Los Angeles District

GEOPHYSICAL PROVE-OUT (GPO) PLAN

Borrego Maneuver Area
San Diego, Imperial, and Riverside Counties, California

Contract No. W912PL-05-0007

Prepared for:
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Los Angeles District
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JULY 7, 2006

TABLE OF CONTENTS

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ACRONYMS

ASR	Archive Search Report
BMA	Borrego Maneuver Area
CESPL	United States Army Corps of Engineers, Los Angeles District
DID	Data Item Description
DGM	Digital Geophysical Mapping
GIS	Geographic Information System
GPO	Geophysical Prove-Out
GPS	Global Positioning System
MARRS	MARRS Services, Inc.
MEC	Munitions and Explosives of Concern
MRA	Munitions Response Area
NGS	National Geodetic Survey
PLS	Professional Land Surveyor
QC	Quality Control
RI	Remedial Investigation
RTK	Real-time Kinematic
TDEM	Time-domain Electromagnetic
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance

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1.0 GEOPHYSICAL PROVE-OUT PLAN

This plan provides a description of the Geophysical Prove-Out (GPO) approach for the overall Borrego Maneuver Area (BMA) RI process. The purpose of the GPO is to evaluate Digital Geophysical Mapping (DGM) geophysical instruments, determine the standard response of selected instruments, evaluate the instrument configurations, deployment techniques, and provide operator certification for instrument use. The GPO will be performed in accordance with DIDs MR-005-05 and MR-005-05A. All data obtained during the GPO will be submitted to CESPL in accordance with the BMA project guidelines. Mobilization to perform DGM at the BMA will not begin until the CESPL reviews and concurs with the findings of the GPO.

The objective of the GPO is to establish a protocol to evaluate technologies and equipment that can accurately detect and map MEC items typically found at the various sites within the BMA. The GPO will evaluate the site-specific performance of the geophysical equipment, the positioning equipment and operator, as well as the data processing and management systems to be deployed to the field. The design of our test plot allows for prove-out of systems in both total-survey coverage and single-path transect modes for both detector-aided visual investigations and DGM investigations. The equipment selected for prove-out and potential use for DGM includes the Geonics EM61-MK2 Time-Domain Electromagnetic (TDEM) high-sensitivity metal detector and the Geometrics G858 cesium vapor magnetometer. These instruments may be used with a variety of positioning systems; however, the primary positioning system will be the Trimble 4700/5700 Real-Time Kinematic (RTK) GlobalPositioning System (GPS) for both acquisition and reacquisition positioning activities. Additional systems or equipment proposed for field use will require testing and evaluation at the GPO prior to field deployment.

The equipment selected for prove-out and potential use for detector-aided visual investigations and the intrusive investigation includes the Schonstedt GA-52 fluxgate magnetic gradiometer and the Garrett GTI 2500 electromagnetic handheld detector.

1.1 TEST PLOT DESIGN

1.1.1 Test Plot Size and Location

MARRS will construct a test plot within the primary geologic setting. The test plot will be constructed within a desert terrace (plain) setting. This setting was selected because it represents the dominant geologic setting where geophysical data will be obtained. The proposed test plot will be approximately 30 m by 30 m (100 ft by 100 ft). The actual size and location of the test plot will be determined based on client, stakeholder, and project requirements.

The test plot will be established such that it may be used to prove-out geophysical systems in both single-path transect and total-survey coverage modes. Distribution of munitions seed items within the test plot will be pseudo-random to allow prove-out of systems in both the total survey coverage and single-path linear transecting methodologies. The test plot will include a standardization line and adequate survey control for setup and QC of positioning systems used during the prove-out process. The conceptual design of the test plot is shown in Figure 1. In addition to the test plot corners, survey control points are placed along the perimeter of the test plot to allow its use in the single-path transect mode, as described below. Survey control points will also be established in close proximity to the test plot for the setup and use of positioning base/reference stations used to support the geophysical systems demonstrated in the test plot. The location of these control points are not shown in Figures 1 and 2.

