OE-1021A
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Quality Assurance Project Plan
Superfund Response Actions
Former Fort Ord, California

Volume II
Munitions Response

Appendix B
Advanced Geophysical Classification for Munitions Response
Quality Assurance Project Plan
Addendum – Draft Final

Single Award Task Order Contract
Contract No. W9123820D0004
Task Order No. W9123822F0043

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ABBREVIATIONS AND ACRONYMS

ANJV	Acorn SI and NAEVA Joint Venture
APP	Accident Prevention Plan
Army	U.S. Department of the Army
BLM	Bureau of Land Management
CA	corrective action
CAP	corrective action plan
CAR	corrective action report
CSDGM	Content Standard for Digital Geospatial Media
CSM	conceptual site model
DAGCAP	Department of Defense Advanced Geophysical Classification Accreditation Program
DDESB	Department of Defense Explosives Safety Board
DFW	definable feature of work
DGM	digital geophysical mapping
DMM	discarded military munitions
DoD	Department of Defense
DQO	data quality objective
EM	engineer manual
EMI	electromagnetic induction
EPA	Environmental Protection Agency
ESRI	Environmental System Research Institute
ESTCP	Environmental Security Technology Certification Program
FGDC	Federal Geographic Data Committee
FP	Follow-Up Phase
FS	feasibility study
AGCMR-QAPP	Advanced Geophysical Classification for Munitions Response Quality Assurance Project Plan
GIS	geographic information system
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HMP	Habitat Management Plan
IDQTF	Intergovernmental Data Quality Task Force
IMU	inertial management unit
IP	Initial Phase
ISO	industry standard object
ISO 80	schedule 80 small industry standard object
IVS	instrument verification strip
LUCs	land use controls
MEC	munitions and explosives of concern
MEC-QAPP	Munitions and Explosives of Concern Quality Assurance Project Plan

MMRP	Military Munitions Response Program
MPC	measurement performance criteria
MR	munitions response
MRA	munitions response area
MRS	munitions response site
MQO	measurement quality objectives
NCR	Non-Conformance Report
NSSDA	National Standard for Spatial Data Accuracy
OESS	Ordnance and Explosives Safety Specialist
PDF	portable document format
PE	Professional Engineer
PP	Preparatory Phase
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RA	Remedial Action
RCA	root cause analysis
RD	remedial design
RI	remedial investigation
ROD	Record of Decision
RTK	real-time kinematic
SATOC	Single award task order contract
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and Environment
SOP	standard operating procedure
SSWP	site-specific work plan
SUXOS	Senior Unexploded Ordnance Supervisor
TOI	target of interest
TP-18	Technical Publication – 18
UFP	Uniform Federal Policy
USACE	United States Army Corps of Engineers
UXA	UX-Analyze Advanced
UXO	unexploded ordnance
UXOSO	Unexploded Ordnance Safety Officer
UXOQCS	Unexploded Ordnance Quality Control Specialist

EXECUTIVE SUMMARY

This Addendum to the Advanced Geophysical Classification for Munitions Response - Quality Assurance Project Plan (AGCMR-QAPP; KEMRON 2016b) has been prepared in support of the U.S. Army Corps of Engineers (USACE), Sacramento District, under the Fort Ord Interim Munitions and Explosives of Concern (MEC) Support Single Award Task Order Contract (SATOC), contract number W9123820D0004 for the continuation of the Comprehensive Environmental Response, Compensation, and Liability Act Remedial Action (RA) at Former Fort Ord in accordance with the requirements of the *Uniform Federal Policy for Quality Assurance Project Plans* (UFP-QAPP Manual (Intergovernmental Data Quality Task Force [IDQTF], March 2005), *Optimized UFP-QAPP Worksheets* (IDQTF, March 2012), and the Interim Guidance Document 14-01, *Technical Guidance for Military Munitions Response Actions*, Engineer Manual (EM) 200-1-15 (USACE, October 2018). The MEC remedial action in the Impact Area Munitions Response Area (MRA) is being conducted in accordance with the *Final Track 3 Record of Decision (ROD), Impact Area Munitions Response Area, Track 3 Munitions Response Site, Former Fort Ord, California* (U.S. Department of the Army [Army], 2008) and *Final Work Plan, Remedial Design/Remedial Action (RD/RA), Track 3 Impact Area Munitions Response Area, Former Fort Ord, California* (USACE, 2009).

This AGCMR-QAPP is based on the 28 optimized worksheets that accompany the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP; IDQTF, 2012) and is intended to be the primary work plan for MEC removal utilizing advanced electromagnetic induction (EMI) geophysical classification to support remedial action objectives. The included worksheets will serve as a guideline for project activities and data quality assessment. This AGCMR-QAPP addresses the quality assurance (QA) and quality control (QC) elements of the American Society for Quality/American National Standards Institute E4-2014 and meets the requirements of EPA/QA G-5. Modifications have been made to the standard worksheets based on the munitions response (MR) advanced geophysical classification format designed specifically for advanced EMI MR classification projects, as described in *Uniform Federal Policy for Quality Assurance Project Plans Template: Geophysical Classification for Munitions Response, Revised Beta Draft* (IDQTF, 2015). Worksheets deemed not applicable to this advanced geophysical classification-optimized QAPP format have been either modified to meet the intent of the worksheet or excluded.

This document is divided into the following four major sections:

- Project Management describes the project management approach, including the purpose and structure of the AGCMR-QAPP and the project team organization
- Project Quality Objectives defines the conceptual site model, project objectives and background, data quality objectives, and documentation requirements
- Sample Design explains the sampling approach
- Data Management and Data Review describes assessment and oversight procedures to verify and validate data quality

This AGCMR-QAPP contains a series of worksheets that are for both general and specific information pertaining to the MEC remediation activities to be completed in the Impact Area MRA and Bureau of Land Management (BLM) Area B. It describes the planning, implementation, acquisition, and assessment of advanced geophysical classification data using effective methodologies and thorough QC activities that KEMRON Environmental Services (KEMRON), directed by the USACE, may use during MEC RAs at the Former Fort Ord, California. This AGCMR-QAPP includes information for data management, data analysis, and QC activities in support of MEC response actions and is intended for use by field operators, supervisors, data managers, and other technical experts responsible for implementing and coordinating advanced geophysical classification activities for the project.

Several terminology conventions are used throughout this AGCMR-QAPP, including the following:

- *Advanced EMI sensors* are geophysical instruments that utilize transmit and receive coils oriented in three dimensions and placed in multiple locations relative to the center of the sensor array. By analyzing this detailed EMI data with specialized geophysical classifiers, the physical properties of an anomaly source (such as size, aspect ratio, wall thickness, and symmetry) can be estimated, allowing the project team to make informed decisions about whether an item should be excavated or can be safely left in place. Advanced EMI sensors are rapidly evolving, and various DAGCAP-validated sensor systems may be used for advanced geophysical classification work at the former Fort Ord, with approval from the project team and revision of applicable SOPs and measurement performance criteria.
- A *detection survey* is a dynamic digital geophysical mapping (DGM) survey, where sensor data is recorded digitally for later processing, analysis, and target anomaly selection. Detection surveys may utilize traditional geophysical sensors, such as the Geonics EM61-MK2A EMI detector and the Geometrics G-858 gradiometer, or they may utilize advanced EMI sensors.
- A *classification survey* is a survey consisting of cued (static) advanced EMI sensor measurements acquired over anomalies previously identified during a detection survey. The static measurement allows the advanced EMI sensor to acquire detailed EMI data after measuring the response of a buried metallic item at numerous positions and from multiple angles and orientations around the item. This provides the level of detail required for confident classification of the item.
- *DAGCAP* is the Department of Defense Advanced Geophysical Classification Accreditation Program. DoD developed advanced geophysical classification to improve the efficiency of cleaning up munitions and to focus its resources on addressing the potential explosives safety risks at munitions response sites. To ensure quality data, the Office of the Deputy Assistant Secretary of Defense for Environment, Safety and Occupational Health created the DoD Advanced Geophysical Classification Accreditation Program to accredit organizations that use advanced geophysical classification at MRSs. On April 11, 2016, the Assistant Secretary of Defense (Energy, Installations, and Environment) established the DAGCAP, requiring the DoD Components to begin using DAGCAP-accredited organizations for advanced geophysical classification work awarded in calendar year 2017 and after. Accreditation through the DAGCAP is achieved through a two-step process: 1) assessing the organization’s quality system, and 2) successfully

demonstrating capabilities performed at the Aberdeen Proving Ground DAGCAP test site or through a virtual demonstration of capability. The DAGCAP uses third-party accreditation bodies to provide a unified program for organizations to demonstrate competency and document conformance to requirements. The requirements are based on the international standard ISO/IEC 17025:2017, supplemented by the DoD Quality Systems Requirements for Organizations Performing Advanced Geophysical Classification. The scope of accreditation is as follows: ISO 17025:2017, General Requirements for the Competence of Testing and Calibration laboratories, accreditation for Technology (Electro Magnetic Induction), Test (Subsurface Munitions), and Method (Advanced Geophysical Accreditation). The Environmental Data Quality Workgroup provides management and oversight of the DAGCAP. AGC work was conducted at the Former Fort Ord prior to the requirement for DAGCAP accreditation. Future AGC work will be conducted by a fully DAGCAP-accredited geophysical classification organization.

Depending on site-specific conditions and the goals and objectives of each individual activity, advanced geophysical classification may not be the most efficient technique or the best choice to meet individual project objectives. Advanced geophysical classification is an additional tool to be utilized in specific situations, but it will not replace standard MEC removal methods.

1.0 PROJECT MANAGEMENT

1.1 Title and Approval Page (QAPP Worksheets #1 & 2)

Site Name: Track 3 Impact Area Munitions Response Area
Site Location: Former Fort Ord, California
Document Title: Addendum, Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume II, Munitions Response, Appendix B, Advanced Geophysical Classification for Munitions Response Quality Assurance Project Plan
Contract Number: W9123820D0004

REVIEW SIGNATURES

Investigative Organization

Date: 09/08/2023

Andy Gascho
AECOM Program Geophysicist

Steve Crane Date: 09/08/2023

Steve Crane
KEMRON Project Manager

Contracting Organization

SPECHT.JAMES.A.1217829719 Digitally signed by SPECHT.JAMES.A.1217829719 Date: 2023.09.14 16:09:20 -07'00' Date: ____________

James Specht
USACE Senior Project Manager

BRITT.JAMES.CLIFTON.1056168920 Digitally signed by BRITT.JAMES.CLIFTON.1056168920 Date: 2023.09.16 11:11:16 -07'00'

Date: ____________________

James Britt

USACE Ordnance and Explosives Safety Specialist

LINDSAY.KYLE.M.1529297226 Digitally signed by LINDSAY.KYLE.M.1529297226 Date: 2023.09.18 07:03:47 -07'00'

Date: ____________________

Kyle Lindsay

USACE Quality Assurance Geophysicist

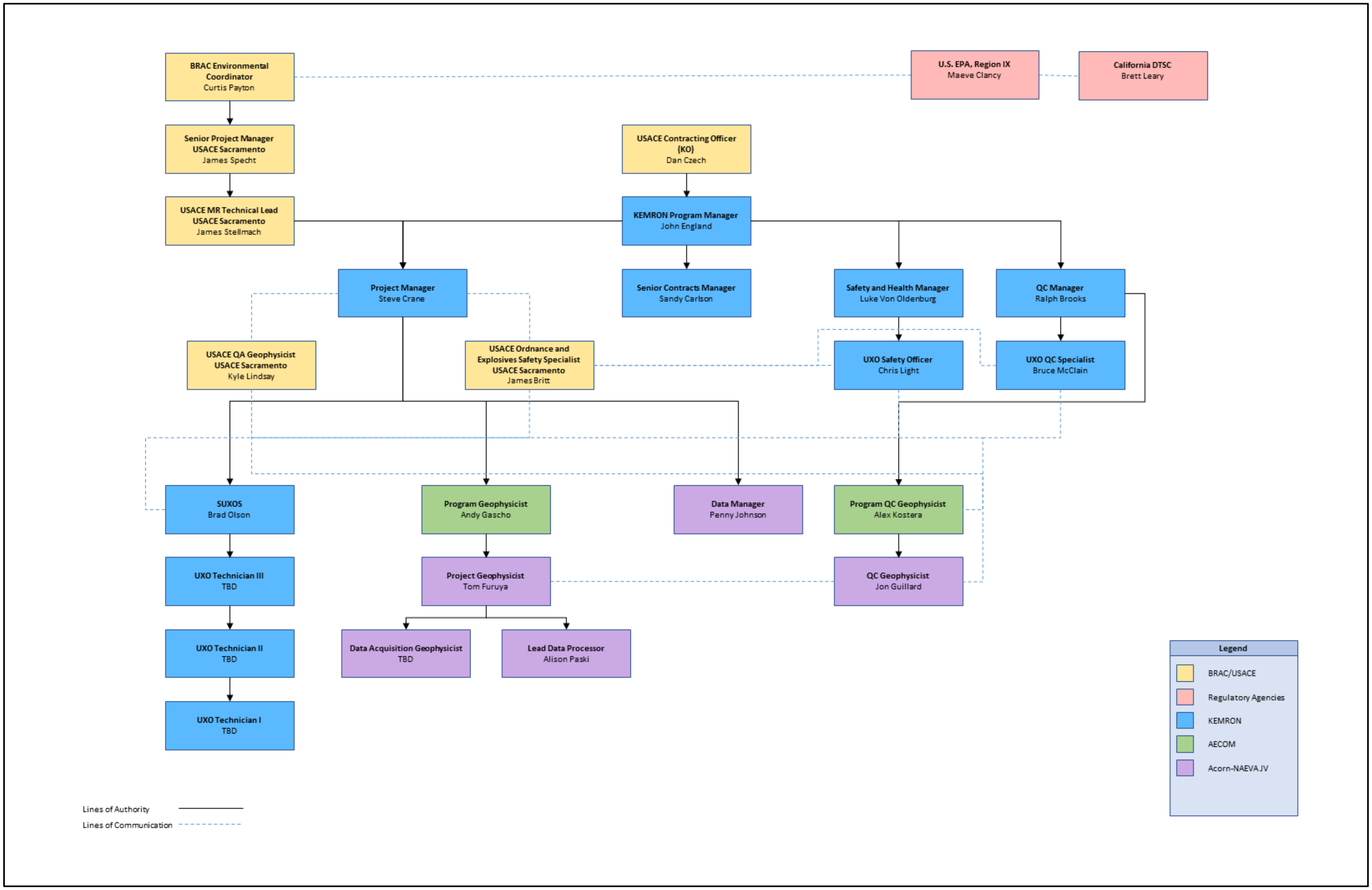
Plans and reports from previous investigations relevant to this project

Title	Company	Date
Reinitiation of Formal Consultation for Cleanup and Property Transfer Actions Conducted at the Former Fort Ord, Monterey County, California (Original Consultation #8-8-09-F-74, 81440-2009-F-0334) [Programmatic Biological Opinion] (BW-2747A)	U.S. Department of the Interior, Fish and Wildlife Service	2017
Remedial Design (RD)/Remedial Action (RA) Work Plan Update, Track 3 Impact Area Munitions Response Area (MRA), Munitions and Explosives of Concern (MEC) Removal, Former Fort Ord, California (OE-0929B)	KEMRON	2018
Volume 2, Technical Information Paper, Supplemental Subsurface MEC Removal, Fuel Breaks, Impact Area Munitions Response Area, Former Fort Ord, California (OE-0985C)	KEMRON	2021
Final Record of Decision, Impact Area Munitions Response Area, Track 3 Munitions Response Site, Former Fort Ord, California (OE-0647)	US Department of the Army (Army)	2008
Final, Track 2, Remedial Investigation/Feasibility Study, BLM Area B and MRS-16, Former Fort Ord, California (OE-0802D, Revision 2)	Gilbane	2015
Quality Assurance Project Plan, Former Fort Ord, California; Volume II, Appendix A, Munitions and Explosives of Concern Remedial Action (OE-0861)	KEMRON	2016
Site-Specific Work Plan, Munitions and Explosives of Concern Remedial Action, MRS-BLM Unit 23 and in Support of Units 11 and 12 Prescribed Burns (Includes Portions of 5A, 9, 25, 28, and 31), Former Fort Ord, California	KEMRON	2015

Title	Company	Date
Final Track 3 Impact Area Munitions Area Munitions Remedial Investigation/Feasibility Study Report, Former Fort Ord, California (OE-0596R)	MACTEC/Shaw	2007
Final Site-Specific Work Plan, Munitions and Explosives of Concern Remedial Action, Non-Burn Areas, Former Fort Ord, California (OE-0685D)	Shaw	2010
Final Work Plan, MRS-BLM Burn Units 01-05 Munitions and Explosives of Concern Removal, Former Fort Ord, California, Revision 0 (OE-0626L)	Shaw E&I	2008
Final Work Plan, Remedial Design/Remedial Action (RD/RA), Track 3 Impact Area Munitions Response Area, Munitions and Explosives of Concern Removal, Former Fort Ord, California (OE-0660K)	USACE	2009
Installation-Wide Multispecies Habitat Management Plan for Former Fort Ord, California (BW-1787)	USACE	1997
Penetration of Projectiles into the Ground, An Analysis of UXO Clearance Depths at Fort Ord	USACE	1997

1.2 Project Organization and QAPP Distribution (QAPP Worksheets #3 & 5)

Figure 1-1. Organizational Structure



1.3 Personnel Qualifications and Sign-off Sheet (QAPP Worksheets #4, 7, & 8)

ORGANIZATION: KEMRON

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date
John England	Program Manager	BS in Civil Engineering, 35 years of combined environmental / Military Munitions Response Program (MMRP) remediation program and project management experience	Registered Professional Engineer, Project Management Professional, Hazardous Waste Operations and Emergency Response (HAZWOPER), 30+ years of program management experience	
TBD	Quality Control Manager			
Steve Crane	Project Manager	MS Civil and Environmental Engineering 42 years of combined experience in environmental engineering, project management, program management, and business unit management Previous Project Manager for the $60 million Fort Ord MEC Removal and Soil Remediation WERS task order for Gilbane (2010 – 2015) and the $87 million Fort Ord MEC Removal and Soil Remediation WERS task order for KEMRON (2015 – 2020)	Registered Civil Engineer (Professional Engineer) [PE], USACE Architect – Engineer Contracting Short Course, USACE-Huntsville, Program for Manager Development, Univ. of North Carolina – Chapel Hill Graduate Business School	
Bradley Olson	SUXOS	DDESB TP-18-Qualified SUXOS, 38 years of EOD and UXO experience	Naval EOD School, USACE CQM, HAZWOPER, HAZWOPER Supervisor, 30-Hour Construction Safety, 10-Hour Construction Safety	
Bruce McClain	Unexploded Ordnance Quality Control Specialist (UXOQCS)	DDESB TP-18-Qualified UXOQCS, 36 years of EOD and UXO experience	Naval EOD School, USACE CQM, HAZWOPER, HAZWOPER Supervisor, 30-Hour Construction Safety, 10-Hour Construction Safety	

Chris Light	Unexploded Ordnance Safety Officer (UXOSO)	DDESB TP-18-Qualified UXOSO, 26 years of EOD and UXO experience	Naval EOD School, 30 Hour Construction Safety, USACE CQM, 1st Aid/CPR, HAZWOPER Supervisor, Served as UXOSO, SUXOS, and UXOQCS on the last 4 Fort Ord MEC contracts, 20 years of work experience at Fort Ord	

ORGANIZATION: AECOM

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date
Andy Gascho	Program Geophysicist	MS Geophysics, 22 years of MMRP geophysics experience, 10 years of advanced geophysical classification experience on 12 advanced geophysical classification projects	Professional Geologist (Colorado), Oasis Montaj Geophysical Data Processing for UXO, ESTCP Geosoft UX-Analyze Advanced Training, HAZWOPER, 30-Hour Construction Safety	
Alexander Kostera	Program QC Geophysicist	BS Geology, 21 years of MMRP geophysics experience, 8 years of advanced geophysical classification experience on 8 advanced geophysical classification projects	Professional Geologist (Virginia), Oasis Montaj Geophysical Data Processing for UXO, Oasis Montaj Geophysical Data Processing for AGC, HAZWOPER	
Larry Carr	GIS Manager	BS Geology, 22 years of experience GIS, (28 years overall experience in industry)	HAZWOPER	

ORGANIZATION: Acorn SI and NAEVA Joint Venture (ANJV)

Name	Project Title/Role	Education/Experience	Specialized Training/Certifications	Signature/Date

Tom Furuya	Project Geophysicist	B.S., Physics and Geology Over 25 years of practical geophysical experience with 21 years focused on munitions response projects	Co-developer of UX-Analyze and instructor of Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) hands-on classification and short courses HAZWOPER	
Jon Guillard	QC Geophysicist	B.S., Geology 26 years of experience analyzing and reviewing geophysical data for MMRP and hazardous, toxic, and radioactive waste projects with 10+ years of QC oversight for geophysical operations, including AGC	Oasis Montaj Geophysical Data Processing for UXO, ESTCP Geosoft UX-Analyze Advanced Training HAZWOPER	
Alison Paski	Lead Data Processor	BS Geophysics, 20 years of experience, 11 years of advanced geophysical classification experience on 12 advanced geophysical classification projects	Oasis Montaj Geophysical Data Processing for UXO, ESTCP Geosoft UX-Analyze Advanced Training	
Penny Johnson	Field Data Manager	BS Geology, 21 years of MMRP geophysics experience, 16 years database management experience on MMRP projects	Microsoft Access, Intermediate/SQL, Oasis Montaj Geophysical Data Processing for UXO, HAZWOPER	

Signatures indicate personnel have read and agree to implement this AGCMR-QAPP as written.

1.4 Communication Pathways (QAPP Worksheet #6)

Communication Driver	Organization	Name	Contact Information	Procedure (timing, pathway, and documentation)
Regulatory agency interface	USACE	James Specht	(916) 557-6796	USACE Fort Ord Senior Project Manager provides routine project updates to Base Realignment and Closure Cleanup Team and stakeholders, including work variances and corrective actions.
Project status reports	KEMRON	Steve Crane	(916) 337-4924	KEMRON Project Manager e-mails weekly status reports to USACE Fort Ord Senior Project Manager for distribution to Fort Ord project delivery team.
Stop work due to safety issues	KEMRON	Chris Light	(831) 521-8204	UXOSO informs KEMRON Project Manager and Health and Safety Manager of critical safety issues and develops report. OESS and USACE Fort Ord Senior Project Manager informed of issue and receive report.
AGCMR-QAPP variances during project execution	AECOM	Andy Gascho	(916) 853-1839	AECOM Program Geophysicist submits Field Change Request to USACE Senior Project Manager for review and approval.
Field corrective actions	AECOM ANJV	Alex Kostera Jon Guillard	(434) 825-0934 (434) 825-8820	Program QC Geophysicist and QC Geophysicist prepare a Non-Conformance Report (NCR) and, as applicable, a Corrective Action Request (CAR) and Corrective Action Plan (CAP). Forms are provided to the KEMRON QC Manager for review and approval. KEMRON QC Manager then provides forms to USACE Fort Ord Senior Project Manager for review and approval.
Blind seeding information and issues	AECOM ANJV	Alex Kostera Jon Guillard	(434) 825-0934 (434) 825-8820	Program QC Geophysicist and QC Geophysicist communicates directly with USACE QA Geophysicist and USACE OESS regarding blind seeding information in accordance with the Blind Seed Firewall Plan (Appendix C).
Geophysical quality control variances	AECOM ANJV	Alex Kostera Jon Guillard	(434) 825-0934 (434) 825-8820	Program QC Geophysicist and QC Geophysicist prepare a NCR and, as applicable, a CAR and CAP. Forms are provided to USACE QA Geophysicist, USACE OESS, and USACE Fort Ord Senior Project Manager for review and approval.
Data verification issues (e.g., incomplete records)	AECOM ANJV	Andy Gascho Tom Furuya	(303) 256-6153 (919) 539-8098	AECOM Program Geophysicist and Project Geophysicist prepare a NCR and, as applicable, a CAR and CAP. Forms are provided to USACE QA Geophysicist, USACE OESS, and USACE Fort Ord Senior Project Manager for review and approval.

Communication Driver	**Organization**	**Name**	**Contact Information**	**Procedure (timing, pathway, and documentation)**
Data review corrective actions	AECOM ANJV	Alex Kostera Jon Guillard	(434) 825-0934 (434) 825-8820	Program QC Geophysicist and QC Geophysicist prepare a NCR and, as applicable, a CAR and CAP. Forms are provided to USACE QA Geophysicist, USACE OESS, and USACE Fort Ord Senior Project Manager for review and approval.

2.2 Project/Data Quality Objectives (QAPP Worksheet #11)

DQOs are qualitative and quantitative statements that outline the decision-making process and specify the data required to support project objectives. DQOs specify the level of uncertainty that will be accepted in results derived from data. The DQO process used for developing data quality criteria and performance specifications for decision making is consistent with the *Guidance on Systematic Planning Using the Data Quality Objectives Process*, Environmental Protection Agency (EPA) QA/G-4 (EPA, 2006). The DQO process consists of the following seven steps:

- Step 1: State the problem
- Step 2: Identify the goals of the project
- Step 3: Identify information inputs
- Step 4: Define the boundaries of the project
- Step 5: Develop the project data collection and analysis approach
- Step 6: Specify project-specific measurement performance criteria
- Step 7: Develop the survey design and project workflow

Step 1: State the Problem. MEC in the form of DMM and UXO are known to be present in portions of the Former Fort Ord. The Army has been conducting MEC investigations and removals in munitions response sites at the former Fort Ord using analog and digital geophysical techniques to detect subsurface metallic items. Within the Impact Area MRA, specific areas are selected for subsurface MEC removal. During traditional subsurface MEC removal utilizing digital geophysical methods, the site is geophysically mapped using EM61-MK2A EMI sensors, supplemented by analog (mag and dig) removal in highly cluttered areas. Because these technologies do not provide a validated means to discriminate between MEC and nonhazardous metallic debris, the locations of all anomalies greater than the detection threshold (specified in the SSWPs) are identified, reacquired, and excavated. Experience has shown that the majority of the cost and effort of subsurface MEC removals are associated with the excavation of non-MEC items. Recent research has resulted in the development of discrimination technologies to reduce the number of excavations of non-MEC items, thus reducing the cost of subsurface removals.

Advanced geophysical classification uses geophysical sensors to detect metal items beneath the ground surface followed by the use of advanced sensors and geophysical classifiers to estimate physical properties of the item (such as size, aspect ratio, wall thickness, and symmetry) and determine whether the item is a target of interest (TOI) or non-TOI. Using this information in a structured decision-making process, the project team will be able to make informed decisions about whether an item should be excavated or can be left in place.

Step 2: Identify the goals of the project. Depending on site-specific conditions and the goals and objectives of each individual activity, advanced geophysical classification may not be the most efficient technique or the best choice to meet individual project objectives. Advanced geophysical classification is an additional tool to be utilized in specific situations, but it will not replace standard MEC removal methods. The goal of the advanced geophysical classification work is to identify geophysical anomalies potentially representing MEC and to determine which of those anomalies require removal and which may be left in place. Advanced geophysical classification may be used to detect anomalies resulting from DMM, UXO, and other metallic debris and to classify those anomalies so that informed decisions can be made as to whether each anomaly is a TOI and should be removed or is a non-TOI and may be left in place. Geophysical detection data will be used to initially detect and document the locations of subsurface anomalies. If deemed appropriate for use at a specific site or area, geophysical data collected using advanced EMI sensors in a cued (static) mode will then be used to classify each anomaly as follows:

1. TOI (i.e., highly likely to be DMM or UXO)
2. Non-TOI (i.e., highly unlikely to be DMM or UXO)
3. Inconclusive.

Detected items classified as "TOI" and "inconclusive" will be targeted for removal. Items classified as non-TOI will be left in place. The results of geophysical detection and classification and the subsequent intrusive investigation must meet established DQOs to complete the investigation.

Step 3: Identify information inputs. The following information inputs are required for successful accomplishment of the project objectives:

- An up-to-date CSM that summarizes site conditions based on previous studies, including:
    - Remedial action objectives
    - Site history and use
    - Range boundaries
    - Types and quantities of MEC known or suspected to be present
    - Expected distribution of MEC present
    - Topography, geology, and vegetation
    - Land use considerations
    - Reasonably anticipated future uses
    - Current and future receptors
    - Exposure pathways
    - Access restrictions or other obstacles to investigation
    - Endangered species, sensitive habitats, and historic or cultural resources that could be affected by traffic or other disturbances occurring during the investigation
    - Assumptions, data gaps, and sources of uncertainty
- Detection survey DGM results, including:
    - Areas covered
    - System QC test results

    - Instrument Verification Strip (IVS) results
    - Surveyed validation seed and QC seed locations
    - Data acquisition point responses and locations
    - Data analysis results, including:
        - Anomaly locations
        - Unique anomaly identification numbers
        - Amplitude response for each anomaly
- Classification survey results, including:
    - Definition of targets of interest
    - Unique anomaly identification numbers and locations
    - System QC results
    - IVS results
    - Background data
    - Surveyed validation seed and QC seed locations and types
    - Site-specific munitions library
    - Anomaly classification results
    - Ranked dig list with stop-dig threshold
    - Classification Survey Validation Report
    - Validation results
    - Classification Survey Data Usability Evaluation
    - Updated CSM
- Intrusive investigation and MEC removal results, including:
    - Excavation results (database)
    - Photos
    - Disposal records
    - Stop-dig threshold verification
    - Comparison of excavated validation digs to predictions
    - Final Data Usability Evaluation
    - Final CSM

Step 4: Define the boundaries of the project. The boundaries of areas within each unit where subsurface MEC removal will be conducted utilizing advanced geophysical classification will be detailed in the SSWP and Technical Memorandum prepared for each activity. Spatial boundaries for each Unit are presented on Figure 2-1 (Site Location Map). The vertical extent of the activity extends from the surface to depths to be specified in the SSWP prepared for each activity.

