INTERGOVERNMENTAL DATA QUALITY TASK FORCE

Uniform Federal Policy For Quality Assurance Project Plans

Munitions Response QAPP Toolkit

Module 1:
Remedial Investigation (RI)/Feasibility Study (FS)

Final, December 2018

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12/27/2018

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12/19/2018

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Frequently Asked Questions

1. The Munitions Response Quality Assurance Project Plan (MR-QAPP) introduces terms, approaches, and Quality Assurance (QA)/Quality Control (QC) requirements that are not consistent with EM-200-1-15. How does DoD plan to reconcile these differences?

Existing DoD guidance will be updated to be consistent with the MR-QAPP Toolkit.

2. The example illustrated in the MR-QAPP is complicated, and not representative of most munitions response sites. For smaller/simpler investigations, can the technical approach be simplified?

The MR-QAPP Module 1 makes use of a complex site in the example to illustrate technically sound approaches that could be applied to other similar sites. The example illustrated in the MR-QAPP Module 1 is a fictional munitions response area (MRA) based on an actual MRA (Camp Beale) for which range usage and configurations were altered multiple times during its use. There are many other formerly used defense sites for which this is the case. For this reason, the Intergovernmental Data Quality Task Force (IDQTF) MR-QAPP Subgroup decided Module 1 would provide the most useful guidance to the widest audience by illustrating its application to a complex site, where considerable uncertainty in the conceptual site model (CSM) exists at the end of the Site Inspection (SI). In the example, the first step of the Remedial Investigation (RI)/Feasibility Study (FS) process is to conduct a preliminary MRS characterization to locate and delineate high density (HD) and low density (LD) areas. This approach is flexible and not prescriptive. For smaller, less complex sites, where range usage and configurations are well documented at the end of the SI, this step may not be necessary, and the technical approach could be simplified by proceeding directly to the HD area characterization step.

3. The example depicted in the MR-QAPP Module 1 describes a phased process for implementing the RI/FS. How can this be accomplished using Firm-Fixed-Price contracts?

As stated in the updated green text (instructions) on Worksheet 9, “Figure 9-1 illustrates the use of a project-planning process for an RI conducted in phases, but it is flexible and should be modified as necessary based on contracting practices and project-specific requirements.“ A phased investigation is well-suited to large, complex MRS, as illustrated in the example, where uncertainty in the CSM exists at the start of the RI/FS. A phased RI/FS may not be necessary at simpler sites (See Frequently Asked Question (FAQ) #2 above). Firm-fixed price contracts can be successfully implemented for an RI/FS conducted in phases, if they include provisions to accommodate flexibility, such as firm-fixed unit-pricing or unfunded subtasks.

[Note to DoD personnel: DoD contracting personnel are strongly encouraged to include firm-fixed unit pricing or unfunded subtasks in requests for proposal (RFPs) to accommodate uncertainty in the pre-award CSM for large, complex sites, where it is likely that unforeseen field conditions could be encountered during project implementation.]

[Note to contractor personnel responding to RFPs: A phased approach to implementation of the RI/FS is the preferred approach for large, complex sites. You are encouraged to contact the contracting officer in cases where the RFP fails to accommodate sufficient flexibility (e.g., firm-fixed unit pricing or unfunded subtasks) to address risks inherent with uncertainty in the pre-award CSM.]

4. Worksheet 10 states that the CSM should be updated throughout the project lifecycle as new data are collected and knowledge of site conditions and exposure pathways changes. When and how should this be done?

The CSM is a description of a site based on existing knowledge, describing sources, receptors, and the potential interactions that link them. The CSM serves as a planning instrument, a modeling and data interpretation aid, and a communication tool to assist the project team in communicating with stakeholders and making informed decisions. For these reasons, it is important to keep the CSM up to date.

CSM development is an iterative process that reflects the progress of activities at a site. As each phase of data collection is completed, knowledge and understanding of the site will change, and the model used to represent that information should also change. An up-to-date CSM facilitates the identification of data gaps. For example, if the results from data collection confirm the predicted model, the CSM is updated to show that the hypothesis is correct. However, if results do not support the predicted outcome, it may indicate the underlying assumptions reflected in the CSM are incorrect and should be revised.

Figures 17-1 through 17-3 illustrate points in the process at which the CSM should be updated. Specific procedures for issuing and updating the CSM should be discussed and agreed to during project planning.

5. What is the basis for the seeding requirements as applied to analog technology?

Seeding is the only way to ***objectively*** assess the performance of analog technology. Analog data quality depends on human factors that cannot be measured, and no permanent electronic record (of either location coordinates or instrument response) is provided; therefore, no auditable decision record exists. The analog seeding requirements in this module represent a consensus among leading quality management experts, state and Environmental Protection Agency (EPA) experts in regulating munitions response actions performed by DoD, and DoD experts in geophysical and statistical methods applied to munitions response. These consensus requirements define testing frequencies and testing depth that attempt to minimize errors in environmental decisions based on analog data.

6. Please clarify the distinction between the high-use area (HUA) boundary and the buffer zone. What purpose does the buffer zone serve?

The boundary of the HUA area is the point at which, moving out from the center of the HUA, the anomaly density drops to background. The buffer zone, which is placed in the LD area around an HD area, accounts for uncertainty in determining the HUA boundary, providing a “buffer” between a HUA and any adjacent non-impacted area (NIA). The buffer zone will always be located in the LD area; that is, the anomaly density in the buffer zone will always be below the critical density. The dimensions of the buffer zone should be based on range usage data contained in the CSM and reflect uncertainty in the sampling design (e.g. transect spacing). Worksheet #17 provides examples of processes used to establish buffer zones for different types of targets at Camp Example.

7. In the example, why is no intrusive investigation being proposed in low use area (LUA) and NIA?

Once target areas (HUA) have been identified and mapped, in most cases, no meaningful purpose would be served by intrusive investigation in LD areas. Characterization of LD areas occurs following the characterization of high density (HD) areas, so boundaries for HUAs and buffer zones will already have been established. It is not practical to select a sample size large enough to prove that a LUA or NIA contains no munitions and explosives of concern (MEC), munitions debris (MD) or range-related debris (RRD); therefore, designation as a LUA or NIA must be made based on the strength of evidence in the CSM.

If the CSM contains evidence of munitions use or presence in a LD area, then it is a LUA. If the CSM contains sufficient evidence documenting no munitions use in a LD area, then it is a NIA. If the CSM contains data gaps (insufficient information to make those designations), those gaps should be addressed. It may be possible, for example, to characterize the types of debris present, if that information serves a particular purpose. The intended uses of all collected information should be explained in Worksheet #11.

8. The MR-QAPP Module 1 provides no guidance on conducting the baseline risk assessment. Why not?

Existing statutes and regulations (both the National Contingency Plan (NCP) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended require performance of a Baseline Risk Assessment. While procedures have long been in place for addressing chemical exposure, including munitions constituents, there still is no standard consensus process for performing a Baseline Risk Assessment (BRA) addressing exposure to MEC. The threats presented by MEC are different from those presented by chemicals/munitions constituents (MCs). MEC presents an acute hazard of direct physical injury resulting from the blast, heat, or fragmentation resulting from contact. The concept of chronic, long-term exposure does not apply to hazards posed by MEC. MC and Hazardous, Toxic and Radioactive Waste (HTRW), on the other hand, are contaminants which may present a risk to human health and the environment through both acute and chronic exposures.

Pending the development of consensus methods for assessing and quantifying hazards posed by MEC, project teams will need to develop site-specific approaches to assessing these hazards. The RI/FS module of the MR-QAPP aims to ensure the collection of the correct types of data needed to do so. These data elements, which include the facility profile, physical profile, release profile, and land use and exposure profile will allow project teams to evaluate MEC hazards in decision-making.

9. How will the document be released? How will training and outreach will be conducted?

As was the case for the Advanced Geophysical Classification – Quality Assurance Project Plan (AGC-QAPP), this document will be signed out as an IDQTF document. It represents the RI/FS Module of the MR-QAPP Toolkit. The IDQTF Munition Response Subgroup is planning on developing and delivering both web-based and classroom training to accompany the document.

10. Why is the feasibility study being included in the discussion of the data quality objectives (DQOs)? What decision rules are relevant to the FS?

Because the feasibility study is integrated with the remedial investigation, the data quality objectives need to consider what types of data will be required to permit the identification and evaluation of remedial alternatives, should they become necessary. In most cases, the presence of a HUA will require a formal decision-making process, and the feasibility study is an integral part of that process. The first decision rule relevant to the FS is mandated by the NCP; specifically, if the results of the baseline risk assessment indicate an unacceptable risk due to explosive hazards exists, or may exist in the future, a feasibility study will be conducted to develop and evaluate appropriate remedial alternatives for presentation to decision-makers and ultimately support remedy selection. CERCLA has established nine criteria for evaluating remedial alternatives, which are listed in Worksheet #11, Step 5, Section E.

11. How does my project team decide on a value for Expected Target Area Density Above Background needed when designing transects using the VSP Transect Spacing Planning Tool?

You will need to estimate two inputs used in this VSP tool: the background anomaly density and the target area anomaly density.

- The background anomaly density depends on geology and the non-munitions related use of the site.
- The target area density will be dominated by munitions fragments and will depend on the type and intensity of munitions use. Different types of munitions will produce different numbers and sizes of fragments that will travel different distances. In general, high explosive (HE) munitions will produce numerous small fragments for every round fired, whereas practice munitions typically remain largely intact.

Background and target area anomaly density values are both dependent on the detection system, including the sensor modality, the platform, and the target selection criteria. Most modern sensors are capable of detecting a substantial fraction of the near surface fragments that will be indicative of a target area. Sensors mounted on platforms that ride 10’s of cm above ground surface will detect fewer tiny metal objects than sensors deployed nearer to the surface.

Background anomaly density is estimated based on previous geophysical data for the area. If no prior geophysical data have been collected, you will need to make an educated guess about background density. The initial data collected should be used to evaluate whether the planning estimate was correct and it may be necessary to refine the VSP transect spacing if it proves to be inaccurate. In some cases, the background density may not be the same across the site. Based on previous experience and collected data across multiple sites, typical background values can be grouped into three categories for planning.

- Quiet – remote, not easily accessible, not frequently impacted by human activity: 10-50 anomalies per acre
- Moderate – impacted by human activity such as camping, hiking, ranching, agriculture: 50-150 anomalies per acre
- Noisy – severe geology, urban or industrial use – hundreds of anomalies per acre

Target area anomaly densities are typically modeled in VSP as bivariate normal distributions – that is the density falls off from a peak at the center in a normal (Gaussian) function in either a circular or an elliptical pattern. There are three ways to express the target area density in VSP – the peak at the highest density part (center) of the target area, the average density across the target area, or the density as the edge of the target area. Target area anomaly density should be conservatively selected to represent the smallest or lowest intensity use (i.e., lowest reasonable density) of concern at the site. Historical information can give some information about the munitions use and intensity. Records will often specify the scope of training or testing and the time span of use. Heavily used target areas will often have average anomaly densities above background of hundreds or thousands per acre, whereas lightly used targets may have average densities barely above background.

12. What are the critical inputs for the VSP transect analysis tool and how does my project team establish these values?

The VSP transect analysis tool identifies areas with elevated anomaly densities. The tool searches along each transect, calculating the anomaly density in a user-defined **search window** to flag segments where the density is either 1) above the background anomaly density, or 2) above a user-defined **critical anomaly density**. The critical anomaly density is the project-specific, user-defined value for anomaly density, inclusive of background, used to delineate high density (HD) areas from low density (LD) areas. The project team uses knowledge from the CSM, estimates of the background and expected target area anomaly density, and transect spacing to establish the initial window size and critical density.

The **window size** is dependent on the size of the target area of interest, transect width, and spacing between transects. The optimum window will aggregate a sufficient length on a transect to capture the local density without including such a large area that potential high-density areas can be masked by the surrounding low-density areas in the window. That is, if the anomalies are spaced every few meters along the transect, the window size needs to be large enough (likely tens to more than one hundred meters) to capture a sufficient number of anomalies to make an accurate density estimate. As a general rule, the window diameter should be less than the diameter of the target area of interest and no smaller than the spacing between adjacent transects.

The **critical density** should be set high enough to avoid flagging natural variations in the background density and low enough to flag the lowest target area density expected. Using a critical density that is set too close to background will flag nearly all anomalies as potential target areas. Using a critical density that is set too high will risk missing true target areas.

The sum of your Initial estimates of background and target area density can provide a starting point for analysis, but iteration will likely be necessary to reflect the true site conditions. During the analysis, the actual background density is calculated from the transect data using the “Geostatistical Mapping of Anomaly Density” tool. You can use the “Locate and Mark Impact Areas Based on Elevated Anomaly Density” tool to understand your site and explore various selections of background or critical densities. This tool allows one to visualize the flagged patterns on a spatial map and produce an anomaly density histogram. The flagged pattern can reveal if your critical density is marking single, spatially random points, indicating that you are likely capturing natural variations in background density. The histogram can show whether there are distinguishable background and target area densities and can guide the refinement of the critical density.

Acknowledgement

The Intergovernmental Data Quality Task Force would like to thank the members of the IDQTF Munitions Response Subgroup for their time and efforts preparing this document. Comprised of technical experts and stakeholders representing DoD, the Strategic Environmental Research Demonstration Program (SERDP), the Environmental Security Technology Certification Program (ESTCP), the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), and the states of Colorado and California, the Munitions Response Subgroup includes the following members:

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The IDQTF also thanks the members of the Munitions Response Dialog, including Ms. Deborah Morefield (DoD Co-chair), Mr. Doug Maddox (EPA Co-chair), and Mr. Steve Cobb (State Co-chair) for their support and gratefully acknowledges the National Association of Ordnance Contractors for their insights and many helpful comments and suggestions during the development of this document.

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Preface

The Intergovernmental Data Quality Task Force (IDQTF), Munitions Response Subgroup, has developed the Munitions Response Quality Assurance Project Plan (MR-QAPP) Toolkit to assist project teams in planning for the characterization and remediation of buried munitions and explosives of concern (MEC) at Department of Defense (DoD) installations and formerly used defense sites (FUDS) (collectively referred to as Munitions Response Sites (MRS)). The MR-QAPP Toolkit is based on requirements and guidance contained in the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP, IDQTF, 2005) and makes use of the Optimized UFP-QAPP Worksheets (IDQTF, 2012). It employs the systematic planning process (SPP) to illustrate scientifically sound approaches to characterizing and remediating MRS in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) as amended. Use of the Toolkit will help project teams plan data collection efforts and generate QAPPs addressing all elements of the national consensus standard ANSI/ASQ E4-2004, *Quality Systems for Environmental Data and Environmental Technology Programs.*

MR-QAPP Module 1: RI/FS (this document) illustrates approaches for planning and implementing the Remedial Investigation (RI)/Feasibility Study (FS) phase of investigation. The IDQTF plans to update and reissue the Advanced Geophysical Classification Quality Assurance Project Plan (AGC-QAPP) as MR-QAPP Module 2: RA, to illustrate approaches for planning and implementing the Remedial Action (RA). In both modules, green text provides instructions for completing each worksheet and blue text provides examples of the types of information typically needed.

Where applicable, minimum recommended requirements contained in worksheets are presented in black text. Defining the minimum, recommended quality assurance (QA) and quality control (QC) requirements (performance requirements) to ensure that data meet their intended uses is consistent with performance-based contracting mechanisms. They describe requirements for the successful outcome; they do not prescribe a particular process that must be followed. Project teams must provide the rationale for changes to black text, which are subject to regulatory review and acceptance. A convenient and efficient way to do this is to provide an appendix to the project-specific QAPP describing any changes and providing the rationale.

The blue text in Module 1 is based on a fictional site, “Camp Example”, based on an actual Munitions Response Area (MRA), for which range usage and configurations were altered multiple times during its use. The IDQTF MR-QAPP Subgroup decided Module 1 would provide the most useful guidance to the widest audience by illustrating its application to a complex site. The systematic planning process and data collection activities described in this example are conducted in phases, requiring planning steps and QAPP revisions between phases. A phased investigation is well-suited to a complex MRS where uncertainty in the preliminary conceptual site model (CSM) exists at the start of the RI/FS. The process of both QAPP development and project implementation are scalable, however, and may be simplified for smaller, less complex projects.

The technical approaches provided in Module 1 make use of both digital and analog geophysical technology, to illustrate the appropriate applications of each. These approaches are flexible and should be tailored to project-specific Data Quality Objectives. It should be noted, however, that the use of analog technology should be limited to applications where it is the only viable alternative (See Uses and Limitations of Analog Technology, which follows on page 5).

Perhaps most importantly, Module 1 illustrates the process for conducting the Data Usability Assessment (DUA), a critical component of data analysis and decision-making, which is conducted at the end of the investigation by key members of the project team. Module 1, Worksheet #37, provides a detailed example of the DUA for the fictional “Camp Example”.

Users of the MR-QAPP Toolkit must comply with any applicable State, Federal, and DoD Component-specific requirements, policies, and procedures.

Table 1. Crosswalk: Optimized UFP-QAPP Worksheets to MR-QAPP Module 1: RI/FS

Optimized UFP-QAPP Worksheets		**MR-QAPP Module 1: RI/FS**
1 & 2	Title and Approval Page	Included
3 & 5	Project Organization and QAPP Distribution	Included
4 , 7 & 8	Personnel Qualifications and Sign-off Sheet	Included
6	Communication Pathways and Procedures	Included
9	Project Planning Session Summary	Included
10	Conceptual Site Model	Included
11	Project/Data Quality Objectives	Included
12	Measurement Performance Criteria	Included
13	Secondary Data Uses and Limitations	Included
14 & 16	Project Tasks & Schedule	Included
15	Project Action Limits and Laboratory-Specific Detection/Quantitation Limits	Not applicable – No chemical testing being performed
17	Sampling Design and Rationale	Included – Title changed to “Survey Design and Project Work Flow”
18	Sampling Locations and Methods	Not applicable – No environmental samples being collected
19 & 30	Sample Containers, Preservation, and Hold Times	Not applicable – No environmental samples being collected
20	Field Quality Control (QC)	Worksheet not included – Field QC procedures are included on Worksheet #22
21	Field Standard Operating Procedures (SOPs)	Worksheet not included – SOPs are referenced on Worksheet #22
22	Field Equipment Calibration, Maintenance, Testing, and Inspection	Included – Title changed to “Equipment Testing, Inspection, and Quality Control
23	Analytical SOPs	Not applicable – No laboratory analysis being performed
24	Analytical Instrument Calibration	Not applicable – No laboratory analysis being performed

Table 1. Crosswalk: Optimized UFP-QAPP Worksheets to MR-QAPP Module 1: RI/FS

Optimized UFP-QAPP Worksheets		**MR-QAPP Module 1: RI/FS**
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	Not applicable – No laboratory analysis being performed
26 & 27	Sample Handling, Custody, and Disposal	Not applicable – No samples being collected
28	Analytical Quality Control and Corrective Action	Not applicable – No laboratory analysis being performed
29	Project Documents and Records	Included – Title changed to "Data Management, Project Documents and Records"
31, 32 & 33	Assessments and Corrective Action	Included
34	Data Verification and Validation Inputs	Included – Title changed to "Data Verification, Validation, and Usability Inputs"
35	Data Verification Procedures	Included – Title changed to "Data Verification and Validation Procedures"
36	Data Validation Procedures	Worksheet not included – Data validation is addressed in Worksheet #35
37	Data Usability Assessment	Included

Uses and Limitations of Analog Technology

Introduction: Over the past ten years, due in large part to efforts conducted under the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP), and supported by the Interstate Technology & Regulatory Council (ITRC), geophysical technology employed to permit the detection, classification, and removal of munitions and explosives of concern (MEC) at munitions response sites has matured and been successfully demonstrated. Available tools now include advanced geophysical sensor platforms, planning and data analysis software, and more accurate and reliable geolocation and navigation tools. According to The DoD/EPA Management Principles for Implementing Response Actions at Closed, Transferring, and Transferred (CTT) Ranges (March 7, 2000) "Rapid employment of the better performing, demonstrated technologies needs to occur."

Relevant Requirements: The DoD Information Quality Guidelines (February 10, 2003) prescribe policy and procedures for ensuring and maximizing the quality of information disseminated to the public by DoD. Specifically, the level of quality necessary for influential scientific data requires that such information ***be capable of being substantially reproduced.*** With regard to analysis of risks to health, safety, or the environment, the guidelines adopt the quality principles of the Safe Drinking Water Act (SDWA), which are to use:

- ***The best available, peer-reviewed science*** and
- ***Data collected by accepted methods or best available methods***

As further provided and explained in The DoD/EPA Management Principles, adequate characterization of ranges, which is necessary to make informed risk management decisions and conduct effective response actions, requires the following:

- A permanent record of the data including a clear audit trail of data analysis and resulting decisions and actions. ***Exceptions should be limited to emergency response actions or cases where impractical.***
- Selection of the most appropriate and effective detection technologies.
- Regulatory and public involvement when selecting the most appropriate detection technologies at a site.

Geophysical Detection Systems: EM 200-1-15 Chapter 6 provides a comprehensive description of the capabilities and limitations of various geophysical systems used to detect geophysical anomalies associated with targets of interest (TOI). The two principal sensor technologies used are electromagnetic induction (EMI) and magnetometer, both of which of which can be operated in either an analog or digital recording mode. The detection and location of TOI depend on the ability of the systems to distinguish the measured signals arising from TOI from those of the surrounding environment.

In 2005-2006, the ITRC, together with the SERDP, conducted a survey of existing studies to document the application and performance of munitions detection technologies available at that time, including magnetometer and EMI in both analog and digital modes. The study found that while both technologies are capable of detecting most munitions under typical site conditions, there are large variations in performance across demonstrators, even when using systems based around the same basic sensors. It further found that "digital geophysical mapping (DGM) generally achieved a higher probability of detection (Pd) and lower false-alarm rate than mag and flag. Across all technologies the report observed, "The ability of a system to achieve optimum performance is a function of both the capabilities of the detection technology and quality of its implementation. Real-world challenges such as terrain, geologic noise, overlapping signatures, surface clutters, variations in operator technique, target selection, and data processing all degrade from and affect optimum performance. Quality control and quality assurance programs are critical to achieving successful results with any munitions detection technology."

<u>Analog geophysical tools</u> produce an audible output, meter deflection, and/or numeric output, which is interpreted in real time by the instrument operator. Analog tools include handheld metal (EMI) detectors, and ferrous locators (magnetometers). The operator holding the sensor serves as the survey platform, positioning system, and data-processing system. UXO technicians have used analog tools ("Mag & Flag" or "Mag & Dig") for many years to screen areas for TOI and conduct clearance activities. When an anomaly is detected, the location is marked immediately by placing a small flag in the ground. Analog tools can be effective in certain applications because they provide real-time field observations, anomaly locations can be manually flagged at the time the signal is observed and excavated immediately following the survey, and there are few constraints due to vegetation or topography. Their use is limited by the following, however:

- Data quality depends on human factors that cannot be measured (including attentiveness/distraction and hearing ability).
- Decisions are made in the field based on the operator's judgment.
- The instrument response provides no information regarding the source of the anomaly; therefore, it is unable to distinguish munitions from non-hazardous debris or geology.
- The probability of detection, for munitions of concern, has been demonstrated to be between 50 and 72% (ITRC 2006).
- No permanent electronic record (of either location coordinates or instrument response) is provided; therefore, no auditable decision record exists.

<u>Digital geophysical tools</u> (DGM) measure the same physical properties but also digitally record and geo-reference data to measurement locations. All digital tools provide a permanent electronic record of the data, ensuring data reproducibility and permitting after-the-fact data analysis. Data can be interpreted immediately or at any time after data collection is complete. DGM instruments also include advanced EMI sensors that provide information on the physical attributes of the anomaly source, enabling the classification of anomalies as TOI or non-TOI. Their use is limited in areas where vegetation or topography limit access or impede the function of positioning systems.

Quality Considerations: The data recorded using DGM methods support a range of quality checks that can verify the quality of the overall data package, as well as the proper operation of individual components of the detection system; for example, (1) in the IVS, measured responses morning and evening consistent with known responses of previously characterized munitions or test objects verify sensor operation and correspondence of measured and known seed locations verify geolocation, (2) in field data, track files verify actual coverage is consistent with planned coverage and reveal any deficiencies, (3) locations and signals of seeds in field data verify ongoing performance of the system, (4) measures of battery strength and/or transmit current verify the sensor is operating within specifications, (5) anomaly selection criteria are quantitative and analyst adherence to specified criteria can be verified. These checks and others can be used to verify the system is in control throughout data collection and analysis operations.

None of the above quality measures can be applied to analog systems, constraining quality control and quality assurance options. In the absence of demonstrating that a system (and/or its components) is continuously in control with quantitative parameters, QC is limited to whether the system is detecting the items of interest. This approach requires extensive seeding to demonstrate that the system is operating as required throughout data collection operations, requiring that each system (i.e., operator) encounter and detect multiple seeds per day that represent the TOI. If the data are only to be used to identify the location of a high-density area, the TOI (and therefore the seeds) may be any metal object. However, if the data are ultimately to be used to estimate the site-specific performance of a technology in a remedial action, the seeds must represent the munitions of interest at the depth of interest.

Summary: Because of significant developments of geophysical technology during the past ten years, analog tools currently do not represent the best available science for most applications. Specifically, they do not provide a permanent, auditable record of the data, and do not generate data capable of being substantially reproduced. Developing rigorous QC measures capable of assessing operator performance is more challenging and less precise than for digital methods. For these reasons analog geophysical tools should not be used for munitions response activities, except in rare cases where threatened or endangered vegetation or difficult terrain precludes the use of digital tools. Furthermore, when using analog technology and making analog data publicly available, project teams must disclose the uses and limitations of the data; specifically, the probability of detection is inferior to that achieved using digital methods and the manner in which coverage is assessed is qualitative and subjective.

Glossary
Part 1 – Abbreviations and Acronyms

(AGC) Advanced Geophysical Classification

(AGC-QAPP) Advanced Geophysical Classification Quality Assurance Project Plan

(AP) Armor Piercing

(ARAR) Applicable or Relevant and Appropriate Requirement

(ASR) Archives Search Report

(BRA) Baseline Risk Assessment

(CERCLA) Comprehensive Environmental Response, Compensation and Liability Act

(CA) Corrective Action

(CAR) Corrective Action Request

(CSM) Conceptual Site Model

(DDESB) Department of Defense Explosives Safety Board

(DFW) Definable Feature of Work

(DGM) Digital Geophysical Mapping

(DMM) Discarded Military Munitions

(DoD) Department of Defense

(DQI) Data Quality Indicator

(DQO) Data Quality Objective

(DUA) Data Usability Assessment

(EE/CA) Engineering Evaluation/Cost Analysis

(EPA) U.S. Environmental Protection Agency

(ESRI) Environmental System Research Institute

(ESTCP) Environmental Security Technology Certification Program

(FUDS) Formerly Used Defense Sites

(GIS) Geographic Information System

(GPS) Global Positioning System

(HAZWOPER) Hazardous Waste Operations and Emergency Response

(HD) High Density

(HE) High Explosive

(HUA) High Use Area

(IDQTF) Intergovernmental Data Quality Task Force

(IMU) Inertial Measurement Unit

(ISO 80) Schedule 80 small Industry Standard Object

(ITRC) Interstate Technology Regulatory Council

(IVS) Instrument Verification Strip

(LD) Low Density

(LUA) Low Use Area

(MC) Munitions Constituents

(MD) Munitions Debris

(MEC) Munitions and Explosives of Concern

(MPC) Measurement Performance Criteria

(MQO) Measurement Quality Objective

(MR) Munitions Response

(MRA) Munitions Response Area

(MRS) Munitions Response Site

(MSL) Mean Sea Level

(NCP) National Contingency Plan

(NIA) Non-Impacted Area

(NIRIS) Naval Installation Restoration Information Solution

(NTCRA) Non-Time-Critical Removal Action

(PA) Preliminary Assessment

(Pd) Probability of Detection

(PM) Project Manager

(QA) Quality Assurance

(QC) Quality Control

(QAPP) Quality Assurance Project Plan

(RA) Remedial Action

(RAO) Remedial Action Objective

(RCA) Root Cause Analysis

(RFP) Request for Proposal

(RI/FS) Remedial Investigation/Feasibility Study

(ROE) Right of Entry

(RPM) Remedial Project Manager

(RRD) Range-Related Debris

(RTK-GPS) Real Time Kinematic Global Positioning System

(RTS) Robotic Total Station

(SDSFIE) Spatial Data Standards for Facilities, Infrastructure, and Environment

(SDZ) Surface Danger Zone

(SERDP) Strategic Environmental Research and Development Program

(SHORAN) Short-Range Navigation

(SI) Site Inspection

(SNR) Signal to noise ratio

(SOP) Standard operating procedure

(SPP) Systematic Planning Process

(SUXOS) Senior UXO Supervisor

(TCRA) Time-Critical Removal Action

(TOI) Target of Interest

(Tx/Rx) transmit/receive

(UFP QAPP) Uniform Federal Policy for Quality Assurance Project Plans

(USACE) U.S. Army Corps of Engineers

(UX-A) UX-Analyze

(UXO) Unexploded Ordnance

(UXOQCS) Unexploded Ordnance Quality Control Specialist

(UXOSO) Unexploded Ordnance Safety Officer

(VSP) Visual Sample Plan

(WDZ) Weapon Danger Zone

Part 2 – Definitions

Background anomaly density: The anomaly density in an area where anomalies occur solely from geologic material or anthropogenic clutter not related to DoD range activities. This information may not be known prior to Remedial Investigation activities. Background anomalies are assumed to be uniformly distributed throughout the site, or defined sub-areas of the site, as explained in the preliminary CSM. Initial estimates of background density are based on information contained in the CSM, including site history, geology, and the results of previous investigations. The actual background density can be measured using geophysical sensors in areas where no range activities have occurred.

Buffer zone: A low density (LD) area surrounding a confirmed High Use Area (HUA) designed to accommodate uncertainty associated with establishing HUA boundaries. The buffer zone provides a "buffer" between a HUA and any adjacent non-impacted area (NIA). The buffer zone will always be located in the LD area; that is, the anomaly density in the buffer zone will always be below the critical density. Project teams will determine the size and configuration of buffer zones based on uncertainty in the sampling design and site-specific properties related to range design, e.g. type of munitions used and surface danger zone (SDZ)/weapon danger zone (WDZ) calculations. Within a buffer zone, the presence of intact munitions is much less likely than in a HUA but has not been ruled out.

Critical (anomaly) density: [A VSP input parameter] The project-specific, user-defined value for anomaly density (inclusive of background) used to delineate high density (HD) areas from LD areas.

HD Area: High density area: Area within a munitions response site (MRS) where the anomaly density has been determined to be ≥ critical density. HD areas will be presumed to result from munitions use unless and until it can be demonstrated otherwise.

HUA: High use area: HD area where munitions use has been confirmed. Unexploded ordnance (UXO) and/or discarded military munitions (DMM) are anticipated to be present in HUAs.

LD Area: Low density area: Area(s) within an MRS where the anomaly density has been determined to be < critical density). LD areas can include both low use areas (LUA) and non-impacted areas (NIA).

LUA: Low use area: LD area where the potential presence of munitions cannot be ruled out. Examples of LUA include buffer zones and maneuver areas.

Maneuver area: A type of LUA for which the CSM indicates activities involving munitions (e.g., transport, training, and practice) may have occurred. The anomaly density in a maneuver area is less than the critical density.

NIA: Non-impacted area: 1) LD area for which the CSM contains adequate evidence no munitions were used in the area, or 2) HD area determined to be not related to munitions use. All available and relevant lines of evidence supporting this delineation (e.g., historical records review (HRR), historical photo interpretation, visual observations, and interviews) must be considered.

Survey unit: A portion of the site for which geophysical survey data and other field observations and measurements, including quality control (QC) results and results for blind QC seeds and quality assurance (QA) seeds, will be collected, verified, validated, and reported as a unit, for evaluation and use by the project team. Survey units are established by the project team during project planning. The survey unit is not necessarily a geographically contiguous unit, and, for investigations conducted in phases, survey units for one phase may or may not be the same as those for a different phase.

Target Area Density (above background): [A VSP input parameter] The expected anomaly density of a target area, above background, used in the VSP Transect Spacing planning tool. When a "Bivariate Normal" distribution of anomalies across a target is assumed, the target area density can be expressed in one of three ways. The default option is "Target Average", or the average anomaly density (above background) across the target. Other options are "Outer Edge of Target" and "Center of Target", which refer to the expected density near the perimeter of the target area and the center of the target area, respectively. [Note: The examples in Module 1 make use of the "outer edge of target" option.]

Target (or HUA) boundary: For the purpose of this document, the location, moving away from the target (or HUA) center, where the anomaly density drops to background. (Note: the background density is assumed to be uniform throughout the site or defined subsets of the site as explained in the preliminary CSM.)

Worksheet #1 & 2: Title and Approval Page
(UFP-QAPP Manual Section 2.1)

This worksheet identifies the principal points of contact for all organizations having a stakeholder interest in the project. Signatories usually include the DoD Remedial Project Manager (RPM) and Quality Assurance (QA) Manager, contractor Project Manager (PM) and QA Manager, and individuals with oversight authority from regulatory agencies. Signatures indicate that officials have reviewed the QAPP, have had an opportunity to provide comments, and concur with its implementation as written. Add signature lines as necessary to reflect additional stakeholders having approval authority (e.g., explosives safety organizations.) If separate concurrence letters are issued, the original correspondence should be maintained with the final, approved QAPP in the project file. It is the lead organization's responsibility to make sure all signatures are in place before work begins.

1. Project Identifying Information
    a. Site name/project name
    b. Site location/number
    c. Lead organization
    d. Contractor
    e. Contract number

2. Lead Organization
    a. DoD Remedial Project Manager (RPM)

       ____

       (name/title/signature/date)
    b. DoD QA Manager

       ____

       (name/title/signature/date)

3. Prime Contractor
    a. Prime Contractor PM

       ____

       (name/title/signature/date)
    b. Prime Contractor QA Manager

       ____

4. (name/title/signature/date)Subcontractor[1]
    a. Subcontractor PM

       ____
       (name/title/signature/date)

    b. Subcontractor QA Manager

       ____
       (name/title/signature/date)

5. Federal Regulatory Agency

   ____
   (name/title/signature/date)

6. State Regulatory Agency

   ____
   (name/title/signature/date)

7. Other Stakeholders (as needed)

   ____
   (name/title/signature/date)

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

9. The undersigned concur that the use of analog technology is justified in area <u>(to be completed)</u>
    a. Lead Organization, Flag Level

       ____
       (name/title/signature/date)

    b. Lead Regulatory Agency

       ____
       (name/title/signature/date)

[1]Project Teams should decide which subcontractors should be listed on, and required to sign, this Project Title and Approval Page. In general, any subcontractors participating in project planning activities should be listed.

Worksheet #3 & 5: Project Organization and QAPP Distribution
(UFP-QAPP Manual Section 2.3 and 2.4)

This worksheet identifies key project personnel, as well as lines of authority and lines of communication among the lead organization, prime contractor, subcontractors, and regulatory agencies. Two examples follow. Figure 3-1 provides an example of the project organization for Munitions Response activities, and Figure 3-2 provides an example of the project organization for Explosives Safety Operations. [Note: Although this template does not address explosives safety per se, including a copy of the organizational structure for Explosives Safety Operations is useful for facilitating project communications.] Project Teams May combine Figures 3-1 and 3-2. For the purpose of the draft QAPP, it is permissible to show "to be determined" (TBD) in cases where roles have not been assigned; however, the final, approved QAPP must identify all key personnel. If the Explosives Safety Operations organization is addressed in a separate submittal, that document may be referenced.

For the purpose of document control, this worksheet also can be used to document recipients of controlled copies of the QAPP. The draft QAPP, final QAPP, and any changes/revisions must be provided to all QAPP recipients shown on this chart. Use asterisks or other symbols to designate QAPP recipients. [Alternatively, a list of QAPP recipients along with their contact information may be attached.] Contractors and subcontractors shown on this chart are responsible for document control within their organizations.

