AD NO. ___________________________
DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC 9914

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

SCORING RECORD NO. 921

SITE LOCATION:
U.S. ARMY ABERDEEN PROVING GROUND

DEMONSTRATOR:
G&G SCIENCES, INC.
23 ROAD
GRAND JUNCTION, CO 81505

TECHNOLOGY TYPE/PLATFORM:
METAL MAPPER/DUAL MODE

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
ABERDEEN PROVING GROUND, MD 21005-5059

APRIL 2009

Prepared for:
U.S. ARMY ENVIRONMENTAL COMMAND
ABERDEEN PROVING GROUND, MD 21010-5401

U.S. ARMY DEVELOPMENTAL TEST COMMAND
ABERDEEN PROVING GROUND, MD 21005-5055

DISTRIBUTION UNLIMITED, APRIL 2009.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **APR 2009**	2. REPORT TYPE **Final**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE **Standardized UXO Technology Demonstration Site Scoring Record No. 921**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER **8-CO-160-UXO-021**
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Commander U.S. Army Aberdeen Test Center ATTN: TEDT-AT-SLE Aberdeen Proving Ground, MD 21005-5059**	8. PERFORMING ORGANIZATION REPORT NUMBER **ATC-9914**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) **Commander US. Army Environmental Command IMAE RTA Aberdeen Proving Ground, MD 21010-5401**	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**SAR**	**103**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

DISPOSITION INSTRUCTIONS

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
April 2009	Final	15 September through 4 October 2008

4. TITLE AND SUBTITLE STANDARDIZED UXO TECHNOLOGY DEMONSTRATION SITE SCORING RECORD NO. 921	**5a. CONTRACT NUMBER**
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) McClung, J. Stephen	**5d. PROJECT NUMBER** 8-CO-160-UXO-021
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Commander U.S. Army Aberdeen Test Center ATTN: TEDT-AT-SLE Aberdeen Proving Ground, MD 21005-5059	**8. PERFORMING ORGANIZATION REPORT NUMBER** ATC-9914
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Commander U.S. Army Environmental Command ATTN: IMAE-RTA Aberdeen Proving Ground, MD 21005-5401	**10. SPONSOR/MONITOR'S ACRONYM(S)**
	11. SPONSOR/MONITOR'S REPORT NUMBER(S) Same as Item 8

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This scoring record documents the efforts of G&G Sciences, Inc. to detect and discriminate inert unexploded ordnance (UXO) utilizing the APG Standardized UXO Technology Demonstration Site blind grid and open field sites. This scoring record was coordinated by J. Stephen McClung and the Standardized UXO Technology Demonstration Site Scoring Committee. Organizations on the committee include the U.S. Army Corps of Engineers, the Environmental Security Technology Certification Program, the Institute for Defense Analysis, the U.S. Army Environmental Command, and the U.S. Army Aberdeen Test Center.

15. SUBJECT TERMS

G&G Sciences, Inc., APG, Standardized UXO Technology Demonstration Site, blind grid, open field, direct and indirect fire, Metal Mapper, dual mode.

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(Include area code)*
Unclassified	Unclassified	Unclassified	SAR		

ACKNOWLEDGMENTS

Authors:

Dennis Teefy
J. Stephen McClung Jr.
William Burch
Homeland Defense and Sustainment Division (HDSD)
U.S. Army Aberdeen Test Center (ATC)
U.S. Army Aberdeen Proving Ground (APG)

Rick Fling
Aberdeen Test Support Services (ATSS)
Sverdrup Technology, Inc.
U.S. Army Aberdeen Proving Ground

Christina McClung
Aberdeen Data Services Team (ADST)
Logistics Engineering and Information Technology Company (Log.Sec)/Tri-S
U.S. Army Aberdeen Proving Ground

Contributor:

Patrick McDonnell
Booz Allen Hamilton (BAH)
U.S. Army Environmental Command (USAEC)
U.S. Army Aberdeen Proving Ground

(Page ii Blank)

TABLE OF CONTENTS

PAGE

SECTION 4. TECHNICAL PERFORMANCE RESULTS

PAGE

SECTION 5. ON-SITE LABOR REQUIREMENTS

SECTION 6. APPENDIXES

SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of military munitions (MM) (i.e., unexploded ordnance {UXO} and discarded military munitions {DMM}) require testing so that performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland, and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in munitions and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multiagency program spearheaded by the U.S. Army Environmental Command (USAEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP), and the Army Environmental Quality Technology (EQT) Program.