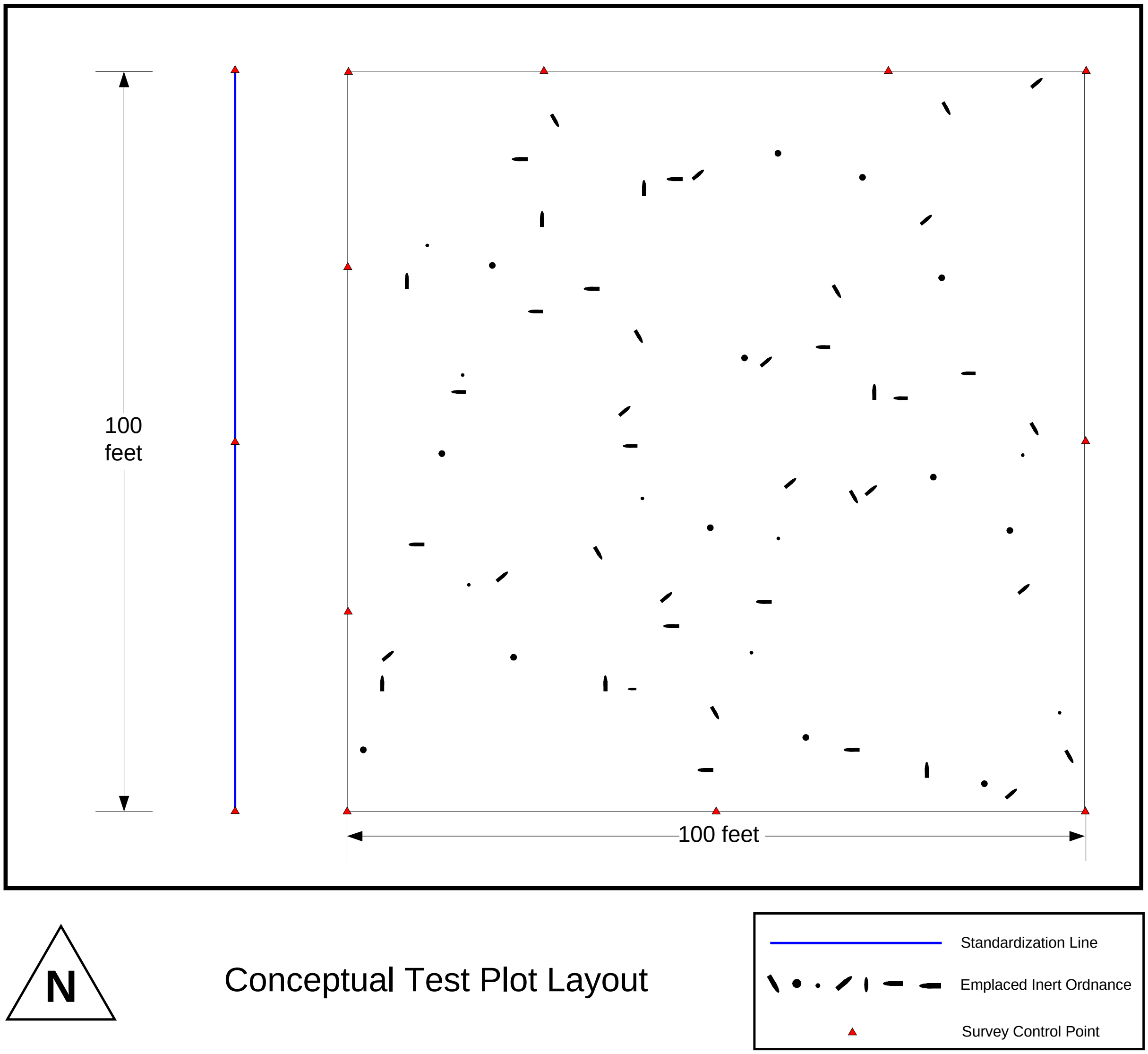

Figure 1, Test Plot Conceptual Design.

To use the test plot for total-coverage prove-out of systems, data will be acquired using appropriately spaced (system-based) transects to achieve total-coverage across the entire test plot. To use the test plot to prove-out systems in the single-path linear transect mode, a line is extended between perimeter control points to create a network of single-path transect lines as shown in Figure 2.