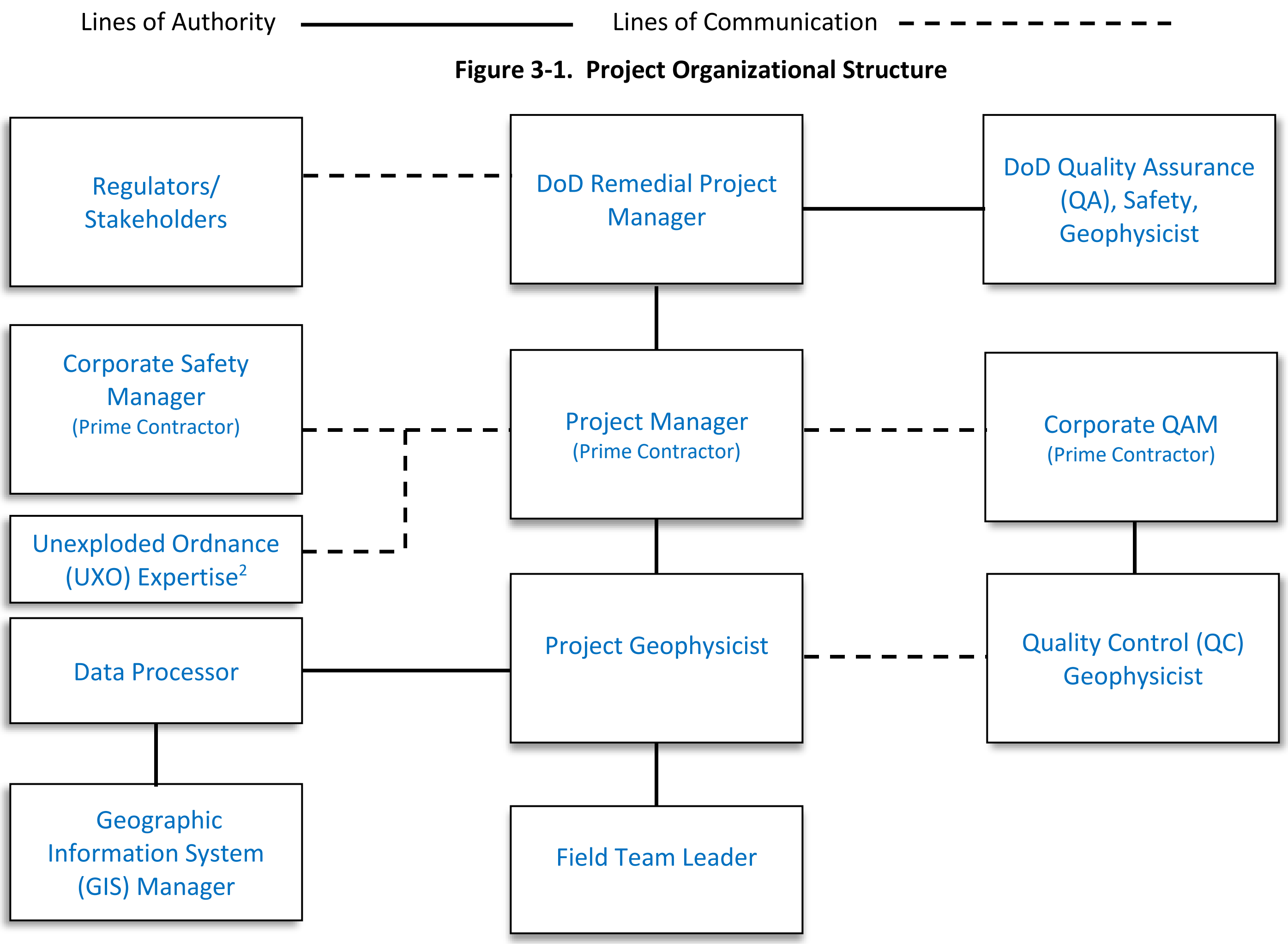
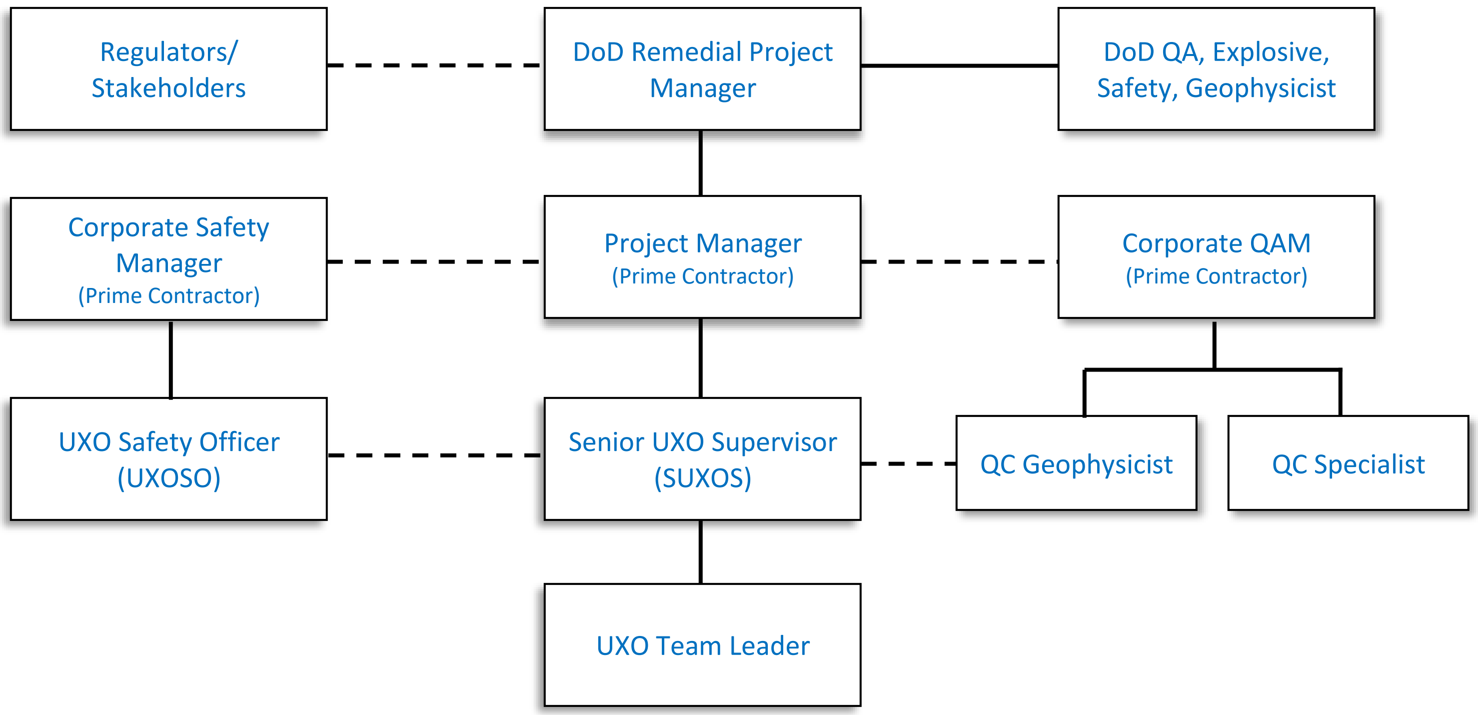


Figure 3-1. Project Organizational Structure

[2] UXO expertise is required to make sure the TOI, which can range from intact munitions to sub-components or fragments with residual explosive and/or chemical constituents, are defined.

Lines of Authority ——— Lines of Communication - - - -

Figure 3-2. Explosives Safety Operations Organizational Structure



Worksheet #4, 7 & 8: Personnel Qualifications and Sign-off Sheet
(UFP-QAPP Manual Section 2.3.2 – 2.3.4)

This worksheet identifies key project personnel for each organization performing tasks defined in this QAPP and summarizes their title or role, qualifications (e.g. training and experience), and any specialized training, licenses, certifications, or clearances required by the project. With the appropriate qualifications, personnel may fill more than one role. Examples are provided in blue text. It is outside the scope of this document to establish minimum qualifications for personnel. Users of this template should add spaces for additional organizations and personnel as needed. Resumes or documentation of relevant experience and training should be contained in an appendix to the QAPP. Signatures indicate personnel have read the QAPP and agree to implement it as written

Table 4-1. Prime Contractor and Subcontractors

Name/ Contact Information	Project Title/Role	Education/Experience[3]	Specialized Training	Required Licenses/Certifications/ Authorizations[4]	Signature/Date
	Project Manager	M.S. Chemistry __ years Managing munitions response projects Project Manager for __ munitions response projects			
	Corporate Quality Assurance Manager (QAM)	B.S. Civil Engineering Corporate Quality Control Manager for __ years Oversight of __ munitions response projects			

[3] Resumes should be included in an appendix.
[4] This column should include any State-specific requirements.

Table 4-1. Prime Contractor and Subcontractors

Name/ Contact Information	Project Title/Role	Education/Experience[3]	Specialized Training	Required Licenses/Certifications/ Authorizations[4]	Signature/Date
	Corporate Safety Manager	M.S. Industrial Engineering		Certified Industrial Hygienist	
	Project Geophysicist	M.S. Physics Project Geophysicist on ESTCP Geophysical Classification demonstration at __	Oasis Montaj Geophysical Data Processing for UXO 3-day UX-Analyze instruction by ESTCP		
	Quality Control (QC) Geophysicist	M.S. Physics Project Geophysicist on ESTCP Geophysical Classification demonstration at __	Oasis Montaj Geophysical Data Processing for UXO 3-day UX-Analyze instruction by ESTCP		
	Field Team Leader	B.S. Engineering Field Geophysicist on ESTCP Geophysical Classification demonstration at __	Oasis Montaj Geophysical Data Processing for UXO Working with UX-Analyze		

Table 4-1. Prime Contractor and Subcontractors

Name/ Contact Information	Project Title/Role	Education/Experience[3]	Specialized Training	Required Licenses/Certifications/ Authorizations[4]	Signature/Date
	Data Processor	B.S. Physics Project Geophysicist on ESTCP Geophysical Classification demonstration at __	Oasis Montaj Geophysical Data Processing for UXO 3-day UX-Analyze instruction by ESTCP		
	Geographic Information System (GIS) Manager	M.S. in Geoinformatics and Geospatial Intelligence			

Table 4-2. Explosives Safety Operations Organization

Name/ Contact Information	Project title/Role	Education/Experience[4]	Specialized Training	Required Licenses/Certifications/ Authorizations[5]	Signature/Date
	Project Manager	M.S. Geology __ years managing munitions response projects PM for __ advanced geophysical classification projects	Project Management Professional		
	Corporate QC Manager	B.S. Civil Engineering Corporate QC manager for __ Years Oversight of __ munitions response projects			
	Corporate Safety Manager	M.S. Industrial Engineering		Certified Industrial Hygienist	
	Senior UXO Supervisor (SUXOS)	Graduate Naval EOD School	Hazardous Waste Operations and Emergency Response (HAZWOPER)	Qualified Senior UXO Supervisor i/a/w Department of Defense Explosives Safety Board (DDESB) TP-18	

[4] Resumes should be included in an appendix
[5] This column should include any State-specific requirements

Table 4-2. Explosives Safety Operations Organization

Name/ Contact Information	Project title/Role	Education/Experience[4]	Specialized Training	Required Licenses/Certifications/ Authorizations[5]	Signature/Date
	Unexploded Ordnance QC Specialist (UXOQCS)	B.S. Civil Engineering	HAZWOPER	Qualified UXOQCS i/a/w DDESB TP-18	
	QC Geophysicist	M.S. Physics Project Geophysicist on ESTCP Geophysical Classification demonstration at __	Oasis Montaj Geophysical Data Processing for UXO 3-day UX-Analyze instruction by ESTCP		
	UXO Safety Officer	B.S. Civil Engineering	HAZWOPER	Qualified Unexploded Ordnance Safety Officer (UXOSO) i/a/w DDESB TP-18	
	UXO Team Leader		HAZWOPER	Qualified UXO III i/a/w DDESB TP-18	

Worksheet #6: Communication Pathways and Procedures (UFP-QAPP Manual Section 2.4.2)

This worksheet documents specific issues (communication drivers) that will trigger the need for formal (documented) communication with other project personnel or stakeholders. Its purpose is to ensure there are procedures in place for providing notifications, obtaining approvals, and generating the appropriate documentation when handling important communications, including those involving regulatory interfaces, approvals to proceed from one DFW to the next, field changes, emergencies, non-conformances, and stop-work orders. Communication pathways and procedures should be agreed upon by the project team during project planning. Examples are provided below; additional communication drivers and procedures should be added as needed.

Table 6-1. Communication Pathways and Procedures

Communication Driver	Initiator (name, project title)	Recipient (name, project title)	Procedure (timing, pathway, documentation)
Regulatory agency interface	Name, DoD Remedial Project Manager (RPM)	Name, Regulatory Organization	DoD RPM provides weekly project update memorandum to Regulator via email. DoD RPM will seek concurrence on QAPP changes and provide notification of quality failure.
Daily field progress reports	Name, Contractor Senior Unexploded Ordnance Supervisor (SUXOS)	Name, Contractor Project Manager (PM)	The SUXOS provides daily progress by phone or email.
Mishap notification	Name, Contractor Unexploded Ordnance Safety Officer (UXOSO)	Name, Contractor PM Name, DoD RPM	UXOSO will notify Contractor PM by phone immediately. Contractor PM will notify the DoD RPM within X hours.
Stop work due to safety issues	Name, Contractor SUXOS	Name, Contractor PM	As soon as possible following discovery, the SUXOS informs Contractor PM by phone of critical safety issues and generates follow-up Stop Work Memorandum.

Table 6-1. Communication Pathways and Procedures

Communication Driver	Initiator (name, project title)	Recipient (name, project title)	Procedure (timing, pathway, documentation)
Quality assurance stand-down (missed validation seed)	Name, DoD RPM	Name, Contractor PM	DoD RPM notifies contractor and the regulator by email
Resume work following a stop work or QA stand-down	Name, DoD RPM	Name, Contractor PM	The DoD RPM will provide the Contractor PM with written notice of approval before work may resume.
Minor QAPP changes during project execution[6]	Name, Quality Control (QC) Geophysicist	Name, Corporate QC Manager and Name, Project Geophysicist	Minor QAPP changes will be noted on the Daily QC reports and forwarded to the Project Geophysicist and the Corporate QC Manager at the end of each day.
Major QAPP changes during project execution	Name, Contractor PM	Name, DoD RPM Name, Contractor Quality Assurance (QA) manager	Within 24 hours, Contractor PM submits field change request form to Corporate QAM and DoD RPM for approval. Following approval, DoD RPM informs regulator via email.
Surface sweep activities are complete	Name, Contractor SUXOS	Name, Contractor PM	Upon completion of surface sweep activities, the SUXOS informs the Contractor PM via Surface Sweep Memorandum.
Daily and weekly QC reports	Name, Contractor PM	Name, DoD RPM	At end of each day/week of field work, Contractor PM provides daily/weekly QC reports to the DoD RPM via email.

[6] Project teams should determine what constitutes minor and major QAPP changes during project planning.

Table 6-1. Communication Pathways and Procedures

Communication Driver	Initiator (name, project title)	Recipient (name, project title)	Procedure (timing, pathway, documentation)
Geophysical QC nonconformance	Name, Contractor QC Geophysicist	Name, Project Geophysicist and Name, Corporate QC Manager	QC Geophysicist generates Corrective Action Request (CAR) form and transmits to Project Geophysicist and Corporate QC Manager. Project Geophysicist notifies PM by email.

Worksheet #9: Project Planning Session Summary
(UFP-QAPP Manual Section 2.5.1)

The MR-QAPP worksheets will be completed in a series of project planning sessions, and a copy of Worksheet #9 should be completed for each session. This worksheet provides a concise record of participants, key decisions or agreements reached, and action items. Multiple planning sessions typically are conducted to complete the QAPP, and sessions should involve key technical personnel and decision-makers needed for that specific stage of planning and documentation.

Regardless of planning session format (e.g., phone conference, web-conferencing, or face-to-face meeting), this worksheet should be used to document each session. Meeting minutes can be included in an appendix to the QAPP, if necessary. Project teams will find it helpful to have a copy of all MR-QAPP worksheets on hand for all planning sessions in whatever state of completion they may be.

Note: The Remedial Investigation (RI)/Feasibility Study (FS) at Camp Example (described in blue text throughout this document) is being conducted in phases. In a phased investigation, planning sessions should continue to be held as each phase is completed, and relevant worksheets needed for the next phase (e.g., Worksheets #10: CSM, #11: DQO, and #17: Sampling Design) should be updated as necessary. Figure 9-1 illustrates the use of a project-planning process for a RI conducted in phases, but the process is flexible and should be modified as necessary based on contracting practices and project-specific requirements; for example, planning sessions may be consolidated.

The following table may be modified to suit project-specific documentation requirements.

Date of planning session:
Location:
Purpose:
Participants:

Name	Organization	Title/Role	Email/Phone

Notes/Comments:
Consensus decisions made:

Action Items:

Action	Responsible Party	Due Date

Figure 9-1. Example Project Planning Process for a Phased RI/FS

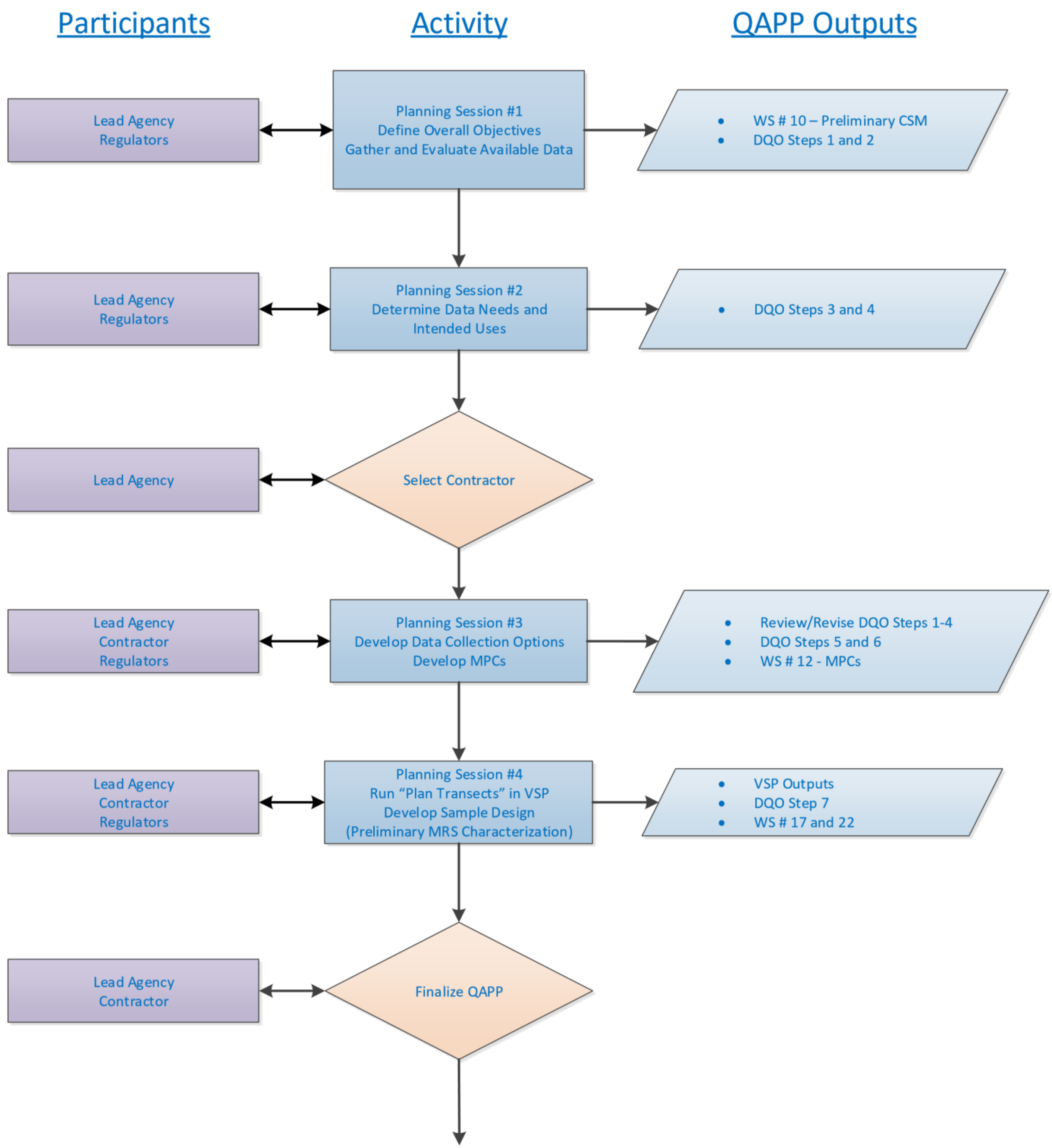
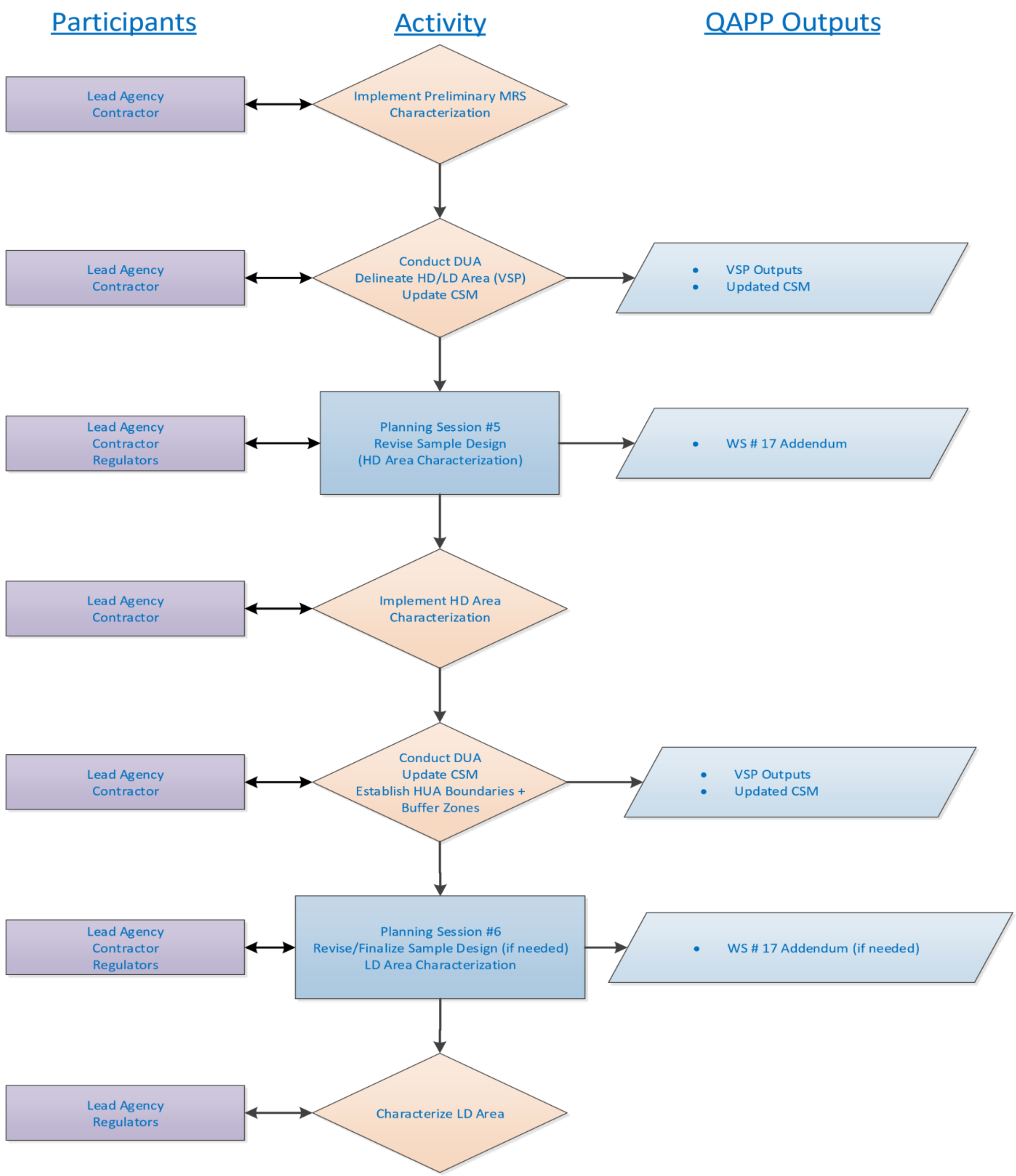


Figure 9-1. Example Project Planning Process for a Phased RI/FS



Worksheet #10: Conceptual Site Model
(UFP-QAPP Manual Section 2.5.2)

This worksheet is used to present a concise summary of the project's CSM at the start of the proposed investigation: a working, iterative model that depicts the current understanding of sources, pathways, and receptors. The major elements of the CSM include the facility profile, physical profile, release profile, and land use and exposure profile. As a tool to assist in the visualization and communication of site conditions and the development of DQOs, the CSM may include text, maps, graphic images, and tables. The working version of the CSM should be updated throughout the project life cycle, as new data are collected and knowledge of site conditions and exposure pathways changes. This does not require issuing an update to the QAPP. [See Figure 9-1 for examples of points in the process where it may be useful to update the CSM.]

In most cases, the CSM at the end of the site inspection (SI) will serve as the CSM for the start of the RI/FS phase of investigation. It should include the following information, if available. Any data gaps or uncertainty should be described.

Facility Profile:

- Site location, size and ownership
- Concise history of the use, storage, and disposal of munitions and other hazardous substances at the site
- Identification of munitions and hazardous substances known or suspected to be present
- Concise summary of relevant findings from previous investigations

Physical Profile:

- Topography and vegetation
- Geologic and Hydrogeologic setting
- Climate
- Endangered species, sensitive habitats, and cultural resources
- Areas that are inaccessible to investigation

Release Profile:

- Description and locations of any known or suspected areas where munitions and explosives of concern (MEC) was handled, used, stored, or disposed (e.g., targets, maneuver areas, storage facilities or open-burning (OB)/open detonation (OD) areas
- Current understanding of the location and distribution (horizontal and vertical) of munitions and hazardous substances
- Evaluation of prior land-disturbing activities that may have had the potential to redistribute MEC.

Land Use and Exposure Profile:

- Current and reasonably anticipated future site uses
- Neighboring land uses
- Current and reasonably anticipated future receptors and exposure pathways
- Access conditions and frequency of use

[Following is an example of a CSM for the fictional munitions response area (MRA) at "Camp Example". The 18,000-acre MRA includes a variety of historic ranges and targets (shown on Figure 10-1) which have been included in this example to illustrate different objectives, technical approaches and decision-making strategies that could come into play during an RI/FS. This MRA encompasses a joint range complex with artillery, mortar, and bomb targets, as well as a maneuver area. The CSM suggests the area was used extensively to train at least three divisions during WWII. The SI confirmed the presence of MEC in the MRA but did not confirm the exact locations of all potential target areas. For this reason, the MRA is divided into two munitions response sites (MRS): MRS A (Figure 10-2) is the northern section where bombing training is known to have occurred. MRS B (Figure 10-3) is the southern section where maneuver, artillery, and mortar training are known to have occurred. All lands to the west of the MRA are part of the still active Example AFB, which includes the portion of the maneuver area not included in this MRA. For clarity, only a subset of the ranges is shown on the figures and discussed in this example.]

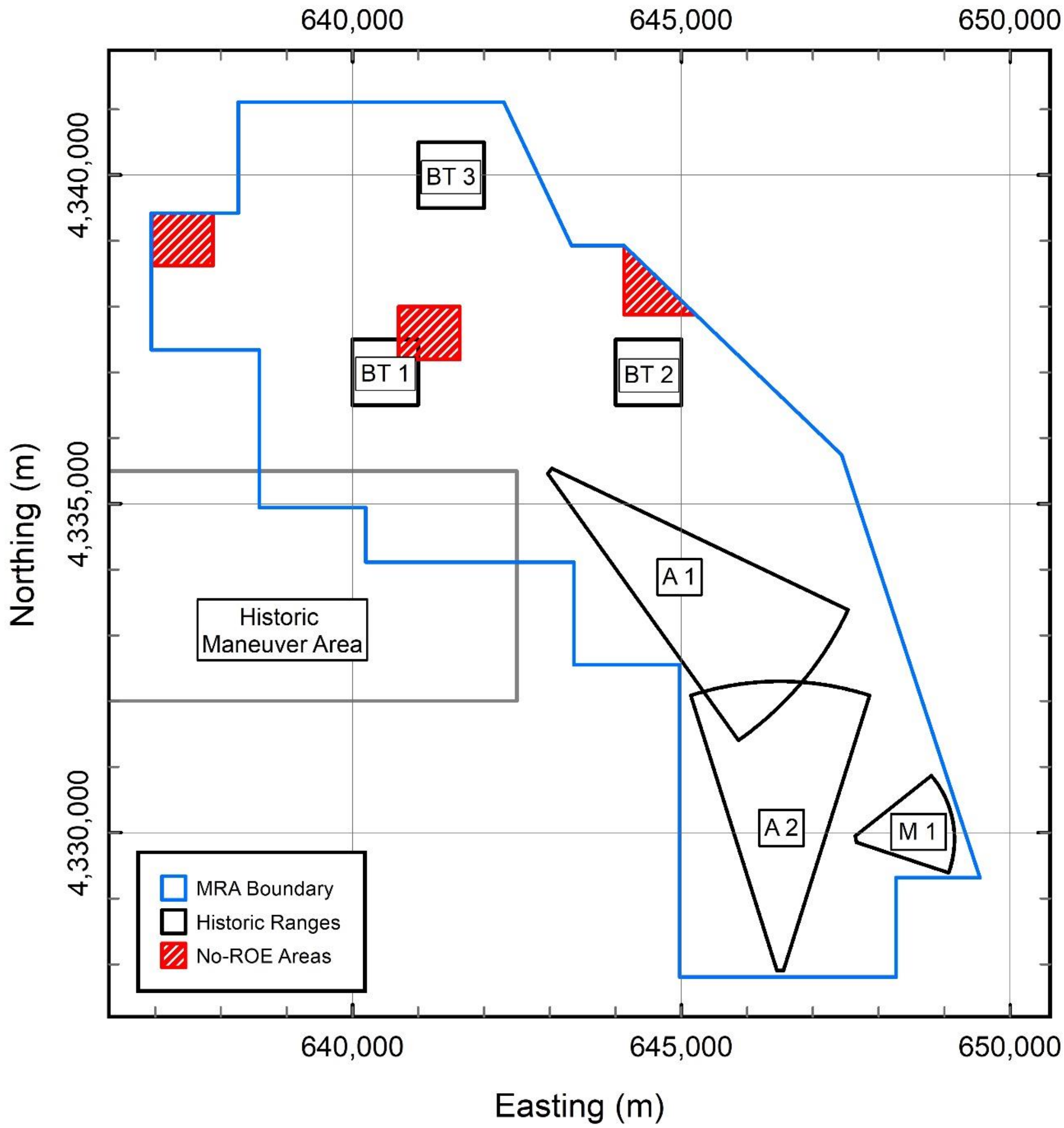


Figure 10-1. Camp Example Showing Historic Ranges

Facility Profile:

Site history, location, size, and ownership: The former Camp Example is located in Yuba and Nevada counties, California, along the foothills of the Sierra Nevada Mountains. In 1940, the Camp Example area consisted of grassland, rolling hills, and the abandoned mining town of Exampleville. The U.S government purchased 87,000 acres in 1942 for a training post for the 13th Armored Division. Camp Example also held training facilities for the 81st and 96th Infantry Division, a 1,000-bed hospital, and a prisoner of war camp. As a complete training environment, Camp Example had training maneuver areas, mortar and rifle ranges, bombardier-navigator training, and chemical warfare classes. In 1948, Camp Example became Example Air Force Base.

Known/suspected high-use areas (HUA) in munitions response site (MRS) A include three bombing targets shown on Figure 10-2.

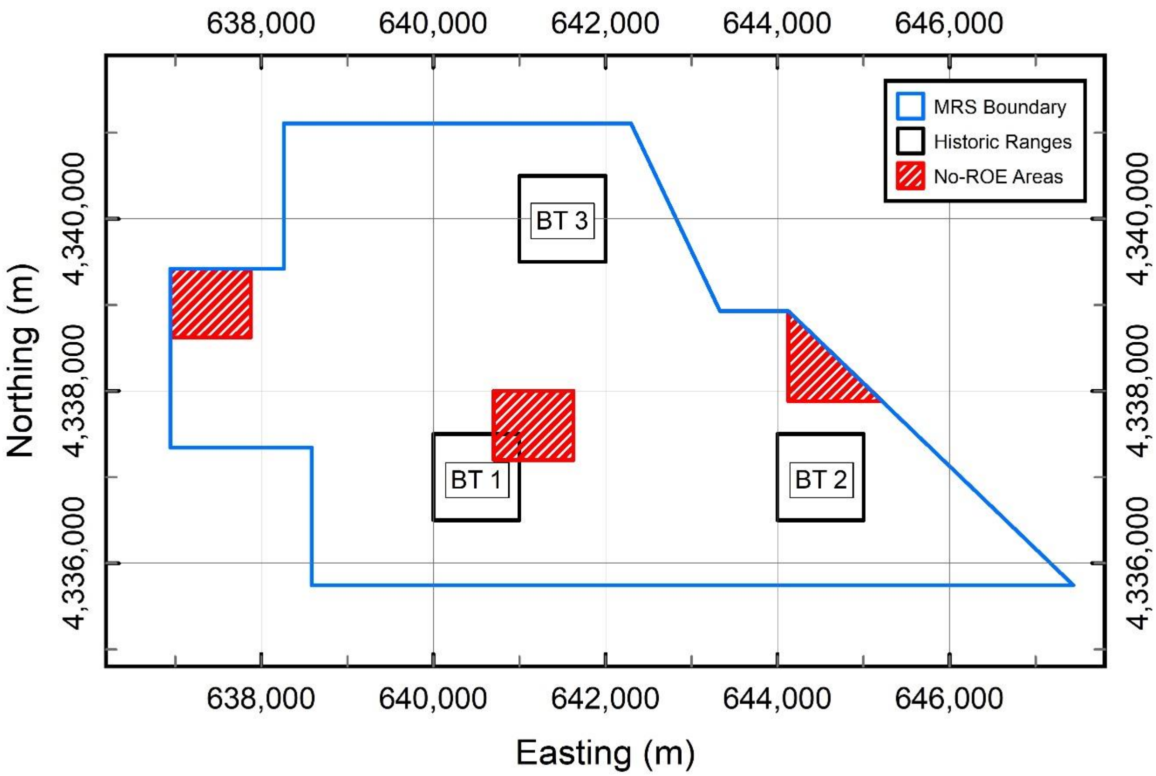


Figure 10-2. Known/Suspected High Use Areas in MRS A

Known/suspected HUA in MRS B include two artillery ranges, a mortar range and a historic maneuver area shown on Figure 10-3.

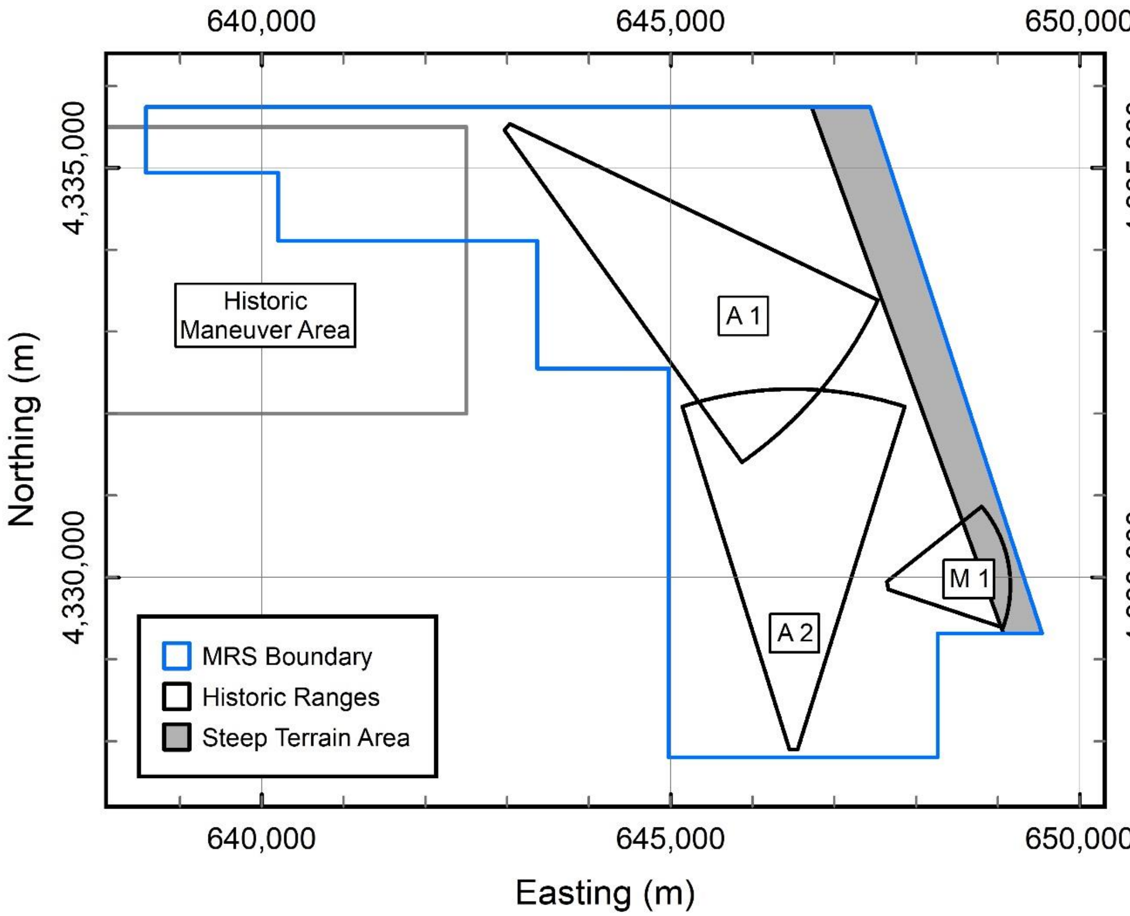


Figure 10-3. MRS B Showing Historic Targets and Steep Terrain Area

In 1959, the installation ceased being used as a bombing range, and the U.S. government declared portions of Example Air Force Base as excess, eventually transferring 60,805 acres to private individuals and the State of California. On December 21, 1959, 40,952 acres on the eastern side of the base were sold at auction. An additional 11,213 acres were transferred to the State of California between 1962 and 1964 and now comprise the Example Wildlife and Recreational Area. Between 1964 and 1965 another 9000 acres were sold at auction.

