: For Remedial Responses that do not meet the criteria as specified in the remedial action UFP QAPP, there is reason to suspect the RAO has not been met. The project team must determine whether the deficiencies impact the achievement of the RAO, whether for the whole MRS Scenario, partial MRS Scenario, or if achievement of the RAO can still be supported. Justification for the decision must be provided. For instance, difficult terrain encountered during remedy prevented search of 100% of the MRS. MEC was encountered throughout the remedy of the areas immediately surrounding and within difficult terrain areas of the MRS. The PDT must determine if the reduction of the amount of MEC, with consideration of the confidence in the data can support achievement the RAO. A selection of "No" in the decision tree indicates the physical remedy did not achieve the RAO, where the likelihood of encounter, severity and sensitivity is still unacceptable, and therefore further remedial action is required. (See Post Remedy Decision Point 2b below.)

YES: For physical responses that meet the RAO, additional remedial actions (e.g., LUCs) will not be required to support an acceptable end state. In Figure A3-2, the data supports that the remedial response above the detection depth of the instrument and within the boundaries for the MRS was successful to meet the RAO. All assumptions and quality control data were met,

supporting high confidence in remedy implementation. After the remedy is implemented at 100% of the MRS Scenario, the amount of MEC is confidently reduced to support selection of "unlikely" in Matrix 1, resulting in a D determination in Matrix 2. The reduction of items within the depth interval for current and reasonably anticipated future land users also supports selection of "Inconsequential" in Matrix 3.

For MRS scenarios where the physical response achieves the RAO, the project team must then assess whether UU/UE can be supported. Examples at Figures A3-2 and A3-3 are used to illustrate this subsequent post remedy data assessment for UU/UE considerations. (See ***Post Remedy Decision Point 2a*** below.)

Post Remedy Decision Point 2a: If the result of Decision Point 1 is "YES", the team must consider the achievement of UU/UE. Figures A3-2 and A3-3 are used as an example to illustrate how a post remedy data assessment can be used to support the consideration of UU/UE.

- *Outcome A: UU/UE Supported.* In further evaluation of the data, a significant gap exists below the lowest item found during implementation of the physical response and the known detection depth of the instruments used. The gap provides confidence that residual MEC at the MRS is "unlikely" to be present. In this case, a UU/UE determination is supported by the post remedy data assessment.

  Additional considerations: Another consideration for UU/UE is the limits of physical remedy imposed by site-specific limitations, such as bedrock. Removal to shallow bedrock over 100 % of the MRS Scenario, with appropriate quality data in the UFP QAPP may also be used to support a UU/UE determination.

- *Outcome B: UU/UE Not Supported.* In this example, two TOI were found near or just below the detection depth of the instrument, categorized as "catastrophic" in the severity Matrix 2. Both were identified as an explosive hazard. Based on the distribution of TOI in the subsurface, primarily in the 0-20 cm interval, the single detection of the 37mm at 30 cm, and the single detection of the 81mm at 70 cm are atypical of the remaining data set. However, because the items detected were "live", there is less confidence that residual presence of MEC below the RAO boundaries is "unlikely." If UU/UE is not supported, Five-Year Reviews will be required to assess long term protectiveness of the remedy to ensure the remedy remains protective.

  Consider, though, if the items at these depths were identified as inert fragments, the determination of UU/ UE may further be supported, as the dataset may suggest that MEC was limited to within 20cm of the surface.

Post Remedy Decision Point 2b: When the result of Decision Point 1 is "NO", the Decision Tree provides consideration of the existing data to re-assess the MRS Scenario and determine whether further remedial actions (e.g., LUCs) may be implemented to further support an Acceptable end state, according to Matrix 4.

- *Outcome C: UU/UE Not Supported.* If LUCs can be implemented to support achievement of the RAO, Outcome C is achieved, and response is complete.[21] Five Year Reviews will be required to assess long term protectiveness; however, if inclusion of LUCs does not support an acceptable end state, the project team must consider additional response actions, and return to the Remedial process.

[21]Consideration of LUCs at this decision point should be included as a discussion in the Feasibility Study, and Proposed Plan/Decision Document. Consideration of LUCs as part of a remedial alternative may occur if the physical remedy alone is not anticipated to achieve the RAO, and these measures will further reduce Matrix 4 to an acceptable end state. Alternatively, (post physical remedy) there may be cases where the physical remedy alone is anticipated to achieve the RAO, and if after the physical remedy is complete this is not the case, a decision document amendment or an explanation of significant differences (ESD) may be required to include LUCs or include additional remedial measures. The DERP Manual requires consideration of a remedial alternative that includes LUCs. The implementation of a LUC is (or may be part of) a remedial action, so a determination that LUCs are necessary after completion of a remedy that does not include LUCs should be infrequent.

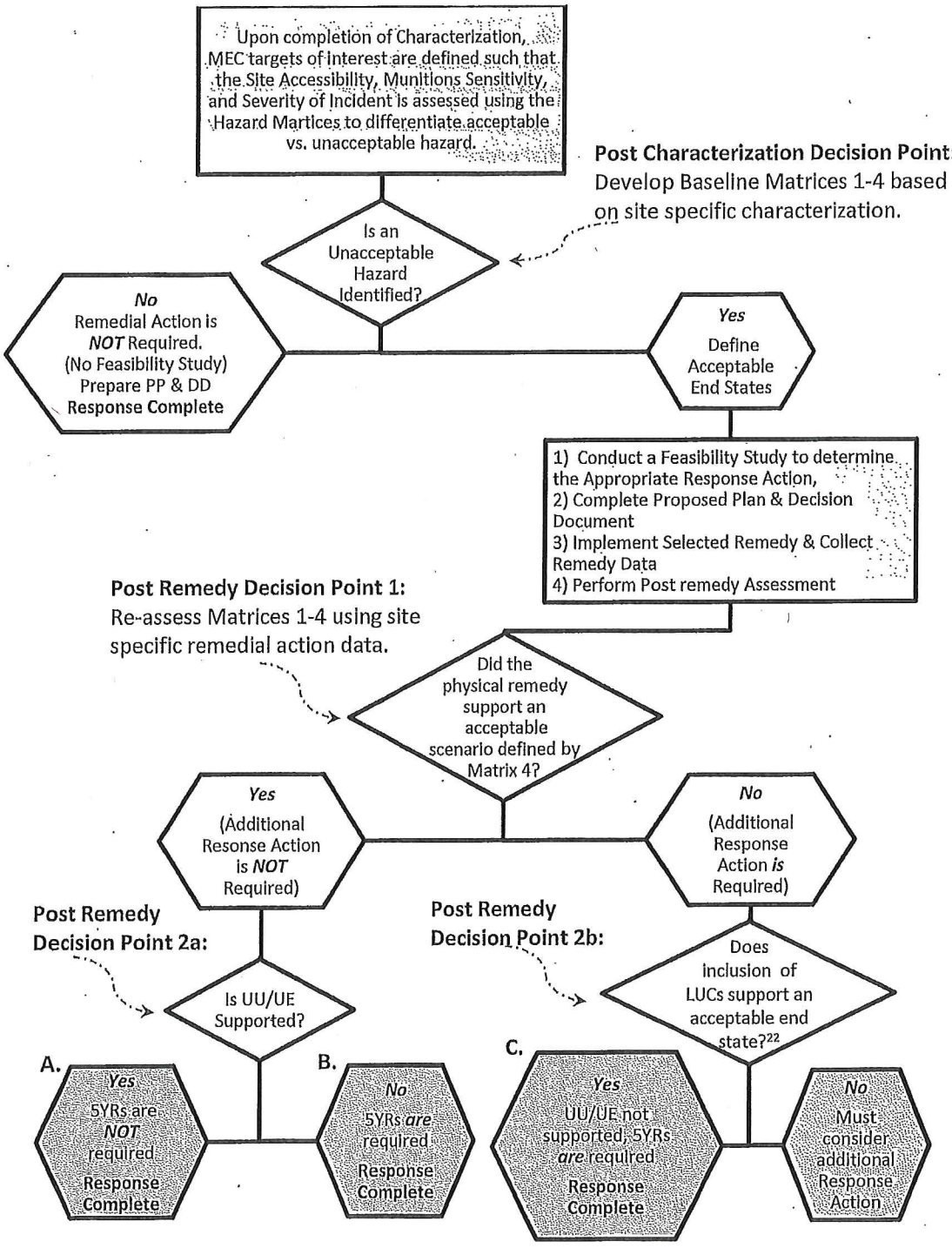


Figure A3-1. Decision Logic for post-Remedial Action data assessment, where a physical remedy is conducted. End States A, B, or C are the potential outcomes of a remedial action. Figures A3-2 and A3-3 illustrate additional consideration of UU/UE for outcome of A vs. B, where the RAO is achieved.

As illustrated below, achievement of the RAO when physical remediation is conducted should be assessed post remedy in order to determine whether the RAO is met or if additional response is required to meet the RAO. Furthermore, if the RAO is met, then assessment of UU/UE is evaluated separately from the remedial process, also conducted post remedy. If UU/UE cannot be supported by the data, Five-Year Reviews will be required.

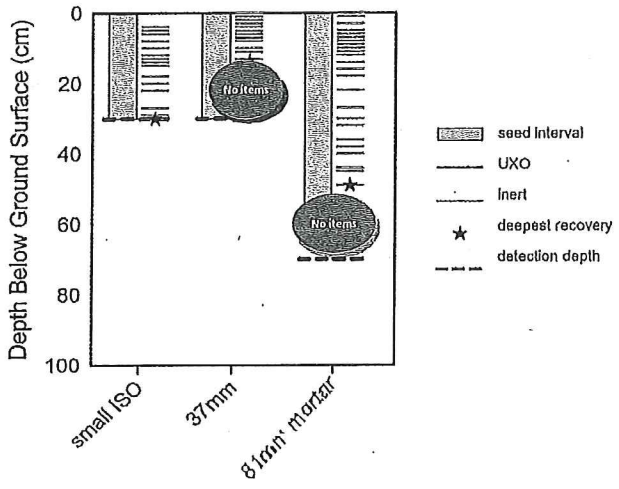


Figure A3-2. Example Outcome A. After a physical response action for 100% of the MRS, the data assessment shows that all targets of interest (TOI) were recovered from the MRS and all were well within the detection capabilities of the instrument such that there is high confidence that any potential residual presence of UXO is negligible. The end state for the MRS from Matrix 4 is 3-D. This is defined by the "Unlikely" resulting from Matrix 1, and "Inconsequential" rating in Matrix 3. There are no detections below 50 cm down to the instrument detection depth of 65 cm for the 81mm, nor below 15 cm down to the instrument detection depth of 30 cm for the 37mm. This "buffer" in the detection data versus instrument capability provides confidence that UU/UE can be reasonably supported for the MRS.

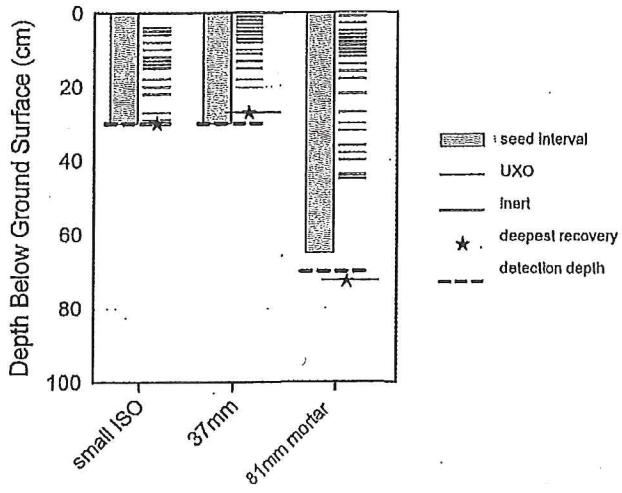


Figure A3-3. Example Outcome B. After a physical response action for 100% of the MRS, the data assessment shows that all detectable targets of interest were recovered from the MRS, but few TOI were recovered near the limits of the detection capabilities of the instrument. Like Outcome A, the supported end state within the recovery area for the MRS, Matrix 4, is 3-D. In this case, there is lower confidence in accepting the residual presence of TOI below detection depth for the MRS. UU/UE may not be supported if there is some evidence of residual hazard remaining on the MRS with some likelihood of exposure. If UU/UE is not supported, Five-Year Reviews will be required.

Attachment 4: Glossary- (Hazard versus Risk)

Definitions of Terms Found in DA Pam 385-30: [22]

Hazard. Hazard is a condition with the potential to cause injury, illness, or death of personnel; damage to or loss of equipment or property; or mission degradation. Therefore, a hazard can have several possible negative outcomes or losses (for example, injury, death, damage, mission failure, mission degradation, increased resource(s) expenditures, and adverse public relations).

Risk. Risk is determined after hazards are identified and analyzed. Risk is defined as the probability and severity of loss linked to hazards. It is simply the measure of the expected loss from a given hazard or group of hazards, usually estimated as the combination of the likelihood (probability) and consequences (severity) of the loss.

Residual risk. The risk associated with a hazard that remains after implementing all planned countermeasures or controls to eliminate, reduce, or control the impact of the hazard. The residual risk may be equal to the initial risk, especially when the initial risk is so low that the hazard does not warrant expenditure of funds to mitigate.

Probability. An approximation of the likelihood of a hazard scenario or mishap occurring. Probability is assessed as frequent, likely, occasional, seldom, or unlikely.

Severity. An approximation of the amount of potential harm, damage, or injury associated with a given mishap.

Additional definitions added to this study for purposes of munitions risk management:

Sensitivity. An approximation of the likelihood that a human receptor will be able to interact with a MEC item such that it will detonate.

[22] The DA Pam 385-30 definition for "hazard" includes some aspects, such as "damage, mission failure, mission degradation," etc., that have no specific application for the MMRP conducted under CERCLA. As such, the definitions were used as a benchmark for this study, and are included here only as a guide to users in making risk management evaluations to recognize the presence of MEC as the "hazard", but to separate the term from the determination of "risk" as the *probability* of an incident and severity of loss due to a hazard and conditions around it. It is not intended to expand CERCLA response authority past death or injury. Additionally, these definitions recognize cases where some "residual hazard" may be determined to be acceptable, as discussed in section 4.2.

Attachment 5: Acronyms

AR	Army Regulation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMUA	Concentrated Munitions Use Area
DA Pam	Department of the Army Pamphlet
DD	Decision Document
DMM	Discarded Military Munitions
DODI	Department of Defense Instruction
EM	Engineer Manual
FS	Feasibility Study
HE	High Explosive
HTRW	Hazardous Toxic and Radioactive Wastes
LUCs	Land Use Controls
MD	Munitions Debris
MEC	Munitions and Explosives of Concern
MEC HA	MEC Hazard Assessment
MMRP	Military Munitions Response Program
MRS	Munitions Response Sites
MRSPP	Munitions Response Site Prioritization Protocol
NCMUA	Non Concentrated Munitions Use Area
PA	Preliminary Assessment
PDT	Project Delivery Team
PP	Proposed Plan
RAO	Remedial Action Objective
RC	Response Complete
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RIP	Response in Place
SI	Site Inspection
TOI	Targets of Interest
UFP QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USACE	U.S. Army Corps of Engineers
UU/UE	Unlimited Use, Unrestricted Exposure
UXO	Unexploded Ordnance

NEW RISK MANAGEMENT METHODOLOGY FEEDBACK FORM

Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites

FUDS Property/Project Number:
Property Name:
Project Name:
MRSPP Overall Score:

1. List historically known or suspected munitions and specify what evidence of MEC was found during characterization. (If multiple munitions exist, and or different areas are identified, these areas may be presented separately):

Amount of MEC Justification: _____
_____

Sensitivity Justification: _____
_____

Severity Justification: _____
_____

2. Specify Land Use and Site Receptors. (If multiple Land Use/Receptors exist as different areas, these areas may be identified separately):

Access Condition Justification: _____
_____

Likelihood to Impart Energy Justification: _____
_____

3. For each area having separate conditions above, indicate the Risk Management Results for the following:

Matrix 1:	Frequent	Likely	Occasional	Seldom	Unlikely
Matrix 2:	A	B	C	D	
Matrix 3:	1	2	3		
Matrix 4:	(result of combining Matrices 2 and 3 above, e.g., A-2, B-1, etc.)				
Risk Determination:	Acceptable		Unacceptable		

4. Other Comments, (Please identify limitations or suggestions, if any.):
_____
_____

5. Compare use of RAO methodology to MEC HA, if applied:
_____
_____

APPENDIX S

LABORATORY QA MANUAL

Provided on CD.

CT LABORATORIES

delivering more than data from your environmental analyses

Quality Assurance Manual

CT Laboratories LLC
1230 Lange Court
Baraboo, WI 53913
608.356.2760

Approved By:

2Oct2018

David Berwanger, Laboratory Director Date

Reviewed By:

2Oct2018

Christelle Newsome Quality Assurance Manager Date

TABLE OF CONTENTS

1 INTRODUCTION 8
1.1 QUALITY POLICY AND DATA INTEGRITY STATEMENT 8
2 ORGANIZATIONAL ROLES AND RESPONSIBILITIES 8
2.1 Organization and Responsibilities 8
2.2 Laboratory Organizational Structure 9
2.3 Responsibility and Authority 10
2.3.1 Laboratory Director 10
2.3.2 Quality Assurance Officer 11
2.3.3 Group Leaders 12
2.3.4 Project Managers 13
2.3.5 Health and Safety Personnel 13
2.3.6 Analysts/Technicians 13
2.4 Minimum Personnel Education, Training and Experience Requirements 13
3 QUALITY SYSTEMS 15
3.1 Quality Objectives 15
4 DOCUMENT MANAGEMENT 17
4.1 Controlled Documents 17
4.2 Standard Operating Procedures 17
5 REVIEW OF REQUESTS, TENDERS AND CONTRACTS 19
5.1 Procedure for the Review of Work Requests 19
5.2 Documentation of Review 20
6 SUBCONTRACTING OF TESTS 21
6.1 Procedure 21
7 PURCHASING SERVICES AND SUPPLIES 22
7.1 Procedure for Purchases 22
7.2 Procedure for Receipt of Supplies 22
7.3 Procedure for Storage of Supplies 22
7.4 Laboratory Grade Water 22
8 SERVICE TO THE CLIENT 23
8.1 Client Confidentiality 23
9 CUSTOMER INQUIRES/COMPLAINTS 24
10 CONTROL OF NON-CONFORMING WORK 25

11 CORRECTIVE ACTION 26
11.1 Non-Conformances 26
11.2 Long Term Corrective Action 27
11.3 Exceptionally Permitting Departures from Documented Policies and Procedures 27
12 PREVENTIVE ACTION 28
12.1 Preventative Action 28
13 CONTROL OF RECORDS 29
14 STATISTICAL CONTROL 30
14.1 Precision 30
14.2 Accuracy 30
14.3 Uncertainty 30
15 AUDITS & MANAGEMENT REVIEW 31
15.1 Management Reviews 31
15.2 Internal Audits 31
15.3 External Audits 33
15.4 Performance Audits 33
16 TRAINING AND DATA INTEGRITY 34
16.1 Data Integrity and Ethics 34
16.2 Ethics Policy 34
16.3 Training Orientation 34
16.4 Ethics/Data Integrity Training 35
16.5 General Training 35
17 ACCOMMODATIONS & ENVIRONMENTAL CONDITIONS 37
18 TEST METHODS AND METHOD VALIDATION 39
18.1 Demonstration of Capability (DOC) 39
18.2 Continuing Demonstrations of Analyst Capability 40
18.2.1 Initial Test Method Evaluation 40
18.2.2 Method Detection Limits (MDL) 40
18.2.3 Limit of Detection (LOD) 41
18.2.4 Limit of Quantitation (LOQ) 41
18.2.5 Precision 41
18.2.6 Accuracy 41
18.3 Uncertainty 42
18.4 Laboratory-Developed or Non-Standard Method Validation 42
18.5 Control of Data 42

19 EQUIPMENT 44
19.1 General Equipment Requirements 44
19.2 Equipment Operation and Calibration 44

20 EQUIPMENT MAINTENANCE 45
20.1 Support Equipment 46
20.2 Support Equipment Maintenance 47
20.3 Analytical Equipment 50
20.3.1 Maintenance for Analytical Equipment 50
20.3.2 Initial Instrument Calibration 52
20.3.3 Continuing Instrument Calibration 54
20.3.4 Unacceptable Continuing Instrument Calibration Verifications 54

21 MANUAL INTEGRATION 56

22 MEASURMENT TRACEABILITY 57
22.1 Reference Standards 57
22.2 Reference Materials 57
22.3 Transport and Storage of Reference Standards and Materials 58
22.4 Labeling of Reference Standards, Reagents, and Materials 58

23 SAMPLE MANAGEMENT 60
23.1 Sample Receipt 60
23.2 Sample Acceptance 60
23.3 Sample Identification 61
23.4 Sample Storage 62
23.5 Sample Disposal 62
23.6 Sample Transport 63
23.7 Sampling Records 63

24 QUALITY OF TEST RESULTS 64
24.1 Essential Quality Control Procedures 64
24.2 Internal Quality Control Practices 65
24.3 Method Blanks 67
24.4 Laboratory Control Samples & Laboratory Control Sample Duplicates 67
24.5 Matrix Spikes, Matrix Spike Duplicates, and Matrix Duplicates 68
24.6 Surrogate Spikes 68
24.7 Proficiency Testing Studies 69
24.8 Data Review 70

25 REPORTING OF RESULTS 71

25.1 Test Reports 71
25.2 Supplemental Test Report Information 72
25.3 Environmental Testing Obtained from Subcontractors 72
25.4 Electronic Transmission of Results 72
25.5 Amendments to Test Reports 73
25.6 GLOSSARY 74

FIGURE

Figure1: Laboratory Organization Chart 10

TABLES

Table 20.2-1 Acceptanace Criteria for Support Equipment 47
Table 20.2-2 Support Equipment Calibration 48
Table 20.3-1 Analytical Equipment Maintenance 50
Table A9-1 Quality Control Check Definitions, Purpose & Evaluation 108
Table A9-2 Quality Control Elements for Microbiology 113

APPENDICES

Appendix 1 Scope of Testing 82
Appendix 2 Master SOPs List 86
Appendix 3 Ethics & Data Integrity Agreement 91
Appendix 4 List of Current Accreditions and Certification 93
Appendix 5 Demonstration of Capability Certificate 94
Appendix 6 Demonstration of Capability 95
Appendix 7 List of Laboratory Instrumentation 96
Appendix 8 Sample Acceptance Terms & Conditions 101
Appendix 9 Common SOP Sections 105
Appendix 10 Security Awareness 107

REFERENCES 114
Description of Changes 115

Acronyms

A list of acronyms generally used in quality systems and their definitions are:

AA	–	Accrediting Authority or Atomic Absorption
ANSI	–	American National Standards Institute
ASQC	–	American Society for Quality Control
ASTM	–	American Society for Testing and Materials
Blk	–	Blank
°C	–	degrees Celsius
cal	–	calibration
CAS	–	Chemical Abstract Service
CCV	–	Continuing calibration verification
COA	–	Certificate of Analysis
COC	–	Chain of custody
DO	–	Dissolved oxygen
DoD	–	Department of Defense
DOC	–	Demonstration of Capability
EPA	–	Environmental Protection Agency
g/L	–	grams per liter
GC	–	gas chromatography
GC/MS	–	gas chromatography/mass spectrometry
ICP	–	inductively coupled plasma
ICV	–	Initial calibration verification
ISO/IEC	–	International Organization for Standardization/International Electrochemical Commission
lb/in2	–	pound per square inch
LCS	–	Laboratory control sample
LFB	–	Laboratory fortified blank
LIMS	-	Laboratory Information Management System
LOD	-	Limit of Detection
LOQ	-	Limit of Quantitation
MDL	–	method detection limit
mg/Kg	–	milligrams per kilogram
mg/L	–	milligrams per liter
MS	–	matrix spike
MSD	–	matrix spike duplicate
NELAC	–	National Environmental Laboratory Accreditation Conference
NELAP	–	National Environmental Laboratory Accreditation Program
NIST	–	National Institute of Standards and Technology
PT	–	Proficiency Test(ing)
PTOB	–	Proficiency Testing Oversight Body
PTPA	–	Proficiency Testing Provider Accreditor
QA	–	Quality Assurance
QC	–	Quality Control
QM	–	Quality Manual
QCS	–	Quality Control Sample
QAM	–	Quality Assurance Manager
RL	–	Reporting level
RPD	–	Relative percent difference
RSD	–	Relative standard deviation
SOPs	–	Standard operating procedures
spk	–	spike

SVOC	–	Semivolatile organic compound
std	–	standard
TCLP	–	Toxicity Characteristic Leachate Procedure
TNI	–	The NELAC institute
µg/L	–	micrograms per liter
UV	–	Ultraviolet
VOC	–	Volatile organic compound
WET	–	Whole effluent toxicity

1 INTRODUCTION

The purpose of this manual is to outline the organization, specify the procedures, and define the technical requirements utilized by CT Laboratories LLC. The goal is to ensure that all data generated is of the required quality, is reproducible, and is generated in a timely manner. This manual details a Quality Assurance/Quality Control program encompassing the entire analytical efforts at CT Laboratories (CTL) from project initiation to report generation. Some areas are covered with only a cursory discussion, while others are covered in detail, or are included in more than one section, depending on their importance. This manual describes the realistic functions of the quality programs in place, with an understanding that not every situation is covered nor every contingency explored.

1.1 QUALITY POLICY AND DATA INTEGRITY STATEMENT

The objective of CTL's quality system, and the commitment of management, is to understand and meet the requirements of clients while exceeding their service expectations; to provide services and deliverables that are technically sound, of known and documented quality, and are responsive to client's needs; and to maintain a focus on continuous quality improvement. Our policy is to use sound professional practices, to incorporate data integrity procedures into all processes, to maintain client confidentiality, and to comply with NELAP, ISO/IEC17025, and DOD QSM guidance documents. CTL ensures that personnel are free from any commercial, financial, and other undue pressures, which might adversely affect the quality of their work, and that they avoid involvement in any activity that might diminish confidence in CTL'S competence, impartiality, judgment or operational integrity. This policy is implemented and enforced through the unequivocal commitment of management, at all levels, to the Quality Assurance principles and practices outlined in this manual.

The primary responsibility for quality rests with each individual within the laboratory. Every CTL employee ensures that the generation and reporting of quality data are a fundamental priority. Employees familiarize themselves with the quality documentation to implement the policies and procedures in their work. All employees are trained annually on principles of ethics and procedures surrounding the data that are generated.

2 ORGANIZATIONAL ROLES AND RESPONSIBILITIES

2.1 Organization and Responsibilities

Standard of quality refers to a specific, pre-established level of excellence, which is defined by organizations such as the National Environmental Accreditation Program (NELAP), Department of Defense (DoD), and ISO 17025.

A pre-defined standard of quality is maintained for every CT Laboratories project and work element. The vehicle through which this standard is documented and communicated is this Quality Assurance Manual, in conjunction with a Project Profile and/or Quality Assurance Project Plan (QAPP). Quality planning, contract review, and project management, are inherently interrelated processes and addressed by laboratory specific standard procedures.

The Project Scoping Form, in conjunction with the Client Contract set up in the Laboratory Information Management System (LIMS), summarizes specific project requirements, including quality control and deliverable requirements, method references, analyte lists, subcontracted analyses, certification requirements, turnaround times, project manager, client report and invoice contacts. The requirements can also be customized in the Quality Assurance Project Plan (QAPP), Analytical Quote, Proposal, and/or Contract, as applicable, which together comprise the quality plan for the laboratory deliverable. This allows the client to add, supersede or take exception to basic laboratory QA Manual guidance in order to satisfy the needs of individual projects or programs with specialized requirements. Laboratory personnel are available to develop and/or discuss advantages and disadvantages of quality control options for inclusion in QAPPs.

Typical information included in QAPPs is listed below, but inclusion is dependent on project scope, program requirements and client needs.

- Project description
- Project organization and responsibility
- Quality assurance objectives
- Sample custody
- Analytical methods
- Analytes, compounds and MDL/LOD/LOQs
- Internal quality control checks
- Corrective action
- Reporting requirements

CT Laboratories provides environmental testing services to commercial, industrial and governmental clients including the US Department of Defense, projects overseen by various US EPA Regions, as well as numerous municipalities in various States.