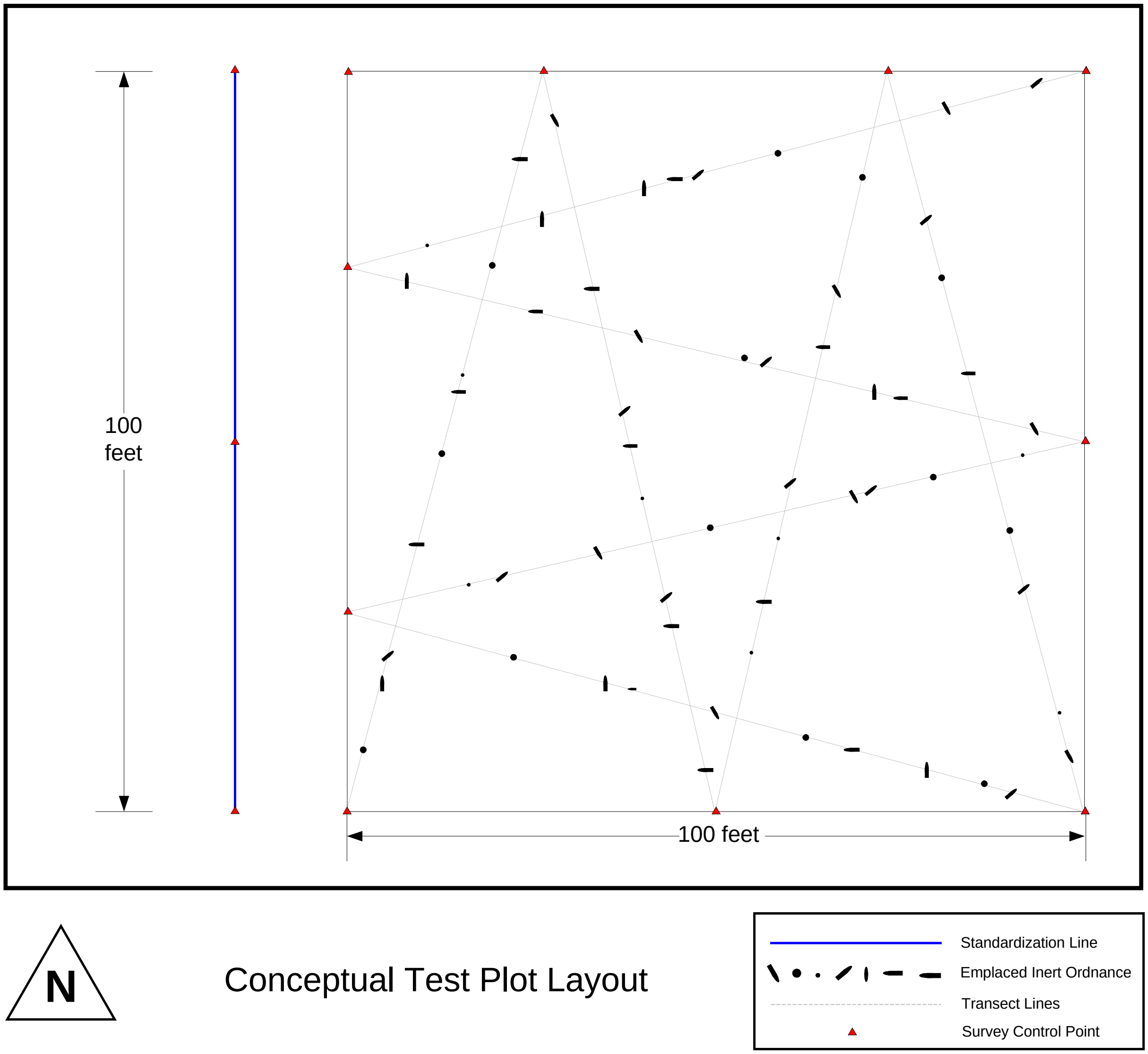

Figure 2, Systems Prove-out Design for Single-Path Transect Mode

1.1.2 Seed Items

Inert munitions items and munitions simulants, clearly marked as inert, are designated as munitions seed items. Use of inert munitions items are preferred over munitions simulants and will be used when available. The munitions seed items will be painted blue and tagged with a non-biodegradable label identifying the items as inert and providing the contract number, a point of contact address, phone number, and target identifier.