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios with various targets, geology, clutter, density, topography, and vegetation.

b. To determine cost, time, and workforce requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized Target Lists with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages: response stage and discrimination stage. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of clutter detection (P_{cd}) or the probability of false positive (P_{fp}). Those that do not correspond to any known item are termed background alarms. The background alarms are addressed as either probability of background alarm (P_{ba}) or background alarm rate (BAR).

b. The response stage scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate munitions from other anomaly sources. For the blind grid response stage, the demonstrator provides a target response from each and every grid square along with a threshold below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, includes amplitudes both above and below the system noise level. For the open field, the demonstrator provides a list of all anomalies deemed to exceed a demonstrator selected target detection threshold. An item (either munition or clutter) is counted as detected if a demonstrator indicates an anomaly within a specified distance (Halo Radius (R_{halo})) of a ground truth item.

c. The discrimination stage evaluates the demonstrator's ability to correctly identify munitions as such and to reject clutter. For the blind grid discrimination stage, the demonstrator provides the output of the discrimination stage processing for each grid square. For the open field, the demonstrator provides the output of the discrimination stage processing for anomaly reported in the response stage. The values in these lists are prioritized based on the demonstrator's determination that a location is likely to contain munitions. Thus, higher output values are indicative of higher confidence that a munitions item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking may be based on rule sets or human judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e. that is expected to retain all detected munitions and reject the maximum amount of clutter).

d. The demonstrator is also scored on efficiency and rejection ratios, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of munitions detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonmunitions items. Efficiency measures the fraction of detected munitions retained after discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the maximum number of munitions detectable by the sensor and its accompanying clutter detection/false positive rate or BAR.

e. Based on configuration of the ground truth (GT) at the standardized sites and the defined scoring methodology, in some cases, there exists the possibility of having anomalies within overlapping halos and/or multiple anomalies within halos. In these cases, the following scoring logic is implemented:

(1) In situations where multiple anomalies exist within a single R_{halo}, the anomaly with the strongest response or highest ranking will be assigned to that particular GT item. If the responses or rankings are equal, then the anomaly closest to the GT item will be assigned to the GT item. Remaining anomalies are retained and scored until all matching is complete.

(2) Anomalies located within any R_{halo} that do not get associated with a particular GT item are excess alarms and will be disregarded.

f. In some cases, groups of closely spaced munitions have overlapping halos. The following scoring logic is implemented (fig. A-1 through A-9):

(1) Overall site scores (i.e., P_d) will consider only isolated munitions and clutter items.

(2) GT items that have overlapping halos (both munitions and clutter) will form a group and groups may form chains.

(3) Groups will have a complex halos composed of the composite halos of all its GT items.

(4) Groups will have three scoring factors: groups found, groups identified, and group coverage. Scores will be based on 1:1 matches of anomalies and GT.

(a) Groups Found (Found): the number of groups that have one or more GT items matched divided by the total number of groups. Demonstrators will be credited with detecting a group if any item within the group is matched to an anomaly in their lists.

(b) Groups Identified (ID): the number of groups that have two or more GT items matched divided by the total number of groups. Demonstrators will be credited with identifying that a group is present if multiple items within the composite halo are matched to anomalies in their lists.

(c) Group Coverage (Coverage): the number of GT items matched within groups divided by the total number of GT items within groups. This metric measures the demonstrator accuracy in determining the number of anomalies within a group. If five items are present and only two anomalies are matched, the demonstrator will score 0.4. If all five are matched, the demonstrator will score 1.0.

(5) Location error will not be reported for groups.

(6) Demonstrators will not be asked to call out groups in their scoring submissions. If multiple anomalies are indicated in a small area, the demonstrator will report all individual anomalies.

(7) Excess alarms within a halo will be disregarded.

g. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 4.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response stage ROC curves:

(1) Probability of detection (P_d^{res}).

(2) Probability of clutter detection (P_{cd}).

(3) Background alarm rate (BAR^{res}) or probability of background alarm (P_{ba}^{res}).

b. Discrimination stage ROC curves:

(1) Probability of detection (P_d^{disc}).

(2) Probability of false positive (P_{fp}).