Analytical programs and methods are based on the following:

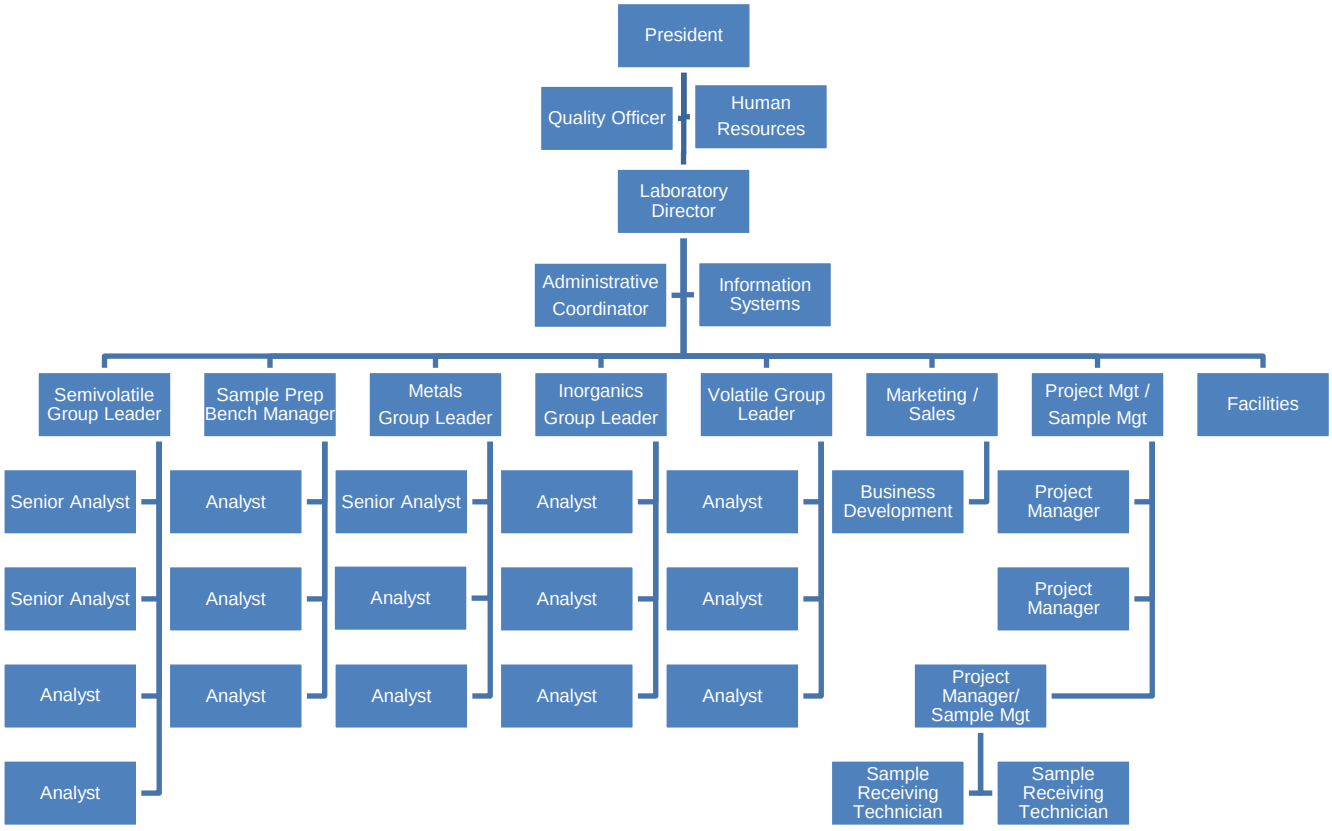
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- Clean Water Act (CWA)
- National Pollutant Discharge Elimination System (NPDES)
- Resource Conservation and Recovery Act (RCRA)
- Safe Drinking Water Act (SDWA)
- Toxic Substances Control Act (TSCA)

2.2 Laboratory Organizational Structure

CT Laboratories LLC is a commercial laboratory, founded in 1987 as the laboratory testing division of Mid-State Associates. The laboratory was acquired by the current owners, two long-term employees, in October 2011.The laboratory employs approximately 30 professionals and operates in Baraboo, WI.

The organizational structure indicated minimizes the potential for conflicting or interests that might influence the technical judgment of analytical personnel. All laboratory personnel are involved in the Quality Assurance program.

Figure 1: Laboratory Organization



2.3 Responsibility and Authority

The specific duties and responsibilities of key positions and personnel are listed below.. The quality assurance/quality control program depends on the commitment of the entire organization, including management and every individual on the laboratory staff. Each individual is responsible for the quality of his/her work. Management processes have been reviewed to ensure that personnel are free from commercial, financial, and other undue pressures that might adversely affect the quality of the work.

In the absence of any one individual, staff within each department, who have the required skills and/or training, perform the function of the absent personnel. This allows for the continuance of the day-to-day operations of the laboratory. The Group Leaders provide backup during the absence of either the Laboratory Director or the QA Officer.

2.3.1 Laboratory Director

The ultimate responsibility for the generation of reliable laboratory data and the actual day-to-day supervison of operations rests with the Laboratory Director. The Laboratory Director has the

authority to affect those policies and procedures to ensure that only data of the highest level of excellence are produced. It is the Laboratory Director responsibility to see that all tasks performed in the laboratory are conducted according to the requirements of this Quality Assurance Manual, the Project Profile and/or the appropriate QAPP; to assure that the quality of service provided complies with the project's requirements. The Laboratory Director is also responsible for the overall direction of a project, has primary responsibility for project quality assurance, and is accountable for the following:

- Assuring the preparation of a tailored Project Profile and/or Quality Assurance Project Plan (QAPP) as applicable,
- Ensuring peer review of the adequacy of QAPPs as applicable,
- Ensuring allocation of proper quality control budgets,
- Attaining concurrence with Group Leaders on performance and/or results objectives,
- Achieving acceptable project implementation performance, and
- Oversees Waste Management Programs

The Laboratory Director is responsible for planning, organizing, directing and managing resources for laboratory services in all departments. These responsibilities include: budget, recruitment and effective management of staff; achieving quality outcomes, cost and productivity management, process improvement and positive working relationships with staff, departments and managers.

At CT Laboratories, the Laboratory Director is responsible for providing data security by controlling access and for providing for disaster recovery of the Network and the security of the data stored on the LIMS. The Laboratory Director is also responsible for providing procedures and training to all laboratory computer related operations, as appropriate, to assist in making backup copies of local data within the respective operating unit.

The Laboratory Director has line authority over those performing the work. The Laboratory Director provides support and authority for policies maintained by the QA/QC Department. If the Laboratory Director is absent for a period exceeding 15 calendar days, the Senior Group Leader will temporarily perform the function. The QA Officer will notify the Accreditation Body in writing if the absence exceeds 35 calendar days (NELAP) or 65 calendar days (DoD).

2.3.2 Quality Assurance Officer

The Quality Assurance Manager for CTL is responsible for ensuring that the quality system is established, implemented and maintained. He/she is the focal point for QA/QC activities and is responsible for oversight and/or review of QC data. Data are evaluated objectively and assessments are performed without managerial influence. The QA Officer has documented training and/or experience in QA/QC procedures, as well as knowledge of the quality system as defined under NELAP and DoD QSM.

The QA Officer assists with proposals, and the preparation, compilation, and review of client quality assurance plans. These are reviewed for consistency with organizational and/or contractual requirements. Appropriate personnel (e.g., the Laboratory Director or Project Manager) are advised of deficiencies or areas needing further attention.

The QA Officer has the authority to stop work until any condition affecting the quality of the data is resolved. Should a situation arise where acceptable resolution of identified problems cannot

be agreed upon at the laboratory level, the QA Officer has the support of senior management, as needed, to ensure that QA policies and procedures are enforced.

The QA Officer reports to the President n performance of the quality system for review and continuous improvement. QA Officer has (Access to the highest levels of management) sufficient authority, work area access, and organizational freedom (including sufficient independence from cost and schedule considerations) to:

- Ensure that quality documentation is available to, understood by, and implemented by all laboratory personnel,
- Monitor the Quality System,
- Arrange for or conduct internal audits annually
- Assist in the preparation of Standard Operating Procedures (SOPs) and quality assurance documentation for the laboratory at least annually,
- Assist in the identification and initiation of preventative or corrective actions for any problems affecting the product, process and Quality System,
- Assure that further work is stopped or controlled until proper resolution of a non-conformance, deficiency, or unsatisfactory condition has occurred and the deficiency or unsatisfactory condition has been corrected,
- Tracks performance evaluation studies, personnel training (including Initial and Continuing Demonstrations of Capability), and MDL/IDL (LOD/LOQ) studies,
- Manages records management and document control, and
- Maintains certifications and approvals.

2.3.3 Group Leaders

The Group Leaders report to the Laboratory Director and are responsible for daily operations, including all activities pertaining to operational and technical performance of the laboratory. The laboratory staff gives the data to the Group Leaders for final approval. The Group Leaders ensure sufficient equipment, space, resources, and personnel are available to conduct analyses and implement the Laboratory Quality Assurance Program. They possess authority commensurate with their responsibilities for the day-to-day enforcement and monitoring of laboratory activities.
The Group Leaders:

- Require effective implementation of the Laboratory Quality Assurance Program to ensure the overall quality of all data and laboratory reports generated,
- Ensure appropriate corrective action is taken when analytical systems are out-of-control or questionable,
- Ensure timeliness of data reporting through coordination of work schedules and assignment of target completion dates for analyses,
- Resolve technical problems with Inorganic and Organic personnel.

Group Leaders and the Quality Assurance Department have the responsibility for ensuring that personnel are adequately trained to perform analyses; that equipment and instrumentation under their control is calibrated and functioning properly; and that system and performance audits are performed on an as-needed basis. These performance audits include the analysis of external check samples to determine the analyst/instrument capability to identify and quantify routine analyses.

Group Leaders serve as technical experts on assigned projects, provide technical liaison, and assist in resolving any technical issues within the area of their expertise. They are responsible for providing input and review in the development and implementation of project-specific QA/QC requirements; and for providing the critical review of proposal and project work for programs as directed by the Laboratory Director. They coordinate these activities with the Project Manager and Quality Assurance Officer.

2.3.4 Project Managers

CT Laboratories recognizes the importance of efficient project management. The laboratory Project Managers (PMs) are responsible for preparing the project profile, summarizing QA/QC requirements for the project and setting up the requirements in the LIMS; informing the laboratory and management of the project schedule; ensuring that technical requirements are understood by the laboratory; and advising the client, Laboratory Director and Group Leaders of all variances. The laboratory PM provides technical guidance and the necessary laboratory related information to the preparer of project-specific Quality Assurance Project Plans (QAPP) (usually the client), and provides peer review of the final document to ensure accuracy of the laboratory information. The Project Managers are responsible for coordinating receipt of data from the various service groups within the laboratory. They also produce and review electronic data deliverables (EDDs).

2.3.5 Health and Safety Personnel

The Health and Safety Manager (H&S) is responsible for safety and well-being of all employees while at the laboratory. This includes, but is not limited to, developing a safety plan that complies with federal regulations, conducting laboratory safety tours for new employees, providing instructions on safety equipment and instructing personnel of laboratory procedures for emergency situations. The H&S Manager or designee is on-call for cleaning up laboratory spills and all laboratory emergency situations. Health and Safety Personnel maintain responsibility for waste management of laboratory-generated hazardous waste in accordance with appropriate regulations. This includes maintenance of required documentation, such as waste manifests, segregation of waste in accordance with requirements, and training of personnel in proper segregation of waste.

2.3.6 Analysts/Technicians

Analysts and Technicians report to the Group Leader for the section in which they work. They are responsible for the performance of analyses using approved methods and procedures. Each analyst is responsible for the quality of his/her work. The initial review for acceptability of analytical results rests with the analyst conducting the test. Observations made by the analyst during the performance of an analytical method may indicate that the analytical system is not in control. Therefore, quality control indicators are used to assure that the method is in-control before results are reported. Analysts perform instrument calibration, maintenance and troubleshooting and are responsible for authoring and updating analytical SOPs at the direction of their Group Leader, QA Officer or Laboratory Director.

2.4 Quality Systems Manual Technical Positional Requirements

2.4.1 Technical Director

- BS/BA in Chemistry or any discipline with a Chemistry focus- at least 24 college credit hours in chemistry.
- At least 5 years prior experience in an environmental environment
- At least 2 years prior management experience. Self-motivated and willing to assume the responsibility and authority for laboratory management and improvement
- At least 3 years financial management experience.
- Able to delegate authority when absent, and willing to support consequences for decisions made while absent
- Willing and able to find/choose a replacement and motivate towards that goal

2.4.2 Group Leader

- BA/BS in any environmental or science related discipline
- At least 3 years' experience working in an environmental laboratory
- Display competency in the testing procedures of the group
- Preferred ability to transfer to any group, learn and display competency in those additional areas
- Demonstrated leadership ability by training new laboratory employees
- Able to delegate authority when absent, and willing to support consequences for decisions made while absent
- Self-motivated and willing to assume the responsibility and authority for laboratory management and improvement
- Willing and able to find/choose a replacement and motivate towards that goal
- Display competency in using computers, spreadsheets and word processing
- Better than average grammatical skills

2.4.3 Senior Laboratory Analyst/Bench Supervisor (in addition to Laboratory Analyst)

- Display willingness to accept leadership role in development of new analysts
- Minimum of 3 years demonstrated competency in group lab testing
- Able to delegate authority when absent, and willing to support consequences for decisions made while absent
- Able and willing to validate other analyst work results quickly and with quality

2.4.4 Laboratory Analyst

- BA/BS in any environmental or science related discipline
- Display competency in using computers, spreadsheets and word processing
- Self-motivated and willing to learn new procedures and display core group competency
- Display competency in the testing procedures of the group

2.4.5 Laboratory Technician

- Minimum HS degree or GED equivalent with a scientific interest and ability to learn new procedures
- Display competency in using computers, spreadsheets and word processing

2.4.6 Log-in Analyst/Technician – Shipping Technician

- Minimum HS degree or GED equivalent

- Display competency in using computers, spreadsheets and word processing
- Self-motivated and willing to learn new procedures and display core group competency
- Display ability to work quickly in a multitasking environment while minimizing mistakes
- Comfortable interacting with Project Managers to work through log-in issues
- Able to comfortably lift 50 pounds
- Able to comfortably interact with clients and provide basic information for testing

2.4.7 **QA Officer**

- All of the requirements listed in Group Leader Position
- Ability to understand and demonstrate quality objectives of the laboratory
- Competently administer all necessary certifications required by the laboratory for operation
- Competently source and administer PE samples required for certifications
- Continually update knowledge regarding QA objectives of NELAC and DoD.

2.4.8 **Project Manager**

- BA/BS in Chemistry/Sciences or related field (or 4 years of related experience)
- Responsible for all phases of laboratory interaction with the client's project requirements
- Review of project-required documentation including QAPPs, worksheets and SOPs
- Managing LIMS contracts containing project-specific requirements
- Ability to provide technical support to aid clients' understanding of analytical results
- Strong communications, interpersonal and problem-solving skills, effective time management

3 QUALITY SYSTEMS

The laboratory's Quality System is documented in this *Quality Manual* and associated quality system documents. Together they describe the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of the organization for ensuring quality in its work processes, products, and services.

3.1 Quality Objectives

It is the objective of CT Laboratories to be known as an organization that has effectively implemented its Quality Policy. The laboratory recognizes that it is essential to:

- Develop a reputation for dependability by maintaining the highest standards of professionalism and ethical business practices.
- Deal fairly at all times with suppliers, competitors, and clients in accordance with those standards.
- Protect confidential and proprietary rights.
- Protect electronic storage and transmission of results.
- Offer environmental analyses that demonstrate compliance with high quality, traceability, and legally defensible performance standards.
- Practice complete honesty in the production and reporting of data. To avoid any possible misrepresentation of data, CT Laboratories prohibits the use of either the TNI or ILAC logos in advertising.

CT Laboratories' principal focus is the analysis of environmental samples. Associated with this activity are services to assure client requirements are known, communicated, and satisfactorily addressed, and to provide a complete self-explanatory deliverables package presenting the analytical results. The laboratory is committed to ensuring that resources are available and deployed to meet client expectations. All bids and proposals are signed or approved by the President, thus verifying that the laboratory has the appropriate facilities and resources in place to perform the work. Other project information is gathered prior to sample receipt to ensure client expectations will be met with respect to:

- Sampling containers
- Analytical methods employed
- Accuracy and precision
- Limit of Detection (LOD) and Quantitation (LOQ)
- Personnel qualifications, training, and experience
- Calibration and quality control measures employed
- Regulatory requirements
- Report contents
- Supporting documentation, records and evidence
- Validation of data
- Applicable accreditation

Organizational support for implementing the quality policy and achieving the quality objectives is derived from the Quality Assurance Manual and Standard Operating Procedures. Within these documents, management with executive responsibilities ensures that the quality policy is understood, implemented, and maintained at all levels of the organization. The development and implementation of appropriate accountabilities, duties, and authority by organizational positions are clearly delineated.

4 DOCUMENT MANAGEMENT

CT Laboratories maintains a quality system to ensure that analytical products and services conform to client specified requirements. The quality system is documented by this Quality Assurance Manual and associated standard operating procedures (SOPs). The QA department maintains a master listing or index of standard operating procedures (Appendix 2). The Quality Assurance Manual provides an outline and structure of the documentation used in the quality system, and is reviewed annually for accuracy and adequacy and revised as necessary to remain current with laboratory operations.

External Reference Materials come from sources other than the laboratory, but are used within the context of the quality system.

4.1 Controlled Documents

The CT Laboratories' document control procedures describe the mechanisms used to maintain control and accountability of laboratory controlled distribution documents.

All SOPs and Forms are assigned a unique procedure identifier. Other information included in every SOP is the effective date, revision number, total number of pages, and identification of any individual page revisions. CT Laboratories Document Control procedures are detailed in SOP QA-003.

Approved SOPs are stored securely on the network "Library" drive. This drive is accessible to all laboratory personnel. Copies of all outdated SOPs and Forms are marked as obsolete, the SOP and Form is removed from the Library and moved to a secure "Obsolete" Network drive for archiving. Printed documents are considered uncontrolled.

The QA Officer coordinates the laboratory's controlled distribution electronic document system. QA/QC department is responsible for maintaining the document's change, record sheet, and the document in complete and current form. The Master List of CT Laboratories' SOPs is presented in Appendix-2.

4.2 Standard Operating Procedures

Standard Operating Procedures (SOPs) are used to ensure consistency of application of common procedures, are written procedures that describe in detail how to accurately reproduce laboratory processes, and are of two types: 1) test method SOPs, which have specifically required details, and 2) general use SOPs which document the more general organizational procedures.

SOPs are reviewed annually and are the bases for internal method audits. If there are changes made to an SOP during review, an SOP review form is completed and appended to the last page of the original SOP kept on file. Specific details of writing/developing an internal SOP are outlined in CT Laboratories' SOP Preparation procedure QA-004.

Analytical SOPs must incorporate or reference the following topics:

1. Identification of test method
2. Applicable matrix or matrices
3. Detection limit

4. Scope of application
5. Summary of test method
6. Definitions
7. Interferences
8. Safety
9. Equipment and supplies
10. Reagents and standards
11. Sample collection, preservation, storage, and handling
12. Quality control
13. Calibration
14. Procedure
15. Calculations
16. Method performance
17. Pollution prevention
18. Data assessment and acceptance criteria
19. Corrective action for out-of-control data
20. Handling out-of-control data
21. Waste management and
22. References
23. Tables, Diagrams, Flowcharts, and Validation Data.

5 REVIEW OF REQUESTS, TENDERS AND CONTRACTS

The review of all new work assures that oversight is provided so that requirements are clearly defined, the laboratory has adequate resources and capability, and the test method is applicable to the customer's needs. This process assures that all work will be given adequate attention without shortcuts that may compromise data quality.

Contracts for new work may be formal bids, signed documents, verbal, or electronic.

5.1 Procedure for the Review of Work Requests

Management and project managers take part in determining if the laboratory has the necessary accreditations and resources; including schedule, equipment, deliverables, and personnel, to meet the work request.

Management or project managers take part in informing the client of the results of the review if it indicates any potential conflict, deficiency, lack of accreditation, or inability of the lab to complete the work satisfactorily.

The client is informed of any deviation from the contract including the test method or sample handling processes. All differences between the request and the final contract are resolved and recorded before any work begins. It is necessary that the contract be acceptable to both the laboratory and the client.

The review process is repeated when there are amendments to the original contract by the client. The participating personnel are given copies of the amendments. Any suspensions, revocations, or voluntary withdrawals of accreditation, affecting the scope of the project, are reported to the client. Any amendments to the contract after work has commenced, shall be communicated to all affected personnel.

For routine projects and other simple tasks, a review by the project manager is considered adequate. The project manager confirms that the laboratory has required certifications, it can meet the client’s data quality and reporting requirements, and has the capacity to meet the client’s turnaround needs.

For new, complex or large projects, the proposed work contract is given to Management, who will in turn forward the work contract to the appropriate personnel to evaluate such items as:

- contractual obligations and payment terms
- method capabilities, analyte lists, reporting limits, and quality control limits
- turnaround time feasibility
- QA/QC issues, including certification/accreditation
- formal laboratory quote
- final report formatting and electronic deliverable documents
- time required to keep sample in house
- final sample disposal requirements

Management or Marketing/Sales staff will submit the bid and formal quote to the client. The President maintains copies of all signed contracts.

5.2 Documentation of Review

Records are maintained for every contract or work request, including any work that is subcontracted. This includes pertinent discussions with a client relating to the client's requirements or the results of the work during the period of execution of the contract. These records are maintained by the Marketing and Sales staff and Project Managers and filed according to client project.

6 SUBCONTRACTING OF TESTS

When subcontracting analytical services, the laboratory assures work requiring accreditation is placed with an appropriately accredited laboratory or one that meets applicable statutory and regulatory requirements for performing the tests. When requested by the client, samples for analyses outside the analytical scope of CT Laboratories can be subcontracted to another laboratory. Unless otherwise specified or required by the client, samples will be subcontracted to a NELAP, DoD-ELAP accredited, ISO-17025 or State-program specific certified laboratory.

6.1 Procedure

A list of approved subcontractor laboratories is maintained by the President. Subcontracting records include evidence of compliance to NELAP, DoD-ELAP and/or ISO17025 accredited and are reviewed annually.

The laboratory notifies the client of the intent to subcontract the work either verbally or in writing. The laboratory makes all efforts to gain the approval of the client preferably in writing to subcontract their work prior to implementation.

The laboratory performing the subcontracted work is identified in the final report. Non-accredited work performed is clearly identified. The laboratory is responsible to the client for the subcontractor's work except in the case where a client or a regulating authority specified which subcontractor is to be used. Subcontracted work will be reported on the respective laboratory letterhead but is included in CT Laboratories' Certificate of Analysis.

7 PURCHASING SERVICES AND SUPPLIES

The laboratory ensures that purchased supplies and services that affect the quality of environmental tests are of the required or specified quality by using 17025 approved suppliers and products. A2LA also requires that reference material used in the calibration of test equipment shall be obtained from a reference material producer accredited to ISO Guide 34 or ISO 17034.

Management reviews and approves the supplier of services and supplies and approves technical content of purchasing documents prior to ordering. The evaluation of suppliers is accomplished by ensuring the supplier ships the product or material ordered and that the material is of the appropriate quantity by signing packing slips or other supply receipt documents. The purchasing documents contain the data that adequately describe the services and supplies ordered.

The laboratory keeps a list of approved suppliers in the network database. The procedure for purchasing of laboratory reagents and materials is detailed in SOPs AD-003 QA-011 and summarized below.

7.1 Procedure for Purchases

The analyst requests supplies using a supply form found in the laboratory. The analyst initials this request and verifies that the items requested meet quality specifications.

The Group Leader or personnel designated by the management places the orders with the vendor, using a Purchase Order Number for tracking purposes.

7.2 Procedure for Receipt of Supplies

Supplies received are reconciled against the packing list and inspected for damage. Supplies, reagents and chemical standards are checked-in (date, initial and expiration date where appropriate) and distributed to the appropriate individuals, departments or storage areas. See SOPs QA-024 and QA-025 for specifics on documentation of reagents and standards where supplies are given a unique identifier which encompasses lot number, date received, and expiration date. All documents received with supplies attesting to their use compliance (sterility, purity, cleanliness, etc.) are maintained and stored on the network H: Drive. Safety Data Sheets (SDSs), formerly known as Material Safety Data Sheets (MSDSs) are scanned and stored on the network S: drive.

7.3 Procedure for Storage of Supplies

Supplies received are stored according to manufacturer's instructions, laboratory SOP, or test method specifications.

7.4 Laboratory Grade Water

Laboratory grade deionized water is especially important for quality results. The laboratory maintains a vendor to supply and service the lab grade DI system for the lab. The water is monitored to determine when the tanks require changing. The laboratory also maintains a Milli Q water system to provide Type II reagent water. These systems are monitored to determine when filters need changing or five years after installation, whichever is more frequent.

8 SERVICE TO THE CLIENT

The laboratory collaborates with clients and/or their representatives in clarifying their requests and in monitoring of the laboratory performance related to their work. Each request is reviewed to determine the nature of the request and the laboratory's ability to comply with the request within the confines of prevailing statutes and/or regulations without risk to the confidentiality of other clients.

8.1 Client Confidentiality

The laboratory confidentiality policy is to not divulge or release any information to a third party without proper authorization. For specific procedures on client confidentiality see SOP QA-019.

All electronic data (storage or transmissions) are kept confidential, based on technology and laboratory limits, as required by client or regulation.

The following confidentiality notice is to be included with each email or fax transmission to our clients.

CONFIDENTIALITY NOTICE

The information contained in this document is privileged, confidential, and protected under applicable law. It is intended solely for the individual or entity to whom it is addressed. If you are not the intended recipient, you are hereby notified that any dissemination, distribution or copying of the communication is strictly prohibited. If you have received this communication in error, please notify the sender immediately by telephone and destroy the document.

9 CUSTOMER INQUIRES/COMPLAINTS

CT Laboratories is committed to customer service and assures that when a customer complaint arises, it is addressed immediately and resolved as quickly as possible. This includes requests to verify results of analtyical data. Both positve and negative feedback provide an opportunity to improve laboratory operation and client satisfaction. The laboratory provides an electronic survey link on our website, which gives our clients the opportunity to assess our service. Complaints by cutomers or other parties are reviewed by the management and an appropriate action is determined.

All customer complaints are documented on thePreventative Action Request Form FQA7-01, by the person receiving the complaint. A member of management is immediately notified of the Non-Conformance and an investigation is initiated. During the complaint resolution process, managemement and the analysts and/or staff member involved will meet to discuss the situation that gave rise to the complaint. This investigation can include but is not limited to a complete review of the raw data and/or reanalysis of the sample. The client will be notified of the outcome of the investigation and the necessary actions being implemented. If required, the Certificate of Analysis will be revised and resubmitted upon determining that the data is affected and the reason for the resubmittal is documented in the case narrative. If it is determined that the complaint has merit, the procedures outlined in Section 11 – Corrective Action are utilized and documented in the Non-Conformance Tracking System. If it is determined that a complaint is without merit, the Non-Conformance Tracking Form can be closed immediately as no further investigation or review is required.

A complaint such as a concern that data is repeatedly late is reiewed for preventative action (see Section 12 – Preventative Action) to minimize a future occurrence.

10 CONTROL OF NON-CONFORMING WORK

When a non-conforming event or process deviation has occurred, corrective action is required. A written standard operating procedure (plan for corrective action) provides the steps for dealing with an out-of-control testing situation. The assessment of whether the process is out-of-control is based on predetermined limits for laboratory operations.

Non-conformances based on statistical analysis or quality control samples are readily apparent and easy to identify. A process deviation, which does not have a directly observable impact on data quality, is more difficult to discern. Examples of the latter, subtler types of non-conformances include volatile samples not properly stored; oily layers in certain types of samples that may interfere with analysis; or a water-soaked sample label whose information is barely legible. Discovery of a non-conforming event or process deviation can result from the observations of a staff member, a review of laboratory data at any level, the result of an audit, or a client complaint. A corrective action will be initiated within one week of the discovery of any nonconformance investigation.

The time frame required to resolve a specific deficiency and implement the corrective action is dependent on the magnitude of the problem and the defensibility and use of the data. Most non-conformances should be resolved within 30 days from the initiation date. Non-conformances that specifically impact sample results should be resolved within 5 days.

The project manager will contact the client within 15 business days after the determination that there quality issues that impact the data for QSM work and as soon as practical after the determination that there is a negative impact to the data for non-QSM work.