There are no established temporal boundaries for the project other than the period of performance. However, restrictions due to biologic concerns, such as sensitive species and habitats, will be addressed by the Project Biologist prior to initiation of field activities. These concerns are discussed in the appropriate site-specific work plan.

Step 5: Develop the project data collection and analysis approach. Advanced geophysical classification work will use the results from advanced geophysical sensors (decay curves) and Geosoft's UX-Analyze Advanced (UXA) software to measure, model, and classify target anomalies detected during the geophysical detection survey. Geophysical data from advanced sensors will be interpreted with physics-based models to estimate the physical attributes of the anomalies, and classifier models will be used to evaluate the likelihood that the anomalies are intact munitions. Anomalies will be classified into one of three categories described in Step 2 above. The final product of the geophysical investigation will be a "ranked anomaly list" that classifies each anomaly, justifies the classification, and identifies whether a detected object will be removed or left in place. Anomalies on the list will be ranked in order of greatest likelihood to be a TOI to greatest likelihood to be a non-TOI, based on their confidence metrics.

The advanced geophysical classification approach also addresses concerns related to the geologic conditions described in Worksheet 10. These geologic conditions are not anticipated to adversely impact advanced geophysical classification activities for the following reasons:

- The advanced geophysical classification systems utilize electromagnetic induction sensors, which are typically less affected by geologic conditions than other geophysical sensor types.
- Advanced sensor investigations include periodic background measurements that are used to subtract the non-target component (sensor response due to the sensor system itself and the ambient environment in which the target is buried) from the overall sensor measurement, leaving only the signature of the target.

The presence of groundwater has minimal effect on the advanced geophysical classification system sensor and is therefore not expected to be an issue during advanced geophysical classification activities. Standard practice requires the acquisition of at least one background measurement every two hours to allow subtraction of the responses from the instrument itself and the ambient environment from the sensor measurements. In the event of changing soil moisture conditions due to precipitation, more frequent background measurements will be taken, as necessary, to accurately isolate and remove moisture-related response from the sensor measurements.

Advanced geophysical classification activities will be performed in accordance with the HMP and monitored by natural resources personnel to ensure compliance with the Endangered Species Act and to minimize potential adverse impacts to listed species.

DETECTION SURVEY

The anomaly detection survey may be conducted using standard EM61-MK2 DGM as described in the Munitions and Explosives of Concern Quality Assurance Project Plan (MEC-QAPP; KEMRON, 2016a) or using advanced EMI sensors. If advanced EMI sensors are used for the detection phase, the following parameters of interest, inferences, and decision rules will be utilized.

Parameters of interest from detection survey data: Anomaly measurements with an amplitude and signal to noise ratio greater than or equal to the site-specific threshold values described in the SSWP.

Type of inference: Measurements meeting the decision rule criteria will be considered potential TOI and selected as anomalies for further evaluation during the classification phase.

Site-specific anomaly selection threshold values will be dependent on detection goals specified in the SSWP for each project area.

Decision rules:

- If an anomaly has a response amplitude and signal to noise ratio greater than or equal to the site-specific threshold value, as determined by test pit measurements or other site-specific methods, then it will be selected and placed on the cued investigation list for the classification survey.

CLASSIFICATION SURVEY

The characteristics of interest in the cued advanced geophysical classification sensor data are the physical characteristics intrinsic to each anomaly source that allow the classification process to determine whether the anomaly most likely represents a TOI or non-TOI. The sensor data from each measurement will be processed and analyzed to create a model of the target that best fits the measured data. In many cases, the best fit to the measured data will be a combination of multiple targets. The model (or models) will then be compared to the classification library of known MEC signatures to classify the target as one of the following:

1. TOI – Targets that are likely to be MEC items or QC or validation seed (formerly referred to as QA seed) items
2. Non-TOI – Targets that are unlikely to be MEC items or QC or validation seed items
3. Inconclusive – Targets for which the modeled response is not highly-correlated with the observed response, and the acquired data therefore does not support a confident classification decision

Parameters of interest from classification survey data: Cued measurement noise value (beta noise points), inversion fit coherence, inversion outputs of β1, β2, β3, x, y, and z, and library match confidence metrics.

Type of inference: Classification decision (TOI/non-TOI) based on modeled parameters of interest.

Decision rules:

- If an anomaly signature matches (within specifications established on Worksheet 22) that of an item in the project-specific TOI library, then the anomaly will be classified as a TOI and added to the dig list.
- If an anomaly signature does not match (within specifications established on Worksheet 22) that of an item in the project-specific TOI library, then the anomaly will be classified as a non-TOI and will not be added to the dig list.
- If an anomaly signature is consistent with the characteristics of a MEC item (size, shape, symmetry, and wall thickness) thought to exist at the site, then the anomaly will be classified as a TOI and added to the dig list.
- If an anomaly is one of a cluster of three or more similar-signature anomalies identified as TOI through intrusive investigation, then the anomaly will be classified as a TOI and added to the dig list.
- If an anomaly has poor inversion fit coherence (where the modeled response is not highly correlated with the observed response) after considering all available information, then it will be classified as inconclusive and added to the dig list.

INTRUSIVE INVESTIGATION

Anomalies classified as either TOI or inconclusive will be intrusively investigated, and the sources of the anomalies will be removed. Items classified as non-TOI will be left in place. A subset of non-TOI anomalies will be identified in the final Advanced Geophysical Classification Validation Plan (the draft version of which is included in Appendix D) and intrusively investigated as validation digs to demonstrate that appropriate classification decisions were made. If an investigated anomaly from the validation list is determined to be a TOI, a root cause analysis (RCA) will be performed.

Intrusive investigation results, including precise recovery depths, will be recorded, and photographs will be taken of recovered items. Additionally, details regarding specific varieties of recovered MEC items (e.g., HE vs. practice munitions) will be recorded.

Decision rules:

- If an anomaly is on the dig list, then it will be intrusively investigated, and its source will be removed.
- If an anomaly source is not encountered, then the intrusive investigation will proceed to a depth 12 inches below the predicted source depth.
- If an anomaly source of comparable size and shape to the predicted anomaly source is not encountered within the 12 inches beyond the predicted source depth, then the intrusive investigation will be subject to QC review.

Step 6: Specify project-specific measurement performance criteria. Project-specific measurement performance criteria (MPC), the criteria that acquired data must meet to satisfy the DQO, are presented in Worksheet 12. Failure to achieve the MPC may have an impact on end uses of the data, which will be discussed in the Data Usability Evaluation Report.

Step 7: Develop the survey design and project workflow. The MPC established during Step 6 of the DQO process were used to develop the sample design, which is described in Worksheet 17. The sample design is broken down into a series of specific processes and data acquisition steps, termed definable features of work (DFW). Figure 3-1 provides an advanced geophysical classification decision tree that will be used in the execution of the sample design to evaluate the conformance of specific DFW to established MPC.

3.0 SAMPLE DESIGN

3.1 Sampling Design and Rationale (QAPP Worksheet #17)

This worksheet details the specific DFWs to be performed to meet the objectives of the investigation. Each of these work elements, the SOPs that define the methods for performing the activities, and other supporting documentation for performing the investigation are presented in the table below. The principal tasks associated with the DFWs are detailed following the table. In this worksheet, "detection survey" refers to dynamic surveys conducted with advanced EMI sensors.

DFW	Associated Activities (Referenced SOPs are provided in Appendix B)	Supporting Document(s)
Pre-Mobilization Activities	Prepare AGCMR-QAPP	AGCMR-QAPP
	Prepare Blind Seed Firewall Plan	Blind Seed Firewall Plan
	Prepare draft Advanced Geophysical Classification Validation Plan	Advanced Geophysical Classification Data Validation Plan
Mobilization and Site Preparation	Mobilize staff	AGCMR-QAPP
	Mobilize equipment	ANJV SOP 2
	Kickoff/Safety Meeting	ANJV SOP 3
	Habitat conservation training for project personnel, including minimization measures outlined in the project-specific habitat checklist	HMP
	Place subsurface QC seed items (KEMRON) and validation seed items (USACE) with UXO/anomaly avoidance and survey locations	
	Establish IVS	

DFW	Associated Activities (Referenced SOPs are provided in Appendix B)	Supporting Document(s)
Detection Survey	Assemble advanced EMI sensor system for detection survey and verify operation Perform initial dynamic IVS survey and prepare IVS Memorandum Perform advanced EMI sensor detection survey	AGCMR-QAPP ANJV SOP 1MM2 ANJV SOP 2 ANJV SOP 4 ANJV SOP 5 ANJV SOP 11
Detection Survey Data Verification	Verify quality of detection survey data prior to data analysis and target selection (daily)	AGCMR-QAPP ANJV SOP 5
Detection Survey Data Processing, Analysis and Target Selection	Process detection survey data Select target anomalies and generate the classification investigation list for the classification survey GIS incorporation	AGCMR-QAPP ANJV SOP 5
Detection Survey Quality Control	Validate data that has undergone data verification (weekly) Validate data that has undergone analysis and target selection process (weekly, or other predefined scheduled frequency)	AGCMR-QAPP ANJV SOP 5
Classification Survey	Assemble advanced EMI sensor system for classification survey and verify operation Perform initial cued IVS survey and prepare IVS Memorandum Perform test pit measurements to populate classification library with site-specific TOI signatures, if necessary Establish background measurement locations Perform advanced EMI sensor classification survey	AGCMR-QAPP ANJV SOP 1MM2 ANJV SOP 2 ANJV SOP 6 ANJV SOP 7 ANJV SOP 8 ANV SOP 11
Classification Survey Data Verification	Verify quality of classification survey data prior to inversion and classification (daily)	AGCMR-QAPP ANJV SOP 8

DFW	Associated Activities (Referenced SOPs are provided in Appendix B)	Supporting Document(s)
Classification Survey Data Processing, Analysis and Classification	Process classification survey data – background corrections and inversions Add site-specific signatures to classification library, if necessary Classify anomalies and generate TOI/non-TOI classification spreadsheet, ranked dig lists GIS incorporation Finalize Advanced Geophysical Classification Validation Plan	AGCMR-QAPP ANJV SOP 8
Classification Survey Quality Control	Validate data that has undergone data verification (weekly) Validate completeness of the classification library Validate data that has undergone classification and ranking process (weekly, or other predefined scheduled frequency)	AGCMR-QAPP ANJV SOP 8
Intrusive Investigation	Reacquire and flag anomalies selected for intrusive investigation Investigate anomalies and remove identified anomaly sources	AGCMR-QAPP SOP AGCMR-09 ANJV SOP 9 ANJV SOP 10 ANJV SOP 11 ANJV SOP 13
Demobilization	Demobilize personnel and equipment	AGCMR-QAPP
Reporting	Prepare final Advanced Geophysical Classification Technical Memorandum/Data Usability Report	AGCMR-QAPP Advanced Geophysical Classification Data Validation Plan

Pre-Mobilization Activities

Prepare AGCMR-QAPP

The AGCMR-QAPP will be prepared in accordance with Guidance on QAPP, Final Draft. (EPA, 2012), UFP for QAPP, Part 2a (Revised): Optimized UFP-QAPP Worksheets (IDQTF, 2012), and UFP for QAPP Template: Geophysical Classification for MR, Revised Beta Draft (IDQTF, 2015). The AGCMR-QAPP and a detailed Site-Specific Work Plan will be provided for regulatory review prior to commencement of advanced geophysical classification field activities.

Prepare Blind Seed Firewall Plan

A Blind Seed Firewall Plan is provided in Appendix C detailing the project team's approach to limiting distribution of the QC seed information (i.e., types, depths and locations of QC seed items placed at the site).

Prepare Draft Advanced Geophysical Classification Validation Plan

A draft Advanced Geophysical Classification Validation Plan, designed to provide assurance that TOI are correctly classified and that no TOI have been classified as non-TOI, is provided in Appendix D. The plan details the approach to validation, including validation of appropriate anomaly selection methods and thresholds for library matching, cluster analysis and feature analysis. The document will be finalized after completion and delivery of the final classification results to USACE and prior to performance of validation digs.

Mobilization and Site Preparation

A mobilization period will include mobilizing staff and securing and deploying equipment. Mobilization activities will include general activities, site-specific training, and a kickoff and safety meeting. During field work activities, all environmental protection measures described in the MEC-QAPP (KEMRON 2016a) will be implemented and followed.

General Activities

The general activities to be performed as part of mobilization include the following:

- Identify/procure, package, ship, and inventory project equipment
- Finalize operating schedules
- Assemble and transport the work force
- Test and inspect equipment (See Worksheet 22 for details)
- Conduct site-specific training on the AGCMR-QAPP, MEC procedures and hazards, and habitat conservation for all project personnel
- Verify that all forms and project documentation are in order and KEMRON Team members understand their responsibilities with regard to completion of project reporting requirements, including appropriate nomenclature, terminology, and avoidance of unprofessional language in project documents and reporting forms.

Kickoff/Safety Meeting

During mobilization, a kickoff and site safety meeting will be conducted. This meeting will include a review of this AGCMR-QAPP and review and acknowledgment of the Accident Prevention Plan (APP) by all site personnel. Additional training topics to be discussed include the environmental protection measures described in the MEC-QAPP (KEMRON 2016a) and the minimization measures outlined in the project-specific habitat checklist. Additional meetings will occur as needed, as new personnel, visitors, and/or subcontractors arrive at the site.

Place Subsurface QC and Validation Seeds

The QC Geophysicist will place subsurface QC seed items across the investigation area in accordance with ANJV SOP 3 (Appendix B) prior to onset of the advanced EMI sensor survey. The seed item frequency is designed to demonstrate the quality of each production unit, generally assumed to be one day of advanced EMI sensor data acquisition. While encountering at least one seed item every day of the survey cannot be guaranteed, QC seed items will be placed such that each data acquisition team, whether acquiring detection or cued data, should encounter between one and three seed items per day, on average. The QC seed items will be ISOs that will be placed up to the maximum target depth for the investigation. Specific seed item information and burial depths will be detailed in the SSWP. The QC seed item information will be documented and provided to USACE as a separate database in accordance with the Blind Seed Firewall Plan (Appendix C).

Validation seeding will be conducted by USACE. Validation seeding details, including types of seed items, quantities, and burial locations, depths, and orientations will not be known to the contractor.

Establish IVS

In order to test the advanced EMI sensor system and verify that it is functioning properly, an initial IVS survey will be performed as described in ANJV SOP 2 (Appendix B). The IVS will be constructed at a location convenient for daily access and will include two ISO and one 'blank' location, where nothing is buried. One ISO will be buried horizontally, perpendicular to the transect, and one will be buried vertically, at depths described in the SSWP. IVS item locations will be recorded with real-time kinematic (RTK) global positioning system (GPS), and depths and orientations will be measured as accurately as possible.

Detection Survey

Assemble Advanced EMI Sensor for Detection Survey and Verify Operation

The advanced EMI sensor system will be assembled and tested in accordance with ANJV SOP 1MM2 and ANJV SOP 11 (Appendix B).

Perform initial dynamic IVS survey and prepare IVS Memorandum

After assembly of the advanced EMI sensor system for dynamic detection surveys, the IVS strip will be used to perform an initial dynamic IVS survey for each system in accordance with ANJV SOP 2 (Appendix B) to verify proper assembly and functionality.

After performance of the initial dynamic IVS, an IVS Memorandum will be prepared detailing the dynamic IVS survey operation and results, including documentation of compliance with the dynamic IVS MQOs provided in Worksheet 22. The IVS Memorandum will be provided to the project team for review and concurrence within 3 working days of completion of the initial IVS survey. If the initial IVS results meet the dynamic IVS MQOs, the Project Geophysicist may elect to begin the detection survey prior to project team review of the IVS Memorandum.

Perform dynamic detection survey

The dynamic detection survey will be performed in accordance with ANJV SOP 4 (Appendix B).

Data Verification

Data verification will be conducted each day of data acquisition to demonstrate that project MQOs have been achieved and will be documented in a weekly QC report. Detection survey data verification procedures are conducted both in the field during data acquisition activities and remotely during data processing activities. Field verification of data quality will be conducted in accordance with ANJV SOP 4, Section 3.4. Data processing verification of data quality will be conducted in accordance with ANJV SOP 5, Section 3.1.1.

Quality control of advanced geophysical detection data and processing will be conducted by ANJV Geophysicists experienced in advanced geophysical classification work. Every week, data that has undergone quality verification by the data processor will be provided to the QC Geophysicist for validation prior to data processing. The QC Geophysicist will validate the data quality by monitoring the data for agreement with the MQOs in Worksheet 22 and return the data to the data processor within one week for completion of data processing and target identification.

Data Processing, Analysis and Target identification

Process dynamic detection survey data, identify anomalies with response values and signal to noise ratios greater than the values described in the SSWP, and generate the cued investigation list for the classification survey.

Data processing and classification will be performed in accordance with ANJV SOP 5.

Classification Survey

Assemble Advanced EMI Sensor for Classification Survey and Verify Operation

The advanced EMI sensor system will be assembled and tested in accordance with ANJV SOP 1MM2 and ANJV SOP 11 (Appendix B).

Perform Initial Cued IVS Survey and Prepare IVS Memorandum

After assembly of the advanced EMI sensor system for classification surveys, the IVS strip will be used to perform an initial cued IVS survey for each system in accordance with ANJV SOP 2 (Appendix B) to verify proper assembly and functionality.

After performance of the initial cued IVS, an IVS Memorandum will be prepared detailing the cued IVS survey and results, including documentation of compliance with the cued IVS MQOs provided in Worksheet 22. The IVS Memorandum will be provided to the project team for review and concurrence within 3 working days of completion of the initial IVS survey. If the initial IVS results meet the cued IVS MQOs, the Project Geophysicist may elect to begin the classification survey prior to project team review of the IVS Memorandum.

Perform Test Pit Measurements

The library of advanced geophysical classification munitions data will be based on the munitions classification library developed and maintained by the DoD. The DoD munitions classification library was developed by acquiring advanced EMI sensor data over sample munitions items in a controlled environment. The data were then inverted to determine the primary axis polarizabilities for each sample munitions item. The DoD munitions classification library contains signature polarizabilities in both Hierarchical Data Format version 5 and Geosoft Oasis Montaj formats and allows classification comparisons for data acquired by various advanced EMI sensors utilizing a variety of data acquisition parameters to meet specific project needs.

Test pit measurements will be conducted as necessary prior to the classification survey to acquire signatures of TOI that are not currently in the classification library. Test pit measurements will be conducted by placing the item at precisely measured depths and orientations in an excavated pit below the advanced EMI sensor and acquiring cued measurements as described in ANJV SOP 7 (Appendix B). The test pit measurements will be processed as described in ANJV SOP 8 (Appendix B) and added to the site-specific classification library utilizing the purpose-built classification library utilities in UX-Analyze Advanced.

Establish Background Measurement Locations

Background measurement locations will be established throughout the survey area as described in ANJV SOP 6 (Appendix B) to allow background measurements to be acquired under conditions closely resembling those of the classification survey acquisition. The suitability of each background location will be verified and documented as described in ANJV SOP 6.

Perform Advanced EMI Sensor Classification Survey

Anomalies identified for cued interrogation will be surveyed in accordance with ANJV SOP 7 (Appendix B).

Data Verification

Data verification will be conducted each day of data acquisition to demonstrate that project MQOs have been achieved and will be documented in a weekly QC report. Classification survey data verification procedures are conducted both in the field during data acquisition activities and remotely during data processing activities. Field verification of data quality will be conducted in accordance with ANJV SOP 7, Section 3. Data processing verification of data quality will be conducted in accordance with ANJV SOP 8, Section 3.2.

Quality control of advanced geophysical classification data, processing and classification will be conducted by ANJV Geophysicists experienced in advanced geophysical classification work. Every week, data that has undergone quality verification by the data processor will be provided to the QC Geophysicist for validation prior to data processing and classification. The QC Geophysicist will validate the data quality by monitoring the data for agreement with the MQOs in Worksheet 22 and return the data to the data processor within one week for completion of data classification. The QC Geophysicist will also validate the completeness and quality of the site-specific classification library.

Data Processing, Analysis and Classification

Process Classification Survey Data, Classify Anomalies and Generate TOI/Non-TOI Classification Spreadsheet

Data processing and classification will be performed in accordance with ANJV SOP 8 (Appendix B). Each anomaly will be classified as TOI, non-TOI or inconclusive on the ranked dig list. If an anomaly is classified as TOI, it will be intrusively investigated. If an anomaly is classified as non-TOI, it will not be intrusively investigated (unless it is selected for investigation on the validation dig list). If an anomaly is classified as inconclusive, it will be intrusively investigated.

A preliminary database of anomaly classifications will be provided to USACE after completion of the initial classification. A final classification database and technical memorandum will be provided after any necessary threshold verification digs have been performed and the results used to finalize the classification process.

The data processing, classification, and ranking process will be validated against the MQOs in Worksheet 22 by the QC Geophysicist prior to finalization of the ranked dig list and delivery to the client.

Geographic Information System Incorporation

All relevant geospatial-related data and information will be incorporated into the existing Fort Ord GIS. The final submittal in electronic format will contain all required project (ArcGIS.mxd) files and layout files for all drawings that are presented in the final report. Environmental Systems Research Institute, Inc. (ESRI)–compliant formats (shapefiles, coverages, or geodatabases) will be used to present GIS data during the project, with supporting tabular data provided in Microsoft Excel format, Microsoft Access format, or both, as needed.

In addition, each GIS data set will be accompanied by metadata conforming to Federal Geographic Data Committee's (FGDC) *Content Standard for Digital Geospatial Metadata* (CSDGM) and be provided in a geodatabase that is compliant with the *Spatial Data Standards for Facilities, Infrastructure, and Environment* (SDSFIE). The horizontal accuracy of GIS data created by KEMRON will be tested in accordance with the National Standard for Spatial Data Accuracy (NSSDA), and the results will be recorded in the metadata.

Finalize Advanced Geophysical Classification Validation Plan

The draft Advanced Geophysical Classification Validation Plan (Appendix D) will be evaluated and revised as necessary for final review and approval by USACE prior to the performance of the validation digs. Additional anomalies beyond the 'Stop Dig' point, the cutoff threshold for the library match metric, will be defined in the final Advanced Geophysical Classification Validation Plan and placed on the validation list to verify that the 'Stop Dig' point was selected at an appropriate cutoff point.

Intrusive Investigation

Intrusive investigation will include reacquisition and flagging of anomalies selected for removal and the excavation of the sources of those anomalies. Anomalies to be intrusively investigated will include those identified as TOI and inconclusive as well as those selected as part of the validation process. All intrusive operations will be performed in accordance with the Fort Ord MEC-QAPP (KEMRON 2016a), SOP AGCMR-09, ANJV SOP 9, ANJV SOP 10, and ANJV SOP 13 (Appendix B).

Reacquire and Flag Anomalies Selected for Removal

Anomalies selected for removal will be reacquired by KEMRON personnel using RTK GPS to place a flag at the modeled target location derived through the data processing and classification process in accordance with SOP AGCMR-09 (Appendix B). Reacquisition teams will include one geophysicist and one UXO Technician II. The anomaly ID will be written in indelible marker on a survey flag placed at the anomaly location.

Investigate Anomalies and Remove Identified Anomaly Sources

After reacquisition of the anomalies selected for removal, each anomaly will be intrusively investigated in accordance with SOP AGCMR-09 (Appendix B). The initial anomalies to be investigated will be those selected as threshold verification digs in order to determine whether certain signatures should be added to the classification library from the cluster analysis and to verify the appropriate threshold (see the draft Advanced Geophysical Classification Validation Plan in Appendix D). After completion of the threshold verification digs, the intrusive team will proceed to investigate the remainder of the anomalies identified on the dig list. The final set of anomalies to be investigated will be those selected as part of the validation process approved in the final Advanced Geophysical Classification Validation Plan.

Specific intrusive investigation procedures, including vertical and lateral excavation limits, are detailed in SOP AGCMR-09 (Appendix B). Due to the precision of advanced geophysical classification data and modeling results, as well as to the nature of classification surveys, where non-TOI metallic items are purposely left in the ground, intrusive investigations will be conducted with different procedures than those of intrusive investigations based on standard DGM. Each excavation will be conducted only in the immediate vicinity of the reacquired target location, with an approximate search radius of one standard shovel width. The investigation will proceed until the predicted item (or a metallic item of comparable size and shape) is recovered or until the excavation depth has reached 12 inches below the predicted depth.

Post-investigation anomaly resolution will be verified by comparing the modeled classification results (predicted item identity and depth) to the actual intrusive investigation results in accordance with ANJV SOP 9. Any anomaly investigated from the validation dig list and identified as a TOI will trigger an RCA and corrective action, as appropriate. Documentation of the intrusive investigation results will be performed in accordance with Section 7.3.4 (MMRP Database) of the Fort Ord MEC-QAPP (KEMRON 2016a) and ANJV SOP 13.

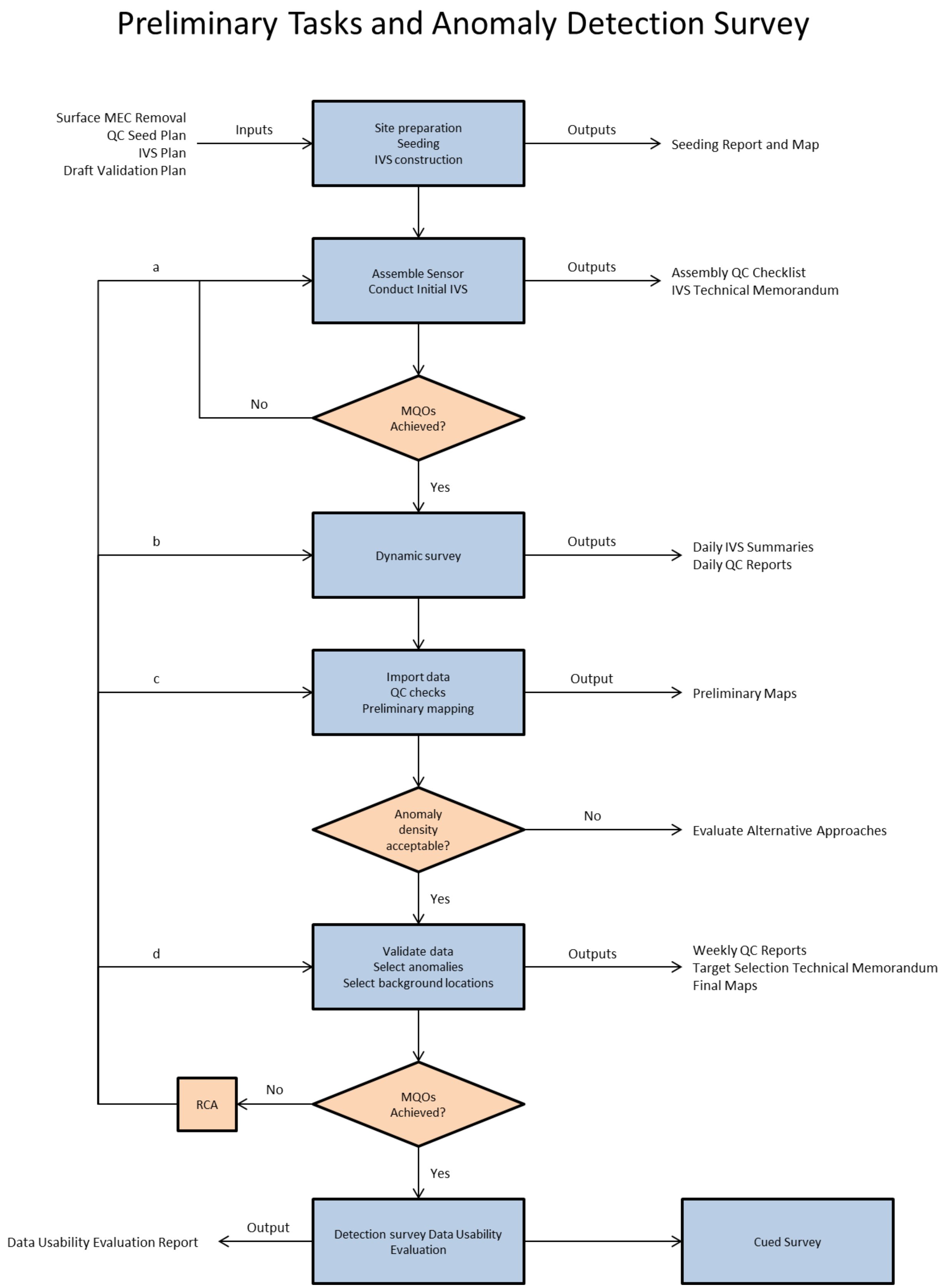
Demobilization

After completion of all field operations, equipment and personnel will be demobilized from the project site.