The MRA currently encompasses a wildlife refuge, scattered houses, lands used for cattle grazing, and a parcel that faces the highest development pressure of any part of this formerly used defense site.

Physical Profile: [The following description applies to the entire MRA.]

Physiography and Topography: Former Camp Example lies along the foothills of the Sierra Nevada Mountains. Topography varies from a valley west of the site to mountains to the east. Site elevation ranges between approximately 120 and 200 feet above mean sea level (MSL). Terrain consists of grasslands and rolling hills. The eastern portion of the site is drained by Dry Creek and Rock Creek. Hilly areas in the northern and western portions of the site are drained by Reeds Creek and Hutchinson Creek.

Soils: The predominant soils are the Sobrante-Auburn soils, formed in material that was weathered from basic metavolcanic rocks (USDA, 1998). Soils are moderately deep to shallow and well-drained.

Geologic and Hydrogeologic setting: [Refer to 2007 SI Report]

Endangered species, sensitive habitats: [Refer to 2007 SI Report]

Cultural resources: Numerous prehistoric and historic sites have been identified including village sites, campsites, bedrock milling stations, mining and ranching sites, and WWII military training areas.

Climate: Former Camp Example experiences cool, wet winters (35-50°F) and warm, dry summers (60-98°F. The average annual precipitation is 28 inches.

Access constraints: Areas on MRS A where right-of-entry has not been secured are shown in red on Figure 10-1 and 10-2. Because of its steep terrain, the easternmost area of MRS B, shown on Figure 10-3, is accessible for analog instrument use only.

Release Profile:

MRS A:

Bombing Target No. 1: This target was proposed, but no evidence of its use was found during the SI.

Bombing Target No. 2: This target was used by the Air Force during the 1950s. During the SI, several distinct craters and numerous pieces of munitions debris (MD), including fuze caps and tail fins from 100-lb practice bombs, were found in this target area. Numerous subsurface anomalies were identified using a hand-held magnetometer.

Bombing Target No. 3: This target was proposed for use with radar to provide 100-lb HE bomb releases for short-range-navigation (SHORAN) training. During the SI, however, no evidence of the target’s use was found.

MRS B:

Artillery Range No. 1: This range was used toward the end of WWII for training exercises using 75mm high explosive (HE)/armor piercing (AP) projectiles.

Artillery Range No. 2: This range was used toward the end of WWII for training exercises using 105mm HE/AP projectiles.

Mortar Range No. 1: This mortar range reportedly was used during the early 1940s for firing 60mm HE mortars.

Historic Maneuver Area: This area was documented as used near the end of WWII for troop maneuvering and encampment. No records of live-fire training have been recovered.

Munitions known or suspected to be present: MEC items that have been identified as likely to be present at the former Camp Example include the following:

MRS A

- 100-lb M38A2 practice bombs
- 100-lb (M30A1) HE bombs
- nose fuzes AN-M103 Series
- tail fuzes AN-M100 Series
- M1A1 spotting charges for 100-lb practice bombs

MRS B

- 60mm M49A2 HE mortars
- M935 PD fuzes
- M935 PD fuzes w/ booster
- M734 Multi Option fuzes
- 75mm M41A1 HE projectiles
- BD M66 integrated boosters
- PD M48, M57 and M78 fuzes for HE
- PD M48, M57 and M78 fuzes w/ boosters
- 105mm M1 HE projectiles
- BD M62 integrated boosters

Land Use and Exposure Profile:

Current land uses: The majority of Camp Example is privately owned, with low-density residential, agricultural and wildlife preserve areas. The southeastern portion of the site is used for cattle grazing, and the central portion of the site includes Example Wildlife and Recreation Area, which supports hunting, fishing, horseback riding, mountain-biking, hiking and camping. Areas to the northwest include moderately populated residential areas. Much of the surrounding area is used for ranching and remains undeveloped.

Anticipated future land uses: For the foreseeable future, the land use at Camp Example is projected to remain the same as its present use, except for the Highlands Community. The proposed Highlands Community area straddles the northwest boundary of the site. Development may begin in approximately three years, with the construction of up to 1,800 residential dwellings.

Potential receptors and exposure pathways: Current and reasonably anticipated future receptors include ranchers, farmers, hunters, hikers, campers, residents, U.S. Forestry Service personnel, and construction workers. Potentially complete exposure pathways include exposure to surface and/or subsurface MEC.

Tables 10-1 and 10-2 summarize the CSM for MRS A and MRS B, respectively.

Table 10-1. Overview of Preliminary Conceptual Site Model, Camp Example – MRS A

<table>
<tr><th>Site Details</th><th>Potential/Suspected Location and Distribution of MEC</th><th>Known/ Suspected Munitions</th><th>Exposure Medium</th><th>Current and Future Receptors</th><th>Exposure Pathways</th></tr>
<tr><td rowspan="3">Camp Example, MRS A

Boundaries and acreage: See Figure 10-2

Background anomaly density (estimated): 75/acre

Known/suspected past DoD activities (release mechanisms):
Bombing Target #1: Proposed, but no evidence of use
Bombing Target #2: 100-lb practice bombs
Bombing Target #3: Proposed but no evidence of use

Current land use: Low-density residential, agricultural, and wildlife preserve

Future land use: Future increased residential density expected in northwest area of MRS</td><td>HUAs:
-Evidence of munitions handling or use (e.g., target areas)
-High likelihood of finding residual MEC, MD, or range-related debris (RRD)
-Anomaly density ≥ critical density</td><td rowspan="3">-Bomb, HE, M30A1
-Bomb, practice, 100-lb, M38A2
-nose fuze, AN-M103 Series
-tail fuze, AN-M100 Series
M1A1 spotting charges for 100-lb practice bombs</td><td rowspan="3">Surface soil and subsurface soil</td><td rowspan="3">Ranchers
Farmers
Hunters
Hikers
Campers
Residents
U.S. Forestry Service</td><td>HUAs: Potentially complete exposure to surface and/or subsurface MEC</td></tr>
<tr><td>Low use areas (LUAs):
-Low likelihood of finding residual MEC, MD, or RRD
-Anomaly density < critical density</td><td>LUAs: Potentially complete exposure to surface and/or subsurface MEC</td></tr>
<tr><td>Non-impacted Areas (NIAs):
-No evidence of munition use</td><td>NIAs: Incomplete</td></tr>
</table>

Table 10-2. Overview of Preliminary Conceptual Site Model, Camp Example – MRS B

Site Details	Potential/Suspected Location and Distribution of MEC	Known/Suspected Munitions	Exposure Medium	Current and Future Receptors	Exposure Pathways
Camp Example, MRS B Boundaries and acreage: See Figure 10-3 Background anomaly density: Digital Geophysical Mapping (DGM) area: 75/acre; Analog area: 225/acre Known/suspected past DoD activities (release mechanisms): Artillery Range No.1: 75mm HE/AP projectiles Artillery Range No.2: 105mm HE/AP projectiles Mortar Ranges No. 1: 60mm HE mortars Historic Maneuver Area: None known Current land use: Low-density residential, agricultural, and wildlife preserve Future land use: Same	HUAs: -Evidence of munitions handling or use (e.g., target areas) -High likelihood of finding residual MEC, MD, or RRD -Anomaly density ≥ critical density LUAs: -Low likelihood of finding residual MEC, MD, or RRD -Anomaly density < critical density NIAs: -No evidence of munitions use	-60mm M49A2 HE mortars -M935 PD Fuze -M935 PD Fuze w/ booster -M734 Multi Option Fuze -M734 Multi Option Fuze w/ booster -75mm M41A1 HE projectile -BD M66 Fuze for AP -BD M66 w/ booster -PD M48, M57 and M78 Fuze for HE -PD M48, M57 and M78 Fuze w/ booster -105mm M1 HE projectile -PD M48 series Fuze for HE -PD M48 w/ booster -BD M62 Series Fuze for AP -BD M62 w/ booster	Surface soil and subsurface soil	Ranchers Farmers Hunters Hikers Campers Residents U.S. Forestry Service Construction workers	HUAs: Potentially complete exposure to surface and/or subsurface MEC LUAs: Potentially complete exposure to surface and/or subsurface MEC NIAs area: Incomplete

Worksheet #11: Data Quality Objectives
(UFP-QAPP Manual Section 2.6.1)

This worksheet documents DQOs, which are developed during project planning sessions using a systematic planning process (SPP). The process described below is based on EPA's seven-step DQO process as applied to the Remedial Investigation (RI)/Feasibility Study (FS) phase of investigation involving munitions and explosives of concern (MEC).

Step 1: State the Problem. Define the problem that necessitates the study. The problem should be stated in terms specific to the MRS in question, considering the CSM in place at the start of the RI.

[Example] Evidence from previous investigations (cite the sources) indicates that MEC in the form of Unexploded ordnance (UXO) and discarded military munitions (DMM) may be present at MRS A and MRS B resulting from their use between 19XX and 19XX as bombing targets, artillery ranges, and mortar ranges involving the use of both practice munitions and high explosives (HE). Further investigation is needed to:

1) Confirm the locations of targets,
2) Establish boundaries for high-use areas (HUA) and low-use areas (LUA),
3) Characterize the type, nature and distribution of munitions within each HUA and LUA,
4) Evaluate risk,
5) Support determinations of non-impacted areas (NIA), and
6) Collect data to support a feasibility study (FS) if necessary.

Depending on the types and distribution of MEC potentially remaining in the munitions response site (MRS), remedial action may be required to mitigate risks to current or reasonably anticipated future receptors. Results of the investigation will be used to evaluate site risks, estimate cleanup costs, and support a remedial action decision for MRS A and MRS B.

Step 2: Identify the goals of the data collection. Identify principal study questions. State how data will be used in meeting objectives and solving the problem. Define alternative outcomes.

<u>Principal study questions:</u> [Example]

1) What are the nature and extent (i.e. horizontal and vertical distribution) of explosive hazards at MRS A and MRS B?
2) What current and potential future threats may be posed to human health and the environment by MEC remaining at the site?
3) What are alternative actions for mitigating current and potential threats (if identified) posed by MEC remaining at the site?

<u>Remedial Investigation:</u> The project team will collect geophysical data and conduct an intrusive investigation to answer the following questions:

[Example]

1) Has the horizontal boundary of the site been confirmed? [Note: When establishing horizontal boundaries, it is critical to ensure the entire MRS boundary and acreage in the database of record (e.g., FUDSMIS, AEDB-R, or NIRIS) is characterized. Geographic Information Systems (GIS) files from previous investigations may not exactly match the MRS boundary in the database of record. (Source: EM 200-1-15, Section 8.2.1)]
2) Within the MRS, what are the horizontal boundaries of:
   a. High-Use Areas (e.g., bombing targets, firing ranges, or disposal areas)?
   b. Low-Use Areas (e.g., maneuver areas and buffer areas surrounding targets)?
   c. Non-impacted Areas?
3) Within each high-use area, what is the horizontal distribution of anomalies?
4) Within each high-use area, what is the vertical distribution of sources?
5) What types of MEC, munitions debris (MD), range-related debris (RRD), and other metallic debris are/may be present in the high-use areas and low-use areas?
6) For MEC potentially remaining at the site, what is the sensitivity, potential severity, and likelihood of reaction by explosives (e.g., detonation, deflagration, or burning)?
7) Has soil movement (e.g., scraping, filling, or digging) occurred or will future soil movement be required in association with future use? If so, describe.
5) How is land within the MRS currently being used? What are the reasonably anticipated future land uses (if known)?
6) Who are the current and future potential receptors, where are they located, and what activities are they, or would they be, performing within the MRS?
7) What access restrictions are present?
8) What endangered species, sensitive habitats, and/or historical/cultural resources are present?

Evaluate results from RI data collection: At the conclusion of the Remedial Investigation (RI), the project team will determine which of the following alternatives apply to the entire MRS or specific investigation area within the MRS:

1) The area is a high-use area
2) The area is a low-use area
3) The area is a not impacted by munitions use

Baseline Risk Assessment: The project team will conduct a site-specific baseline risk assessment (BRA) for high-use areas and low-use areas to evaluate whether potentially complete exposure pathways exist, and if so, characterize the current and potential future threats to human health and the environment due to MEC. [Note: At this time, there is no universally accepted method for conducting MEC risk assessments.]

Feasibility Study (FS): The project team will conduct a feasibility study to identify and evaluate remedial alternatives for mitigating exposure to MEC. The primary objective of the FS is to ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning the remedial action options can be presented to a decision-maker and an appropriate remedy selected to meet a remedial action objective (RAO). (NCP Section 300.430 (e)).

For each remedy/action evaluated, the FS will identify the expected outcome, e.g.:

Does the alternative achieve an acceptable end state?

Step 3: Identify information inputs. Identify information needed to fill data gaps in the preliminary CSM and answer the study questions.

Information needed to establish presence/absence of MEC and characterize the potential hazard:

- The expected background anomaly density
- The average target area density above background
- The horizontal and vertical boundaries of high-use area and low-use area
- The anticipated depth of reliable detection for munitions known to be present
- Mapped anomaly locations and anomaly sources:
    - To establish whether HD areas are high-use areas
    - To refine boundaries of high-use areas and low-use areas
    - To build weight of evidence supporting NIA determinations
    - To estimate anomaly density and distribution
- Types of munitions on the site:
    - UXO vs DMM
    - Caliber and type (mortars, bombs, projectiles, etc.)
    - Nature of explosive hazard (i.e., sensitivity of fuzing and ordnance)
    - Associated hazardous components

Additional Information needed to establish exposure potential:

- Current and reasonably anticipated future land use
- Current and reasonably anticipated future receptors
- Potential exposure scenarios based upon current/future land use activities and receptors

Information needed to support the FS, if necessary: [complete with site-specific information.]

- Data to establish the effectiveness of various alternatives, including anticipated detection technology performance
- Data to support costing of various alternatives, including [identify project-specific requirements]
- Information that will impact the practicality of various alternatives, including:
    - Descriptions and locations of natural and cultural resources
    - Terrain, vegetation, geology
    - Institutional analysis

Step 4: Define the boundaries of the project. Specify the target population and characteristics of interest. Define spatial and temporal boundaries.

Target population: [Example] The target population includes any ordnance used, stored, or discarded at Camp Example, including UXO and DMM. The target population also includes MD, which serves as an indicator of potential MEC hazards and potential munitions constituent (MC) contamination. Table 11-1 lists munitions that are known or suspected to be present at Camp Example:

Table 11-1. Munitions known/suspected to be present at Camp Example

Known or suspected munitions used (including nomenclature, if known)	Characteristics of Interest					
	MEC Type (UXO, DMM, or both)	Potential Hazards/Severity (Describe using project-specific terminology)	Expected Fragmentation Distance	Detection Depth	Approx. Diameter	Approx. Length
100-lb M38A2 practice bombs	UXO		Zero	175cm	208mm (8.1”)	1.18m (47”)
100-lb (M30A1) HE bombs	UXO		555m	175cm	208mm (8.1”)	660mm (26”)
nose fuzes AN-M103 Series	UXO		235m	30cm	41mm (1.6”)	164mm (6.4”)
tail fuzes AN-M100 Series	UXO		No data	30cm	41mm (1.4”)	102mm (3.8”) excluding arming vane and vane arm
M1A1 Spotting charges for 100-lb practice bombs	UXO		Zero	40cm	87mm (3.43”)	284mm (11.18”)
60mm M49A2 HE mortars	UXO		403m	59cm	60mm (2.36”)	244mm (9.61”)
M935 PD fuzes	UXO		No data	24cm	50mm (1.95”)	69mm (2.7”)
M935 PD fuzes w/ boosters	UXO		No data	29cm	50mm (1.95”)	91mm (3.58”)
M734 Multi Option fuzes	UXO		No data	29cm	49mm (1.94”)	94mm (3.72”)
75mm M41A1 HE projectiles	UXO		529m	80cm	75mm (2.95”)	248mm (9.77”)
BD M66 (integrated boosters)	UXO		No data	29cm	42mm (1.65”)	89mm (3.5”)
PD M48, M57 and M78 fuzes for HE	UXO		No data	29cm	43mm (1.7”)	(4.53”)
PD M48, M57 and M78 fuzes w/ booster	UXO		95m	29cm	43mm (1.7”)	152mm (5.99”)
105mm M1 HE projectiles	UXO		575m	111cm	105mm	404mm (15.9”) w/out fuze
BD M62 (integrated boosters)	UXO		No data	29cm	33mm (1.3”)	88mm (3.46”)

Spatial and temporal boundaries: Spatial boundaries include both the horizontal area and vertical depth of the study. Establishing the spatial boundary considers the expected horizontal and vertical distribution of MEC in each high-use area and low-use area; the nature and extent of any surface disturbances (e.g., excavation, erosion, accretion) that may have occurred following the use and handling of MEC at the MRS; the maximum predicted depth of future disturbances based on anticipated future land use; and detector limitations, i.e., the maximum depth at which sensors can collect meaningful data for specific munitions.

Establishing spatial boundaries also considers any areas that will be inaccessible to investigation for any reason (e.g., presence of power lines, structures, ponds, sensitive habitats, cultural resources, vegetation, right-of-entry (ROE) issues, and any constraints on vegetation removal). [See note at DQO Step 2.]

Establishing temporal boundaries considers the period of time DoD owned or used the property as well as seasonal conditions (e.g., periods of high rainfall, nesting seasons, etc.) that could limit site access, have an adverse effect on equipment performance, or affect the project schedule. Project teams should consider whether the project will be conducted in a phased effort (multiple mobilizations) or a single mobilization. Project teams should discuss how unforeseen conditions or circumstances having an impact on the schedule or task sequencing will be addressed.

Step 5: Develop the Project Data Collection and Analysis Approach. Define the parameters of interest, specify the type of inference, and develop the logic (decision rules) for drawing conclusions from the data (i.e., CSM updated with results necessary to fill data gaps). For further guidance on selecting a technical approach for characterizing MEC at an MRS, refer to EM-200-1-15, Chapter 8.

[Example] The data collection and analysis approach for the RI/FS at Camp Example will involve three steps:

1) Preliminary MRS Characterization, i.e., Delineating high density (HD) areas and low density (LD) areas,
2) Characterizing HD areas, and
3) Characterizing LD areas.

[The following example may not be applicable to all sites; for example, a preliminary MRS characterization may not be necessary if the locations of targets were well-documented during the SI, as reflected in the preliminary CSM.]

A. Preliminary MRS Characterization

The project team will perform transect surveys to locate anomalies and delineate HD areas from LD areas. Within MRS A, transect surveys will be performed using Time-domain Electromagnetic Multi-sensor Towed Array Detection System (TEMTADS). Within MRS B, transect surveys will be performed using an EM61 array, except in the steep terrain areas inaccessible to the EM61 (shown on figure 10-3 as the shaded area on the eastern boundary of MRS B), where surveys will be performed using a Schonstedt handheld gradiometer.

Parameters of interest: Geophysical anomalies exceeding the project-specific detection threshold (i.e., measurements with an amplitude ≥mV/A, a signal to noise ratio (SNR) ≥5-7, background anomaly density, and average target area density above background.)

Assumptions: [Following is a partial list of underlying assumptions that form the basis for VSP inputs used to select transect spacing.][7]

MRS A: Background, non-MEC-related anomalies are uniformly distributed. Background anomaly density is estimated to be 75/acre. The average target area density (above background) at the outer edge of the target is expected to be 20/acre; therefore, the critical density (at the outer edge of the target) is 95/acre. The smallest target area footprint (218m in diameter) results from a 100-lb bomb.

MRS B: Background, non-MEC-related anomalies are uniformly distributed. Background anomaly density is estimated to be 75/acre in the digital geophysical mapping (DGM) area and 225/acre in the analog area. The average target area density (above background) at the outer edge of the target in the DGM area is expected to be 10/acre; therefore, the critical density (at the outer edge of the target) in the DGM area is 85/acre. The average target area density (above background) at the outer edge of the target in the analog area is expected to be 30/acre; therefore, the critical density (at the outer edge of the target) in the analog area is 255/acre. The smallest target area foot print (112m in diameter) results from a 60mm mortar.

Type of inference:

Areas having an anomaly density ≥ critical density will be identified as HD areas (i.e., potential high-use areas). Areas having an anomaly density < critical density will be identified as LD areas (i.e., potential low-use areas or non-impacted areas depending on information contained in the CSM and subsequent investigation).

[7] See Table 11-2. VSP Inputs.

Decision rules:

1) If an area has an anomaly density ≥ critical density, it will be considered an HD area (potential high-use area).
2) If an area has an anomaly density < critical density, it will be considered an LD area (potential low-use area or non-impacted area).
3) Did the sampling design perform as expected? For example:
    a. If newly acquired data are inconsistent with the CSM or suggest the CSM is incomplete (e.g. an unexpected HD area is located), then the sampling design will be reviewed and revised as necessary.
    b. If any expected HUA(s) have not been located during the initial transect survey, the CSM and sampling design will be reviewed and revised as necessary.

B. HD Area Characterization

For each HD area identified during the preliminary MRS characterization, the project team will determine whether it is munitions-related, and if so, characterize various populations of anomalies (e.g., clusters of specific types of munitions, munitions debris, or non-MEC debris) that may be present, confirm whether the area is, or contains, a HUA, and establish boundaries for the HUA.

Parameters of interest: The sources of anomalies to determine whether HD areas are HUA, and, if so, the horizontal and vertical distribution of munitions-related anomalies to determine HUA boundaries.

Assumptions:

Visual inspection and/or statistical sampling (either through digging or advanced classification) to determine the origin of selected anomalies can indicate with high confidence whether an HD area resulted from munitions-related activity or not.

Type of inference:

Within an HD area, the presence of MEC, or MD associated with munitions that have functioned, will indicate the presence of a high-use area. Moving away from the center of the high-use area, the point at which anomaly density drops to background will mark the location of the HUA boundary. To accommodate uncertainty associated with establishing HUA boundaries, buffer zones will be added. The size and configuration of the buffer zone will depend on the many site-specific properties related to range design, e.g. type of munitions used and surface danger zone (SDZ)/weapon danger zone (WDZ) calculations. The determination that the sources of all sampled anomalies are not MEC, MD, or RRD, and are consistent with other uses, will indicate that the area is not a HUA.

Decision rules:

1) If MEC or MD are identified within the HD area, and the CSM indicates munitions were used in the area, then the area will be confirmed as a high-use area, and the team will characterize and establish a boundary and buffer zone for the area.
2) If MEC or MD are identified within the HD area, but the CSM contains no evidence of munition use, then the project team will determine whether further investigation should be conducted.
3) If no MEC, MD, or RRD are found, the team will revisit the CSM to confirm use of the area and investigate the area as a presumed low-use area or non-impacted area, based on evidence.

C. LD Area Characterization

The primary objective in characterizing the LD area is to differentiate low-use areas from non-impacted areas. Based on information contained in the CSM (updated to reflect results of the previous two steps), the project team will delineate the LD area into presumed LUA and presumed NIA. All available and relevant lines of evidence for this delineation (e.g., historical records review (HRR), historical photo interpretation, visual observations, and interviews) will be considered. No further sampling or intrusive investigation will be performed unless required to fill data gaps in the CSM necessary to complete the baseline risk assessment and feasibility study.

Parameters of interest: Proximity to target areas, historical information on munitions use, field observations including surface sweep results, and sources of anomalies.

Assumptions:

The anomaly density within low-use areas is less than the critical density; however, the presence of an isolated MEC and/or MD cannot be ruled out through sampling. A thorough review of all available and relevant records (compiled in the CSM) indicating no evidence of MEC, MD, or RRD will be necessary to indicate a presumed non-impacted area.

Type of inference:

The presence of MEC, MD, or RRD; other indications of munitions use; and/or proximity to an already established high-use area will indicate a presumed low-use area. The absence of MEC, MD, or RRD observed during field activities and corroborated by the CSM (e.g., no historical record of munitions use, no indication of munitions use discovered during the SI, no aerial photographs showing craters or target areas) will indicate a non-impacted area.

Decision Rules:

1) If any evidence of munitions use exists in an LD area (i.e., is contained in the CSM or found during the field investigation), the area will be presumed to be a LUA, and the project team will characterize the area based on the evidence.
2) If no evidence of munitions use (MEC, MD, or RRD) exists in the area (i.e., is contained in the CSM or observed in the area during field activities), and the area is not a buffer zone, the RI results will be compiled into the CSM to support the conclusion the area is a non-impacted area.

D. Baseline Risk Assessment:

A site-specific baseline risk assessment will be conducted to characterize the current and potential threats to human health and the environment that may be posed by MEC remaining at the MRS. The results of the baseline risk assessment will help identify remedial alternatives in the FS. [Note: At this time, there is no universally accepted method for conducting, a BRA for MEC.]

Parameters of interest: Current and reasonably anticipated future land use, current and future receptors, site accessibility, MEC types, MEC density and distribution, and MEC characteristics.

Type of inference: [To be established by the project team on a site-specific basis, until consensus guidance becomes available.]

Decision rules: [To be established by the project team on a site-specific basis, until consensus guidance becomes available.]

E. Feasibility Study:

If the results of the baseline risk assessment indicate an unacceptable risk due to explosive hazards exists, or may exist in the future, a feasibility study will be conducted to develop and evaluate appropriate remedial alternatives for presentation to decision-makers and ultimately support remedy selection. Alternatives will be developed that protect human health and the environment by eliminating, reducing, and or managing explosive hazards posed through each exposure pathway.

Parameters of Interest: The project team will define the remedial action objectives for HUAs and LUAs (or groups thereof) in terms of general response actions. The FS will identify and evaluate remedial alternatives against the nine Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) evaluation criteria, which include:

Threshold Criteria:

1) Overall protection of human health and the environment
2) Compliance with applicable or relevant and appropriate requirements (ARARs)

Balancing Criteria:

3) Long-term effectiveness and permanence
4) Reduction of toxicity, mobility, or volume through treatment
5) Short-term effectiveness
6) Ease of implementation
7) Cost

Modifying Criteria:[8]

8) Regulatory acceptance
9) Community acceptance

[8] The modifying criteria are formally assessed after the public comment period on the RI/FS report; however, to the extent they are known, they are factored into identification of the preferred alternative.

Decision Rules: [To be determined on a project-specific basis.]

Step 6: Specify Project-specific Measurement Performance Criteria (MPC). Considering Steps 1-5, derive project-specific MPCs that collected data must meet to minimize the possibility of making erroneous decisions (e.g., concluding that a non-impacted area is a high-use area, or concluding that a high-use area is a non-impacted area). MPCs are the qualitative and quantitative specifications for accuracy, sensitivity, representativeness, completeness, and comparability that collected data must meet to satisfy the DQOs described in Steps 1 through 5 above. MPCs guide the development of the sampling design (which is developed during Step 7 and presented in Worksheet #17), and they are the criteria against which data usability will be evaluated at the end of the study.

[Example] The project team has agreed that the risks associated with incorrectly designating a high-use area as a non-impacted area far outweigh the risks associated with incorrectly designating a non-impacted area as a high-use area. Because designation as a high-use area is based on actual, physical observations of MEC, MD or RRD, the risk of incorrectly identifying a non-impacted area or low-use area as a high-use area is low and the consequences involve manageable efforts and costs. Project-specific MPCs are presented in Worksheet #12. Project-specific MPCs are the criteria that collected data must meet to satisfy the DQOs. Failure to achieve the MPCs may have an impact on end uses of the data, which will be addressed during the data usability assessment (DUA) described on Worksheet #37.

Step 7: Sampling Design and Project Work Flow. Develop a resource-effective design for collecting data that will meet project-specific DQOs and MPCs. This step usually summarizes the overall approach and refers to Worksheet #17, which should describe the sampling design and project work flow in detail. In the example presented in blue text, the RI is being conducted in phases, where the results of the first phase (Preliminary MRS Characterization) inform the sampling design for the subsequent phases (HD Area and LD Area Characterization). For this reason, the level of detail presented in Worksheet #17 will evolve as the investigation proceeds.

For RIs conducted in a phased approach, the version of Worksheet 17 contained in the QAPP at the start of the investigation will describe a detailed sampling plan for the Preliminary MRS Characterization and a general approach for subsequent phases. Results from the Preliminary MRS Characterization will be used to update the CSM (i.e., refine assumptions) and revise the detailed sampling approach for the HD Area Characterization and LD Area Characterization if necessary. An addendum to Worksheet #17 should be prepared and incorporated into the QAPP as necessary. [Note: Modifications and updates to the sampling design may be documented using other methods, e.g. technical memoranda, if agreed to during project planning.]

Table 11-2. Visual Sample Plan (VSP) Input [Example]

The transect sampling plan for the Preliminary MRS Characterization was prepared using VSP with the following inputs and assumptions:

VSP Input	**MRS A**	**MRS B**	
	DGM Area	DGM Area	Analog Area
Design Objective: Ensure high probability of traversal and detection			
Target Area Size and Pattern (VSP to calculate)	100-lb bomb, air-dropped	60mm mortar, surface-launched	60mm mortar, surface-launched
Target Diameter	218m	112m	112m
Background Density	75/acre	75/acre	225/acre
Average Target Area Density (above background)	20/acre	10/acre	30/acre
Average Target Area Density (above background) input determined at:	Outer edge of target	Outer edge of target	Outer edge of target
Target Distribution	Bivariate Normal Density	Bivariate Normal Density	Bivariate Normal Density
Probability of Traversing and Detecting Target Area	100	100	100
Transect Width	1m	3m	1.5m
Probability of Detection	100%	100%	90%
Transect Pattern	Parallel	Parallel	Parallel
Orientation	NS	NS	NS – reoriented to parallel to slope

VSP was used to create a graph (probability of detection vs. transect spacing). Transect spacing was selected from the graph (the maximum spacing for which the graph indicated 100% likelihood of traversing and locating the target area).

Table 11-3. VSP Output [Example]

VSP Output	**MRS A**	**MRS B**	
	DGM Area	DGM Area	Analog Area
Transect Spacing	250m	225m	129m
Detection System	TEMTADS	EM61 Array	Schonstedt

The MPCs established during Step 6 of the DQO process (documented in Worksheet #12) were used to develop the initial sampling design which is described in Worksheet #17. The CSM (Worksheet #10) and sampling design (Worksheet #17) will be updated at the end of each phase of investigation.

Worksheet #12: Measurement Performance Criteria (MPC)
(UFP-QAPP Manual Section 2.6.2)

This worksheet documents the project-specific measurement performance criteria (MPC) in terms of data quality indicators (DQI) (i.e., accuracy, sensitivity, representativeness, completeness, and comparability) for the characterization of munitions response sites (MRS). [Note: Accuracy, sensitivity and completeness can be measured quantitatively. Representativeness and comparability can only be evaluated qualitatively.] MPCs are the minimum performance specifications that the remedial investigation must meet to ensure collected data will satisfy the DQOs documented in Steps 1-5 on Worksheet #11. They are the criteria against which the intermediate and final data usability assessment (DUA) will be conducted as documented on Worksheet #37. The DUA must evaluate and document the data quality and decision-making impacts of any failures to meet these criteria (See Worksheet #37). Minimum recommended MPCs applicable to the RI/FS phase are presented in black text. Project teams may revise these MPCs or establish additional MPCs if necessary to achieve project-specific DQOs; however, the project-specific QAPP must explain and justify any changes to black text. An appendix may be used for this purpose.

Table 12-1. Measurement Performance Criteria

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
Site Preparation			
1. Accessibility	Completeness	All areas inaccessible to investigation or inaccessible to use of proposed geophysical systems are identified and mapped in a geographic information system (GIS).	Lead organization will visually inspect the site and/or review the GIS
Sampling Design			
2. Planned survey coverage (Preliminary MRS Characterization)	Representativeness/ Completeness	Planned, initial transect spacing will be sufficient to detect HUA with a radius of X at a confidence level of 100%. Infill transects will be designed to achieve the MPC for anomaly density estimates (see MPC 13).	QC geophysicist reviews Visual Sample Plan (VSP) output. [VSP *Post-Survey-Probability-Of-Traversal* tool.]
3. Detection threshold (transects & grids)	Sensitivity	5 x RMS noise [Note: This is expected to be sufficient to permit detection of both munitions and munitions debris.]	1) Review of sampling design 2) Initial verification at instrument verification strip (IVS) 3) Background analysis prior to VSP analysis

Table 12-1. Measurement Performance Criteria

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
Data Acquisition			
4. Background data collection (Advanced Geophysical Classification (AGC))	Representativeness/ Accuracy	Background locations will be selected such that background data will be representative of the various subsurface conditions expected to be encountered within each survey unit at the site.	Data verification/data validation
5. Positioning requirement (locating transects and sampling grids)	Accuracy	Actual positions must be within X (e.g., 10m) of planned positions.	Review of sampling design Quality Control (QC) Geophysicist and lead agency oversight
6. Positioning requirement (full coverage grid mapping and reacquisition)	Accuracy	Recorded measurement positions must be within 0.1m of actual positions.	Review of sampling design Initial verification at IVS
7. Survey coverage: maximum speed on transect (analog)	Accuracy/ Completeness	98% ≤ 0.45 meter/second (approx. 1 mile/hr); 100% ≤ 0.5 meter/second [Note: A hand-held GPS can be used for this purpose.]	QC geophysicist/lead agency (or designee) oversight
8. Survey coverage (transects)	Accuracy/ Completeness	100% of planned transects are sampled	Actual course over ground is recorded and evaluated for each survey unit
9. Survey coverage (grids)	Accuracy/ Completeness	100% of specified acreage is sampled at the calculated lane spacing.	Data validation
10. QC seeding (AGC and Digital Geophysical Mapping (DGM)) (grids only)	Accuracy/ Completeness	(High density (HD) Area Characterization) Contractors will place blind QC seeds at the rate of 1 seed/system/day. Planning documents must describe the blind seed firewall.	Lead agency verifies all QC seed failures are explained and corrective action implemented
11. QC seeding (analog)	Accuracy/ Completeness	QC seeding is recommended during investigation of full coverage grids, but not required.	To be completed by project team if QC seeding is conducted

Table 12-1. Measurement Performance Criteria

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
Data Acquisition			
12. QA Seeding: grids (analog) (Except when analog sensors are used for screening purposes prior to the use of digital sensors.)	Sensitivity/Representativeness/ Completeness	HD Area Characterization: Blind quality assurance (QA) seeds will be placed at the site by the Government/independent third party at the rate of 5-6/person/day. The entire grid must be resurveyed until all seeds are located. Blind QA seeds must be detectable as defined by the DQOs and located at depth (defined in Worksheet #11 Step 4) throughout the horizontal survey boundaries defined in the DQOs.	HD Area Characterization: Lead agency oversight
13. Anomaly density estimates (assessed during intrusive investigations associated with population testing	Accuracy/ Representativeness	Contiguous sub-areas (e.g. grids) within Target Area(s) will be mapped, and all anomalies meeting the project-specific detection threshold will be identified for classification or excavation. The anomaly density in each sub-area (grid) will not differ from that predicted by more than +50% or -30%.	Total number of anomalies divided by the grid area will be compared to the anomaly density predicted from geostatistical anomaly density analyses (i.e. Kriging of transect data) for that location
Anomaly Resolution/Classification			
14. Anomaly resolution (DGM and analog)	Accuracy/ Completeness	HD Area Characterization: 100% excavation in representative transects/grids. (Sample acreage to be specified in WS #17). Excavation must continue vertically until anomaly is resolved or other obstruction encountered.	QC Geophysicist (or designee) verifies
15. Anomaly resolution (DGM and analog)	Completeness	All items within X m laterally must be recovered for each flag	QC Geophysicist (or designee) verifies

Table 12-1. Measurement Performance Criteria

Measurement	Data Quality Indicator	Specification	Activity Used to Assess Performance
Anomaly Resolution/Classification			
16. Anomaly resolution (AGC)	Accuracy/ Representativeness	Preliminary Characterization: All anomalies must be characterized and all MEC-like anomalies must be excavated. HD Area Characterization: Excavation of anomalies will be performed in representative grids where necessary to fill data gaps in the CSM. Inversion results correctly predict one or more physical properties (e.g. size, symmetry, or wall thickness) of the recovered items (specific tests and test objectives established during project planning)	Qualitative examination and documentation of recovered items
17. Anomaly classification (AGC)	Completeness/ Comparability	Library must include signatures for all items considered by the project team to be Target of interest (TOI), as listed in the CSM.	Verification of site-specific library
18. Anomaly classification (AGC)	Completeness	All detected anomalies classified as: 1. TOI 2. Non-TOI 3. Inconclusive	Data verification
19. Anomaly classification (AGC)	Accuracy	100% of predicted non-TOI that are intrusively investigated are confirmed to be non-TOI.	Visual inspection of recovered items from classification validation
NIA Confirmation			
20. NIA Confirmation	Representativeness/ Completeness	Well-developed CSM, confirmed by RI results, showing no evidence of munitions use.	DUA

Worksheet #13: Secondary Data Uses and Limitations
(UFP-QAPP Manual Section 2.7)

This worksheet should be used to identify sources of secondary data (i.e., data generated for purposes other than this specific project, or data pertinent to this project generated under a separate QAPP) and summarize information relevant to their uses for the current project. This worksheet should describe specifically how all secondary data will be used. The project team needs to carefully evaluate the quality of secondary data (in terms of project-specific measurement performance criteria (MPCs)) to ensure they are of the type and quality necessary to support their intended uses. Examples of secondary data include the following: sampling and testing data collected during previous investigations, historical data, background information, interviews, modeling data, photographs, aerial photographs, topographic maps, and published literature. When evaluating the reliability of secondary data and determining limitations on their uses, consider the source of the data, the time period during which they were collected, data collection methods, data verification/validation procedures, potential sources of uncertainty, the type of supporting documentation available, and the comparability of data collection methods to the currently proposed methods. Examples are provided below.