11 CORRECTIVE ACTION

To consistently achieve technical and regulatory requirements, the data produced by CT Laboratories is supported by an effective corrective and preventive action system. The system is capable of isolating and correcting both random and systematic errors. Problems requiring corrective action are identified through nonconformance corrective action reports, internal and external audits and surveillances; data review, and client inquiries. When evaluation of performance against established criteria for good laboratory practices shows a condition that could adversely affect the quality of services provided, or when there are departures from documented policies, procedures or applicable Standards, corrective action is initiated. Procedures for Nonconformances (NCR), and corrective actions, are detailed in SOP QA-002. Preventative action procedures are discussed in this manual.

All corrective actions, whether immediate or long-term, will contain the following steps to ensure a closed-loop process:

1. Definition of the problem,
2. Assignment of responsibility for investigating the problem,
3. Determination of a corrective action to eliminate the problem,
4. Assignment of responsibility for implementation the corrective action (and commitment of responsible party,
5. Implementation of the correction, and
6. Assessment of the effectiveness of the corrective action, including verification that the problem has been eliminated and that the solution will prevent reoccurrence.

11.1 Non-Conformances

Quality indicators are evaluated against method, client specified, or laboratory established QA/QC requirements. The initial responsibility to monitor the quality of a function or analytical system lies with the analyst performing the task or procedure. Laboratory quality control procedures usually identify the situations that require immediate correction. In these cases, the analyst has relatively quick feedback that a problem exists, e.g., calibration does not meet or quality control check samples exceed allowable criteria, and can take immediate action to repair the system. Types of quality control check samples, their frequency, acceptance criteria, and corrective action can be found in the method SOPs.

When an acceptable resolution cannot be met or data quality is negatively affected, the analyst notifies the Group Leader, Laboratory Director, QA, or Project Manager and initiates a Nonconformance Report in the LIMS based on SOP QA002. Data generated during an out-of-control situation are evaluated for usability. If the deficiency does not affect the usability of the results, data are reported and the deficiency noted in the case narrative. For DoD project, a copy of the NCR is included in the data package, if requested by the client. Data that are negatively impacted by an out-of-control system are not released without approval of either the QA Officer, or Laboratory Director, and the client. If the validity of results is in question, the project manager will contact the client as soon as practical and within 15 business days of the discovery for a DoD project. Records of the corrective actions taken to resolve the non-conformance will be submitted to DoD project clients within 30 business days of the discovery.

If QA receives a large number of NCRs, or further action is required, a Corrective Action Report (CAR) (SOP QA002) is initiated. A CAR may also be initiated by any laboratory employee for problems not suited to or broader in scope than NCRs. These reports are a key tool for monitoring trends.

Any analyst, with the concurrence of the Quality Assurance Manager has the authority to stop the analysis if there is a failure to meet method or project requirements. The QA Officer may authorize holding all analyses of samples affected by an out-of-control situation. The analysis cannot be restarted without appropriate documentation including the QA Officer's approval.

11.2 Long Term Corrective Action

Long-term corrective actions are generally initiated for QA issues that have been identified through internal and external audits. A long term corrective action requires a deeper investigation into the root cause of the nonconformance, and the problem may take much longer to identify and resolve. Staff training, method revision, replacement of equipment, and LIMS reprogramming, are examples of long-term corrective action.

Group Leaders are responsible for elevating correction of out-of-control situations to the highest priority. Associated corrective actions, once verified for effectiveness, are incorporated into standard procedures. Ineffective actions are re-evaluated and the process repeated until acceptable resolution is achieved. Senior analysts are accountable to the Group Leader to ensure that final acceptable resolution is achieved.

Any out-of-control situations that are not addressed adequately at the laboratory level may be elevated to the Laboratory Director and/or President, indicating the nature of the out-of-control situation and problems encountered with resolution. This provides the QA Officer with support outside direct laboratory supervision, if needed; to ensure QA policies and procedures are enforced.

11.3 Exceptionally Permitting Departures from Documented Policies and Procedures

CT Laboratories allows the release of non-conforming data only with approval by the Laboratory Director or their designee on a case-by-case basis. Planned departures from procedures or policies do not require audits or investigations.

Permitted departures for non-conformances are fully documented and include the reason for the departure. For specific procedures for processing samples outside of the quality system guidelines, see SOP QA-018.

12 PREVENTIVE ACTION

12.1 Preventative Action

CT Laboratories maintains preventive action programs to define, improve, or eliminate potential causes of nonconforming product and/or nonconformance to the quality system. The preventive action process is a proactive continuous process improvement activity that can be initiated by clients, employees, business providers, and affiliates. The QA department has the overall responsibility to ensure that the preventive action process is in place, and that relevant information on actions is submitted for management review.

Preventive action opportunities may be identified from information obtained through activities related, but not limited, to the corrective action process, performance evaluation program, internal audits, and management review. Established standard procedures for preventive action are included in CT Laboratories' SOPs. Examples include, but are not limited to, annual refresher training for analysts, instrument maintenance, document control, and communicating client requirements to analysts and project set-up in the LIMS. Corrective action reports document on going preventive actions to insure that non conformities do not recur.

For specific preventive action procedures, see SOP QA-007.

13 CONTROL OF RECORDS

The laboratory will retain all records related to sample analysis including raw test data, calculations, derived data, calibrations and copies of test reports. These paper records will be stored in systematic manner for a minimum of five years, while electronic records are currently held for a minimum of 10 years. Longer periods of storage shall be arranged at the request of the client. If the laboratory ceases operations, clients will be notified at least 60 days (if time permits) prior to closure of the laboratory and will receive a final report for all submitted samples. The client notification will request instructions on the retention or distribution of laboratory records and will provide contact information for after the closure. Software/hardware permitting the access of electronic data must be maintained.

The copy of client reports is stored electronically on a secured network. Archived reports are available through limited tracked access on the secure server. All archived logbooks, corrective actions, PT results, training records, and other QA/QC reports are also stored on a secure CT Laboratories' network. Written and printed data records (bench sheets, logbooks, electronic printouts, etc.) are boxed and placed in the storage area. Electronic data is stored on a dedicated server. CT Laboratories' data are removed from the servers and stored at a secure location and but can be reloaded by submitting a request to IT. The safety officer keeps safety and disposal information. The Human Resources keeps personnel information in locked files.

Archived electronic and paper copies of data are stored on-site until capacity is met. The storage of records are monitored and protected from fire and theft, loss, environmental deterioration, vermin and in the case of electronic records, electronic or magnetic sources.

For specific control of records procedures see SOP QA-003 and for specific records management procedures see SOP QA-009. The procedure for the control of laboratory notebooks and logbooks is detailed in SOP QA-010. The procedures for the documentation or organic and inorganic reagents and standards are detailed in SOPs QA-024 and QA-025 respectively.

14 STATISTICAL CONTROL

As part of the analytical quality control program, the precision and accuracy for each analytical method is established by the use of control charts. The charts are used to assess the method performance over a period of time. A minimum of 30 points are used to establish a control chart. Control limits of ± three standard deviations are utilized. The procedure for control charting and quality control samples can be found in SOP QA-017.

Control charts are used to predict trends (positive or negative) in the analytical processes and to determine when an analysis is out of control. Examples of conditions reflected in control charts are:

- Shift in mean - usually caused by incorrectly prepared standards or reagents, contamination of sample, problems in instrument calibration, or analyst error.
- Trend of mean downward - usually caused by deterioration of standards or reagents.
- Trend of mean upward - usually caused by concentration of standard due to solvent evaporation or deterioration of reagents
- Increase in variability - usually caused by poor analyst technique or deviation from procedure.

14.1 Precision

Precision is defined as the degree to which a set of observations or measurements of the same property, obtained under similar conditions conform themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms. (NELAC 2003) Precision is the measure of how closely multiple analyses of a particular sample agree with each other. To determine the precision of the method and/or laboratory analyst, a routine program of duplicate analyses is performed. The results of the duplicate analyses are used to calculate the relative percent difference (RPD), which is the governing quality control parameter for precision. The relative percent difference (RPD) for duplicate analyses is defined as 100 times the difference (range) of each replicate set, divided by the average value (mean) of the duplicate set.

14.2 Accuracy

Accuracy is defined as the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator. (QAMS) Accuracy is the measure of the closeness of an observed value to the “true” value (theoretical or reference value or population mean). The accuracy of an analytical method and/or the laboratory analyst is based on the analysis of laboratory control standards. LCS results are used to calculate the quality control parameter for accuracy evaluation, the percent recovery (%R). The %R is defined as 100 times the observed concentration divided by the true concentration of the spike.

14.3 Uncertainty

Uncertainty can be calculated using the Quality Control based Nested approach, as described in SOP QA-021. Uncertainty will only be calculated if requested by the client. The approach uses batch QC over a period of time. This approach can also incorporate sample uncertainty if field QC is available. A minimum of 30 measurements is required.

15 AUDITS & MANAGEMENT REVIEW

Audits measure laboratory performance and verify compliance with accreditation/certification and project requirements. Audits specifically provide management with an on-going assessment of the quality system. They are also instrumental in identifying areas where improvement in the quality system will increase the reliability of data. Audits are of four main types: internal, external, performance, and system.

Notification of clients for events that cast doubt on the validity of the results is completed as soon as practical.

CT Laboratories considers management reviews and internal reviews as separate activities.

15.1 Management Reviews

CT Laboratories management conducts periodic meetings as a review of the laboratory's quality system and environmental testing activities to ensure their continuing suitability and effectiveness, and to introduce necessary changes or improvements. This is a system-wide assessment upon the review at least once annually; the President writes a report summarizing the weekly meeting findings and any new policy decisions. The Management Review procedures are detailed in SOP QA-013-Management Review.

The review will include at least the following over the course of one year:

- The suitability of policies and procedures;
- Reports from managerial and supervisory personnel;
- Corrective and preventive actions;
- Assessments and audits (external and internal respectively)
- The results of proficiency tests;
- Changes in the volume and type of the work;
- Client feedback;
- Complaints;
- Adequacy of staff, equipment, and facility resources; and
- Recommendations for improvement.

15.2 Internal Audits

Internal audits are conducted using a predetermined schedule, documented by the QA Department and include all methods included in the laboratories scope of accreditation. A member of the QA Department or a trained and qualified designee, who is independent of the activity being audited, performs the audits as described below. For the complete Internal Audit Procedure see SOP QA-006. As part of the scheduling, all technologies and Departments must be reviewed at least annually. Audits are documented with records maintained in the QA Department. The goal of internal audits is to determine if

lab activities meet the requirements of the quality system and the DoD ELAP/NELAC and 17025 standards.

System audits are performed to determine if all aspects of the QA program are operational under the guidance of audit checklist. The QA Officer reviews all information pertaining to QA system, summarizes the situation and notes any deficiencies. A report is prepared based on the audit and is distributed to management in a timely manner. The report is also discussed with laboratory personnel so that a concerted effort can be made to correct any deficiencies as well as provide positive feedback. The QA Officer reviews the following elements of the program:

- Sample handling, including custody and storage procedures
- Sample analysis
- Records
- Preventive maintenance
- Check sample programs (proficiency testing)
- Training
- Project Management

Method audits are performed throughout the year. These audits focus on a specific method or technology. An analyst is observed performing the method including QC and client samples. The goal of the audit is to determine if the SOP is being followed and traceability of the standards and documentation is maintained. Additionally, the SOP is reviewed for method compliance and is updated as necessary. Part of the system audit is performed at this time including training of analyst performing the tests and performance in the PT program. After the audit, a report is issued to the Laboratory Director and President. Follow-up audits are necessary to determine if changes are being implemented.

Should an audit finding cast doubt on the effectiveness of the operations or on the correctness or validity of the results, the laboratory shall take timely corrective action and notify DoD clients in writing within 15 business days if the investigation show that the results may have been affected.

Monthly audits are performed to check support system compliance. A member of QA staff performs these audits and a report is summarized into a Quarterly Quality Review which is issued to the Laboratory Director. Follow-up and corrective action is performed as necessary. At least the following items are reviewed:

- Personnel
- Equipment
- Proficiency Test
- Secondary Equipment
- Subcontracted Laboratories
- Vendors for Critical Supplies and Reagents
- Review of Non Conformance Table and Corrective Actions

- Labeling of Standards and Reagents
- Chain of Custody Procedures.

15.3 External Audits

External audits and assessments are scheduled through the QA Officer with accrediting bodies, regulators and clients. It is the policy of CT Laboratories that all information pertaining to that client or scope of accreditation be available for review by the auditor(s). Client confidentiality must be maintained throughout the audit process. The QA Officer is responsible for monitoring the audit, reviewing all findings, issuing a corrective action plan within the timeframe specified and follow-up to ensure approved changes are implemented. All documentation pertaining to the audit is kept on file.

15.4 Performance Audits

Performance audits may be Proficiency Test Samples, internal single-blind samples, double-blind samples through a provider and/or client, or anything that tests the performance of the analyst and method.

The policy and procedures for Proficiency Test Samples are discussed in Section 23.7 of this manual.

16 TRAINING AND DATA INTEGRITY

16.1 Data Integrity and Ethics

Data integrity is the result of the processes that together assure valid data of known and documented quality.

Data integrity and ethics procedures in the laboratory include training, signed and dated integrity documentation for all laboratory employees and management, periodic monitoring of data integrity, and documented data integrity procedures.

16.2 Ethics Policy

CT Laboratories utilizes a clearly stated ethics policy in the Ethics and Data Integrity Statement. This agreement is discussed with all new employees during orientation and signed and retained with the employee's training file. Violation of the agreement is basis for termination of employment. In addition, each employee receives training in data integrity and signs the ethical policy and CT Laboratories' Code of Ethics and Data Integrity Agreement in (Appendix 3) annually. Any instances of inappropriate and prohibited practices must be reported to the DoD Accrediting Body (DoD AB) within 15 business days of the discovery. The laboratory must submit to the DoD AB records of the taken or proposed corrective actions within 30 business days of the discovery.

Examples of unethical behavior include but are not limited to:

- Fabricating Results
- Altering Instrument Settings
- Altering the Chain of Custody
- Altering Calculations
- Altering Approved Standard Operating Procedure
- Lack of reporting unethical behaviors by others

16.3 Training Orientation

The following is a general over view of the training program utilized by CT Laboratories, for specific details see SOP QA-005 Employee Training. Human Resources, in conjunction with QA, initiate training orientation for each new employee on the first day of employment. Orientation includes completion of various training items listed on the New Employee Checklist. This checklist provides documentation of the orientation after being signed by the new analyst and the trainer and become a part of the employee's permanent training record. A new employee will fill out the Electronic Signature Verification form. The hard copy of the form is stored in the employee's training file and is used to generate an electronic signature. This signature is distributed to the employee and the original electronic signature stored in a secure location. Initially and annually thereafter, employees shall have training in security awareness; Appendix 10: Security Awareness Training form. Included in the training are the Laboratories requirements for the security of the lab's computer system.

16.4 Ethics/Data Integrity Training

Data integrity training is provided for all employees initially upon hire and annually thereafter.

Attendance at an initial data integrity training (part of new employee orientation) and the annual refresher training is required and recorded with a signature attendance sheet or other form of documentation that demonstrates all staff have participated and understand their obligations related to data integrity.

Training records regarding data integrity and ethics are signed and dated by individual employees.

When contracted technical or support personnel are used, management is responsible for ensuring that they are trained to the laboratory's quality system and data integrity procedures, competent to perform the assigned tasks, and appropriately supervised.

Key topics covered during data integrity training include: the organizational mission and its relationship to the need for honesty and full disclosure in all analytical reporting; how and when to report data integrity issues; recordkeeping; discussion regarding all data integrity procedures; data integrity training documentation; in-depth data monitoring; data integrity procedure documentation; improper data manipulations; adjustments of instrument time clocks; inappropriate changes in concentrations of standards; the importance of proper written narration on the part of the analyst with respect to those cases where analytical data may be useful, but are in one sense or another partially deficient; written ethics agreements; examples of improper practices; examples of improper chromatographic manipulations; requirements for external ethics program training; any external resources available to employees; and consequences for data integrity infractions.

It is the intent of CT Laboratories to consistently report data of the highest quality. For this to be possible, analysts are instructed in accordance with the level of data quality desired and are provided with an environment conducive to its achievement. Besides providing the analyst with all necessary supplies and equipment, the work environment is maintained as free from undue pressures as possible. Such pressures may be through internal peer pressure or deadlines, or through external customer complaints or priority requests. It is the responsibility of management to insulate the analyst from such pressures as much as possible. Data quality cannot be compromised without reason and the analyst will not be reprimanded for adhering to established quality protocols in the face of such pressures. During the orientation with human resources, these policies will be explained and the employee asked to review and sign a Code of Ethics/Data Integrity Policy Agreement. This agreement documents the understanding between management and the new employee concerning management's position on data quality, sample analysis and data reporting, and the consequences of improper actions. The signed agreement is retained as part of the employee's permanent record.

16.5 General Training

The following is a general over view of the training program utilized by CT Laboratories. For program specifics, see SOP QA-005. It is the policy of CT Laboratories to hire employees with an educational background and/or experience in an analytical field. On-the-job training takes place for all new employees based on needs identified by the respective job description and tasks of the position.

Selection of qualified candidates for laboratory employment relies on documentation of minimum education, training, and experience prerequisites needed to perform the prescribed task. Chemists/technicians accountable for performing tasks in any of the following areas must meet associated minimum experience requirements. See section 2.4 for specific minimum education, experience and training.

All personnel who are involved in activities related to sample analysis, evaluation of results or who sign test reports, must perform demonstration of capabilities in their area of responsibility. See SOP QA-005 for Employee Training specifics. Appropriate supervision is given to any personnel in training and the person supervising an analyst in training is accountable for the quality of the analytical data and must review and approve data and associated corrective actions.

Personnel are qualified to perform the tasks they are responsible for, based on education, training, experience and demonstrated skills as required for their area of responsibility (Note: some states/agencies require additional training experience and documentation. These will be addressed on a case-by-case basis during the proposal process or contract review.)

The laboratory provides goals with respect to education, training and skills of laboratory staff. Training needs are identified at the time of employment and when personnel are moved to a new position or new responsibilities are added to their job responsibilities. Ongoing training, as needed, is also provided to personnel in their current positions. The effectiveness of the training must be evaluated before the training is considered complete.

Each employee participates in a comprehensive training program tracked by the laboratory's quality manager. This program is designed to provide an introduction to laboratory policies and procedures and document the processes that provide proof of an analyst's proficiency. Data Integrity is stressed in all areas of training. Highlights of the program include an orientation process that includes CT Laboratories' commitment to quality, ethical standards and data integrity; initial training to attain requisite proficiency; continual monitoring of the employee's progress; opportunity for career enhancement seminars or training courses; and documentation files to track each analyst's progress. Training for Health and Safety and Waste Management procedures include handling of samples containing mixed/hazardous waste. Annual refresher training reviews the Quality Assurance Manual and Quality Systems, Ethics Policy and Data Integrity, and Health & Safety.

Demonstration of Capability (DOC) Appendix 5 and 6 forms are included in the analyst training files to document qualifications for method performance. For methods where a DOC is not applicable, e.g., solids, paint filter test; a PE sample and/or training with an experienced analyst will satisfy the requirement. The successful analysis of routine quality control indicators (e.g., calibrations, method QC are demonstrative of ongoing demonstrations of capability. For specific demonstration of capability requirements, see SOP QA-022.

17 ACCOMMODATIONS & ENVIRONMENTAL CONDITIONS

Laboratory facilities are designed and organized to facilitate testing of environmental samples. Factors affecting tests include but are not limited to energy sources, lighting, temperature, humidity, biological sterility, and cleanliness. These conditions are monitored to ensure that they do not invalidate results or adversely affect the required quality of any measurement.

Environmental analyses are stopped when the environmental conditions jeopardize these analyses.

Access to, and use of areas affecting the quality of the environmental tests is controlled by restriction of areas to authorized personnel only.

The laboratory work spaces are adequate for their use, and appropriately clean to support environmental testing and ensure an unencumbered work area.

Procedure

Laboratory space is arranged to minimize cross-contamination between incompatible areas of the laboratory.

Extraction room: Negative pressure
Metals: Negative pressure
Volatiles Lab: Positive pressure with discreet air handling system

If the laboratory environment is required to be controlled by method or regulation, the adherence is recorded.

Procedure for Unencumbered Work Area

- The laboratory is cleaned nightly by a CT Laboratories' facilities employee
- Each employee is responsible for straightening up their work area at the end of the day
- All samples are returned to sample refrigerators at the end of each day
- All reagents and solvents are properly capped and returned to appropriate storage location at the end of each day
- All glassware is cleaned and put away
- All counter tops are wiped down

Procedure for Environment Control

- Testing occurs only within the laboratory.
- Laboratory space is maintained and monitored to the specifications required for laboratory space and the testing performed.
- Electronic balances are located away from drafts and doorways and mounted on marble slabs in areas where their use is protected by vibrations.
- Biological work areas are sterilized between uses. Neighboring test areas of incompatible activities are effectively separated.

- Specific work areas are defined and access is controlled. (Only authorized laboratory personnel and escorted signed-in visitors may enter the work area.)
- Good housekeeping measures are employed to avoid the possibility of contamination.
- Smoking is prohibited.
- All equipment and reference materials required for the accredited tests are available in the laboratory.
- Records are maintained for all equipment, reference measurement materials, and services used by the laboratory.
- Reference materials traceable to national standards of measurement or to national standard reference materials are stored away from heavy use areas or major equipment that may affect the proper operation of the materials.
- Certificates of Traceability are available for the reference thermometers and the Class 1 weights. The reference materials are used only for calibration to maintain the validity of performance.

18 TEST METHODS AND METHOD VALIDATION

A method used under an accredited program is validated before it is put into use. All validated methods are published or documented.

Note: It is understood that some testing may be requested by clients that does not fall under an accreditation program and full validation may not be required for analysis.

Policy

The introduction of test methods developed by the laboratory for its own use is a planned activity assigned to qualified personnel equipped with adequate resources to accomplish validation. Plans are updated as necessary and communicated to all involved personnel.

18.1 Demonstration of Capability (DOC)

Demonstration of Capabilities (DOC) is documented and completed forms are kept in the training files for each analyst. All supporting data contributing to the DOC is retained and available.

A DOC is performed for each analyte whenever the method, analyst, full work cell, analyte(s), or instrument type is changed. When a member of a work cell is changed, a DOC must be performed by the new member and must pass all DOC criteria before that member can work independently.

The Laboratory Director or the Quality Manager or his/her designee certifies that technical staff members in their area of expertise are trained and authorized to perform all tests for which we are accredited by signing the DOC form.

The process for DOC is found in SOP QA-022 and is summarized below:

a) A quality control sample is obtained from an outside source or prepared using stock standards which are independent from those used in instrument calibration.

b) The analyte(s) is prepared using a clean quality system matrix sufficient to prepare four aliquots at the concentration specified, or if unspecified, to a concentration of 1-4 times the limit of quantitation.

c) At least four aliquots are prepared and analyzed according to the test method either concurrently or over a period of days.

d) Using all of the results, calculate the mean recovery in the appropriate reporting units and the standard deviations of the population sample (in the same units) for each parameter of interest. When it is not possible to determine mean and standard deviations, such as for presence/absence and logarithmic values, the performance is assessed against established and documented criteria.

e) Compare the information from (d) above to the corresponding acceptance criteria for precision and accuracy in the test method (if applicable) or in laboratory-generated acceptance criteria (if there are not established mandatory criteria). If all parameters meet the acceptance criteria, the analysis of actual samples may begin. If any one of the parameters do not meet the acceptance

criteria, the performance is unacceptable for that parameter. The acceptance criteria must be defined prior to the analyst performing the method.

f) When one or more of the tested parameters fail at least one of the acceptance criteria, the analyst must proceed according to 1 or 2 below.

1. Locate and correct the source of the problem and repeat the test for all parameters of interest beginning with c) above.

2. Beginning with c) above, repeat the test for all parameters that failed to meet criteria.

Repeated failure, however, confirms a general problem with the measurement system. If this occurs, the source of the problem is located and corrected and the test repeated for all compounds of interest beginning with c).

18.2 Continuing Demonstrations of Analyst Capability

A Continuing Demonstration of Capability (CDC) after the demonstration of capability is completed; on-going proficiency is maintained and demonstrated at least annually through the analysis of either single-blind samples or performing another DOC compared to pre-determined acceptance limits for precision and accuracy. This is documented in the training file of each analyst.

18.2.1 Initial Test Method Evaluation

For chemical analyses, the initial test method evaluation involves the determination of the Limit of Detection (LOD), confirmation of the Limit of Quantitation (LOQ), an evaluation of precision and bias, and an evaluation of the selectivity of the method.

For microbiological analyses, the initial test method evaluation involves comparison with an approved method, or analyzing 10 spiked samples of a representative matrix, or by analyzing and passing one proficiency test series by an approved PT provider.

18.2.2 Method Detection Limits (MDL)

The method detection limit (MDL) is the lowest concentration that can be measured for a given analytical method and sample matrix with 99% confidence that the analyte is present and one way to establish a detection limit not the Limit of Detection. The MDL is determined according to Appendix B of 40 CFR 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants". MDLs reflect a calculated (statistical) value determined under ideal laboratory conditions in a clean matrix, and may not be achievable in all environmental matrices. MDL studies are retained by the QA department. The full MDL procedure is found in SOP QA-023.

18.2.3 Limit of Detection (LOD)

The LOD is the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%.

LODs are determined from a quality system matrix using all sample processing steps, and are verified quarterly or when there is a change in the test method or instrument that affects sensitivity.

The laboratory performs an MDL study for all analytes for which a spike can be created and the LOD is determined based on this study as specified in 40 CFR Part 136 Appendix B. The LOD is then set at the concentration at which it was verified and may be reported to the same significant figures as the samples using laboratory rounding rules.

Validity of the LOD is confirmed quarterly by analyzing a qualitative QC sample in each matrix at no more than 1-3 X the MDL for a single analyte test and 1-4 X for multiple analyte tests. This verification must be performed on each instrument used for sample analysis to report data.

{NOTE: When more than one instrument is used for the same test, the LODs are determined on each instrument. The highest LOD is then used for all instrumentation and the same verification concentration is used on all instruments.}

18.2.4 Limit of Quantitation (LOQ)

The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence

The lowest calibration standard may be equal to or less than the LOQ, but not above the LOQ.

The LOQ will always be greater than or equal to the LOD.

The LOQ is verified quarterly using a quality systems matrix sample spiked at 1-2 times the determined LOQ that returns a concentration within the acceptance criteria for accuracy according to the requirements of the Laboratory Control Samples.

18.2.5 Precision

Precision is the measure of how closely multiple analyses of a particular sample agree with each other. To determine the precision of the method and/or laboratory analyst, a routine program of duplicate analyses is performed. The results of the duplicate analyses are used to calculate the relative percent difference (RPD), which is the governing quality control parameter for precision. The relative percent difference (RPD) for duplicate analyses is defined as 100 times the difference (range) of each replicate set, divided by the average value (mean) of the duplicate set.

18.2.6 Accuracy

Accuracy is the measure of the closeness of an observed value to the “true” value (theoretical or reference value or population mean). The accuracy of an analytical method and/or the

laboratory analyst is based on the analysis of laboratory control standards. The results laboratory control standards are used to calculate the quality control parameter for accuracy evaluation, the Percent Recovery (%R). The %R is defined as 100 times the observed concentration divided by the true concentration of the spike.

The QA targets for all inorganic analyses are defined in the SOP with less than 20 RPD for precision. The organic QA targets are statutory in nature; warning and control limits for organic analyses are initially set for groups of compounds based on preliminary method validation data. When additional data is available, the QA targets may be reconsidered. All QA targets are routinely re-evaluated at least annually (and updated, if necessary) against laboratory generated data to insure targets continue to reflect realistic, methodologically achievable goals.

18.3 Uncertainty

Uncertainty can be calculated using the Quality Control based nested approach as described in Estimation of Analytical Measurement Uncertainty- SOP QA-021. Uncertainty will only be calculated if requested by the client. The approach uses batch quality control over a period of time. This approach can also incorporate sample uncertainty if field quality control is available. A minimum of twenty measurements is required.

18.4 Laboratory-Developed or Non-Standard Method Validation

Laboratory developed, modified standard methods, and non-standard methods may require method validation.

Where applicable, the laboratory validates non-standard methods, laboratory-designed/developed methods, standard methods used outside their published scope, and amplifications and modifications of standard methods to confirm that the methods are fit for the intended use. The range and accuracy of the values obtainable from validated methods (e.g. the uncertainty of the results, detection limit, selectivity of the method, linearity, limit of repeatability and/or reproducibility, robustness against external influences and/or cross-sensitivity against interference from the matrix of the sample/test object), is assessed for the intended use and whether it is relevant to the clients' needs.