Munitions seed items will be emplaced within the Test Plot at various locations and buried at various depths in accordance with this plan. The coordinates, depths, and orientation of each munitions seed item will be surveyed, recorded and used as part of the GPO process. Information on the munitions seed item locations and depths will be migrated to and maintained within the GPO GIS and not released to the geophysical test participants until after prove-out of their system(s). In order to reliably achieve/assess these results, the number of seed items for a test plot of this size and complexity should be no less than 33 with an optimum number near 45.

BMA ASRs indicated munitions use ranging in size from 40mm projectiles to the 500 lb Bomb. The detection depths for the 100 lb and 500 lb practice bombs will be calculated based on the results of the GPO for other munitions or a free-air test. However, it is anticipated that these larger sheet-metal based practice bombs will not penetrate to depths greater than 2 feet below the ground surface. It is anticipated that the smallest munitions item will be a 40-mm projectile. The geophysical equipment will be configured to detect the smallest munitions of concern at the maximum depths listed in Table 1.

Table 1, Munitions and Calculated Detection Depths

Munitions	Munitions diameter mm / in	Calculated Detection Depth meters / feet
40mm HE (MKII, MKI)	40 / 1.57	0.44 / 1.4
90mm HE (M71)	90 / 3.54	0.99 / 3.2
2.25" Practice (SCAR)	57 / 2.25	0.63 / 2.1
3.25" Practice (M2)	83 / 3.25	0.91 / 3.0
5" HEAT (MK1 MOD 0)	127 / 5.0	1.40 / 4.6
3 lbs (MK5, AN-MK23)	56 / 2.20	0.61 / 2.0
4.5 lbs (MK 43)	56 / 2.20	0.61 / 2.0
100 lbs Practice (MK15/M38)	203.2 / 8.0	2.24 / 7.3

NOTE: This table assumes intact munitions items. The actual detection depths are often different than the calculated maximum detection depth values from DID MR 005-05.

1.2 SITE PREPARATION

A GPO location that presents minimal subsurface clutter is desirable and considered in identifying the specific GPO footprint where munitions seed items will be installed. Prior to the performance of a background survey and test plot installation, a surface clearance will be performed to remove all visible metal from the footprint of the proposed test plot. It is anticipated that other types of metal detecting instruments (e.g., Schonstedt™ GA 52 magnetometers and Garrett GTI2500 metal detectors) will be used to scan the standardization area and test plot location to assist in the removal of existing metal. The assessment will include evaluation of the site for a suitable area to perform system calibration and testing.

Care will be taken to select sites with representative natural obstructions to most closely imitate field conditions. In order to replicate field conditions and anticipated vegetation removal constraints, minimal surface preparation will be performed.

1.3 LOCATION SURVEYING

All coordinates will be recorded in Universal Transverse Mercator (UTM), Zone 11S, grid coordinate system and referenced to the National Geodetic Survey (NGS) NAD83, and presented in meters. Location surveying and establishment of survey control for GPO setup will be performed by a California-licensed Professional Land Surveyor (PLS).

Extents of the test plot, location (ends and center) of munitions seed items, and other required control points will be surveyed to an accuracy of at least 3 cm horizontally and 5 cm vertically. Additional survey control points will be added to the perimeter of the plot to allow prove-out of systems in the single-path transect mode. Additionally, three control points will be surveyed in close proximity to the test plot for system calibration, static response evaluation, standardization and dynamic evaluation. Other survey control, such as positional base station control points will be established as required by the PLS. The test plot grid corners, the transect end points, and calibration strip endpoints will be marked in the field with #8 rebar. Positional data including the extents of the test plot and location (ends and center) of seeded targets will be migrated to and maintained within the GPO GIS.