(3) Background alarm rate (BAR^{disc}) or probability of background alarm (P_{ba}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False positive rejection rate (R_{fp}).

(3) Background alarm rejection rate (R_{ba}).

d. Other:

(1) Probability of detection by size, depth, and density.

(2) Classification by type (i.e., 20-, 40-, 105mm, etc.).

(3) Location accuracy for single munitions.

(4) Equipment setup, calibration time, and corresponding worker-hour requirements.

(5) Survey time and corresponding worker-hour requirements.

(6) Reacquisition/resurvey time and worker-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

POC: Mr. Skip Snyder
408 954-0522

Address: G&G Sciences, Inc.
23 Road
Grand Junction, CO 81505

2.1.2 System Description (provided by demonstrator)

With support from the Environmental Security Certification Program (ESTCP) Geometrics is commercializing an advanced electromagnetic induction (EMI) system for UXO detection and characterization. The system will have dual-mode (electromagnetic/magnotometer (EM/MAG)) capability. Called the Metal Mapper, the new system draws elements of its design from advanced systems currently being developed by G&G Sciences, Inc. with funding from Naval Systems Command (NAVSEA) (the advanced ordnance locator (AOL) 2 project) and by the Lawrence Berkeley Laboratories (the Berkely UXO discriminator (BUD) system) with SERDP and ESTCP funding. The Metal Mapper system is unique and innovative in several respects:

a. Multiple Transmitter Loops1: The Metal Mapper antenna platform includes three mutually orthogonal transmitter loops.

b. 3-Axis Sensor Array2: The Metal Mapper antenna platform includes a spatial array of seven 3-axis receiver antennas (21 independent measurements of the secondary magnetic field).

c. Electronically Switched time-gated electromagnetic (TEM) Transmitter Loop Driver: The Metal Mapper system is unique in its ability to drive its transmitter loop array. Under control of the data acquisition (DAQ) computer, the output of the transmitter can be directed to any single loop or automatically multiplexed between loops. There is also control of the fundamental waveform period, duty-cycle, and pulse polarity. Typically, however, the loops are driven with a classical bipolar pulse type TEM waveform (i.e., alternating pulse polarity with a 50-percent duty-cycle. Depending on the survey mode (e.g., Static/Dynamic), the fundamental frequency of transmission can be varied from a low of $1.11 \leq f \leq 810$ Hz.

Figure 1. Demonstrator's system, Metal Mapper.

2.1.3 <u>Data Processing Description (provided by demonstrator)</u>

Acquisition Modes.

a. The Metal Mapper system is, by design, a very flexible system for acquisition of time domain EM (TEM) data. It is beyond the scope of this document to fully describe that flexibility. Simply stated, data are acquired in time blocks that consist of a fixed number of transmitter cycle Repeats. Both the period (T) and the repeat factor (N) are operator selectable and are varied in multiplicative factors of three. It has two data acquisition modes:

(1) Static-Mode Acquisition. In this mode, data sampled transients from each of the 21 receiver loops plus a channel to sense the transmitter loop current are rectified and stacked for a specified number of acquisition blocks. The resulting transients are (optionally) decimated into a set of logarithmically spaced time gates after which they are stored to a single binary data file. As its name implies, static-mode acquisition is used to obtain precise data while the antenna platform is parked at a single spatial data point.

(2) Continuous-Mode Acquisition. As its name implies, continuous-mode data acquisition results in the data acquisition cycle being repeated until the operator intervenes to halt it. Each of the Data Points are appended to single binary data file and thus the resulting data file may consists of 10s or even 100s of data points. This mode is used for dynamic surveying. Typically, a data file consists of all the points acquired along a single profile.

b. Regardless of the acquisition mode, the TEM data thus acquired includes the most current Global Positioning System (GPS) position and the platform attitude angles (magnetic heading, pitch, and roll). By properly selecting the block period (T) and the repeat factor (R), the operator can set the sampling rate to as high 30 samples/sec. As we have stated above, the data are stored as binary formatted files. However, the processing software includes the capability to export the data to a Geosoft Oasis Montaj data base for further quality control (QC) and map compilation. The processing also includes the capability to export the data to text files and to Matlab™.

c. Target Selection. G&G Sciences, Inc. plan is to complete dynamic surveys over both the calibration and blind grids. The surveys will consist of parallel profiles acquired with 1-meter offsets. Using these data, we will compile a detection parameter map of the surveyed area. The detection map is based on the magnitude of the secondary fields measured at each of the nine triaxial receiver sensors. The following processing steps, accomplished using Geosoft Oasis montaj™, are required.