The use of non-standard methods by the laboratory is agreed upon in advance with the client.

Any updates to the method development plans are communicated to all involved personnel.

18.5 Control of Data

All calculations and all relevant data are subject to appropriate checks in a systematic manner and verified manually.

New software is tested and verified for accuracy before being implemented on the system. Documentation of software approved for use is maintained in a verification file and kept by the QA Officer. After implementation, all users are advised of the changes and requested to report any

problems with the software to the IT and/or LIMS Coordinator. When updates are received from the manufacturer, the revised name and date/time stamp provide version control.

All computer workstations are protected from outside access using Windows Active Directory. When workstations are not in use or are not monitored, they are automatically locked using the native Windows OS .

Work Cells are identified and use common Login credentials within the cell to control instrument workstations and to allow for work cell access to common data. The personnel identified as part of the work cell are provided with the instrument login account information.

Procedure

The laboratory assures that computers and software are protected, maintained, and secure through measures such as documentation, locked access, and control of the laboratory environment. For the specific procedure for good automated laboratory practices, see SOP QA-008.

Only authorized personnel have access to the laboratory and any storage areas. All computers are password protected. Annually, employees will update their LIMS password.

The laboratory assures that computers, user-developed computer software, automated equipment, or microprocessors used for the acquisition, processing, recording, reporting, storage, or retrieval of environmental test data are:

a) documented in sufficient detail and validated as being adequate for use;

b) protected for integrity and confidentiality of data entry or collection, data storage, data transmission and data processing;

c) maintained to ensure proper function and are provided with the environmental and operating conditions necessary to maintain the integrity of environmental test data; and

d) held secure including the prevention of unauthorized access to, and the unauthorized amendment of, computer records.

19 EQUIPMENT

19.1 General Equipment Requirements

The purchase of analytical instrumentation is based on anticipated sample volume and the need to maintain superior quality data. Specifications are carefully examined to be sure new instrumentation meets current and anticipated needs. Warranty and service contract information is gathered at the time bids are reviewed and this information is considered in making the final selection. An extensive performance check-out before the instrument is accepted is mandatory. New equipment must undergo a rigorous method validation before being put into service. Operators of new instruments are sent to training courses if necessary. Inventory records are maintained for all major capital equipment.

Laboratory equipment and instrumentation are maintained in compliance with instrumentation manuals. All equipment is kept in working condition to allow for conformity to each approved method. A list of instrumentation and equipment is maintained by the QA/QC Department and is included in Appendix 7. Laboratory equipment is uniquely identified.

19.2 Equipment Operation and Calibration

Equipment is defined as any non-disposable mechanical and/or electronic device used in the generation or measurement of data.

The calibration of instruments and support equipment is required to ensure that the analytical system is operating correctly and functioning within acceptable precision, accuracy and sensitivity limits. Calibration is defined as the systematic determination of the relationship of the response of the measurement system to a known standard. If traceable chemical standards are not available, standards are prepared according to the laboratory quality control procedures or the project's requirements. The calibration requirements for each type of equipment or instrument are defined in the standard operating procedures.

{Note: The calibrations or calibration checks are performed with reference standards traceable to primary standards (e.g. NIST or other certified standards)}.

It is the responsibility of the analyst to verify that the instrument configuration and operating conditions used satisfy the analytical requirements and to maintain quality control data confirming instrument performance and analytical results. The inability to achieve calibration is an indication that the equipment needs maintenance. It is not acceptable for an analyst to repeat analysis of calibration or quality control standards beyond what is allowed by the SOP until “acceptable” results are achieved.

If equipment outside the permanent control of the laboratory is used, it must meet the same criteria. The laboratory shall ensure that the function and calibration status of the equipment is checked and shown to be satisfactory before it is put into service and must meet all requirements of DoD ELAP NELAC and 17025: 2005 standards.

20 EQUIPMENT MAINTENANCE

Maintenance is defined as cleaning and/or replacing equipment components to assure that the equipment has been properly and periodically serviced and is in satisfactory condition. The equipment manual is a good guideline to determine preventive and routine maintenance schedules. These manuals also assist in identification of commonly needed replacement parts so that an inventory of these parts can be properly maintained.

A maintenance log is issued for each piece of equipment. It shall be maintained by the analyst to describe problems, the maintenance performed on the instrument and outcome. This includes routine service checks by laboratory personnel (unless described in the SOP) as well as factory service calls. This log also provides a written source for future use in preventive maintenance. The logs are periodically reviewed by QA.

In order to prevent system down time, minimize corrective maintenance cost and to help insure data validity, CT Laboratories uses a system of preventive maintenance. All routine maintenance is performed as recommended by the manufacturer. Periodic preventive maintenance is performed in-house and immediate service for corrective actions. Manufacturer representatives are called when services cannot be performed in-house.

When a piece of equipment is deemed defective, it is taken out of service and identified with an "OUT OF SERVICE" label. For support equipment such as balances, ovens, coolers, and pipettes, the QA/QC Department is notified so that proper servicing and repair can be scheduled. The analysts perform routine and preventive maintenance for major instrumentation. Satisfactory instrument performance must be verified prior to returning to service of any repaired equipment. All equipment is calibrated or checked before being placed into use to ensure that it meets laboratory specifications and the relevant standard specifications. Additional, ongoing checks or calibrations are performed as necessary to comply with required specifications.

Each item of equipment and the software used for testing and significant to the results is uniquely identified and records of equipment and software are maintained. This information includes the following:

a) identity of the equipment and its software;
b) manufacturer’s name, type identification, serial number or other unique identifier;
c) checks that equipment complies with specifications of applicable tests;
d) current location;
e) manufacturer’s instructions, if available, or a reference to their location;
f) dates, results and copies of reports and certificates of all calibrations, adjustments, acceptance criteria, and the due date of next calibration;
g) maintenance plan where appropriate, and maintenance carried out to date; documentation on all routine and non-routine maintenance activities and reference material verifications;
h) any damage, malfunction, modification or repair to the equipment;
i) date received and date placed into service (if available); and
j) condition when received, if available (new, used, reconditioned).

See Appendix 7 for a complete list of laboratory equipment.

20.1 Support Equipment

Support equipment includes, but is not limited to: balances, ovens, refrigerators, freezers, incubators, water baths, temperature measuring devices, volumetric dispensing devices, and thermal/pressure sample preparation devices (see Table 20.2-1). Specific procedure for the selection, care and use of volumetric and weighing equipment can be found in SOP QA-012 and the procedure for thermometer calibration can be found in SOP QA-026.

All support equipment is maintained in proper working order and records are kept of all repair and maintenance activities, including service calls.

All raw data records are retained to document equipment performance. These records include logbooks, data sheets, or equipment computer files.

All support equipment is calibrated or verified quarterly and in some cases annually, over the entire range of use using NIST traceable references and where available to the SI. The results are recorded that the calibration of support equipment are within specifications or (1) the equipment is removed from service until repaired, or (2) records are maintained of correction factors to correct all measurements.

Support equipment such as balances, ovens, refrigerators, freezers, and water baths are checked with a NIST traceable reference if available, each day prior to use, to ensure they are operating within the expected range for the application for which the equipment is to be used.

Mechanical volumetric dispensing equipment, including burettes (except Class A glassware), is checked for accuracy daily prior to use.

Glass micro-liter syringes have a certificate attesting to the established accuracy. If the certificate of accuracy for glass micro-liter syringes is not available, the accuracy of the syringe is demonstrated upon receipt and documented.

For chemical tests that use autoclaves, the temperature, cycle time, and pressure is documented by use of chemical indicators or temperature recorders and pressure gauges.

For microbiology analyses, records for autoclaves used in the laboratory are required for the following:

- initial performance of the autoclave functional properties (supplied by the installer);
- temperature demonstration of sterilization continuous monitoring device or maximum registering temperature;
- for every cycle, record date, contents, maximum temperature reached, pressure, total run time, and analysts initials;
- quarterly check of autoclave timing device against a stopwatch; and
- monthly maintenance check to include a pressure check and calibration of temperature device.

20.2 Support Equipment Maintenance

Regular maintenance of support equipment, such as balances and fume hoods is conducted at least annually.

Maintenance on other support equipment, such as ovens, refrigerators, and thermometers is conducted on an as needed basis.

Records of maintenance to support equipment are documented on the individual instrument or the Instrument Maintenance Logs. Each piece of support equipment does not necessarily have its own logbook. Maintenance logbooks may be shared with equipment that is housed in the same laboratory area.

Table 20.2-1 Acceptance Criteria for Support Equipment

Unit #	Unit Description	Use	Acceptance Criteria
1	Walk-in Cooler #1	SVOC sample storage	0 – 6°C
2	Walk-in Cooler #2	Wet Chem sample storage	0 – 6°C
3	BOD Walk-in Incubator	BOD / TCLP	BOD 19 - 21°C TCLP 21 - 25°C
4	Volatiles Soil Refrigerator	VOC soil samples	0 – 6°C
5	Volatiles Water Refrigerator	VOC water samples	0 – 6°C
6	Volatiles Standards Freezer	Volatile Standards	< -10°C
7	Volatiles Sample Freezer	Volatile soil samples	< -10°C
8	Wetchem Standards Refrigerator	Wetchem Standards	0 – 6°C
9	SV Extractions Refrigerator	Extraction standards	0 – 6°C
10	SV Extraction Freezer	SVOCs	< -10°C
11	SV Refrigerator #1	SVOCs	0 – 6°C
12	SV Refrigerator #2	SVOCs	0 – 6°C
13	SV Freezer#2	SVOCs	< -10°C
14	SV Soils Room	Soil / Tissue drying / grinding	< 26°C
15	SV Refrigerator Overflow	SVOCs	0 – 6°C
16	Micro Waterbath	Microbiology samples	44.5°C +/- 0.2°C
17	Micro Incubator	Microbiology samples	34.5°C – 35.5°C
18	Drying Oven #1	TOC Soils	74-76°C (QSM = +/- 5%)
19	Drying Oven #5	TSS	103 – 105°C (QSM = +/- 5%)
20	Drying Oven #6	% Solids	103 – 105°C (QSM = +/- 5%)
21	Drying Oven #7	Overflow as needed	Documented upon use
22	Drying Oven #8	TDS	178-180°C (QSM = +/- 5%)
All	Fume Hoods	Evaporation of fumes	Avg. face velocity 100 fpm

Table 20.2-2 Calibration And Maintenance

Instrument	Activity	Frequency	Acceptance Criteria
Balances	1. Clean 2. Calibrated/ Verified bracketing range of use 3. Service Contract	1. As needed 2. Daily or before use 3. Annually	Top-loading balance: ± 2% or ± 0.02 g, whichever is greater Analytical Balance: ± 0.1% or ± 0.5 mg, whichever is greater
ASTM Class 1 Weights	1. Only use for the intended purpose 2. Use plastic forceps to handle 3. Keep in case 4. Re-calibrate	Once every 5 years	Certificate of Calibration from accredited calibration laboratory
Thermometers: 1. Glass 2. Dial thermometers	Check at the temperature used, against a reference NIST certified thermometer	Liquid in glass: Before first use and annually Electronic: Before first use and quarterly; if only a single temperature is used, at the temperature of use	Apply correction factors or replace thermometer
pH electrometers	Calibration: 1. pH buffer aliquot are used only once 2. 3 point calibration performed at pH 4, 7, 10	Each day of use	90-110% slope
pH probe	Maintenance: Use manufacturer's specifications Rinsed between samples	As needed Each sample	Per manufacturer specifications
Spectrophotometer	1. Keep cells clean 2. Service 3. Wavelength accuracy check	1. Each use 2. As needed 3. Each day of use	± 2 nm @ 2 wavelengths
Automatic or digital type pipettes	Calibrate for accuracy and precision using reagent water and analytical balance	Daily before use	Bias: Mean within ± 2% of nominal volume Precision: RSD ≤ 1% of nominal volume (based on 10 replicate measurements) [Note: for variable volume pipettes, the nominal volume is the largest user-selectable volume setting]
Refrigerator/Freezer temperature	Monitoring of refrigerator/ freezer temperature	Daily (i.e., 7 days per week) (MIN/MAX thermometers allowed)	Refrigerators: 0 °C to 6 °C Freezers: ≤ -10 °C
BOD Incubator temperature	1. Thermometer is immersed in liquid to the appropriate immersion line. Thermometer is graduated in increment of 1^0C or less.	Daily (i.e., 7 days per week) (MIN/MAX thermometers allowed)	Incubator temperature must be 20 ± 1^0C
Autoclave Sterilizer	1. Use a maximum-temperature-registering thermometer or a continuous recording device. 2.Verify temperature 3. In house maintenance of autoclave or service contract.	1. Each cycle 2. Monthly 3. As needed	15 psi 121 °C

Table 20.2-2 Calibration And Maintenance

Instrument	Activity	Frequency	Acceptance Criteria
Microbiological incubators, and water baths	1. Thermometers in each unit are immersed in liquid to the appropriate immersion line 2. The thermometers will be graduated in increments of 0.1°C	Temperature of incubators and will be recorded twice a day for each day in use with readings separated by at least four hours Temperature of incubators are recorded twice daily separated by at least four hours.	Test specific
TCLP Rotator	1. Check rotation per minute 2. Temperature	1.Each use 2.Each use	30 ± 2rpm 23 ± 2^0C
Hot Block digesters	Check temperature	Verify temperature prior to use across surface. Verify Daily Prior to use.	95 ± 5^0C
WetChem Hot Blocks	Check temperature	Verify Daily Prior to use	COD 150±2° Cyanide 190±10° TKN/ TPhos soil 380±10° Phenolics 200±10° Hexavalent Chrom 90±2°
All Fume Hoods	Check Air Flow	Annually	Avg. face velocity 100 fpm

20.3 Analytical Equipment

20.3.1 Maintenance for Analytical Equipment

All equipment is properly maintained, inspected, and cleaned. For a list of typical equipment maintenance see Table 20.3-1.

Maintenance of analytical instruments and other equipment may include regularly scheduled preventive maintenance or maintenance on an as-needed basis due to instrument malfunction and is documented in Instrument Maintenance Logs, which become part of the laboratory's permanent records.

Table 20.3-1Analytical Equipment Maintenance

Instrument	Procedure	Frequency
Thermo Scientific AA's (Graphite Furnace)	Clean windows	As needed
	Replace windows	As needed
	Change graphite tube/platform	As needed
	Check level of rinse solution	Daily, when used
	Check waste container level	Daily, when used
	Check sample introduction probe	After tube change & as needed
	Check gas supply	Daily, when used
	Change contact rings	Approx. every 6 mo.
(Flame)	Clean nebulizer	As needed
	Align/Clean burner head	As needed
	Check gases	Daily, when used
	Check waste level	Daily, when used
	Replace tubing	As needed
Hydra II Mercury Analyzer	Check tubing for wear	Daily, when used
	Fill rinse tank with 3% HCl	Daily, when used
	Change PTFE filter	Daily, when used
	Fill reductant bottle with 10% Stannous Chloride	Daily, when used
Thermo Scientific ICP's	Check pump tubing	Daily, when used
	Check liquid argon supply	Daily, when used
	Check fluid level in waste container	Daily, when used
	Check filters	Monthly
	Clean or replace filters	As needed
	Check/align torch	Daily, when used
	Rinse sample spray chamber	Daily, when used
	Clean nebulizer	As needed
	Check entrance slit for debris	Monthly
	Replace pump tubing	Approx. every other day
UV-Vis Spectrophotometer	Clean cell	Daily, when used
	Precision check/alignment of flow cell	As needed
	Wavelength verification check	Daily, when used
Auto Flow Analyzer	Clean sampler	Daily, when used
	Check all tubing	Daily, when used
	Clean flow cell	Daily, when used
	Clean pump well and pump rollers	Quarterly
	Check/refill wash fluid	Daily, when used
	Oil rollers/chains/side rails	As needed
	Clean optics and cells	Daily, when used
Hewlett Packard GC/MS	Ion gauge tube degassing	As needed
	Pump oil-level check	Monthly
	Pump oil changing	Annually
	Analyzer bake-out	As needed
	Clean ion source	As needed
	Resolution adjustment	As needed
	Replace quadrapoles	As needed
	Replace gas scrubbers	Annually
	Check Helium supply	Daily, when used
Hewlett Packard Gas Chromatographs	Compare standard response to last initial calibration	Daily, when used
	Check carrier gas flow rate in column	Daily via retention time data
	Check gas pressure @ tank	Daily, when used
	Check temp. of detector, inlet, column oven	Daily, when used
	Septum replacement	As needed
	Inlet liner replacement	As needed
	Seal replacement	As needed
	Check system for gas leaks with SNOOP	W/cylinder change
	Check for loose/fray wires and insulation	Monthly
	Bake injector/column	As needed
	Change/remove sections of guard column	As needed
	Replace connectors/ferrules	As needed
	Change/replace column(s)	As needed
	Clean/change autosampler syringe	As needed
Electron Capture Detector (ECD)	Detector wipe test (Ni-63)	Semi-annually
	Detector cleaning	As needed
	Change detector liners	As needed
Flame Ionization Detector (FID)	Detector cleaning	As needed
Photoionization Detector (PID)	Change O-rings	As needed
	Clean lamp window	As needed
Archon Purge & Trap Autosampler	Recalibrate	As needed

Tekmar Purge & Trap Sample Introduction Assembly	Change trap Change sample liner	As needed (approx. quarterly) Approx. annually
Skalar TOC Analyzer	Replace catalyst	As needed
Balances	Class "S" traceable weight check, bracketing range of use Clean pan Field service	Daily, when used As needed As needed
Conductivity Meter	0.01 M KCl calibration	Daily, when used
Turbidimeter	Check light bulb	Daily, when used
Deionized/Distilled Water	Check conductivity Check deionizer light Monitor for VOA's System cleaning Replace cartridge & large mixed bed resins	Weekly Daily, when used Daily, when used As required As required
Drying Ovens	Temperature monitoring Temperature adjustments	Daily, when used As required
Refrigerators/ Freezers	Temperature monitoring Temperature adjustment Defrosting/cleaning	Daily, when used As needed As needed
Vacuum Pumps/ Air Compressors	Change oil	Annually
pH/Specific Ion Meter	Calibration/check slope Clean electrode	Daily, when used As needed
BOD Incubator	Temperature monitoring Coil and incubator cleaning	7 days a week As needed
Centrifuge	Check brushes and bearings	As needed
Water Baths	Temperature monitoring Water replaced Cleaned	Daily, when used As needed As needed
Turbovaps	Temperature Monitoring Clean	Daily, when used As needed
TCLP Rotator	Check rotation	As needed
Autoshaker	Lubricate system	As needed
Desiccators	Check color of desiccant Bake/dry desiccant & refill Change desiccant	Daily, when used As needed Semi-annually

20.3.2 **Initial Instrument Calibration**

Initial instrument calibration and continuing instrument calibration verification are an important part of ensuring data of known and documented quality. If more stringent calibration requirements are included in a mandated method or by regulation, those calibration requirements override any requirements outlined here or in laboratory SOPs. Generally, instrument calibrations are provided in test methods.

All initial instrument calibrations are verified with a standard obtained from a second source traceable to a national standard when commercially available. If a second source is not available, a standard prepared from a separate lot may be used as long as the manufacturer can demonstrate the lot was prepared independently from other lots purchased.

If the reference or mandated method does not specify the number of calibration standards to use, the minimum number is three for inorganics and 5 for organics not including blanks or a zero standard, except for pH analyses.

Any samples that are analyzed after an unacceptable initial calibration are re-analyzed.

The lowest calibration standard is the lowest concentration for which quantitative results can be reported without qualification. The lowest calibration standard is equal to or less than the Limit of Quantitation and is equal to or greater than the limit of detection.

The highest calibration standard is the highest concentration for which quantitative results can be reported unless otherwise stated by the method or SOP. Data reported that are greater than the highest calibration standard without dilution are considered to be an estimate and are reported with a qualifier and explained in the case narrative.

Initial instrument calibration includes calculations, integrations, acceptance criteria, and associated statistics referenced in the method specific SOPs.

Sufficient raw data records are collected to allow reconstruction of the initial instrument calibration. These include, at a minimum, calibration date, test method, instrument, analysis date, analyte names, analysts signature or initials, concentration and response, calibration curve or response factor, or unique equation or coefficient used to reduce instrument responses to concentration.

Corrective actions are performed when the initial calibration results are outside acceptance criteria. If reanalysis of samples is not possible, data is reported with appropriate qualifiers. Calibration points are not dropped from the middle of the curve to make the data pass. If the low or high calibration point is dropped from the curve, the working curve is adjusted and sample results outside the curve are qualified.

Results that are less than the lower calibration standard are considered to have increased uncertainty, and are reported with a qualifier code and explained in the case narrative.

Results that are greater than the highest calibration standard are either diluted to within the calibration range, or considered to be an estimate; and are reported with a qualifier code and explained in the case narrative.

For instrumentation where single point calibration is recommended by manufacturer's instructions and utilized, the following apply:

a) For single point plus zero blank calibrations, the zero point and the single point standard are analyzed prior to the analysis of samples, and the linear range of the instrument established by analyzing a series of standards, one of which is at the lowest quantitation level.

b) Zero blank and single point calibration standards are analyzed with each analytical batch for methods where they are specified.

c) A standard corresponding to the limit of quantitation is analyzed with each analytical batch and must meet established acceptance criteria when using single point plus zero blank calibrations.

d) The linearity of single point plus zero blank calibrations is verified at a frequency established by the method or the manufacturer.

20.3.3 **Continuing Instrument Calibration**

The validity of the initial calibration and ongoing calibration is verified prior to sample analysis by use of a continuing calibration verification (CCV) standard. The source of the CCV should be the same as for the initial calibration standards, and the concentration of the CCV should be between the lowest standard and the mid concentration of the calibration range.

The baseline for evaluating the CCV is the initial calibration curve. Corrective action is initiated for continuing instrument calibration verification results that are outside of acceptance criteria.

Continuing instrument calibration verification is performed at the beginning and end of each analytical batch, except for instances when an internal standard is used. For methods employing internal standards, verification is required only at the beginning of the analytical batch.

Continuing instrument calibration verification is performed whenever it is expected that the analytical system may be out of calibration or might not meet verification acceptance criteria.

Continuing instrument calibration verification is performed when the time period for calibration or the most recent calibration verification has expired.

Continuing instrument calibration verification is performed for all analytical systems that have a calibration verification requirement.

Calibration is verified for each compound, element, or other discrete chemical species.

The calculations and associated statistics for continuing instrument calibration are included or referenced in the test method SOP.

Sufficient raw data records are retained to allow reconstruction of the continuing instrument calibration verification. Continuing instrument calibration verification records connect the continuing verification date to the initial instrument calibration.

All acceptance criteria for continuing instrument calibration verification is referenced in the individual test SOP.

20.3.4 **Unacceptable Continuing Instrument Calibration Verifications**

If a CCV fails, routine corrective action is taken to correct the problem and the CCV is analyzed again right away. If the CCV passes, the analysis of the next samples may continue.

{Note: For DoD work, all samples analyzed prior to the failed CCV must also be analyzed after the passing CCV.}

If routine corrective action fails to immediately produce acceptable calibration verification, a new calibration is performed or acceptable performance is demonstrated after corrective action with two consecutive calibration verifications.

Samples associated with a failed calibration verification must be qualified if reanalysis is not possible, or results may be useable under the following conditions:

a) If the acceptance criteria are exceeded high (high bias) and the associated samples are below detection, then those sample results that are non-detects may be reported as non-detects.

b) If the acceptance criteria are exceeded low (low bias) and there are samples that exceed the maximum regulatory limit, then those exceeding the regulatory limit may be reported.

21 MANUAL INTEGRATION

Modern chromatographic data systems allow analysts to review data and manipulate integration parameters (manual integration). Such manipulations may have a profound impact on data integrity. When used properly, manual integration can allow an experienced analyst to overcome limitations of an automated data system. It also has the potential for misuse. All data must be integrated consistently in standards, samples and quality control samples. Manual integration is a corrective action measure and must never be used solely to meet quality control criteria. Performing improper manual integrations, including peak shaving, peak enhancing, or baseline manipulation to meet quality control criteria or to avoid correction action is strictly prohibited. For DoD, all samples and analytes for which manual integration occurred, including the cause and justification, must be documented in the case narrative. See Manual Integration SOP QA-016 for examples of acceptable manual integration procedures for CT Laboratories.

22 MEASURMENT TRACEABILITY

Measurement quality assurance comes in part from traceability of standards to certified materials.

All equipment used that affects the quality of test results are calibrated prior to being put into service and on a continuing basis. These calibrations are traceable to national standards of measurement where available.

Measurements from laboratory equipment provide the uncertainty required by test method or client.

If traceability of measurements to SI units is not possible or not relevant, evidence for correlation of results through inter-laboratory comparisons, proficiency testing, or independent analysis is provided.

All equipment that affects the quality of test results are calibrated according to the minimum frequency suggested by the manufacturer, by regulation, by method, or as needed.

22.1 Reference Standards

Reference Standards are standards of the highest quality available at a given location, from which measurements are derived.

Reference Standards, such as ASTM Class 1 weights or traceable thermometers, are used for calibration only and for no other purpose unless it is shown that their performance as reference standards will not be invalidated.

Reference standards are calibrated by an entity that can provide traceability to national or international standards. Reference standards shall be calibrated before and after any adjustment. The following reference standards are to be calibrated to a national standard:

a) Reference thermometers are sent out for calibration or replaced upon expiration of certification.
b) Class 1 weights are sent out for calibration every 5 years.

22.2 Reference Materials

Reference materials are measuring devices such as pipettes and balances that are sufficiently well established to use for calibration or as a frame of reference.

Reference materials, where commercially available, are traceable to national standards of measurement such as ISO Guide 34 or ISO 17034, or to Certified Reference Materials, usually by a Certificate of Analysis.

Internal reference materials are checked as far as technically and economically possible.

Procedure

Purchased Reference Materials require a Certificate of Analysis where available. Otherwise, purchased reference materials are verified by application to a certified reference material and/or inter-laboratory comparison.

Internal Reference Materials, such as working standards and intermediate stock solutions, are checked with inter-laboratory comparison studies quality control samples and proficiency tests.

a) All digital thermometers are checked quarterly against the NIST certified reference thermometer.
b) Balances are checked against Class 1 weights on each day of use
c) Mechanical pipettes are verified for accuracy gravimetrically on a quarterly basis.
d) Class A Glassware is verified when there is evidence of deterioration. 10 replicates must yield mean of ± 2% and RSD of 1% or less.
e) Class B Glassware is verified before first use. 10 replicates must yield mean of ± 2% and RSD of 1% or less.

22.3 Transport and Storage of Reference Standards and Materials

The laboratory handles and transports reference standards and materials in a way that protects their integrity.

Reference standard and material integrity is protected by separation from incompatible materials and/or minimizing exposure to degrading environments or materials.

Reference standards and materials are stored according to manufacturer's recommendations and separately from working standards or samples.

22.4 Labeling of Reference Standards, Reagents, and Materials

Reference standards and materials are tracked from purchase, receipt, and storage through disposal. Once received into the laboratory, they are recorded into Labtrack and assigned a unique ID code along with the date received and lot number.

When specified by method, only reagents of that quality will be used. If not specified, analytical reagent grade is used. Reagent quality is verified during routine blank analyses and/or prior to use.

Procedure

Records for all standards, reagents, reference materials, and media include:

1. the manufacturer/vendor name (or traceability to purchased stocks or neat compounds)
2. the manufacturer's Certificate of Analysis or purity (if supplied)
3. the date of receipt
4. reference to the method of preparation
5. date of preparation
6. an expiration date after which the material shall not be used

7. preparer's initials (if prepared)
8. Lot number

In methods where the purity of reagents is not specified, analytical reagent grade is used. If the purity is specified, that is the minimum acceptable grade. Purity is verified and documented according to Section 7, Purchasing, Services, and Supplies.

All containers of standards, reagents, or materials, whether original or prepared, are labeled with an expiration date. Expiration dates are determined as follows:

1. Neat Standards/Reagents (not prepared in the laboratory)
    a. Manufacturer's expiration date or
    b. SOP stated expiration date
    c. 2 years from opening, but not to exceed manufacturer's expiration date
2. Stock Standards/Reagents
    a. SOP stated expiration date or
    b. Manufacturer's recommended expiration date
    c. But not to exceed 6 months from preparation
3. Working Standards/Reagents
    a. SOP stated expiration date or
    b. Manufacturer's recommended expiration date or
    c. 1 month if no guidelines are given

Standards, reference materials and reagent shall not be used after their expirations dates unless their reliability is verified by the Lab. If a standard exceeds its expiration date and is not re-certified, the Lab shall remove the standard or clearly designated as for qualitative purposes only. All containers of prepared standards and reference materials have a preparation date and unique identifier.