1.4 PRE-SEEDING INVESTIGATION

After a suitable test plot location has been identified the final step in the pre-seeding process is to perform a background survey over the selected test plot location with each type of equipment proposed for use during this investigation. These pre-seeding investigations will include the construction of the calibration strip to be used in standardization of all equipment. The final assessment will entail the acquisition of background readings within the test plot to document existing anomalies. During the background survey, any anomaly that is detected by at least two systems within a radius of one meter will be considered an "existing anomaly" and marked as a "non-emplaced" item. The location and response of these "existing anomalies" will be documented and used in the analysis and compensation for the effects of these items in the prove-out results.

1.5 QUALITY CONTROL (QC)

QC standards for the GPO will reflect the same QC procedures as proposed for the field operations. These QC procedures will follow the accepted procedures laid out in Attachment B of DID MR-005-05.

The quality control elements and procedures for the GPO will include:

- Equipment Setup / Warm-up
- Personnel Test
- Sensor Positions
- Mechanical Vibration Test (cable shake)
- Static Test
- Reference Item Test
- 6-line Test
- Azimuthal Test (Magnetometer only)
- Octant Test (Magnetometer only)
- Height Optimization (For variable height instruments)
- Dynamic Noise Evaluation

1.6 ANOMALY AVOIDANCE

Standard UXO avoidance techniques will be used to ensure the location of each excavation and corner marker/stake is clear of metallic anomalies before placing seed items, corner markers and survey control hubs/stakes. The results from the background investigation will be used as a primary avoidance tool by mapping potential targets in the field prior to inserting any seed items.

1.7 SEEDING

Seeding will be performed using mechanical/manual excavations to facilitate the proper placement of target items. The munitions seed items will be installed in the test plot using the pseudo-random placement previously described. The location, orientation, and depth below ground surface to the top of each munitions seed item will be surveyed in accordance with section 1.3 and recorded for use in all future evaluations. Table 2 below provides details of the proposed munitions seed items, depth and orientations to be used within the test plot. This table presents the anticipated munitions seed items to be emplaced within the test plot; however, the actual items used in each test plot will be dependant upon the quantity availability of the items described in this list. The final GPO target layout including the actual munitions seed items used, their location, and orientation will be submitted to the CESPL geophysicist for final approval and presented in the "as-built" configuration maps and tables.

Table 2, Munitions Seeding Guidelines

Munitions	Maximum Depth (m / ft)	Munitions Orientation	Number of Items
40mm Projectile	0.45 / 1.4	Vertical (nd)	1
40mm Projectile	0.305 / 1	Vertical (nu)	1
40mm Projectile	0.305 / 1	Inclined (45 deg, ns)	1
40mm Projectile	0.305 / 1	Horiz (ns, ew, n45e n45w)	4
90mm Projectile	1 / 3.24	Vertical (nd)	1
90mm Projectile	0.61 / 2	Vertical (nu)	2
90mm Projectile	0.61 / 2	Inclined (45 deg, ns)	1
90mm Projectile	0.61 / 2	Horiz (ns, ew, n45e n45w)	4
2.25in Practice Rocket	0.61 / 2	Vertical (nd)	1
2.25in Practice Rocket	0.46 / 1.5	Vertical (nu)	1
2.25in Practice Rocket	0.46 / 1.5	Inclined (45 deg, ns)	1
2.25in Practice Rocket	0.46 / 1.5	Horiz (ns, ew, n45e)	3
3.25in Practice Rocket	0.91 / 3	Vertical (nd)	1
3.25in Practice Rocket	0.61 / 2	Vertical (nu)	1
3.25in Practice Rocket	0.61 / 2	Inclined (45 deg, ns)	1
3.25in Practice Rocket	0.61 / 2	Horiz (ns, ew, n45w)	3
5in HE Rocket	1.4 / 4.6	Vertical (nd)	1
5in HE Rocket	1.07 / 3.5	Vertical (nu)	1
5in HE Rocket	1.07 / 3.5	Inclined (45 deg, ns)	1
5in HE Rocket	1.07 / 3.5	Horiz (ns, ew, n45e n45w)	4
3lb Practice Bomb	0.61 / 2	Vertical (nd)	1
3lb Practice Bomb	0.46 / 1.5	Vertical (nu)	1
3lb Practice Bomb	0.46 / 1.5	Inclined (45 deg, ns)	1
3lb Practice Bomb	0.46 / 1.5	Horiz (ns, ew, n45e)	3
4.5lb Practice Bomb	0.61 / 2	Vertical (nd)	1
4.5lb Practice Bomb	0.46 / 1.5	Vertical (nu)	1
4.5lb Practice Bomb	0.46 / 1.5	Inclined (45 deg, ns)	1
4.5lb Practice Bomb	0.46 / 1.5	Horiz (ns, ew, n45w)	3