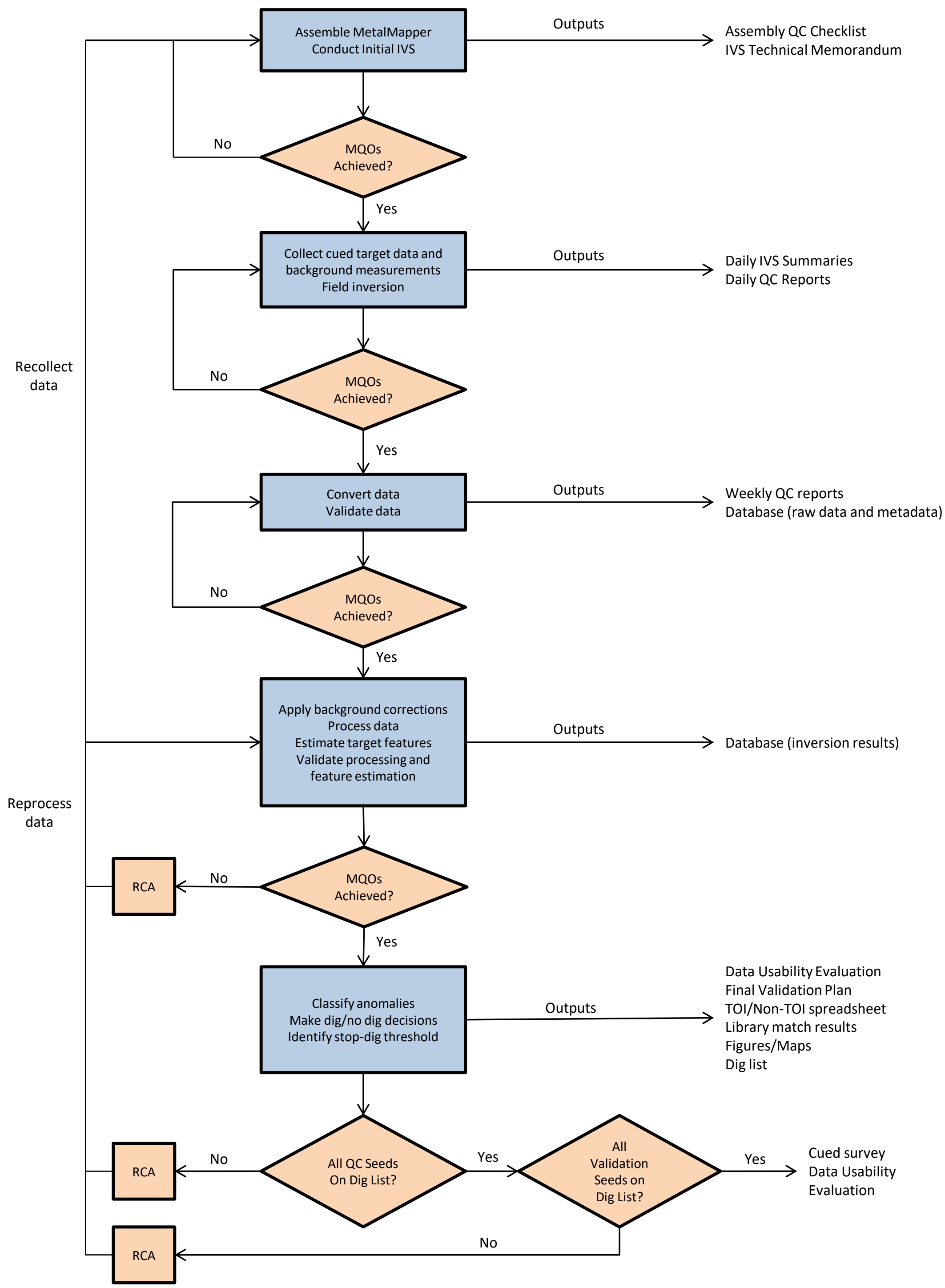
Reporting

Final reporting will include the preparation of an Advanced Geophysical Classification Technical Memorandum to summarize advanced geophysical classification activity details and results. A Data Usability Assessment will be prepared as described in Worksheet 37.

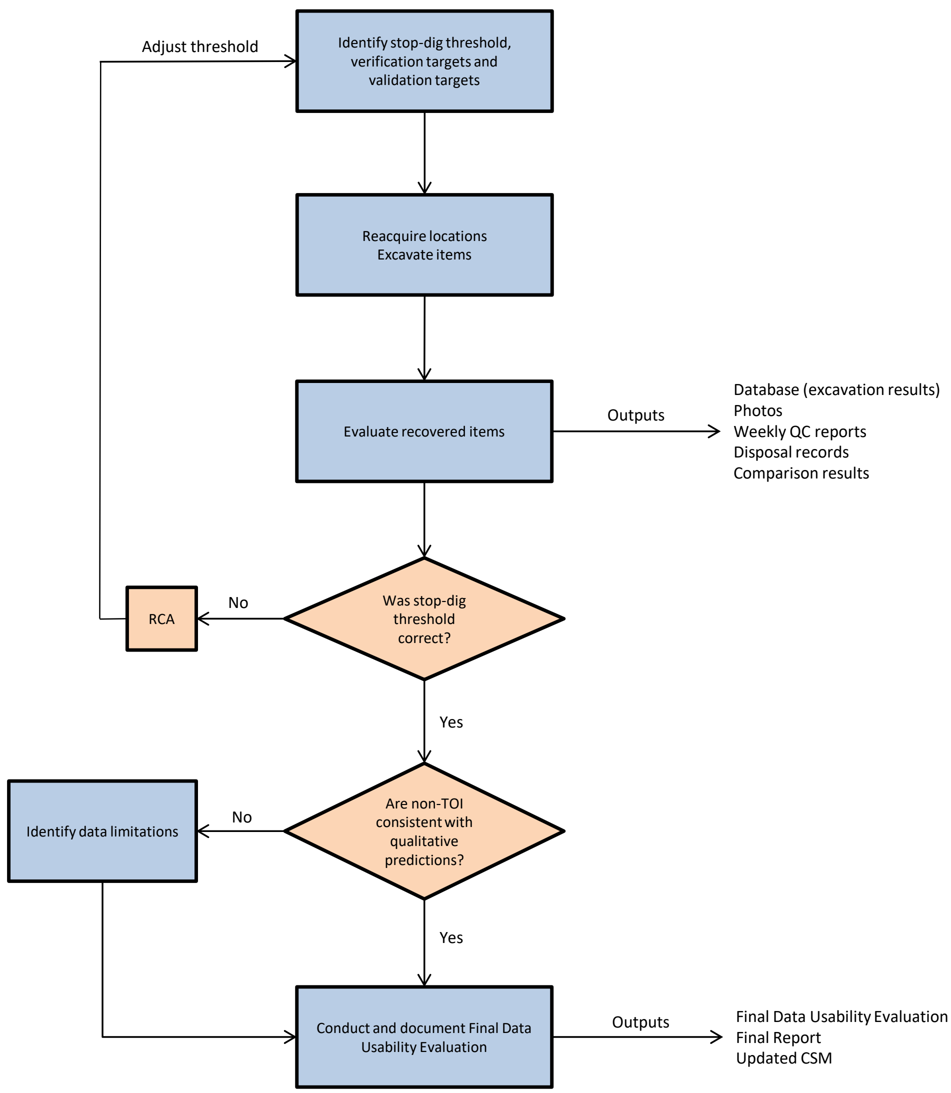
Figure 3-1. Advanced Geophysical Classification Decision Tree



Classification Survey



Intrusive Investigation



3.2 Standard Operating Procedures References Table (QAPP Worksheet #21)

This worksheet documents specific SOPs for advanced geophysical classification work. SOPs currently include procedures and information specific to the MetalMapper 2x2 system and will be updated to include other advanced EMI sensors if those sensors are selected for use at Fort Ord. Applicable SOPs will be readily available to all field personnel responsible for their implementation. The SOPs listed below are included in Appendix B.

SOP Reference No.	Title, Revision, Date	Modified for Project Work? (Y/N)	Comments
ANJV SOP 1MM2	Assemble the MetalMapper 2x2 System	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 2	Sensor and System IVS	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 3	Production Area QC or QA Seeding	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 4	Perform Dynamic Survey	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 5	Process Dynamic Survey Data	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 6	Collect Static Background Measurements	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 7	Collect Cued Target Measurements	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 8	Process Cued Geophysical Data	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 9	Recovered Item Verification	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 10	Validate Classification	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 11	Assemble the RTK GPS Positioning System	No	SOP has been prepared as a general document for advanced geophysical classification activities.
ANJV SOP 13	Recording data for AGC Intrusive Investigations	No	SOP has been prepared as a general document for advanced geophysical classification activities.
AGCMR-09	Anomaly Reacquisition and Intrusive Investigation	No	SOP has been prepared as a general document for advanced geophysical classification activities.

3.3 Equipment Testing, Inspection and Quality Control (QAPP Worksheet #22)

This worksheet documents procedures for performing testing, inspections and quality control for all field equipment. References to the applicable DFWs and SOPs are included. Where appropriate, the failure response will proscribe a corrective action (CA). Otherwise, both an RCA and CA are required. MQOs developed specifically for use of the MetalMapper 2x2 system at Fort Ord are currently presented in this worksheet. If other advanced EMI sensors are selected for use, appropriate MQOs will be developed and submitted to the project team for approval prior to implementation of those systems.

Detection (Dynamic) Survey (MetalMapper 2x2)

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
QC seed item placement	Place Subsurface QC Seeds/ ANJV SOP 3/Blind Seed Firewall Plan (Appendix C)	Evaluated for each QC seed item	Program QC Geophysicist and QC Geophysicist / Final Seed Report	Each seed item has been buried away from the immediate vicinity of strong anomalies, the burial parameters have been recorded with 1-inch precision for locations, 2-inch precision for depths, and 10° precision for inclinations and azimuths, and a photograph has been taken of the item in place.	CA: Replace the seed item, if necessary, or reacquire burial parameter information prior to commencement of data acquisition activities.
Verify correct MetalMapper 2x2 assembly	Dynamic Detection Survey/ ANJV SOP 1MM2/ ANJV SOP 11	Once following assembly	Data Acquisition Geophysicist/Assembly Checklist	As specified in ANJV SOP 1MM2, Assembly Checklist	CA: Make necessary adjustments and re-verify

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
Initial sensor function test (five measurements over an emplaced IVS item, 1 with item directly under center of array and 1 each with item centered under each diagonal quadrant of the array). Derived polarizabilities for each measurement are compared to the classification library using UXA	Dynamic Detection Survey/ ANJV SOP 1MM2/ ANJV SOP 8	Once following assembly	Data Acquisition Geophysicist/Assembly Checklist/Lead Data Processor	Library Match metric ≥ 0.95 for each of the five sets of inverted polarizabilities	CA: make necessary repairs/adjustments and re-verify
Initial sensor function test (five measurements over an emplaced IVS item, 1 with item directly under center of array and 1 each with item centered under each diagonal quadrant of the array). Modeled locations are compared to the known locations of the ISO for each measurement.	Dynamic Detection Survey/ ANJV SOP 1MM2/ ANJV SOP 8	Once following assembly	Data Acquisition Geophysicist/Assembly Checklist/Lead Data Processor	Modeled location of each measurement is under the correct quadrant of the MetalMapper 2x2 sensor array	CA: make necessary repairs/adjustments and re-verify
Initial derived target position accuracy (IVS)	Dynamic Detection Survey/ ANJV SOP 2/ ANJV SOP 4/ ANJV SOP 5ANJV SOP 5	Once during initial system IVS test	Lead Data Processor, Project Geophysicist, and Program Geophysicist/Initial IVS Technical Memorandum	All IVS item fit locations within 10 inches of ground truth locations	CA: make necessary repairs/adjustments and re-verify

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
Initial detection response amplitudes (IVS)	Dynamic Detection Survey/ ANJV SOP 2/ ANJV SOP 4/ ANJV SOP 5	Once during initial system IVS test	Lead Data Processor, Project Geophysicist and Program Geophysicist/Initial IVS Technical Memorandum	Response amplitudes within 25% of predicted (or baseline) amplitudes	CA: make necessary repairs/adjustments and re-verify
Ongoing derived target position precision (IVS)	Dynamic Detection Survey/ ANJV SOP 2/ ANJV SOP 4/ ANJV SOP 5	Twice daily, at the beginning and end of data acquisition, as part of IVS testing	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	All IVS item fit locations within 10 inches of the average locations	RCA/CA
Ongoing detection response precision (IVS)	Dynamic Detection Survey/ ANJV SOP 2/ ANJV SOP 4/ ANJV SOP 5	Twice daily, at the beginning and end of data acquisition, as part of IVS testing	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	Response amplitudes ≥ 25% average	RCA/CA
Down-line measurement spacing	Dynamic Detection Survey/ ANJV SOP 4	Verified for each survey unit using existing UX Detect tools based upon monostatic Z coil data positions	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	98% ≤ 8 inches between successive measurements	RCA/CA CA assumption: Reacquire portions that fail
Coverage	Dynamic Detection Survey/ ANJV SOP 4	Verified for each survey unit using existing UX Detect tools based upon GPS antenna positions	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	95% (or greater) of the lane spacing is to be at the project design lane spacing of 2 ft. 100% of the lane spacing is to be at 3 ft. No unexplained data gaps.	RCA/CA CA assumption: Gaps require fill-in survey to achieve required coverage
Transmit current levels	Dynamic Detection Survey/ ANJV SOP 4	Evaluated for each sensor measurement	Data Acquisition Geophysicist/failures noted in field log and tracking summary	Peak transmit current ≥ 5.5 amps	CA: reject data acquired with current levels outside of the acceptable range

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
Dynamic detection performance	Dynamic Detection Survey/ ANJV SOP 4/ ANJV SOP 5	Evaluated for each dataset	Program QC Geophysicist and QC Geophysicist/tracking summary	All blind seed items detected and positioned within 16-inch radius of ground truth location	RCA/CA
Position data are valid (1 of 2)	Dynamic Detection Survey/ ANJV SOP 4/ ANJV SOP 5	Evaluated for each sensor measurement	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	GPS status flag indicates RTK fix	RCA/CA
Position data are valid (2 of 2)	Dynamic Detection Survey/ ANJV SOP 4/ ANJV SOP 5	Evaluated for each sensor measurement	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	Orientation data valid Data input string checksum passes	RCA/CA

Classification (Cued) Survey (MetalMapper 2x2)

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
QC seed item placement	Place Subsurface QC Seeds/ ANJV SOP 3	Evaluated for each QC seed item	Program QC Geophysicist and QC Geophysicist / Final Seed Report	Each seed item has been buried away from the immediate vicinity of strong anomalies, the burial parameters have been recorded with 1-inch precision for locations, 2-inch precision for depths, and 10° precision for inclinations and azimuths, and a photograph has been taken of the item in place.	CA: Replace the seed item, if necessary, or reacquire burial parameter information prior to commencement of data acquisition activities.
Verify correct MetalMapper 2x2 assembly	Cued Classification Survey/ ANJV SOP 1MM2/ ANJV SOP 11	Once following assembly	Data Acquisition Geophysicist/Assembly Checklist	As specified in ANJV SOP 1MM2, Assembly Checklist	CA: Make necessary adjustments and re-verify
Initial sensor function test (five measurements over an emplaced IVS item, 1 with item directly under center of array and 1 each with item centered under each diagonal quadrant of the array). Derived polarizabilities for each measurement are compared to the classification library using UXA	Cued Classification Survey/ ANJV SOP 1MM2/ ANJV SOP 8	Once following assembly	Data Acquisition Geophysicist/Assembly Checklist/Lead Data Processor	Library Match metric ≥ 0.95 for each of the five sets of inverted polarizabilities	CA: make necessary repairs/adjustments and re-verify

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
Initial sensor function test (five measurements over an emplaced IVS item, 1 with item directly under center of array and 1 each with item centered under each diagonal quadrant of the array). Modeled locations are compared to the known locations of the schedule 80 small industry standard object (ISO 80) for each measurement.	Cued Classification Survey/ ANJV SOP 1MM2/ ANJV SOP 8	Once following assembly	Data Acquisition Geophysicist/Assembly Checklist/Lead Data Processor	Modeled location of each measurement is under the correct quadrant of the MetalMapper 2x2 sensor array	CA: make necessary repairs/adjustments and re-verify
Initial IVS background measurement (five background measurements – 1 centered at the flag and 1 offset 15 inches (40cm) in each cardinal direction)	Cued Classification Survey/ ANJV SOP 2/ ANJV SOP 7/ ANJV SOP 8	Once during initial system IVS test	Data Acquisition Geophysicist/Initial IVS Technical Memorandum/ Lead Data Processor	Decay amplitudes are below the selected background threshold at each offset background location	CA: reject/replace BG location
Initial derived polarizabilities accuracy (IVS)	Cued Classification Survey/ ANJV SOP 2/ ANJV SOP 7/ ANJV SOP 8	Once during initial system IVS test	Lead Data Processor, Project Geophysicist, and Program Geophysicist/Initial IVS Technical Memorandum	Library Match metric ≥ 0.9 for each set of inverted polarizabilities	RCA/CA
Initial derived target position accuracy (IVS)	Cued Classification Survey/ ANJV SOP 2/ ANJV SOP 7/ ANJV SOP 8	Once during initial system IVS test	Lead Data Processor, Project Geophysicist, and Program Geophysicist/Initial IVS Technical Memorandum	All IVS item fit locations within 5 inches of ground truth locations	RCA/CA

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
Ongoing IVS background measurements	Cued Classification Survey/ ANJV SOP 2/ ANJV SOP 7/ ANJV SOP 8	Twice daily as part of IVS testing	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	All decay amplitudes lower than project threshold and qualitatively agree with initial measurement	RCA/CA CA assumption: rejection of BG measurement (unless RCA indicates system failure)
Ongoing derived polarizabilities precision (IVS)	Cued Classification Survey/ ANJV SOP 2/ ANJV SOP 7/ ANJV SOP 8	Twice daily as part of IVS testing	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	Library match to initial polarizabilities metric ≥ 0.9 for each set of three inverted polarizabilities	RCA/CA
Ongoing derived target position precision (IVS)	Cued Classification Survey/ ANJV SOP 2/ ANJV SOP 7/ ANJV SOP 8	Twice daily as part of IVS testing	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	All IVS item fit locations within 5 inches of average of derived fit locations	RCA/CA
Initial measurement of production area background locations	Cued Classification Survey/ ANJV SOP 6/ ANJV SOP 8	Once per background location	Data Acquisition Geophysicist and Lead Data Processor/ tracking summary	All decay amplitudes lower than project threshold	CA: reject BG location and find alternate
Ongoing production area background measurement frequency	Cued Classification Survey/ ANJV SOP 6/ ANJV SOP 7	Evaluated for each background measurement	Data Acquisition Geophysicist/failures noted in field log and tracking summary	Time separation between background measurement and anomaly measurement < 2 hour	CA: reject data that does not have a corresponding background measurement recorded within acceptable time period
Ongoing production area background measurement	Cued Classification Survey/ ANJV SOP 6/ ANJV SOP 7/ ANJV SOP 8	Evaluated for each background measurement	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	All decay amplitudes lower than project threshold and qualitatively agree with initial measurement	CA: background measurement rejected and reacquired

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
Transmit current levels	Cued Classification Survey/ ANJV SOP 7	Evaluated for each sensor measurement	Data Acquisition Geophysicist/failures noted in field log and tracking summary	Peak transmit current ≥ 5.5 amps	CA: reject data acquired with current levels outside of the acceptable range
Initial anomaly (flag) location interrogated	Cued Classification Survey/ ANJV SOP 7/ ANJV SOP 8	Evaluated for each flag position	Data Acquisition Geophysicist/failures noted in field log and tracking summary	For each anomaly, a measurement must be acquired with the center of the array < 16 inches from the flag location.	CA: Reacquire measurement at flag location
Position data are valid (1 of 2)	Cued Classification Survey/ ANJV SOP 7	Evaluated for each sensor measurement	Data Acquisition Geophysicist/failures noted in field log and tracking summary	GPS status flag indicates RTK fix	RCA/CA
Position data are valid (2 of 2)	Cued Classification Survey/ ANJV SOP 7/ ANJV SOP 8	Evaluated for each sensor measurement	Data Acquisition Geophysicist/Lead Data Processor/tracking summary	Orientation data valid Data input string checksum passes	RCA/CA
Confirm inversion model supports classification (1 of 2)	Cued Classification Survey/ ANJV SOP 8	Evaluated for all models derived from a measurement (i.e., single item and multi-item models)	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	Derived model response must fit the observed data with a fit coherence > 0.8	CA: If no valid model is derived, classify as inconclusive
Confirm inversion model supports classification (2 of 2)	Cued Classification Survey/ ANJV SOP 8	Evaluated for derived target	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	Fit location estimate of item ≤ 15 inches from center of sensor	CA: If no target within 15 inch radius using multi-solver inversion, classify as inconclusive

MQO	DFW/SOP Reference	Frequency	Responsible Person/Report Method	Acceptance Criteria	Failure Response
Confirm all anomalies classified	Cued Classification Survey/ ANJV SOP 8	Evaluated for each anomaly (flag) location	Lead Data Processor, Project Geophysicist, and Program Geophysicist/tracking summary	100% of anomalies are classified as: TOI/ Non-TOI/Inconclusive	Documentation required identifying reason for missing data with RCA/CA if necessary. If data cannot be acquired, classify as inconclusive.
Confirm reacquisition GPS accuracy and precision	Intrusive Investigation/ SOP AGCMR-09	Daily	Reacquisition Geophysicist/Daily Report	Benchmark positions repeatable to within 3 inches	CA: Make adjustments and re-verify
Confirm derived features match ground truth (1 of 2)	Intrusive Investigation/ SOP AGCMR-09	Evaluated for all recovered items	Program QC Geophysicist and QC Geophysicist/QC reports	95% of recovered item positions < 10 inches from predicted position	RCA/CA
Confirm derived features match ground truth (2 of 2)	Intrusive Investigation/ SOP AGCMR-09	Evaluated for all recovered seed items	Program QC Geophysicist and QC Geophysicist/QC reports	100% of predicted seed item positions < 10 inches from known position	RCA/CA
Classification performance	Intrusive Investigation/ SOP AGCMR-09/ ANJV SOP 9	For each delivered dig list	Program QC Geophysicist and QC Geophysicist/QC reports	100% of seed items classified as TOI	RCA/CA
Classification validation	Intrusive Investigation/ SOP AGCMR-09/ ANJV SOP 10	For each delivered dig list	Program QC Geophysicist and QC Geophysicist/QC reports	100% of predicted intrusively investigated non-TOI are confirmed to be non-TOI	RCA/CA

4.0 DATA MANAGEMENT AND DATA REVIEW

4.1 Project Documents and Records (QAPP Worksheet #29)

Part 1: Data Management Specifications

GIS: The existing Fort Ord GIS will be used to store and manage all relevant geospatial-related data and information. All geospatial data will conform to the FGDC *Geospatial Positioning Accuracy Standards, Part 2: NSSDA*, and *Part 4: Standards for Architecture, Engineering, and Construction (A/E/C) and Facility Management*. Each GIS data set will be accompanied by metadata conforming to the FGDC CSDGM and provided in a database that complies with the *SDSFIE*. The final GIS submittal will contain all required ArcGIS.mxd files and layout files for all drawings contained in the final report.

Unless otherwise noted, GPS survey data will meet or exceed the Third Order, Class I specification. Horizontal GPS data will be repeatable to within 3 cm. The horizontal accuracy of GIS data will be tested in accordance with the National Standards. In addition, the location, identification, coordinates, and elevations of all established control points will be plotted on one or more site maps. Each control point will be identified on the map by its name and number and the final adjusted coordinates.

ESRI-compliant formats (shapefiles, coverages, or geodatabases) will be used to present GIS data, with supporting tabular data provided in Microsoft Excel, Microsoft Access, or both, as needed.

Computer Files and Digital Data: All final document files, including reports, figures, and tables, will be submitted in electronic format (both Microsoft Office, and portable document format [.pdf]) on CD-ROM. CDs containing .pdf files will also include Adobe™ Acrobat Reader®.
Classification Library: The specific version and date of the DoD classification library used for each advanced geophysical classification project will be documented in the site-specific work plan for that project. Procedures used to update the library for each project, including QC and QA measures used to verify and validate the site-specific classification library will be documented in the final report. The complete classification library for each project will be included in the final data deliverables.

Part 2: Control of Documents, Records, and Databases

Fields Records/Data				
Record	**Generation**	**Verification**	**Frequency (generation of document / record)**	**Format/Storage Location**
Safety Log	UXOSO	Project Manager	Daily	Database, .pdf/KEMRON network
Geophysical Log	Data Acquisition Geophysicist	Program Geophysicist	Daily during detection or cued data acquisition	Database, .pdf/KEMRON network
QC Log	UXOQCS, QC Geophysicist	Project Manager	Daily	Database, .pdf/KEMRON network
QC/Safety Daily Reports (including QC audits)	UXOQCS, QC Geophysicist, UXOSO	Project Manager	Daily	Database, .pdf/KEMRON network
QC Weekly Reports (including QC audits)	UXOQCS, QC Geophysicist	Project Manager	Weekly	Database, .pdf/KEMRON network
Safety Bi-Weekly Reports	UXOSO	Project Manager	Bi-Weekly	Database, .pdf/KEMRON network
SUXOS Daily Reports	SUXOS	Project Manager	Daily	Database, .pdf/KEMRON network
SUXOS Bi-Weekly Reports	SUXOS	Project Manager	Bi-Weekly	Database, .pdf/KEMRON network
Photo Documentation	Various	Project Manager	As necessary	.jpg/KEMRON Network
QC Seed Item Locations, Depths, and Orientations	QC Geophysicist	Program Geophysicist	Daily during QC seeding	Microsoft Excel/KEMRON network (limited to QC personnel)
MetalMapper 2x2 Assembly Checklist	Data Acquisition Geophysicist	Program Geophysicist	On initial use of equipment	Microsoft Word/KEMRON network
IVS Memorandum	Project Geophysicist	Project Manager	After completion of initial dynamic IVS and initial cued IVS	Microsoft Word/KEMRON network
UXO Team Leader Log (paper or digital records)	UXO Team Leader	Project Manager	Daily during UXO Team operations	Database, .pdf/KEMRON network

Fields Records/Data				
Record	**Generation**	**Verification**	**Frequency (generation of document / record)**	**Format/Storage Location**
Geophysical Data	Data Acquisition Geophysicist	Program Geophysicist	Daily during detection or cued data acquisition	Various/KEMRON network
Nonconformance, root cause analysis and corrective action reports	UXOQCS, AECOM Program QC Geophysicist, QC Geophysicist	QC Manager	As necessary	Various/KEMRON network
Equipment and Instrument Check Logs	Data Acquisition Geophysicist/UXO Team Leader	Program Geophysicist	As necessary	Various/KEMRON network
Data Usability Assessment	Project Geophysicist	Project Manager	After completion of AGCMR activity	Microsoft Word/KEMRON network
Advanced Geophysical Classification Technical Memorandum	Project Geophysicist	Project Manager	After completion of AGCMR activity	Microsoft Word/KEMRON network

Daily QC Reports

Daily work activity summary reports will be maintained by the QC Geophysicist. These daily reports may include, but are not limited to, the following items:

- QC reports and findings
- H&S reports
- Training logs
- SUXOS reports (including activity log)
- Emergency response action reports
- MEC discovery and classification of the item
- Records of site work and progress

The daily QC reports provide backup information and are intended to aid in the preparation of the weekly QC report discussed below.

Weekly QC report

The QC Geophysicist is responsible for preparing and submitting a weekly QC report to the USACE Quality Assurance Geophysicist. The weekly QC report is to be submitted to the USACE Quality Assurance Geophysicist on the first work day following the dates covered by the report. The weekly QC report is to provide an overview of QC activities during the previous two weeks, including those performed by subcontractors. The weekly QC reports must present an accurate and complete picture of QC activities by reporting both conforming and deficient conditions. Reports should be precise, factual, legible, and objective. Copies of supporting documentation, such as checklists and surveillance reports, are to be attached.

Copies of weekly QC reports with attachments and field QC logs no longer in use are to be maintained in the project QC file. Upon project closeout, all QC reports are to be included in the project QC file.

Field Logs

The data acquisition team leader will maintain a field log or digital record in a tablet device to record activities that occur each work day. In addition to field conditions and daily system functional test information, log entries will include a record of anomalies investigated, any unusual conditions related to the acquisition of data for individual anomalies, and a record of background measurement locations and acquisition times. At the conclusion of the project, field logs will become a permanent part of the contract record.

Safety Log

The UXOSO will also maintain a log of daily safety activities. This safety log will document compliance with the APP. The safety log will be maintained as paginated, bound, and dated hard copy logs or digital records in a tablet device. The safety log will record such information as the date, the start and stop times of work, weather conditions, the names of field team personnel, specific description of the work being conducted, break times, names and times of visitors to the site, and any incidents or other unusual events that occurred that day. This includes documentation of the performance and content of daily health and safety meetings.

The safety log will describe conditions or activities leading up to or contributing to safety incidents or lost time due to safety issues. The safety log will be archived by the Project Manager and become a permanent part of the contract record.