Standard preparation records are kept in Labtrack and indicate traceability to purchased stocks or neat compounds, reference to the method of preparation, date of preparation, expiration date, and preparer's initials.

Prepared reagents are verified to meet the requirements of the test method through internal QC measures and/or blank analysis.

23 SAMPLE MANAGEMENT

23.1 Sample Receipt

Procedure

When samples are received at the laboratory, their condition is documented, they are given unique identifiers, and they are logged into the sample tracking system.

23.2 Sample Acceptance

The laboratory maintains a Sample Acceptance Policy that is available to sample collection personnel and outlined in SOPs PM003 Chemistry Microbiology Sample Receiving and Processing and PM005 Regulated Soil Sample Receiving and Processing as well as in the CT Laboratories' Terms and Conditions (Appendix8). This policy is provided as a stand-alone document, on the laboratory's Chain of Custody form, and on the company's website.

The minimum conditions a sample must meet on receipt are found on the sample condition report, which include the following items: The use of custody seals, agreement between bottle label and chain of custody, temperature, preservation, holding time, bottle type, appropriate sample volume, and VOC headspace.

A complete Chain of Custody must accompany all samples. It must include: sample identification, location, date and time of collection, collector's name, preservation type, sample type, and any special remarks concerning the sample.

If these conditions are not met, the client is contacted prior to any further processing.

All documents received with the sample including transmittals, memos, and chains of custody records are retained.

The laboratory checks samples for the conditions above, where appropriate, to evaluate sample acceptance.

The following preservation checks are performed and documented upon receipt:

Thermal preservation:

a) For samples that require temperature preservation, the acceptable range is from just above freezing to 6°C.
b) Samples that are delivered to the lab the same day as they are collected are likely not to have reached a fully chilled temperature. This is acceptable if there is evidence that chilling has begun, i.e. samples received on ice.
c) Record on the receipt form if ice is present and the temperature received.

Chlorine checks:

d) Microbiological samples from chlorinated water systems do not require a chlorine check as all Microbiological sample containers are pre-preserved with sufficient sodium thiosulfate (to neutralize 5mg/L chlorine for drinking water and 15 mg/L chlorine for wastewater).

pH checks:

e) The pH of samples requiring acid/base preservation is checked upon sample receipt or upon initiation of analysis.

The sample acceptance policy is available to sample collection personnel, and emphasizes the need for a completed chain of custody, unique sample identification(s), use of water resistant ink, use of appropriate containers, adherence to holding times, sample volume requirements, special remarks about the sample(s), and what to do with compromised samples.

If the checks performed upon sample receipt indicate the criteria are not met, then 1) the sample is rejected as agreed with the client, 2) the decision to proceed is documented and agreed upon with the client, 3) the condition is noted on the Chain of Custody form and/or lab receipt documents, and 4) the data are qualified in the report if deemed necessary.

23.3 Sample Identification

Samples including subsamples, extracts, and digestates, are uniquely identified in a permanent chronological record in the database to prevent mix-up and to document receipt of all sample containers. This ID code is placed on the sample container with a durable label. Identification is maintained throughout the life of the sample.

Procedure

Samples are assigned sequential numbers that reference more detailed information kept in the data base (LIMS).

The following information is collected in the LIMS and/or sample conditions form.

a) Client or project name
b) Date and time of sampling
c) Date and time of receipt at lab
d) Unique laboratory identification number
e) Unique field identification number linked to the laboratory identification number
f) Initials of recorder
g) Analyses requested
h) Comments regarding rejection (if any).

23.4 Sample Storage

Refrigerated storage is maintained at, or just above freezing to 6°C unless otherwise directed by state or Agency requirements. The temperature of each unit is recorded daily. If there is a temperature excursion that cannot be returned to an in-control status, the samples are moved to an alternative unit until the problem is corrected. Storage is designed to segregate samples in such a way as to minimize the possibility of cross-contamination. This includes the storage of volatile samples separate from semi-volatiles and inorganic samples. Within each unit, samples are organized for easy retrieval. Extracts are maintained in refrigerated storage until needed for analysis. Digestates typically do not need refrigeration, and are stored in the preparation area.

23.5 Sample Disposal

Wastes generated in the laboratory can be divided into types: hazardous, non-hazardous, and mixed wastes. The EPA defines wastes as hazardous if they exhibit the characteristics of ignitability, corrosivity, reactivity, or toxicity as identified in 40 CFR 261, Subpart C, or are listed in 40CFR 261, Subpart D. For the intents and purposes of laboratory waste management procedures, substances that may be disposed of as hazardous wastes include, but are not limited to:

Environmental samples (disposal 30 days after the data report is submitted to the client unless longer specific contract/program requirements were established. Disposal may include return of the samples to the client.)

- By-products of sample preparation or analysis,
- Standards or reagent solutions,
- End products of sample preparation or analysis,
- Used chemicals, or chemicals that have exceeded their shelf life, and
- Waste products generated from spill cleanup.

CT Laboratories maintains appropriate documentation and records demonstrating that samples have been properly disposed of, in accordance with Federal, State, and local regulations. See WS-001. Waste Managers are trained in accordance with 49 CFR 172.700 Subpart H. Waste haulers DOT certification will be verified prior to use.

The Laboratory is classified as a Conditionally Exempt Small Quantity Generator (CEQG). Whenever possible, all non-hazardous liquids are disposed of by use of Elementary neutralization. All other samples, digestates, leachates, and extracts are categorized into one of the following waste streams and disposed of through a licensed and bonded hazardous waste disposal firm. All records are kept in a binder and maintained by the Waste Disposal personnel.

1) Flammable liquids, toxic, n.o.s. (ether, endrin) 3 UN1992 PG III
2) waste flammable liquids, toxic, n.o.s. (dichloromethane, gasoline)3 UN1992 PG III
3) waste flammable liquids, corrosive, n.o.s. (sulfuric acid, ether))3 UN2924 PG II
4) waste mercury 8 UN2809 PG III
5) hazardous waste liquid, n.o.s. (arsenic, barium) 9 NA 3082 PG III
6) waste flammable liquids, corrosive, n.o.s. (hexane, sulfuric acid) contains < 1% PCB's
7) waste corrosive, liquids, acidic, inorganic n.o.s. (sulfuric acid, chromic acid) 8 UN3264 PG II

8) Non-hazardous, non-RCRA, Non-DOT, Soils

23.6 Sample Transport

Samples that are transported under the responsibility of the laboratory, where necessary, are done so safely and according to storage conditions. This includes moving bottles within the laboratory.

23.7 Sampling Records

The Laboratory is not involved in sampling. Sub-sampling within the laboratory is performed so that a representative portion of the sample is used. This may be accomplished by coring, mixing or shaking the sample. Specific details are outlined in SOP PR-07.

24 QUALITY OF TEST RESULTS

24.1 Essential Quality Control Procedures

All essential quality control elements are collected and assessed on a continuing basis and used to determine usability of the data.

The qualities of test results are recorded in the LIMS so that trends may be detectable, and where practicable, are statistically evaluated.

For test methods that do not provide acceptance criteria for an essential quality control element or where no regulatory criteria exist, acceptance criteria are developed. Control limits are developed using the mean, plus or minus 3 standard deviations. All limits can be found in the LIMS.

The quality control procedures specified in the SOPs or QAPP are followed by laboratory personnel. The most stringent of control procedures are used in cases where multiple controls are offered. If it is not clear which is the most stringent, use the one that is mandated by test method or regulation.

Procedure
To monitor the validity of environmental tests performed, review includes any one or combination of the techniques below:

a) use of certified reference materials or cultures and/or internal quality control using secondary reference materials;
b) participation in proficiency testing programs;
c) replicate testing using the same or different methods;
d) retesting of retained samples; and/or
e) correlation of results for different characteristics of a sample.

Written procedures to monitor quality controls including acceptance criteria are located in the SOPs, except where noted, and include such procedures as:

a) use of laboratory control samples and blanks to serve as positive and negative controls for chemistry methods;
b) use of laboratory control samples to evaluate the performance of the total analytical system, including all preparation and analysis steps and to monitor test variability of laboratory results;
c) use of calibrations, continuing calibrations, certified reference materials and/or PT samples to monitor accuracy of the test method;
d) measures to monitor test method capability, such as limit of detection, limit of quantitation, and/or range of test applicability, such as linearity;
e) use of regression analysis, internal/external standards, or statistical analysis to reduce raw data to final results;
f) use of reagents and standards of appropriate quality;
g) procedures to ensure the selectivity of the test method;

h) measures to assure constant and consistent test conditions, such as temperature, humidity, rotation speed, etc., when required by test method;

i) use of sterility checks for equipment, media and dilution water for microbiology; and

j) use of positive and negative culture controls for microbiology.

24.2 Internal Quality Control Practices

This section describes the types of quality control samples used in the laboratory and how they are used to assess data precision and accuracy. When the analysis of a sample set is completed, the results will be reviewed and evaluated to assess the validity of the data set. All quality control is processed and analyzed using the same conditions as the samples.

A reagent and/or method blank is prepared and analyzed with each set of samples. Field blanks (if provided by the client) are analyzed to determine possible sample contamination during collection and shipment to the laboratory.

Trip blanks are applicable to volatile organics analysis (VOA) where volatile contaminants can be introduced from ambient air on site, during shipment, and in the laboratory. Storage blanks are also used in volatile refrigerators and analyzed every 2 weeks. The reagent and/or method blank results are evaluated for high readings characteristic of background contamination. If high blank values are observed, laboratory glassware and reagents shall be checked for contamination and the analysis halted until the system can be brought under control before further sample analysis proceeds. For DoD projects the concentration of an analyte in a reagent blank must be less than ½ the reporting limit or less than 5% of the analyte detected in the associated samples. Field blank results are evaluated for high readings similar to the reagent and/or method blanks described above. If high field blank readings are encountered, the procedure for sample collection, shipment, and laboratory analysis will be reviewed.

If the reagent and/or method blanks and the field blank exhibit significant background contamination, the source of contamination is probably within the laboratory. In the case of VOA's, ambient air in the laboratory and reagents shall be checked as possible sources of contamination. If method blanks are not acceptable, the associated samples must be re-prepped and analyzed

Where frequency of quality control measures is linked to an analytical batch, a batch shall be defined as samples that are analyzed together with the same method, personnel, & reagents, and not to exceed 20 samples. See Table A9-1 for quality control definition, Purpose, and Evaluation

The following general controls are used:

Positive and Negative Controls:

a) Blanks (negative) – Matrix similar to the associated samples known to be free of analytes

b) Laboratory control sample (positive) – Matrix similar to the associated sample with a known concentration of analyte

c) Sterility checks and control cultures (positive and negative).

Selectivity is assured through:

a) absolute and relative retention times in chromatographic analyses;

b) two-column confirmation when using non-specific detectors;

c) use of acceptance criteria for mass-spectral tuning (found in test method SOPs);

d) use of acceptance criteria per method (found in test method SOP's)

e) use of the correct method according to its scope assessed during method validation; and

f) use of reference cultures (positive and negative) from a recognized manufacturer (where applicable).

Consistency, Variability, Repeatability, and Accuracy are assured through:

a) proper installation and operation of instruments according to manufacturer's recommendations or according to the processes used during method validation;

b) monitoring and controlling environmental conditions (temperature, access, proximity to potential contaminants);

c) selection and use of reagents and standards of appropriate quality; and

d) cleaning glassware appropriate to the level required by the analysis. Normal cleaning procedures are as follows. Additional cleaning procedures, when required, are provided in individual test method SOPs.

   1. Glassware, if used for organic analyses, is rinsed with solvent prior to washing.
   2. All glassware is washed with soap and water.
   3. Glassware is washed in a dishwasher when space permits.
   4. All glassware is rinsed with DI water.

e) following SOPs and documenting any deviation, assessing for impact, and treating data appropriately;

f) testing to define the variability and/or repeatability of the laboratory results, such as replicates;

g) use of measures to assure the accuracy of the test method, including calibration and/or continuing calibrations, use of certified reference materials, proficiency test samples, or other measures;

h) use of duplicate plate counts on positive samples (microbiology only).

Acceptance or rejection criteria are created according to laboratory policy where no method or regulatory criteria exist. Acceptance criteria define the boundary for the appropriate response from laboratory personnel, such as corrective action, reporting with qualifiers, reanalysis, review, and others.

Test Method Capability is assured through:

a) establishment of the limit of detection where appropriate;

b) establishment of the limit of quantitation or reporting level; and/or

c) establishment of the range of applicability such as linearity;

Data reduction is assured to be accurate by:

a) selection of appropriate formulae to reduce raw data to final results such as regression;

b) periodic review of data reduction processes to assure applicability;

c) microbiological calculations, data reduction, and statistical interpretations specified by each test method.

Tables A9-1 and A9-2 in Appendix 9 summarizes the key elements of a quality control system for a laboratory performing chemistry and microbiology testing.

24.3 Method Blanks

Contaminated blanks are identified according to the acceptance limits in the test method SOPs or laboratory documentation.

Samples associated with a contaminated blank are evaluated as to the appropriate corrective action for the samples (e.g. reprocessing or data qualifying codes).

Procedure
The laboratory identifies a blank as contaminated when analyte results are equal to or greater than the Limit of Detection (if reporting to LOD), or the blank is equal to or above the reporting limit ***and*** if the contamination is greater than 1/10 of that found in the sample.

{Note: DoD identities a blank as contaminated when it exceeds ½ the reporting limit ***and*** is greater than 1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).}

When a blank is determined to be contaminated and impacts the data, the cause must be investigated and measures taken to minimize or eliminate the problem. All corrective actions are documented.

Data that are unaffected by the blank contamination (non-detects or other analytes) are reported unqualified.

Sample data that are suspect due to the presence of a contaminated blank are reanalyzed, qualified, or deleted.

24.4 Laboratory Control Samples & Laboratory Control Sample Duplicates

LABORATORY CONTROL SAMPLES (LCS) and Laboratory Control Sample Duplicates (LCSD) are prepared from analyte free water, and spiked with verified and known amounts of analytes for the purpose of establishing precision or bias measurements.

Laboratory control samples are analyzed at a frequency mandated by method, regulation, or client request, whichever is more stringent. They are at or below the mid concentration of the calibration curve when the method or client does not specify a concentration.

The results of laboratory control samples (LCS) are calculated in percent recovery or other appropriate statistical technique that allows comparison to established acceptance criteria. The laboratory calculates LCS percent recovery as:

(LCS Spike measured concentration – Method blank measured concentration) / LCS spiked concentration x 100
The individual LCS is compared to the acceptance criteria as published in the mandated test method, or where there are no established criteria, the laboratory established limits.

For DoD samples, LCS is spiked with all target analytes required by the project.

24.5 Matrix Spikes, Matrix Spike Duplicates, and Matrix Duplicates

MATRIX SPIKES (MS) are environmental samples fortified with a known amount of analyte to help assess the accuracy of method performance.

Matrix duplicates are the analysis of replicate aliquots of a sample to evaluate the precision of the analysis. Matrix Spike Duplicates (MSD) are 2 identical samples fortified with the same known amount of analyte to help assess both accuracy and precision of the method. Either MSDs or duplicates can be used in an analysis, but both are not required.

The MS/MSD and duplicate results are used to help assess the effect of the sample matrix on method performance.

Procedure
The laboratory procedure for MS/MSD includes spiking appropriate analytes at appropriate concentrations specified by the method, the client, or by regulation, then calculating percent recoveries and evaluating and reporting the results compared with the mandated test method.

$$\% \text{ Recovery} = \frac{(\text{MS Result} - \text{Nonspiked Sample Result}) \times 100}{\text{Spike Concentration Added}}$$

For matrix duplicates and MSDs the laboratory calculates the relative percent difference (RPD) of the 2 samples and evaluates and reports the results compared with the mandated test method.

$$\% \text{ RPD} = \frac{|\text{Result 1} - \text{Result 2}| \times 100}{(\text{Result 1} + \text{Result 2})/2}$$

Where there are no established criteria, the laboratory uses static control limits established per method or control limits derived from LCS/LCSD studies, as the control limits for MS/MSD and duplicates.

For MS/MSD and duplicate results outside established criteria corrective action may be documented or the data are reported with appropriate data qualifying codes.

For multiple analyte tests use same frequency default criteria as LCS above for MS/MSD.

All analytes in a multiple analyte test are analyzed in the MS/MSD at least every 2 years. For interim analysis, the following number of analytes in the MS/MSD is followed (exception – chlordane, toxaphene, and PCBs follow method):

- 1-10 compound tests require all analytes
- 11-20 compound tests require 10 or 80% (whichever is greater)
- >20 compound tests require at least 16 analytes

24.6 Surrogate Spikes

SURROGATES are substances with chemical properties and behaviors similar to the analytes of interest used to assess method performance in individual samples.

Surrogates are added to all samples, blanks, and standards (in test methods where surrogate use is appropriate) prior to preparation or extraction, except where the matrix precludes its use or when not commercially available.

Surrogate recovery results are compared to the acceptance criteria as published in the mandated test method.

Where there are no established criteria, the laboratory uses static limits listed in the method SOP or statistically derived control limits. Clients may also specify project specific acceptance criteria.

For surrogate results outside established criteria, data are evaluated to determine the impact. Corrective actions include reanalysis, qualifying the data or notations in data packages and/or certificates of analyses as appropriate.

24.7 Proficiency Testing Studies

CT Laboratories participates in three Proficiency Test (PT) studies list below. The QA Officer orders the necessary studies at approximately six months intervals from a vendor who is ISO 17025:2005 accredited by an International Laboratory Accreditation Cooperation (ILAC)/Signatory. Once the study results are released, the QA/QC department reviews all of the analytes and any outliers are recorded. The out of control performances are documented and reviewed by both the analysts who performed the analyses, their direct management, and the QA/QC department. A corrective action report documenting why the results were outside acceptable ranges is generated. These records are kept with the QA/QC department Officer and are included with the annual internal audit and management review.

CT Laboratories Proficiency studies include:

Soil – semiannually

WP– semiannually

Drinking Water – semiannually

When samples are received they are logged into the LIMS, work order etc. All PT studies are analyzed as client samples, with the normal batch quality control performed. It is the policy of CT Laboratories that PT studies are handled as client samples throughout the analytical process. It is inappropriate to analyze multiple duplicates or dilutions unless this procedure is described in the approved analytical SOP as the required.

The QA/QC department is responsible for the final review and reporting of PT results to the PT provider. PT results and batch quality control are reviewed carefully. Also reviewed are sample prep for appropriate dilution, reported concentration, consistency across methods, logical results, and transcription errors. Batch quality control failures will require re-analysis of the PT sample, or comments in the case narrative. If, in the QA Officer's opinion, the laboratory must withdraw from a PT study, and all accrediting authorities shall be informed in writing of the status.

Results are reported to the PT provider via fax and/or electronic submission. Review of Proficiency Test Studies documents any recurring trends or problems evident in PT studies and evaluates their effect on environmental data. Procedures regarding corrective action for failing PT and steps taken during

analyses are detailed in PT SOP QA-15.

24.8 Data Review

The laboratory reviews 100% all data generated in the laboratory for compliance with method, laboratory and, where appropriate, client requirements.

All data review is documented.

Initially, the analyst reviews 100% of the data they produce for acceptability of quality control measures and accuracy of the final result(s). This review includes:

- Determination of whether the results meet the laboratory-specific quality control criteria.
- Checks to ensure that the appropriate sample preparatory and analytical SOPs and methods were followed, and that COC and holding time requirements were met.
- Checks to ensure that all calibration and quality control requirements were met.
- Checks for complete and accurate explanations of anomalous results, corrective action, and the use of data qualifiers in the case narrative.

After the initial review, a second review of 100% data takes place by a technically qualified person. This review includes:

- Confirmation of calculations.
- Checks to determine consistency with project-specific measurement quality objectives.
- Checks all manual transfers of data.
- Spot checks electronic transfers of data.

Once the analyst analyzes and enters the data into LIMS, the status is changed to “ENTERED’ in LIMS. Upon completion of the second review, the management approves the data in the LIMS and the status of the batch changed to “VALIDATED”. The technical director or designee confirms that the previous reviews were documented properly and the data package is complete. The signature on the certificate of analysis documents this confirmation.

Lastly, at least 10% of data is reviewed quarterly by the Quality Manager or designee to confirm the review process is performed correctly and for completeness and accuracy. This review is not always completed before data set is issued. If data quality issues are discovered during the review, the client shall be notified within 15 business days of the discovery.

25 REPORTING OF RESULTS

The result of each test carried out is reported accurately, clearly, unambiguously, and objectively and complies with all specific instructions contained in the test method. Data are reported without qualification if they are greater than the lowest calibration standard, lower than the highest calibration standard, and without compromised sample or method integrity. The specific procedures for data reporting can be found in SOP QA-020.

General Qualification Code Definitions

A – Analyte averaged calibration criteria within acceptable limits
B – Analyte detected in associated Method Blank
C – Toxicity present in BOD sample
D – Diluted out
E – Safe, No total Coliform detected
F – Unsafe, Total Coliform detected, no e. Coli detected
G – Unsafe, Total Coliform detected and e. Coli detected
H – Holding time exceeded
J – Estimated value
L – Significant peaks were detected outside the chromatographic window
M – Matrix Spike and/or Matrix Spike Duplicate recovery outside acceptance limits
N – Insufficient BOD oxygen depletion
O – Complete BOD oxygen depletions
P – Concentration of analyte difference more than 40% between primary and confirmation analysis
Q – Laboratory Control Sample outside acceptance limits
R – See narrative for further explanation
S – Surrogate standard recovery outside acceptance limits due to apparent matrix effects
T – Sample received with improper preservation or temperature
U – Analyte concentration was not above the detection level
V – Raised Quantitation or Reporting Limit due to limited sample amount or dilution for matrix background interference
W – Sample amount received was below program minimum
X – Analyte exceeded calibration range
Y – Replicate/Duplicate precision outside acceptance limits
Z – Calibration criteria exceeded

25.1 Test Reports

The report format has been designed to accommodate each type of test performed and to minimize the potential for misunderstanding or misuse. It includes all information requested by the client and necessary for the interpretation of the test results

Procedure

Each analytical test report generated contains the following information (unless not required by the client):

a) the title: Analytical Report
b) the name and address of the laboratory, contract number, the phone number, and name of a contact person;

c) unique identification of the test report, such as a Laboratory ID #, on each page and a pagination system that ensures that each page is recognized as part of the test report and a clear identification of the end of the report, such as 3 of 10;

d) the name and address of the client as well as the project name;

e) the identification of the test method used;

f) an unambiguous identification of the sample(s), including the client identification code;

g) the date of sample receipt, date and time of sample collection, dates and times the samples were prepared and analyzed.

h) the test results with failures identified with qualifiers, units of measurement, an indication of whether results are calculated on a dry weight or wet weight basis.

i) the name, function, and signature or an equivalent electronic identification of the person authorizing the test report, and the date of issue;

j) a statement that the report shall not be reproduced except in full without written approval of the laboratory;

k) certification that the results are in compliance with the NELAC/DoD ELAP and/or ISO 17025 standards if accredited to be in compliance or provide reasons and/or justification if they do not comply.

25.2 Supplemental Test Report Information

When necessary for interpretation of the results or when requested by the client, test reports include the following additional information:

a) deviations from, additions to, or exclusions from the test method, information on specific test conditions, such as environmental conditions, and any non-standard conditions that may have affected the quality of the results, and any information on the use and definitions of data qualifiers;

b) a statement of compliance/non-compliance when requirements of the quality systems are not met, including identification of test results that did not meet NELAC sample acceptance requirements, such as holding time, preservation, etc.;

c) where appropriate and needed, opinions and interpretations. When opinions and interpretations are included, the basis upon which the opinions and interpretations are documented. Opinions and interpretations are clearly marked as such in the test report.

d) additional information which may be required by specific methods or client including any information supplied concerning sampling;

e) qualification of results with values outside the working range.

25.3 Environmental Testing Obtained from Subcontractors

Test results obtained from test performed by subcontractors are clearly identified on the test report by subcontractor name and/or accreditation number. The test results from subcontractors are reported in writing or electronically. A copy of the subcontractors report is made available to the client.

25.4 Electronic Transmission of Results

All test results transmitted by telephone, fax, e-mail, or other electronic means comply with the requirements of this *Quality Manual* and associated procedures to protect the confidentiality and proprietary rights of the client.

25.5 Amendments to Test Reports

Material amendments to a test report after it has been issued are made only in the form of another document or data transfer. All supplemental reports meet all the requirements for the initial report and the requirements of this *Quality Manual*.

It is CT's policy to re-issue a report in the event it is deemed necessary to amend the report. The amended report is identified with a notation that the report is a reissue of a previously released certificate of analysis with the date and reason for the reissue.

When it is necessary to issue a completely new report, the new report is uniquely identified and contains a reference to the original that it replaces.

25.6 GLOSSARY

The following definitions are used in the text of Quality Systems. In writing this document, the following hierarchy of definition references was used: ISO 8402, ANSI/ASQC E-4-2004, EPA's Quality Assurance Division Glossary of Terms, and finally definitions developed by NELAC. The source of each definition, unless otherwise identified, is the Quality Systems Committee.

Quality Systems Definitions: Additional terms and clarifications used in the DoD QSM but not included in the NELAC Glossary are included in gray text boxes throughout this Appendix.

Acceptance Criteria: Specified limits placed on characteristics of an item, process, or service defined in requirement documents.

Accreditation: The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory. In the context of the National Environmental Laboratory Accreditation Program (NELAP), this process is a voluntary one.

Accrediting Authority: The Territorial, State, or Federal agency having responsibility and accountability for environmental laboratory accreditation and which grants accreditation.

Accreditation Body: Authoritative body that performs accreditation.

Accuracy: The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator.

Aliquot: A discrete, measured, representative portion of a sample taken for analysis.

Analyst: The designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.

Analyte: The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family, and which are analyzed together.

Assessment: The evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its systems to defined criteria (to the standards and requirements of NELAC).

Assessment *(Clarification*): The evaluation process used to measure the performance or effectiveness of a system and its elements against specific criteria.

Note: In this standard, assessment is an all-inclusive term used to denote any of the following: audit, performance evaluation, peer review, inspection, or surveillance.

Audit: A systematic evaluation to determine the conformance to quantitative and qualitative specifications of some operational function or activity.

Batch: Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A preparation batch is composed of one to 20 environmental samples of the same NELAC-defined matrix, meeting the above-mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An analytical batch is composed of prepared environmental samples (extracts, digestates or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples.

Atomization: A process in which a sample is converted to free atoms.

Blank: A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results.

Blind Sample: A sub-sample for analysis with a composition known to the submitter. The analyst/ laboratory may know the identity of the sample but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.

Calibration: Set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards.

1) In calibration of support equipment the values realized by standards are established through the use of Reference Standards that are traceable to the International System of Units (SI).

2) In calibration according to test methods, the values realized by standards are typically established through the use of Reference Materials that are either purchased by the laboratory with a certificate of analysis or purity, or prepared by the laboratory using support equipment that has been calibrated or verified to meet specifications.

Calibration Curve: The graphical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response.

Calibration Method: A defined technical procedure for performing a calibration.

Calibration Range: The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metal analysis with a single-point calibration, the low-level calibration check standard and the high standard establish the linear calibration range, which lies within the linear dynamic range.

Calibration Standard: A substance or reference material used to calibrate an instrument.

Certified Reference Material (CRM): A reference material, one or more of whose property values are certified by a technically valid procedure, accompanied by or traceable to a certificate or other documentation which is issued by a certifying body.

Chain of Custody Form: A record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; collector; time of collection; preservation; and requested analyses.

Chain of Custody: An unbroken trail of accountability that verifies the physical security of samples, data, and records.

Client: Any individual or organization for whom items or services are furnished or work performed in response to defined requirements and expectations.

Congener: A member of a class of related chemical compounds.

Confirmation: Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to:

- Second column confirmation;
- Alternate wavelength;
- Derivatization;
- Mass spectral interpretation;
- Alternative detectors; or
- Additional cleanup procedures.

Conformance: An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements.

Consensus Standard: A standard established by a group representing a cross-section of a particular industry or trade, or a part thereof.

CONUS: Contiguous United States.

Continuing Calibration Verification: The verification of the initial calibration that is required during the course of analysis at periodic intervals. Continuing calibration verification applies to both external standard and internal standard calibration techniques, as well as to linear and non-linear calibration models.