Table 13-1. Secondary Data Uses and Limitations

Data type	Source	Data uses relative to current project	Factors affecting the reliability of data and limitations on data use
Topographic data	USGS	• Pre-planning for geophysical method selection • Land-use estimating	None noted

Range boundaries	• ASR/PA
	• SI
	• EE/CA
		• Transect Planning
		• Identify potential LUA
			• ASRs/PAs may not include comprehensive searches of historical records sources
			• Range constructions do not always follow design plans or are not always accurately depicted on maps
			• EE/CA DQOs focused on identifying starting points for NTCRA, not characterizing the MRS
			• This specific SI:
			  • Investigated only a small portion of the MRS with a ribbon walk that approximated site boundaries
			  • The inspection may have occurred when heavy vegetation obscured portions of the ground surface

Infrastructure locations	• ASR/PA/SI • Google Earth • USGS maps • Historical photo analysis	• Locating potential firing points • Land-use estimating	Limited number of dates having historical photos

Table 13-1. Secondary Data Uses and Limitations

Data type	Source	Data uses relative to current project	Factors affecting the reliability of data and limitations on data use
Range history	• ASR/PA/SI • Historical photo analysis • Previous clearance activities by EOD • ECA/TCRA/NTCRA • EE/CA	ASR/PA/SI/Historical Photos: • Locating potential firing points • Locating suspected target areas • Locating potential disposal areas Previous Clearances: • Types of munitions used • Areas used for target practice	ASR/PA/SI/Historical Photos: • Limited number of dates having historical photos • ASR/PA may not include comprehensive searches of historical records sources • Range constructions do not always follow design plans or are not always accurately depicted on maps • Investigated only small portion of MRS with a ribbon walk Previous clearance activities by EOD: • Incomplete records of areas actually investigated ECA/TCRA, EE/CA: • Investigated only a small portion of MRS • DGM Thresholds not established to detect fragments • Analog sensitivity settings not monitored to meet detection needs for this RI

Table 13-1. Secondary Data Uses and Limitations

Data type	Source	Data uses relative to current project	Factors affecting the reliability of data and limitations on data use
Munitions use and disposal	• Previous EOD responses • TCRA/NTCRA using analog methods • EE/CA	• Identify locations of munitions recoveries • May be used to support HUA/LUA boundary based on quantities of MEC & MD recorded per acre • May be used to support LUA/NIA boundary	Previous EOD responses: • Low Pd • Undocumented field methods • Undocumented QC TCRA/NTCRA: • Low Pd, particularly for items not near the surface • Incomplete supporting documentation EE/CA: • Focused on small part of MRS; DQOs focused on identifying starting point for NTCRA, not characterizing the MRS

Worksheet #14 & 16: Project Tasks & Schedule
(UFP-QAPP Manual Section 2.8.2)

The QAPP should include a project schedule showing specific tasks, the person or group responsible for their execution, and planned start and end dates. The following template may be used or a Gantt chart can be attached and referenced. Examples of activities that should be listed are shown below. Any critical steps and dates should be highlighted.

Table 14-1. Project Tasks and Schedule

DFW	Activity	Responsible party	Planned start date	Planned completion date	Deliverable(s)	Deliverable due date
1	Site Preparation					
1	Surface Sweep					
1	Transect Placement					
2	IVS Construction					
3	Sensor Assembly					
3	Initial Instrument Verification Strip (IVS)					
4	Initial Transect Survey					

Table 14-1. Project Tasks and Schedule

DFW	Activity	Responsible party	Planned start date	Planned completion date	Deliverable(s)	Deliverable due date
5	Anomaly Selection					
5	Data Validation					
6	Visual Sample Plan (VSP) Analyses					
6	Preliminary Data Usability Assessment (DUA)					
6	High Density (HD)/Low Density (LD) Delineation					
7	Finalize Sampling Design					
8	Seed Emplacement					
9	Data Collection					
10	Anomaly Selection					

Table 14-1. Project Tasks and Schedule

DFW	Activity	Responsible party	Planned start date	Planned completion date	Deliverable(s)	Deliverable due date
10	Data Validation					
11	Determine Anomaly Source Characteristics					
12	Conduct DUA					
12	Characterize High Use Area (HUA)					
12	Establish HUA Boundaries + Buffer Zones					
12	Update CSM					
13	Review CSM					
13	Collect Data to Fill Remaining Data Gaps					

Table 14-1. Project Tasks and Schedule

DFW	Activity	Responsible party	Planned start date	Planned completion date	Deliverable(s)	Deliverable due date
13	Establish Low Use Area (LUA)/Non-impacted Area (NIA) Boundaries					
14	Conduct Final DUA					
14	Finalize CSM					

Worksheet #17: Sampling Design and Project Work Flow
(UFP-QAPP Manual Section 3.1.1)

This worksheet describes and justifies the design for the RI. It documents Step 7 of the DQO process.

The sampling design and project work flow should include the following:

1. A map showing physical boundaries for each munitions response site (MRS).
2. A work flow diagram (See Figures 17-1 through 17-3 for examples).
3. Concise descriptions for each DFW, including required documentation and deliverables. (Standard Operating Procedures (SOPs) containing detailed procedures must be included in an appendix to the project-specific QAPP).
4. Contingencies in the event field conditions affecting the sampling design are different than expected (e.g. a portion of the site is inaccessible at the time the site work is planned to occur, or anomaly density is higher than expected).
5. Points in the process at which lead organization, regulator, and stakeholder interface will occur, as agreed upon during project planning.

[Note: The project work flow and example presented below are designed to illustrate a sampling design for a Remedial Investigation (RI) conducted in phases (i.e., multiple mobilizations), at a large MRS involving multiple types of targets. The example incorporates the use of both analog and digital technology. Many "real-life" scenarios will be less complex, and the sampling design should be adapted accordingly. For example, at sites where the locations and uses of targets were well-documented during the SI, as reflected in the preliminary CSM, it may not be necessary to conduct the RI in phases (i.e., the Preliminary MRS Characterization Phase may be unnecessary). Project teams may modify the project work flow described below to accommodate the project-specific sampling design.]

Project Work Flow: This section should provide concise descriptions for each definable feature of work and highlight government (lead organization and/or regulatory) inspection/oversight activities, key deliverables, and decision points, as they have been agreed upon during project planning. Where applicable, worksheet #17 should reference SOPs containing detailed procedures.

Preliminary MRS Characterization: Describe the technical approach to be used to delineate high density (HD) areas from low density (LD) areas. [Note: If this was successfully accomplished during the SI, provide a brief explanation, and proceed to the HD Area Characterization.] HD areas will be considered potential high-use areas (HUA), and LD areas will be considered potential low-use areas (LUA) or non-impacted areas (NIA), subject to decision rules presented in Worksheet #11, Step 5.

DFW 1: Place transects and conduct site preparation (contractor and lead organization): Describe or reference procedures used to establish and document survey boundaries and transect locations, including the use of control points for data positioning. Identify activities that must be completed prior to conducting site work (e.g., surface sweep; vegetation clearance; construction of silt fences or other barriers to prevent access by or exposure to potential receptors during site activities; and activities to preserve cultural resources or sensitive habitats, if needed).

Figure 17-1. Work Flow Diagram Preliminary MRS Characterization [Example]

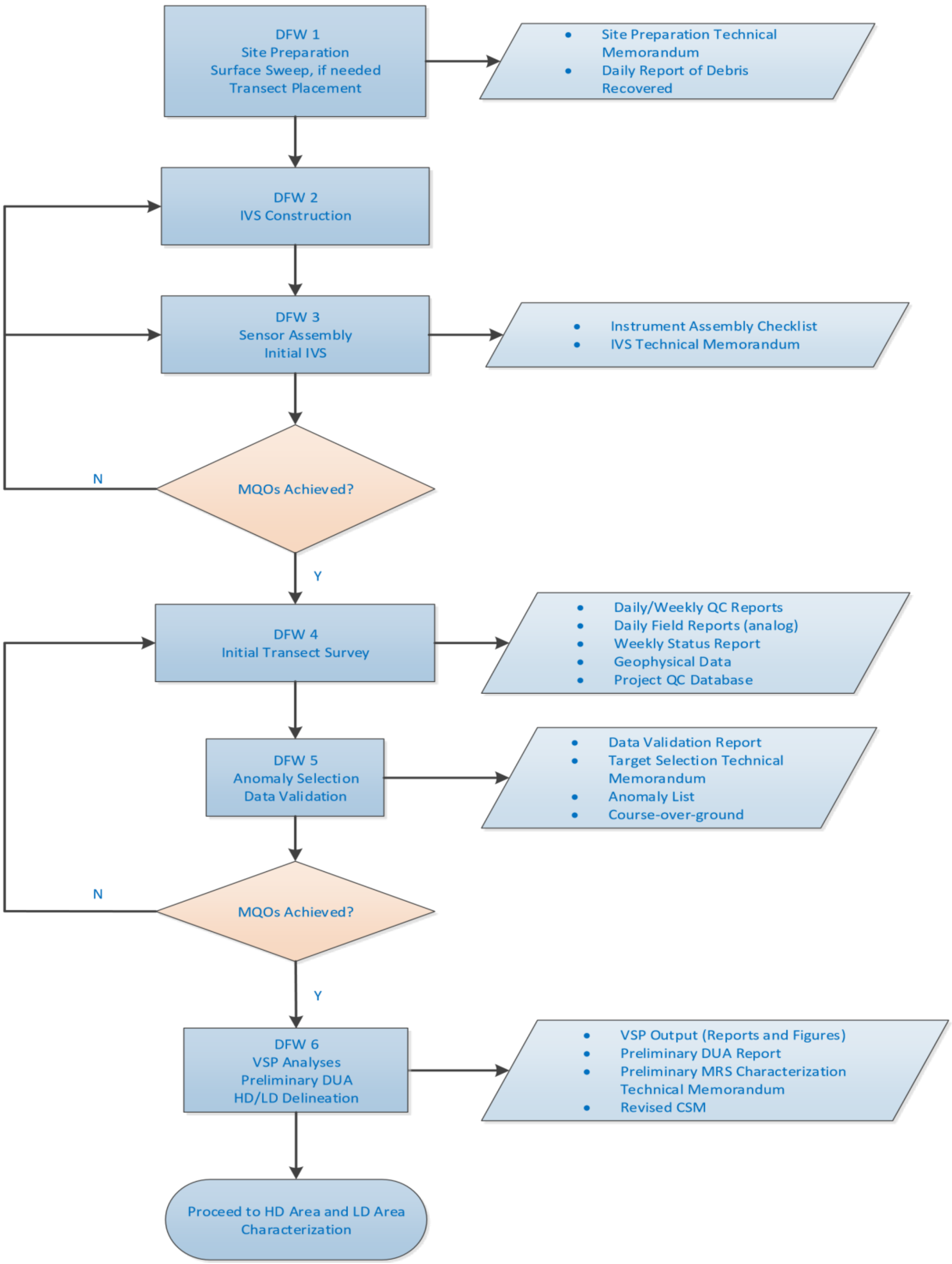


Figure 17-2. Work Flow Diagram HD Area Characterization [Example]

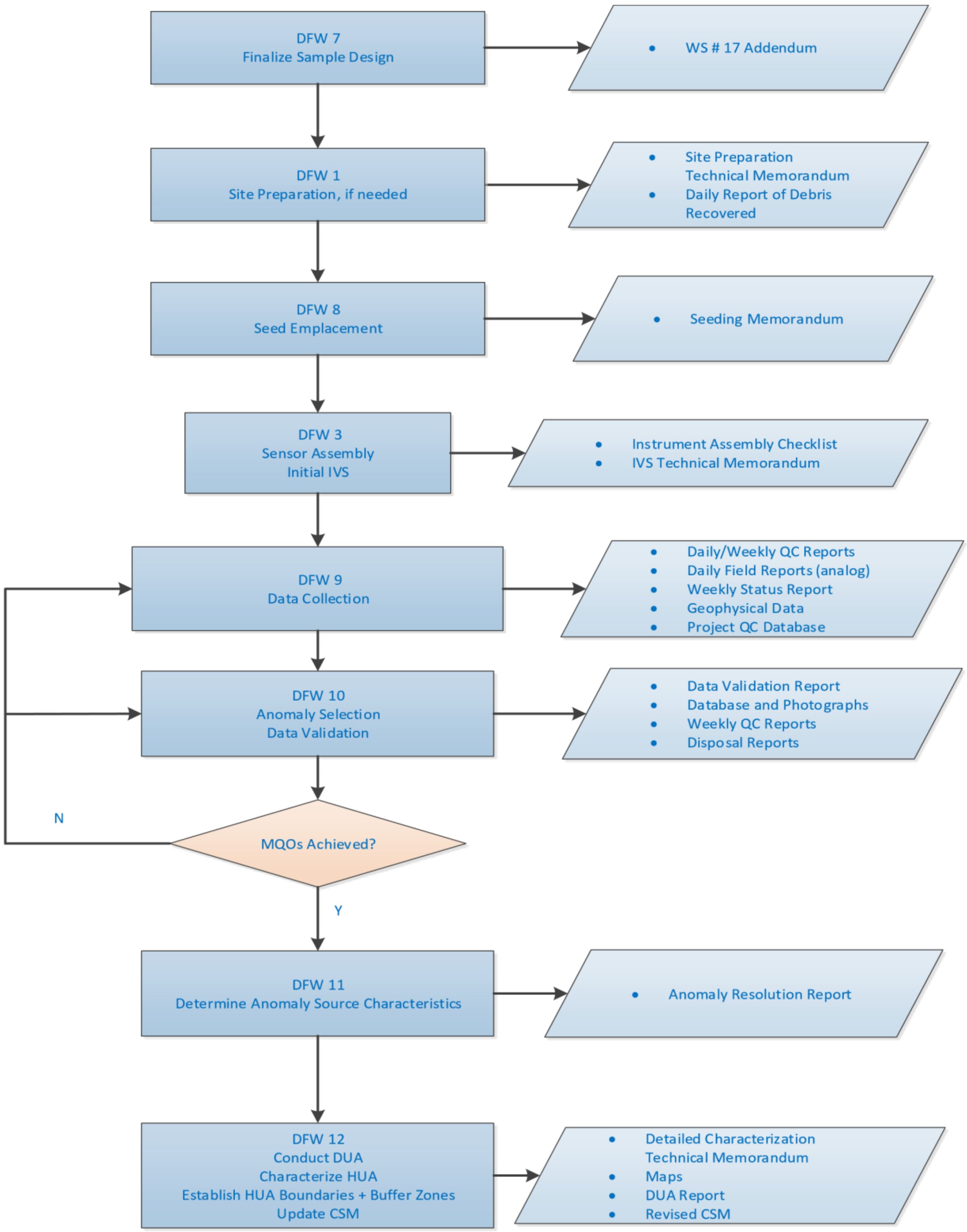
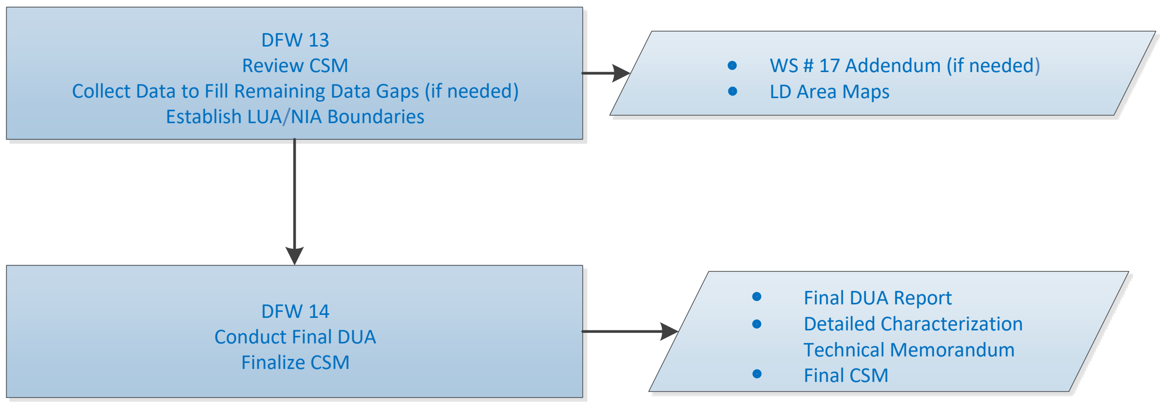


Figure 17-3. Work Flow Diagram LD Area Characterization [Example]



Documentation: Site Preparation Technical Memorandum; Daily report (including photographs) of debris recovered.

[Example] Contractor: The contractor will conduct site preparation activities at MRS A and MRS B, including areas needed for equipment ingress/egress. Beginning in the NW corner of the site at 4,337,000 Northing and 638,000 Easting, the contractor will mark the locations of the start and end point of each transect separated as indicated in Worksheet #11 Table 11-3. The contractor will conduct surface sweep to make geophysical mapping paths along marked transects safe for field personnel. The contractor will document the location of any munitions and explosives of concern (MEC) encountered and note any recognizable munitions debris (MD) that is not consistent with the uses described in the CSM. Following the lead organization's inspection and acceptance of the surface sweep, the contractor will [describe remaining site preparation activities]. Detailed procedures are contained in SOP(s) __ [list relevant SOPs].

Lead organization: Following the site preparation activities, the lead organization (or designee) will review the Site Preparation Technical Memorandum and visually inspect the cleared paths.

DFW 2: Construct Instrument Verification Strip (IVS) (contractor and lead organization): Describe or reference procedures for constructing the IVS, including the number, descriptions, depths, and orientation of targets.

Documentation: [Instrument Verification Strip (IVS) Technical Memorandum to be submitted at the completion of DFW 3]

[Example] Contractor: The contractor will select a location free of existing anomalies that is 2m wide and 25m long. The contractor will emplace two small ISO80 and two inert 37mm projectiles, all at a minimum separation distance of 5m. The site team selected small objects for the IVS, since the site characterization relies primarily on the detection of MD and RRD, which are small. The contractor will survey the location of each object in the IVS using cm-level GPS and record the as-buried positions.

DFW 3: Assemble and verify correct operation of geophysical sensor to be used for the preliminary MRS characterization (contractor and lead organization): Describe or reference procedures to be used to assemble and verify correct operation of the instrument (initial function test). Describe or reference procedures for testing sensor operation at the IVS.

Documentation: Instrument Assembly Checklist; IVS Technical Memorandum

[Example]: The contractor will assemble equipment as described on SOP__. The contractor will perform the required instrument function test to verify correct operation and record the measured responses. The contractor will survey the IVS and verify correct responses.

Lead organization: The lead organization (or designee) will review the IVS Technical Memorandum and visually inspect the IVS.

Decision point: Have measurement quality objectives (MQOs) been met?

DFW 4: Conduct initial transect survey (contractor and lead organization): Describe or reference the equipment and procedures to be used to conduct the initial transect survey, including ongoing field quality control (QC) activities. Describe requirements for detection and positioning. Describe requirements for visually inspecting and recording observations of surrounding areas during ingress, egress, and field activities.

Documentation: Daily/Weekly QC Reports (including surface debris encountered and transect locations), Daily Field Reports (analog), Weekly Status Report, Geophysical Data, Project QC Database

[Example] Contractor: The contractor will collect transect data in MRS A using Time-domain Electromagnetic Multi-sensor Towed Array Detection System (TEMTADS) advanced geophysical classification (AGC). The contractor will collect transect data in MRS B using an EM61 digital geophysical mapping (DGM) array in all areas except the area marked that has been determined inaccessible to DGM, where transect data will be collected using a Schonstedt. The contractor will perform QC activities as indicated in Worksheet #22.

MRS A

TEMTADS: Based on the Visual Sample Plan (VSP) input parameters in Worksheet #11, the contractor will collect transect data in MRS A using TEMTADS in its standard cart configuration. Transects will be spaced 250m apart and run in the N-S orientation, as shown in Figure 17-4. The contractor will document field observations of site conditions that may aid in interpreting the transect data and supporting the CSM, including the location and nature of indications of munitions or non-munitions-related activity encountered. Detailed procedures are contained in SOP(s) __.

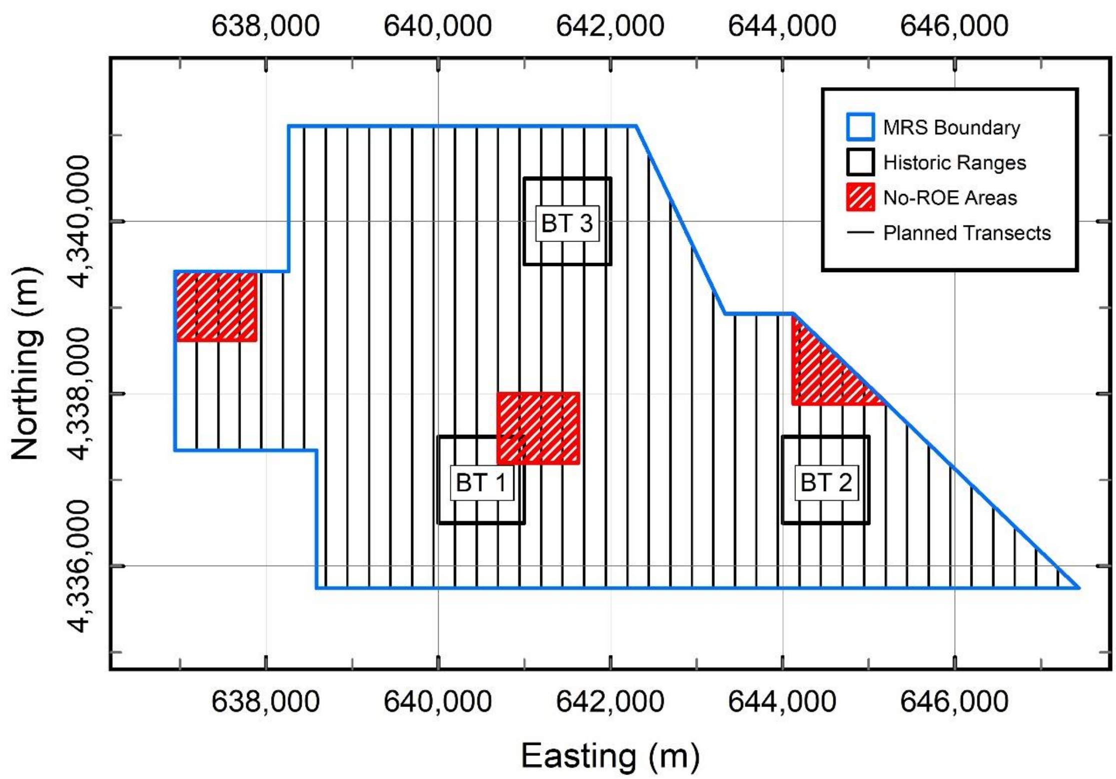


Figure 17-4. Planned transects for collection of TEMTADS data in MRS A

MRS B

EM61. The contractor will use a 3m wide EM61 array to collect data over planned transects. EM61 transects will be spaced 225m apart and run in the N-S orientation, as shown in Figure 17-5. The system will be equipped with cm-level GPS and an electronic navigation system for locating and following planned transects. The contractor will document field observations of site conditions that may aid in interpreting the transect data and supporting the CSM, including the location and nature of indications of munitions or non-munitions related activity encountered. Detailed procedures are contained in SOP(s) __.

Analog. In the area inaccessible to the EM61, shown in grey in Figure 17-5, the contractor will survey transects using a Schonstedt handheld gradiometer. Transects will be 1.5m wide, spaced 129m apart, and will follow parallel to the slope. The operator will use a handheld GPS to record a waypoint at the location of each identified anomaly. The contractor will document field observations of site conditions that may aid in interpreting the transect data and supporting the CSM, including the location and nature of indications of munitions or non-munitions related activity encountered. Detailed procedures are contained in SOP(s) __.

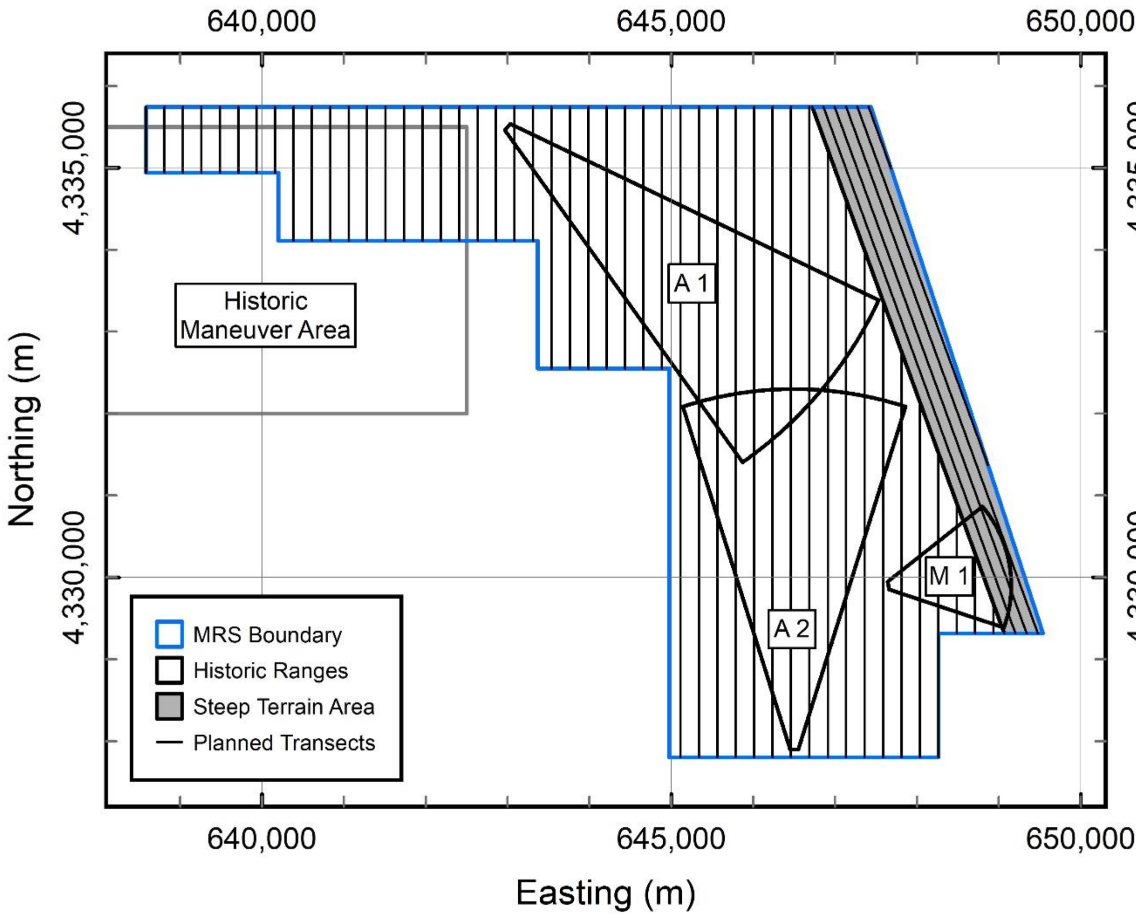


Figure 17-5. Planned transects for collection of DGM and Analog data in MRS B

Lead organization: The lead organization (or designee) will review reports and data as submitted.

DFW 5: Select anomalies and conduct data validation (contractor and lead organization): Describe the procedures to be used to validate the transect survey data (Worksheet #35 may be referenced) and select anomalies.

Documentation: Data Validation Report, Target Selection Technical Memorandum, Anomaly List, and Course-over-Ground

[Example] Contractor: The contractor will verify that all information is complete for each day of field activities and any changes or exceptions are documented and have been reported in accordance with requirements. The contractor will verify that all MQOs have been achieved, with any exceptions noted, and that any necessary corrective actions have been completed and documented.

TEMTADS and DGM: The contractor will preprocess the data as described in SOP__ and SOP__, respectively. From segments of the transect data where no anomalies are present, the contractor will measure the RMS background noise. This will be done in more than one location if significant variation in background is observed. The contractor will select and record the location of all anomalies that exceed a threshold of five times the RMS background noise. Detailed procedures are contained in SOP(s) __.

Analog: Not relevant.

Lead organization: The lead organization (or designee) will review reports and data as submitted and verify coverage.

<u>Decision point: Have MQOs been met?</u>

<u>DFW 6: Perform VSP analyses, conduct Preliminary Data Usability Assessment (DUA), and delineate HD/LD areas:</u> Describe the procedures to be used to identify HD areas. Document and discuss any changes to planning assumptions based on field work (e.g., different background density observed, evidence of unexpected munitions).

<u>Documentation:</u> VSP Output (reports & figures), DUA Report, Preliminary MRS Characterization Memorandum, Updated CSM

[Example] Contractor: The contractor will analyze transect data using VSP to identify areas of elevated anomaly density (HD areas) according to the decision rules outlined in Worksheet #11. The contractor will update the VSP inputs to reflect actual background anomaly densities and assess whether any adjustments are needed to the critical density. The initial VSP analysis will provide a preliminary estimate of size and density of HD areas. The locations of the HD areas will be compared to the CSM. Any unexpected HD areas, and any planned target areas that are not HD areas, will be noted.

Lead organization: Following the Preliminary Characterization analysis, the lead organization (or designee) will review the Preliminary Characterization Technical Memorandum, and when it is determined to be satisfactory, will provide authorization to proceed.

[Appendix A provides an example of a Preliminary MRS Characterization Memorandum that would be generated at the conclusion of DFW 6 for Camp Example.]

<u>HD Area Characterization:</u> [Note: The planning for this phase will depend on the results of the Preliminary Characterization. As such, it will be completed following the analysis of the initial transect survey data, and an addendum to Worksheet #17 will be prepared at that time. The example presented below includes both the general planning text that would be contained in Worksheet #17 prior to the Preliminary Characterization step and the updated, detailed text that would be included in the Worksheet #17 Addendum when the Preliminary Characterization was complete.]

The objective of HD Area Characterization is not to locate every item of MEC, but to gather sufficient data to determine whether the HD area is a high-use area, support a baseline risk assessment, and support a cost estimate and anticipated technology performance if a remedial action is warranted. Describe the technical approach to be used to (1) confirm whether the area is, or contains, one or more high-use areas by documenting munitions-related features such as the presence of MEC, munitions debris (MD) or range-related debris (RRD); (2) characterize various populations of anomalies that are present in HD areas, including evidence of the type(s) of munitions, their horizontal and depth distributions, and any cultural or geological anomaly sources that may impact technology performance; (3) establish boundaries for high-use areas, defined as the point at which, moving outward from the center of the high-use area, the anomaly density drops to the background density; and (4) define "buffer areas" associated with high use areas.

DFW 7: Design Additional Sampling Required for HD Area Characterization (contractor and lead organization). Describe the process for determining whether and what additional data will be required to adequately characterize the HD area(s), including visual inspection, collection of additional transect data, geophysical surveys of full coverage grids, and/or anomaly source identification.

Documentation: Worksheet #17 Addendum

[Example Planning Text]: Contractor: For each HD area identified in the Preliminary Characterization, the contractor will (1) determine whether the area corresponds to a known target or other high-use area in the CSM, (2) determine whether field notes provide a likely source of any unexpected HD areas, (3) determine whether a physical inspection of the HD area is needed, (4) determine whether additional transect data are needed to characterize the size and density of the area in support of a cost estimate accurate to +50/-30% and, if so, design additional transects using VSP, (5) determine whether digging the locations of transect anomalies will provide useful characterization information, and (6) determine whether collecting additional geophysics data in grids will be useful and, if so, design the size, number and placement of grids.

In HD areas where munitions use is documented, the project team has determined that the contractor will survey a minimum of five ¼-acre grids. This value will be adjusted as necessary to demonstrate representative coverage depending on the size and homogeneity of the site or to reflect other information that indicates the likely origin of the HD area. The grids will be placed to sample from the highest density areas toward the periphery the HD area in multiple directions. For large HD areas and/or areas with multiple hot spots, the contractor will recommend and justify additional grids for adequate characterization. In very high density areas, the contractor may recommend and justify using smaller grids to attain a sufficient number of anomalies for characterizations. Unexpected variability in the results from the initial grids will indicate that additional data collection is needed. In HD areas that are determined to be HUA, the contractor will recommend and justify a process for designating "buffer zones," that considers the known uses of the target, as well as the uncertainties inherent in the HUA characterization.

For other areas, the contractor will recommend and justify a data collection plan. Supplemental decision rules, if needed, should be documented in the Worksheet #17 Addendum.

[Example of specific text to be included in the Worksheet #17 Addendum after Preliminary Characterization]

MRS A

BT1 and BT3. No HD areas corresponding to these locations were found. The site inspection (SI) found no evidence these planned targets were ever used. Any further investigation needed will be conducted during the LD Area Characterization.

BT2. This HD area corresponds to the location of a known target area in the CSM. The SI documented the presence of craters, MD, and RRD, and the field notes of the surface sweep team confirm this. No additional physical inspection is needed. The original transects were 250m apart. To support a more accurate estimate of the target size and density/number of anomalies, TEMTADS data will be collected on additional interleaved transects separated by 125m. The locations of all anomalies from the transect data that are consistent with intact munitions will be dug. The target boundary will be drawn at the point where the kriging analysis indicates that the anomaly density does not exceed background anomaly density. The Detailed Characterization Memorandum will document the basis for delineating the buffer zone as it relates to use of the HUA and uncertainty inherent in the sampling design.

To confirm the CSM and gather additional information about the types of munitions used on the site and the depth profile necessary to support costing estimates for the feasibility study, ten ¼-acre grids will be surveyed with the TEMTADS and all anomalies will be analyzed. Based on the estimate of target size and density from the preliminary characterization, the ten grids will represent one grid per 50 acres and their biased placement in the higher density areas should provide in excess of 2000 anomalies for characterization. The ten grids are expected to be sufficient for characterization since the HD area consists of a single hot spot for which anomaly density falls off in a normal manner surrounding the documented target center. The locations of the additional "in-fill" transects and grids are shown in Figure 17-6.

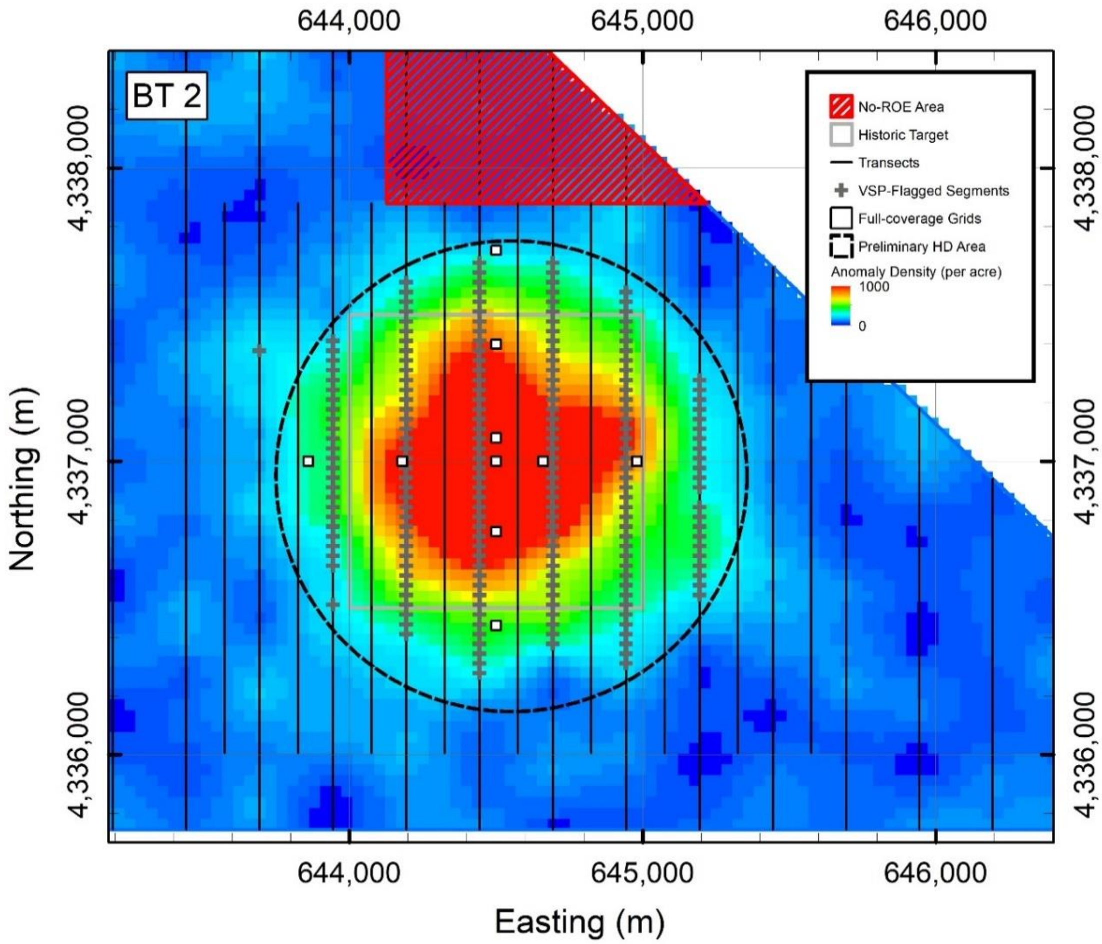


Figure 17-6. HD Area Characterization Plan for BT2 showing additional transects and grids

The advanced geophysical classification (AGC) analysis results will be used to establish a depth profile. The contractor will dig (1) any anomalies that match to target of interest (TOI), (2) anomalies with the characteristics of TOI (e.g., long, axially symmetric, and/or thick-walled), and (3) a representative sample of any unexpected clusters of anomalies that have similar characteristics in the AGC analysis.