Quality Control Log

The QC Geophysicist will maintain a QC log of field QC inspections. This QC log will document compliance with this AGCMR-QAPP and specify workmanship acceptability. The QC log will be maintained as paginated, bound, and dated hard copy logs or digital records in a tablet device. The area, the DFW being inspected, and the date will be recorded. Each log entry will be event-, area- or site-specific and clearly noted accordingly. The QC log will be archived by the UXOQCS and will become a permanent part of the contract record, in addition to the completed specific QC forms specified above.

Test and Maintenance Records

Equipment test and maintenance tasks will be documented digitally in tablet devices or on appropriate forms or field logbooks by the individual performing the task. Testing and maintenance of equipment will be performed according to the manufacturer's specifications, this AGCMR-QAPP, and applicable SOPs. Geophysical detection equipment will be tested daily when in use. At a minimum, the test or maintenance log will contain the date and time of the task, equipment name and identification numbers, name of individual performing the task, and results of the task. Upon project closeout, all test and maintenance records will be included in the project QC file.

The QC Geophysicist is responsible for ensuring that the tests are performed and that the results are summarized and provided with the weekly QC report. To track each failing test for future retesting, the failing test must be noted on the CAR. Resolution of the failing test is complete when retesting is performed and the corrective action is verified on the CAR.

Training Records

The SUXOS will maintain a file for each site employee, including KEMRON and subcontractor personnel, to document qualifications and the successful completion of required training courses. Documentation may be in the form of a certificate, letter, memorandum, or other written form of documentation but must include training completion dates. If required refresher training courses do not take place by the anniversary date of the employee's initial training, a record must be added to the employee's file indicating why the training has been delayed and when the training will be completed.

Photograph Log

Photographic history and evolution of the project will be documented in a photograph log. The log will be used by the SUXOS, team leaders, and UXOQCS to document the location, date, and subject of each photo taken. Handheld forms digitally recording the same information may take the place of or supplement the photograph log.

4.2 Assessments and Corrective Action (QAPP Worksheets #31, 32, & 33)

This worksheet documents assessment standards for field activities described in the AGCMR-QAPP and specifies the minimum requirements that must be met, including the extent to which QC monitoring must be conducted and documented. The specific QC monitoring requirements for each DFW are discussed below. References to the applicable DFW and standard operating procedures are included. Failures will result in stop work, generation of an NCR and, as applicable, generation of a CAR, RCA and CAP.

The QC Team, which consists of the UXOQCS and QC Geophysicist, is responsible for verifying compliance with this portion of the AGCMR-QAPP through implementation of a three-phase control process comprising a preparatory phase, an initial phase, and a follow-up phase. The three-phase inspection process will verify that project activities in each DFW comply with the approved plans and procedures. Each phase is relevant for verifying necessary product quality, but the preparatory and initial inspections are particularly valuable for preventing problems before they escalate. Work will not be performed on a DFW until the preparatory and initial phase inspections have been completed and non-conformance issues are resolved.

Checklists for the preparatory, initial, and final phase inspections for each DFW are included as attachments to the SOPs in Appendix B. The QC checklists include the inspection requirements and the QC Team members responsible for each inspection.

Preparatory Phase Inspection

The preparatory phase comprises the planning and design process leading up to the actual field activities. A member of the QC Team will perform a preparatory phase inspection before beginning each DFW. The purposes of this inspection are to review applicable specifications and plans to verify that the necessary resources, conditions, and controls are in place and compliant before the commencement of work activities.

During the preparatory phase inspection, a member of the QC Team will review the applicable sections of the AGCMR-QAPP and verify the following:

- Required plans and procedures have been approved and are available to the field staff
- Field equipment is appropriate, available, functional, and properly tested for its intended/stated use
- Personnel responsibilities have been assigned and communicated
- Personnel have the necessary knowledge, expertise, and information to perform their assigned tasks;
- Arrangements have been made for necessary support services
- Personnel have completed training in accordance with the requirements of this AGCMR-QAPP
- Mobilization tasks have been completed.

Project personnel must correct or resolve discrepancies between existing conditions and the approved AGCMR-QAPP identified by the QC Team during the preparatory phase inspection. A member of the QC Team will verify that unsatisfactory and/or nonconforming conditions have been corrected before beginning work.

Upon completion of the preparatory phase inspection, a member of the QC Team will complete the Preparatory Phase Inspection Checklist.

Initial Phase Inspection

The Initial Phase (IP) occurs at the onset of field activities associated with each DFW.
The main objectives of the IP inspection are to check preliminary work for compliance with procedures and specifications, establish an acceptable level of workmanship, check for omissions, and resolve differences of interpretation. During the IP inspection, the QC Team will ensure that discrepancies between site practices and approved plans or specifications are identified and resolved. The resolution of discrepancies is a critical step in the IP inspection. The IP inspection will also verify that the APP/SSHP adequately identifies all hazards associated with actual field conditions and verify that appropriate safe work practices are being followed. The inspection results will be documented by the QC Team in the form of daily reports. Should results of the inspection be unsatisfactory, the IP will be rescheduled and performed again.

Upon completion of the IP inspection, a member of the QC Team will complete the IP Inspection Checklist.

Follow-up Phase Inspection

The follow-up phase (FP) inspection, which covers the routine day-to-day activities at the site, will begin upon completion of the IP inspection and will include inspections at regular intervals during the performance of each DFW. The FP inspection ensures continuous compliance with procedures and specifications and verifies an acceptable level of workmanship. During the FP inspection, a member of the QC Team will review the applicable sections of the AGCMR-QAPP and monitor onsite practices and operations to verify continued compliance with the specifications and requirements of the AGCMR-QAPP. Information documented in the FP inspection may be accompanied by Field QC Inspection Form. The QC Team will also verify that daily health and safety inspections are performed and documented as prescribed in the health and safety plan. Discrepancies between site practices and approved plans or specifications will be resolved, and corrective actions for unsatisfactory and nonconforming conditions or practices will be completed before continuing work.

Upon completion of FP inspections, a member of the QC Team will complete the FP Inspection Checklist.

Additional Inspections

Additional inspections performed on a DFW may be required at the discretion of USACE, the Project Manager, the SUXOS, the appropriate senior technical consultant, the QC Manager, or any member of the QC Team. Additional preparatory and IP inspections could be warranted under any of the following conditions:

- Unsatisfactory work, as determined by KEMRON or USACE
- Changes in key personnel
- Resumption of work after a substantial period of inactivity (2 weeks or more)
- Changes to the project scope of work

Additional inspections will be documented on the appropriate inspection checklist forms and in the QC Daily Report.

Final Phase Inspection

The final phase inspection is performed upon conclusion of a DFW and before closeout to verify that project requirements relevant to that DFW have been satisfied. Outstanding and nonconforming items will be identified and documented on the Final Inspection Checklist.

Notification of Definable Features of Work and Three Phases of Control

The QC Team will ensure that the three-phase control process is implemented for each DFW listed in Worksheet 17.

Audit Procedures

The QC Team is responsible for verifying compliance with this AGCMR-QAPP through audits and surveillance. The QC Team is required to audit and inspect the quality of work being performed for each DFW and verify that work practices conform to the specifications of the AGCMR-QAPP and other applicable guidance. Discrepancies are to be communicated to the responsible individual and documented in the daily and weekly QC reports. Corrective actions are to be verified by the QC Team and recorded in the daily QC report.

The Assessment Schedule is to be used by the QC Team for planning, scheduling, and tracking the progress of audits. The information on the form must be current and reviewed by the QC Team. Audit activities and corrective actions are to be documented by the QC Team, and the audit records are to be maintained as part of the project QC file.

Detailed QC procedures for advanced geophysical classification activities are included in the SOPs associated with this AGCMR-QAPP. The QC activities performed for advanced geophysical classification work will be audited and documented by the QC Geophysicist on a daily basis.

Preventative and Corrective Actions

The preventative and corrective actions incorporated within this AGCMR-QAPP are designed to prevent and correct quality problems that may arise during the project work. The procedures facilitate process improvements and describe the available mechanisms to identify, document, and track discrepancies until a corrective action has been verified.

Continual Improvement

A continual improvement process will be implemented for the project. Project personnel at all levels will be encouraged to provide recommendations for improvements in established work processes and techniques to identify activities that are compliant but could be performed in a more efficient or cost-effective manner. Typical quality improvement recommendations include identifying an existing practice that can and should be improved (e.g., a bottleneck in production) and/or recommending an alternative practice that would provide a benefit without compromising prescribed standards of quality. Project personnel should bring their recommendations to the attention of the SUXOS or QC Team through verbal or written means. Deviations from established protocols will not to be implemented without prior written approval.

Deficiency Identification and Resolution

While deficiency identification and resolution occurs primarily at the operational level, QC audits provide a backup mechanism to address problems that are either not identified or cannot be resolved at the operational level. Through implementation of the audit program prescribed in this AGCMR-QAPP, the project team is responsible for verifying that deficiencies are identified, documented, and corrected in a timely manner. Deficiencies identified by the project team will be corrected by operational staff and documented by the QC Team.

Corrective Action Request

A CAR can be issued by any member of the project team, including subcontractor personnel. If the individual issuing the CAR is also responsible for correcting the problem, he/she should document the results on Part B of the CAR. Otherwise, the CAR should be forwarded to the QC Team who is then responsible for evaluating the validity of the request. If the CAR is valid, the QC team will address the corrective action with the appropriate individuals to resolve the deficiency.

The QC Team will determine if an RCA and/or CAP are necessary. The CAP will include assigning personnel and resources, and will specify and enforce a schedule for corrective actions. Once a corrective action has been completed, the CAR, CAP and supporting information will be forwarded to the QC Manager for closure.

The recommendations provided in the CAP and implemented on the project will be reviewed during follow-up QC inspections. The CAP review has the following objectives:

- Verify that established protocols are properly implemented
- Verify that corrective actions have been implemented
- Verify that corrective actions are effective in resolving problems

- Identify trends within and among similar work units
- Facilitate system root cause analysis of larger systemic problems

The QC Team will determine whether a written CAP is necessary, based on whether any of the following conditions are met:

- The CAR priority is high
- The identified deficiency requires a rigorous corrective action planning process to identify work products or activities affected by the deficiency
- Extensive resources and planning are required to correct the deficiency and to prevent recurrence

The CAP will be developed by the QC Team and approved and signed by the QC Manager. The CAP will indicate whether it is submitted for informational purposes or for review and approval. In either event, operational personnel are encouraged to discuss corrective action strategy with the QC Team throughout the process.

Corrective Action Request Tracking

Each CAR will be given a unique identification number and tracked until corrective actions have been implemented in the field, documented in Part B of the CAR form, and the CAR has been submitted to the Project Manager for verification and closure.

Lessons Learned and Other Documentation

Lessons learned through the discrepancy management process are documented on CARs and CAPs. To share the lessons learned, these documents will be submitted to USACE through the Daily QC Report, which summarizes daily QC activities conducted.

Minor deficiencies identified during a QC audit that are readily correctable and can be verified in the field will be documented in the QC log (hardcopy or digital) and daily QC Report. Discrepancies that cannot be readily corrected will be documented by a member of the QC Team on a CAR and in the daily QC Report. Copies of CARs will be referenced in and attached to the daily QC Report. CAPs will also be attached to daily QC Reports to document the final outcome of the deficiency and corrective action. Similar or related deficiencies may be addressed on a single CAP.

Assessment Schedule

DFW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
Pre-Mobilization Activities	AGCMR-QAPP	Verify the AGCMR-QAPP has been developed and approved.	Preparatory Phase (PP)	Once	AGCMR-QAPP has been prepared and approved, all parties agree to the technical and operational approach	Do not proceed with field activities until criterion is passed
	Blind Seed Firewall Plan	Verify the Blind Seed Firewall Plan has been developed and approved.	PP	Once	Blind Seed Firewall Plan has been prepared and approved	Do not proceed with field activities until criterion is passed
	Draft Advanced Geophysical Classification Validation Plan	Verify the draft Advanced Geophysical Classification Validation Plan has been developed and approved.	PP	Once	Draft Advanced Geophysical Classification Validation Plan has been prepared and approved, all parties agree to the approach	Do not proceed with field activities until criterion is passed
Mobilization and Site Preparation	Kickoff/Safety Meeting	Verify that AGCMR-QAPP and site-specific safety requirements have been reviewed with project team and document appropriate signatures.	PP/IP	Once	Documents have been reviewed and signed by appropriate project team members	Personnel who are not familiar with the AGCMR-QAPP and site-specific safety requirements may not proceed with field activities until criteria are passed
	Verify Site-Specific Training	Verify that all site-specific training has been performed and documented.	PP/IP	Once	Site-specific training is performed and documented	Do not proceed with field activities until criterion is passed

DFW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	Subsurface QC Seed Item Placement	Verify QC seed items have been properly placed and their positions properly recorded. Complete ANJV SOP 3 Preparatory Checklist.	PP/IP	Once/Daily/As Required	QC seed items have been properly placed, covered and surveyed	Do not proceed with classification surveys until QC seed items have been appropriately placed and recorded
	Establish Instrument Verification Strip	Verify that IVS is constructed in accordance with AGCMR-QAPP. Complete ANJV SOP 2 Preparatory Checklist.	PP/IP	Once	IVS constructed in accordance with AGCMR-QAPP	Do not proceed with IVS survey until IVS is properly constructed or alternate construction is approved by USACE Project Manager
Detection Survey	Daily Safety Briefing	Confirm that the UXOSO or his representative conducted a daily safety briefing and all field personnel acknowledged by signature.	PP/IP/FP	Daily	The UXOSO or his representative conducted a daily safety briefing and all field personnel acknowledged it by signature	Personnel not receiving a safety briefing are not authorized in the Impact Area until it is received and acknowledged by signature
	MetalMapper 2x2 Assembly	Observe assembly and initial function testing of MetalMapper 2x2. Complete ANJV SOP 1MM2 Preparatory Checklist.	PP	Once	System assembled in accordance with ANJV SOP 1MM2 and ANJV SOP 11	Do not proceed with IVS until system is properly assembled

DFW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	Initial IVS Survey	Verify that IVS related MQOs are being met and documented in the IVS Memorandum. Complete ANJV SOP 2 Initial Checklist.	IP/FP	Once	MQOs are being met and documented in the IVS Memorandum	Root cause analysis and corrective action
	Dynamic Detection Survey	Verify detection survey related MQOs are being met. Complete ANJV SOP 2 Follow-On Daily Checklist. Complete ANJV SOP 4 Follow-On Checklist.	IP/FP	Daily/As Required	MQOs are being met	Root cause analysis and corrective action
Detection Survey Data Processing, Analysis, and Classification Target Selection	Process and Analyze Detection Data and Select Targets for Classification Survey	Verify dynamic detection processing related MQOs are being met. Complete ANJV SOP 5 Follow-On Checklists.	IP/FP	Daily/As Required	MQOs are being met	Root cause analysis and corrective action
	Geographic Information System Integration	Verify that relevant geospatial-related data and information is incorporated into the Fort Ord GIS.	IP/FP	Once/Daily/As Required	Relevant geospatial-related data and information is incorporated into the Fort Ord GIS	Root cause analysis and corrective action

DFW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
Classification Survey	Daily Safety Briefing	Confirm that the UXOSO or his representative conducted a daily safety briefing and all field personnel acknowledged by signature.	PP/IP/FP	Daily	The UXOSO or his representative conducted a daily safety briefing and all field personnel acknowledged it by signature	Personnel not receiving a safety briefing are not authorized in the Impact Area until it is received and acknowledged by signature
	MetalMapper 2x2 Assembly	Observe assembly and initial function testing of MetalMapper 2x2. Complete ANJV SOP 1MM2 Preparatory Checklist.	PP	Once	System assembled in accordance with ANJV SOP 1MM2 and ANJV SOP 11	Do not proceed with IVS until system is properly assembled
	Initial IVS Survey	Verify that IVS related MQOs are being met and documented in the IVS Memorandum. Complete ANJV SOP 2 Initial Checklist.	IP/FP	Once	MQOs are being met and documented in the IVS Memorandum	Root cause analysis and corrective action

DFW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	Classification Survey	Verify classification survey related MQOs are being met. Complete ANJV SOP 2 Follow-On Daily Checklist. ANJV SOP 6 Preparatory, Initial, and Follow-On Checklists. Complete SOP ANJV SOP 7 Follow-On Checklist.	PP/IP/FP	Daily/As Required	MQOs are being met	Root cause analysis and corrective action
Classification Survey Data Processing, Analysis, and Classification	Process, Analyze, and Classify Cued Data	Verify classification processing related MQOs are being met. Complete ANJV SOP 8 Follow-On Checklists.	IP/FP	Daily/As Required	MQOs are being met	Root cause analysis and corrective action
	Geographic Information System Integration	Verify that relevant geospatial-related data and information is incorporated into the Fort Ord GIS.	IP/FP	Once/Daily/As Required	Relevant geospatial-related data and information is incorporated into the Fort Ord GIS	Root cause analysis and corrective action

DFW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	Finalize Advanced Geophysical Classification Validation Plan	Verify that the Advanced Geophysical Classification Validation Plan has been evaluated and revised as necessary and submitted to USACE for final review and approval.	IP/FP	Once	The Advanced Geophysical Classification Validation Plan has been evaluated and revised as necessary and submitted to USACE for final review and approval	Do not proceed with validation digs until the Advanced Geophysical Classification Validation Plan has been evaluated and revised as necessary and submitted to USACE for final review and approval
Intrusive Investigation	Daily Safety Briefing	Confirm that the UXOSO or his representative conducted a daily safety briefing and all field personnel acknowledged by signature.	PP/IP/FP	Daily	The UXOSO or his representative conducted a daily safety briefing and all field personnel acknowledged it by signature	Personnel not receiving a safety briefing are not authorized in the Impact Area until it is received and acknowledged by signature
	Anomaly Reacquisition	Verify anomaly reacquisition performed in accordance with QCMR-QAPP and SOP AGCMR-09. Complete SOP AGCMR-09 Follow-On Checklist.	IP/FP	Once/Daily/As Required	Anomaly reacquisition is being performed in accordance with AGCMR-QAPP and SOP AGCMR-09	Root cause analysis and corrective action

DFW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	Handheld Metal Detector Functional Checks	Team Leader to verify personnel conduct equipment checks and the detector is serviceable by visually observing the checks and documenting the checks in the daily log (hardcopy or digital).	PP/IP/FP	Daily	Personnel conducted equipment check, the detector is serviceable and functioning properly, and the team leader has completed the daily log entry	Repair or replace a malfunctioning instrument. Complete the daily log entries.
	Exclusion Zone Boundaries	UXOSO to verify that signs are in place to identify the work site exclusion zone. QC to perform daily spot checks.	PP/IP/FP	Daily	Signs are in place to identify the work site exclusion zone.	Stop operations until signs are put in place.
	Investigate Anomalies	Verify intrusive investigation performed in accordance with AGCMR-QAPP and SOP AGCMR-09. Complete SOP AGCMR-09 Follow-On Checklist.	IP/FP	Daily/As Required	Intrusive Investigation is being performed in accordance with AGCMR-QAPP and SOP AGCMR-09	Root cause analysis and corrective action
	Backfilling Excavations	QC to verify that all excavations have been backfilled, seedbed (plug) has been replaced, and leveled to grade.	PP/IP/FP	Daily/As Required	All excavations backfilled, seedbed (plug) replaced, and leveled to grade.	Root cause analysis and corrective action

DFW	Task with Auditable Function	Audit Procedure	QC Phase	Frequency of Audit	Pass/Fail Criteria	Action if Failure Occurs
	Database Updates	Confirm database is updated with intrusive investigation results.	IP/FP	Daily/As Required	Database is updated on a daily basis with intrusive investigation results	Root cause analysis and corrective action
Demobilization	Demobilize from the site	Verify equipment and personnel have been demobilized from the site and the site is returned to pre-mobilization condition.	FP	Once	Equipment and personnel have been demobilized from the site and the site is in pre-mobilization condition	Notify responsible party if equipment is left behind; responsible party will be responsible for equipment or materials left behind after completion of field work

4.4 Data Verification and Validation Procedures (QAPP Worksheet #35)

This worksheet documents procedures that will be used to verify and validate project data. Data verification is a completeness check to confirm that all required activities were conducted, all specified records are present, and the contents of the records are complete. Data validation is the evaluation of conformance to stated requirements.

Activity and Records Reviewed	Requirements and Specifications	Process Description and Frequency	Responsible Person	Documentation
Subsurface QC Seeding	AGCMR-QAPP ANJV SOP 3	Subsurface QC seeding has been conducted in accordance with ANJV SOP 3. The Preparatory QC Seeding Checklist has been completed. MQOs have been achieved, with exceptions noted. If appropriate, corrective actions have been completed. Verify signatures and dates are present on any hard copies generated.	Program QC Geophysicist	ANJV SOP 3 Preparatory QC Checklist QC Seed Database Daily QC Report
Field Data Forms	AGCMR-QAPP	Verify that data for each form have been filled out properly and are complete	Program Geophysicist	Daily QC Report
Instrument Assembly	ANJV SOP 1MM2 ANJV SOP 11	Instrument assembly has been completed in accordance with ANJV SOP 1MM2 and ANJV SOP 11. The Preparatory MetalMapper 2x2 Assembly Checklist has been completed. MQOs have been achieved, with exceptions noted. If appropriate, corrective actions have been completed. Verify signatures and dates are present on any hard copies generated.	Program Geophysicist	ANJV SOP 1MM2 Preparatory QC Checklist Daily QC Report
Initial IVS Survey	AGCMR-QAPP ANJV SOP 2	Initial IVS survey has been conducted in accordance with ANJV SOP 2. The Initial IVS Survey Checklist has been completed. MQOs have been achieved, with exceptions noted. If appropriate, corrective actions have been completed. Verify signatures and dates are present on any hard copies generated.	Program Geophysicist	ANJV SOP 2 Initial QC Checklist Daily QC Report
Detection Survey	AGCMR-QAPP ANJV SOP 4	Dynamic detection survey has been conducted in accordance with ANJV SOP 4. The Follow-on Dynamic Detection Data Acquisition Checklist has been completed. MQOs have been achieved, with exceptions noted. If appropriate, corrective actions have been completed. Verify signatures and dates are present on any hard copies generated.	Program Geophysicist	ANJV SOP 4 Follow-on Checklist Daily QC Report

Activity and Records Reviewed	Requirements and Specifications	Process Description and Frequency	Responsible Person	Documentation
Detection Data Processing, Analysis, and Target Selection	AGCMR-QAPP ANJV SOP 5	Dynamic detection data processing, analysis, and classification have been conducted in accordance with ANJV SOP 5. The Follow-on Dynamic Detection Data Processing and Analysis Checklist have been completed. All data has been processed and analyzed, targets have been selected, MQOs have been achieved, with exceptions noted, and QC seed items have been detected. If appropriate, corrective actions have been completed. Verify signatures and dates are present on any hard copies generated.	Program QC Geophysicist	ANJV SOP 5 Follow-on QC Checklist Daily QC Report
Classification Survey	AGCMR-QAPP ANJV SOP 7	Classification survey has been conducted in accordance with ANJV SOP 7. The Follow-on Cued MetalMapper 2x2 Data Acquisition Checklist has been completed. MQOs have been achieved, with exceptions noted. If appropriate, corrective actions have been completed. Verify signatures and dates are present on any hard copies generated.	Program Geophysicist	ANJV SOP 7 Follow-on Checklist Daily QC Report
Cued Data Processing, Analysis, and Classification	AGCMR-QAPP ANJV SOP 8	Classification survey data processing, analysis, and classification have been conducted in accordance with ANJV SOP 8. The Follow-on Cued MetalMapper 2x2 Data Processing and Analysis Checklist have been completed. All anomalies have been classified, MQOs have been achieved, with exceptions noted, and QC seed items have been correctly classified. If appropriate, corrective actions have been completed. Verify signatures and dates are present on any hard copies generated.	Program Geophysicist Program QC Geophysicist	ANJV SOP 8 Follow-on QC Checklist Daily QC Report
Anomaly Reacquisition	AGCMR-QAPP SOP AGCMR-09	Anomaly Reacquisition has been conducted in accordance with SOP AGCMR-09. The Follow-on Anomaly Reacquisition Checklist has been completed. All target anomalies have been reacquired, and MQOs have been achieved, with exceptions noted. If appropriate, corrective actions have been completed. Verify signatures and dates are present on any hard copies generated.	Program Geophysicist	SOP AGCMR-09 Follow-on QC Checklist Daily QC Report

Activity and Records Reviewed	Requirements and Specifications	Process Description and Frequency	Responsible Person	Documentation
Intrusive Investigation	AGCMR-QAPP SOP AGCMR-09 ANJV SOP 13	Intrusive Investigation has been conducted in accordance with SOP AGCMR-09. The Follow-on Intrusive Investigation Checklist has been completed. All intrusive investigations have been completed, and MQOs have been achieved, with exceptions noted. If appropriate, corrective actions have been completed. Signatures and dates are present.	UXOQCS Program Geophysicist Program QC Geophysicist	SOP AGCMR-09 Follow-on QC Checklist Daily QC Report

4.6 Data Usability Assessment (QAPP Worksheet #37)

This worksheet documents procedures that will be used to perform the data usability assessment. The data usability assessment will be performed at the conclusion of data acquisition and classification activities, using the outputs from data verification and data validation (Worksheet 35, Worksheet 36, and the Final Validation Report). The data usability assessment will be a qualitative and quantitative evaluation of acquired data against project MPCs and DQOs to determine if the project data are of the right type, quality, and quantity to meet the project objectives and support future decisions. It involves a retrospective review of the systematic planning process to evaluate whether underlying assumptions are supported, sources of uncertainty have been managed appropriately, data are representative of the population of interest, and the results can be used as intended with an acceptable level of confidence.

Personnel responsible for participating in the data usability assessment preparation or review:

Name	Title	Organization	Role in Usability Assessment
James Specht	Fort Ord Senior Project Manager	USACE	Review
James Britt	Ordnance and Explosives Safety Specialist (OESS)	USACE	Review
Kyle Lindsay	QA Geophysicist	USACE	Review
Steve Crane	Project Manager	KEMRON	Preparation
TBD	QC Manager	KEMRON	Preparation
Andy Gascho	Program Geophysicist	AECOM	Preparation
Tom Furuya	Project Geophysicist	ANJV	Preparation
Alison Paski	Lead Data Processor	ANJV	Preparation
Alex Kostera	Program QC Geophysicist	AECOM	Preparation
Jon Guillard	QC Geophysicist	ANJV	Preparation

Documents used as input to the data usability assessment:

- AGCMR-QAPP
- Contract Specifications
- Final Advanced Geophysical Classification Validation Plan
- Weekly QC Reports
- Assessment Reports
- CARs
- Production Area Seed Report
- IVS Memorandum
- Site-Specific Library

- Classification Survey Validation Report
- Prioritized Dig List
- Target Classification Report
- Validation Dig Report

Describe how the usability assessment will be documented:

The data usability report will be included as an appendix to the final advanced geophysical classification report. The following steps will be followed in conducting the data usability assessment:

Step 1	**Review the project's objectives and sampling design** Review project 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** Review the site-specific munitions classification library for completeness. Review available QA/QC reports, including weekly QC reports, assessment reports, corrective action reports, and the data validation report. 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 corrective actions. 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.

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APPENDIX B
STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE 1 MM2

Assemble the MetalMapper 2x2 System and Verify Correct Operation

1. Purpose and Scope

The purpose of this Standard Operating procedure (SOP) is to identify the methods to be employed when assembling the MetalMapper 2x2 sensor system for dynamic collection and verifying that all components are correctly assembled, operating normally, and capable of acquiring quality data.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP. The following individuals will be involved in the assembly and verification of the MetalMapper 2x2:

- Project Geophysicist
- Field Team Leader
- Quality Control (QC) Geophysicist
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 and 8.

The following is a list of required equipment and materials:

- MetalMapper 2x2 sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) or Robotic Total Station (RTS) and Inertial Measurement Unit (IMU) for orientation measurements
- a serialized Industry Standard Object (ISO) from Geometrics for sensor function testing
- a digital camera or cell phone. (Note, personnel should not have cell phones when operating the MetalMapper)

3. Procedures and Guidelines

The MetalMapper 2x2 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 a 10-cm three-axis receive cube centered in the transmit coil. The transmitters are energized in sequence and the decay curve is recorded up to 25 milliseconds 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 1.

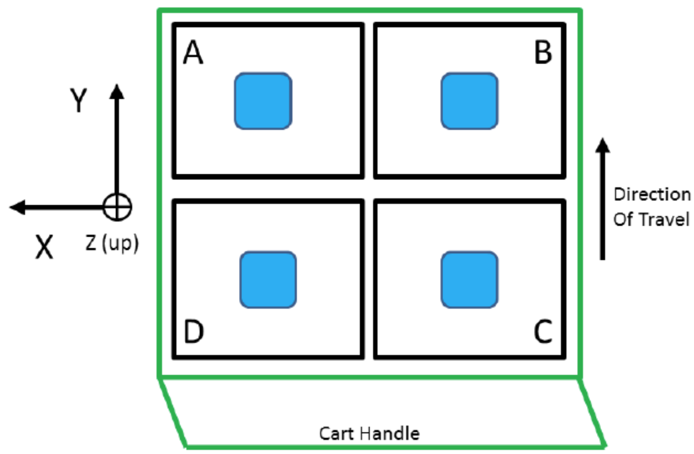

Figure 1. Orientation of the Four MetalMapper 2x2 Sensor Elements (top view)

Positioning of the MetalMapper 2x2 is accomplished using an RTK GPS or RTS. The MetalMapper 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 MetalMapper 2x2 in the correct orientation.