Corrective Action: The action taken to eliminate the causes of an existing nonconformity, defect or other undesirable situation in order to prevent recurrence.

Data Audit: A qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality (i.e., that they meet specified acceptance criteria).

Data Reduction: The process of transforming raw data by arithmetic or statistical calculations, standard curves, concentration factors, etc., and collation into a more useable form.

Definitive Data: Analytical data of known quality, concentration, and level of uncertainty. The levels of quality and uncertainty of the analytical data are consistent with the requirements for the decision to be made. Suitable for final decision-making.

Demonstration of Capability: A procedure to establish the ability of the analyst to generate acceptable accuracy.

Detection Limit (DL): The lowest concentration or amount of the target analyte that can be identified, measured, and reported with confidence that the analyte concentration is not a false positive value.

Detection Limit (DL) (Clarification): The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. At the DL, the false positive rate (Type I error) is 1%.

Digestion: A process in which a sample is treated (usually in conjunction with heat) to convert the sample to a more easily measured form.

Document Control: The act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.

Duplicate: The analyses or measurements of the variable of interest performed identically on two subsamples of the same sample. The results of duplicate analyses are used to evaluate analytical or measurement precision but not the precision of sampling, preservation or storage internal to the laboratory.

Eluent: A solvent used to carry the components of a mixture though a stationary phase.

Elute: To extract; specifically, to remove (adsorbed material) from an adsorbent by means of a solvent.

Elution: A process in which solutes are washed though a stationary phase by the movement of a mobile phase.

Environmental Data: Any measurements or information that describe environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology.

Environmental Monitoring: The process of measuring or collecting environmental data. (UFP-QAPP)

False Negative: An analyte incorrectly reported as absent from the sample, resulting in potential risks from their presence.

False Positive: An item incorrectly identified as present in the sample, resulting in a high reporting value for the analyte of concern.

Finding: An assessment conclusion referenced to a NELAC Standard and supported by objective evidence that identifies a deviation from a NELAC requirement.

Finding *(Clarification)*: An assessment conclusion that identifies a condition having a significant effect on an item or activity. An assessment finding may be positive or negative and is normally accompanied by specific examples of the observed condition.

Note: For DoD the finding must be linked to a specific requirement.

Holding Times (Maximum Allowable Holding Times): The maximum times that samples may be held prior to analysis and still be considered valid or not compromised.

Holding Times (DoD Clarification): The time elapsed from the time of sampling to the time of extraction or analysis, or from extraction to analysis, as appropriate.

Homologue: One in a series of organic compounds in which each successive member has one more chemical group in its molecule than the next preceding member. For instance, CH3OH (methanol), C2H5OH (ethanol), C3H7OH (propanol), C4H9OH (butanol), etc., form a homologous series.

Inspection: An activity such as measuring, examining, testing, or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformance is achieved for each characteristic.

Interference, spectral: Occurs when particulate matter from the atomization scatters the incident radiation from the source or when the absorption or emission of an interfering species either overlaps or is so close to the analyte wavelength that resolution becomes impossible.

Interference, chemical: Results from the various chemical processes that occur during atomization and later the absorption characteristics of the analyte.

Internal Standard: A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.

International System of Units (SI): The coherent system of units adopted and recommended by the General Conference on Weights and Measures.

Instrument Blank: A clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination.

Isomer: One of two or more compounds, radicals, or ions that contain the same number of atoms of the same elements but differ in structural arrangement and properties. For example, hexane (C6H14) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane.

Laboratory: A body that calibrates and/or tests.

Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank, or QC check sample): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to assess the performance of all or a portion of the measurement system.

Laboratory Duplicate: Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.

Limit of Detection (LOD): An estimate of the minimum amount of a substance that an analytical process can reliably detect. An LOD is analyte- and matrix-specific and may be laboratory-dependent.

Limit of Detection *(Clarification)*: The smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%.

Limits of Quantitation (LOQ): The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

Limit of Quantitation *(Clarification):* The lowest concentration that produces a quantitative result within specified limits of precision and bias. For DoD projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard.

Manager (however named): The individual designated as being responsible for the overall operation, all personnel, and the physical plant of the environmental laboratory. A supervisor may report to the manager. In some cases, the supervisor and the manager may be the same individual. (NELAC)

Management: Those individuals directly responsible and accountable for planning, implementing, and assessing work.

Management System: System to establish policy and objectives and to achieve those objectives

Matrix: The substrate of a test sample

Field of Accreditation Matrix: These matrix definitions shall be used when accrediting a laboratory.

- Drinking Water: Any aqueous sample that has been designated a potable or potential potable water source.
- Non-Potable Water: Any aqueous sample excluded from the definition of Drinking Water matrix. Includes surface water, groundwater, effluents, water treatment chemicals, and TCLP or other extracts.
- Solid and Chemical Materials: Includes soils, sediments, sludges, products and by-products of an industrial process that results in a matrix not previously defined.
- Biological Tissue: Any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.
- Air and Emissions: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbent tube, impinger solution, filter, or other device. (NELAC)

Quality System Matrix: These matrix definitions are an expansion of the field of accreditation matrices and shall be used for purposes of batch and quality control requirements (see Table 9A-1). These matrix distinctions shall be used:

- Aqueous: Any aqueous sample excluded from the definition of Drinking Water matrix or Saline/Estuarine source. Includes surface water, groundwater, effluents, and TCLP or other extracts.
- Drinking Water: Any aqueous sample that has been designated a potable or potential potable water source.
- Saline/Estuarine: Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake.
- Non-aqueous Liquid: Any organic liquid with <15% settleable solids.
- Biological Tissue: Any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.
- Solids: Includes soils, sediments, sludges and other matrices with > 15% settleable solids.
- Chemical Waste: A product or by-product of an industrial process that results in a matrix not previously defined.
- Air and Emissions: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbent tube, impinger solution, filter or other device.

Matrix Spike (spiked sample or fortified sample): A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency. (QAMS)

Matrix Spike Duplicate (spiked sample or fortified sample duplicate): A second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte. (QAMS)

May: Denotes permitted action, but not required action. (NELAC)

Measurement Quality Objectives (MQOs): The desired sensitivity, range, precision, and bias of a measurement.

Measurement System: A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the test and the operator(s).

Method: 1. See Test Method. 2. Logical sequence of operations, described generically, used in the performance of measurements. (VIM 2.4)

Method Blank: A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses. (NELAC)

Method Detection Limit: One way to establish a Limit of Detection, defined as the minimum concentration of a substance (an analyte) that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.

Method Detection Limit (MDL) *(Clarification):* The MDL is one way to establish a Detection Limit, not a Limit of Detection.

Method of Standard Additions: A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration. (This process is often called spiking the sample.)

National Environmental Laboratory Accreditation Conference (NELAC): A voluntary organization of State and Federal environmental officials and interest groups purposed primarily to establish mutually acceptable standards for accrediting environmental laboratories. A subset of NELAP.

National Environmental Laboratory Accreditation Program (NELAP): The overall National Environmental Laboratory Accreditation Program of which NELAC is a part. (NELAC)

Negative Control: Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results. (NELAC)

Nonconformance: An indication or judgment that a product or service has not met the requirement of the relevant specifications, contract, or regulation; also the state of failing to meet the requirements.

Performance Audit: The routine comparison of independently obtained qualitative and quantitative measurement system data with routinely obtained data in order to evaluate the proficiency of an analyst or laboratory.

Positive Control: Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.

Precision: The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.

Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical and/or biological integrity of the sample.

Proficiency Testing: A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.

Proficiency Testing Oversight Body/Proficiency Testing Provider Accreditor (PTOB/PTPA): An organization with technical expertise, administrative capacity and financial resources sufficient to implement and operate a national program of PT provider evaluation and oversight that meets the responsibilities and requirements established by NELAC standards.

Proficiency Testing Program: The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.

Proficiency Testing Study Provider: Any person, private party, or government entity that meets stringent criteria to produce and distribute NELAC PT samples, evaluate study results against published performance criteria and report the results to the laboratories, primary accrediting authorities, PTOB/PTPA, and NELAP.

Proficiency Test Sample (PT): A sample, the composition of which is unknown to the analyst and is provided to test whether the analyst/laboratory can produce analytical results within specified acceptance criteria.

Protocol: A detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) which must be strictly followed.

Quality Assurance: An integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence.

Quality Control: The overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users.

Quality Control Sample: A sample used to assess the performance of all or a portion of the measurement system. QC samples may be Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking.

Quality Manual: A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.

Quality System: A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC.

Quantitation Range: The range of values in a calibration curve between the LOQ and the highest successfully analyzed initial calibration standard. The quantitation range lies within the calibration range.

Raw Data: Any original factual information from a measurement activity or study recorded in a laboratory notebook, worksheets, records, memoranda, notes, or exact copies thereof that are necessary for the reconstruction and evaluation of the report of the activity or study. Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic media, including dictated observations, and recorded data from automated instruments. If exact copies of raw data have been prepared (e.g., tapes which have been transcribed verbatim, data and verified accurate by signature), the exact copy or exact transcript may be submitted.

Reagent Blank (method reagent blank): A sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.

Reference Material: A material or substance, one or more properties of which are sufficiently well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.

Reference Standard: A standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived.

Reference Toxicant: The toxicant used in performing toxicity tests to indicate the sensitivity of a test organism and to demonstrate the laboratory's ability to perform the test correctly and obtain consistent results

Replicate Analyses: The measurements of the variable of interest performed identically on two or more sub-samples of the same sample within a short time interval.

Reporting Limit: A client-specified lowest concentration value that meets project requirements for quantitative data with known precision and bias for a specific analyte in a specific matrix.

Requirement: Denotes a mandatory specification; often designated by the term "shall".

Retention Time: The time between sample injection and the appearance of a solute peak at the detector.

Sample: Portion of material collected for analysis, identified by a single, unique alphanumeric code. A sample may consist of portions in multiple containers, if a single sample is submitted for multiple or repetitive analysis

Second source calibration verification (ICV): A standard obtained or prepared from a source independent of the source of standards for the initial calibration. Its concentration should be at or near the middle of the calibration range. It is done after the initial calibration.

Selectivity: (Analytical chemistry) The capability of a test method or instrument to respond to a target substance or constituent in the presence of non-target substances.

Sensitivity: The capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest.

Signal to Noise Ratio: The signal carries information about the analyte, while noise is made up of extraneous information that is unwanted because it degrades the accuracy and precision of an analysis and also places a lower limit on the amount of analyte that can be detected. In most measurements, the average strength of the noise is constant and independent of the magnitude of the signal. Thus, the effect of noise on the relative error of a measurement becomes greater and greater as the quantity being measured (producing the signal) decreases in magnitude.

Spike: A known mass of target analyte added to a blank sample or sub-sample; used to determine recovery efficiency or for other quality control purposes.

Standard: (Document) The document describing the elements of laboratory accreditation that has been developed and established within the consensus principles of NELAC and meets the approval requirements of NELAC procedures and policies.

Standard: (Chemical) Standard samples are comprised of a known amount of standard reference material in the matrix undergoing analysis. A standard reference material is a certified reference material produced by the US National Institute of Standards and Technology (NIST) and characterized for absolute content, independent of analytical test method.

Standard Method: A test method issued by an organization generally recognized as competent to do so.

Standard Operating Procedure (SOP): A written document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks.

Standardized Reference Material (SRM): A certified reference material produced by the U.S. National Institute of Standards and Technology or other equivalent organization and characterized for absolute content, independent of analytical method.

Surrogate: A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes.

Target Analytes: Analytes specifically named by a client (also called project-specific analytes).

Test: A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. The result of a test is normally recorded in a document sometimes called a test report or a test certificate.

Test Method: An adoption of a scientific technique for performing a specific measurement as documented in a laboratory SOP or as published by a recognized authority.

Testing Laboratory: Laboratory that performs tests.

Test Sensitivity/Power: The minimum significant difference (MSD) between the control and test concentration that is statistically significant. It is dependent on the number of replicates per concentration, the selected significance level, and the type of statistical analysis

Traceability: The property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

Tuning: A check and/or adjustment of instrument performance for mass spectrometry as required by the method.

Validation: The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.

Verification: Confirmation by examination and provision of evidence that specified requirements have been met.

Note: In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment.

The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.

Work Cell: A well-defined group of analysts that together perform the method analysis. The members of the group and their specific functions within the work cell must be fully documented.

APPENDIX 1: SCOPE OF TESTING

	Surface / Groundwater	Wastewater	Drinking Water	Soil / Sediment	Waste / Leachate / Sludge	Tissue	Method References
SERVICE GROUP: INORGANICS							
ACIDITY*	✓	✓					SM2310B
ALACHLOR	✓						8270D
ALKALINITY	✓	✓	✓		✓		EPA 310.2 / SM 2320B
ANIONS IC (Bromide, Chloride, Fluoride, Nitrate, Nitrite, ortho-Phosphate, Sulfate)	✓	✓	✓	✓	✓		EPA300.0 / 9056A/ SM4110B
ATRAZINE	✓						8270D
BICARBONATE ALKALINITY	✓	✓			✓		EPA 310.2
BIOCHEMICAL OXYGEN DEMAND (BOD)	✓	✓			✓		SM 5210B
CARBONACEOUS BOD	✓	✓			✓		SM 5210B
CARBON DIOXIDE	✓	✓	✓				RSK-175 / SM 4500-CO2D
CARBON: INORGANIC TOTAL / DISSOLVED (TIC/DIC)	✓	✓					EPA 9060A / 415.1
CARBON: ORGANIC TOTAL / DISSOLVED (TOC/DOC)	✓	✓	✓	✓	✓	✓	EPA 9060A / 415.1 / SM 5310B / Lloyd Kahn
CARBONATE ALKALINITY	✓	✓			✓		EPA 310.2
CHLORINE, RESIDUAL	✓	✓	✓				SM 4500CL
CHEMICAL OXYGEN DEMAND (COD)	✓	✓		✓	✓		EPA 410.4
COLOR*	✓	✓	✓				EPA 110.2
CONDUCTIVITY	✓	✓	✓	✓	✓		SM 2510B / EPA 9050A / 120.1
CORROSIVE INDEX*			✓				SM 2330
CYANIDE	✓	✓	✓	✓	✓		EPA 9010B/ 9012A / 335.4
CYANIDE, REACTIVE	✓	✓		✓	✓		Ch. 7.3.3
CYANIDE, WEAK & DISSOCIABLE*	✓	✓	✓		✓		SM 4500-I
FLAMMABILITY SCREEN				✓	✓		EPA 1030
FLASHPOINT	✓	✓		✓	✓		EPA 1010
FREE LIQUIDS	✓	✓		✓	✓		EPA 9095B
HEXAVALENT CHROMIUM	✓	✓		✓	✓		EPA 3060A / 7196A
IGNITABILITY				✓	✓		EPA 1030

LIPID, PERCENT*						✓	Lab SOP
NITROCELLULOSE	✓			✓			EPA 9056M
NITROGEN, AMMONIA	✓	✓	✓	✓	✓		SM 4500-NH3H / EPA 350.1
NITROGEN, ORGANIC	✓	✓		✓	✓		EPA 350.1 / 351.2
NITROGEN, TOTAL	✓	✓			✓		EPA 351.2/300.0
NITROGEN, KJELDAHL	✓	✓		✓	✓		EPA 351.2
NO2+NO3	✓	✓		✓	✓		EPA 353.2/ 9056A
ODOR*	✓		✓				SM 2150A
OIL & GREASE	✓	✓		✓	✓		EPA 1664A / EPA 9071B
OXIDIZER SCREEN*				✓	✓		ASTM D4981
PERCENT MOISTURE				✓	✓	✓	SM 2540G
PERMANGANATE*							SM 4500KMNO4
PH	✓	✓	✓	✓	✓		EPA 9040C / 150.1 / 9045D
PHENOLICS	✓	✓		✓	✓		EPA 9066 / 420.4 /
PHOS WATER EXT					✓		PSU Method
PHOSPHOROUS	✓	✓	✓	✓	✓		EPA 365.4 / 365.1
RESIDUE TOTAL			✓				SM 2540-C
SALINITY*	✓	✓		✓			EPA 2520B
SEDIMENT CONC*	✓	✓			✓		ASTM D3977-977
SOIL OXIDANT DEMAND*							LAB SOP
SOLIDS TOT DISS	✓	✓	✓		✓		SM 2540C
SOLIDS TOT SUSP	✓	✓			✓		SM 2540M
SOLIDS TOTAL	✓	✓	✓				SM 2540B
SOLIDS, ASH-FREE				✓	✓		EPA 160.4
SOLIDS, PERCENT				✓	✓	✓	EPA 8000C / SM 2540B
SOLIDS, SETTLEABLE	✓	✓			✓		SM 2540F
SOLIDS, TOTAL VOL	✓	✓		✓	✓		EPA 160.4
SOLIDS, VOLT SUS	✓	✓			✓		SM2540D
SULFIDE	✓	✓	✓		✓		SM 4500-S2F / EPA 9034 , 376.1
SULFIDE, REACT	✓	✓		✓	✓		ASTM D4978
TOC as % OM*	✓	✓	✓	✓	✓		MOSA 29-4,3,4
TOTAL COLIFORM	✓		✓				SM 9223
SERVICE GROUP: MICROBIOLOGY							
CHLOROPHYLL A, B & C	✓			✓			SM 10200H

E. COLI	✓	✓	✓	✓	✓		9223B
FECAL COL MF 7 of 7*	✓	✓		✓	✓		SM 9222D / SM 9221
FECAL COLIFORM (MF)*	✓	✓					SM 9222D
HETEROTROPHIC PLATE COUNT*	✓	✓	✓				SM 9215D
MICROCYSTIN*	✓						Lab SOP
PHEOPHYTIN A*	✓	✓					SM 10200H
SERVICE GROUP: METALS							
ANTIMONY	✓	✓	✓				EPA 7010 / 200.9 / 7041
ARSENIC	✓	✓	✓	✓	✓		EPA 7010 / 200.9 / 7060A
CHROMIUM III	✓	✓		✓	✓		EPA 6010C
HARDNESS	✓	✓	✓		✓		SM2340B / 6010 / EPA 200.7
ICP METALS	✓	✓	✓	✓	✓	✓	EPA 6010C / 200.7
BORON	✓	✓		✓	✓		EPA 6010C / 200.7
POTASSIUM	✓	✓	✓	✓	✓		EPA 6010C / 200.1 / 200.7
LITHIUM	✓						EPA 6010C
LEAD	✓	✓	✓	✓	✓		EPA 6010C / 7010 / 200.9
SILICA	✓	✓		✓	✓		EPA 6010C / EPA 200.7
SULFUR	✓	✓		✓			EPA 6010C
IRON III	✓						EPA 6010C
MERCURY	✓	✓	✓	✓	✓		EPA 7470A / 7471B / 245.2 / 7471A
SELENIUM	✓	✓	✓	✓	✓		EPA 7010 / 200.9 / 7740
SILVER	✓	✓	✓				EPA 200.9
THALLIUM	✓	✓	✓	✓	✓		EPA 7010 200.9
TURBIDITY	✓	✓	✓				EPA 180.1
SERVICE GROUP: ORGANICS							
DRO/ERO	✓			✓			EPA 8015C
BTEX	✓	✓		✓			EPA 8260C / 8021
SIM EXPLOSIVES SIM	✓			✓			EPA 8270D
SIM PESTICIDES	✓	✓		✓			EPA 8270D
EXPLOSIVES	✓			✓	✓		EPA 8330B / 8330A
CO2	✓	✓	✓		✓		Mod RSK 175
DRO WI	✓	✓		✓	✓		WDNR DRO
DRO	✓	✓		✓	✓		EPA 8015C / 8015
ETHYLENE & PROPYLENE GLYCOL	✓	✓					EPA 8015C

FINGERPRINT ID	✓	✓	✓	✓	✓		EPA 8015
GRO	✓	✓		✓	✓		EPA 8015C
GRO WI	✓	✓		✓	✓		WDNR GRO
METHANE, ETHANE, ETHENE, ACETYLENE	✓	✓			✓		Mod RSK 175
PAH	✓	✓		✓	✓		EPA 8310
PAH SIM	✓			✓	✓		EPA 8270D-SIM
PCB	✓	✓		✓	✓	✓	EPA 8082A
PESTICIDES	✓	✓		✓	✓	✓	EPA 8081B / 8081
PVOC	✓	✓		✓	✓		EPA 8020A
SVOC 8270	✓	✓		✓	✓		EPA 8270D
SVOC TICS	✓	✓		✓			EPA 8270D
VOC	✓	✓	✓	✓	✓		EPA 524.2 / 8021M/ 8260C
VOC TICS	✓	✓		✓			EPA 8260C
SERVICE GROUP: GEOTECH							
BULK DENSITY*				✓			MOSA 13-2.1
GRAIN SIZE ANALYSIS*				✓			ASTM C136-84A
SIEVE P200*				✓			ASTM D421-85
SPECIFIC GRAVITY*	✓	✓	✓	✓	✓		SM 2710F
SOIL OXIDANT DEMAND*				✓			LAB SOP
ELUTRIATE PREP*	✓			✓	✓		LAB SOP
INCREMENTAL SAMPLE PRE/ HOMOGENIZATION *				✓	✓	✓	LAB SOP

* Indicates tests / procedures for which the lab is not accredited

APPENDIX 2: MASTER SOPs LIST

Form: FQA3-03 Rev #: 1.0
Effective Data: 07/16/14

Code	Document Control #	File Name
AD-xxxx-*Administrative*		
AD	001	Automated Computer System Back-ups
AD	002	Computer Software Verification
AD	003	Procurement of Materials and Services
AD	004	LABTrack Electronic Lab Notebook Software Usage
WC-XXX-*Wet Chemistry*		
WC	001	Reactive Cyanide Screen
WC	002	Reactive Cyanide Distillation
WC	003	Cyanide, Total & Amenable to Chlorination
WC	005	Color
WC	006	Turbidity
WC	007	Corrosivity - Langelier & Aggressive Indices
WC	008	Alkalinity, Automated Colorimetric
WC	009	Alkalinity, Titrimetric
WC	010	Biological Oxygen Demand (BOD & CBOD)
WC	011	Chemical Oxygen Demand, Closed Reflux
WC	012	Specific Conductance
WC	013	Ammonia-Nitrogen, Automated
WC	014	Ammonia In-line Distillation
WC	015	Nitrate+Nitrite, Automated Colormetric
WC	016	TKN & KN
WC	017	Phosphorus, Total
WC	018	Phosphorus, Soil Cupric Digestion
WC	019	Phenolics
WC	020	pH- Liquids
WC	021	pH- Soils and Waste
WC	022	Free Liquids (Paint Filter)
WC	024	Solids, Dissolved
WC	025	Solids, TSS
WC	026	Solids, Total
WC	027	Solids, T Volatile
WC	028	Reactive Sulfide Screen
WC	030	Sulfide
WC	031	Residual Chlorine
WC	032	Hex Chrom, Automated Colormetric
WC	033	Hex Chrom, Alkaline Dig - Colormetric Analysis
WC	034	Flash-Point by Pensky-Martens Closed Cup Tester
WC	036	Specific Gravity
WC	037	Ion Chromatography
WC	039	Total Organic Carbon in Water
WC	040	Total Organic Carbon in Soil
WC	043	Salinity
WC	044	Cyanide Automated Colorimetric In-Line Distillation
WC	045	Percent Lipids

Form: FQA3-03 Rev #: 1.0
Effective Data: 07/16/14

Code	Document Control #	File Name
PR-XXX *Preparation*		
PR	001	Automated Cleaning of Laboratory Glassware
PR	002	TCLP / SPLP Extraction, Volatile Fraction (ZHE)
PR	003	TCLP / SPLP Extraction, Non-Volatile Fraction
PR	004	ASTM Water Leach
PR	006	**OPEN**
PR	007	Subsampling Guidance
PR	008	Homogenization of Fish Tissue
GC-XXX General Chemistry		
GC	001	Chemistry Sample Management
GT-XXX GeoTechnical		
GT	001	Elutriate Test Preparation
GT	002	Grinding of Multi-incremental Samples by Puck Mill and Sub-sampling for Metals Analysis Prior to Grinding
GT	004	Grain Size
GT	007	Soil Bulk Density- Core Method
GT	008	Total and Air-Filled Porosity
MT-XXX *Metals*		
MT	003	Acid Digestion of Waters for Dissolved or Total Metals
MT	007	Acid Digestion of Solids and Semi-solids for Total Metals by GFAA and ICP
MT	009	Inductively Coupled Plasma (ICP) Emission – ICP-OES 6000
MT	010	Data Capture for ICP
MT	011	Graphite Furnace Atomic Absorption (GFAA)
MT	012	Mercury Cold Vapor Atomic Absorption (CV)
MT	013	Mercury in Water by CVAF Spectrometry
MB-XXX *Microbiology*		
MB	002	Coliform Bacteria Using Colilert
MB	003	Fecal Coliforms in Aqueous Samples - Membrane Filtration
MB	004	Fecal Coliforms in Solid Samples - Membrane Filtration
MB	005	Fecal Coliforms in Biosolids Samples - MPN
MB	006	Heterotrophic Bacteria - Membrane Filter
MB	008	Autoclave Operation
MB	009	Chlorophyll a - Spectrophotometric Determination
PM-XXX *Project Management*		
PM	001	Subcontracting of Laboratory Samples
PM	003	Chemistry & Microbiology Sample Receiving and Processing
PM	004	SOP for Sample Containers: Purchasing, Receipt & Dissemination
PM	005	Regulated Soil Sample Receiving and Processing
PM	006	Project Coordination

Form: FQA3-03 Rev #: 1.0
Effective Data: 07/16/14

Code	Document Control #	File Name
QA-XXX *Quality Assurance*		
QA	001	Quality Assurance Manual
QA	002	Nonconformance ID & Corrective Action
QA	003	Document Control
QA	004	Preparation of Technical Standard Operating Procedures
QA	005	Employee Training
QA	006	Internal Audits
QA	007	Preventative Actions
QA	008	Good Automated Laboratory Practices
QA	009	Records Management
QA	010	Laboratory Notebooks/Logbooks
QA	011	Laboratory Reagents and Materials
QA	012	Selection, Care and Use of Volumetric and Weighing Equipment
QA	013	Management Reviews
QA	014	OPEN
QA	015	Proficiency Testing
QA	016	Manual Integration
QA	017	Quality Control Samples & Charting
QA	018	Processing of Sample Outside of Quality System Guidelines
QA	019	Confidentiality/ Proprietary Information
QA	020	Data Reporting
QA	021	Estimation of Analytical Measurement Uncertainty
QA	022	Demonstration of Competence (IDC)
QA	023	Initial Method Performance and Reporting (MDL)
QA	024	Organic Chemistry Standards Documentation
QA	025	Inorganic Reagent and Standard Documentation
QA	026	Thermometer Calibration Checks
QA	027	Balance Calibration
SV-XXX *Semivolatiles*		
SV	001	Diesel Range Organics by GC
SV	002	Organochlorine Pesticide by GC w/extended list
SV	004	Polychlorinated byphenyls (PCBs) as Aroclors by GC
SV	006	Semi-volatile Organic Compounds by 8270D
SV	007	Semi-volatile Organic Compounds by GC/MS SIM
SV	008	Polynuclear Aromatic Hydrocarbons by HPLC
SV	009	Explosives by Modified Method 8330A
SV	010	Explosives by Modified Method 8330B w/ Extended Analyte List
SV	012	Wisconsin's Diesel Range Organics by GC
SV	014	Semivolatiles Gel Permeation Chromatography (GPC) Cleanup
SV	015	HEM - Oil and Grease
SV	016	Ethylene Glycol and Propylene Glycol by GC
SV	018	Thiodiglycol by HPLC
SV	019	Oil & Grease by Soxhlet
SV	020	Fox River: Polychlorinated byphenyls (PCBs) as Aroclors by GC
SV	021	Microwave Extraction of Semi-Volatiles Solid Samples
SV	022	Separatory Funnel Extraction of Semi-Volatiles Liquid Samples

Form: FQA3-03 Rev #: 1.0
Effective Data: 07/16/14

Code	Document Control #	File Name
SV	023	Concentration of Semivolatile Sample Extracts
SV	024	Solid Phase Extraction of Semi-Volatiles Liquid Samples
SV	025	Florisil Cartridge Cleanup
SV	026	Sulfur Cleanup SOP
SV	027	Waste Dilution
SV	028	Sulfuric Acid Cleanup
SV	029	TCLP Acid Herbicides
VO-XXX *Volatiles Organic*		
VO	001	Analysis of Dissolved Methane, Ethene, Ethane & Carbon dioxide in Water
VO	002	Analysis of Volatile Organic Compounds by GC/MS for Safe Drinking Water
VO	004	Analysis of Volatile Organic Compounds by GC/MS (8260C)
VO	005	Analysis of BTEX and GRO by GC
VO	007	Analysis of BTEX and GRO by GC (Wisconsin)
VO	008	Preparation of Nitrocellulose Soils and Waters for Analysis of Nitrate/Nitrite by Ion Chromatography
VO	009	
WS-XXX *Waste Disposal*		
WS	001	Laboratory Waste Disposal
HS-XXX *Health & Safety*		
HS	001	CTL Health and Safety Manual
CP-XXX Client Procedures		
CP	001	BAAP Well Sampling
CP	002	Fox river Method

Form: FQA3-03 Rev #: 1.0
Effective Data: 07/16/14

Code	Document Control #	File Name
DCE-XXX Document Control External		
DCE	001	A2LA P102 Policy on Metrological Traceaility
DCE	002	A2LA P102a Policy on Reference Material Traceability for Life Sciences Testing Laboratories
DCE	003	A2LA P102b Policy Annex on Requesting an Exception to Measurement Traceability
DCE	004	A2LA P103 Policy on Estimating Measurement Uncertainty for Testing Laboratories
DCE	005	A2LA P103b Policy Annex on Estimating Measurement Uncertainty for Life Science Testing Laboratories
DCE	006	A2LA P113 Policy on Measurement Traceability for Life Science Testing
DCE	007	A2LA P118 Policy Technical Consensus Decision from the Life Science Advisory Committee
DCE	008	A2LA R101 General Req- Accreditation of ISO IEC 17025 Laboratories
DCE	009	A2LA R102 General Req-Conditions for Accreditation
DCE	010	A2LA R103 General Req- Proficiency Testing for ISO IEC 17025 Laboratories
DCE	011	A2LA R103a General Req- Annex to Proficiency Testing
DCE	012	A2LA R105 General Req- Requirements when making Reference to A2LA Accreditated Status
DCE	013	A2LA R206 Specific Req-Environmental Testing Laboratory Accreditation Program
DCE	014	A2LA R220 Specific Req- A2LA DoD Environmental Laboratory Accreditation Program

APPENDIX 3: ETHICS & DATA INTEGRITY AGREEMENT

CT LABORATORIES EMPLOYEE
ETHICS, DATA INTEGRITY, AND SECURITY AWARENESS
STATEMENT AND AGREEMENT

CT Laboratories Employee Ethics and Data Integrity Statement

As an employee/contractor of CT Laboratories, I understand the high standards of integrity required of me with regard to the duties I perform, and the data I report in connection with my employment at CT Laboratories. Our core values are honesty, success, service and integrity. I understand that it is critical for our long-term success that each and every employee aligns with all company core values.