Area of Concern (AOC) A. This HD area does not correspond to any known or planned target area. The geophysics team field notes indicate the presence of the entrance to an abandoned mine. The field crews did not observe any signs of MEC, MD, RRD, or craters. Presence of a mine entrance will be confirmed, photographed, and the global positioning system (GPS) location documented by a physical inspection. One ¼-acre grid will be surveyed with the TEMTADS, as shown in Figure 17-7, and all anomaly sources within the grid will be identified by digging.

Decision Rule: If no MEC, MD, or RRD is found, the field work will cease. If any MEC, MD, or RRD is found, additional site characterization will be planned.

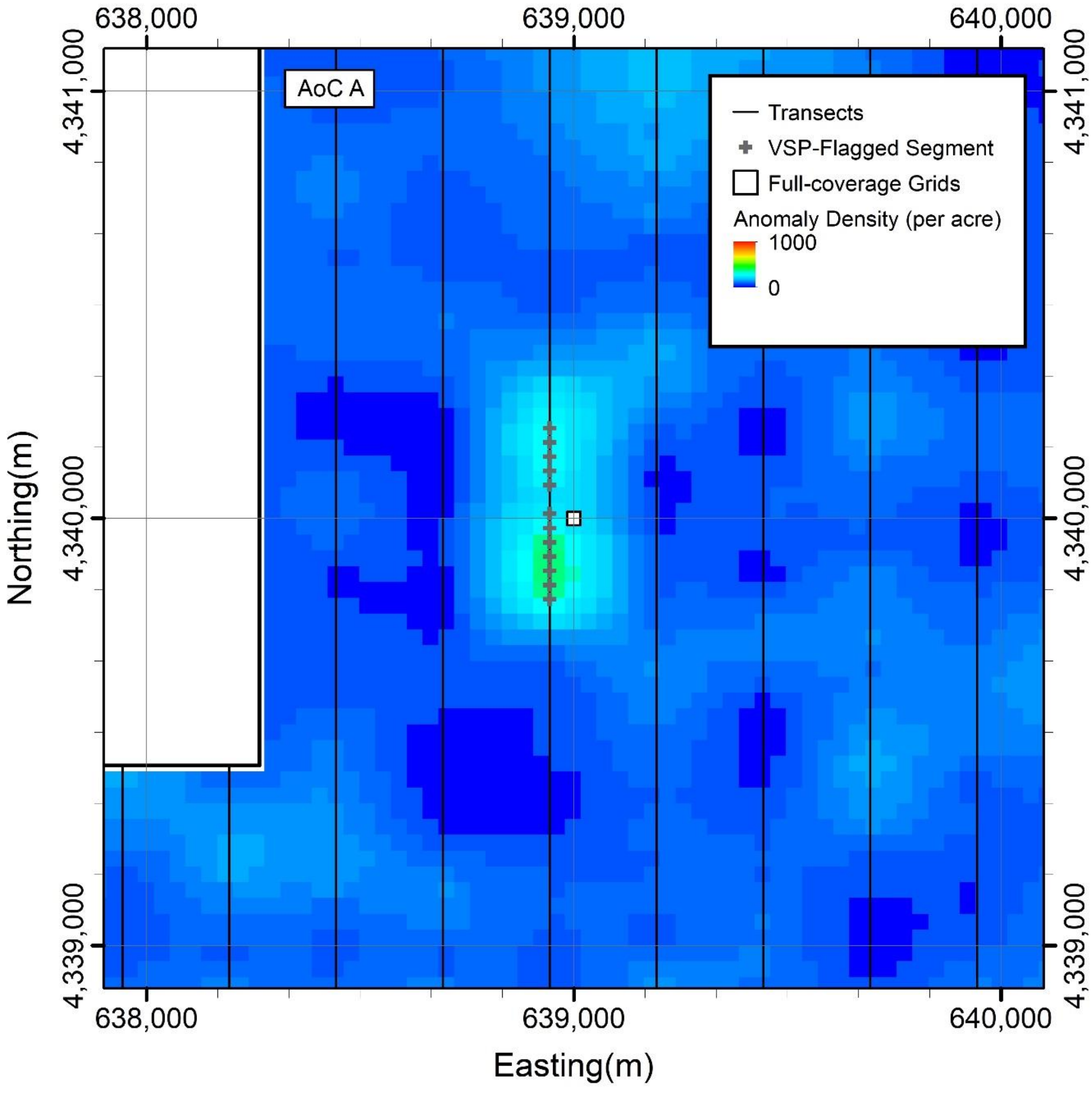


Figure 17-7. HD Area Characterization Plan for AOC A showing the location of a single grid

AOC B. This HD area does not correspond to any known or planned target area. The geophysics team field notes do not indicate the presence of surface MD or suggest any other use that would result in a concentration of metal objects. To determine whether the HD area is the result of munitions use and, if so, gather additional information about the types of munitions used on the site and the depth profile, seven ¼-acre grids will be surveyed with the TEMTADS, as shown in Figure 17-8, and all anomalies will be analyzed. Based on the estimate of target size and density from the preliminary characterization, this represents one grid per 30 acres and should yield in excess of 400 anomalies. The analysis results will be used to establish a depth profile.

The contractor will dig (1) any anomalies that match to TOI, (2) anomalies with the characteristics of TOI (e.g., long, axially symmetric, and/or thick walled), and (3) a representative sample of any unexpected clusters of anomalies that have similar characteristics in the AGC analysis.

Decision Rule: If no munitions-related items are recovered in the AGC-guided digging, the contractor will dig all anomalies in the one grid with the highest anomaly density. If no munitions-related items are recovered at this point, the contractor will document the source(s) of anomalies that make up the HD area.

Decision Rule: If munitions use is confirmed, additional transects separated by 125m will be interleaved to support a more accurate estimate of the target size and density/number of anomalies.

All anomalies from the transect data that are consistent with intact munitions will be dug. The target boundary will be drawn at the point where the kriging analysis indicates that the anomaly density does not exceed background anomaly density.

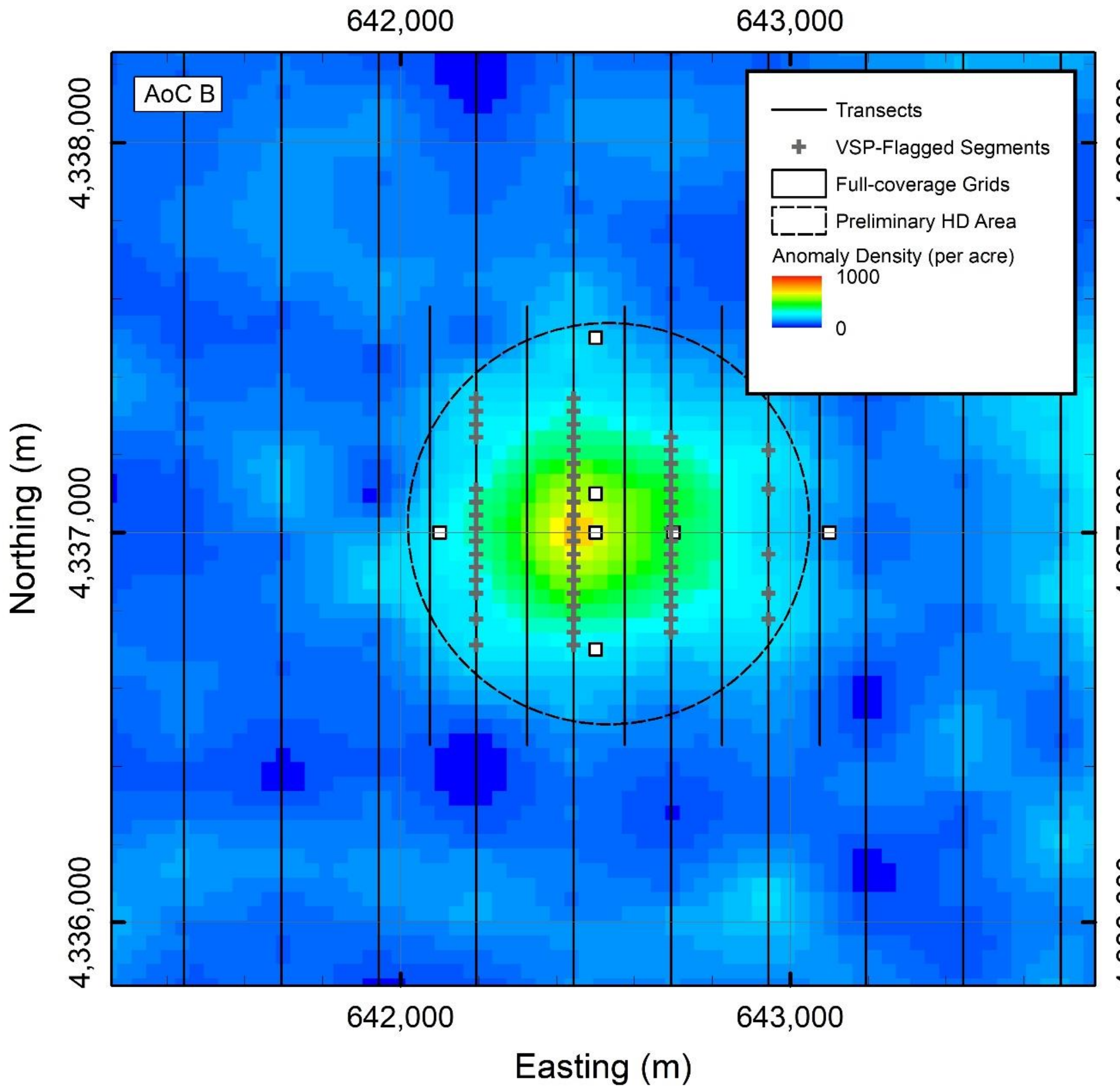


Figure 17-8. HD Area Characterization Plan for AOC B showing additional transects and grids

MRS B

A1 and A2. This HD area corresponds to the locations where the firing fans and impact areas from artillery targets A1 and A2 meet as documented in the CSM. The presence of MD and RRD was noted in the SI, and the field notes of the surface sweep team confirm this. No additional physical inspection is needed. The original transects were 225m apart. To support a more accurate estimate of the size and density/number of anomalies, additional transects separated by 112.5m will be interleaved. The target boundary will be drawn at the point where the kriging analysis indicates that the anomaly density does not exceed background anomaly density.

To confirm the CSM and gather additional information about the types of munitions used on the site and the depth profile necessary to support costing estimates for the feasibility study, one 20-foot by 20-foot grid will be surveyed in the highest density portion of the site and an additional ten ¼-acre grids will be surveyed with the EM61, to achieve one grid per 50 acres and yield a minimum of 800 anomalies. The planned data collection is shown in Figures 17-9 and 17-10. The locations of all anomalies selected in the grid survey data will be dug. The contractor will record the depth of each item recovered and whether the source was MEC, MD, RRD or non-munitions related. All MEC and any unexpected MD or RRD will be photographed and documented.

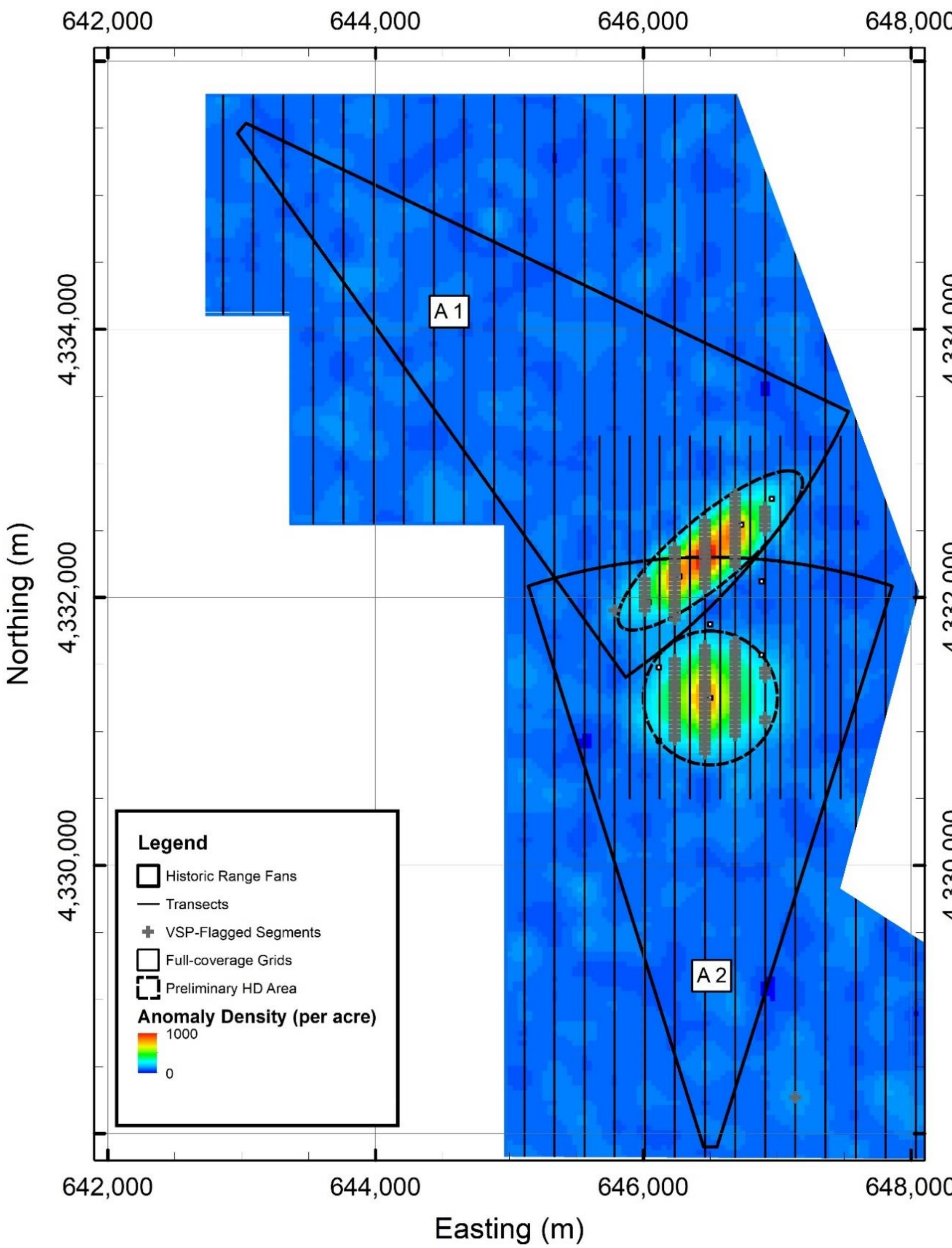


Figure 17-9. HD Area Characterization Plan for A1 and A2

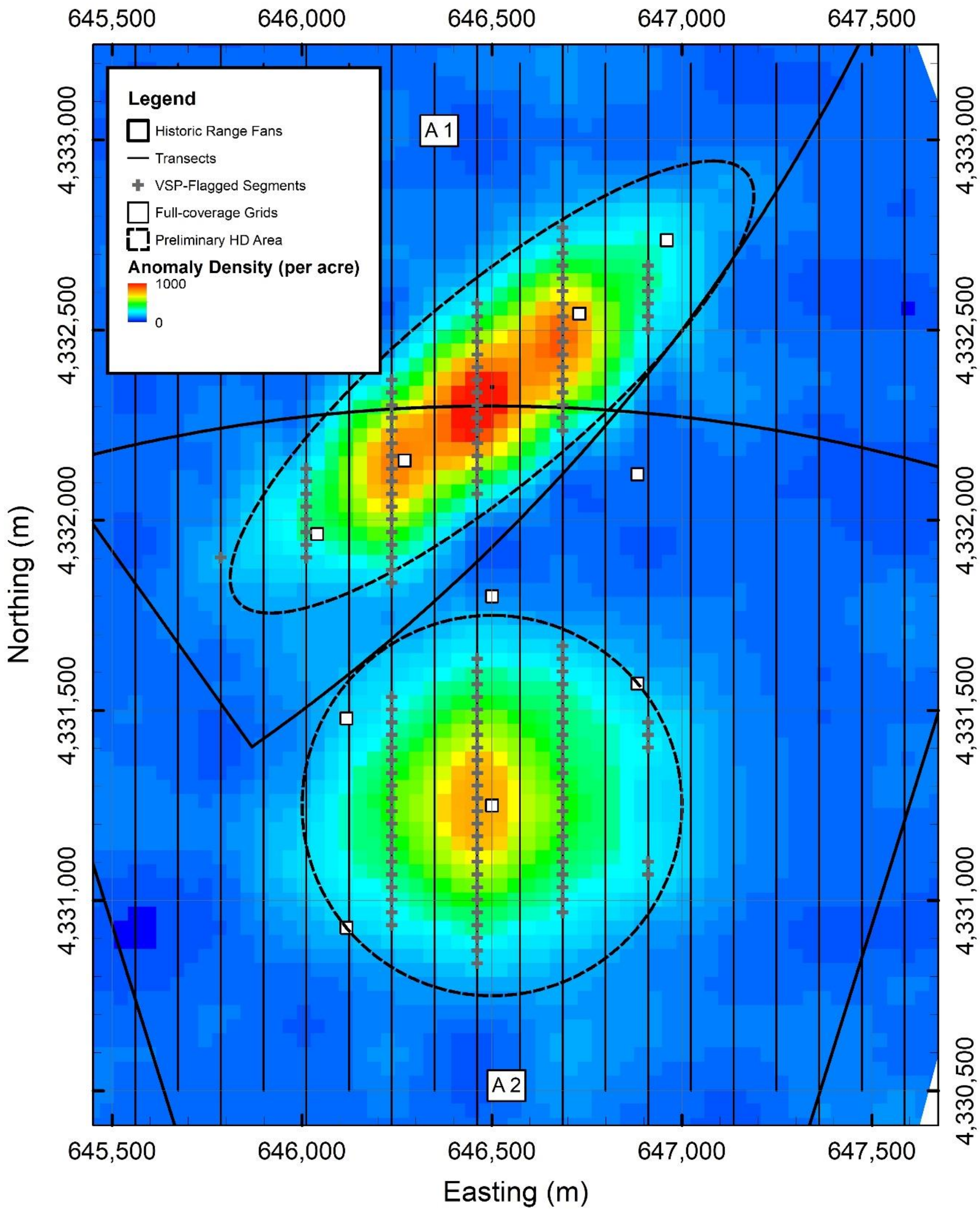


Figure 17-10. Detail of HD Area Characterization Plan for A1 and A2

M1. This HD area corresponds to the location of the target area within the range fan of a mortar target as documented in the CSM. The presence of MD and RRD was noted in the SI, and the field notes of the surface sweep team confirm this. No additional physical inspection is needed. The original transects were 129m apart for the analog survey.

To support a more accurate estimate of the size and density/number of anomalies, additional transects separated by 64.5m will be interleaved. The target boundary will be drawn at the point where the kriging analysis indicates that the anomaly density does not exceed background anomaly density. To confirm the CSM and gather additional information about the types of munitions used on the site and the depth profile, five ¼-acre grids (one per 30 acres) will be surveyed with the Schonstedt and a representative number of anomalies (e.g. 150 per grid) will be dug. The grids should yield well in excess of 1000 anomalies since the locations are biased to the high density areas. If the initial digs do not confirm the CSM, additional digs will be conducted. The additional transects and grids are shown in Figure 17-11. The contractor will record the depth of each item recovered, whether the source was MEC, MD, RRD, or non-munitions related. All MEC and any unexpected items will be photographed and documented.

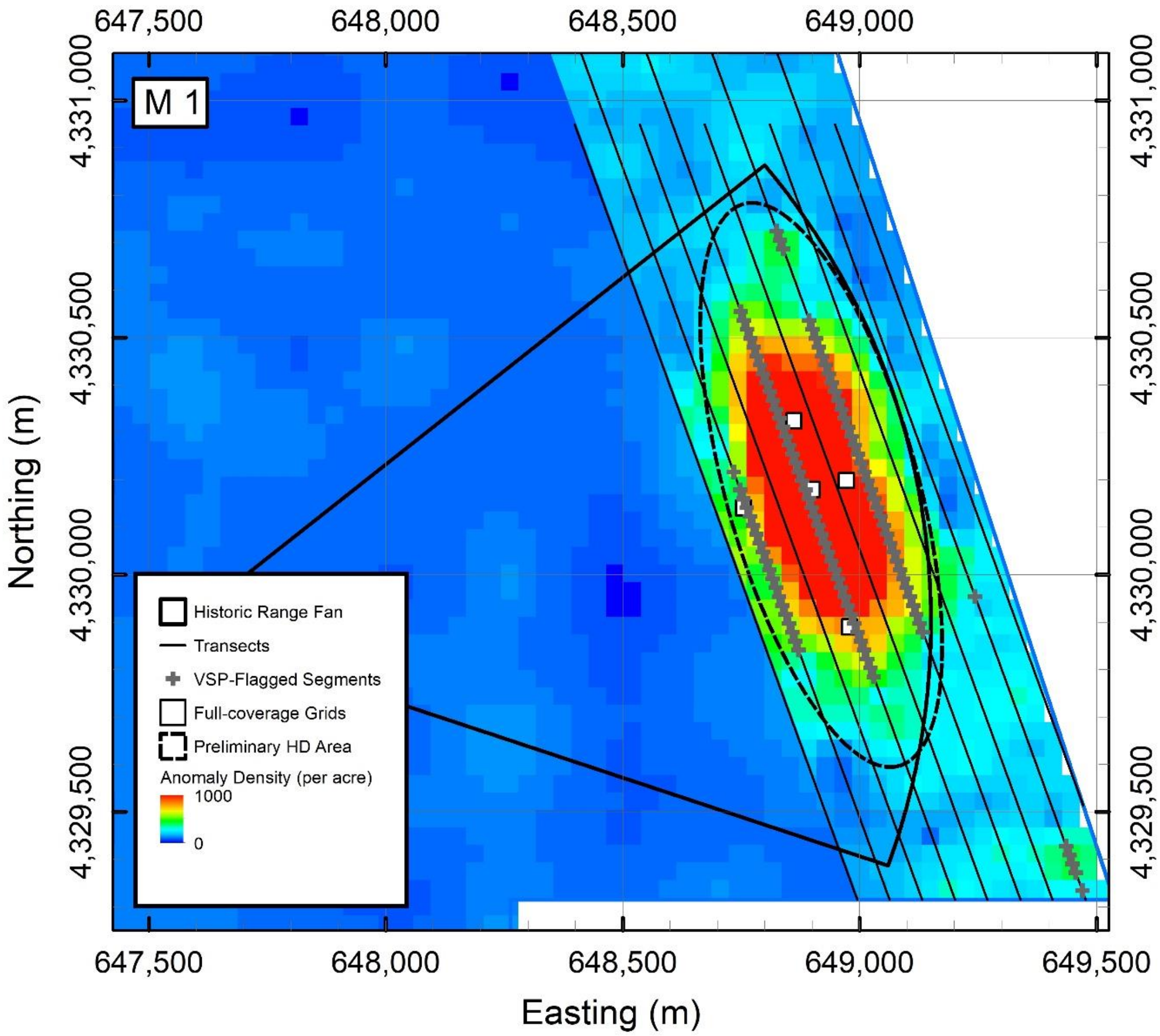


Figure 17-11. HD Area Characterization Plan for M1

Lead organization: The lead organization (or designee) will review the Worksheet #17 Addendum and, when it is determined to be satisfactory, provide authorization to proceed.

DFW 1: Conduct additional site preparation, if needed. See description of DFW 1 in Preliminary MRS Characterization.

DFW 8: Seed Emplacement: Describe procedures to be used for developing a seed plan and emplacing seeds. (Worksheet #22 may be referenced.)

Documentation: Contractor and government seed plans, contractor and government seeding memoranda.

[Example]: The contractor will emplace QC seeds to support the MQOs described in Worksheet #22. The contractor will survey and record the location of each QC seed. The contractor will establish and document an internal firewall between the QC activities and the field and data analysis activities. The contractor QC geophysicist will alert the government to any missed QC seeds and submit an RCA/CA.

Lead Organization, Analog only: The government team will emplace QA seeds to support the MQOs described in Worksheet #22. The government team will survey and record the location of each QA seed.

DFW 3: Assemble instrument, if needed: See description of DFW 3 in Preliminary MRS Characterization.

DFW 9: Conduct data collection (contractor and lead organization): Describe technology and procedures to be used for data collection, including the procedures and frequency for conducting field QC. (Worksheet #22 may be referenced.)

Documentation: Daily/Weekly QC Reports (including surface debris encountered and transect locations), Daily Field Reports, Weekly Status Report, Geophysical Data, Project QC Database

Example:

MRS A

AGC. The contractor will use TEMTADS in its standard cart configuration to collect data over the planned transects and grids. The contractor will document field observations of site conditions that may aid in interpreting the geophysical data and supporting the CSM, including the location and nature of indications of munitions or non-munitions related activity encountered. Detailed procedures are contained in SOP(s) __.

MRS B

DGM. The contractor will use a 3m wide EM61 array to collect data over planned transects and grids. The system will be equipped with cm-level GPS and an electronic navigation system for locating and following planned transects. The contractor will perform QC activities as indicated in Worksheet #22, including specified visits to the IVS and daily assessments of data completeness. The contractor will document field observations of site conditions that may aid in interpreting the geophysical data and supporting the CSM, including the location and nature of indications of munitions or non-munitions related activity encountered. Detailed procedures are contained in SOP(s) __.

Analog. In the area inaccessible to the EM61, the contractor will collect data over the planned transects and grids using a Schonstedt handheld gradiometer. The operator will use a handheld GPS to record a waypoint at the location of each identified anomaly along transects. The contractor will mark locations of each audible signal in the grids with a pin flag. The contractor will document field observations of site conditions that may aid in interpreting the geophysical data and supporting the CSM, including the location and nature of indications of munitions or non-munitions related activity encountered. Detailed procedures are contained in SOP(s) __.

Lead organization: The lead organization will review the IVS and QC reports.

DFW 10: Conduct anomaly selection and data validation (contractor and lead organization): Contractor: Describe the procedures for conducting data validation and process for selecting anomalies. The contractor typically conducts validation each day of data collection and generates a weekly QC report for review by the lead organization.

Documentation: Data Validation Report, Database (raw data, metadata, and photographs), Weekly QC Reports

[Example] Contractor: The contractor will verify that all information is complete for each day of field activities, and any changes or exceptions are documented and have been reported in accordance with requirements. The contractor will verify that all MQOs have been achieved, with any exceptions noted and that any necessary corrective actions have been completed and documented. The contractor will preprocess the data as described in SOP__. The contractor will select and record the location of all anomalies that exceed a threshold of five times the RMS noise. Detailed procedures are contained in SOP(s) __.

Lead organization: The lead organization (or designee) will review the data and reports as they are submitted.

Decision point: Have MQOs been met?

DFW 11: Determine anomaly source characteristics (contractor and lead organization): Describe the procedures for analysis of AGC data and/or excavation and determination of sources of anomalies.

Documentation: Anomaly Resolution Report and Disposal Reports

[Example] Contractor:

- In the area where AGC was used, the contractor will perform analyses as described in SOP__. The AGC analysis results will be used to establish the vertical profile of anomaly sources and guide digging.
- In the DGM area, the contractor will excavate each anomaly location to determine its source.
- In the analog area, the contractor will dig at the location of each pin flag.

All digging will be conducted according to the detailed procedures described in SOP__. For each anomaly location, the contractor will record the approximate size, depth, and the most specific information that can be obtained about the identity of the source(s) (e.g., generic frag, tail boom of a 60--mm mortar, fuze, wire, horse shoe). For analog surveys, the contractor will report the number of seeds recovered and their identification numbers. The contractor will document all TOI as described in Worksheet #22. If the contractor fails to recover all seeds, the contractor will resurvey the grid until all seeds are recovered and document the number of passes required to recover all seeds.

Lead organization: The lead organization (or designee) will review the Anomaly Resolution Report and inform the contractor of any seeds that were not recovered.

DFW 12: Conduct DUA (lead organization and contractor), characterize high-use areas, establish high-use area boundaries and buffer zones, and update CSM (contractor): Describe the various anomaly populations encountered in the HUA, characterize the HUA, and establish boundaries and buffer zones. Update the CSM based on RI results.

Documentation: Detailed Characterization Technical Memorandum, Maps, DUA Report, Revised CSM

[Example]: For each HD area, the contractor will summarize the evidence as to the origin of the elevated anomaly density, including the information in the initial CSM, any relevant field observations, and the sources of anomalies. For areas that are determined to be high-use areas, the contractor will provide (1) estimates of the location of the center of the area, size, anomaly density, and total number of anomalies predicted from analysis of the transect and/or grid data, and (2) information from field observations and anomaly sources about the types and depths of munitions present. The contractor will update the CSM to reflect findings from the HD area characterization. The contractor will determine if any changes in the CSM from the HD area characterization impact the robustness of the sampling design.

[Appendix B provides an example of an Detailed Characterization Technical Memorandum that would be generated at the conclusion of DFW 12.]

LD Area Characterization: The planning for this section may depend on the results of the HD Area Characterization. If so, it will be completed following the analysis of the HD area survey data and a Worksheet #17 addendum will be prepared at that time. The example here includes both the general planning text that would be appear in the QAPP prior to the Preliminary Characterization step and the updated detailed text that would be added once the HD Area Characterization was complete.

Within an LD area, the presence of MEC, MD, and RRD or other indications of munitions handling will indicate a low-use area. Designation as a non-impacted area must be supported by multiple lines of evidence (e.g., historical records review, historical photo interpretation, visual observations, and interviews).

DFW 13: Review CSM and establish boundaries for LUA and NIA (contractor and lead organization): Describe the process to be used to differentiate non-impacted areas from low-use areas. Describe the process that will be used to establish boundaries for each low-use area.

Documentation: LD Area Maps, Work Sheet #17 Addendum if necessary

[Example Planning Text] Contractor: The contractor will analyze available data for LD areas compiled in the CSM (i.e., areas that do not meet the definition of HD areas) to distinguish low-use areas from non-impacted areas. The contractor will (1) determine whether any planned target area identified in the

CSM is in the LD area, (2) determine whether field notes provide a line of evidence to support determination of low-use versus non-impacted areas, (3) determine whether collecting additional geophysics data in grids will be useful and, if so, design the size, number and placement of grids and the decision rules that will be used to distinguish low use areas from non-impacted areas, (4) Determine whether any digging will be required, and (5) draw and justify boundaries around any remaining low-use areas.

[Example of specific text to be included in Worksheet #17 Addendum after Preliminary Characterization and HD Area Characterization.]

Maneuver Area. The LD area marked "MA" is determined with no further investigation to be a low-use area. It is an historical maneuver area. No elevated anomaly density is expected and, even if further sampling does not uncover evidence of munitions use, it cannot be ruled out. No further characterization work is planned for this area. The maneuver area boundary is the polygon that defined the MA in the CSM.

BT1 and BT3. The areas marked BT1 and BT3 were identified in the CSM as planned target areas, but no evidence was documented in the SI to suggest either of them had been constructed or used. No corresponding HD areas were found in the Preliminary Characterization. The contractor will inspect the areas for visible indications of munitions use. The contractor will collect additional geophysics data using TEMTADS in three ¼-acre 100% coverage grids in each area, as shown in Figures 17-12 and 17-13, and dig all the anomalies detected. Based on the background anomaly density, the grids should yield approximately 50 anomalies in each area.

Decision Rule: If any MEC, MD, or RRD are discovered, the areas will be considered LUA and the contractor will determine whether additional characterization work is needed. If no MEC, MD, or RRD are discovered, the areas will be considered non-impacted areas and no additional characterization will be done.

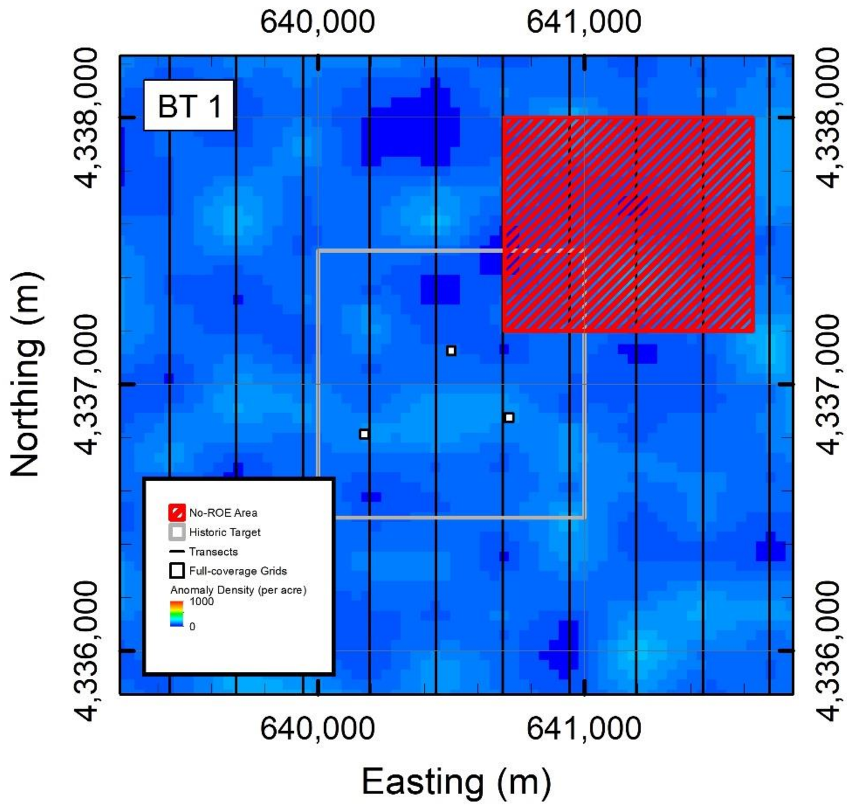


Figure 17-12. LD Area Characterization Plan for BT1

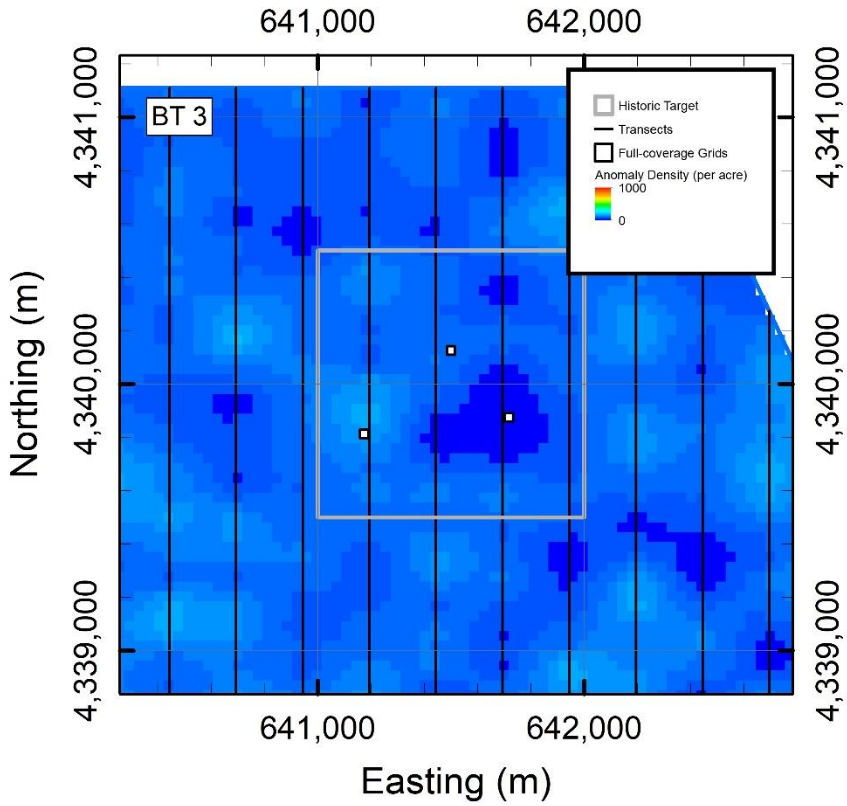


Figure 17-13. LD Area Characterization Plan for BT3

No additional field work is planned for the remainder of the LD area. The project team will compile lines of evidence supporting the area is not impacted by munitions use.

<u>DFW 14: Conduct Final DUA and Prepare Final CSM (contractor and lead agency):</u> Describe the methods used to characterize any LUA that required additional work, characterize the LUA, and establish boundaries. Update the CSM.