3.1. Assemble the MetalMapper 2x2

All assembly operations are described in the MetalMapper 2x2 unpacking instructions and operating manual (MetalMapper 2x2 Manual- 1.01.pdf) available from Geometrics and the detailed instructions contained there should be followed precisely. The assembly steps include:

1. Remove the sensor assembly from the packing crate.
2. Attach handle, wheels, or sled as appropriate.
3. Securely attach the GPS antenna or RTS prism to the top of the mounting platform. If GPS/RTS is not being used, move to Step 4.
4. Set the IMU onto its position below the GPS antenna/RTS prism. 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, GPS/IMU, Ethernet cable, and battery power cable to the electronics box.

3.2. Turn On and Initialize the Data Acquisition Computers

Following the instructions in Section 4 of the MetalMapper 2x2 manual, start the data acquisition system. The last step in Section 4 involves observing the IMU output. Leave the system in this state for the next operation.

3.3. Verify IMU Orientation and Values

The procedure to verify the correct orientation of the IMU follows:

1. Facing the direction of travel, rotate the IMU around the along-track axis to produce a positive ROLL as shown in Figure 2. Verify that the data acquisition system records a positive ROLL, Figure 3. If it does not, reorient the IMU on its mount and test again.

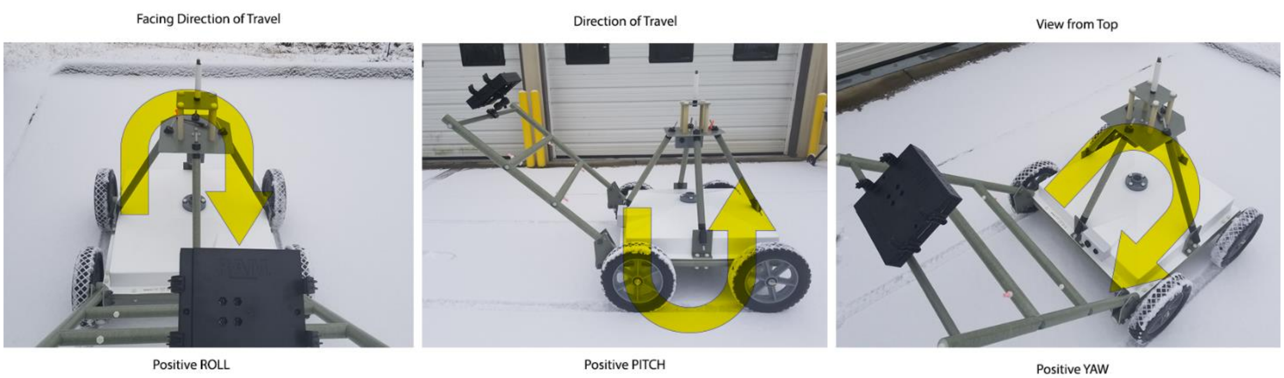

Figure 2. Positive ROLL, PITCH, and YAW Rotations of the IMU

Figure 3. Electronics Box Screen Showing Orientation Inputs (YPR)

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 2. 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 2. 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.
4. Use a cell phone applet, such as SPIRIT Level, to verify that the roll, pitch, and yaw readings are not materially biased. To verify, start Spirit Level (or similar app) on the phone, place the phone on the sensor frame such that it is on the same plane as the IMU sensor, and verify that the readings using the cell phone application agree with the IMU values on the data logger to within 2 degrees (Figure 4). Document the bias using the ANJV Android QC Application, Sensor Setup checklist.

Figure 4. Cell phone running SPIRIT Level, an independent measurement of sensor roll and pitch, to guard against materially significant bias in the IMU sensor.

3.4. Photograph the Sensor

Using a cell phone or other camera, photograph the installed sensor. Verify that the photograph(s) shows the locations and orientations of the GPS/RTS and IMU sensors.

3.5. Set up the Data Acquisition Parameters

In preparation for the sensor function test, use the [Project Settings] tab in the acquisition software to set the correct data acquisition parameters for the dynamic survey. The standard parameters are listed in Table 1.

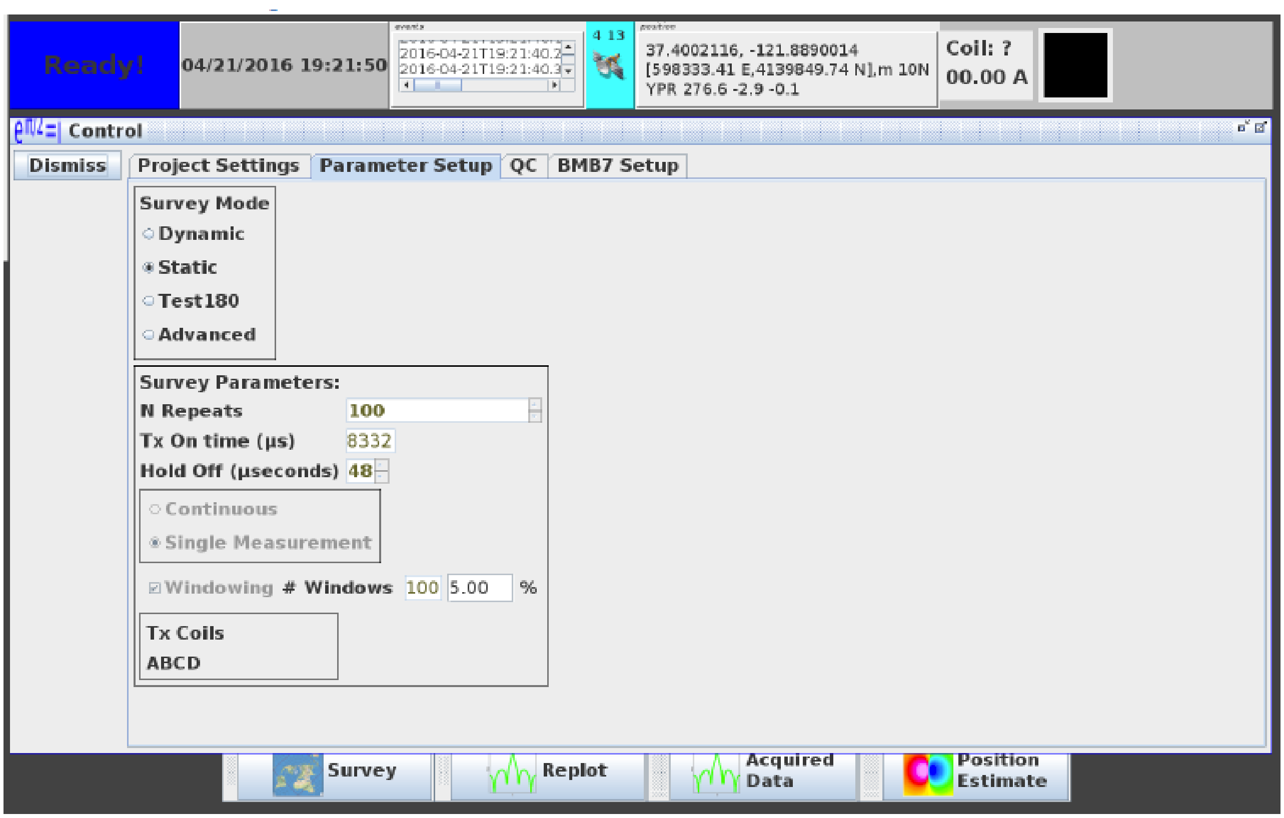

Figure 5. Standard Acquisition Parameters for Static Surveys

Table 1. Standard Data Acquisition Parameters

Parameter	**Cued Survey**	**Dynamic Survey**
Acq Mode	Decimated	Decimated
Gate Width	5%	20%
Stacks	1	1
Repeats	100	3
Stack Period	0.9	0.033

3.6. Perform a Sensor Function Test

Select the reference SFT or DFT response for the combination of hardware and data acquisition parameters you are using on the [QC] tab.

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 by selecting Background from the dropdown menu on the main survey screen of the data acquisition software.
2. Without moving the sensor, mount the serialized ISO in the hole on the top of the sensor housing (Figure 6).
3. Select Sensor Function from the dropdown menu and collect sensor function data. If the results agree with the reference values, a position estimate with delta values is displayed; these values must be less than 2.0 to pass. If they do not agree, a warning dialog with a summary of the incorrect results.
4. Transfer the background and sensor function data files to the Data Processor/QC Geophysicist for archiving.
5. The Data Processor/QC Geophysicist will verify the sensor function test using the purpose-built tool “Sensor Function Test” in UX-Analyze.

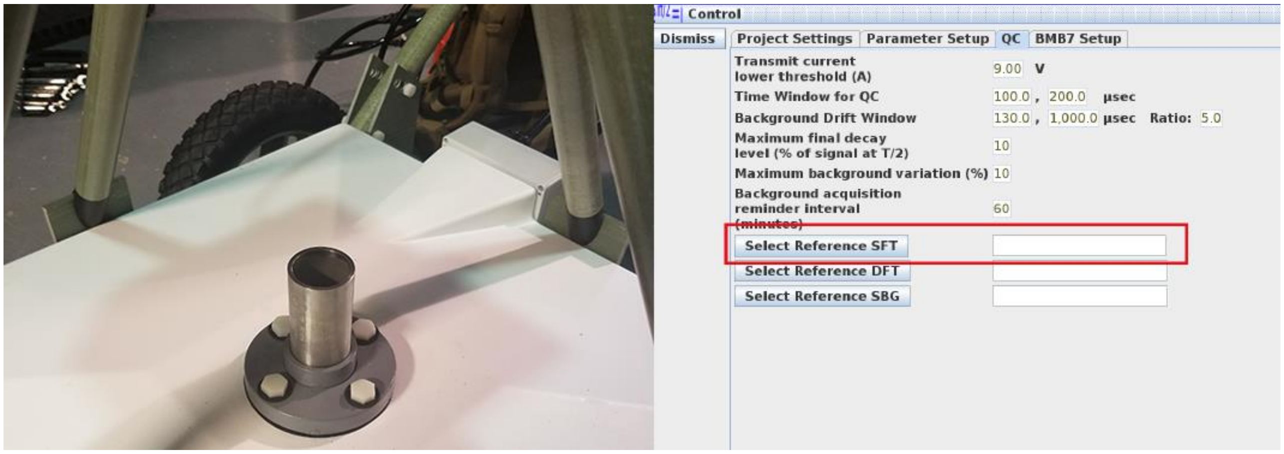

Figure 6, left panel – photograph of the standardized test object on the MetalMapper sensor. Right panel – screen snapshot of the data logger

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

Input data consists of the assembly and operation instructions for the MetalMapper 2x2 contained in the operating manual from Geometrics.

4.2. Output Data

The sensor function test described in Section 3.6 will be saved in the project database. Also, 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.

5. Quality Control

As this definable feature of work is accomplished only during the preparatory phase, only preparatory QC checks will be performed on this activity. QC consists of performing the inspections on the Preparatory Phase Quality Control Checklist that is included as Attachment 1 to this SOP. 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.

The measurement quality objective (MQO) (QAPP Worksheet #22) for this SOP is verification that the assembly instructions have been followed. The MetalMapper 2x2 will not be tested on the IVS (see SOP 2) until this has been documented as described below.

6. Reporting

Achievement of the Sensor Assembly MQO will be documented by the Field or Project Geophysicist by completion of the Preparatory QC Checklist (ANJV QC application) and will be verified by the QC Geophysicist.

The delivered data package for the assembled and tested MetalMapper 2x2 will be included in a section of the IVS Letter Report and will include:

- 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 Geophysicists and checked by the QC Geophysicist verifying the assembly and orientation tests described above.
- the Sensor Function Test result.

7. Revision History

1-19-18 Initial release.

10-23-18 Removed reference to specific title of IVS report

4-2-19 Added Android QC Application check of IMU bias, section 3.3, and removed reference to vendor specific IMU software calibration tool.

1-15-2020 DK review – no change

12/30/2020 DK review – no change

12/30/2021 DK review – no change

01/02/2023 DK review – no change

STANDARD OPERATING PROCEDURE 2

Test Sensor and System at the Instrument Verification Strip (IVS)

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.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following individuals will be involved in verifying correct operation of an advanced electromagnetic induction (EMI) sensor (Metal Mapper, TEMTADS, MM2x2, MPV, etc.) at the IVS:

- Project Geophysicist
- QC Geophysicist
- Field Team Leader
- Data Processor

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 munitions and explosives of concern (MEC) avoidance, as needed, in the field. Information on the specific qualifications for various UXO personnel support roles can be found in the project Health and Safety Plan.

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 and 8.

The following is a list of required equipment and materials:

- Advanced EMI sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) 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 Metal Mapper during data collection
- inert munitions and/or ISOs 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

3. Procedures and Guidelines

3.1. Advanced Digital Geophysical Mapping System

The advanced digital geophysical mapping (DGM) will be conducted using an advanced EMI sensor. The Geometrics MetalMapper, TEMTADS and MPV are examples of advanced EMI sensors that have been extensively validated in a series of demonstrations conducted by DoD's Environmental Security Technology Certification Program (ESTCP). The MetalMapper, TEMTADS, MM2x2 and MPV are advanced electromagnetic induction sensors designed for the detection and classification of buried metal objects. The MetalMapper sensor consists of three orthogonal 1-m x 1-m transmit coils for target illumination and seven three-axis receive cubes. Its sampling is electronically programmable and therefore flexible. It measures the decay curve up to 8-ms after the transmitters are turned off for each of the 21 receive channels. The TEMTADS 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 recorded up to 25 milliseconds after the transmitters are turned off for each of the 12 (4 cubes with 3 axes each) receive channels. The MM2x2 sensor is very similar to the TEMTADS sensor. It 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 a 10-cm three-axis receive cube centered in the transmit coil. The transmitters are energized in sequence and the decay curve is recorded up to 8 milliseconds after the transmitters are turned off for each of the 12 (4 cubes with 3 axes each) receive channels. The MPV is a handheld sensor consisting of a circular 50cm diameter transmitter coil and five 8-cm three-axis receive cubes distributed in a cross pattern within the MPV sensor head. For cued interrogation, the sensor head is augmented with a pair of orthogonal horizontal axis transmitter loops. These are supplied as detachable rectangular shaped units that can be placed on top of the main sensor head. The transmitters are energized in sequence and the decay curve is recorded up to 25 milliseconds after the transmitters are turned off for each of the 15 (5 cubes with 3 axes each) receive channels.

Positioning of the sensor will be accomplished using RTK GPS or RTS. With adequate satellite visibility, RTK GPS can provide antenna locations with accuracies on the order of 5 cm. The sensor orientation is measured using a six-degree-of-freedom inertial measurement unit (IMU). Combining the sensor orientation and location measurements in this manner typically results in derived target locations within 15 cm of the ground truth.

3.2. 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 construction details and verification procedures described in this document apply to each IVS location.

3.2.1. 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, and is determined to be relatively free of subsurface metal objects. The IVS is constructed as one or more survey transects.

3.2.2. IVS Objects

Seed objects for the IVS can be either actual inert munitions or ISOs. Using inert munitions that match those expected to be found on the site may be preferable as this demonstrates to stakeholders that the system is able to accurately classify the exact MEC of concern. However, using ISOs is the technical equivalent and extraordinary measures to obtain inert munitions are not warranted.

ISOs, if used, should approximate the size of the MEC expected to be found on the site and more than one type of ISO should be used if MEC of various sizes are expected. Small, medium, or large ISOs, singly or in combination, can be selected. Table 1 shows the specifications for the three possible ISO and Figure 1 is a photograph of the three ISO.

Table 1. Industry standard objects characterized for use as munitions surrogates

Item	Nominal Pipe Size	Outside Diameter	Length	Part Number[1]	Schedule
Small ISO80	1 inch	1.3 inch (33 mm)	4 inch (102 mm)	4550K226	80
Medium ISO40	2 inch	2.4 inch (60 mm)	8 inch (204 mm)	44615K529	40
Large ISO40	4 inch	4.5 inch (115 mm)	12 inch (306 mm)	44615K137	40

[1] Part number from the McMaster-Carr catalog (http://www.mcmaster.com/).

Figure 1. Small, medium and large ISO

3.2.3. IVS Procedures

Figure 2 illustrates the overall IVS process and the procedures to be followed during the siting, emplacement, and use of the IVS.

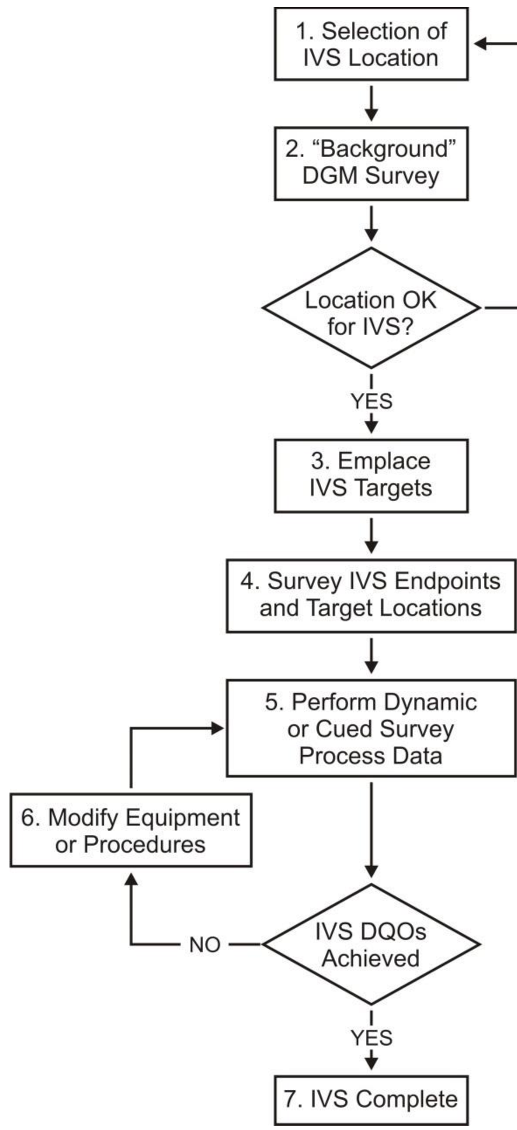

Figure 2: IVS siting, emplacement, and use

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. A background DGM survey will be performed with the advanced EMI sensor using RTK GPS or RTS. 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, Field and QC Geophysicists for evaluation.
3. Once the IVS area is 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. The generalized diagram of the seeded IVS transect is presented as Figure 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.

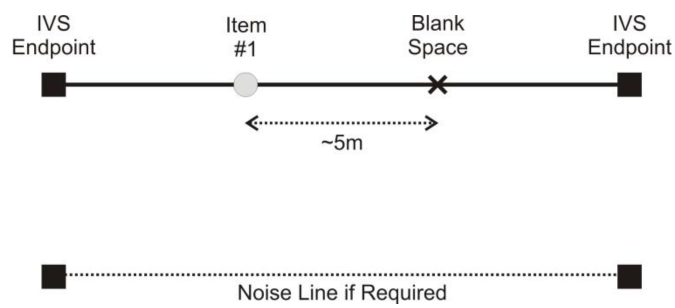

Figure 3. Example layout of the IVS

Measurements of the item depths will be to the center of mass of each item. 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. IVS construction personnel will bury the ISOs and record the following information:

- transect endpoints
- target type
- target emplacement location
- target emplacement depth
- target emplacement orientation (azimuth and inclination)

4. The holes will then be filled 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 surface to prevent interference with the advanced EMI sensor when passing over them.

5. Prior to collecting production data and each morning before beginning field operations, the advanced EMI sensor will be used to collect IVS data as follows:

Cued:

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 .hdf files for each measurement will be passed to the data processor who will perform the following steps:

a. Examine the cued data from each IVS location and verify that all measured decays are valid.
b. Verify the data collected over the blank space is suitable for use as a background reading.
    i. If this is the first measurement on this IVS, verify that all decay amplitudes are below the threshold set in UX-Analyze.
    ii. Otherwise, verify that all decay amplitudes qualitatively match those previously measured at this location.
c. Use the measurement over the blank space to background correct the other data sets and invert the corrected data.
d. Verify that the resulting polarizabilities match the expected library values with a match statistic of greater than 0.9 or the value listed in the approved project QAPP.

Dynamic:

Dynamic data will be collected along the IVS and noise lines. A minimum of three lines at the project line spacing will be collected over the IVS items with the center line directly over the IVS targets. In addition, two lines will be collected directly over the items in opposite line directions to assess and monitor potential system latency errors. The raw .tem files and converted .csv files or .hdf files for both measurements will be passed to the data processor who will perform the following steps:

a. Calculate the RMS variation along the noise line.
    i. If this is the first noise measurement on this IVS, verify that the site noise is compatible with project planning assumptions and will allow project detection goals to be met.
    ii. Otherwise, verify that the RMS noise is within 10% of the mean of those previously measured at this location.
b. Background correct the survey data over the IVS using the patch over the blank spot or a suitable de-median or high pass filter.
c. Calculate the latency correction to remove the errors in data caused by instrument timing delays.
    i. If this is the first latency measurement on this IVS, apply the latency correction to the data.
    ii. Otherwise, apply and verify that the latency correction is consistent with those previously measured over the IVS.
d. Run the target location algorithm as described in the Target Selection section of SOP 05 and/or approved project QAPP. The IVS will use the same anomaly detection approach as

the production areas. Verify that the resulting positions match the emplaced positions of each IVS item to 25 cm or the value listed in the approved project QAPP.

6. If the initial measurement quality objectives (MQOs) have not been met, the QC Geophysicist will initiate a root cause analysis to determine the source of the discrepancies. If modifications to the instrument or procedures can be made so that the MQOs can be met, these modifications will be made. If the 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.
7. Once the initial (or modified) MQOs have been met, the IVS survey will be complete and the system and operators verified for field data collection.

4. Data Management

4.1. Input Data Required

Input data required for this SOP are the locations and identities of the IVS items and the library polarizabilities for each.

4.2. Output Data

The test measurements over the IVS items described in Section 3.2.3, Step 5 will be saved in the project database along with the inversion results and library match metric for each of the measurements. Also, the QC checklists in Attachments 1 through 3 of this SOP will be completed, signed, and filed as proof of performance.

5. Quality Control

5.1. IVS Quality Control

This procedure is performed throughout the project and, therefore, has Preparatory, Initial and Follow-on QC checks. Performance of the required QC checks will be documented by the Field or Project Geophysicist on the Preparatory, Initial and Follow-on QC checklists in Attachments 1 through 3 to this SOP. The QC Geophysicist will verify and document successful completion of the following procedures in the Geophysics Daily QC Report:

- The Preparatory QC Checklist covers the construction of the IVS and preparation of the advanced EMI sensor prior to the first IVS tests. This checklist is completed once per project.
- The Initial QC Checklist covers the initial IVS tests to demonstrate proper functioning of the advanced EMI sensor prior to performing production data acquisition.
- The Follow-on QC Checklist documents the IVS tests that are performed at least twice per day throughout the project, each morning prior to starting production data collection and at the conclusion of data collection.
- The QC tests in the following attachments will be performed as part of IVS procedure. In addition, instrument-specific start-up and function checks for the advanced EMI sensor will also be performed at start-up prior to all data collections including IVS data collection.

- Achievement of the IVS MQOs will be verified by the Field and QC Geophysicist on their QC checklists.
- During review of the Initial and Follow-on data packages, the Data Processor will overlay the polarizabilities of each IVS target from all measurements to observe the time variation of the inverted results. Should an issue be detected (such as a data trend indicating a MQO limit is being approached) or a MQO is not met, a comprehensive root-cause analysis will be performed and a corrective action determined.

5.2. Measurement Quality Objective (MQOs)

The MQOs for the IVS are presented in Worksheet #22 of the QAPP. The advanced EMI sensor 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.

6. Reporting

This procedure will be documented through the completion of the Preparatory, Initial and Follow-on QC Checklists (ANJV QC application). The IVS construction and implementation will be documented in an IVS Letter Report and a copy of the completed Preparatory Checklist from SOP 1 and the Preparatory and Initial Checklists from this SOP (including the advanced EMI sensor Start-up Checklist from Attachment 1 of SOP 1) will be included as attachments to that report. A Follow-on QC Checklist will be completed by the Field or Project Geophysicist each time IVS data is collected during the production survey and a copy of these completed checklists will be included with the Classification Project Report at the end of the project.

7. Revision History

3-13-17 Added 'Revision History' section to SOP.
01-03-18 Revised text to be suitable for advanced sensors in general and not specific to the TEMTADS and MetalMapper
01-05-18 Added the ANJV logo
10-23-18 Added option for project specific thresholds
01-08-19 Added text to dynamic target selection process
1-15-2020 DK review – no change
12-04-2020 DK formatting change only
12/30/2020 DK review – no change
12/30/2021 DK review – no change
01/02/2023 DK review – no change

STANDARD OPERATING PROCEDURE 3
Production Area QC or QA Seeding

1. Purpose and Scope

The purpose of this Standard Operating procedure (SOP) is to identify the methods to be employed when emplacing QC or QA seeds in the production area.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following individuals will be involved in production area seeding:

- QC Geophysicist
- QC Geophysicist Onsite
- ANJV Quality Manager (as appropriate for review and procedures)
- Project Geophysicist (limited information)

Only the QC geophysicist(s) and ANJV Quality Manager (as appropriate) will have knowledge and access to the QC seed information. A Blind seed firewall will be implemented to prevent ANJV personnel involved in data collection, processing / classification, and intrusive activities from having access to the QC seed information. The Project Geophysicist can discuss general information with the QC geophysicist to help provide information that the QC geophysicist may need to develop the QC seed plan. General information refers to information that is found in non-firewalled documents, such as the QAPP. The project specific Blind Seed Firewall plan may list other personnel with access to the QC seed information.

Approval from the Project Geophysicist or ANJV Quality Manager is require before the QC Firewall is knowingly breached.

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 munitions and explosives of concern (MEC) avoidance, as needed, in the field. Information on the specific qualifications for various UXO personnel support roles can be found in the project Health and Safety Plan.

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 & 8.

The following is a list of required equipment and materials:

- inert munitions and industry standard objects (ISO) to emplace the seeds
- hand-held geophysical sensor (typically a Schonstedt magnetic locator, White's metal detector, or possibly an MPV)
- AGC sensor (required only for QA seed emplacement)
- hand tools including shovels, pickaxes, breaker bars, etc. to emplace the seeds

- excavators if required by the production seed plan
- RTK GPS, RTX, or RTS 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

3. Procedures and Guidelines

The positioning system shall pass daily quality control checks.

The production area seed plan 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.

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 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 (40 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 within the immediate vicinity of any strong anomaly and should ***not*** be within 60 cm of another seed.

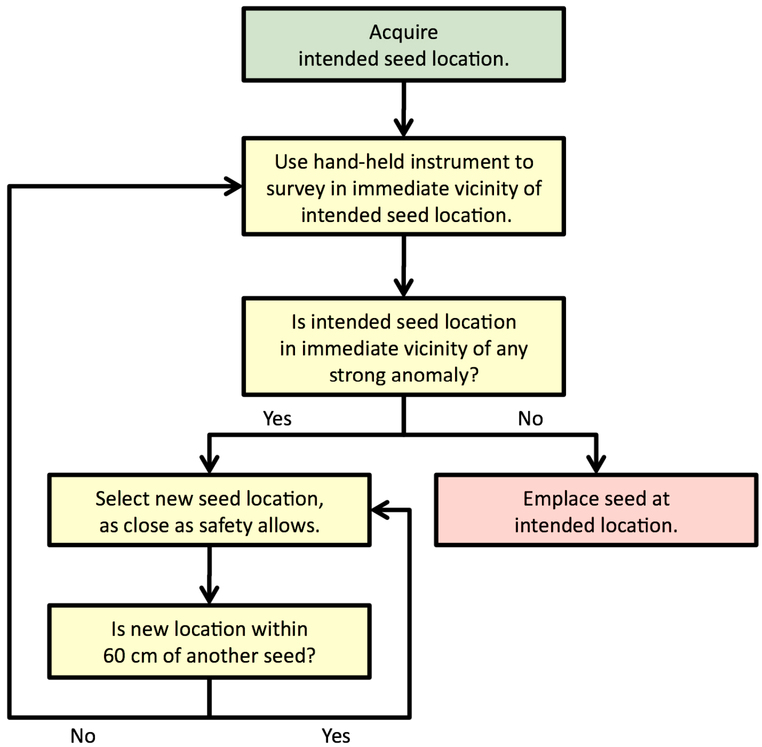

Figure 1: Anomaly avoidance during seed emplacement.

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 seeds' intended burial parameters. 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, as this 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 listed in the attached spreadsheet. 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 horizontal or exactly vertical 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:

- using the RTK GPS, RTX, or TLS, measure and record the geospatial center (XY plane) of the seed, with coordinates reported in UTM (NAD 83) meters,
- repeat the RTK GPS, RTX, or TLS measurement for QC purposes,
- 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:

- ensure the seed is marked with blue paint (inert).
- replace any metallic items that were found in the hole (i.e., emplace the metallic items in the hole along with the seed).
- replace dirt in the hole as completely as possible.
- level the burial location.
- replace the grass plug over the burial location (if possible).