I agree that in the performance of my duties for CT Laboratories and its clients, I shall conform to the following ethics standards and will report immediately to the appropriate supervisor and QA Manager any information concerning misrepresentation of analytical data that includes, but is not limited to:

1. Altering an instrument computer or clock for any inappropriate purpose;
2. Altering the contents of logbooks and/or data sheets to misrepresent data;
3. Misrepresenting an analyst's identity;
4. Changing raw data documents with correction fluid;
5. Preparation and submittal of fabricated data packages;
6. Inappropriate calibration techniques such as peak shaving, setting fraudulent integrator parameters, or use of computer macros that alter QC results.
7. Deviate from laboratory's manual integration procedures when applicable.
8. Changing reported results without proper documentation and approval;
9. Altering injection volumes for calibration and misrepresenting the true values;
10. Failure to comply with standard operating procedures or methods without proper documentation and approval;
11. Any attempt to misrepresent data or events as they actually occur in the course of data production, review or reporting;
12. Disposing of or deleting electronic data files or hardcopy of raw data;
13. Engaging in any practice that ultimately misrepresents data or narratives in any way; I will not *knowingly* participate in any such activity and will not tolerate unethical practices by other employees. I understand that confidentiality will be strictly enforced by CT LABORATORIES when dealing with these matters. As a further extension of my commitment to this program, I am responsible for seeking approval to report data resulting from techniques or procedures that deviate from standard operating procedures, methods, or industry standard practices. Any such reporting of data will include a laboratory narrative that must be approved by the appropriate supervisor and the QA Manager.

If I am unsure of how to properly handle data generated by me, I am responsible for seeking advice from the appropriate supervisor, laboratory director and/or the QA Manager. I agree to inform the appropriate supervisor and/or the Quality Assurance Manager of any accidental reporting of erroneous data by others or myself within 24 hours of discovery.

CT Laboratories has a zero tolerance policy for illegal, unethical, and improper practices affecting the integrity of the testing process. Therefore, I understand that *if I knowingly participate* in any such prohibited activity, I may be subject to disciplinary action that may include termination by CT Laboratories. I also understand that intentional falsification(s) of data may include prosecution by local, state or federal agencies with punishments as dictated by in a Court of Law.

However, it is not the purpose, nor the intent of these statements and agreement to punish anyone for an accidental mistake or oversight. Employees <u>will not</u> face disciplinary actions in these cases. Repeated careless or neglectful behavior will be subject to corrective action. Covering up a mistake or oversight is not acceptable behavior and will result in termination. Mistakes or oversights are to be immediately reported to the appropriate supervisor and/or Quality Assurance Manager.

Security Awareness

As part of our compliance requirements for DoD/QSM, all employees are to be annually reminded of the computer security requirements for CT Laboratories Computer Systems and email. Please read the following information carefully:

1. PC's are provided by CT Laboratories for use by its employees, and are restricted for use to ***only*** CT Laboratories employees.
2. Standalone PC's should be logged off by the employee when they complete their task. If the employee has not completed their task and wishes to remain logged on *with open work files*, then the computer should be locked by the employee.
3. No software should be installed *on any PC* without IT approval.
4. Occasionally, it may be necessary to attach a flash drive to a PC. The flash drive should only be a CT Laboratories provided flash drive that has been previously checked by IT.
5. Software viruses are always a potential problem. Antivirus software is installed on all PC's, and no attempt should be made to disable this software. If antivirus software is interfering with your duties or collection of data from instrumentation, contact IT for remediation.
6. Through our Barracuda Web Security appliance, many websites are automatically blocked. This is to avoid malicious websites (security), as well as to maintain a certain amount of control over employee browsing of websites not associated with their responsibilities (and inadvertently compromising security).
   a. The Barracuda automatically checks for known viruses and exploits (for example, ransomware) on pages coming/going from our IP address.
   b. Additionally our spam service (currently, SpamStopsHere by Greenwood Data) automatically checks incoming email for viruses, malware and spam sent through our email server, and blocks delivery to the CTL Exchange server. Any emails that you feel are inadvertently being blocked (which can happen), should be reported to IT for correction.
7. Emails are checked for viruses and exploitation software, *however checking is done only for known threats.* New threats are developed daily, and if a suspicious email is received (you were not expecting it, unknown sender, etc.), ***don't open it;*** either send it to IT or delete it immediately.
8. Embedded links in emails and web pages *should always be treated cautiously, and as a rule of thumb, should NOT be opened*! Many embedded addresses can be easily "spoofed" and will direct you to a webpage that may *look* legitimate, but are really *knockoffs* designed to collect information about you, the Company, passwords, credit cards, etc**. Instead of clicking on an embedded website, *type*, do not copy, the address in the browser bar at the top of the web browser page.**
9. No Internet devices should be connected to the CT Laboratories network without the permission of IT.
10. Finally, if you see something suspicious, please say something. *Malicious software can and has shut down our network*, making it impossible to perform your duties as well as those of everyone in the company.
11. CT Laboratories will periodically throughout the year conduct Security Awareness Training and employee testing. It is required that all employees complete the assigned training tasks to remain eligible to use the CT Laboratory computers and network.
12. CT Laboratories maintains a sophisticated firewall to prevent outside access to our network, without permission. If outside access is necessary, please discuss with the IT Manager.

My signature affirms my understanding of Ethical Standards and Security Awareness as it pertains to my employment at CT Laboratories, and that I will contact my supervisor for clarification should any questions arise.

Name (Printed): _____ Signature: _____ Date: _____

APPENDIX 4: Current List of Accreditations and Certifications

Accrediting Body	Certificate Expiration	Certificate #	Laboratory Identifier
DoD-ELAP			
A2LA	04/30/2018	3806.01	
NELAP			
Louisiana *	06/30/2017	4091	115843
Illinois	09/30/2017	3953	
Kansas	10/31/2017	E-10368	
Pennsylvania	04/30/2018	008	68-04201
Virginia	12/14/2017	8955	460203
Non-NELAP			
Maryland	12/31/2017	344	
Wisconsin	08/31/2018		157066030
Wisconsin-DATCP	12/31/2017	274485-D3	105-289

**Primary NELAP accreditation*

APPENDIX 5: DEMONSTRATION OF CAPABILITY CERTIFICATE

CT LABORATORIES
delivering more than data from your environmental analyses

DEMONSTRATION OF CAPABILITY CERTIFICATION STATEMENT

DATE RANGE FOR IDC: **Check One: [ ] Initial [ ] Annual**

Analyst(s) Name(s): Signature _____ Date: _____

Note: by signing above, the analyst(s) certify that they have performed the DOC study in compliance with CT Laboratories Quality Manual (QA-001) and DOD ELAP, NELAP, & 17025 quality systems

Matrix: (examples: laboratory pure water, soil, air, solid, biological tissue)

Method number, SOP#, Rev#, and analyte, or Class of Analytes or Measured Parameters (examples: barium by 200.7, trace metals by 6010, benzene by 8260, etc...)

We, the undersigned, CERTIFY that:

1) The analyst (s) identified above, using the cited test method(s), in use at this facility for the analysis of samples has met the Demonstration of Capability.
2) The test method(s) was performed by the analyst (s) identified on this certification.
3) A copy of the test method(s) and the laboratory specific SOP(s) are available for all personnel onsite.
4) The data associated with the Demonstration of Capability are true, accurate, complete, and self-explanatory (1).
5) All raw data (including a copy of this certification form) necessary to reconstruct and validate these analyses have been retained at the facility, and that the associated information is well-organized and available for review by authorized assessors.

_____	_____	_____
Group Leader	Signature	Date
_____	_____	_____
Quality Assurance Officer	Signature	Date

TEST/ANALYTE	ANALYTICAL METHOD	MATRIX	ANALYSIS INFORMATION (date/ time/run info)	SOP #	REV #	Data File

This certification must completed each time a demonstration of capability study is completed.
(1) *True*: Consistent with supporting data.
Accurate: Based on good laboratory practices consistent with sound scientific principles/practices.
Complete: Includes the results of all-supporting performance testing.
Self-explanatory: Data properly labeled and stored so that the results are clear and require no additional explanation.

APPENDIX 6: DEMONSTRATION OF CAPABILITY

Form # FQA1-02
Rev. # 1.0
Effective Date: 01/19/17

IDC_Analyst	Folder_No	Sample_No	Test_Desc_and_Rep	Prep_Method	Prep_Run	Prep_Date	Prep_Analyst	Method	Run_No	Analysis_Date	Analyst	CAS NUMBER	Analyte	RESULTS	UNIT	Spike_Amnt_or_True	%Recovery	Avg Recovery	Recovery LCL	Recovery UCL	Recovery Pass-Fail	Avg Measured Value	Std Deviation	%RSD	RSD Limit	RPD Pass-Fail
																	#DIV/0!									
																	#DIV/0!									
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!
																	#DIV/0!									
																	#DIV/0!	#DIV/0!	50	110	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	20	#DIV/0!

APPENDIX 7: LIST OF LABORATORY INSTRUMENTATION

Instrument Description	Serial Number	Manufacture, Model
Volatiles Lab		
PVOC 1 GC- Autosampler	EST, Archon	12950
PVOC 1 GC- Concentrator	Tekmar, LSC 2000	92174003
PVOC 1-GC	HP 5890	3033A30354
PVOC 2 GC-Autosampler	EST, Archon	12076
PVOC 2 GC-Concentrator	Tekmar, Stratum	US14043005
PVOC 2-GC	HP 5890	3121A35577
PVOC 4-GC	HP 5890	3133A37113
Backup-VMS 2-Vol-Autosampler	EST, Archon	12075
Backup-VMS 2-Vol-Concentrator	Tekmar, LSC 2000	90206049
Backup-MS 2-Vol-GC	HP5890	3336A50464
Backup-VMS 2-Vol-MS	HP5972	3329A00850
VMS 3-Vol-Autosampler	EST, Centurion	Cent266120808
VMS 3-Vol-Concentrator	EST, Encon Evolution	EV124081108
VMS 3-Vol-GC	Agilent 6890N	US10217020
VMS 3-Vol-MS	Agilent 5973 Network	US10462147
VMS 4-Vol-GC	Agilent 6890N	US10340068
VMS 4-Vol-MS	Agilent 5973 Network (5975 electronics upgrade)	US10350354
VMS 4-Vol-Autosampler	EST, Centurion W/S	CENTS314072213
VMS 4-Vol-Concentrator	EST, Encon Evolution	EV219082109
VMS 5-Vol-Autosampler	EST, Archon	12950
VMS 5-Vol-Concentrator	Tekmar, Stratum	US14043005
VMS 5-Vol-GC	Agilent 6890N Network	CN10511073
VMS5-Vol-MS	Agilent 5973 (Diffusion Pump)	US10442265
SRI GC	SRI 8610	1120
Backup- Concentrator (PVOC2)	Tekmar, LSC 2000	90324020
Backup- Concentrator	Tekmar, LSC 2000	91044001
Backup- Concentrator-2	Tekmar, LSC 2000	91317002
VOB01, Top Loading Balance	Metler Toledo, BD202	03649
Drying Oven # 1 (L-C Oven)	Labline, 3512	0678
Drying Oven # 3 (IsoTemp 500 Series)	Fisher, 526G	104O0226
Drying Oven # 6 (IsoTemp)	Fisher, 737F	5070N0051
Drying Oven # 7 (IsoTemp 500 Series)	Fisher 526G	005O0156
TOC H2O Autosampler	Skalar, LAS-160	11151
TOC Soil Analyzer	Skalar, MC10	11123
TOC H2O Analyzer	Skalar, CA16	11159
Millipore VO MilliQ 2	Milli Q System	16874
Glove Box	TerraUniversal, 3305-00G	335-00GP13752413

Instrument Description	Serial Number	Manufacture, Model
Semi-volatile Lab		
HPLC1 Controller	Shimadzu, SCL-10A	20190E
HPLC1 Pump	Shimadzu, LC-10AS	20236A
HPLC1 Pump	Shimadzu, LC-10AS	30380A
HPLC1 UV Detector	Shimadzu, SPD-10AV	40109C
HPLC1 Autosampler	Shimadzu, SIL-10A	C20473301678
HPLC Oven	Shimadzu, CTO-10AS	C21043550039
HPLC2 Controller	Shimadzu, SCL-10A	40188E
HPLC2 Pump	Shimadzu, LC-10AS	40202A
HPLC2 Pump	Shimadzu, LC-10AS	20267A
HPLC2 UV Detector	Shimadzu, SPD-10AV	20116D
HPLC2 Autosampler	Shimadzu, SIL-10A	60230F
HPLC Degasser	Shimadzu, DGU-14A	SS101062
SVMS1 GC	HP, 6890	US00028255
SVMS1 MS	HP, 5973	US42590767
SVMS1 Autosampler	HP, 7683	US91606760
SVMS2 GC	HP, 6890	US00025531
SVMS2 MS	HP, 5973	US42590795
SVMS2 Autosampler	HP, 7683	CN24428001
Semi 1 GC - ECD	Agilent, 6890	CN10534022
Semi 1 Autosampler	Leap, CTCA200SE	14632
Semi 2 GC - FID	HP, 5890II	2938A24859
Semi 2 Controller	HP, 7673 - 18594B	3138A26935
Semi 2 Autosampler - Tray	HP, 7673 - 18596M	3227A29036
Semi 2 Autosampler - Tower	HP, 7673 - 18593B	3120A26773
Semi 4 GC - FID	HP, 5890II	3022A28946
Semi 4 Controller	HP, 7673 - 18594B	3044A23379
Semi 4 Autosampler - Tray	HP, 7673 - 18596B	3021A21368
Semi 4 Autosampler - Tower	HP, 7673 - 18593B	3013A20597
Semi 6 GC - ECD	Agilent, 7890A	CN10261058
Semi 6 Autosampler - Tray	Agilent, 7683B - G2614A	CN92553323
Semi 6 Autosampler - Tower	Agilent, 7683B - G2913A	CN92256835
Semi 7 GC - ECD	Agilent, 6890	US10136020
Semi 7 Autosampler	Leap, CTCA200S	12928
Semi 8 GC	Agilent, 6890N	US10312014
Semi 8 Autosampler	Leap, CTCA200S	167/90
Turbovap	Zymark, TurboVapII	TV9607N6658
Turbovap	Zymark, TurboVapII	TV9547N6503
Turbovap	Zymark, TurboVapII	TV9548N6517
SVB02, Top Loading Balance	Fisher, XD-2200	2342
SVB03, Top Loading Balance	Ohaus, SP402	7132160674
Sonicator	Bransonic, PC 620R-1	RFA100594391
Sonicator	Fisher, FS-28	182230
Microwave Digester	CEM, MARSXpress	MD1677
GPC	Gilson, GX-271	260DGJ015
Dionex Autotrace	SPE 280	11121463
OAS Heating System	Organomation, 5086	17439
OAS Heating System	Organomation, 11129	57563
OAS Heating System	Organomation, 585	14166
Sep Funnel Shaker	Eberbach, 6010	080513
Sep Funnel Shaker	Eberbach, 6010	080514
Sep Funnel Shaker	Eberbach	SVS01

Instrument Description	Serial Number	Manufacture, Model
Metals Lab		
ICAP (ICP6000)	Thermo Sci., 6000 series	ICP20070314
ICAP (ICP6500)	Thermo Sci., 6000 series	ICP20082101
GFAA M Series	Thermo Sci., Solaar Furnace	605779
GFAA M Series	Thermo Sci., Autosampler	GF01164816
Hg analyzer	Hydra II C, CVAAS	3134
Autosampler	Hydra II C	
Turbidmeter	Hach, 2100P	920400001056
Hot Block A	Env. Exp., Hot Block	990310-92TS/819
Hot Block B	Env. Exp., Hot Block	9805310-91TS/859
pH Meter	Corning 450	001627
ASXpress (Cetac Autosampler upgrade)	Cetac, ASXpress Plus	011207XPS
ASXpress (Cetac Autosampler upgrade)	Cetac, ASXpress Plus	021301XPS
Pump for ASXpress	Cetac	011207XPS+VP
Recirculating Chiller (ICP6000)	Thermo Sci., Merlin M33	106268066
Recirculating Chiller (ICP6500)	Thermo Sci., Thermofles 900	109013036
Recirculating Chiller (GFAA)	Thermo Sci., Merlin M33	106304043
Recirculating Chiller (Backup)	Thermo Sci., Merlin M33	108046042
GTB01, Ohaus Analytical Balance	OhausAP250D	1114050585
Denna I	Seal Analytics, Denna II	020150
Denna II	Seal Analytics, Denna II	020151

Instrument Description	Serial Number	Manufacture, Model
Classical Chem Lab		
Lachat 8500	8500	120900001463
Lachat 8500 In-Line TN/TP	a30111	120900002170
Lachat 8500 Pump	ism1135	a82000-2735
Lachat 8500 Autosampler	ASX-520	120900002143
Lachat 8500 Autodilutor	PDS200	120900000642
Milton Roy Spectrometer	401	3815045022
Metler pH Meter	Easy Seven	1227196086
Dionex IC -2	DX-120	00120715
Dionex IC -2 Autosampler	AS-40	96050606
Dionex IC-2 Spare Autosampler	AS-40	02100299
Metrohm IC-3	881.003	188100012117
Metrohm IC-3 Autosampler	858.002	1858002003547
WCB01, Analytical Balance- Ohaus	VP214CN	K3421127422771P
WCB03, Top Load Balance Sartorius	Entris 2202-1s	33304453
Oakton Conductivity Meter	CON5	202101
Hach CL Test Kit	DR-100	961100093457
Fisher Isotemp Oven Muffle	550-58	60500052
Westco Easy Dist	483-8000-01	1067
Westco Easy Dist Controller		1115
Eberbach shaker table		WC1234
VWR Vortex	VM3000	080820007
Abraxis	6+	6808632
AI Scientific Controller	AIM 600 Digestion system	5146400345
Hach COD Block A	16500-10	880110117
Hach COD Block B	16500-10	870108679
Bioscience COD Block D		061113006
Pensky/Martens		BCO2
Drying Oven # 5	NCL-C3	05030204
Drying Oven # 8	Fisher ISO, 725 F	507NO100
Lachat 8500 2	8500	080900001027
Lachat 8500 2 Autosampler	ASX-500	A81010-1023
Lachat 8500 2 Autodiluter	PDS 200	060700000400
Lachat 8500 2 Pump	ISM 1135	A82000-1211
Lachat 8500 2 In-Line TN/CN	a30113	120900002174
Magnetic Stirrer 1	HI 190M	914096
Magnetic Stirrer 2	HI 190M	1012244
Fisher Stirrer	14-505-21	161310
Laboratory Stirrer	PC-310	LR-33491
Nuova II Stir Plate	SP18425	30623668
Oakton Salinity Meter	Acorn Series SALT 6	59573
Hach Detergents Test Kit	DE-2	1432-03
Titrette	Brand	05N89105
Lachat 8500 3	8500	16120002001
Lachat 8500 3 Autosampler	ASX-500	060335ASX
Lachat 8500 3 Autodilutor	pds 200	161200000815
Lachat 8500 3 Pump	ism1135	a82000-2130
Lachat 8500 3 Inline TN/CN	a30113	161200002277
Hanna Insturment Block E	HI 839800	J0019923
Millipore WC MilliQ 1	Milli Q System	04786-C
Heated Stir Plate	IKA, RT 15 S001	03.487967
BOD Auto EZ-2	Thermo Fisher, 10060020	A008O

Instrument Description	Serial Number	Manufacture, Model
Microbiology Lab		
Fisher Microscope	SPT-ITH	8711
Tuttnaur Autoclave	2540M	9412404
IEC Centrifuge	HN-SII-120	235518564
Black Ray Lamp	UVL-56	1010-1-92
Thermo Scientific Precision Water Bath	2866	123576-689
Fisher Isotemp Incubator	630D	A005372
Geo Tech Lab		
Sample Drying Racks - 3	17 pan each	NA
GTB02, Top Load Balance	Denver Inst., APX-6001	A61117006
Sieve Shaker	Gilson, SS-15	6010
Sieve Shaker #2	Humboldt, H 4310	NA
Puck Mill	Essa, 100304	220280-004
Ball Mill	Glen Mills, Jar Mill	NA
Sample Divider	Retsch, DR/PT 100	127261004D
Soil Mixer	Gilson, SA-10	NA
Liquid Limit Apparatus	Gilson, SA-62	NA
Evaporator (N-EVAP) (use=Nitrocellulose)	Organomation, 111	14421

APPENDIX 8: SAMPLE ACCEPTANCE TERMS & CONDITIONS

CT LABORATORIES

CT Laboratories Terms and Conditions

Where a purchaser (Client) places an order for laboratory, consulting or sampling services from CT Laboratories (CTL), CTL shall provide the ordered services pursuant to these Terms and Conditions, and the related Quotation, or as agreed in a negotiated contract. In the absence of a written agreement to the contrary, the Order constitutes an acceptance by the Client of CTL's offer to do business under these Terms and Conditions, and an agreement to be bound by these Terms and Conditions. No contrary or additional terms and conditions expressed in a Client's document shall be deemed to become a part of the contract created upon acceptance of these Terms and Conditions, unless accepted by CTL in advance of the start of the project and in writing.

1. ORDERS AND RECEIPT OF SAMPLES (Sample Acceptance Policy)

1.1 The Client may place the Order (i.e., specify a Scope of Work) either by submitting a purchase order to CTL in writing, by telephone (confirmed in writing) or by negotiated contract. Whichever option the Client selects for placing the Order, the Order shall not be valid unless it contains sufficient information to enable CTL to carry out the Client's requirements. It is the policy of CTL that samples not meeting the acceptance criteria, outlined in the NELAC standards and Section 5.8.3.2 of the DOD QSM, will not be accepted by the laboratory or will be qualified on the final report. All samples submitted to the laboratory must: (a) be accompanied by proper, full and complete documentation, including sample identification, location, date and time of collection, the collector's name, type of preservation (if any), type of sample, any special comments concerning the sample and any additional pertinent fields on the chain-of-custody. In the absence of any of the required information, the laboratory will attempt to contact the client to obtain the information; if unable to obtain the necessary information, the final report will be qualified.
(b) samples must be labeled appropriately with a unique sample identification written with indelible ink on water resistant labels. If the laboratory cannot determine the identity of a sample, it may be rejected and the client will be contacted for further instructions or resampling. (c) samples must be in an appropriate sample container. If the container is inappropriate, the client will be contacted for further instructions or resampling. If analysis is possible, the final report will be qualified. CTL can provide a sampling guide containing approved containers and preservations for analytical methods requested. (d) adhere to method specified holding times. If samples are received with less than ½ the holding time remaining for the requested test, CTL will make its best effort to analyze the samples and notify the client. If holding times are exceeded, the final report will be qualified. (e) contain adequate sample volume to perform the necessary testing. If sufficient volume is not present, the sample may be rejected and the client will be contacted for further instructions or resampling. If samples show signs of damage, contamination or inadequate preservation, the client will be notified. If analysis can be performed, the final report will be qualified. If not, the samples will be rejected and the client notified for further instructions or resampling. It is the Client's responsibility to understand and package samples correctly and provide the proper amount of temperature control (ice) suitable to current weather conditions.
1.2 CTL must be supplied with complete written disclosure of the known or suspected presence of any hazardous substances, as defined by applicable federal or state law. Where any samples which were not accompanied by the required disclosure, cause interruptions in the lab's ability to process work due to contamination of instruments or work areas, the Client will be responsible for the costs of clean up and recovery.
1.3 Prior to Sample Acceptance, the entire risk of loss or damage to samples remains with the Client. In no event will CTL have any responsibility or liability for the action or inaction of any carrier shipping or delivering any sample to or from CTL's premises. Client is responsible to assure that any sample containing any hazardous substance which is to be delivered to CTL's premises will be packaged, labeled, transported and delivered properly and in accordance with applicable laws.
1.4 Clients using CTL's shipping account(s) do so at their own risk and must purchase separate insurance if they do not wish to assume risk of loss. CTL will not assume any risk whatsoever for any samples outside of CTL's

control and not successfully delivered to the laboratory within specified hold times.
1.5 CTL will not accept liability for any sample(s), except sample(s) damaged or broken by log-in staff prior to successful log-in of the sample(s) into the CTL- LIMS system. This includes, but may not be limited to: complete, valid COC documentation, all sample receiving issues being resolved from a delay caused by the Client in CTL's ability to log-in samples, including missed turnaround and hold times, delay in processing and, ultimately, additional charges to the Client.
1.6 CTL will only reject samples per directions from the Client. CTL's sole liability is to inform the Client of any sample receipt issues, and may provide an indication how proceeding with the analysis may affect results and final acceptance by the regulating agency. Ultimately, suitability for use is between the Client and the regulating agency(s).
1.7 Signing of this COC by the Client or Client's representative, or directions to CTL via email or Fax constitutes acceptance of these Terms and Conditions, and guarantees payment by the Client to CTL.

2. PAYMENT TERMS
2.1 Services performed by CTL will be in accordance with prices quoted and later confirmed in writing or as stated in the Price Schedule. Invoices may be submitted to Client upon completion of any sample delivery group. Payment in advance is required for all Clients except those whose credit has been established with CTL. For Clients with approved credit, payment terms are net 30 days from the date of invoice by CTL. All overdue payments are subject to an additional interest and service charge of one and one-half percent (1.5%) or the maximum rate permissible by law, per month or portion thereof from the due date until the date of payment. All fees are charged or billed directly to the Client. The billing of a third party will not be accepted without a statement, signed by the third party that acknowledges and accepts payment responsibility. CTL may suspend work and withhold delivery of data under this order at any time in the event Client fails to make timely payment of its invoices. Client shall be responsible for all costs and expenses of collection including reasonable attorney's fees. CTL reserves the right to refuse to proceed with work at any time based upon an unfavorable Client credit report.