nu = nose up
nd = nose down
ns = north – south
ew = east – west

1.8 DATA COLLECTION VARIABLES

Data collection variables will be determined for each type of equipment evaluated during the GPO. These variables will include geophysical equipment, positioning systems, lane spacing, acquisition rates, and survey speeds. We will also consider the survey method as a data collection variable which may include both transect data acquisition and total coverage acquisition. Data collection and instrument standardization will be performed in accordance with DID MR-005-05.

The data collection variables to be evaluated will include:

- Geophysical Equipment
- Instrument Height / Orientation / Direction of Travel
- Sampling Rate / Survey Speed
- Measurement Interval / Lane Spacing
- Positioning Method / Equipment
- Data Integration
- Instrument Channel Selection

Data acquisition will follow the same procedures as proposed for the production survey. After functional checks and standardization have been performed at the established standardization area, the geophysical methods, systems and equipment will be deployed in the proposed operating modes within the test plot. Sample rates and lane spacings will be representative of the proposed field investigation protocols and production survey operations. The Project Geophysicist will document all prove-out details including instrument type, operators, equipment setup/quality results, date, time and data filename in the Geophysical Field Log.

1.8.1 Geonics EM61 MK2 Acquisition Parameters

Data collection will be performed using real-time integration of the EM61 and RTK GPS data streams using the Allegro data logger. The sampling rate to be used for the EM61 will be 8 readings per second for the man-portable sensor. A single transect along each predefined segment will be obtained to evaluate transect based survey performance. For grid-based performance evaluation, parallel transects will be spaced at intervals no greater than 1 m (3.28 ft). Data acquisition will be performed using a two-man production crew.

1.8.2 Geometrics G858 Acquisition Parameters

Data collection will be performed using real-time integration of the G858 magnetometer and RTK GPS data streams using the Geometrics data logger. The sampling rate to be used for the G858 will be 8 readings per second for the man-portable sensor. A single transect along each predefined segment will be obtained to evaluate transect-based survey performance. For grid based performance evaluation parallel transects will be spaced at intervals no greater than 0.8 m (2.6 ft). Data acquisition will be performed using a two-man production crew.

1.9 DATA ANALYSIS AND INTERPRETATION

MARRS will utilize equipment-specific data acquisition and field processing software to perform data acquisition and conversion to x, y, z, and response values for additional data processing. Data analysis and interpretation for both magnetic and electromagnetic data will be performed using Geosoft's Oasis Montaj™, UX Process™, and UX Detect™.

Initial data processing will include the record keeping review, download and positioning of field data, and QC evaluation. QC evaluation will include mechanical, static and dynamic noise evaluation, standard response results, and data coverage. Standard data processing will be performed only after it has been shown that the data conform to the existing QC standards. Acceptable data will then be subjected to diurnal corrections where appropriate, sensor drift corrections, any leveling or sensor bias corrections, and latency corrections. After all corrections have been applied, data interpretation is performed.

Data interpretation includes the analysis, target selection, and presentation of results. The geophysicist will determine the optimum processing parameters to include the gridding method, search criteria, display parameters, and additional filtering techniques. A review of the gridding results compared to the system noise parameters will be used to determine the optimum target selection criteria for evaluation of these data. After DGM data processing and interpretation, selected targets with predicted coordinates are migrated to the GPO GIS for dig sheet and map generation. The geophysical mapping results and data evaluation will be presented in accordance with DID MR-005-05.