3.3. Collect Cued Measurement with AGC sensor

When QA seeds are emplaced, AGC data shall be collected directly above the seeded item. The purpose of the AGC collection is to confirm invertibility and document seed location, depth, and orientation details.

All steps and procedures in ANJV SOP 7, 'Collect Cued Target Measurements' must be followed, including the collection and storage of quality control data that validate proper sensor functionality.

Once collected, the acquired AGC data shall be checked for quality, and if pass, inverted using AcornSI's UX-FieldQC software for source parameters for each emplace seed. AGC data that does not pass UX-FieldQC's checks will be discarded. Data recollections will occur after duly considering and correcting the source of the failure.

3.4. Safeguarding of QC Seed information

All seed information and associated databases must be deleted from field tablets (or similar) and GPS/RTS/SLAM units upon completion of QC Seeding activities.

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 QC or QA seed plan, which contains a table of seed items, initial locations, and depths and orientations, is required for emplacement of QC seeds.

4.2. Output Data

The output data from this SOP is the final seed report and, if emplacing QA Seeds, AGC data. The report consists of 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.

The AGC data collected in support of QA seeding consists of all cued collections and processed data used to confirm seed emplacement and document invertibility; to include all QC (*.sqc, *.sft, *.sbr, *.sbg) files and field notes.

4.3. Out of Scope QC Seeds

QC Seeds will be tracked using a QC Seed Tracking database or Excel file. The final QC Seed Report serves as the basis for the QC Seed Tracking database. Because the QC Seed Tracking database is updated throughout the project, it details the final disposition of all emplaced QC Seeds at the conclusion of the effort.

If a QC seed's disposition is questioned, ANJV's QC Seed team, or the UXOQCS, or their designee will try to determine the disposition of the seed in question. This includes (1) conducting a visual and sensor-aided surface search of a 20-foot radius, which also requires performing and logging the GPS function test, and (2) conducting a visual search and photographic record of locations of interest as defined by ANJV QC within a 50-foot radius.

If a QC Seed becomes no longer relevant due to changes in TOI definition, coverage limitations, SRA's, depth of burial, or threshold changes associated with noise-based schemes, it will be recorded as Out of Scope in the QC Tracking database and will not be included in the project's performance metrics. The term Out of Scope is used here to identify an emplaced QC Seed that no longer is useful for its intended purpose.

5. Quality Control

Successful completion of the measurement quality objective (MQO) (QAPP Worksheet #22) for this SOP is verification that all seeds have been emplaced with the specified precision. No field work will be performed until this has been documented as described below.

6. Reporting

This procedure will be documented through the completion of the Preparatory QC Checklist (ANJV QC application). Production area seeding will be documented in Production Area Seed Report as described in Section 4.2.

7. Revision History

3-13-17 Added 'Revision History' section to SOP.
1-5-18 Added ANJV logo
1-15-2020 DK review – no change
12/30/2020 DK review – no change

02/01/2021 DK added data collection and inversion in support of QA Seeding
02/01/2021 DK review – no change
02/04/2022 DK – added details to section 2 to clarify roles and statement regarding knowingly breaching the firewall.
08/07/2022 DK – added section 4.3 regarding Out of Scope QC Seeds
08/07/2022 DK – added language for RTX and required 2nd measurement of GPS/RTX/TLS at each seed
01/02/2023 DK review – no change
03/10/2023 DK – added section 3.4
04/26/2023 DK – added paragraph in Section 4.3 describing efforts related to finding a QC seed

STANDARD OPERATING PROCEDURE 4

Perform Dynamic Surveys - Advanced EMI sensor

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 an advanced electromagnetic induction (EMI) sensor (MetalMapper, TEMTADS, MM2x2, MPV, etc.) for target detection.

Dynamic advanced EMI 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 QAPP.

The observed signal measured by the advanced EMI sensor is composed of 1) the EMI response of potential buried targets, 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 comprised of 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 targets of interest are mapped and selected for further investigation. Details of the data processing and analysis of dynamic data are covered in SOP 5.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment, and materials required to implement this SOP.

The following individuals will be involved in the collection of dynamic survey data:

- Project Geophysicist
- QC Geophysicist
- Field Team Leader
- Data Processor

The personnel qualifications are documented in the QAPP Worksheet #4, 7 & 8.

Required equipment includes:

- Advanced EMI sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) or Robotic Total Station (RTS) and orientation sensor
- transport vehicle (skid steer, tractor, extended reach forklift) used to move the MetalMapper during data collection
- Tablet
- field survey grade tape measure

Required material may also include

- traffic cones or equivalent for lane marking, or
- marking paint

3. Procedures and Guidelines

3.1. Survey Grid Preparation

Grid preparation involves demarking the site boundaries and survey transects required to achieve the coverage specified in the project-specific QAPP. The site will be subdivided into grids with sizes depending upon the site conditions such that the sensor can be precisely navigated along the desired transect. Line guidance methods will vary according to the advanced sensor used but will either use manual methods or software based navigation. In the manual method, the transect ends will be measured and pre-marked and traffic cones may be used to identify the start and end of each transect. In the software based method, survey transect locations will be generated using the "survey layout" function in UX-Detect. The generated lines will be exported in a .XYZ file that can be imported into EM3D, the data collection software.

3.2. Function Test Measurements

Function test measurements (described in SOP 1) will be performed in conjunction with background measurements to confirm that all transmit and receive components of the sensor are operational. At a minimum the Function test measurements are performed shortly after the sensor is powered on and prior to IVS or production data collection and prior to sensor shutdown.

3.3. Daily IVS Survey

Prior to the start and at the end of each day of data collection, measurements of the set of IVS targets will be performed (described in SOP 2).

3.4. Dynamic Data Collection

Dynamic survey for DGM involves collecting data along transects across the survey area. In combination with SOPs for sensor assembly (SOP 1) and testing at the IVS (SOP 2), in-motion data is collected along each transect at a spacing appropriate to the site and project needs, as defined in the project-specific QAPP. Data collection is controlled by the user with the EM-3D software, which allows the user to assign a numerical 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 when the obstacle is encountered 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 processor. Data gaps that are the result of line spacing over the defined acceptable spacing will be determined by the data processor and provided to the field geophysicist for recollection. Data acquisition will be performed using the following steps:

1. **Start-up and test the advanced EMI sensor**. The geophysical and navigation systems are started and a function test is performed prior to every data collection sortie (event). In addition, the

data acquisition software is monitored to ensure that all data streams (EMI, global positioning system, [GPS], or RTS and inertial measurement unit [IMU]) are valid and being recorded.

2. **Navigate and collect data along transects**. Navigation along transects is either performed visually with the assistance of markers, which are determined at the discretion of the field geophysicist or by following the preloaded survey lines plotted on the data acquisition screen When using visual navigation, markers may include, but are not limited to, ropes, tapes, spray paint, or flags. These markers can be used to show the track of the inside wheels as the sensor moves along a transect. Positioning in the data is captured through the use of the RTK GPS or RTS system and the IMU.
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 data collection screen to ensure that:
   - the data collection starts and stops in coordination with the beginning and end of each transect.
   - the transmit current for each transmitter was within an acceptable range.
   - each transect is assigned a unique numerical identifier (ID), in sequential order.
   - the amplitude responses measured by each receiver coil appear reasonable (i.e., not 'flat-lined').
4. **Verify complete coverage of survey area**. 100% coverage surveys will require appropriate line spacing (presented in QAPP Worksheet #12). Data gaps resulting from obstacles or inaccessible terrain will be marked and verified by the field geophysicist. Data gaps exceeding the MQOs identified QAPP Worksheet #22 will be reacquired using RTK GPS or RTS and recollected.

4. Data Management

4.1. Data Inputs

The data inputs required are:

- a list of coordinates identifying the site boundaries.
- a list of instrument verification strip (IVS) transect start and end points.

4.2. Data Outputs

The data outputs are:

- dynamic advanced EMI 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 or other digitally recorded table presenting data filenames as delivered and rectified field notes [i.e. differences between delivered digital filenames and field notes are resolved]).

5. Quality Control

Practical considerations limit the real-time quality control (QC) of the dynamic data acquisition activities to qualitative assessments. Quantitative QC and assessment of the collected data will be performed as part of SOP 5 dealing with the processing of dynamic advanced EMI sensor detection data. The Quality Control checklist presented as Attachment 1 to this SOP will be filled out and delivered as part of the reporting requirement for this SOP.

The measurement quality objectives (MQOs) for dynamic data acquisition are presented in Worksheet #22 of the project-specific QAPP. Performance relative to the MQOs will be assessed during the processing of the collected data (SOP 5). Dynamic advanced EMI sensor 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 checklist (ANJV QC application).

7. Revision History

3-13-17 Added 'Revision History' section to SOP.
12-13-17 Revised text to be suitable for advanced sensors in general and not specific to the TEMTADS and MetalMapper.
1/5/18 Added ANJV logo
1/1/2019 DK review – no change
1/15/2020 DK review – no change
1/16/2020 TF review – Added language to Section 3.2 - Function test measurements
12/30/2020 DK review – no change
12/30/2021 DK review – no change
01/02/2023 DK review – no change

STANDARD OPERATING PROCEDURE 5

Process Dynamic Survey Data - Advanced EMI sensor

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 an advanced electromagnetic induction (EMI) sensor (Metal Mapper, TEMSENSE, MM2x2, MPV, etc.) for target detection.

Dynamic advanced EMI 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 Geophysical Classification for Munitions Response (GCMR) Quality Assurance Project Plan (QAPP). Processing the dynamic data involves processing and assessing all QC tests (including daily function tests and 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 daily to validate the operation of the various components of the advanced dynamic survey system.

In the dynamic survey data, the observed signal measured by the advanced EMI sensor 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 comprised of 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.

2. Personnel and Equipment

This section describes the personnel and equipment required to implement this SOP.

The following individuals will be involved in the analysis of dynamic data:

- Project Geophysicist
- QC Geophysicist
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 & 8.

The only required equipment is a data processing computer suitable for and equipped to run the processes provided in the UXA-advanced module of Geosoft's Oasis Montaj geophysical processing environment.

3. Procedures and Guidelines

This section describes the procedures used to process the dynamic production data including positioning and leveling of the data, process/assess the QC activities related to dynamic data collection, select target anomalies and classify sources from the final processed data.

3.1. Processing of Dynamic Advanced EMI data

The processing of dynamic advanced EMI data is achieved in the following steps:

1. Data import and QC
2. Data positioning and background removal
3. Target selection
4. Source Classification (if applicable)

3.1.1. Data Import/initial QC

The raw *.TEM data files are converted to ASCII *.csv files using Convert_TEMSENSE (TEMSENSE) or EM3D plot export utility (MetalMapper and MPV) and imported into a Geosoft Database (*.gdb) using a purpose built utility in UXA-Advanced. In the case of the MM2x2, the raw HDF5 files are directly imported into a Geosoft Database. Once imported the data are inspected and assessed against the measurement quality objectives (MQOs) provided in Worksheet #22 for:

- transmit (Tx) current within limits
- Global positioning system (GPS) fit quality
- valid inertial measurement unit (IMU) data
- compare the calculate course over ground (COG) to Yaw from IMU for bias
- EMI response signal not saturated

Data measurements that do not pass the MQOs are automatically identified by a purpose-built utility in UXA-Advanced that is used to default the associated data where the MQOs are not met. This prevents the out-of-specification data from being mapped and used for detection. The out-of-specification data are flagged in the databases and overall statistics for each of the data streams is calculated for each line collected and output as a plot and spreadsheet for reporting and documentation purposes.

3.1.2. Data Positioning and Leveling

A second purpose-built software routine automatically assigns the monostatic, Z-component EMI measurements positions based upon the GPS antenna or RTS prism location, platform geometry and platform attitude (IMU) data. If necessary, a latency correction is applied to correct instrument timing delay errors. A site-specific de-median filter is applied to the raw EMI data to derive an estimate of the background model. This model is subtracted from the raw data to provide a background removed or 'leveled' data set. Figure 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.

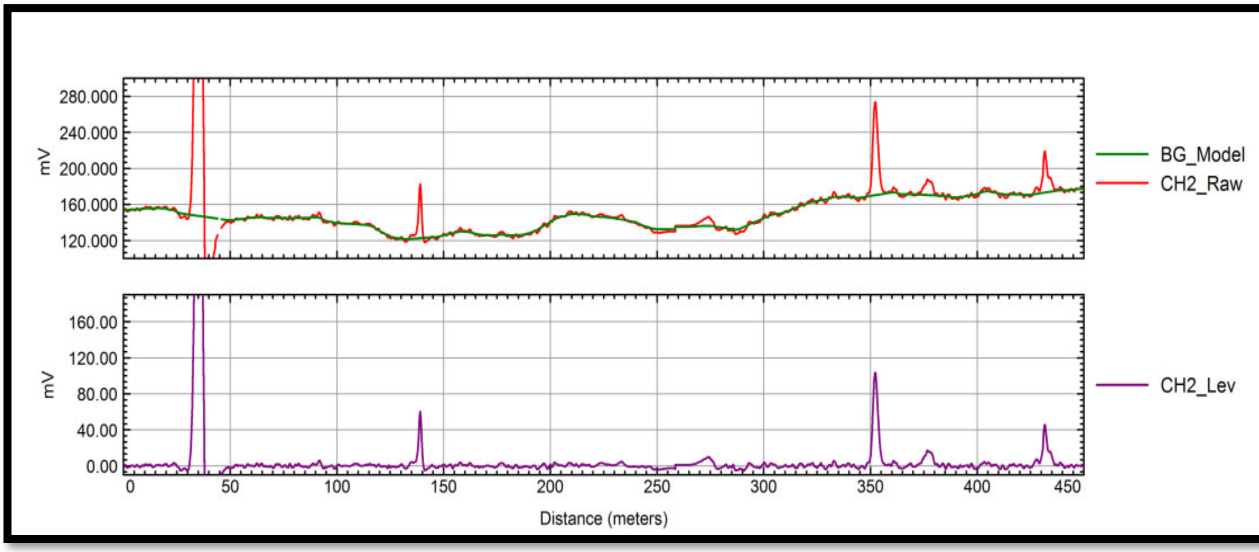

Figure 1. Example of Raw and Leveled Data

The leveled monostatic data are gridded and mapped using conventional Geosoft tools. The mapped monostatic Z-component data are then used for amplitude response based target selection whereby the position of peak responses in the data that exceed the project threshold are selected and identified as target anomalies for further analysis.

The gridded and mapped monostatic Z-component data are also suitable for use to select background locations, which in turn can be used to level all the Tx/Receive (Rx) coil combination data in a manner similar to that used for background removal of cued target measurements.

3.1.3. Target Selection

Target selection using the advanced EMI dynamic data is performed using the traditional amplitude response metric using the mapped Z-component data described above. Alternately a dipole response filter approach or other advanced anomaly selection technique that uses a larger subset of the available data can be used.

3.1.3.1. Response Amplitude Detection:

Traditional anomaly selection is based almost entirely on signal response amplitude. Using the advanced EMI dynamic survey monostatic Z-component response amplitude as a detection metric is essentially the same as using a Geonics EM61 response amplitude detection. After the data have been gridded, the Geosoft automatic grid peak detection algorithm is used to extract locations of all grid peaks that are above the project detection threshold. These target anomaly locations are reviewed by the project geophysicist and manual additions and deletions are made to this list. The final list is reviewed by the quality control (QC) geophysicist prior to finalization of the target list.

3.1.3.2. Dipole Response Filter Detection:

The 'dipole response filter' approach to anomaly detection makes use of the rich data set output of the advanced sensors. This target selection routine takes advantage of all the measured data – not just the monostatic Z component – by employing an automated dipole inversion routine to estimate the source locations. The process involves:

1. assuming a target's location (at every 10-20 centimeters [cm] spaced grid node across the site)
2. extracting data within a specified sensor footprint
3. inverting for dipole polarizations
4. extracting the 'goodness-of-fit parameter' as the detection metric

The 'goodness-of-fit' filter output is the squared correlation between the full multi-axis, multi-static advanced EMI data set and a dipole model fit to those data. This filter output is mapped in the same manner as the amplitude response and peaks in the detection metric indicate target locations as illustrated by Figure 2.

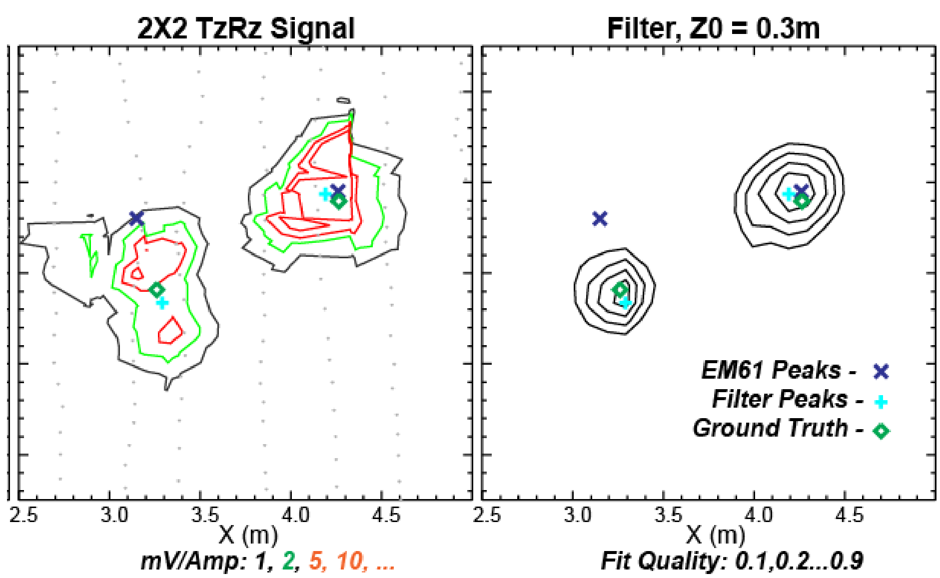

Figure 2. Data subset showing mapped response amplitude (left) and mapped filter response output (right) with ground truth information superimposed.

Accordingly, target selection using the dipole filter fit coherence metric is accomplished in the same manner as for the amplitude response approach. After running the automatic peak detection routine, the target list will be reviewed and manual additions/deletions will be made. The automatic peak detection routine in UX-Analyze allows detections based on the amplitude response, dipole fit coherence or a combination of both. This target list is the input into the next stage of the source selection process which involves:

1. extracting data within a specified sensor footprint

2. inverting the data in separate passes for one, two, or three dipole sources (N-dipole inversion), enabling spatial resolution for multiple sources within the footprint of the original dipole response region
3. resulting sources are examined and valid sources with at location greater than 0.45m from the original fit coherence peak require an additional inversion using data centered on the fit position of the source
4. inversion results for all sources are examined and optional screening of the sources based on size and decay metrics are performed (informed source selection [ISS])
5. closely located valid sources (typically within 0.2-0.3m of one another but will vary according to the TOI) are merged into one source to form the final target list

3.1.4. Dynamic Classification

If the AGC sensor used to perform the dynamic survey was DAGCAP approved for dynamic classification, the data can be used to classify the targets and generate a ranked dig list. Classification of targets will be based upon objective, numeric criteria. Using these criteria, a prioritized list is created with high likelihood target of interest (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 of the list. The primary method for classification will be library matching, supplemented by cluster analysis and feature space analysis.

N-dipole target inversion routines in UX-Analyze are 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 (principal axis polarizabilities) related to the object size shape and composition. The intrinsic parameters, otherwise known as betas (β) are used for classification.

The “N” in the N-dipole solver indicates the number of sources the solver presupposes. The default setting is to run 1, 2, and 3 source solvers for each cued measurement. The number or sources can be increased if ground truth, training data or other information suggests the 3 source model is insufficient to extract accurate target parameters. A separate fit coherence value is derived for each solution and can aid in this determination. Model results will only be used for classification if they pass the MQOs identified to confirm that they support classification (QAPP Worksheet #22).

3.1.4.1. Site Specific Munitions Library

A site-specific library of βs for candidate munitions items identified in the conceptual site model (CSM) will be used for classification. Intrinsic parameters for items listed in the CSM not confirmed to be in the existing library will be derived from test measurements prior to the start of the classification process if the items are available for test or the closest available item in size and shape will be used as a surrogate.

In addition to the comparison using the site-specific library, the polarizabilities may also be compared to a comprehensive library containing items not expected at the site. A sample of those targets that produce a high confidence match may be requested as training data. Representative signatures of any training targets that are identified as TOI will be added to the site-specific library.

3.1.4.2. Library Matching

Classification is based primarily on the goodness of fit metric (values from 0.0 to 1.0) generated by UXA during a comparison of the β values estimated for each surveyed target and the β values in the munitions library developed for the project. This comparison is performed via the library match utility in UX-Analyze. The goodness of fit metric is a measure of the amplitude and shape mismatch between a target and the library entry that best fits that target, with higher values indicating a better match between the target and the corresponding item in the library. The library fit analysis matches the following four combinations of βs to those of the candidate library TOIs:

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

The confidence metrics for each fit combination are averaged to derive a 'decision statistic'. This library matching process is performed on each source output from the N-dipole solver. For each flag position, the best decision statistic is used from all the sources to rank and classify the target list. Values below the analyst's threshold (nominally 0.85) are considered non-TOI.

A set of training digs may be identified by the analyst. The intrusive investigation results of these digs as well as decision metrics derived for other known TOI (IVS and seed items) are used to finalize the analyst threshold.

3.1.4.3. Cluster Analysis / Feature Space Analysis

Cluster analyses are performed whereby the clusters of anomalies with similar β signatures are identified using the self-match utility in UX-Analyze. For each identified cluster, a representative sample may be intrusively investigated as part of the training data. If the intrusive investigation identifies a hazardous item, a representative signature is placed in the site-specific library and the matching process will be repeated to ensure that all similar items are classified as TOI.

Individual items that do not match any library items but have βs that indicate a large, axially symmetric, thick-walled object are identified and investigated as part of the training data and added to the library if they are identified as TOI.

3.1.4.4. Threshold Selection and Final Classification

The UX-Analyze tool to perform classification and ranking of targets allows for user input of selected thresholds and applies classification expressions to rank the targets. The classification expressions contain the logic for sorting the sources into a ranked target list. The initial expressions are provided with the UX-Analyze module and can be customized to best suit the project goals. Initial threshold selection values will be defined during preliminary library matching and cluster analysis and will incorporate system performance observed at the test pit and IVS. The stop dig point will be verified by ensuring the defined threshold encapsulates all QC seeds and TOI revealed during the training data verification.

All sources output from the N-dipole solver will be consolidated into a ranked list. For each flag position, the best decision statistic is used from all the sources to rank and classify the target list. If multiple sources at a flag position produce a decision statistic above the analyst's threshold, they are all kept if they are at unique locations. Classification decision plots displaying a size/decay plot, library match, decision rank plot, cluster plot and target parameters along with the target features database will be reviewed with the interactive classification tool by the data processor to refine the sorting of the prioritized target list. Further refinement of the analysis process may occur at this time, and details of the classification process will be documented in a target classification report.

3.1.4.5. Generate Prioritized Target List

A preliminary ranked list containing all anomalies will be delivered to the QC Geophysicist to determine if all relevant MQOs (including QC seed classification) have been met. Every investigated target will be included on the prioritized list and will be classified as TOI, non-TOI, or can't analyze and sorted based on their likelihood to be TOI. All targets in the can't analyze and TOI categories will be selected for intrusive investigation.

After the QC Geophysicist has performed all relevant checks and has provided feedback to the data processor, a final review of the ranked list will be performed to generate the prioritized target list.

The target classification report will include descriptions and values for all thresholds and classification expressions used to generate interim and final ranked target lists.

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 are comprised of function tests (described in SOP 1) and transects along the 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 SOP 1) are performed prior to each sortie to confirm that all transmit and receive components of the advanced EMI sensor are operational. The data from each function test are assessed relative to the MQOs presented in Worksheet #22, 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 SOP 2). 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, 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 (root cause analysis (RCA)/corrective action (CA) are taken. Depending upon the findings of the RCA, the survey data associated with the IVS MQO failure may need to be re-collected.

3.2.3. Advance Anomaly Selection

The 'dipole response filter' approach to anomaly detection uses inversion results to screen sources based on size and decay metrics. The size and decay rate thresholds used to assign the source of an anomaly as potential TOI or non-TOI needs to be assessed. This is done at the end of the targets selection process by collecting cued data over 200 anomalies that were excluded on the basis of the 'dipole response filter' approach. These cued data will be analyzed using the procedures described in SOP 08 and an assessment of the size and decay rate thresholds is conducted. If 100% of the excluded anomalies are classified as non-TOI, the thresholds are deemed valid otherwise a RCA/CA is performed.

4. Data Management

4.1. Data inputs

The data inputs required for processing dynamic advanced EMI data are:

- a list of coordinates identifying the site boundaries.
- raw Dynamic advanced EMI data files.
- amplitude response minimum detection threshold (derived from the project-specific QAPP).

4.2. Data Outputs

The data outputs of the processing of dynamic advanced EMI data are:

- QC reports summarizing daily QC measurement results
- mapped detection metric data (Z-component amplitude and dipole response coherence) in ASCII (x,y,z) and/or Geosoft database format
- target anomaly list (identifier (ID), X, Y)
- prioritize target list (optional)
- letter report detailing processing approach including leveling, target selection and classification (if applicable) procedures

5. Quality Control

The Quality Control checklist (ANJV QC application) will be filled out and delivered as part of the reporting requirement for this SOP.

The MQOs for processing dynamic advanced EMI data are presented in Worksheet #22 of the project-specific QAPP. Performance relative to the MQOs will be assessed during the processing of the data. Dynamic advanced EMI data will not be used to select or 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 following:

- digital Field notes
- data processing log detailing the following for each sortie (chronologically contiguous data collection set):
  - survey date
  - % invalid data with regard to transmit (Tx) current, GPS fix quality, IMU data quality, EMI response within range
  - standard quality control checks performance
    - correct coordinates for grids
    - coverage
    - line gaps
    - background response
    - dropouts
    - downline density
    - appropriate leveling
    - appropriate anomaly selection
  - associated Function Test filename
  - associate IVS Test filename(s)
  - area subset (grid ID)
- QC report summarizing daily QC results (Function tests and IVS tests)
- target List – final list of identified anomalies for delivered area subset
- prioritize list (optional) – final list of sources sorted from those most likely TOI to least likely
- final data archive (gdb or xyz format) for delivered area subset
- final grids of Z-component amplitude response for delivered area subset
- final grids of detection metric (if not amplitude response) for delivered area subset
- processing/classification/data selection letter report

7. Revision History

3-13-17 Added ‘Revision History’ section to SOP.
01-03-18 Revised text to be suitable for advanced sensors in general and not specific to the TEMTADS and MetalMapper.
1-5-18 Added ANJV logo

1-3-19 Added text to document the QC procedures if the dipole filter approach it used to select anomalies
1-15-20 Added text regarding the collection of ground truth information for 200 cued data over anomalies that were excluded based on the advanced anomaly selection
1-16-20 Added text regarding comparing the COG vs YAW in Section 3.1.1
12/30/2020 DK review – no change
12/30/2021 DK review – no change
01/02/2023 DK review – no change
02/24/2023 Added dynamic classification procedures

STANDARD OPERATING PROCEDURE 6
Collect Static Background Measurements

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 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 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 a geology representative of that 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 GPS antenna, etc.) will cause the sensor or environmental contribution to the background reading to change.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following individuals will be involved in the collection of background data:

- Project Geophysicist
- QC Geophysicist
- Field Team Leader
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 & 8.

The following is a list of required equipment and materials:

- Advanced electromagnetic induction (EMI) sensor (MetalMapper, TEMTADS, MM2x2, MPV, etc.) coupled with a real-time kinematic Global Positioning System (RTK GPS) or Robotic Total Station (RTS) and orientation sensor
- a standard test object (Industry Standard Object (ISO), sphere, etc.) for sensor function testing

3. Procedures and Guidelines

Background measurements will be recorded no less than every two (2) hours throughout the survey day and at one or more geographic locations as required to document the EMI signatures of near-surface soils present at the site. Sensor specific durations will be listed in project specific QAPP. Background measurements involve positioning the sensor and collecting static measurements over a pre-identified set of background locations. In combination with SOPs for sensor assembly (SOP 1) and testing at the IVS (SOP 2), background data are collected that are used to correct the static data described in SOP 7.

Prior to cued data collection, the correct operation of the geophysical sensor and navigation and orientation systems must be verified at the Instrument Verification Strip (IVS) as described in SOP 2.

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. 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, attempts should be made to create a “clear” 2-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 should be collected in areas that are close to the survey area(s) to minimize travel time.

Once an adequate number of background locations have been identified, an initial measurement should be collected over each of the background locations in turn as illustrated in Figure 1 on the next page.