3. CHANGE ORDERS, TERMINATION
3.1 Changes to the Scope of Work, price, or result delivery date may be initiated by CTL after Sample Acceptance due to any condition which conflicts with analytical, QA or other protocols warranted in these Terms and Conditions. CTL will not proceed with such changes until an agreement with the Client is reached on the amount of any cost, schedule change or technical change to the Scope of Work, and such agreement is documented in writing.
3.2 Changes to the Scope of Work, including but not limited to increasing or decreasing the work, changing test and analysis specification or acceleration in the performance of the work may be initiated by the Client after sample acceptance. Such a change will be documented in writing and may result in a change in cost and turnaround time commitment. CTL's acceptance of such changes is contingent upon technical feasibility and operational capacity.
3.3 Suspension or termination of all or any part of the work may be initiated by the Client. CTL will be compensated consistent with Section 2 of these Terms and Conditions. CTL will complete all work in progress and be paid in full for all work completed.

4. WARRANTIES AND LIABILITY
4.1 Where applicable, CTL will use analytical methodologies which are in substantial conformity with published test methods. CTL has implemented these methods in its Laboratory Quality Manuals and referenced Standard Operating Procedures and where the nature or composition of the sample requires it, CTL reserves the right to deviate from these methodologies as necessary or appropriate, based on the reasonable judgment of CTL, which deviations, if any, will be made on a basis consistent with recognized standards of the industry and/or CTL's Laboratory Quality Manuals. Client may request that CTL perform according to a mutually agreed Quality Assurance Project Plan (QAPP). In the event that samples arrive prior to agreement on a QAPP, CTL will proceed with analyses under its standard Quality Manuals then in effect, and CTL will not be responsible for any resampling or other charges if work must be repeated to comply with a subsequently finalized QAPP.
4.2 CTL shall start preparation and/or analysis within holding times provided that Sample Acceptance occurs within 48 hours of sampling or 1/2 of the holding time for the test, whichever is less. Samples received that do not meet this provision will be charged as expedited samples and the appropriate rate will be added accordingly. Where resolution of inconsistencies leading to Sample Acceptance does not occur within this period, CTL will use its best efforts to meet holding times and will proceed with the work provided that, in CTL's judgment, the

chain-of-custody or definition of the Scope of Work provide sufficient guidance. Reanalysis of samples to comply with CTL's Quality Manuals will be deemed to have met holding times provided the initial analysis was performed within the applicable holding time. Where reanalysis demonstrates that sample matrix interference is the cause of failure to meet any Quality Manual requirements, the warranty will be deemed to have been met.
4.3 CTL warrants that it possesses and maintains all licenses and certifications which are required to perform services under these Terms and Conditions provided that such requirements are specified in writing to CTL prior to Sample Acceptance. CTL will notify the Client in writing of any decertification or revocation of any license, or notice of either, which affects work in progress.
4.4 The warranty obligations set forth in Sections 4.1, 4.2 and 4.3 are the sole and exclusive warranties given by CTL in connection with any services performed by CTL or any Results generated from such services, and CTL gives and makes NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND, EXPRESS OR IMPLIED. No representative of CTL is authorized to give or make any other representation or warranty or modify this warranty in any way.
4.5 Client's sole and exclusive remedy for the breach of warranty in connection with any services performed by CTL, will be limited to repeating any services performed, contingent on the Client's providing, at the request of CTL and at the Client's expense, additional sample(s) if necessary. Any reanalysis requested by the Client generating Results consistent with the original Results will be at the Client's expense. If resampling is necessary, CTL's liability for resampling costs will be limited to actual cost or one hundred or one hundred fifty dollars ($150) per sample, whichever is less.
4.6 CTL's liability for any and all causes of action arising hereunder, whether based in contract, tort, warranty, negligence or otherwise, shall be limited to the lesser amount of compensation for the services performed or $100,000. All claims, including those for negligence, shall be deemed waived unless suit thereon is filed within one year after CTL's completion of the services. Under no circumstances, whether arising in contract, tort (including negligence), or otherwise, shall CTL be responsible for loss of use, loss of profits, or for any special, indirect, incidental or consequential damages occasioned by the services performed or by application or use of the reports prepared.
4.7 In no event shall CTL have any responsibility or liability to the Client for any failure or delay in performance by CTL which results, directly or indirectly, in whole or in part, from any cause or circumstance beyond the reasonable control of CTL. Such causes and circumstances shall include, but not be limited to, acts of God, acts of Client, acts or orders of any governmental authority, strikes or other labor disputes, natural disasters, accidents, wars, civil disturbances, equipment breakdown, matrix interference or unknown highly contaminated samples that impact instrument operation, unavailability of supplies from usual suppliers, difficulties or delays in transportation, mail or delivery services, or any other cause beyond CTL's reasonable control.

5. RESULTS, WORK PRODUCT

5.1 Data or information provided to CTL or generated by services performed under this agreement shall only become the property of the Client upon receipt in full by CTL of payment for the whole Order. Ownership of any analytical method, QA/QC protocols, software programs or equipment developed by CTL for performance of work will be retained by CTL, and Client shall not disclose such information to any third party.
5.2 Data and sample materials provided by Client or at Client’s request, and the result obtained by CTL shall be held in confidence (unless such information is generally available to the public or is in the public domain or Client has failed to pay CTL for all services rendered or is otherwise in breach of these Terms and Conditions), subject to any disclosure required by law or legal process.
5.3 Should the Results delivered by CTL be used by the Client or Client's client, even though subsequently determined not to meet the warranties described in these Terms and Conditions, then the compensation will be adjusted based upon mutual agreement. In no case shall the Client unreasonably withhold CTL's right to independently defend its data.
5.4 CTL reserves the right to subcontract services ordered by the Client to another laboratory or laboratories, if, in CTL's sole judgment, it is reasonably necessary, appropriate or advisable to do so, and with the Client’s permission. CTL will in no way be liable for any subcontracted services and all applicable warranties, guarantees and insurance are those of the subcontracted laboratory.
5.5 CTL shall dispose of the Client's samples and extracts 30 days after the analytical report is issued, unless instructed to store them for an alternate period of time or to return such samples to the Client, in a manner consistent with U.S. Environmental Protection Agency regulations or other applicable Federal, state or local

requirements. Additional charges will apply for samples or extracts stored longer than 30 days at the Clients request. Any samples for projects that are canceled or not accepted, or for which return was requested, will be returned to the Client at Client expense. CTL reserves the right to return to the Client any sample or unused portion of a sample that is not within CTL's permitted capability or the capabilities of CTL's designated waste disposal vendor(s), or will make arrangements to dispose of these samples at Client direction and expense.
5.6 Unless a different time period is agreed to in any order under these Terms and Conditions, CTL agrees to retain all records for five (5) years.
5.7 In the event that CTL is required to respond to legal process related to services for Client, Client agrees to reimburse CTL for hourly charges for personnel involved in the response and attorney fees reasonably incurred in obtaining advice concerning the response, preparation to testify, and appearances related to the legal process, travel and all reasonable expenses associated with the litigation.

6. INSURANCE

6.1 CTL shall maintain in force during the performance of services under these Terms and Conditions, Workers' Compensation and Employer's Liability Insurance in accordance with the laws of the states having jurisdiction over CTL's employees who are engaged in the performance of the work. CTL shall also maintain during such period, Comprehensive General and Contractual Liability (limit of $2,000,000 per occurrence/ aggregate), Comprehensive Automobile Liability, owned and hired, ($1,000,000 combined single limit), and Professional/Pollution Liability Insurance (limit of $5,000,000 per occurrence/aggregate). Any Client required changes to these limits or conditions will result in a change in cost to the Client.

7. AUDIT

7.1 Upon prior notice to CTL, the Client may audit and inspect CTL's records and accounts covering reimbursable costs related to work done for the Client, for a period of one (1) year after completion of the work. The purpose of any such audit shall be only for verification of such costs, and CTL shall not be required to provide access to cost records where prices are expressed as fixed fees or published unit prices.

APPENDIX 9: Sections Common to all Analytical SOPs

Pollution Prevention

Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. Whenever feasible, laboratory personnel shall use pollution prevention techniques to address their waste generation.

The quantity of chemicals purchased shall be based on expected usage during its shelf life and disposal cost of unused material. Actual reagent preparation volumes shall reflect anticipated usage and reagent stability.

Corrective Measures for Out-of-Control Data

When data is out of control, a number of corrective actions may be taken. If the nonconformities involve failing QC within the analytical sequence batch, then reanalysis of samples may eliminate any out of control data. If the out of control data is the result of instrument malfunctions, then maintenance or repair of the downed instrument followed by reanalysis of affected data may correct the problem. If sample matrix effect or contamination is the reason for poor data, the instrument may need cleaning and decontamination, and the sample may need diluting to reduce matrix effect. In all cases, when out of control data presents itself, the appropriate corrective measures need to be enacted to eliminate unusable data. The Quality Control Requirements chart in the appendix of each SOP can be used as a guide as to which corrective actions should be taken for different QC-type failures or nonconformities.

Contingencies for Handling Out-of-Control or Unacceptable Data

Due to limited sample volume, expiration of hold times, downed instrumentation, and analyst error, the sample data may become out-of-control or unacceptable to report. In these cases, contingency plans need to be in place to prevent and/or minimize their effect on data.

- To avoid sample hold time issues, the analyst's first responsibility is to plan accordingly. Analysts must budget enough time for sample reanalysis if problems arise during initial analysis.
- Some preventative measures exist that should be utilized by analysts to avoid producing unacceptable or out-of-control data:
    - When limited sample volume is the issue, the analyst should determine if splitting the sample into lesser volumes or weights is an option.
    - Loss of data due to downed or malfunctioning instrumentation can be addressed with the use of backup instrumentation if possible or available. If an instrument becomes unusable, the samples should be analyzed on a different instrument system.
    - Analyst error can be minimized by second analyst confirmation and validation. If the initial analyst makes an analysis error or inadvertently reports unacceptable data, the second analyst is responsible for finding and/or correcting those errors.
- When out-of-control or unacceptable data is produced and it is too late for corrective measures, a number of actions can be taken:
    - First alert the client service personnel of the problem.
    - It is client services responsibility to inform the client and/or responsible parties. The client may provide instructions before proceeding.

- In all instances, if results are reported from data that is potentially out-of-control, that data should be qualified according to the QC Requirements Table (Table 1) and CT Laboratories' Quality Assurance Manual (QAM). Once the client has been notified and he or she chooses for us to report the data, then qualify the data indicating which type of nonconformity has occurred.

- Out-of-control data is still retained by the laboratory, filed, and archived along with acceptable data. The file folder should be labeled as such, indicating that the data is out-of-control.

- A non-conformance/corrective action report (CAR) form must be filled out whenever these events occur. The information on the report includes the problem encountered, planned corrective actions, and corrective action follow-up. The form is then discussed with and signed by the analyst, the client representative, the QA officer, and the laboratory manager. The purpose of the form is to document problems in order to eliminate the possibility of repeating nonconformance and to ensure that the proper corrective actions are employed.

Waste Management

Samples are routinely held (refrigerated) for up to six weeks from analysis date before they enter the waste stream. Waste disposal of samples and standards follows the procedures documented in the Laboratory Waste Disposal SOP WS-001.

Equipment / Instrument Maintenance, Computer Hardware & Software & Troubleshooting

All maintenance and troubleshooting is documented in a Maintenance Logbook designated for a particular instrument setup. Documentation shall include problem encountered and corrective action or maintenance performed (including replacement of parts). If outside service is required, a copy of the maintenance invoice is to be included in the Maintenance Logbook. Date of maintenance or repair along with analyst initials is also documented. The Maintenance Logbook is then periodically reviewed (Initialed and dated) by the Group leader or a second analyst.

- Check the specific instrument's Maintenance Logbook to determine if the current problem has occurred in the past. If the problem has previously occurred, the workaround or fix should have been documented. Follow the instructions for repairing the problem, document and proceed with the analysis.

- If review of the Maintenance Logbook yields no resolution to the problem, review the specific instrument/software manual for repair/ workaround options. If a solution is presented in the manual, proceed with the repair, document in the Instrument Run/Maintenance log book and continue with the analysis.

- If neither the Maintenance Logbook nor the specific instrument/software manual results in a solution to the problem, contact your supervisor for help in resolving the issue. This may involve contacting the vendor. Refer to the specific instrument/software manual for contact information.

Troubleshooting – Computers

Computers cannot be diagnosed or repaired in the laboratory. If it has been previously determined that the current problem cannot be resolved with a hardware or software fix, contact your IS representative for repair or replacement. Document the problem resolution in the Instrument Maintenance log book.

APPENDIX 10: Security Awareness Training

Form #: FQA1-05
Rev. #: 0.0
Effective Date: 04/07/17
Page 1 of 1

CT Laboratories Security Awareness Training

As part of our compliance requirements for DoD/QSM, all employees are to be annually reminded of the security requirements for CT Laboratories Computer Systems.

1. PC's are provided by CT Laboratories for use by its employees, and are restricted for use to ***only*** CT Laboratories employees.
2. Standalone PC's are to be logged off by the employee when they complete their task. If the employee has not completed their task and wishes to remain logged on with open work files, then the computer should be locked by the employee.
3. No software should be installed *on any PC* without IT approval.
4. No flash drives should be attached to any PC that has not been previously checked by IT.
5. Software viruses are always a potential problem. Antivirus software is installed on all PC's, and no attempt should be made to disable this software. If antivirus software is interfering with your duties or collection of data from instrumentation, contact IT for remediation.
6. Through our Barracuda Web Security appliance, many websites are automatically blocked. This is to avoid malicious websites (security), as well as to maintain a certain amount of control over employee browsing of websites not associated with their responsibilities (and inadvertently compromising security).
    a. The Barracuda automatically checks for known viruses and exploits (for example, ransomware) on pages coming and going from our IP address.
    b. Our spam service automatically checks for viruses, malware and spam sent to our email server.
7. Emails are checked for viruses and exploitation software, *however checking is done only for known threats.* New threats are developed daily, and if a suspicious email is received (you were not expecting it, unknown sender, etc.), ***don't open it;*** either send it to IT or delete it immediately.
8. Embedded links in emails and web pages *should always be treated cautiously*! Many embedded addresses can be easily "spoofed" and will direct you to a webpage that may *look* legitimate, but are really *knockoffs* designed to collect information about you, the Company, passwords, credit cards, etc. Instead of clicking on an embedded website, type the address in the browser bar at the top of the web browser page.
9. No Internet devices should be connected to the CT Laboratories network without the permission of IT.
10. Finally, if you see something suspicious, please say something. *Malicious software can and has shut down our network*, making it impossible to perform your duties as well as those of everyone in the company.

Employee Acknowledgement:

Signature:_____Date_____

Print:_____

Table A9-1: Summary of Quality Control Check Definitions, Purpose and Evaluation

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Breakdown check (Endrin and DDT – Method 8081, DDT - Method 8270)	Analysis of a standard solution containing Endrin and DDT. Area counts of these compounds and their breakdown products are evaluated to assess instrument conditions.	To verify the inertness of the injection port because DDT and Endrin are easily degraded in the injection port.	If degradation of either DDT or Endrin exceeds method-specified criteria, corrective action must be taken before proceeding with calibration.
Calibration blank	Reagent water containing no analytes of interest.	To determine the zero point of the calibration curve for all initial and continuing calibrations.	This is a required QC procedure. Continuing calibration blank responses above the LOD require corrective action.
Confirmation of positive results (organics only)	Use of alternative analytical techniques (another method, dissimilar column, or different detector such as MS detector) to validate the presence of target analytes identified.	To verify the identification of an analyte.	All positive results must be confirmed.
Continuing calibration verification (CCV)	The verification of the ICAL that is required during the course of analysis at periodic intervals. Continuing calibration verification applies to both external standard and internal standard calibration techniques, as well as to linear and non-linear calibration models.	To verify that instrument response is reliable, and has not changed significantly from the current ICAL curve.	If the values for the analytes are outside the acceptance criteria, the ICAL may not be stable. Results associated with out-of-control CCV results require reanalysis or flagging.
Demonstrate acceptable analytical capability	QC samples are analyzed in series to verify ability to produce data of acceptable precision and bias.	To verify the ability to produce data of acceptable precision and bias for a specific instrument type, matrix, method, and analyst.	The average recovery of the spikes and standard deviation of the replicates must be within designated acceptance criteria. Analysis of field samples may not be conducted until this check is successful.
Dilution test (metals only)	Analysis of a positive sample, which has been diluted to a concentration one-fifth of the original, to confirm that there is no interference in the original sample analysis.	To assess matrix interference.	Agreement within 10% between the concentration for the undiluted sample and five times the concentration for the diluted sample indicates the absence of interferences, and such samples may be analyzed without using the method of standard additions. Results outside acceptance limits indicate a possible matrix effect. For ICP, a post-digestion spike must be run; for GFAA, a recovery test must be run.

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Duplicate sample (replicate)	Two identical portions of material collected for chemical analysis, and identified by unique alphanumeric codes. The duplicate may be portioned from the same sample, or may be two identical samples taken from the same site. The two portions are prepared and analyzed identically.	To provide information on the heterogeneity of the sample matrix or to determine the precision of the intralaboratory analytical process for a specific sample matrix.	A duplicate sample will provide information on the heterogeneity of the sample matrix. The greater the heterogeneity of the matrix, the greater the relative percent difference between the sample and the sample duplicate. If the sample matrix is homogeneous (such as with drinking water) and the relative percent difference is high, this could indicate a problem in the analytical system.
GC column performance check (Methods 8280)	Analysis of method-specified compounds to verify chromatographic separation of dioxin isomers.	To evaluate the performance of the analytical system and establish retention time window markers for dioxin isomers.	Sample analysis may not begin until method-specified criteria are met.
Initial calibration for all analytes (ICAL)	Analysis of analytical standards at different concentrations that are used to determine and calibrate the quantitation range of the response of the analytical detector or method.	To establish a calibration curve for the quantification of the analytes of interest.	Statistical procedures are used to determine the relationship between the signal response and the known concentration of analytes of interest. The ICAL must be successful before any samples or other QC check samples can be analyzed.
Instrument detection limit (IDL) study (Methods 6010 and 6020 only)	The process to determine the minimum concentration of a substance (analyte) that an instrument can differentiate from noise. The procedure for calculating varies by method.	To provide an evaluation of instrument sensitivity.	IDLs must be established before samples can be analyzed.
Interference check solutions (ICP and ICP/MS only)	A pair of solutions containing interfering elements that are used to verify the correction factors of analytes of concern.	To verify the established correction factors by analyzing the interference check solution at the beginning of the analytical sequence.	No samples can be run if this check does not pass acceptance criteria.
Internal standards	A substance that is introduced in known amount into each calibration standard and field and QC sample of the analyte.	The ratio of the analyte signal to the internal standard signal is then used to determine the analyte concentration.	Any samples associated with out-of-control results must be reanalyzed.

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Laboratory control sample (LCS) containing all analytes to be reported	A sample matrix, free from the analytes of interest, spiked with known amounts of analytes or a material containing known and verified amounts of analytes.	Used to evaluate the performance of the total analytical system, including all preparation and analysis steps. Assesses the ability of the laboratory/analyst to successfully recover the target analytes from a control (clean) matrix. Control limits for LCS recovery, typically expressed as percent recovery, are used for the development of statistical control limits and serve as acceptance criteria for determining whether an analytical run is in control (batch acceptance).	This is a required QC check. The inability to achieve acceptable recoveries in the LCS indicates problems with the precision and bias of the measurement system. Failure to achieve acceptable recoveries in a “clean” matrix is an indicator of possible problems achieving acceptable recoveries in field samples.
Linear dynamic range or high-level check standards (ICP and ICP/MS only)	High-level check standard periodically analyzed to verify the linearity of the calibration curve at the upper end.	To verify quantitative accuracy of data up to the high-level standard.	This QC check establishes the upper linear range of the calibration.
Low-level calibration check standard (ICP only)	A reference standard that contains a quantity of analyte equal to or less than the reporting limit.	To confirm the accuracy of measurements at or near the RL.	This QC check must be within acceptance criteria before any samples are analyzed.
Matrix spike (MS)	A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.	To assess the performance of the method as applied to a particular matrix. Matrix spikes are used, for example, to determine the effect of the matrix on a method’s recovery efficiency. The recovery of target analytes from the matrix spike sample is used to determine the bias of the method in the specific sample matrix.	The lack of acceptable recoveries in the matrix spike often points to problems with the sample matrix. One test of this is a comparison to the LCS recoveries. If the corresponding LCS recoveries are within acceptable limits, a matrix effect is likely. The laboratory should not correct for recovery; only report the results of the analyses and the associated matrix spike results and indicate that the results from these analyses have increased uncertainty.
Matrix spike duplicate (MSD)	A second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of recovery for each analyte.	To assess the performance of the method as applied to a particular matrix and provide information on the homogeneity of the matrix. Also used to determine the precision of the intralaboratory analytical process for a specific sample matrix.	When compared with the MS, the MSD will provide information on the heterogeneity of the sample matrix. The greater the heterogeneity of the matrix, the greater the RPD between the matrix spike and the matrix spike duplicate. If the sample matrix is homogeneous, such as with drinking water, and the RPD is high, this could indicate a problem in the analytical system.

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Matrix verification sample (hexavalent chromium only)	A pH-adjusted filtrate that has been spiked with hexavalent chromium to ensure that the sample matrix does not have a reducing condition or other interferents that could affect color development.	To ensure that the sample matrix does not have a reducing condition or other interferents that affect color development.	To verify the absence of interference, the spike recovery must be between 85% and 115%. If the result of verification indicates a suppressive interference, the sample should be diluted and reanalyzed. If the interference persists after sample dilution, an alternative method (Method 7195, Coprecipitation, or Method 7197, Chelation/Extraction) should be used.
Method blank	A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.	To assess background interference or contamination in the analytical system that might lead to high bias or false positive data. Results of method blanks provide an estimate of the within-batch variability of the blank response and an indication of bias introduced by the preparation and analytical procedure.	This is one of the QC samples used to measure laboratory accuracy/bias. This sample could indicate whether contamination is occurring during sample preparation and analysis. If analytes are detected > ½ RL, reanalyze or qualify (B-flag) all results for the specific analyte(s) in all samples in the associated preparatory batch, as appropriate. For common laboratory contaminants, no analytes detected > the RL.
Method of standard additions (ICP/GFAA only)	A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration. (This process is also called spiking the sample.)	To compensate for a sample constituent that enhances or depresses the analyte signal, thus producing a different slope from that of the calibration standards. It will not correct for additive interferences that cause a baseline shift.	This is the method used when matrix interferences are present and do not allow determination of accurate sample results.
Post digestion spike addition (ICP and Hexavalent Chromium)	An analyte spike added to a portion of prepared sample to verify absence or presence of matrix effects.	To confirm the presence of a matrix interference. Assess matrix effects based on, (1) the occurrence of new and unusual matrices included within the batch, or (2) contingency analysis based on serial dilution or matrix spike failures.	To verify the absence of an interference, the spike recovery must be between 75% and 125%. Results outside the acceptance limits require a method of standard additions (MSA) for all samples within the batch.
Recovery test (GFAA only)	An analyte spike added to a portion of prepared sample to verify absence or presence of matrix effects.	To confirm the presence of a matrix interference. Assess matrix effects based on, (1) the occurrence of new and unusual matrices included within the batch, or (2) contingency analysis based on serial dilution or matrix spike failures.	To verify the absence of an interference, the spike recovery must be between 85% and 115%. Results outside the acceptance limits require a MSA for all samples within the batch.

Summary of Quality Control Check Definitions, Purpose, and Evaluation			
QC Check	Definition	Purpose	Evaluation
Retention time window position establishment for each analyte (and surrogate) (all chromatographic methods only)	Determination of the placement of the retention time window (i.e., start/stop time) of each analyte or group of analytes as it elutes through the chromatographic column so that analyte identification can be made during sample analysis. This is done during the ICAL.	To identify analytes of interest.	Incorrect window position may result in false negatives, require additional manual integrations, or cause unnecessary reanalysis of samples when surrogates or spiked compounds are erroneously not identified.
Retention time window width calculated for each analyte (and surrogate) (non-MS chromatographic methods only)	Determination of the length of time between sample injection and the appearance of a peak at the detector. The total length of time (window) is established for each analyte or group of analytes and is set for complete elution of analyte peaks. It is based upon a series of analyses and statistical calculations that establish the measured band on the chromatogram that can be associated with a specific analyte or group of analytes.	To ensure that the chromatographic system is operating reliably and that the system conditions have been optimized for the target analytes and surrogates in the standards and sample matrix to be analyzed. It is done to minimize the occurrence of both false positive and false negative results.	Used to evaluate continued system performance. Tight retention time windows may result in false negatives or may cause unnecessary reanalysis of samples when surrogates or spiked compounds are erroneously not identified. Overly wide retention time windows may result in false positive results that cannot be confirmed upon further analysis.
Second source calibration verification (ICV)	A standard obtained or prepared from a source independent of the source of standards for the ICAL. Its concentration should be at or near the middle of the calibration range. It is done after the ICAL.	To verify the accuracy of the ICAL.	The concentration of the second-source calibration verification, determined from the analysis, is compared with the known value of the standard to determine the accuracy of the ICAL. This independent verification of the ICAL must be acceptable before sample analysis can begin.
Surrogate spike (organic analysis only)	A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes.	To assess the ability of the method to successfully recover specific non-target analytes from an actual matrix. Because surrogates are generally added to each sample in a batch, they can be used to monitor recovery on a sample-specific, rather than batch-specific basis.	Whereas the matrix spike is normally done on a batch-specific basis, the surrogate spike is done on a sample-specific basis. Taken with the information derived from other spikes (LCS, matrix spike), the bias in the analytical system can be determined.
Tuning (mass spectrometer methods only)	The analysis of a standard compound to verify that the mass spectrometer meets standard mass spectra abundance criteria prior to sample analysis.	To verify the proper working of the mass spectrometer.	Proper tuning of the mass spectrometer must be verified prior to sample analysis.

Table A9-2 Essential Quality Control Requirements - Microbiology			
Item	**Frequency**	**Acceptance Criteria**	**Corrective action**
Sterility blank	Each lot of media prior to first use	No growth	Investigate cause
Sterility check containers	One container (bottle) for each lot or batch sterilized (NSGM)	No growth	Investigate cause
Sterility check dilution water	One per batch of dilution water (NSGM)	No growth	Investigate cause
Positive control[1]	pure culture of target organisms/ each lot or batch of medium (prior to first use of medium)	Positive reaction	Investigate cause If necessary reject the medium
Negative control[1]	Pure culture of non-target organisms/each lot or batch of medium (prior to first use of medium)	Negative reaction	Investigate cause If necessary reject the medium
Duplicate colony counts (For numeric results only)	Monthly if sample volume permits.	Same analyst <5% difference between counts Two analysts <10% difference between counts	Investigate cause Qualify data
1) Microorganisms may be single use preparations or cultures maintained by documented procedures that demonstrate the continued purity and viability of the organism.			

Table A9-3 Essential Quality Control Requirements Microbiology – Pour Plate Methods Only			
Item	**Frequency**	**Acceptance Criteria**	**Corrective action**
Sterility blank media	Each lot of media prior to first use minimum one plate per batch	Internally defined Suggest 1 col/plate	Investigate cause

Stock Cultures		
Item	**Frequency**	**Handling**
Reference cultures	Single use	Preserved and handled per mfg. specifications

REFERENCES

EPA QA/R-2, "EPA Requirements for Quality Management Plans", EPA/240/B-01/002, May 2006 and as updated (for content),

EPA QA/R-5, "EPA Requirements for Quality Assurance Project Plans", EPA/240/B-01/003, May 2006 and as updated (for content),

The NELAP Institute (TNI), EL-V1-2009, “Management and Technical Requirements for Laboratories Performing Environmental Analysis”, 2009,

DOD Quality Systems Manual (QSM), Rev. 5.1, January 05, 2017 and as updated/

ISO/IEC 17025:2005

Revision Number	Description of Changes	Date
15.1	QAM changes to update and document the newly implemented Quality System	03/28/2014
15.2	QAM updated with current structure and corrective actions from WI Audit and external assessments for 2015 and 2016	05/31/16
15.3	QAM updated with current structure, SOP list, instrument list; included current list of certifications and accreditation	08/21/17
15.4	Table of contents updated for correct page numbers	09/21/17
15.6	Update procedure for receipt of supplies to reflect practice of maintaining received COAs, updated to reflect procedure of including the time of sample prep and analysis regardless of hold time.	05/25/18
15.7	Update to reflect change in the Quality Manager and Accreditation to DoDELAP QSM 5.1.	09/21/2018