<u>Documentation:</u> Final DUA Report, Detailed Characterization Technical Memorandum, Final CSM

[Example]: The contractor will summarize the evidence as to the determination that an LD area is a low-use area or non-impacted area, including the information in the preliminary CSM, any relevant field observations, and the sources of anomalies.

[Appendix B provides an example of a Detailed Characterization Technical Memorandum that would be generated at the conclusion of DFW 14.]

Worksheet #22: Equipment Testing, Inspection, and Quality Control
(UFP-QAPP Manual Section 3.1.2.4)

This worksheet documents procedures for performing testing, inspections and quality control for all field data collection activities. References to the applicable DFW and standard operating procedures must be included. Failure response must include a root cause analysis (RCA) to determine the appropriate corrective action (CA). Examples are provided in blue text. Minimum recommended specifications are provided in black text. The project-specific QAPP must explain and justify any changes to black text, which are subject to regulatory approval. An appendix may be used for this purpose.

Table 22-1. Site Preparation

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Vegetation clearance Verification (All clearance mechanisms)	SP1	Random locations at frequency of 8 per acre (frequency should be based on site conditions)	Project QC/ Surface Sweep Technical Memorandum/ Lead Organization or designee	All vegetation removed to height not exceeding 15cm; No obstacles (e.g. felled trees or limbs) remain	RCA/CA; Re-verify
Vegetation clearance: Verify correct assembly (Mechanized) (1 of 2)	SP2	Once following assembly	Field Team Leader/ Instrument Assembly Checklist/ Lead Organization or designee	As specified in Assembly Checklist	RCA/CA: Make necessary adjustments, and re-verify
Vegetation clearance: Verify correct deployment (Mechanized) (2 of 2)	SP3	Daily prior to operations	Field Team Leader/ Daily QC Report/ UXOQC, UXOSO	Deck height is set to 30cm	RCA/CA: Make necessary adjustments, and re-verify
Construct IVS: Verify as-built IVS against design plan (Digital sensors)	SP4	Once following IVS construction	Project Geophysicist/ IVS Technical Memorandum/ Lead Organization	Small ISO seed items buried at 15cm; All seeds buried horizontally in the cross-track orientation	RCA/CA; Make necessary changes to seeded items and re-verify

Table 22-1. Site Preparation

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Construct IVS: Verify as-built IVS against design plan (Analog sensors)	SP5	Once following IVS construction	Project Geophysicist/ IVS Technical Memorandum/ Lead Organization	Small ISO seed items for analog methods buried at 30cm; All seeds buried horizontally in the cross-track orientation	RCA/CA; Make necessary changes to seeded items and re-verify
Verify correct assembly (All sensors)	SP6	Once following assembly	Field Team Leader/ Instrument Assembly Checklist/ Project Geophysicist	As specified in Assembly Checklist	RCA/CA: Make necessary adjustments and re-verify
Initial instrument function test: Five measurements over a small ISO80 target, one in each quadrant of the sensor and one directly under the center of the array; Derived polarizabilities for each measurement are compared to the library (AGC)	SP7	Once following assembly	Field Team Leader/ Instrument Assembly Checklist/ Project Geophysicist	Library match metric ≥ 0.95 for each of the five sets of inverted polarizabilities	RCA/CA: Make necessary adjustments, and re-verify
Initial Instrument Function Test (EM61)	SP8	Once following assembly	Field Geophysicist/ Initial IVS Memorandum/ Project Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response	RCA/CA: Make necessary adjustments, and re-verify
Initial Instrument Function Test (Analog)	SP9	Once upon arrival at project site	Field Geophysicist or UXO Team Lead/ Initial IVS Memorandum/ Project Geophysicist or designee	Audible response consistent with expected change in tone in presence of standard object	RCA/CA: Make necessary adjustments, and re-verify

Table 22-1. Site Preparation

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Initial detection survey positioning accuracy (IVS) (Digital)	SP10	Once prior to start of data acquisition	Project Geophysicist/ IVS Memorandum/ QC Geophysicist	Derived positions of IVS target(s) are within 25cm of the ground truth locations	RCA/CA: Make necessary adjustments, and re-verify
Initial detection survey Check for interference surrounding seed response (IVS) (All sensors)	SP11	Once prior to start of data acquisition	Project Geophysicist/ IVS Memorandum/ QC Geophysicist	All seeds placed in locations that are free of detected anomalies within a radius of ≥1.5m	RCA/CA; and re-verify MQO

Table 22-2. Preliminary Characterization (To delineate HD and LD areas) (Instrument: ___________________)

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Ongoing instrument function test (AGC)	PC12	Beginning and end of each day and each time instrument is turned on	Field Team Leader/ Running QC Summary (Excel/Geosoft)/ Project or QC Geophysicist	Response (mean static spike minus mean static background within 20% of predicted response for all Tx/Rx combinations	RCA/CA: Make necessary repairs and reverify
Ongoing instrument function test (DGM)	PC13	Beginning and end of each day and each time instrument is turned on	Field Team Leader/ Running QC Summary/ Project or QC Geophysicist	Response (mean static spike minus mean static background within 20% of predicted response	RCA/CA: Make necessary repairs and reverify
Ongoing instrument function test (Analog)	PC14	Beginning and end of each day and each time instrument is turned on	Field Team Leader/ Running QC Summary/ Project/QC Geophysicist or designee	Audible response consistent with expected change in tone in presence of object with documented response	RCA/CA
Ongoing instrument settings check (Analog)	PC15	Hourly	Field Team Leader/ Running QC Summary/ Project/QC Geophysicist or designee	All instrument settings adjusted to [insert instrument-specific specification]	RCA/CA
Ongoing detection survey positioning precision (IVS) (Digital)	PC16	Beginning and end of each day	Project Geophysicist/ Running QC Summary/ QC Geophysicist	Derived positions of IVS target(s) within 25cm of the average locations	RCA/CA
In-line measurement spacing (Digital)	PC17	Verified for each transect using [describe tool to be used] based upon monostatic Z coil data positions	Project Geophysicist/ Running QC Summary/ QC Geophysicist	98% ≤ 0.25m between successive measurements; 100% ≤1.0m. Coverage gaps are filled or adequately explained (e.g., unsafe terrain)	RCA/CA

Table 22-2. Preliminary Characterization (To delineate HD and LD areas) (Instrument: ________________)

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Maximum velocity (Analog)	PC18	Verified for each transect using [describe tool to be used] based upon recorded survey track (filtered) of each individual operator [Specific procedure to be described in SOP]	Project Geophysicist/ Running QC Summary/ QC Geophysicist	98% ≤ 0.45meter per second (~1 mile per hour); 100% ≤ 0.5 meter/second	RCA/CA
Coverage – Transect mapping (All sensors)	PC19	Verified with target radius from WS#17 for each MRS using VSP 'Post-survey probability of traversal' tool	Project Geophysicist/ VSP Report/ QC Geophysicist	Probability of traversal and detection is 100% (excluding site-specific access limitations, e.g., obstacles, unsafe terrain, ROE refusal)	RCA/CA: Coverage gaps are filled or adequately explained (e.g., unsafe terrain)
Sensor Tx current (AGC)	PC20	Per measurement	Field Team Leader/ Running QC Summary/ Project Geophysicist	Current must be ≥ [Enter minimum instrument-specific requirement]	RCA/CA: out of spec data rejected
Battery voltage (DGM)	PC21	Verify battery voltage is within operating specifications of sensor	Field Team Leader/ Running QC Summary/ Project Geophysicist	Voltage must be ≥ [Enter minimum instrument-specific requirement]	RCA/CA: out of spec data rejected

Table 22-2. Preliminary Characterization (To delineate HD and LD areas) (Instrument: ___________________)

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Reporting Method/ Verified by:	Acceptance Criteria	Failure Response
Transect Survey repeatability in LD area (Analog) [9]	PC22	Daily check of each system (operator), repeating random 10% of 100m (or other appropriate and specified length) sections of transect[10]	QC Geophysicist or designee/ Running QC Summary/ Lead Organization	Number of counts repeatable within a factor of five	RCA/CA; recollect all transects from failed system (operator)
Valid position data: Transects (Analog)	PC23	Per measurement	Field Team Leader/ Running QC Summary/ Project Geophysicist	GPS estimated error indicates position accuracy is within ±10m	RCA/CA: Out-of-spec data rejected
Valid position data: Transects (Analog)	PC24	Per measurement	Field Team Leader/ Running QC Summary/ Project Geophysicist	Track plots in GPS-obstructed areas are filtered to mimic actual survey paths	RCA/CA

[9] The repeatability MQO for analog is governed by the decision that the results of field work will support. Any area that is identified by the transect survey as HD will be subject to HD area characterization and no further evaluation of the transect data quality will be required. In any LD area, where the transect data will support a designation of LUA or NIA, the analog transect data must meet the MQO.

[10] This MQO is intended to demonstrate that the anomaly count along a transect can be reproduced to the extent that both the original and the repeat transects are representative of the underlying population. As such, it is not required that the repeat transect follow exactly the same path as the original transect.

Table 22-3. HD Area Characterization – Detection Survey

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Surface Sweep: Documenting recovered surface MEC and debris within mini-grids (All sensors)	HD25	Daily	UXOQC/ GIS data recorded/ Project QC or designee	All metallic debris collected is counted and documented in the project database for the following attributes: designation as UXO, MD, RRD or other debris; UXO and MD described by type, weight, and as TOI or non-TOI. Photos displaying all MD recovered (individual MD photos not necessary), and photos showing all surfaces of each MEC/TOI are recorded.	RCA/CA; document questionable information in database; justify safety concerns
Geodetic Equipment Function Test	HD26	Daily (RTK GPS) Each time equipment is moved (RTS)	Field Team Leader/ GIS data recorded/ Project QC or designee	Measured position of control point within 10cm of ground truth	RCA/CA; document questionable information in database
Geodetic Accuracy (Confirm Valid Position)	HD27	Evaluated for each measurement	Field Team Leader/ GIS data recorded/ Project QC or designee	GPS status flag indicates RTK fix (RTK GPS) RTS passes Geodetic Function Test (RTS)	RCA/CA; document questionable information in database
Vegetation Clearance Inspection (All sensors)	HD28	Random locations at frequency between four and twelve per acre	Project QC Geophysicist/ Surface Sweep Technical Memorandum/ Lead Organization	All vegetation removed to ≤15cm; All trees less than 6” diameter at breast height are removed; No obstacles (e.g. felled trees or limbs) remain	RCA/CA; and re-verify

Table 22-3. HD Area Characterization – Detection Survey

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Ongoing Instrument Function Test (AGC)	HD29	Beginning and end of each day and each time instrument is turned on	Field Team Leader/ Running QC Summary (Excel/Geosoft)/ Project or QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all Tx/Rx combinations	RCA/CA: Make necessary repairs and re-verify
Ongoing Instrument Function Test (DGM)	HD30	Beginning and end of each day and each time instrument is turned on	Field Team Leader/ Running QC Summary/ Project or QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response	RCA/CA: Make necessary repairs and re-verify
Ongoing Instrument Function Test (Analog)	HD31	Beginning and end of each day and each time instrument is turned on	Field Team Leader/ Running QC Summary/ Project/QC Geophysicist or designee	Audible response consistent with expected change in tone in presence of standard object	RCA/CA: Make necessary repairs and re-verify
Ongoing Instrument Settings Check (Analog)	HD32	Hourly	Field Team Leader/ Running QC Summary Project/QC Geophysicist or designee	All instrument settings adjusted to [insert instrument-specific settings]	RCA/CA
Ongoing derived target position precision (IVS) (AGC all phases)	HD33	Beginning and end of each day as part of IVS testing	Project Geophysicist/ Running QC Summary QC Geophysicist	All IVS items fit locations within 0.25m of average of derived fit locations	RCA/CA
In-line measurement spacing (Digital, all detection phases)	HD34	Verified for each transect/grid using [describe tool to be used] based upon monostatic Z coil data positions	Project Geophysicist/ Running QC Summary/ QC Geophysicist	98% ≤ 0.25m between successive measurements; 100% ≤1.0m	RCA/CA Coverage gaps are filled or adequately explained (e.g., unsafe terrain)

Table 22-3. HD Area Characterization – Detection Survey

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Coverage (Digital using electronic positioning, all phases)	HD35	Verified for each transect/grid using [describe tool to be used] based upon monostatic Z coil data	Project Geophysicist/ Running QC Summary/ QC Geophysicist	≥90% at project design cross-track measurement spacing; 98% ≤ 1.0m	RCA/CA: Collect additional data to increase coverage percentage to meet acceptance criterion
Coverage – Full coverage (Analog and Digital, using line and fiducial positioning, all phases)	HD36	Verified for each transect/grid	Field Team/ Running QC Summary/ QC Geophysicist	Visual inspection and photographic records of survey lanes/lines established using: tape measures and rope lanes; OR tapes and marking paint; OR sub-meter accuracy track-plot (filtered) of each operator's progress through assigned survey lanes (Specific procedure must be described in SOP)	RCA/CA
Transmit current levels (AGC)	HD37	Evaluated for each sensor measurement	Field Team Leader/ Running QC Summary/ Project Geophysicist	Current must be ≥ [insert instrument-specific requirement]	RCA/CA: stop data acquisition activities until condition corrected
Confirm adequate spacing between units (TEMTADS & EM61, all phases)	HD38	Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/ Project Geophysicist	Minimum separation of 50m	RCA/CA: Recollect all coincident measurements
Confirm adequate spacing between units (MetalMapper, MPV, PPV; all phases)	HD39	Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/ Project Geophysicist	Minimum separation of 25m	RCA/CA: Recollect all coincident measurements

Table 22-3. HD Area Characterization – Detection Survey

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Detection survey performance (Digital)	HD40	Average one blind QC seed per instrument per day. Seeds to be placed throughout expected detection depth range	QC Geophysicist/ Running QC Summary/ Lead Organization QA Geophysicist	All blind QC seeds must be detected and positioned within 40cm radius of ground truth	RCA/CA: Verify instrument is functioning correctly; if so, reduce threshold, or determine if item is buried too deep. If instrument is not functioning correctly, recollect data.
Detection survey performance (Analog)	HD41	Average one blind QC seed per instrument per day. Seeds to be placed throughout expected detection depth range	QC Geophysicist/ Running QC Summary/ Lead Organization QA Geophysicist	All blind QC seeds must be detected and positioned within 40cm radius of ground truth	RCA/CA: Verify instrument is functioning correctly; if so, reduce threshold, or determine if item is buried too deep. If instrument is not functioning correctly, recollect data.
Detection survey and coverage performance (Analog)	HD42	Between five and six blind QA seeds per operator per day, placed at anticipated 100% detection depth	QC Geophysicist/ Daily QC Report/ Lead organization QA Geophysicist	All blind QA seeds must be recovered	RCA/CA

Table 22-4. HD Area Characterization – Cueing Survey

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Geodetic Equipment Function Test	HD26	Daily (RTK GPS) Each time equipment is moved (RTS)	Field Team Leader/ GIS data recorded/ Project QC or designee	Measured position of control point within 10cm of ground truth	RCA/CA; document questionable information in database
Geodetic Accuracy (Confirm Valid Position)	HD27	Evaluated for each measurement	Field Team Leader/ GIS data recorded/ Project QC or designee	GPS status flag indicates RTK fix (RTK GPS) RTS passes Geodetic Function Test (RTS)	RCA/CA; document questionable information in database
Initial measurement of production area background locations and background verification (five background measurements: one centered at the flag and one offset at least ½ sensor spacing in each cardinal direction) (AGC)	HD43	Once per background location	Field Team Leader/ IVS Memorandum Project Geophysicist	All five measurements have a library match within 0.9	RCA/CA: reject BG location and find alternative
Ongoing production area background measurements (AGC)	HD44	Background data collected a minimum of every two hours during production	Field Team Leader/ Field Log and Running QC Summary/ Project Geophysicist	BG data from a verified location collected within two hours of all cued data points	RCA/CA: Document environmental changes; Project Geophysicist must approve before proceeding.

Table 22-4. HD Area Characterization – Cueing Survey

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Ongoing production area background measurements Confirm measurements are valid (AGC)	HD45	Evaluated for each background measurement over verified background locations	Project Geophysicist/ Running QC Summary/ QC Geophysicist	A TOI [type/depth based on project objectives] synthetically seeded in the ongoing background, and background-corrected using the initial background measurement results in polarizabilities with a library match of ≥0.9	RCA/CA: BG measurement rejected and removed from active BG measurements
Ongoing derived target position precision (IVS) (Digital)	HD46	Beginning and end of each day as part of IVS testing	Project Geophysicist/ Running QC Summary/ QC Geophysicist	All IVS items fit locations within 0.25m of average of derived fit locations	RCA/CA
Ongoing Instrument Function Test (Instrument response amplitudes) (AGC)	HD47	Beginning and end of each day and each time instrument is turned on	Field Team Leader/ Running QC Summary (Excel/Geosoft)/ Project or QC Geophysicist	Response (mean static spike minus mean static background) within 20% of predicted response for all Tx/Rx combinations	RCA/CA: Make necessary repairs and re-verify
Transmit current levels (AGC)	HD48	Evaluated for each sensor measurement	Field Team Leader/ Running QC Summary/ Project Geophysicist	Insert instrument-specific requirements	RCA/CA: stop data acquisition activities until condition corrected
Confirm adequate spacing between units (AGC)	HD49	Evaluated at start of each day (or grid)	Field Team Leader/ Field Logbook/ Project Geophysicist	TEMTADS: minimum separation of 50m MetalMapper: minimum separation of 25m MPV: minimum separation of 25m	RCA/CA: Recollect data

Table 22-4. HD Area Characterization – Cueing Survey

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Confirm inversion model supports classification (AGC, 1 of 3)	HD50	Evaluated for all models derived from a measurement (i.e., single item and multi-item models)	Project Geophysicist/ UX-A Source Geosoft database/ QC Geophysicist	Derived model response must fit the observed data with a fit coherence ≥ 0.8[11]	Follow procedure in SOP or RCA/CA
Confirm inversion model supports classification (AGC, 2 of 3)	HD51	Evaluated for derived target	Project Geophysicist/ UX-A Source Geosoft database/ QC Geophysicist	Fit location estimate of item ≤ 0.4m from center of sensor	Follow procedure in SOP or RCA/CA
Confirm inversion model supports classification (AGC, 3 of 3)	HD52	Evaluated for all seeds	QC Geophysicist/ Seed Tracking Log/ Lead Organization QA Geophysicist	100% of predicted seed positions ≤ 0.25m radially from known position (x, y). Z ≤ 0 .15m.	RCA/CA
Confirm reacquisition GPS precision (Digital)	HD53	Daily	UXO Tech or Field Tech/ Daily QC Report/ Project Geophysicist	Benchmark positions repeatable to within 10cm	RCA/CA
Classification performance (AGC)	HD54	Evaluated for all seeds	QC Geophysicist/ Seed Tracking Log/ USACE QA Geophysicist	100% of QC seeds classified as TOI	RCA/CA

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

Table 22-5. Intrusive Investigation

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Geodetic Equipment Function Test	HD26	Daily (RTK GPS) Each time equipment is moved (RTS)	Field Team Leader/ GIS data recorded/ Project QC or designee	Measured position of control point within 10cm of ground truth	RCA/CA; document questionable information in database
Geodetic Accuracy (Confirm Valid Position)	HD27	Evaluated for each measurement	Field Team Leader/ GIS data recorded/ Project QC or designee	GPS status flag indicates RTK fix (RTK GPS) RTS passes Geodetic Function Test (RTS)	RCA/CA; document questionable information in database
Documenting recovered sources (All sensors)	HD55	Daily	UXOQC/ GIS data recorded/ QC Geophysicist	All metallic debris collected is documented for the following attributes: Designation as UXO, MD, RRD or OD; UXO and MD described by type, weight, depth, and as TOI or non-TOI. Photos displaying all MD recovered (individual MD photos not necessary), and photos showing all surfaces of each MEC are recorded.	RCA/CA; document questionable information in database
Confirm derived features match ground truth (AGC, 1 of 2)	HD56	Evaluated for all recovered items	Project Geophysicist/ Running QC Summary or Intrusive Database/QC Geophysicist	100% of recovered item positions (excluding inconclusive category) ≤ 0.25m from predicted position (x, y); Recovered item depths are recorded within 15cm of predicted	RCA/CA

Table 22-5. Intrusive Investigation

Measurement Quality Objective	MQO#	Frequency	Responsible Person/ Report Method/ Verified by:	Acceptance Criteria	Failure Response
Confirm derived features match ground truth (AGC, 2 of 2)	HD57	Evaluated for all recovered items including seeds	Project Geophysicist/ Dig List and Intrusive Database/ Project or QC Geophysicist	Cued data analysis shows 100% of seeds & recovered items have polarizability parameters that are consistent with their actual size, shape/symmetry, and wall thickness	RCA/CA
Confirm anomaly resolution (DGM)	HD58	Evaluated for all intrusive results	Project Geophysicist/ Intrusive Database/ QC Geophysicist	Verification of anomaly footprint after excavation, using original instrument, confirms anomaly is resolved AND Reported excavation findings match expectations	RCA/CA

Worksheet #29: Data Management, Project Documents, and Records
(UFP-QAPP Manual Section 3.5.1)

Part 1 of this worksheet provides minimum specifications for all data management tasks and deliverables. Part 2 of this worksheet describes procedures for controlling project documents, records, and databases. Its purpose is to ensure data completeness, data integrity, traceability and ease of retrieval. Where applicable, specific versions or dates of software used should be documented.

Part 1: Data Management Specifications

Computer Files and Digital Data: All final document files, including reports, figures, and tables, will be submitted in electronic format on CD-ROM or as specified by the DoD client. Data management and backup must be performed in accordance with the contractor's documented quality system.

TOI Library: This worksheet must document the version (date) of the DoD target of interest (TOI) library used and describe or reference procedures to be used to develop the site-specific TOI library. The site-specific TOI library used must be included in data deliverables.

Part 2: Control of Documents, Records, and Databases

Table 29-1. Minimum Required Documents and Records

Document/Record	Purpose	Completion/ Update Frequency	Format/ Storage Location/ Archive Requirements
Quality Control (QC) Seed Plan			
Daily QC Reports			
Instrument Verification Strip (IVS) Technical Memorandum			
Target Selection Technical Memorandum			

Table 29-1. Minimum Required Documents and Records

Document/Record	Purpose	Completion/ Update Frequency	Format/ Storage Location/ Archive Requirements
Site Preparation Technical Memorandum			
Daily Report of Debris Recovered			
Instrument Assembly Checklist			
Weekly QC Reports			
Daily Field Reports (analog)			
Weekly Status Report			
Geophysical Data			
Project QC Database			
Data Validation Report			
Anomaly List			
Course-over-ground			
VSP Output (Reports and Figures)			
DUA Report			
MRS Characterization Technical Memorandum			
Updated CSM			
Worksheet #17 Addendum			

Table 29-1. Minimum Required Documents and Records

Document/Record	Purpose	Completion/ Update Frequency	Format/ Storage Location/ Archive Requirements
Seeding Memorandum			
Database			
Disposal Reports			
Anomaly Resolution Report			
Detailed Characterization Technical Memorandum			
Maps			
LD Area Maps			
Final DUA Report			
Final CSM			

Worksheet #31, 32 & 33: Assessments and Corrective Action
(UFP-QAPP Manual Sections 4.1.1 and 4.1.2)

This worksheet is used to document responsibilities and procedures for conducting project assessments, documenting assessments, responding to assessment findings, and implementing corrective action. Appropriately scheduled assessments during each group of related project activities allow management to identify problems while the activities are being implemented, thereby allowing processes to be corrected before they have a negative impact on the achievement of DQOs and measurement performance criteria (MPCs). This worksheet should reference assessment checklists and include them in an appendix to the QAPP.

For this project, related activities are grouped as follows:

1. Site preparation (DFW 1-3)
2. Preliminary Munitions Response Site (MRS) Characterization (DFW 4-6)
3. High Density (HD) area Characterization (DFW 7-12)
4. Low Density (LD) Area Characterization (DFW 13-14)

[Example] For each group of related activities, assessment activities will occur during the following phases:

<u>Preparatory Phase:</u> Comprises the planning and design process leading up to field activities. The Unexploded Ordnance Quality Control Specialist (UXOQCS) will perform a Preparatory Phase assessment before beginning each group of activities. The purpose of this assessment is to review applicable specifications and plans to verify that the necessary resources, conditions, and controls are in place and comply with specifications before field work begins.

<u>Initial Phase:</u> Occurs at the startup of field activities. The purpose of this phase is to check preliminary work for compliance with specifications, check for omissions, and resolve differences of interpretation.

<u>Follow-up Phase:</u> Covers the routine, day-to-day activities at the site. One or more follow-up assessments will be conducted during each related group of activities, depending on the duration of field activities, and the nature of any assessment findings.

Table 31-1. Assessment Schedule

Assessment Type	Schedule/ Frequency	Responsible Party	Assessment Deliverable	Deliverable Due Date	Responsible for Responding to Assessment Findings	Assessment Response Documentation and Timeframe

Worksheet #34: Data Verification, Validation, and Usability Inputs (UFP-QAPP Manual Section 5.2.1 and Table 9)

This worksheet lists the requirements/specifications (e.g. contracts, standard operating procedures (SOPs), planning documents) and inputs that will be used during data verification, data validation, and data usability assessments. Inputs include all field records (both hard-copy and electronic) and interim and final reports. Data verification is a completeness check that all specified activities involved in data collection and processing have been completed and documented and that the necessary records (objective evidence) are available to proceed to data validation. Data validation is a detailed evaluation of data for conformance to stated requirements, e.g., those contained in the contract, SOPs and Worksheet #22. The data usability assessment is an evaluation of the data set making up a delivery unit, to determine whether the data support their intended uses. It is an evaluation of conformance to the measurement performance criteria (MPCs) presented in Worksheet #12. Examples of required documents and records are listed below in blue text.

Requirements/Specifications: (list title, date and other identifying information)

Contract: ______________________

Quality Assurance Project Plan: _______________________________

Government and Contractor Seed Plans: ________________________________

Quality Assurance Surveillance Plan: _________________________________

SOPs are contained in Appendix ____.

Table 34-1. Data Verification, Validation and Usability Inputs

Description	Verification (completeness)	Validation (conformance to specifications)	Usability (achievement of DQOs and MPCs)
Daily Report of Debris Recovered	X		
Daily Field Reports (analog)	X		
Instrument Assembly Checklists	X	X	
Field Logbooks	X	X	
Running QC Summary	X	X	
Daily QC Reports	X	X	

Table 34-1. Data Verification, Validation and Usability Inputs

Description	Verification (completeness)	Validation (conformance to specifications)	Usability (achievement of DQOs and MPCs)
Weekly QC Reports			X
Corrective Action Reports	X	X	X
Assessment Reports and Responses	X	X	X
Site Preparation Technical Memorandum			X
VSP Outputs (reports and figures)	X	X	X
GIS data	X	X	
UX-A Source Geosoft database	X	X	
Seeding Reports/Memoranda	X	X	X
Seed Tracking Logs	X	X	
Geophysical Database	X	X	
Project QC database	X	X	
Site-Specific TOI Library	X		X
Data Validation Reports			X
Target Selection Technical Memorandum	X	X	X
Anomaly List	X		
Course-over-Ground	X		
Disposal Reports	X	X	
Revised CSM	X	X	X

Worksheet #35: Data Verification and Validation Procedures
(UFP-QAPP Manual Sections 5.2.2)

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. [Some examples are provided in blue text; however, this is not a comprehensive list.]

Table 35-1. Data Verification and Validation Procedures

Activity and Records Reviewed	Requirements/ Specifications	Process Description/Frequency	Responsible Person	Documentation
Field Logbook/Running QC Summary	QAPP, SOPs	All information is complete for each day of field activities. Any changes/exceptions are documented and have been reported in accordance with requirements. Required signatures are present.	Project Geophysicist	Daily QC Report
Instrument Assembly	SOP X, WS #22	Instrument Assembly has completed according to SOP X. MQOs have been achieved, with any exceptions noted. If appropriate, corrective actions have been completed. Signatures and dates are present.	Project Geophysicist	SOP X Checklist Daily QC Report
IVS Technical Memorandum	SOP Y, WS #22	Initial IVS Survey has been conducted according to SOP X. Checklist X has been completed. All specifications have been achieved, or exceptions noted. If appropriate, corrective actions have been completed. Signatures and dates are present.	Project Geophysicist	SOP Y Checklist Daily QC Report

Worksheet #37: Data Usability Assessment (DUA)
(UFP-QAPP Manual Section 5.2.3 including Table 12)

This worksheet documents procedures that will be used to perform the data usability assessment (DUA). The DUA can be documented in DUA Reports as described in Worksheet #17 and appended to the Final Report. The DUA is performed by key members of the project team (defined during the systematic planning process (SPP)) at the conclusion of data collection activities. As shown on Figure 17-1, it is integrated into the definable features of work where decision-making occurs. For phased investigations, the DUA and decision-making will occur at each phase.

The DUA involves a qualitative and quantitative evaluation of environmental data to determine if the project data are of the right type, quality, and quantity to support the measure performance criteria (MPCs) and DQOs specific to the investigation. 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.

Identify personnel (organization and position/title) responsible for participating in the data usability assessment: [Note: the same personnel should participate in all phases of the DUA. Regulators will have the opportunity to review and comment on the DUA.]

- DoD Remedial Project Manager (RPM)
- Project Manager
- Project Quality Assurance (QA) Manager
- Project Geophysicist
- Quality Control (QC) Geophysicist
- Field Geophysicist (Lead)

Identify documents and records required as DUA inputs:

Requirements/Specifications:

- Quality Assurance Project Plan
- Contract Specifications
- Government and Contractor seed Plans
- Quality Assurance Surveillance Plan
- Standard Operating Procedures (SOPs)

Project Records:

- Target selection technical memorandum
- Anomaly list
- Visual Sample Plan (VSP) outputs
- Anomaly resolution report
- Revised CSM
- Site-specific target of interest (TOI) library

Data Verification/Validation Reports and supporting documentation, e.g.:

- Weekly QC reports
- Project QC database
- Corrective action reports
- Assessment reports
- Seeding plans and seed reports
- Instrument verification strip (IVS) memoranda

Describe how the usability assessment will be documented: [Note: Data Usability Assessments may be incorporated into technical memoranda and reports or may be included as attachments, as specified during project planning.]

[Example]

The Preliminary Characterization DUA will be included as an attachment to the Preliminary Characterization Technical Memorandum. The DUAs conducted following the high density (HD) Area Characterization and low density (LD) Area Characterization will be incorporated into the Detailed Characterization Memorandum. The final data usability assessment report will be incorporated into the Final Remedial Investigation (RI)/Feasibility Study (FS) Report.

Describe the DUA Process

Step 1	**Review the project's objectives and sampling design** Review the data quality objectives. *Are underlying assumptions valid?* Review the sampling design as implemented for consistency with stated objectives. *Were VSP input parameters representative of actual site conditions? Were sources of uncertainty accounted for and appropriately managed?* Summarize any deviations from the planned sampling design and describe their impacts on the data quality objectives.
Step 2	**Review the data verification/validation outputs and evaluate conformance to MPCs documented on Worksheet #12** Review the Data Verification/Validation reports and supporting data, if necessary (e.g., daily/weekly QC reports, assessment reports, and corrective action reports. *Was the RCA/CA effective? Evaluate the implications of unacceptable QC results.* Evaluate conformance to MPCs documented on Worksheet #12. Evaluate data completeness. *Were all data inputs satisfied? Identify data gaps.*
Step 3	**Document data usability, update the CSM, apply decision rules, and draw conclusions** Assess the performance of the sampling design and Identify any limitations on data use. *Considering the implications of any deviations and data gaps, can the data be used as intended? Are the data sufficient to answer the study questions?* Update the conceptual site model, apply decision rules, 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 the next phase of investigation or future investigations. Prepare the data usability summary report.

The following examples illustrate the performance of the DUA for selected data collection activities at Camp Example. No effort is made to evaluate the entire site. Examples 1 and 2 trace the Preliminary Characterization of munitions response site (MRS) A and the HD Characterization of Area of Concern (AOC) A. Examples 3 and 4 trace the Preliminary Characterization of the analog area of MRS B and the HD Characterization of M1. Remaining DUA discussion will be added in the next version. Bold text explains the purpose and scope of each example.

Example #1: Preliminary DUA at Camp Example, MRS A, conducted at the completion of DFW 6 (with a focus on planning the HD characterization of AoC A)

Summary of key findings from the preliminary characterization:

- Three no-right-of-entry (ROE) areas as shown on preliminary CSM.
- No HD area detected at BT1 (no-ROE area in NE corner). No historical or physical evidence of target use contained in CSM.
- HD area detected at BT2.
- No HD area detected at BT3. No historical or physical evidence of target use contained in CSM.
- Unexpected HD area detected at AOC A – location conforms to location of abandoned mine entrance.
- Unexpected HD area located at AOC B – shape suggests bomb target.
- No visible evidence of munitions and explosives of concern (MEC)/munitions debris (MD)/range-related debris (RRD) at AOC A or AOC B.

Summary of non-conformances, root causes, and corrective action (from data validation report)		
Non-conforming MQO	Root cause	Corrective action implemented?
In-line measurement spacing exceeded 0.25m in 5% of transects in MRS A	Unsafe terrain	N/A – Measurement spacing was ≤1m for 100% of transects.
Transect spacing. No data collected in three no-ROE areas	No ROE	N/A – Data gaps are mapped in CSM. Impacts will be addressed during detailed characterization and final DUA.

Step 1	Review the project's objectives and sampling design Review the data quality objectives. Are underlying assumptions valid? The primary objective of the preliminary characterization in MRS A is to delineate HD areas from LD areas and determine which areas require further detailed characterization. MRS A is suspected to contain one or more bomb targets. The planned transect spacing was based on the VSP-recommended target size for air-dropped bombs of <100 lbs, as documented in WS #11. The preliminary findings are consistent with confirming one bomb target and locating a second HD area that suggests a second bomb target. The assumptions are valid based on everything known about MRS A. Review the sampling design as implemented for consistency with stated objectives. *Were VSP input parameters representative of actual site conditions? Consider sources of uncertainty.* The primary uncertainties related to the preliminary characterization planning are in the assumptions about the background density, target size, and anomaly density contrast. The actual background anomaly density was 86 anomalies/acre, comparable to the 75

<table>
<tr><td></td><td>anomalies/acre planning assumption. The actual radii of BT2 and AOC B were 800m and 500m, respectively. The planning radius assumption of a 112m radius, based on the VSP recommendation for air-dropped bombs <100 lbs, was in fact conservative for locating the observed HD areas. VSP reanalysis using the actual site characteristics indicates 100% probability of traversing and detecting the suspected bomb targets. In short, there is little uncertainty in the preliminary characterization of MRS A: the investigation found what it was designed to find and there were no surprises.

Summarize any deviations from the planned sampling design and describe their impacts on the data quality objectives.
The sampling design was implemented as planned.</td></tr>
<tr><td>Step 2</td><td>Review the data verification/validation outputs and evaluate conformance to MPCs documented on Worksheet #12

Review the Data Verification/Validation Reports and supporting data, if necessary (e.g., daily/weekly QC reports, assessment reports and corrective action reports.
For any non-conformances, was the RCA/CA effective? Evaluate the implications of unacceptable QC results.
The data validation report contained a summary of all non-conformances and RCA/CA. No CA were required. There were no unacceptable QC results.

Evaluate conformance to MPCs documented on Worksheet #12. Evaluate data completeness. Identify data gaps (i.e., data inputs that have not been satisfied.) and summarize their impact on the DQOs.

Data are complete in all accessible areas and are deemed to be useable to locate bomb target areas per design. MPCs have been satisfied. No survey data are available in the no-ROE areas, which were accounted for in the preliminary CSM. In summary,
Near BT2: Transect analysis confirmed a HD area at the expected target location. Extrapolation of the data suggests that the target extends into the adjacent no-ROE area.
Near BT1: The no-ROE area covers a small portion of planned BT1, for which there is no evidence of use in CSM. All surrounding area is LD. If a bomb target were present, some HD area would likely be observed due to expected extent of a BT. There is a low likelihood that an additional HD area would be entirely confined to the no-ROE area, but this cannot be definitively ruled out in the absence of data.
Far west side of site: The CSM contains nothing to suggest munitions use in this part of the MRS, but no data are available to rule it out.</td></tr>
<tr><td>Step 3</td><td>Document data usability, update the CSM, apply decision rules, and draw conclusions

Assess the performance of the sampling design and identify and limitations on data use.
Considering the implications of any deviations and data gaps, can the data be used as intended? Are the data sufficient to answer the study questions?
The sampling design for the preliminary characterization performed as expected. With the exception of the no-ROE areas, the data are suitable for delineating HD and LD areas</td></tr>
</table>

	in MRS A. The data are suitable for use in planning the HD and LD area characterization within MRS A. Update the CSM, apply decision rules, and draw conclusions. Results of the Preliminary Characterization are contained in the Preliminary Characterization Technical Memorandum (see Appendix A). The CSM was updated to reflect the actual background anomaly density, approximate preliminary boundaries of AOC A, AOC B, BT2, and location of mine entrance.
Step 4	**Document lessons learned and make recommendations** Summarize lessons learned and make recommendations for changes to DQOs or the sampling design for the next phase of investigation or future investigations. If this is the final DUA, prepare the final DUA report to be included in the RI/FS report. [The example that follows focuses on recommendations and DQOs specific to the HD area characterization at AOC A.} AOC A: During the preliminary characterization, a small HD area was found that appears to be associated with an abandoned mine. Additional data will be collected to confirm that elevated anomaly density at AOC A is related to the presence of an abandoned mine and not related to munitions use. The DQOs for the HD area characterization at AOC A are as follows: 1. [Note: The updated DQOs and sampling design for the HD area characterization would be developed during the planning session for the HD area characterization, which is shown on Figure 9-1 as Planning Session #5.] Problem Statement: During the Preliminary MRS Characterization, an unexpected HD area was located in MRS A, corresponding to the location of a former mine entrance. The CSM contains no evidence of munitions use at AOC A. Additional data will be collected to confirm that elevated anomaly density at AOC is related to the presence of an abandoned mine and not related to munitions use. 2. Goals of data collection: Determine sources of anomalies to determine whether AOC A has been impacted by munitions use or not. 3. Identify information inputs: Surface sweep results, photographs, intrusive investigation results, field notes. 4. Define the boundaries of the project: AOC A 5. Develop the project data collection and analysis approach: o Conduct a physical inspection at AOC A to gather photographic evidence and confirm no evidence of munitions use present. o Review all surface sweep memoranda and field notes collected to date for descriptions of debris removed. o Survey one ¼-acre grid using TEMTADS and excavate all detected anomalies. o Decision rules: See WS #11 and WS #17 Addendum. 6. Specify MPCs: See WS #12 7. Revise sampling design: See WS #17 Addendum

Example #2: HD Area Characterization DUA for AOC A, conducted at the conclusion of DFW 12.