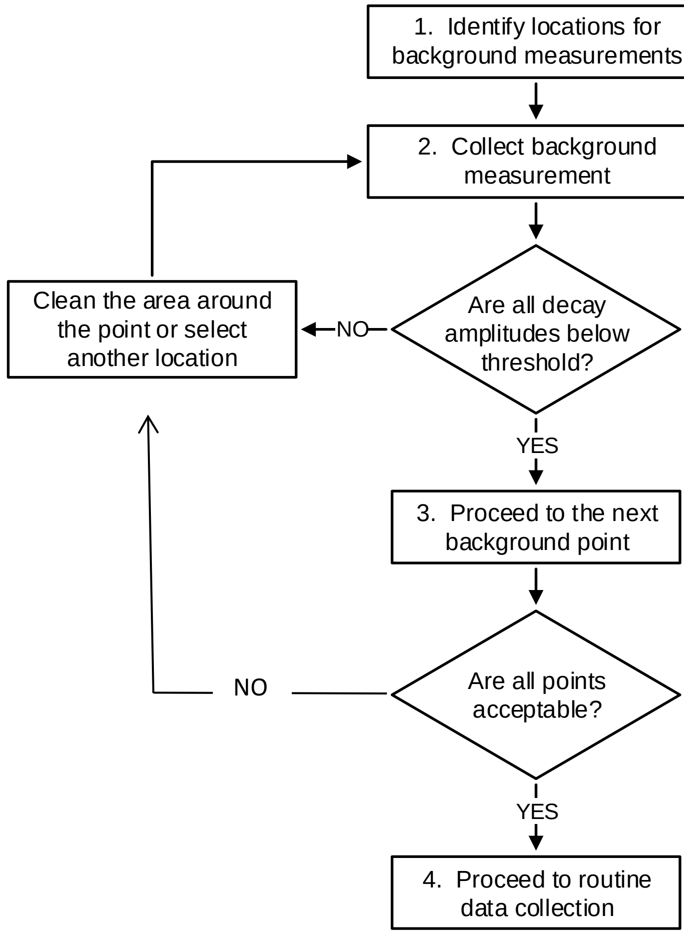

Figure 1. Choosing and verifying locations for background measurements

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.
2. Once an adequate number of initial locations have been identified an initial measurement should be collected over each of the background locations as follows:
   a. Center the advanced EMI sensor over the location chosen as a background point. Mark the corners of the sensor with non-metallic pin flags to allow this same location to be found again for future background readings.
   b. Record the stationary geophysical data at this location and verify that the signal amplitudes for all decays measured are below the threshold chosen for this project. If higher amplitude decays are observed, the location should be inspected and any metal contamination found should be removed. Alternatively, another nearby location can be chosen.
3. Each background location is verified by comparing a set of 5 measurements taken at the intended location: one measurement at the location and one more with the sensor offset by ½ sensor spacing in four orthogonal directions. Next, the forward model of the most challenging target of interest / depth scenario (e.g. 37mm at 30cm depth) is added to the center background

measurement and the background is verified by separately subtracting each of the 4 offset backgrounds and performing a library match to the target of interest. The background location is considered valid if the surrounding background measurements are collected within ½ sensor offset (±50%) of the center background, the ratio of the TOI amplitude to background is greater than the project threshold and/or the library match from all 4 offsets exceeds 0.85. These images will be saved and presented in a background summary report.

4. Continue this process at each of the chosen locations until their suitability for background measurements has been verified.
5. Once this process is complete, these measurements will serve as baseline values for succeeding background measurements at each point.

3.2. Collect Background Measurements throughout the Survey Day

Background measurements should be collected with a minimum spacing of two (2) 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. Sensor specific durations will be listed in project specific QAPP. Careful field notes should be made to document the reasons for extra background readings to guide the Data Processor in choosing the correct background for each cued data set. As an additional check that the sensor is properly functioning, a sensor function test should be performed whenever a background measurement is taken.

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. Collect a background measurement.
3. Without moving the sensor, mount the standard test item in the holder on the sensor housing
4. Collect sensor function data. If the results agree with the reference values, a green LED is displayed. If they do not agree, a red LED is displayed and a summary of the incorrect results is displayed.
5. Compare the Background transient data to the original data at this location.
6. Compare the Background transient data to passed measurements at this location.
7. If deviations exceeding the project thresholds exist, the background measurement is rejected unless environmental changes that may have led to this deviation are documented in the field notes and background use is approved by the Project Geophysicist.

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

In 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. Also, the QC checklist in Attachments 1 through 3 of this SOP will be completed, signed, and filed.

5. Quality Control

This procedure is performed throughout the project and, therefore, has Preparatory, Initial and Follow-on QC checks. Performance of the required QC checks will be documented on the Preparatory, Initial and Follow-on QC checklists as follows:

- The Preparatory Checklist (ANJV QC application) will be completed to document the identification of the background locations.
- The Initial Checklist (ANJV QC application) will be completed to document the initial background readings at each selected background location.

This procedure ensures that the advanced EMI sensor is working properly and that the field geophysical team is collecting data of adequate quality. Therefore, for routine background measurements, this procedure requires only Follow-on QC inspections which are documented through the following steps:

1. The operating software automatically logs the responsible geophysicist's identification in 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 and document this in the Daily Geophysics QC Report.
3. Achievement of the background collection and sensor function MQOs will be documented by the field lead, data analyst, or Project Geophysicist and verified by the QC Geophysicist in the Geophysics Daily QC Report.
4. During review of each background measurement, the Data Processor 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 crew, a comprehensive root-cause analysis will be performed, and a corrective action determined (if required).

The measurement quality objectives (MQOs) for background measurements are presented in Worksheet #22 of the 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 Preparatory, Initial and Follow-on QC Checklists (ANJV QC application) by the Field or Project Geophysicists. The completed checklists 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 background readings taken during the production survey. The QC Geophysicist will review the background readings being collected and will document completion of all checklists in the Geophysics Daily QC Report and copies of the completed checklists will be attached to the report.

7. Revision History

3-13-17 Added 'Revision History' section to SOP.
01-03-18 Revised text to be suitable for advanced sensors in general and not specific to the TEMTADS and MetalMapper
1-5-18 Added ANJV logo
10-23-18 Added sensor function test to background measurement procedures
4-15-19 Section 3 and 3.2. Added text to allow for shorter background periods for specific sensors
1-15-2020 DK review – no change
12/30/2020 DK review – no change
12/30/2021 DK review – no change
11/22/2022 DK Clarified language to state that the QC Geophysicist's review consists of data review and verification rather than field level observations
01/02/2023 DK review – no change

STANDARD OPERATING PROCEDURE 7

Collect Cued Target Measurements

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 (MetalMapper, TEMTADS, MM2x2, MPV, etc.) 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 verification of 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.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following individuals will be involved in the collection of cued target data:

- Project Geophysicist
- QC Geophysicist
- Field Team Leader
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 & 8.

The following is a list of required equipment and materials:

- Advanced EMI sensor coupled with a real-time kinematic Global Positioning System (RTK GPS) or Robotic Total Station (RTS) and orientation sensor

3. Procedures 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 SOPs for sensor assembly (SOP 1), testing at the IVS (SOP 2) and collecting background measurements (SOP 6), a set of static data measurements are collected using an advanced EMI sensor over each anomaly. At each anomaly the data acquisition will be performed using the steps shown in Figure 1.

Prior to cued data collection, the correct operation of the geophysical sensor and navigation and orientation systems must be verified at the Instrument Verification Strip (IVS) as described in SOP 2. This will be verified by completion of the QC checklist attached to SOP 2.

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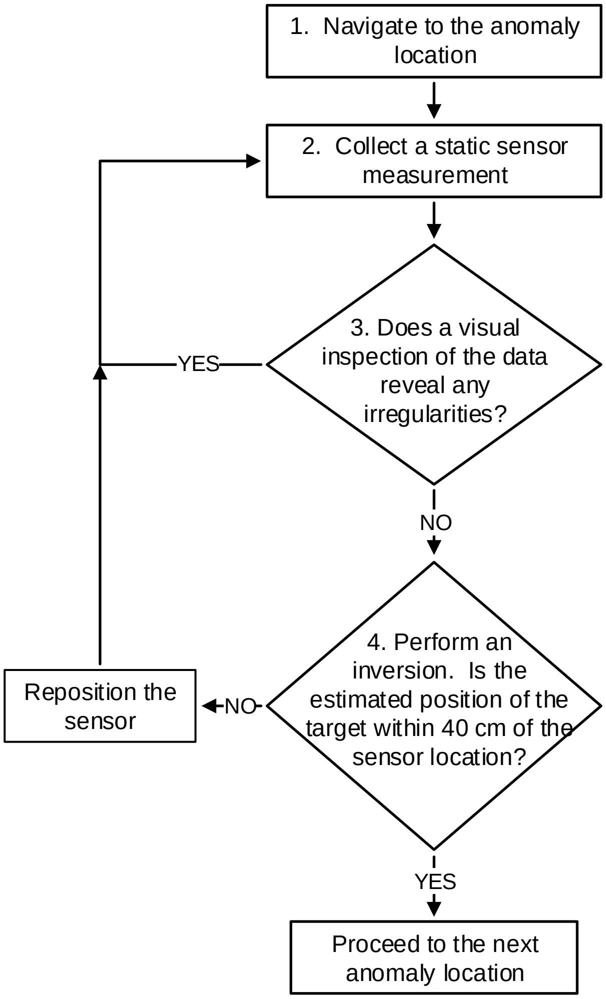

Figure 1. General procedure to collect a cued target measurement. The 40cm distance threshold is sensor specific.

The following is a description of each of the steps shown above:

1. **Navigate to the Anomaly Location**. Navigation to the anomaly location may be performed visually or using the RTK GPS or RTS 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 upon 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 RTK GPS or RTS position relative to the predetermined position.

   If using flags, to implement this step, non-metallic pin flags will be placed at each anomaly location selected for cued measurement based on a target list generated from the dynamic data. If using RTK GPS or RTS, a list of points will be loaded into the survey software and each location navigated to within a few centimeters. A pin flag numbered with a unique target ID will be placed at that location. Once a number of locations have been flagged, the sensor will then be transported to

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and the center of the sensor positioned over the provided anomaly locations for cued measurements.

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 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 with 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 by inspection of the advanced EMI sensor data collection screen to ensure that:
   - the data acquisition cycle completed properly.
   - the transmit current for each transmitter was within an acceptable range.
   - the decay curves measured by each receiver coil appear reasonable (i.e. – not 'flat-lined').
4. **Perform a field inversion**. Valid inversion results require that the target is located within a sensor specific distance from the center of the sensor. The distance is defined in Worksheet #22 of the project specific QAPP. Typical values are 40cm for the MM2x2, TEM2x2 and MM sensors and 20cm for the MPV sensor. The initial target horizontal position may be significantly offset from the center of the sensor for the following reasons:
   - positioning errors in the initial detection survey
   - imprecision in the derivation of the anomaly position from the detection survey data set
   - imprecision in the reacquisition and flagging of the anomaly
   - imprecision in positioning the sensor
   - the presence of multiple anomaly sources in relatively close proximity

   This step includes performance of an in-field inversion and inspection of the results to verify that the estimated horizontal target location is within the sensor specific distance of the center specification. After initiating the in-field inversion algorithm an estimate of the target location relative to the center of the sensor is provided. If the offset is greater than the sensor specific distance, position the sensor over the target location estimate provided by the in-field inversion (visually or using the RTK GPS or RTS data) and repeat Steps 1 and 2.

   This recollection should only be performed once. Assuming the repositioning was performed accurately, if the subsequent position estimate is still > the sensor specific distance from the sensor center, the cause is likely to be multiple anomaly sources and additional data collection and data analysis may be required after further analysis by the QC geophysicist. When moving to the next target, the flags (if utilized) may be bent, painted, or in some other way marked so as to visually track completed locations.

If more than one sensor is being used concurrently at a given site, adequate sensor spacing must be maintained to minimize interference. A minimum separation of 50m must be maintained for NRL

TEMTADs and MetalMapper2x2 sensors. A minimum separation of 25m must be maintained for MetalMapper and MPV sensors.

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 anomaly list consisting of anomaly IDs and UTM Northing and Easting coordinates in meters.

4.2. Output Data

The output data from this SOP will consist of one raw sensor data file (.tem or .hdf5) per anomaly interrogated. These data files will be transferred daily (or more often as dictated by site procedures) to the data analyst.

5. Quality Control

The Preparatory and Initial QC checks for this SOP are performed during the implementation of SOP 2, "Test Sensor and System at the IVS". SOP 2 ensures that the advanced EMI sensor is working properly and that the field geophysical team is collecting data of adequate quality. Therefore, this procedure requires only Follow-on QC inspections which are documented through the following steps:

- The operating software automatically logs the responsible geophysicist's identification in each data file. By logging the data, and thereby taking responsibility for it, the geophysicist logging the data is certifying that they have complied with the requirements of this SOP.
- 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 will be performed, and a 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 measurement quality objectives (MQOs) for cued target measurements are presented in Worksheet #22 of the 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

This SOP will be documented through the completion of the Follow-on QC Checklist (ANJV QC application). Since the Field Team Leader is certifying their compliance with this SOP every time they log data, the Follow-on Checklist will be completed by the QC Geophysicist and will document the successful completion of equipment start-up and the IVS (SOP 2).

The Field Geophysicist will also maintain a field notebook and the QC Geophysicist will review this notebook daily to note issues that potentially affect quality. The completion of all checklists will be tracked by the QC Geophysicist and a copy of the completed checklists will be digitally archived.

7. Revision History

3-13-17 Added 'Revision History' section to SOP.

3-16-17 Added the following text to the bottom of section 3… If more than one sensor is being used concurrently at a given site, adequate sensor spacing must be maintained to minimize interference. A minimum separation of 50m must be maintained for NRL TEMTADs sensors. A minimum separation of 25m must be maintained MetalMapper sensors.

01-03-18 Fixed typo "A minimum separation of 25m must be maintained for MetalMapper sensors.". Revised text to be suitable for advanced sensors in general and not specific to the TEMTADS and MetalMapper.

1-5-18 Added ANJV logo

10-23-18 Changed the 40cm distance tolerance to a general sensor specific value

1-15-2020 DK review, no change

12/30/2020 DK review – no change

12/30/2021 DK review – no change

11/22/2022 DK Clarified language to state that the QC Geophysicist's review consists of data review and verification rather than field level observations

01/02/2023 DK review – no change

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STANDARD OPERATING PROCEDURE 8
Process Cued Advanced EMI Sensor Data

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 (MetalMapper, TEMTADS, MM2x2, MPV, etc.) 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 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.

2. Personnel, Equipment and Materials

This section describes the personnel and equipment required to implement this SOP.

The following individuals will be involved in the processing of cued advanced EMI sensor data for advanced analysis:

- Project Geophysicist
- QC Geophysicist
- Field Team Leader
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 and 8.

The only required equipment is a data processing computer suitable for and equipped to run the processes provided in the UXA-advanced module of Geosoft's Oasis Montaj geophysical processing environment.

3. Procedures and Guidelines

3.1. Data Import/Initial QC

The raw *.TEM data are converted to ASCII *.csv files using:

- a purpose built software utility (Convert_TEMTADS) supplied by the Naval Research Lab (NRL) or
- the EM3D Plot export utility

The data are then imported into Geosoft's UXAnalyze-Advanced (UXA) purpose built processing environment. This process results in separate databases that contain:

- target anomaly measurement data
- background measurement data
- target list

- background list

The cued measurements from the advanced EMI sensor go into the target anomaly or background databases and the Target list is where the sensor parameter information and QC results for each target are summarized. The initial flag locations of the cued measurements are also merged into the target list database.

Once imported the data are inspected and assessed against the measurement quality objectives (MQOs) provided in QAPP Worksheet #22 for:

- Transmit (Tx) current within limits
- Global positioning system (GPS) fit quality
- valid inertial measurement unit (IMU) data
- EMI response signal not saturated
- Distance of sensor array to flag location

3.2. Background Corrections

Background corrections are used to remove the self-signature of the advanced sensor system and the soil response from the measured anomaly data. Background measurements are taken at locations selected from the detection survey data set. Prior to utilizing these locations for background measurements, they need to be verified to be devoid of metal. Additionally, each background measurement needs to be verified as suitable prior to using it for background correction of the target measurement data.

3.2.1. Background Location Verification

Each background location is verified by comparing a set of measurements taken at the intended location: one measurement at the location and one more with the sensor offset by ½ sensor spacing in four orthogonal directions. Next, the forward model of the most challenging target of interest / depth scenario is added to the center background measurement and the background is verified by separately subtracting each of the 4 offset backgrounds and performing a library match to the target of interest. The background location is considered valid if the surrounding background measurements are collected within ½ sensor offset (±50%) of the center background, the ratio of the TOI amplitude to background is greater than the project threshold and/or the library match from all 4 offsets exceeds 0.9. This process is automatically performed and the metrics are calculated using the purpose-built tool “Background Location Validation Test” in UX-Analyze. The tool generates images and a spreadsheet tabulating the metrics for each background location to be presented in a background summary report. A database containing the only the background locations that passed the test is generated for use to test subsequent background measurements.

3.2.2. Background Measurement Verification

Individual background measurements must be verified prior to their use for background corrections. The purpose-built tool "Calculate Background Database QC stats" is used to compared to the initial background verification measurement at the same position and verified as qualitatively similar. This tool performs the following calculations for each background measurement:

i. finds the closest verified background location and verifies its location is within ½ sensor width
ii. calculates the amplitude percent difference to the closest verified background location
iii. calculates statistics of all backgrounds at the same location

The sensor width parameter referred to above is stored in the uxa.config file. The default configuration file is stored in \Geosoft\Desktop Applications 9\etc and the user edited file should be stored in \Geosoft\Desktop Applications 9\user\etc. Under the section "calculate background data qc stats" a "sensorWidth value" is listed for current sensors and should be changed accordingly to meet the value listed in the project QAPP.

Using UX-Analyze's decay plot utility, all the background measurements for each background location are overlain and inspected. Based upon the quantitative metrics output and a qualitative assessment of the results, backgrounds showing a significant variation between measurements are rejected. These images will be saved and presented in a background summary report. Invalid measurements will be removed from background database to ensure that they are not used.

3.2.3. Background Corrections

Background corrections are applied using a purpose-built tool in UX-Analyze that automatically finds the closest background (chronologically and spatially) and will only apply the background corrections that were collected within a preset time limit relative to the target measurement. This preset time limit will be set to 2 hours. The background corrected data are stored in a separate channel. This leveled data channel is submitted to the inversion processes to derive target features. This data channel will not be populated for those target measurements that do not have a suitable background measurement within the 2 hour time limit. A report is automatically generated from the software that tabulates the target measurements that do not have a suitable background measurement.

3.3. Function Test Measurements

Function test measurements (described in SOP 1) are performed in conjunction with the background measurements to confirm that all transmit and receive components of the advanced EMI sensor are operational. These data are background corrected, then the monostatic components are compared to a benchmark set of values to confirm that all components are fully operational. This comparison is performed in the field and the results are provided in real time. The data processor should use the purpose-built tool in UX-Analyze to verify and log the results for QC/quality assurance (QA) purposes.

3.4. Target Feature Estimation

After background corrections are applied, intrinsic and extrinsic features are estimated for the target anomalies as well as the daily QC measurements collected at the IVS.

N-dipole target inversion routines in UX-Analyze are 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 (principal axis polarizabilities) related to the object size shape and composition. The intrinsic parameters, otherwise known as betas (β) are used for classification.

The "N" in the N-dipole solver indicates the number of sources the solver presupposes. The default setting is to run 1, 2, and 3 source solvers for each cued measurement. The number or sources can be increased if ground truth, training data or other information suggests the 3 source model is insufficient to extract accurate target parameters. A separate fit coherence value is derived for each solution and can aid in this determination. Model results will only be used for classification if they pass the MQOs identified to confirm that they support classification (QAPP Worksheet #22).

3.5. Daily IVS Survey

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 SOP 2). These measurements are processed as described above and the derived features are assessed against the MQOs presented in WS #22. These results are documented and summarized in a QC report to be generated for each delivered prioritized list.

3.6. Classification

Classification of targets will be based upon objective, numeric criteria. Using these criteria, a prioritized list is created with high likelihood target of interest (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 of the list. The primary method for classification will be library matching, supplemented by cluster analysis and feature space analysis.

3.6.1. Library Matching

Classification is based primarily on the goodness of fit metric (values from 0.0 to 1.0) generated by UXA during a comparison of the β values estimated for each surveyed target and the β values in the munitions library developed for the project. This comparison is performed via the library match utility in UX-Analyze. The goodness of fit metric is a measure of the amplitude and shape mismatch between a target and the library entry that best fits that target, with higher values indicating a better match between the target and the corresponding item in the library. The library fit analysis matches the following four combinations of βs to those of the candidate library TOIs:

- $\beta 1$, $\beta 1/\beta 2$, $\beta 1/\beta 3$
- $\beta 1$, $\beta 1/\beta 2$
- $\beta 1/\beta 2$, $\beta 1/\beta 3$
- $\beta 1$

The confidence metrics for each fit combination are averaged to derive a 'decision statistic'. This library matching process is performed on each source output from the N-dipole solver. For each flag position, the best decision statistic is used from all the sources to rank and classify the target list. Values below the analyst's threshold (nominally 0.85) are considered non-TOI.

A set of training digs are identified by the analyst. The intrusive investigation results of these digs as well as decision metrics derived for other known TOI (IVS and seed items) are used to finalize the analyst threshold.

3.6.2. Cluster Analysis/Feature space Analysis

Cluster analyses are performed whereby the clusters of anomalies with similar β signatures are identified using the self-match utility in UX-Analyze. For each identified cluster, a representative sample is intrusively investigated as part of the training data. If the intrusive investigation identifies a hazardous item, a representative signature is placed in the site-specific library and the matching process will be repeated to ensure that all similar items are classified as TOI.

Individual items that do not match any library items but have βs that indicate a large, axially symmetric, thick-walled object are identified and investigated as part of the training data and added to the library if they are identified as TOI.

3.6.3. Site Specific Munitions Library

A site-specific library of βs for candidate munitions items identified in the conceptual site model (CSM) will be used for classification. Intrinsic parameters for items listed in the CSM not confirmed to be in the existing library will be derived from test measurements prior to the start of the classification process if the items are available for test or the closest available item in size and shape will be used as a surrogate.

In addition to the comparison using the site-specific library, the cued polarizabilities will also be compared to a comprehensive library containing items not expected at the site. A sample of those cued targets that produce a high confidence match will be requested as training data. Representative signatures of any training targets that are identified as TOI will be added to the site-specific library.

3.6.4. Threshold Selection and Final Classification

The UX-Analyze tool to perform classification and ranking of targets allows for user input of selected thresholds and applies classification expressions to rank the targets. The classification expressions contain the logic for sorting the sources into a ranked target list. The initial expressions are provided with the UX-Analyze module and can be customized to best suit the project goals. Initial threshold selection values will be defined during preliminary library matching and cluster analysis and will incorporate system performance observed at the test pit and IVS. The stop dig point will be verified by ensuring the defined threshold encapsulates all QC seeds and TOI revealed during the training data verification.

All sources output from the N-dipole solver will be consolidated into a ranked list. For each flag position, the best decision statistic is used from all the sources to rank and classify the target list. If multiple sources at a flag position produce a decision statistic above the analyst's threshold, they are all kept if they are at unique locations. Classification decision plots displaying a size/decay plot, library match, decision rank plot, cluster plot and target parameters along with the target features database will be reviewed with the interactive classification tool by the data processor to refine the sorting of the prioritized target list. Further refinement of the analysis process may occur at this time, and details of the classification process will be documented in a target classification report.

3.6.5. Generate Prioritized Target List

A preliminary ranked list containing all anomalies will be delivered to the QC Geophysicist to determine if all relevant MQOs (including QC seed classification) have been met. Every investigated target will be included on the prioritized list and will be classified as TOI, non-TOI, or can't analyze and sorted based on their likelihood to be TOI. All targets in the can't analyze and TOI categories will be selected for intrusive investigation.

After the QC Geophysicist has performed all relevant checks and has provided feedback to the data processor, a final review of the ranked list will be performed to generate the prioritized target list.

The target classification report will include descriptions and values for all thresholds and classification expressions used to generate interim and final ranked target lists.

4. Data Management

4.1. Data inputs

The data inputs required for performing a cued advanced analysis data processing 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 sensor measurement data including those for target anomalies, daily IVS, backgrounds, and function tests
- digital field notes for all data collection activities
- site specific library signatures and/or test stand measurements of intended site specific library items

4.2. Data Outputs

The data outputs of the cued advanced analysis data processing for each delivered survey unit (contiguous subset of the survey site) are:

- QC report including documenting performance relative to QAPP Worksheet #22 for:
  - IVS results
  - function test results
  - background measurements
  - target anomaly measurements
- prioritized target list

- target classification report
- revised validation plan
- target measurement data, background measurement data, and target feature databases
- supporting documents for classification (PDF images)

5. Quality Control

The QC checklist to this SOP (ANJV QC application) will be filled out and delivered as part of the reporting requirement for this SOP.

The measurement quality objectives (MQOs) for cued target measurements are presented in Worksheet #22 of the 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.

6. Reporting

Reporting of the activities associated with this SOP will consist of:

- a QC Report detailing the system performance against the MQOs identified on QAPP Worksheet #22 (including MQOs for daily IVS and Function Test performance as well as for individual measurement metrics).
- a Classification Report detailing specific approach to classification including final library make-up, cut-off threshold, cluster analysis approach and results, and feature space analysis approach and results.

7. Revision History

03-13-17 Added 'Revision History' section to SOP.
01-03-18 Revised text to be suitable for advanced sensors in general and not specific to the TEMTADS and MetalMapper.
01-05-18 Added ANJV logo
03-22-19 Section 3.6.3. Removed requirement of asking a UXO Tech to validate the site-specific library
1-15-2020 DK review, no change
1-16-20 Added language describing the parameter used to set the maximum background location offset in Section 3.2.2
12/30/2020 DK review – no change
12/30/2021 DK review – no change
01/02/2023 DK review – no change

STANDARD OPERATING PROCEDURE 9

Recovered Item Verification

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.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following individuals will be involved in background correction:

- Project Geophysicist
- QC Geophysicist

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 & 8.

The following is a list of required equipment and materials:

- Oasis montaj with the UX-Analyze module activated
- results of the intrusive investigation to include recovery depths, photographs, and descriptions

3. Procedures 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 Item(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. These should agree to within 20 cm for a compact metal object. If the recovered item is irregular in shape both the predicted depth and measured depth have the potential for larger errors and greater differences will be acceptable in these cases.
2. Compare recovered item size to predicted size band. The project database in Oasis montaj will contain a predicted size for the item within three bands. Items defined as small will be the size of a 37-mm projectile and smaller, items defined as medium will be larger than a 37-mm projectile and smaller than a 105-mm projectile, and 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 1. If all three curves are different, then the object is predicted to be non-symmetric.

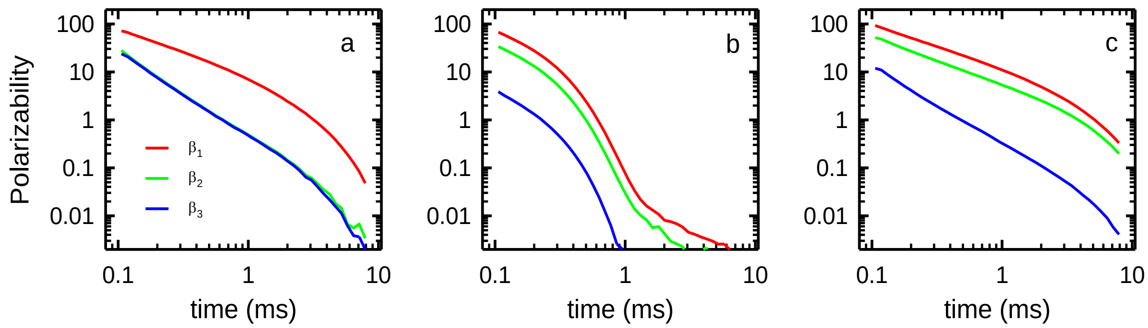

Figure 1. Examples of the polarizability decay curves for a variety of symmetric (or near-symmetric) objects. The curves in plot (a) depict a cylindrical object with one large response and two smaller, but equal responses. In addition, the polarizabilities decay slowly indicating a thick-walled object. 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 the comparison becomes much more difficult as the analyst needs to interpret the inversion results within the context of multiple sources. In addition to multiple sources, the presence of magnetic soil/rock significantly complicates the comparison process.

3.2. Resolution of a Mismatch

A few common causes for a mismatch between the recovered object and the analysis predictions are listed below. These include:

1. A small item is recovered from a shallow depth when the prediction is for a larger item more deeply buried. This may result 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 may result when the anomaly resulted from geologic interference or magnetic soils. In attempting to reproduce the measured anomaly, the inversion routine is driven toward a very deep large anomaly. This is especially true if the decision logic includes matches of the primary polarizability alone.
3. If a multi-stage classifier is used and some of the high confidence TOI classifications are not reasonably explained by the recovered source(s), then at least some, if not all, of the unrecovered sources will be intrusively reinvestigated to confirm or refute the excavation process.

Any other mismatch 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.

4.1. Input Data Required

The analysis predictions for depth, size, and shape are contained in the project database in Oasis montaj. The parameters of the recovered items are contained in the intrusive results file.

A review of intrusive results is required one month after digging begins or after sufficient dig results are obtained to access their completeness and applicability to the project goals. For projects with short durations this review may be done after only a day or two of intrusive survey efforts. The data review will be performed by the QC Geophysicist, UXOQCS and dig team leaders. Items to be discussed include data deliverables (e.g., project-specific terminology, records, photographs, methodology, CONOPS, timing).