The data analysis and interpretation results will be evaluated based on:

- Data Coverage based on Measurement Interval and Lane Spacing
- Positional Accuracy based on Known Seed Coordinates
- Instrument Response
- Percent Detection
- False Alarm Rate

1.9.1 Anomaly Characterization

Anomaly characterization is an iterative approach used to evaluate DGM results in an attempt to classify a given anomaly. Anomaly characterization is best suited to total survey coverage investigations because total survey coverage reduces the investigation variables of sensor position, sensor orientation, and sampling location with respect to the target location. As such total survey coverage results can be used to determine target characteristics. Profile based survey coverage is best suited to determining distribution and density of metallic debris, and should be used carefully to evaluate individual target characteristics. Although anomaly characterization will not be used to score the performance of the geophysical systems it will be used as a beginning reference for anomaly characterization of the production-survey results.

The ability to characterize a detected target as either a MEC or non-MEC item is valuable to the remediation process by potentially reducing the number of non-MEC items (false alarms) that are investigated. However, target characterization is best performed as an iterative approach based on anomaly characterization and intrusive investigation results. At a minimum anomaly characterization should include parameters describing the amplitude, size (width and area), and shape of the anomaly for each target selected. Depending upon the instrument used additional estimates of target depth and/or mass may also be calculated. Secondary distinctions that can be made include the classification of targets as metallic or non-metallic based on signal decay rates. Additional information may be evaluated to assist in classification of targets as surface clutter items or targets at depth.

Anomaly characterization may be based on a combination of the following:

- Instrument Response (anomaly magnitude)
- Anomaly characteristics (size and shape)
- Target Characteristics (mass and depth)
- Time Constant (EM)
- Decay Rate (EM)

1.10 REACQUISITON

Reacquisition of DGM targets will evaluate the ability to navigate back to the predicted target location. Target reacquisition will be performed using RTK GPS and the same geophysical system used for data acquisition. Predicted target coordinates are transferred from the GPO GIS to the RTK GPS survey controller for navigation to the selected target. Upon arrival at the selected target location, the same geophysical system used for data acquisition is used to verify and refine the target location. The refined position is recorded using RTK GPS and migrated to the GPO GIS for feedback and system performance analysis.

Targets will be reacquired using the Geonics EM61 MK2, the Geometrics G858 and the RTK GPS positioning system. First, the RTK GPS will be used to navigate to the predicted target location. Next, the target location will be further refined based on the same instrument used during acquisition. The reacquired position will then be recorded using the RTK GPS system and stored in the reacquisition data file. The offset distance between the reacquired target and the actual target location will be calculated and recorded to evaluate the effectiveness of the reacquisition process. The success rate of the reacquisition process will be evaluated based on the DID MR-005-05 requirements stating that "Horizontally, 95% of all excavated items must lie within a 35 cm radius of their mapped surface location as marked in the field after reacquisition."

1.11 DATA EVALUATION

Each system (operator, equipment and processing) will be evaluated against the baseline target set within the GPO GIS. As stated previously, anomalies not identified during the pre-seeding survey and identified by more than one system will be logged into the database as background items. Evaluation will be performed for each system's mode of use. The Project Geophysicist will evaluate the effectiveness of MEC detection systems based on their performance in five general categories:

Detection – the ability to detect targets, represented by the percent detection calculation.

Characterization (target identification and classification) – the ability to discriminate between MEC and non-MEC targets based on the characteristics of each target identified, represented by the false alarm rate calculation.

Production Rate and Cost– based on each system's field and processing performance.

Equipment Durability – based on observations during data acquisition.

Safety – based on observations during data acquisition.

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2.0 GPO LETTER REPORT

The results of the GPO will be presented in the GPO Letter Report. This letter report will contain the following information supporting our equipment recommendations:

- Introduction and GPO objectives
- As-built drawing of the Test Plots
- Catalogue of the seed items including photographs and placement information
- Summary of the equipment, procedures, data processing and data management
- GPO results including: Data QC Packages, color result maps, and GPO results
- Electronic data from GPO investigations
- Proposed geophysical equipment, technology, and methods for the production survey
- Data to support project recommendations

This information will be provided to the CESPL geophysicist prior to performing production geophysical investigations at the BMA.

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3.0 HEALTH AND SAFETY PLAN

MARRS will perform the GPO work in accordance with the Health and Safety Plan presented in Appendix D of the RI Work Plan.

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