Summary of key findings:

- This HD area results from an abandoned mine.
- Location does not correspond to any known or planned target area.
- Field team observed and documented entrance to abandoned mine.
- Time-domain Electromagnetic Multi-sensor Towed Array detection System (TEMTADS) data collected in one ¼-acre grid and all 86 anomaly locations were dug.
- No MEC, MD or RRD recovered in grid.
- Anomalies recovered from grid include mining and campfire artifacts.

Summary of non-conformances, root causes, and corrective action (from data validation report)		
Non-conforming MQO	Root cause	Corrective action implemented?
Initially failed the coverage MQO for the grid data	Inconsistent field procedures; SOP not specific enough	Fill in missing data. Re-write SOP.

Step 1	**Review the project's objectives and sampling design** Review the data quality objectives. *Are underlying assumptions valid?* The primary objective of HD characterization of AoC A is to determine whether this HD area is associated with a mine and not munitions use. The underlying assumption is that if this is the site of a mine, collecting TEMTADS data in one grid and digging all anomalies will reveal artifacts associated with a mine that will be readily identifiable as such and will uncover no munitions-related objects. All anomaly sources were identified as either mining or camping artifacts. Review the sampling design as implemented for consistency with stated objectives. *Were VSP input parameters representative of actual site conditions? N/A* *Were sources of uncertainty accounted for and appropriately managed?* Upon discovery of an apparent mine in an area where no target expected, the HD area DQOs were reviewed and revised for this site. The change shifted the objective from characterizing the HD area to collecting data to confirm that the HD area was not munitions related. Summarize any deviations from the planned sampling design and describe their impacts on the data quality objectives. The HD area characterization sampling design was implemented as planned for AOC A.

Step 2	**Review the data verification/validation outputs and evaluate conformance to MPCs documented on Worksheet #12** Review the Data Verification/Validation reports and supporting data, if necessary (e.g., daily/weekly QC reports, assessment reports, and corrective action reports. *Was the RCA/CA effective? Evaluate the implications of unacceptable QC results.* RCA/CA effectively implemented for one nonconformance and accepted as effective. Evaluate conformance to MPCs documented on Worksheet #12. All MPCs achieved. Evaluate data completeness. *Were all data inputs satisfied? Identify data gaps.* There are no data gaps. The full coverage grid was surveyed to specifications and all anomaly locations in the grids were excavated and their sources identified. The mine entrance location was surveyed and photographed.
Step 3	**Document data usability, update the CSM, apply decision rules, and draw conclusions** Assess the performance of the sampling design and Identify any limitations on data use. *Considering the implications of any deviations and data gaps, can the data be used as intended? Are the data sufficient to answer the study questions?* Data are sufficient to determine the AOC A is an abandoned mine. Excavation revealed items clearly identified as mine artifacts and no evidence of munitions use. Update the conceptual site model, apply decision rules, and document conclusions The CSM was updated to include results from physical inspection, surface sweep results, and full coverage grid sampling, to support the conclusion AOC A results from the presence of an abandoned mine and is not related to munition use.
Step 4	**Document lessons learned and make recommendations** Summarize lessons learned and make recommendations for changes to DQOs or the sampling design for the next phase of investigation or future investigations. No further investigation is recommended at AoC A. Evidence supporting conclusion AOC A is a non-impacted area will be compiled and presented in the RI/FS report. Prepare the data usability summary report.

Example #3: Preliminary Characterization in the Analog Area of MRS B, conducted at the completion of DFW 6.

Summary of key findings:

- One HD area encompassing approximately 106 acres located in southeastern portion of analog area. Average anomaly density is 640/acre. This HD area corresponds to location of mortar range M1.
- Munitions debris observed and documented during surface sweep.

Summary of non-conformances, root causes, and corrective action (from data validation report)		
Non-conforming MQO	Root cause	Corrective action implemented?
Transect repeatability failed criteria on multiple transects	Operator undercounting anomalies.	Operator was replaced, and data recollected.

Step 1	**Review the project's objectives and sampling design** Review the data quality objectives. *Are underlying assumptions valid?* The primary objective of the preliminary characterization in MRS B is to delineate HD areas from LD areas and determine which areas require further detailed characterization. The analog area of MRS B is suspected to contain one mortar target. The planned transect spacing was based on the VSP-recommended target size for surface-launched 60mm mortars, as documented in WS #11. The preliminary findings are consistent with confirming one mortar target. The assumptions are valid based on everything known about MRS B. Review the sampling design as implemented for consistency with stated objectives. *Were VSP input parameters representative of actual site conditions?* *Were sources of uncertainty accounted for and appropriately managed?* The primary uncertainties related to the preliminary characterization planning are in the assumptions about the background density, target size, and contrast. The measured background density of 200 anomalies/acre is comparable to the planning assumption of 225 anomalies/acre. The semimajor axes of the detected elliptical HD area are 500m and 150m. The smaller of these is comparable to the planning assumption of a circular target with a radius of 122m, based on the VSP recommendation for a surface-launched 60mm mortar. VSP reanalysis using the actual site characteristics indicates 100% probability of traversing and detecting the suspected mortar target. In short, there is little uncertainty in the design of the preliminary characterization of MRS B: the investigation found what it was designed to find and there were no surprises. The sampling design also considered a number of sources of uncertainty associated with the use of analog technology: (1) The Pd is unknown but from prior tests is expected to be in the range of 0.4 to 0.8 for munitions at depth; the Pd is also unknown for MD and RRD. (2) The background anomaly density is expected to be higher due to greater

	detection of small, near-surface clutter. (3) Uncertainties associated with the operator include the ability to navigate in difficult terrain, coverage, sensor height, and bias in selecting anomalies. A lower Pd and higher estimate of background anomaly density were used in the transect planning in VSP to account for the first two of these uncertainties. MQO PC22 regarding transect repeatability accounts for uncertainty in consistency of anomaly counts between operators in LD areas, where decisions are made to delineate LUA and NIA. Summarize any deviations from the planned sampling design and describe their impacts on the data quality objectives. The sampling design was implemented as planned for AOC A.
Step 2	**Review the data verification/validation outputs and evaluate conformance to MPCs documented on Worksheet #12** Review the Data Verification/Validation reports and supporting data, if necessary (e.g., daily/weekly QC reports, assessment reports, and corrective action reports. *Was the RCA/CA effective? Evaluate the implications of unacceptable QC results.* Operator X experienced a QC failure on MQO PC22, repeatability of transect anomaly counts in a LD area. The RCA revealed that the source of the failure was Operator X consistently undercounting anomalies. The operator was replaced and all transect data collected by Operator X were recollected. Recollected data passed the MQO and are deemed usable. Evaluate conformance to MPCs documented on Worksheet #12. RCA/CA effectively implemented. MPCs have been met. Evaluate data completeness. *Were all data inputs satisfied? Identify data gaps.* Following the implementation of corrective action, all data inputs were satisfied. No data gaps remain.
Step 3	**Document data usability, update the CSM, apply decision rules, and draw conclusions** Assess the performance of the sampling design and Identify any limitations on data use. *Considering the implications of any deviations and data gaps, can the data be used as intended? Are the data sufficient to answer the study questions?* Data are sufficient to delineate HD and LD areas in the analog area. The sampling design performed as intended and confirmed an expected mortar target documented in the CSM. The higher background density in LD areas and the unknown Pd introduce an unquantifiable uncertainty in the ability of the sampling design to locate any additional unknown, low-contrast HD areas that may be present in the LD area. Update the conceptual site model, apply decision rules, and document conclusions The CSM was updated to reflect actual background density and the preliminary boundary for target M1.

Step 4	**Document lessons learned and make recommendations** Summarize lessons learned and make recommendations for changes to DQOs or the sampling design for the next phase of investigation or future investigations. M1: This HD area corresponds to the location of a known mortar target. Proceed to HD area characterization. Existing HD Area Characterization DQOs were reviewed and found to be sufficient. The project data collection and analysis approach will be documented in the WS #17 Addendum: • Survey additional infill transects to establish HUA boundary. • Survey representative full coverage grids using Schonstedt and excavate all detected anomalies to establish depth profile and anomaly density. • Decision rules: See WS #11 WS #17 Addendum. For the purpose of the LD area characterization in analog area, greater uncertainty exists. Prepare the data usability summary report.

Example 4: HD Area Characterization of Target M1, conducted at the completion of DFW 12

- M1 is a high-use area (HUA) corresponding to location of a historic mortar range documented in the CSM.
- Presence of MD and RRD documented during site inspection (SI) and surface sweep.
- Additional analog surveys conducted on in-fill transects and five grids.
- QC exceptions noted; root cause analysis (RCA)/corrective action (CA) effectively implemented.
- Quality assurance (QA) seed recovery: Multiple passes were required in several of the full coverage grids to recover all seeds.
- Buffer zone established (See Detailed Characterization Memorandum)

Summary of non-conformances, root causes, and corrective action (from data validation report)		
Non-conforming MQO	Root cause	Corrective action implemented?
QA Seed Recovery: All seeds were not recovered on the first pass in 3 of the five grids	Low Pd	Multiple passes required, but all seeds were recovered

Step 1	**Review the project's objectives and sampling design** Review the data quality objectives. *Are underlying assumptions valid?* The primary objective of HD characterization in M1 is to determine whether the HD area is an HUA and if so, to determine the boundary, anomaly density/count, depth profile, and munitions present. The underlying assumption is that collecting data on additional, more closely spaced, in-fill transects will refine the size and anomaly density estimate, and that surveying sufficient grids and digging anomaly sources will provide the required characterization information. The additional transect data refined the anomaly and size estimate and the excavation in the grids yielded >2000 recovered sources. Assumptions were valid. Review the sampling design as implemented for consistency with stated objectives. *Were VSP input parameters representative of actual site conditions? Were sources of uncertainty accounted for and appropriately managed?* The additional transect data supported finer resolution kriging and refined size and density. A total of 2099 anomalies were dug in the 5 grids, providing a robust sample from which to draw characterization information. The actual size and density of the HD area and background density are consistent with VSP inputs. Uncertainties are managed through QC and QA seeding, which determine whether the system/operator are detecting all TOI. Summarize any deviations from the planned sampling design and describe their impacts on the data quality objectives.

Step 2	**Review the data verification/validation outputs and evaluate conformance to MPCs documented on Worksheet #12** Review the Data Verification/Validation reports and supporting data, if necessary (e.g., daily/weekly QC reports, assessment reports, and corrective action reports. *Was the RCA/CA effective? Evaluate the implications of unacceptable QC results.* In three of the five grids, seeds were missed on the first pass. The number of passes required to recover all seeds for each of the grids were 2,3,1,2, and 1. In each resurvey, additional seeds and additional native items were recovered. The failure to recover all seeds in one pass indicates that the Pd of the analog systems for TOI is well less than 1, as expected. The implications of this for future work is discussed in Step 4 below. Evaluate conformance to MPCs documented on Worksheet #12. Evaluate data completeness. *Were all data inputs satisfied? Identify data gaps.* There are no data gaps. The MPCs were achieved after the multiple passes needed to recover all seeds. For the purposes of HD are characterization, the 2099 items recovered provide a robust population to gather the needed information about depth, type, etc.
Step 3	**Document data usability, update the CSM, apply decision rules, and draw conclusions** Assess the performance of the sampling design and Identify any limitations on data use. *Considering the implications of any deviations and data gaps, can the data be used as intended? Are the data sufficient to answer the study questions?* The sampling design provided the needed characterization information. Data are suitable to answer questions about HD characterization. Limitations of the technology have been documented and will affect following phases. Update the conceptual site model, apply decision rules, and document conclusions. The CSM was updated to show the boundary and buffer zone for Target M1.
Step 4	**Document lessons learned and make recommendations** Summarize lessons learned and make recommendations for changes to DQOs or the sampling design for the next phase of investigation or future investigations. No changes to DQOs. Seed failures document the expected lower Pd on TOI. Analog systems cannot be expected to detect all TOI in any subsequent removal action, if needed. Planning for future work must assume the cost of multiple resurveys and acknowledge the risk that not all TOI will be recovered. Prepare the data usability summary report.

Appendix A: Preliminary MRS Characterization Memorandum Excerpts

The following is a synopsis of selected findings at Camp Example that would be documented in the Preliminary Characterization Technical Memorandum and used to guide the high density (HD) and low density (LD) Characterization to follow.

MRS A

Data Usability: In munitions response site (MRS) A, the measured background anomaly density was 86 anomalies/acre, comparable to the estimate of 75 anomalies/acre used in the planning the Visual Sample Plan (VSP) transects; therefore, the data usability assessment (DUA) determined that the VSP transect plan was valid, and analysis was completed using the data collected. Rights of entry were not granted in the three areas shown in red, so no data were collected in these areas.

The Preliminary Characterization conclusions for MRS A are summarized in Figure A-1 and Table A-1, and discussed below.

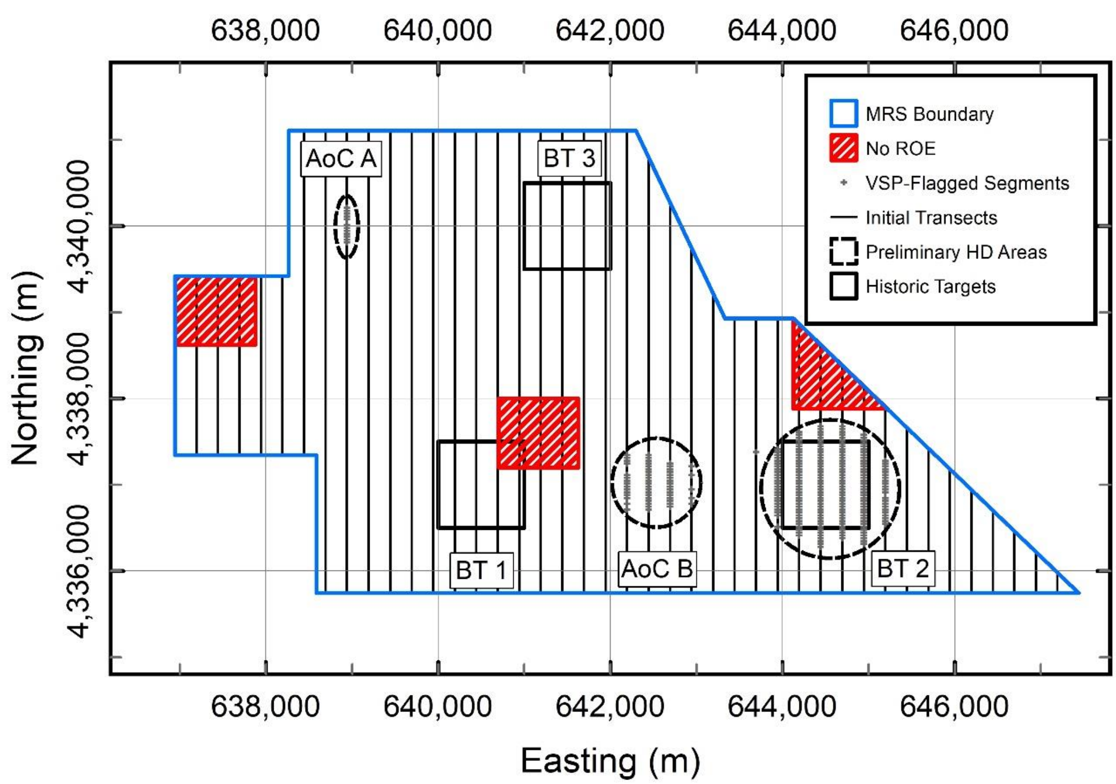


Figure A-1. Preliminary Characterazation of MRS A

Table A-1. Summary of Preliminary Characterization Results for MRS A

CSM Label	VSP Analysis	Visual Observation	Area (acres)	Average Density (anomalies/acre)
BT1	No HD Area	Nothing	N/A	N/A
BT2	HD Area	Frag and Craters	500	406
BT3	No HD Area	Nothing	N/A	N/A
AoC A	HD Area	Mine Entrance	37	225
AoC B	HD Area	Nothing	206	214

BT1. The historical record indicated that a bomb target had been planned for the location labeled "BT1"; however, there was no evidence discovered during the SI that this planned target had ever seen use. There was no surface indication of munitions debris (MD) or range-related debris (RRD) observed during the site visit. The VSP analysis shows no HD area in this location. Due to lack of access, no data could be collected in the NE corner of the historic target boundary.

BT2. The area marked "BT2" corresponds to the location of a bomb target in the historical record. MD and RRD consistent with both practice bombs and HE bombs were found on a site visit during the site inspection SI. The VSP analysis identified a HD area that encompassed 500 acres and had an estimated average anomaly density of 406 anomalies/acre.

BT3. The historical record indicated that a bomb target had been planned for the location labeled "BT3"; however, there was no evidence discovered during the SI that this planned target had ever seen use. There was no surface indication of MD or RRD in the site visit. The VSP analysis shows no HD area in this location.

AOC A. In the Area of Concern marked "AOC A," the VSP analysis indicated an HD area that encompassed 37 acres and had an estimated average anomaly density of 225 anomalies/acre. The original CSM does not indicate that this location was ever used or planned for munitions use. The geophysics team field notes indicate the location contains an entrance to an abandoned mine.

AOC B. In the Area of Concern marked "AOC B," the VSP analysis indicated an HD area that encompassed 206 acres and had an estimated anomaly density of 214 anomalies/acre. The original CSM does not indicate that this location was ever used or planned for munitions use. The geophysics team field notes do not indicate observations of MD. The shape of the HD area and the lack of any indication of another source for this concentration of metal objects suggests that it may be a bomb target.

MRS B

Data Usability: In MRS B, the measured background anomaly density in the DGM area was 92 anomalies/acre for most of the site with elevated background anomaly density of 140 anomalies/acre near the slope on the eastern edge of the site near M1. The background density on the majority of the site is comparable to the estimate of 75 anomalies/acre used in the planning the VSP transects. The measured background anomaly density was 200 anomalies/acre in the analog area, comparable to the estimate used in planning. Analysis was completed on the data collected, including the area with higher background density. [See discussion in Worksheet #37].

The Preliminary Characterization conclusions for MRS B are summarized in Figure A-2 and Table A-2, and discussed below.

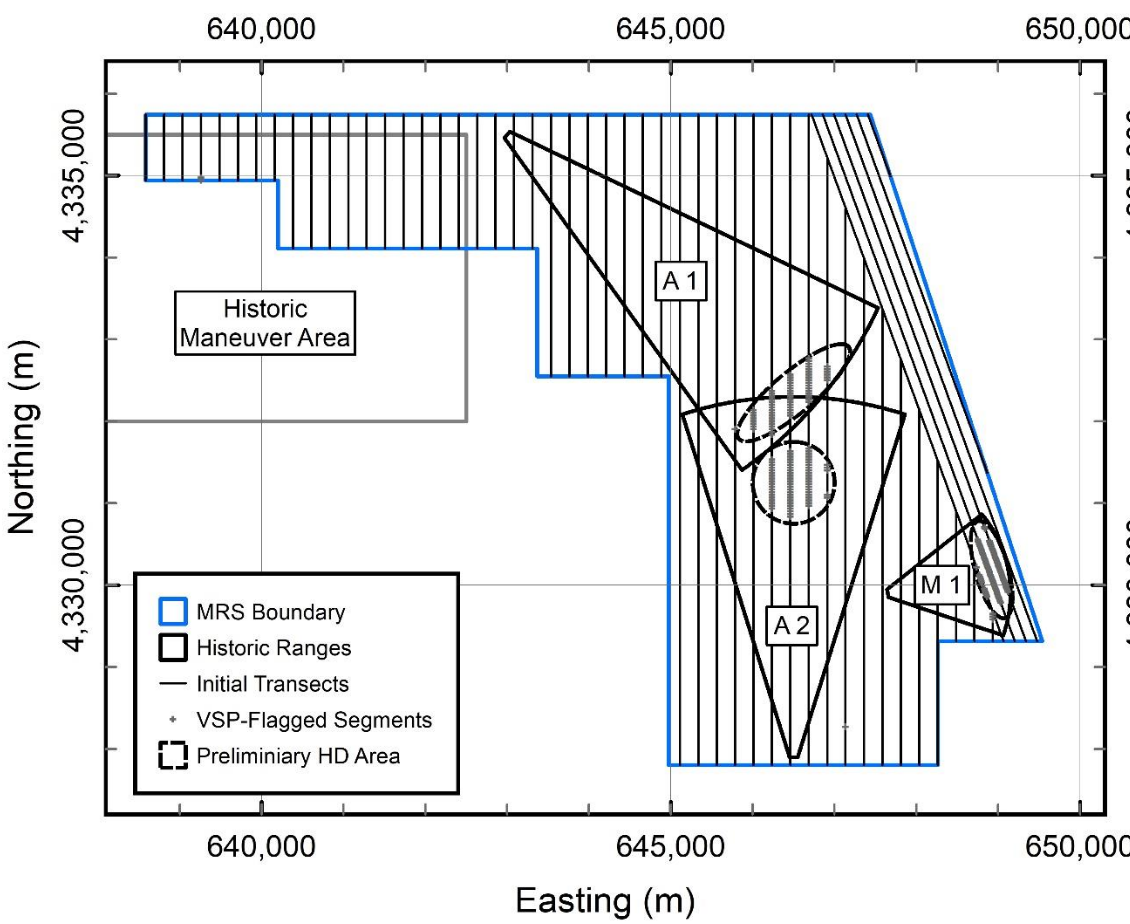


Figure A-2. Preliminary Characterazation of MRS B

Table A-2. Summary of Preliminary Characterization Results for MRS B

CSM Label	VSP Analysis	Visual Observation	Area (acres)	Average Density (anomalies/acre)
A1	HD Area	Frag	170	328
A2	HD Area	Frag	194	328
M1	HD Area	Frag	105	852

A1 and A2. In the areas marked "A1" and "A2" the VSP analysis indicated two adjacent HD areas that encompass 170 and 194 acres and have an estimated average anomaly density of 328 across the combined area. The CSM indicates that this area is at the location of two adjacent artillery ranges.

M1. In the area marked "M1," which was surveyed by analog technology, the VSP analysis indicated an HD area that encompassed 105 acres and had an estimated average anomaly density of 852 anomalies/acre. The CSM indicates that this area is at the location of a mortar range.

Appendix B: Detailed Characterization Technical Memorandum Excerpts

Following is a synopsis of selected findings that would be documented following the high density (HD) and low density (LD) Area Characterization for Camp Example. In this example, all additional field work was completed for both the HD and LD Characterization in a single deployment, so the contractor produced a single memorandum summarizing the results of all detailed characterization work. If multiple sequential planning steps and deployments were required, the contractor would produce multiple memoranda. Regardless of the sequencing of the planning and field work, it is expected that the contractor will provide a detailed discussion of all characterization data and conclusions.

HD Area Characterization Results

Additional geophysics data were collected along transects and in full coverage grids as described in Worksheet #17, shown in Figures B-1 and B-2.

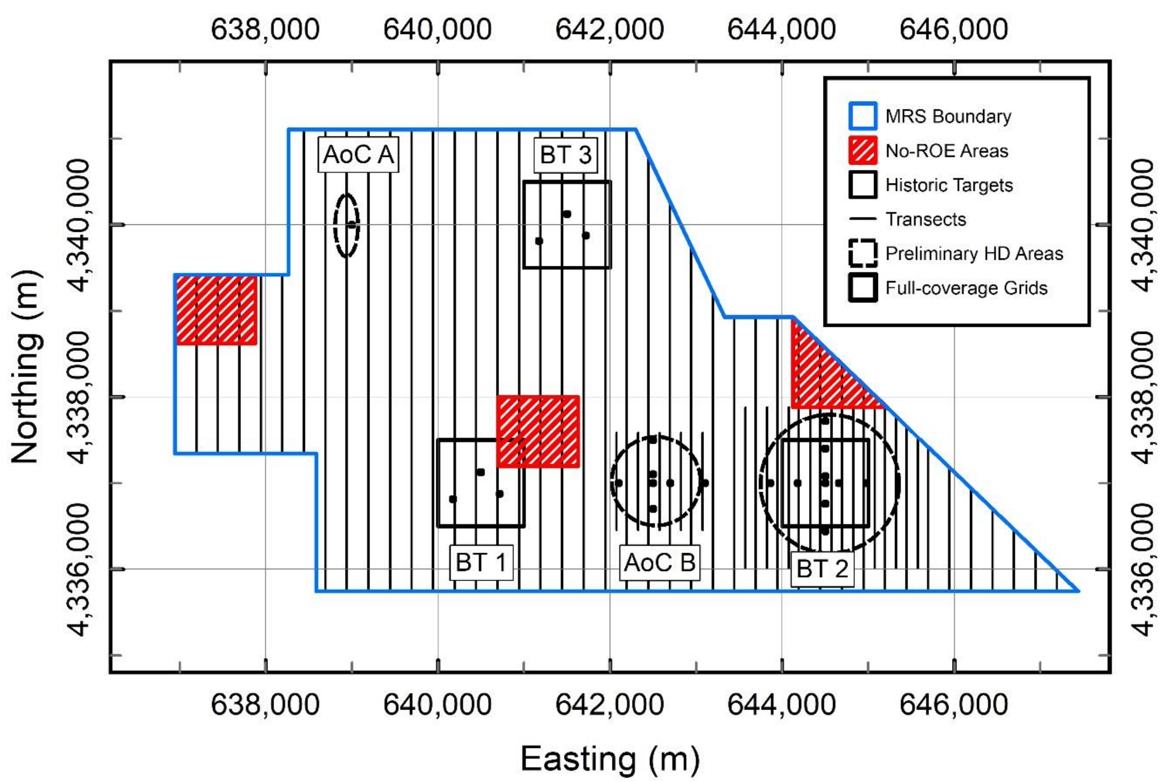


Figure B-1. Additional TEMTADS data collected in the HD characterization of MRS A

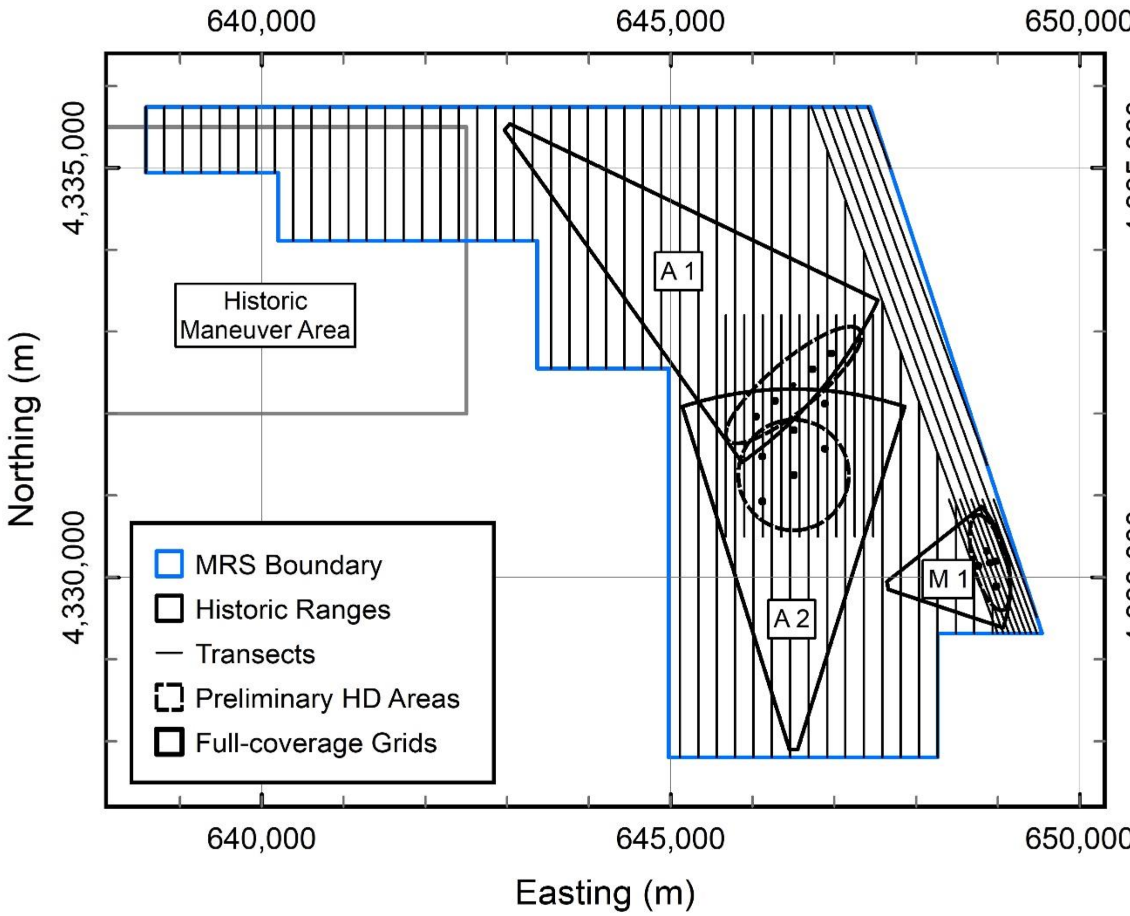


Figure B-2. Additional DGM and analog geophysics data collected in the HD characterization of MRS B

BT2. This HD area is a high-use area. The location corresponds to the location of a known bomb target area documented in the preliminary CSM. Munitions debris (MD) and range-related debris (RRD) were observed during the site inspection (SI) and the field notes of the surface sweep team confirm this. Additional geophysical data were collected with the Time-domain Electromagnetic Multi-sensor Towed Array Detection System (TEMTADS) surveying in-fill transects separated by 125m and 10, ¼-acre, 100%-coverage grids. Visual Sampling Plan (VSP) analysis results of transect data, including the original and additional in-fill transects, are summarized in Table B-1. Figure B-3 shows the results of the VSP Kriging analysis for BT2, indicating that the HUA extends into the adjacent no-right-of-entry (ROE) area.

Buffer Area BT2. VSP analysis shows a circular HD area centered on the coordinates of the historic target location. The buffer area around BT2 reflects the limitations in interpolating to estimate anomaly densities between transects. It is conservatively drawn to extend beyond the high-use area (HUA) a distance of 250m (one transect spacing) in the original transect design. The buffer area of BT2 extends into the no-ROE area and beyond the border of the MRS.

Table B-1. Summary of HD Characterization of BT2

Size of area	856 acres
Estimated number of anomalies from transect analysis	386,000
Estimated number of anomalies from grids	250,000
Estimated anomaly density	450/acre
Target center Northing	4,337,000
Target center Easting	644,500

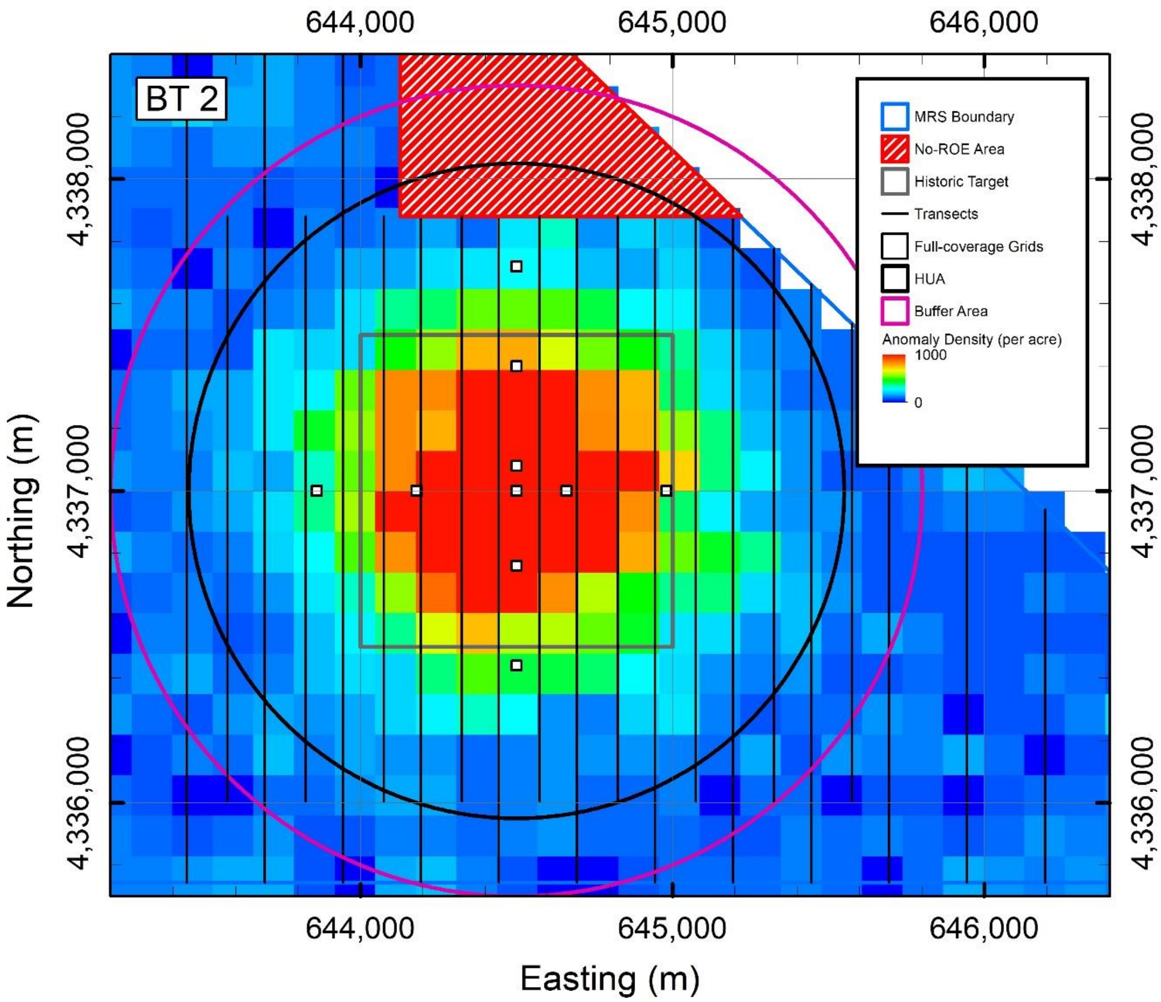


Figure B-3. HD Characterization of BT2

A total of 2475 anomalies were detected in the full coverage grid surveys and all were analyzed using advanced geophysical classification (AGC). Twenty-four anomaly locations were excavated from the grid data, including 12 matches to target of interest (TOI), seven that fit as long, slender, thick-walled objects, and five examples of an unknown cluster of 20 items. Of the 12 matches to TOI, nine were crumpled practice bombs, and the remaining three were large cultural debris. Of the seven TOI-like objects, all were large, elongated scrap from HE bombs. The five objects from the cluster analysis were all bomb fins that had separated from the bomb bodies. All information confirms the CSM, which documents the presence of craters and surface MD associated with HE bombs, that this is the location of a bomb target where both HE and practice bombs were used.

The depth profile of all anomaly sources was determined by AGC analysis of the TEMTADS grid data, shown in Figure B-4, which also shows the depth of the seeds and the depth at which the nine practice bombs were recovered.