4.2. Output Data

The resolution of any mismatches between the recovered items and analysis predictions will be documented in an Analysis Verification Report to be submitted by the Project Geophysicist.

5. Quality Control

QC consists of performing the inspections on the Recovered Object Verification Checklist (ANJV QC application). This checklist will be completed by the QC Geophysicist and will be reviewed by the Project geophysicist who will document the implementation of this SOP in the Geophysics Daily QC Report. Approval from the Project Geophysicist or Technical Manager is required prior to delivering the QC Geophysicist's review to the Project Team.

Although not a requirement in the government approved QAPP templates, the optimal method for clearing an AGC target excavation is to collect AGC data, with infield confirmation inversion, after removing targeted and classified source material. This preferred method is only a recommendation and the method employed by a project will be defined in the final project specific QAPP.

The measurement quality objectives (MQOs) are presented in Worksheet #22 of the QAPP.

6. Reporting

Achievement of the Recovered Object Verification MQOs (see QAPP Worksheet # 22) will be documented by the QC Geophysicist by completion of the QC Checklist in Attachment 1 to this SOP.

7. Revision History

3-13-17 Added 'Revision History' section to SOP.
1-5-18 Added ANJV logo
1-15-2020 DK review, no change

12/30/2020 DK review – no change
05/14/2021 Added text to the depth comparison procedures in section 3.1
1/8/2022 DK review – added clarification for sections 3.1 and 3.2 regarding comparison of dig results to derived polarizabilities.
9/19/2022 Added new requirements in sections 3.2, 4.1 and 5 regarding review and valuation of intrusive data.
11/22/2022 DK Clarified language to state that the QC Geophysicist's review consists of data review and verification rather than field level observations
01/02/2023 DK review – no change

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ADVANCED GEOPHYSICAL CLASSIFICATION

STANDARD OPERATING PROCEDURE 10
Validate Classification Process

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 TOI have validated the ability of the analyst to correctly classify 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.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following individuals will be involved in background correction:

- Project Geophysicist
- QC Geophysicist
- Data Analyst

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 & 8.

The following is a list of required equipment and materials:

- Oasis montaj with the UX-Analyze module activated
- results of the intrusive investigation for the validation items to include recovery depths, photographs and descriptions

3. Procedures and Guidelines

The site team will choose a number of items (to be specified in Worksheet # 22 of the 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 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.

3.2. Excavate the Anomaly

In parallel with the 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 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.

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

The comparison of the recovered items and analysis predictions will be documented in a Validation Report to be submitted by the Project Geophysicist.

5. Quality Control

QC consists of performing the inspections on the Validation Checklist (ANJV QC application). This checklist will be completed by the QC Geophysicist and will be observed by the Project geophysicist who will document the implementation of this SOP in the Geophysics Daily QC Report.

The measurement quality objectives (MQOs) for this SOP are presented in Worksheet #22 of the QAPP.

6. Reporting

Achievement of the Recovered Object Verification MQOs (see the MQOs Worksheet #22) will be documented by the QC Geophysicist by completion of the QC Checklist in Attachment 1 to this SOP.

7. Revision History

3-13-17 Added 'Revision History' section to SOP.

1-5-18 Added ANJV logo

1-15-2020 DK review, no change

12/30/2020 DK review – no change

12/30/2021 DK review – no change

01/02/2023 DK review – no change

STANDARD OPERATING PROCEDURE 11
Assemble the RTK GPS Positioning System

1. Purpose and Scope

The purpose of this Standard Operating procedure (SOP) is to identify the means and methods to be employed when assembling Global Positioning System (GPS) positioning systems and verifying that all components are correctly assembled, operating normally, and can acquire data of sufficient quality.

Multiple GPS systems and service providers offer technologies capable of creating RTK data. We use, as an example system below, the Trimble R8 Real Time Kinematic (RTK). Additional materials can be found in the Trimble R7/R8 GPS Receiver user manual that is included in ANJV's online portal in the Document/External Documents folder.

User manuals for Trimble R10 GNSS Receivers, Trimble R12 GNSS Receivers, and Trimble RTX Correction Services are also included in ANJV's online portal (Document/External Document folder). Information for the Parker LORD 3DM-GQ7 sensor can be found at:

https://s3.amazonaws.com/files.microstrain.com/GQ7+User+Manual/Home.htm.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following individuals will be involved in the assembly and verification of the RTK GPS:

- Field Team Leader
- Quality Control (QC) Geophysicist
- Project Geophysicist
- Data Processor

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 & 8.

The following is a list of required equipment and materials:

- DAGCAP approved AGC sensor
- Trimble R8 RTK GPS survey system (or alternate) and Inertial Measurement Unit (IMU) for orientation measurements
- Method to measure the height of GPS base antenna

3. Procedures and Guidelines

Procedures for setting up a Trimble R8 system with base station are highlighted below. Procedures for Trimble R10 and R12 systems are similar and described in detail in their respective user manuals.

The Trimble R8 system operates with a base station and rover units. To overcome atmospheric distortion of satellite signals the systems utilize a base station receiver and antenna affixed to a known monument tethered to a TDL 450 radio providing real time corrections to the rover receiver via 1 Hertz (Hz) interval. The Trimble base station should be anchored on a fixed monument, either provided from professionally surveyed positions or established through the collection of raw observables over user defined time increments and corrected in conjunction with established Continuously Operated Reference Station (CORS) data. The R8 base station calculates the specific distortion, and the rover unit receives these measurements, which combined with the rover's internal receiver produces accuracy that meets or exceeds the requirements for digital geophysical mapping or other location measurement capabilities.

The Trimble R10 and R12 receivers can utilize RTK corrections broadcast via satellite, the internet, or cellular services. Two example services include Trimble RTX and Parker LORD SensorCloud technologies.

3.1. Assemble the RTK GPS – Trimble R8 example

All instruments will be assembled and calibrated (where required) as specified in their User Manuals.

Trimble R8 and TDL 450 configuration and data storage utilizes the Trimble TSC2 controller operated via a wireless Bluetooth communications port or serial connection to laptop computer or other task specific data logger. The assembly steps are briefly described below:

1. The base station and TDL 450 radio are setup and positioned according to the Trimble R8 manual in areas affording unobstructed views of the sky.
2. The base receiver is securely anchored on a tripod, leveled via bubble sight, and accurately positioned over the known base ground mark with the center leg, plum bob, or borehole sight.
3. The base height is calculated either based on the fixed tripod's known measurements or manually measured from the benchmark to the antenna.
4. A rechargeable removable battery provides up to 5 hours of receive/output availability with additional external power input through the "Y" 7-pin data/power cable sourced from Trimble battery packs. The TDL 450 receives corrections to be transmitted through the "Y" 7-pin radio connector port attached to the base receiver and is externally powered by a 12V deep discharge deep cycle battery, ensuring operation for the duration of the field day.
5. User can select low power output (2W) or up to 35W for higher power and increased range; lower settings preserve battery life. The TDL 450 can be configured to broadcast on user-selected bands from 450 MHz – 470 MHz dependent on site conditions and FCC licensing.
6. The rover unit receives power from an interchangeable, rechargeable, removable Lithium-Ion battery and receives corrections via the internal integrated 450 MHz data link radio. The rover can be mounted on a rigid field staff for surveying activities controlled through the Trimble TSC2 controller or configured to output user selected positional data streams for capture on field data loggers such as during Digital Geophysical Mapping (DGM) activities.

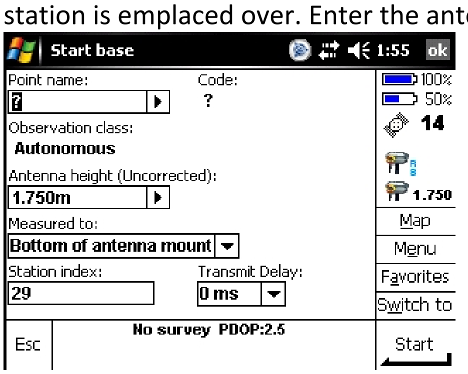
3.2. Turn On and Configure the GPS Base Receiver – Trimble R8 example

The following steps are followed to Start the Trimble GPS base receiver.

1. Turn on the Trimble base receiver and TDL 450 Radio by depressing the labeled power buttons. Green indicator light will flash then remain lit to indicate power. The power LED on the Trimble 450 indicates power when lit. Both the Trimble and TDL 450 power indicators will flash to

indicate low power supply when applicable. Turn on the Trimble TSC2 controller and start the Survey Controller program. Connect to the R8 base receiver via the Bluetooth connection port accessed under Configuration on the main menu. Alternatively, a cable can be connected to the appropriate port on the TSC2.

2. From the main menu select Configuration, Survey styles, RTK and select Base options. User is prompted to select the Base options specific for the base equipment and job site conditions on three separate sub menus. Enabling Tracking of L2e, GPS L2C, and GLONASS in conjunction with an R8 rover unit will allow the maximum number of corrections to be received and provide the highest accuracy for field activities under the most physical limitations, i.e. canopy cover or other obstructions.
3. From the RTK submenu under Survey styles select Base Radio and under Type select Trimble TDL 450. Select Connect to configure Base Radio settings and follow onscreen directions if prompted. Note that most TDL 450 functions and configuration can also be accessed via the LED menu located on the front of the unit at any time. Note that Frequency should be selected based on known clear channels that will not interfere with other base systems in the vicinity and that are unlikely to be utilized by other activities that would conflict with the TDL 450's ability to transmit a strong clear signal.
4. From Survey select RTK… and Start base receiver. Point Name refers to the monument the base station is emplaced over. Enter the antenna height into the appropriate field.



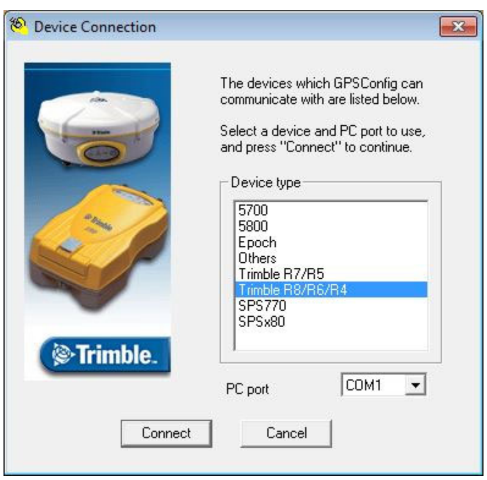
The Tx LED on the Trimble TDL 450 will flash approximately once per second indicating signal transmission. If the Rx LED is blinking or on continuously, a source of interference may be affecting the radio's ability send data, and a new transmission frequency may be required.

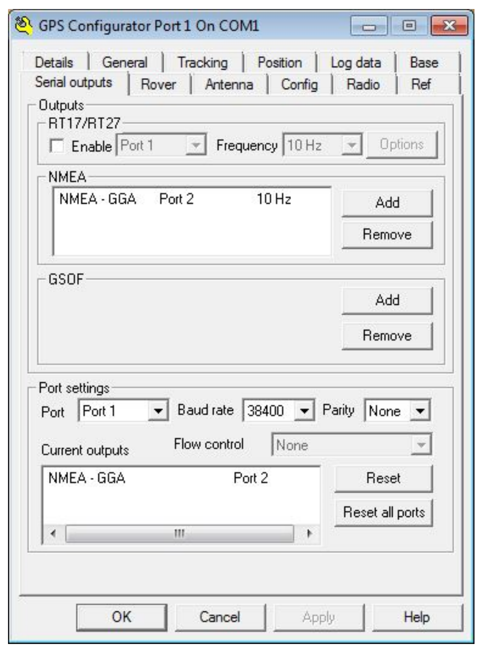
3.3. Turn On and Configure the GPS Rover Receiver – Trimble R8 example

The following steps are followed to Start and configure the GPS rover receiver.

1. Power on the rover unit by depressing the green power indicator on the unit face, the temporary green flashing LED to steady indicates power, and will resume flashing upon battery depletion. Connect the TSC2 to the Trimble rover receiver via the Bluetooth or cable. All main menu data will reflect settings received from the rover unit.
2. From the main menu select Configuration, Survey styles, RTK, and select Rover options. Note that Antenna Type is set to the corresponding antenna (with the R8 the antenna is set to R8 GNSS/SPS88x) and Tracking enables L2e, GPS L2C, and GLONASS, identical to the R8 base receiver settings. Select the same satellite types and settings as were selected on the base receiver.

3. From the RTK submenu under Survey styles select Rover radio. Connect to the rover radio ensuring that Type is Trimble internal and Method is Trimble 450/900. Note that Frequency must be identical to the frequency selected for the base and TDL 450 radio to receive the proper corrections. Base radio mode is set to TT450s at 8000 bps for use with the R8. The Trimble base receiver and rover receiver must have matching protocol and baud rates.
4. From Survey select RTK… and Start Survey. Survey Controller will initiate a new survey and display the quality at the bottom of the screen. It is important to ensure that the rover has achieved a Fixed position before commencing any DGM or surveying activities as this will create the highest quality of location data. Autonomous mode or Float indicates that the rover is not receiving enough corrections or clear radio transmission and should be corrected before proceeding, often by moving out from under canopy or away from obstructions that may limit the receiver's view of the sky. There is also the possibility that the base receiver has not been placed in a clear position and is not receiving corrections required to initiate a fix. The TSC2 controller will audibly and visibly indicate poor PDOP, satellite reception, or radio link.
5. Software utilized for the collection of geophysical data requires National Marine Electronics Association (NMEA) GGA global positioning system fix data. The Trimble rover receiver must be configured to ensure the serial output is capturing the correct positioning data for DGM. Trimble's GPS Configurator or Configuration Toolbox software allows a serial connection through the serial port on a laptop computer to input the desired settings. From the start screen select the Trimble corresponding receiver from the list and appropriate COM for the rover receiver.





6. Select the Serial outputs tab. The user must select Add from the NMEA Outputs window then select Type, Port, and Frequency from the Add NMEA outputs box. Refer to the specific geophysical instrument User Manual for recommended settings. The user also has the ability to Remove previously store outputs by selecting Remove from the Outputs on the Serial outputs tab. Select Apply to store the settings before continuing or exiting.

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

Input data consists of the assembly and operation instructions for the RTK GPS and the coordinates of a fixed monument to be used as the base station location.

4.2. Output Data

Errors in the GPS system are monitored at the fixed (and known) base station, and a series of position corrections are computed. The messages are sent through a radio link to the rover receiver, where they are used to correct the real-time positions of the rover. The RTK GPS data will be saved as part of the AGC-systems data over the IVS and survey area. Also, the base height used during setup will be recorded.

5. Quality Control

The field team will perform a GPS QC check at a surveyed monument every time the GPS base station is setup or moved during the workday. Performance of the required QC checks will be documented by the Field or Project Geophysicist (ANJV QC application). The QC Geophysicist will verify and document successful completion of the procedures in the Geophysics Daily QC Report.

The measurement quality objective (MQO) (QAPP Worksheet #22) for this SOP is verification that the assembly and configuration instructions have been followed. The IVS data (see SOP 2) will be used to observe the location accuracy of the predicted IVS items. Should an issue be detected (such as a data trend indicating a MQO limit is being approached) or a MQO is not met, a comprehensive root-cause analysis will be performed, and a corrective action determined.

6. Reporting

Achievement of the RTK GPS Assembly MQO will be documented by the Field or Project Geophysicist by completion of the QC Checklist in Attachment 1 to this SOP and will be verified by the QC Geophysicist.

The QC Checklist will be completed by the Field or Project Geophysicist each time the GPS base station is assembled during the production survey and a copy of these completed checklists will be included with the Classification Project Report at the end of the project.

The field geophysicist/technician will measure the location of a known point and compare the result to the actual location (ground truth). Offsets less than 10 cm will satisfy the MQO. This check will be performed daily after starting the base station, storing the recorded point identified with the date in the field log.

7. Revision History

3-13-17 Added ‘Revision History’ section to SOP.

1-5-18 Added ANJV logo
6/19/19 Modified language in Section 5 to explicitly require a QC check at a surveyed monument following each base station setup/move.
1-15-2020 DK review, no change
12/30/2020 DK review – no change
12/30/2021 DK review – no change
01/02/2023 DK review – no changes
03/03/2023 DK -added text and user manual references for R10, R12, RTX, and SensorCloud technologies.

STANDARD OPERATING PROCEDURE 13

Recording data for AGC Intrusive Investigations

1. Purpose and Scope

The purpose of this Standard Operating procedure (SOP) is to identify the means and methods to be employed when recording data for Advanced Geophysical Classification (AGC) intrusive investigations. This procedure is intended to ensure enough data is recorded to validate and verify the classification process. In the event of discrepancy, the project specific work plans will take precedent over this SOP.

2. Personnel, Equipment and Materials

This section describes the personnel, equipment and materials required to implement this SOP.

The following individuals will be involved in recording data for AGC intrusive investigations:

- Site Manager
- SUXOS
- UXOSO/UXOQCS
- UXO Tech III
- UXO Tech I or II
- QC Geophysicist
- Data Analyst

The qualifications of the personnel implementing this SOP are documented in the QAPP Worksheet #4, 7 & 8.

The following is a list of required equipment and materials:

- Excavation tools
- White board with visible ruled markings to document the sources recovered during the intrusive investigation of an anomaly
- Measuring tape
- Metal detector
- GPS or RTS unit to record locations of recovered sources
- Digital camera

3. Procedures and Guidelines

Anomaly locations will be investigated using the excavation procedures outlined in Intrusive investigation SOPs. Once the source(s) of an anomaly has been identified, the following information will be documented. Excavations must continue until all metallic source within a volume twice the size of the XY and Z tolerances specified in Worksheet #22 of the QAPP is resolved or the recovered item is comparable to the predicted item's size and depth. For example, if the allowable XY distance is 25 cm and allowable Z distance is 20 cm, the hole should be cleared XY to 50 cm radius and SourceDepth+40 cm in Z. The intrusive data listed below will only be collected if the information can be collected in a safe manner.

Target ID – Record the target (anomaly) ID which consists of the Grid (Geo) ID and Flag (location) ID and optionally the Source ID. The target ID is generated during the AGC process by the data analyst.

Grid ID - Record the Grid (Geo) ID

Flag ID – Record the flag (location) ID

Recovered ID – Each item recovered from the same hole will have a unique ID. If only one item is recovered the ID will be the same as the Target ID. If multiple items are recovered, they will be differentiated by using an alphanumeric character (a, b, c) suffix. When the intrusive investigation uncovers multiple contacts, all recovered TOI will have a separate entry in the spreadsheet. The next largest sized items will also be tabulated until the total recovered items reaches five. All other items may be documented in the spreadsheet using terminology such as "pile of nails" or "frag pit".

Quantity – Number of items recovered.

Dig date – Record the date of the intrusive investigation.

Measured item Location – Record the location of the recovered item.

- Center a hoop, with a radius equal to the XY tolerance specified in Worksheet #22 of the QAPP, around the predicted location
- If the recovered item is inside the hoop document the measured XY location as "< XY tolerance" and substitute "XY tolerance" with the actual number.
- If the recovered item is outside the hoop measure and record the offset and direction of the item. The direction should be estimated using a compass and entered using one of the eight principal winds (N,NE,E,SE,S,SW,W,NW).
- The depth of the recovered item should be estimated and recorded using the following bins; <3", 6", 12", 18", 24", 36", >48" or <.05m, .15m, .3m, .45m, .6m, .9m, >1.2m if using metric.
- Alternatively, a digital spatial positioning system capable of centimeter level accuracy can be used to document the location of each recovered item.

Raw as shot spatial positioning sensor data – Data that is directly downloaded from the spatial positioning data acquisition system that was used to guide the intrusive dig teams to the predicted location.

Post Excavation Response (optional) – Record the sensor response after excavation and ensure it is close to the background response and no other items remain. Note if remaining response is due to other nearby sources.

Dig Type – Record the dig type of the recovered source using one of the following options

- MEC (munitions and explosives of concern)
- Seed
- MD (munitions debris)
- SAA (small arms ammunition)
- OD (other debris)
- NC (no contact)

Description - Describe the recovered items using consistent nomenclature so that similar types of items will group together when the spreadsheet is sorted by this field. If possible, include the specific munition type and model.

Size – Record the size of the recovered item as small, medium or large. Where small is equivalent to a 37mm or smaller, and a large equates to a 105mm and larger, and medium is anything between small and large.

TOI – A true/false entry indicating if the recovered item is a target of interest. This column is optional and should be discussed with the dig team prior to intrusive activities.

Photo – Record the name of the photo associated with the recovered items (see example below). The digital photograph should include all items found at the location in front of a whiteboard that shows the flag number in the upper left-hand corner and marks or grid lines spaced 5cm (2inches) along the bottom (no labels, no rulers, just equally spaced lines). Camera resolution settings should be used that result in an image that clearly shows the item and recorded data with a file size of approximately 300KB. The file size recommendation is optional but proves useful when transmitting the data from remote locations.


Grid: F6D1H2
Date: 25JAN21
Anomaly ID: 3803108
5cm
01/25/2021

Documentation Examples

Single Source item

Documentation of a single item inside the hoop.

Target ID	Grid ID	Flag ID	Recovered ID	Dig date	Predicted Easting (UTM,m)	Predicted Northing (UTM, m)	Quantity	Location Offset (m)	Direction	Depth (m)	Pre-Dig Response (mV)	Post Excavation Response (mV)	Dig Type	Description	Size	TOI	Photo
Test_1	Test	1	Test_1	23-Jul-12	635455.02	3939072.46	1	<0.25	N/A	0.15	8.00	0	SEED	37mm projectile	small	TRUE	Test_1

Single Source item

Documentation of a single item outside the hoop.

Target ID	Grid ID	Flag ID	Recovered ID	Dig date	Predicted Easting (UTM,m)	Predicted Northing (UTM, m)	Quantity	Location Offset (m)	Direction	Depth (m)	Pre-Dig Response (mV)	Post Excavation Response (mV)	Dig Type	Description	Size	TOI	Photo
Test_2	Test	2	Test_122	23-Jul-12	635455.02	3939072.46	1	0.45	NE	<0.05	8.00	0	SEED	37mm projectile	small	TRUE	Test_2

Multiple Source Items

Documentation of multiple items inside the hoop.

Target ID	Grid ID	Flag ID	Recovered ID	Dig date	Predicted Easting (UTM,m)	Predicted Northing (UTM, m)	Quantity	Location Offset (m)	Direction	Depth (m)	Pre-Dig Response (mV)	Post Excavation Response (mV)	Dig Type	Description	Size	TOI	Photo
Test_3	Test	3	Test_3a	23-Jul-12	635455.02	3939072.46	3	<0.25	N/A	<0.05	8.00	0	MD	Frag	small	FALSE	Test_3
Test_3	Test	3	Test_3b	23-Jul-12	635455.02	3939072.46	3	<0.25	N/A	0.15	8.00	0	MD	Frag	small	FALSE	Test_3
Test_3	Test	3	Test_3c	23-Jul-12	635455.02	3939072.46	3	<0.25	N/A	0.3	8.00	0	MD	Frag	small	FALSE	Test_3

No Source Identified

Documentation of a "No contact".

Target ID	Grid ID	Flag ID	Recovered ID	Dig date	Predicted Easting (UTM,m)	Predicted Northing (UTM, m)	Quantity	Location Offset (m)	Direction	Depth (m)	Pre-Dig Response (mV)	Post Excavation Response (mV)	Dig Type	Description	Size	TOI	Photo
Test_4	Test	4		23-Jul-12	635455.02	3939072.46	0				8.00	0	NC	No contact			Test_4

Shared Source

Documentation of a "Shared source".

Target ID	Grid ID	Flag ID	Recovered ID	Dig date	Predicted Easting (UTM,m)	Predicted Northing (UTM, m)	Quantity	Location Offset (m)	Direction	Depth (m)	Pre-Dig Response (mV)	Post Excavation Response (mV)	Dig Type	Description	Size	TOI	Photo
Test_5	Test	5	Test_5	02-Aug-12	635467.84	3939085.59	1	<0.25	N/A	<0.05	8.00	0	MD	Frag same as Test_6)	small	FALSE	Test_5
Test_6	Test	6	Test_6	02-Aug-12	635467.8	3939085.57	1	<0.25	N/A	<0.05	8.00	0	MD	Frag (same as Test_5)	small	FALSE	Test_6

4. Data Management

The following sections describe the data that is needed to perform this SOP.

Input Data Required

The list of anomalies chosen by the site team to excavate is the input to this SOP.

Output Data

A spreadsheet documenting the location and physical attributes of all recovered items. Digital photographs of each of the items will accompany the spreadsheet.

5. Revision History

5-13-2019 Initial release.
6-10-2019 Added language in Section 3 describing search criteria for excavation operations
6-20-2019 Added statement to the TOI entry (page 3 of 8) making it an optional dig team entry
1-1-2020 DK review, no change
1-15-2020 TF Added language in Section 3 describing search criteria for excavation operations
10-7-2020 TF Changed the information required for AGC Intrusive investigations.
12/30/2020 DK review – no change
02-26-2021 DK Added a photograph example
12-30-2021 DK review – no change
09-19-2022 Added a) requirement to receive raw as shot spatial positioning sensor data and b) option to locate each recovered item using a spatial positioning system.
01/02/2023 DK review – no change

APPENDIX E
RESPONSES TO COMMENTS

RESPONSES TO COMMENTS

Document:	Draft Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume II Munitions Response, Appendix B Advanced Geophysical Classification Addendum, July 2023
Commenting Organization:	United States Environmental Protection Agency (EPA)
Name:	Maeve Clancy
Date of Comments:	August 28, 2023

General Comment 1:

The reasons why some of the non-target of interest (non-TOI) anomalies will not be investigated to (a) evaluate whether the advanced geophysical classification (AGC) was done correctly; and (b) ensure that the library being used for classification contains all of the munitions types present at each site, are unclear. Step 2, Identify the goals of the project, in Section 2.2, Project/Data Quality Objectives (QAPP Worksheet #11), page 29, states that TOI and items classified as Inconclusive will be investigated, but non-TOI will be left in place. If some of the non-TOI are not investigated, it may not be possible to meet the project data quality objectives (DQOs). Please revise the AGC Addendum to recommend investigating a percentage of the non-TOI or to explain in detail why this is unnecessary.

Response to General Comment 1:

Comment acknowledged. Data validation procedures, which include the investigation of non-TOI anomalies, are discussed in Section 4.5: "Data Validation Procedures (QAPP Worksheet #36)" and Appendix D (Advanced Geophysical Classification Validation Plan), which are unchanged in the AGCMR-QAPP Addendum and therefore not included with this submission. The AGCMR-QAPP dated August 2016 (Administrative Record #: OE-0868B) remains available in the Fort Ord Administrative Record and will be added to Section 5.0 References of the ACGMR-QAPP Addendum. WS #36 and Appendix D document in detail the procedures that will be used to validate the overall anomaly classification approach and to provide confidence in the ability of the sample design to correctly classify anomalies to distinguish between TOI and non-TOI. Details are included for testing the process through blind QC seeding, conducting threshold verification digs (including the excavation of additional anomalies classified as non-TOI), conducting validation digs, and validating anomaly source depth predictions.

RESPONSES TO COMMENTS

Specific Comment 1:

Section 2.2 Project/Data Quality Objectives (QAPP Worksheet #11), Step 4, Define the boundaries of the project, Pages 30 and 31: The Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4 (the DQO Guidance), dated February 2006, indicates that the Step 4 boundaries of the project should include temporal boundaries (i.e., the time over which the response will be conducted) and the lateral and vertical boundaries, but temporal boundaries were not specified. In addition, the text references Figure 2-1 (Site Location Map) for lateral boundaries, but this figure is missing from Appendix B. Please revise the AGC Addendum to specify the temporal boundaries of the project and provide the missing Figure 2-1.

Response to Specific Comment 1:

Comment acknowledged. This document is applicable to multiple projects and phases of work. A specific work date will therefore not be included in the document. The following text has been added to WS #11, Step 4: "There are no established temporal boundaries for the project other than the period of performance. However, restrictions due to biologic concerns, such as sensitive species and habitats, will be addressed by the Project Biologist prior to initiation of field activities. These concerns are addressed in the appropriate site-specific work plan."

Figure 2-1 is included in WS #10, which was unchanged in the AGCMR-QAPP Addendum and therefore not included with this submission.

Specific Comment 2:

Section 2.2, Project/Data Quality Objectives (QAPP Worksheet #11), Step 5, Develop the project data collection and analysis approach, Pages 31 through 33: All decision rules should be written in if…then format per the DQO Guidance; however, the decision rules under Detection Survey are not written in this format. In addition, (a) it is unclear if there are specific decision rules that will be used to guide the classification of targets as TOI, non-TOI, or inconclusive; and (b) no decision rules were included under the Intrusive Investigation subtopic. Decision rules in the "if…then" format should be provided for each subtopic under Step 5. For example, it is unclear how the decision will be made whether the stop-dig threshold was correct. This should be clarified using one or more decision rules. Please revise the text under Step 5 to provide specific decision rules to guide each decision that will be made.

Response to Specific Comment 2:

Comments acknowledged. The decision rules sections in Section 5 have been modified to the "if…then" format to conform with the DQO Guidance format.