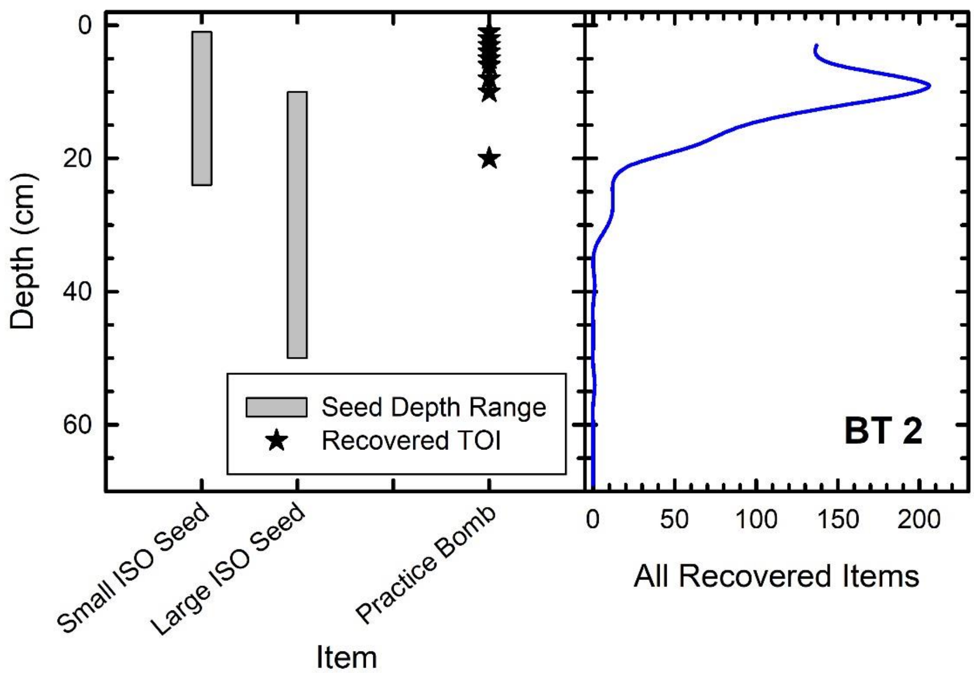


Figure B-4. Depth profile of BT2, as determined by AGC analysis of the TEMTADS data and excavation of selected anomaly sources

Area of concern (AOC) A. This HD area results from an abandoned mine. The location does not correspond to any known or planned target area. The geophysics team field notes indicate the presence of the entrance to an abandoned mine and this was confirmed, photographed, and the GPS location documented by a physical inspection. TEMTADS data were collected in one ¼-acre grid and all 86 anomaly locations were dug. None were found to contain munitions and explosives of concern (MEC), MD, or RRD.

AOC B. Although the location does not correspond to the location of a known bomb target area in the CSM, this HD area is a high-use area. Digging the locations of selected anomalies in the grids yielded MD and RRD, indicating munitions use. TEMTADS data were collected on additional in-fill transects separated by 125m. The VSP results from analysis of both the original and in-fill transect data are summarized in Table B-2. Figure B-5 shows the results of the VSP Kriging analysis of AOC B.

Buffer Area AOC B. VSP analysis shows a circular HD area typical of a bomb target. The buffer area around AOC B reflects the limitations in interpolating to estimate anomaly densities between transects. It is conservatively drawn to extend beyond the HUA a distance of 250m, one transect spacing in the original transect design.

Table B-2. Summary of HD Characterization of AOC B

Size of area	386 acres
Estimated number of anomalies from transect analysis	90,000
Estimated number of anomalies from grids	125,000
Estimated anomaly density	180/acre
Target center Northing	4,337,000
Target center Easting	642,500

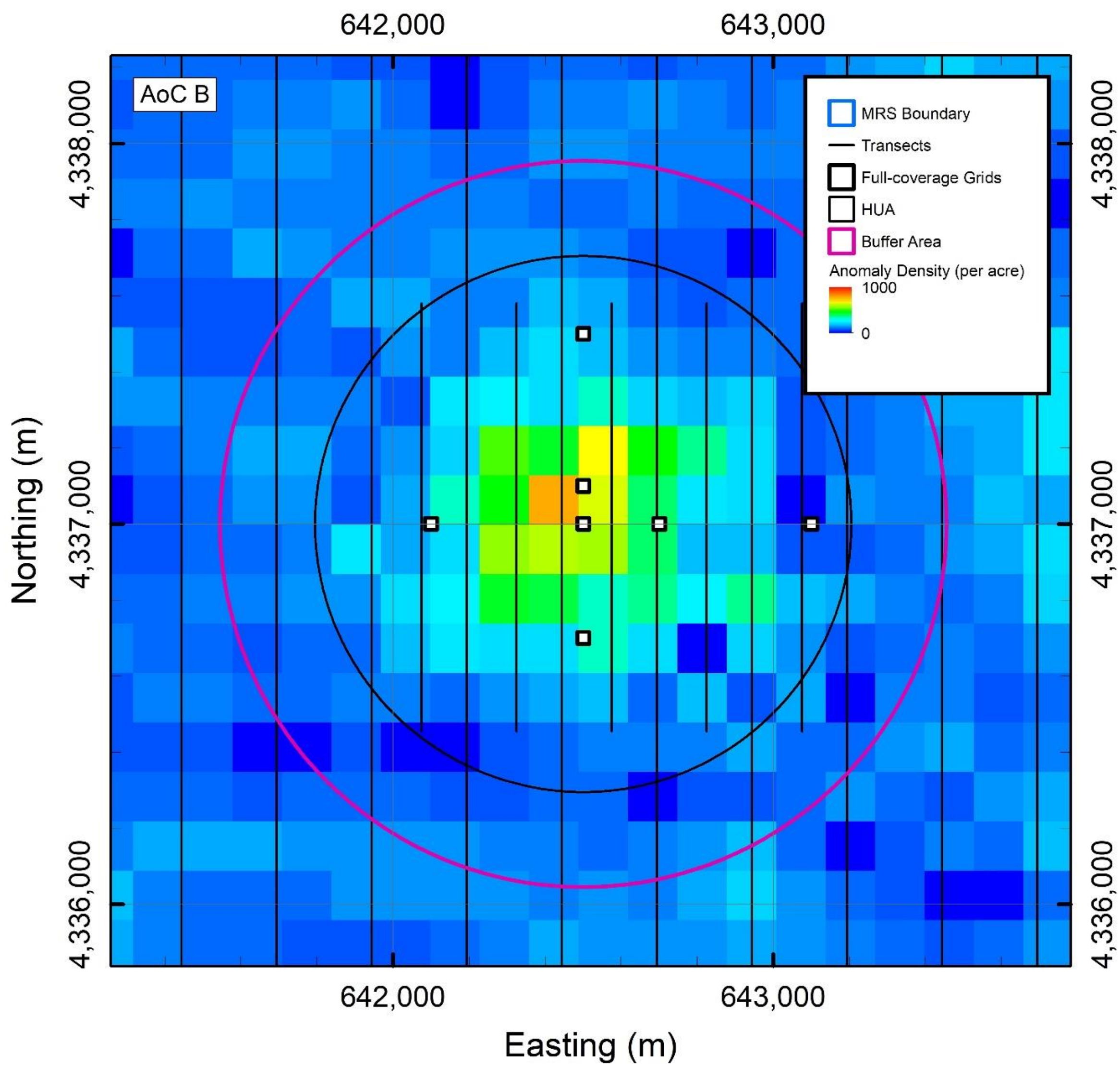


Figure B-5. HD Characterization of AOC B.

A total of 631 anomalies were detected in the grid surveys and analyzed using AGC. Nine anomaly locations were excavated from the grid data, including four matches to TOI and five examples from a cluster of 38 items that do not match to TOI. Of the four matches to TOI, two were crumpled practice bombs and the remaining two were large cultural debris. The five cluster items were spotting charge canisters from practice bombs. All information collected during the RI indicates that this is the location of a practice bomb target.

The depth profile of the anomaly sources was determined by AGC analysis of the TEMTADS grid data. It is shown in Figure B-6, which also shows the depth of the seeds and the depths at which the two practice bombs were recovered.

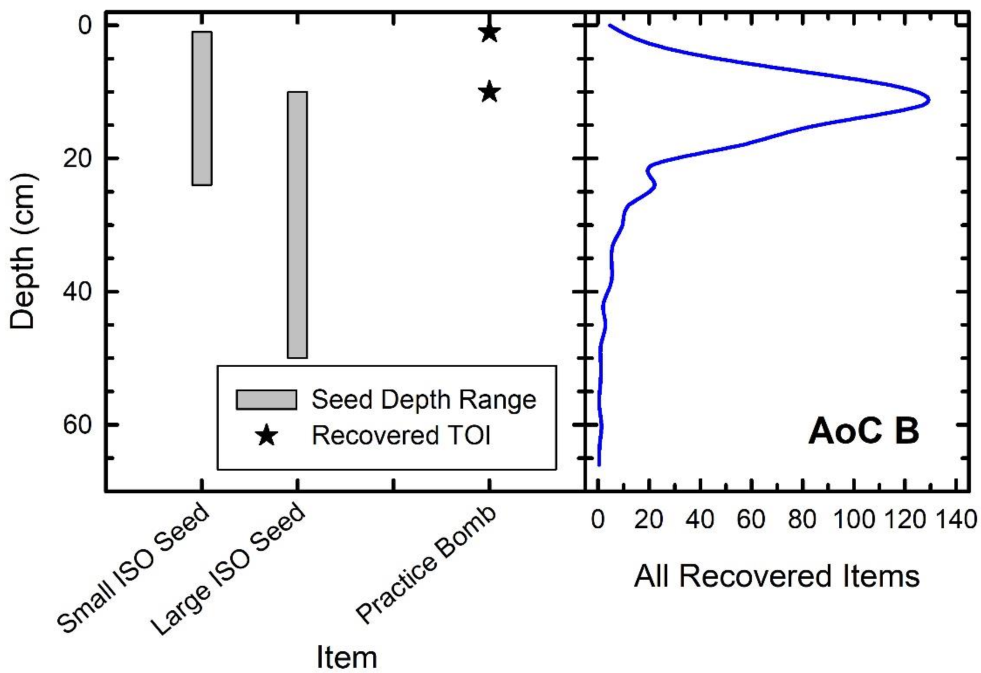


Figure B-6. Depth profile of AOC B, as determined by AGC analysis of the TEMTADS data and the excavation of select anomaly sources

A1 and A2. This is a high-use area. It corresponds to the location where the impact areas of two historic artillery ranges, documented in the CSM, meet. The SI indicates the presence of MD and RDD, which are corroborated by field notes from the surface sweep team. Additional DGM geophysical data were collected on in-fill transects separated by 112.5m and in 16 full coverage grids. The results of the VSP analysis of both the original and in-fill transect data are summarized in Table B-3. The results of the VSP Kriging analysis are shown in Figures B-7 and B-8.

Buffer Area for A1. The buffer area around A1 reflects the limitations in interpolating to estimate anomaly densities between transects, as well as its historical use. The HD area associated with A1 falls within the range fan but appears to be offset to the right of the firing direction from the historic border and it extends to the edge of the historic down-range border. To reflect the actual site use, the historic range was rotated to center on the HD area and the updated cross-range border defines the buffer. In the down-range direction and towards the firing point, the buffer area encompasses one additional transect spacing (225m) to account for uncertainty associated with the original transect spacing.

Buffer Area for A2. The buffer area around A2 reflects the limitations in interpolating to estimate anomaly densities between transects, as well as its historical use. The HD area associated with A2 falls entirely within the historic range fan, and its boundary is located more than one transect spacing from the historic down-range border. Therefore, the down-range and cross-range historic border define the buffer area in the down-range and cross-range directions. To the south in the direction of the firing point, the buffer area encompasses one additional transect spacing (225m) to account for uncertainty associated with the transect spacing in the original transect spacing.

Table B-3. Summary of HD Characterization of A1 and A2

Area	599 acres
Estimated number of anomalies from transect Analysis	175,175
Estimated number of anomalies from grids	205,000
Estimated anomaly density	275/acre
Target center Northing	4,331,906
Target center Easting	646,827

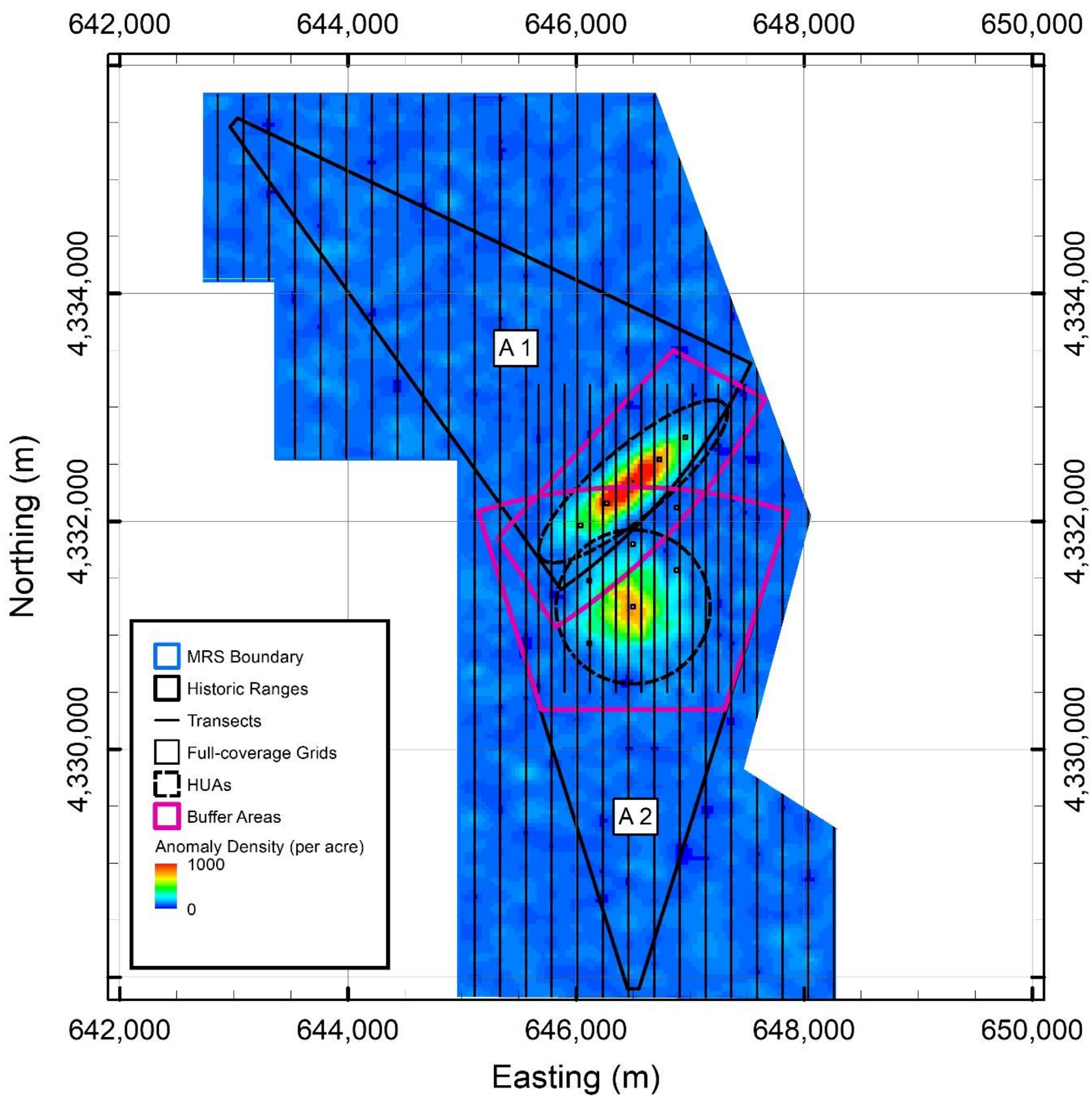


Figure B-7. HD Characterization of A1 and A2

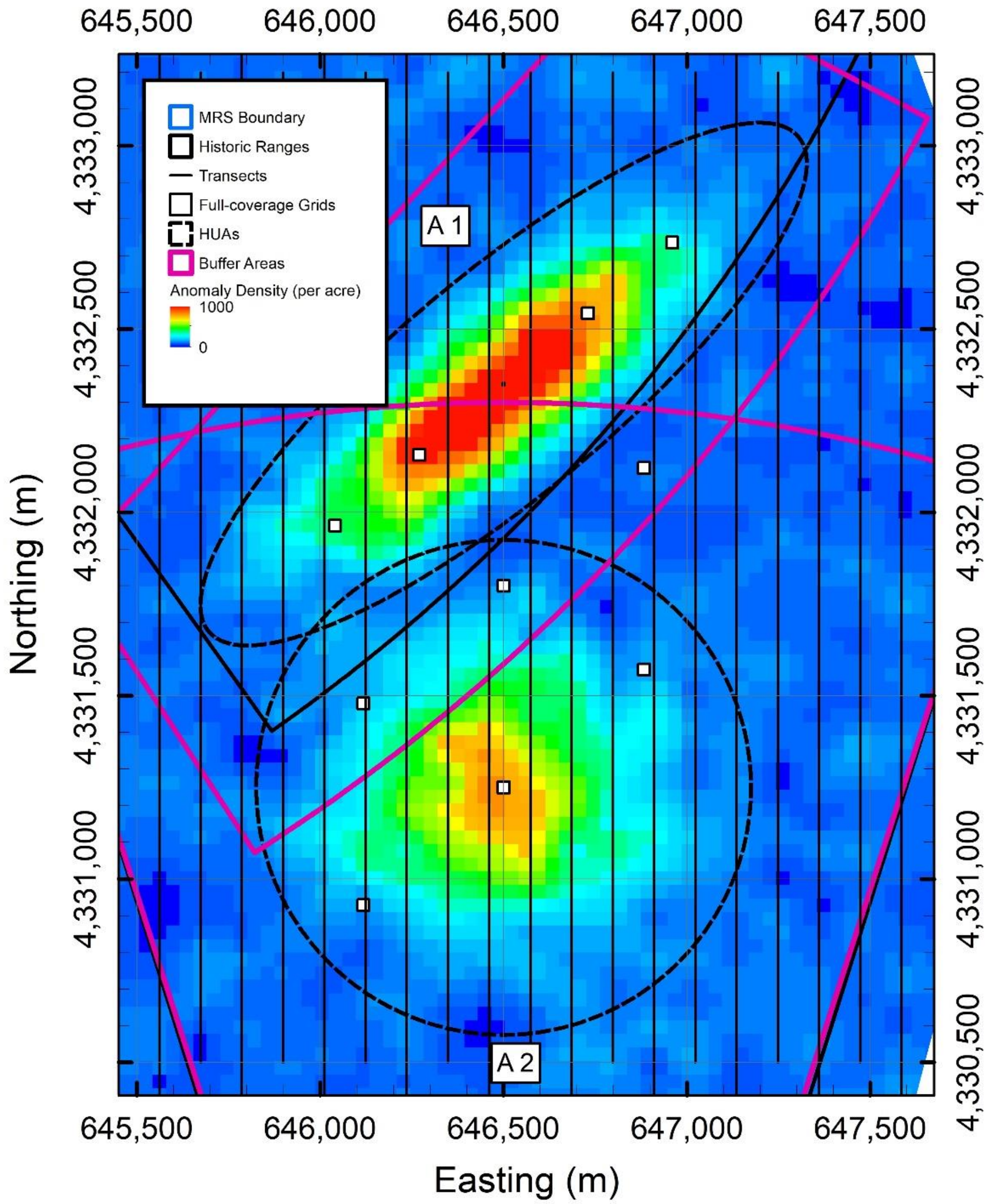


Figure B-8. Detail HD Characterization of A1 and A2

All 1001 anomaly locations in the DGM grid data were excavated. The recovered sources are shown in Table B-4. The total number of recovered exceeds 1001 because multiple objects were recovered from several holes. The 75mm projectile and the 105mm projectile were expected from the historical use documented in the CSM. The recovery of a 155mm projectile was unexpected. All MD recovered at the site was consistent with the larger known projectiles.

Table B-4. Summary of Dig Results for A1 and A2

Category	Number
75mm projectile	1
105mm projectile	1
155mm projectile	1
MD	552
RRD	397
Cultural Debris	87

All information confirms the CSM that this is the location of an artillery target.

The depth profile of the recovered sources is shown in Figure B-9, with the depths of the seeds and the three recovered MEC highlighted.

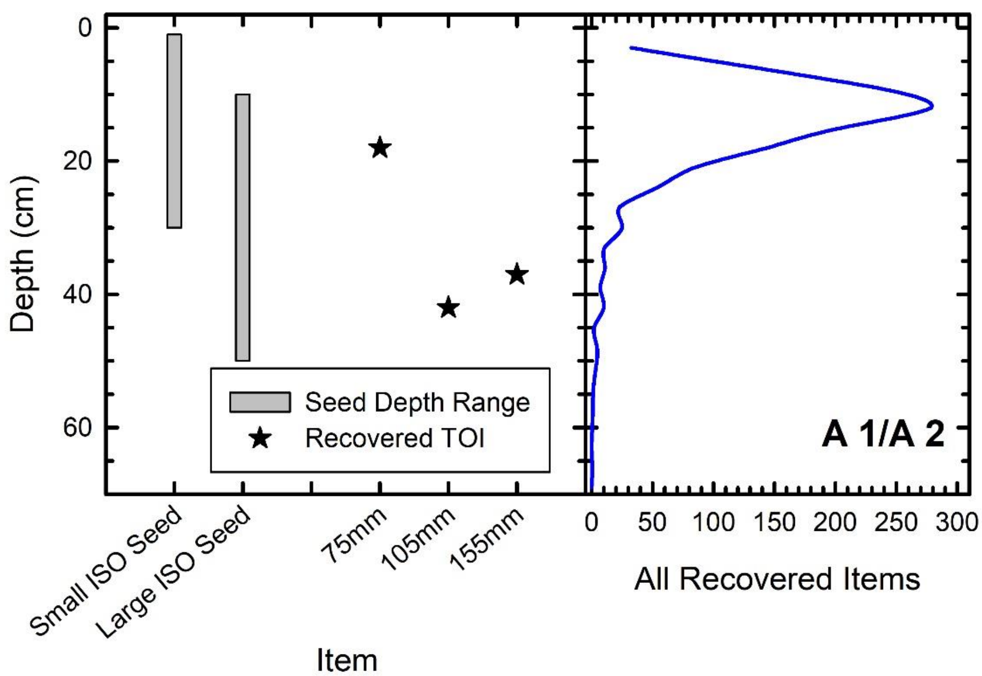


Figure B-9. Depth profile for A1 and A2, as determined by digging all anomaly locations in the full coverage grids.

M1. This HD area is a high-use area that corresponds to the location of a historic mortar range documented in the CSM. SI results indicate the presence of MD and RRD, and the field notes of the surface sweep team confirm this. Additional analog surveys were conducted on in-fill transects separated by 64.5m and in 5 grids. VSP analysis results of transect data, including the additional transects, are summarized in Table B-5. The results of the VSP Kriging are shown in Figure B-10.

Buffer Area for M1. The buffer area around M1 reflects the limitations in interpolating to estimate anomaly densities between transects, as well as its historical use. The HD area associated with M1 falls entirely within the range fan, but its boundary is located more at the edge of the historic down-range border. Therefore, cross-range historic border defines the buffer. To the east in the down-range direction and to the west in the direction of the firing point, the buffer area encompasses one additional transect spacing (129m) to account for uncertainty associated with the original transect spacing.

Table B-5. Summary of HD Characterization of M1

Area	105 acres
Estimate number of anomalies from transect analysis	62,400
Estimated number of anomalies from grids	48,200
Estimated anomaly density	600/acre
Target center Northing	4,330,180
Target center Easting	648,900

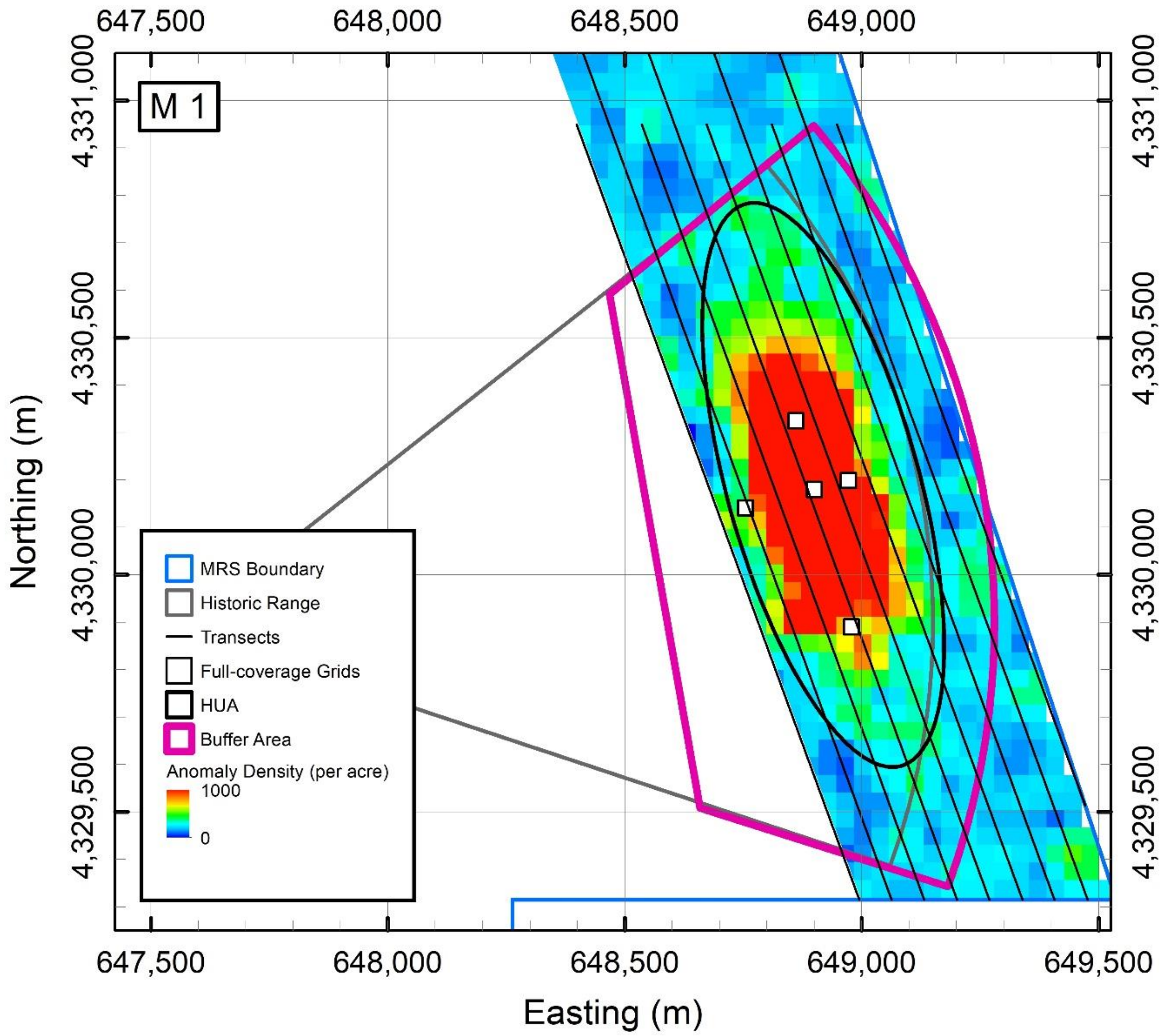


Figure B-10. HD Characterization of M1

All 2099 flagged locations in the grid survey were excavated. The recovered sources are shown in the table in Table B-6. The total number of recovered items does not add to 2099 because multiple objects were recovered from several holes. All MD recovered at the site was consistent with mortars. All information confirms the CSM that this is the location of a mortar target.

Table B-6. Summary of Dig Results for M1

Category	Number
60mm mortar	7
MD	1355
RRD	657
Cultural Debris	105

The depth profile of the recovered sources is shown in Figure B-11, with the depths of the seeds and the seven recovered MEC highlighted.

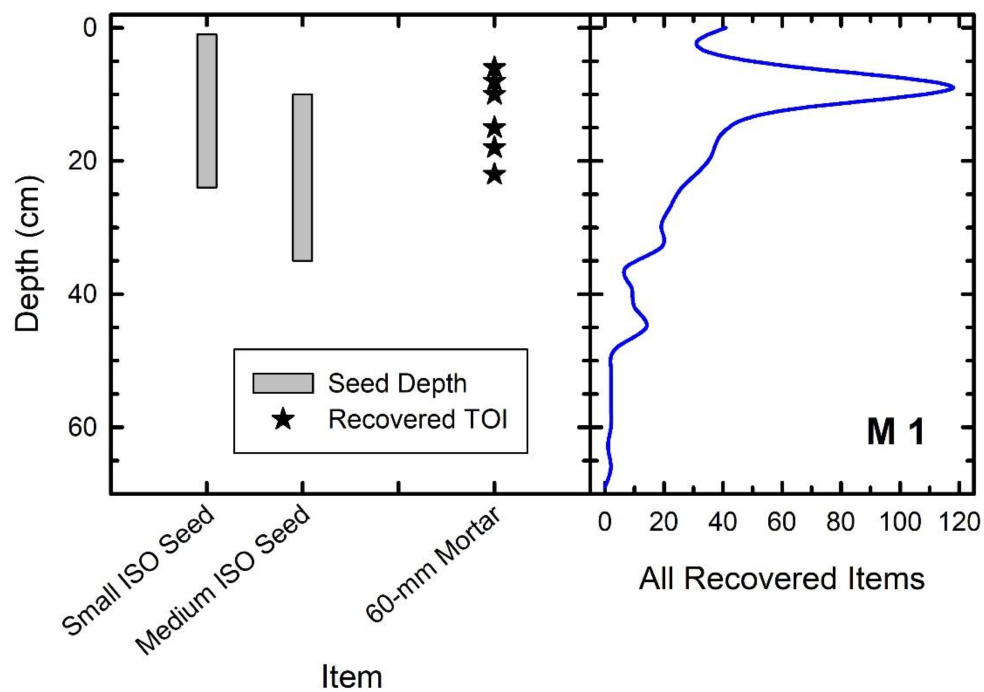


Figure B-11. Depth profile of M1, as determined by digging in the grids

<u>LD Area Characterization</u>

Additional TEMTADS data were collected in three ¼-acre grids in each of the areas marked BT1 and BT3. These areas were designated as planned bomb targets, but there is no evidence to suggest that they were impacted by munitions.

<u>BT1 and BT3</u>. No HD area was found at either of these locations during the preliminary characterization. A visual inspection of each area showed no indications of munitions use. Additional geophysics data were collected in three ¼-acre 100% coverage grids in each area, and the locations of all 66 anomalies detected in BT1 and 42 anomalies detected in BT3 were dug. No MEC, MD, or RRD were discovered. These areas are determined to be non-impacted areas and no additional characterization will be done.

<u>Conclusion</u>

Figures B-12 and B-13 summarize the results of the HD and LD Area Characterization. All areas where the initial CSM indicated potential munitions use and all unexpected HD areas have been characterized with high confidence.

No data were collected in the three areas of MRS A where rights of entry were not obtained.

- North of BT2. Extrapolation of the available surrounding data indicates that the HUA extends into the no-ROE area.
- Far West: Nothing in the CSM suggests munitions use in this area of the MRS, but no data are available and it cannot be definitively ruled out.
- Near BT1. This no-ROE area covers a small portion of planned BT1, for which there is no evidence of use in CSM. The surrounding area on all sides is LD. With the expected extent of a BT, there is a low likelihood that a separate HD area is entirely confined to the unsampled area, but in the absence of data the possibility cannot be definitively ruled out.

With the exception of the historic maneuver area, where statistical sampling does not provide useful characterization information, the remainder of the site is characterized as non-impacted with high confidence.

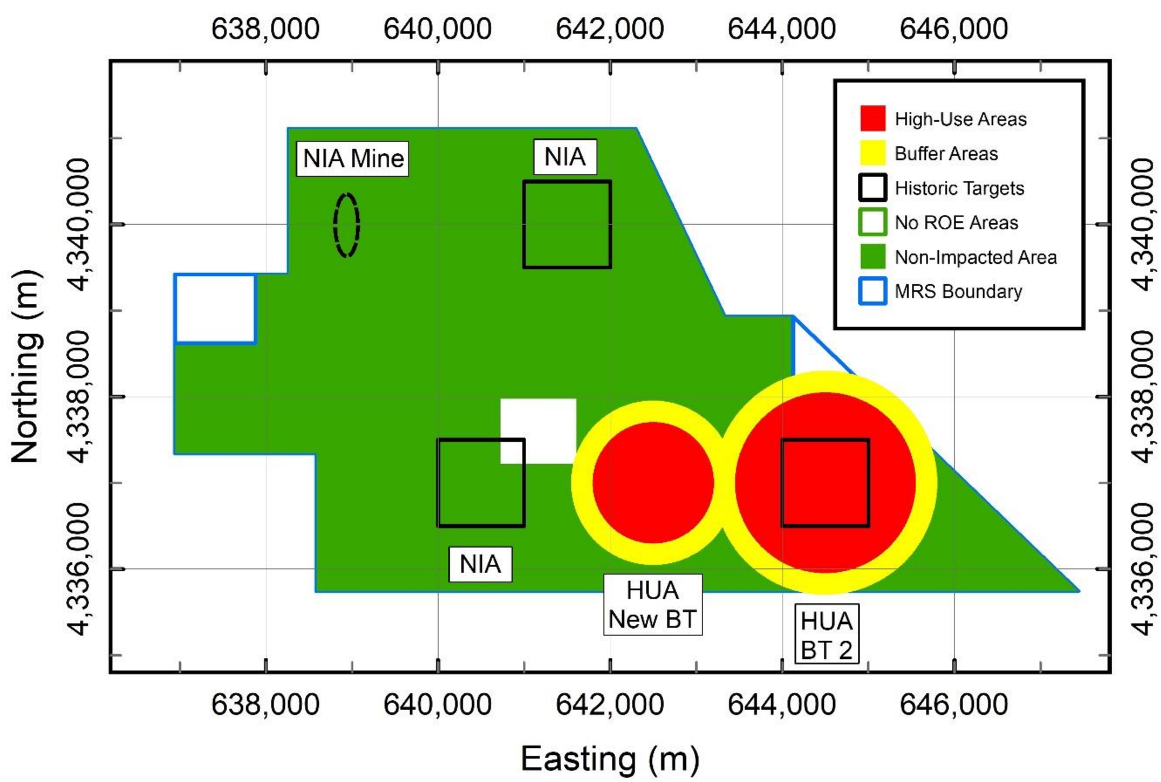


Figure B-12. Summary of Conclusions for MRS A

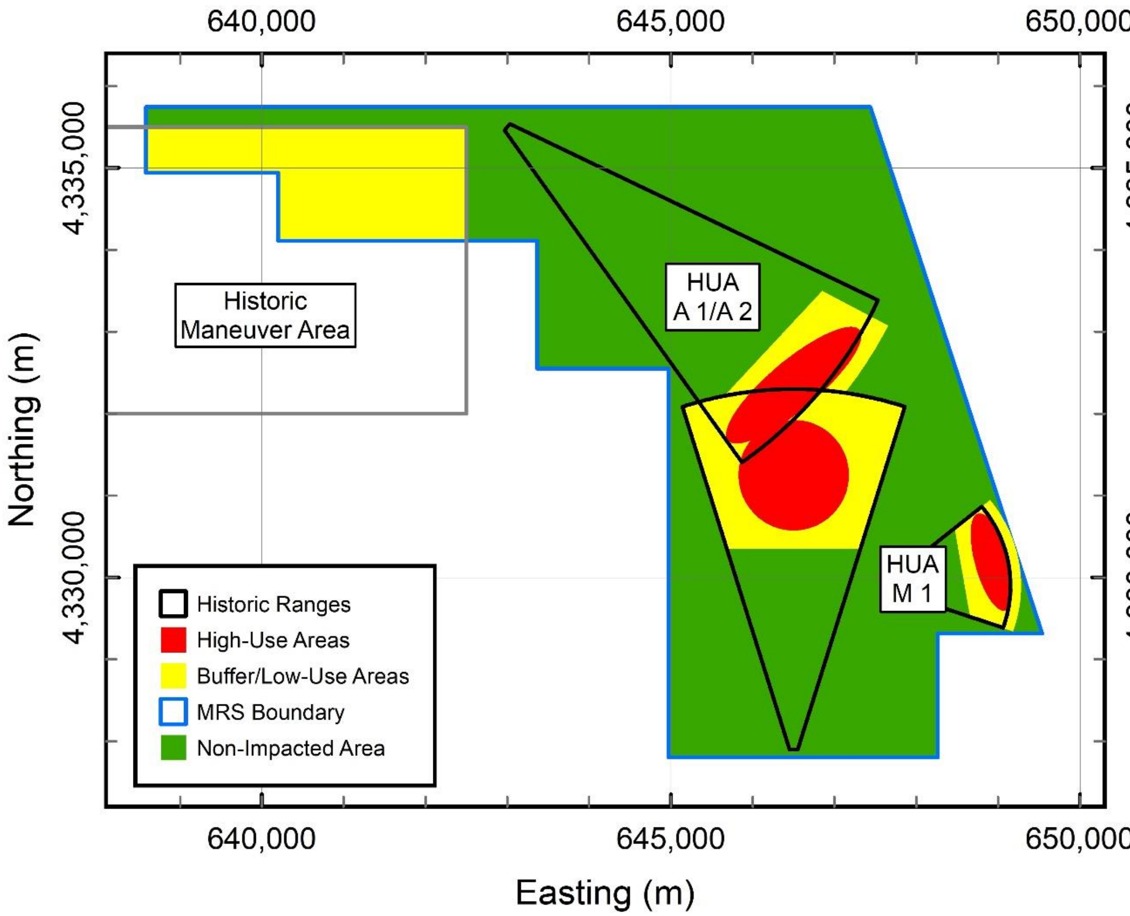


Figure B-13. Summary of Conclusions for MRS B