Target Selection.

a. The plan is to complete dynamic surveys over the calibration grid, the blind grid, the indirect-fire area, and the direct-fire area. These surveys will consist of parallel profiles acquired with 1-meter offsets. From these data, we will compile detection maps and associated target lists for each of the areas surveyed. The detection map is based on the magnitude of the secondary fields measured at each of the seven triaxial receiver sensors. The following processing steps, accomplished using Geosoft Oasis montaj™, are required:

b. Metal Mapper data are recorded as binary files. These data are imported directly into an OM data base where simple editing (e.g., editing line numbers, deselecting duplicate lines, trimming and deleting bad data or stops, etc). All other steps are accomplished from within OM using its standard editing and processing capabilities supplemented where necessary with custom Geosoft Executables (GXs) and Geosoft Scripts (GSs) and Geosoft mathematical expression (EXP) files.

c. Convert Lat/Lon to UTM coordinates.

d. Compute detector gate values for each of the 21 receiver channels.

e. Normalize detector gate values by transmitter current.

f. Select background and remove background (leveling).

g. Generate vector magnitude channels for each of seven triaxial receiver cubes.

h. Make heading channel for each profile.

i. Split each profile into seven separate profiles, corrected for heading and offset distance from the platform measure point (generates seven parallel profiles with 13-cm offsets).

j. Grid cube amplitude data.

k. Apply grid smoothing filters if necessary.

l. Select targets using an amplitude threshold. The (tunable) parameters are:

(1) Signal amplitude.

(2) Detector gate (step 3).

m. Edit target list based on inspection of profiles.

Target Re-Acquisition and Parameter Estimation.

a. Each of the targets generated from the detection map created from the dynamic data are reacquired with the Metal Mapper using a combination of GPS to return to the approximate target location and then a real-time graphics display that allows the operator to center the antenna platform directly over the target. Once the target has been reacquired, a static data set is acquired at that position. In its static acquisition mode, all three transmitter loops are energized in turn. Typically, a static data set will consist of a stack of 50 to 100 data blocks and the acquisition parameters are selected so that 8.33 ms or 25 ms transients are acquired. These data are recorded in the same standard binary format as is the dynamic data. However, each data file includes only a single (stacked) data point rather than a sequence of data points that are stored in a data file recorded in the continuous acquisition mode.

b. Each of the static data files are used as input to the Metal Mapper Inversion (MM/RMP) program.

c. The MM/RMP program is a physics-based inversion program based on approximating the transient response of compact metallic objects with a point dipole characterized by a time6 varying anisotropic polarizability tensor. MM/RMP is actually a wrapper for an implementation of the inverse dipole modeling problem developed by Torquil Smith at LBL in connection with the BUD development project [1]. The program provides optimum estimates the following parameters:

(1) Target position (x, y, and z): The 3-dimensional position of the target with respect to the position of the antenna platform. The Metal Mapper includes an apparatus that senses the platform attitude angles (heading, pitch, and roll). Thus the target position relative to the platform coordinate system can be converted to geographic coordinates.

(2) Target attitude (heading, pitch, and roll): The Metal Mapper Inversion software estimates the target attitude by finding the principal coordinate system for the target polarizability.

(3) Principal polarizability transients (P1, P2, and P3): The Metal Mapper Inversion software estimates the three principal polarizability transients for the target. Examples of the polarizability curves estimated by three different programs using a static data set collected with the AOL at YPG last year. The nine parameters enumerated previously together with the inversion fit statistics are the fundamental data derived from the Metal Mapper inversion. In particular, the principal polarizability transients those containing information about the target. For example, if both targets are elongated and exhibit a single axis of symmetry as indicated by the fact that there is a single major polarizability transient and two nearly identical minor polarizability curves. A measure of target size is provided by the integration beneath the polarizability curves. Note that the units of the polarizability (rate) transients are m^3/s, or, equivalently $cm^3/\mu s$. When integrated over time to find the area beneath the curve, the results are units of volume (m^3 or cm^3) as shown in the formula below:

$$P_0 = P(t=0) = \int_0^\infty \frac{dP(t)}{dt} dt$$

d. G&G Sciences, Inc. uses the root mean square (RMS) value of the three P_0s that can calculate from the three principal polarizability transients that characterized each of the targets as an indication of size. The parameter P_0 defined in equation is an example of a so-called metaparameter that can be derived from the more fundamental target data that are the three principal polarizability curves. For simple classification by shape, one can define other meta-parameters involving the relationship of the three integrated polarizability parameters (P_{0x}, P_{0y}, and P_{0z}) derived from equation to identify elongate targets with an axis of symmetry. Such target features have been used effectively by many to develop classification metrics [2, 3]. Among the more useful parameters are the following:

(1) Transverse Polarizability: $P_{0T} = (P_{0y} + P_{0z})/2$

(2) Polarizability Ratio: $R_{po} = P_{0x}/P_{0T}$

(3) Eccentricity: $EP0 = |P_{0y} - P_{0z}|/P_{0x}$

e. Generally speaking, UXO have a polarizability ratio $RP_0 \geq 1$ and an eccentricity $EP_0 << 1$ indicating an elongate body with an axis of symmetry. The thresholds of discrimination for a classifier are determined using a set of training parameters derived from a data set for which the ground truth is known (e.g., the calibration lanes).

f. Using the training data, a classifier based on principles of pattern recognition using the two or three most significant parameters was developed. Typically the classifier is based on the searching of the nearest neighbors in order to find the (binary) decision boundary providing the best division between ordnance (O) and clutter (C). To facilitate the development of a classifier for a particular data set, we use the Duke Pattern Recognition Toolbox (DPRT), a library of MatLab functions for pattern recognition developed by Leslie Collins and her colleagues at Duke

University. DPRT supports the development of a variety of classifiers including kNN ('k' nearest neighbors) and FLD (Fisher Linear Discriminant). In our limited experience, the kNN classifier (with k = 3) does better than the FLD classifier and the two. The two parameters are the eccentricity (*E*) and the polarizability ratio (*R*). The results from the kNN classifier are effective at discriminating between loops and other targets with good symmetry. However, there is no basis from this data set to discriminate the shot puts from other targets. Indeed, the AOL2 polarizability results show that a number of target types such as the M75, MK118 Rockeye, and BLU-26 exhibit three nearly identical principal polarizability curves, thus indicating near isotropic polarizability. However, the shapes of the principal polarizabilities for each of the targets are distinctly different.

g. Training. The performance of the classifier is very much dependent both on the quality of the training data set and, as well, on the choice of the relevant parameters used in training. Scores from both ATC and the Institute for Defense Analysis (IDA), based on the target list that was submitted last year for AOL work, indicated that there were positive results on both detection (P_d = 95 percent) and on discrimination (P_d = 85 percent). But the training data were flawed in the sense that none of the targets in the calibration lanes is truly clutter. In that regard, it is noted that the newly reconfigured calibration grid at APG now includes eight items of true clutter and with this next opportunity to submit a classified target list, it can hopefully improve the discrimination stage scores.

Parameter Estimation.

a. Which characteristics will be extracted from each detected item and input to the discrimination algorithm (e.g., depth, size, polarizability coefficients, fit quality, etc.)?

The following parameters represent the subset of parameters extracted from each static data set acquired over a detected target. These parameters were used in the generation of a scalar metric used as the basis for discrimination.

Anomaly signal-to-noise ratio (SNR): This scalar parameter represents the ratio of the static anomaly amplitude (after background subtraction) measured over the target divided by a similarly calculated value representing in effect the RMS background noise.

Fit statistic: This scalar is a measure of the quality of the dipole fit to the observed static data.

Target position (X, Y, and Z): This vector represents the vector offset, expressed in geographic coordinates from the platform reference point (center of the Z transmitter coil) to the target center. When added to the geographic position of the platform reference point, these parameters indicate the geographic position of the target.

Target attitude (H,P,R): These are three angles representing the heading (H), pitch (P), and roll (R) angles between the principal axis coordinate system of the target (i.e., x-axis = axis of symmetry) and the geographic coordinate system (positive x-axis is grid east, positive y-axis is grid north, positive z-axis is up). Heading is measured positive clockwise with respect to grid north (Y). Pitch is measured with respect to the target x-axis with respect to the horizontal plane and is positive when it is upward (i.e., a nose-down target has a pitch angle of -90^{o}). The conventions for roll are harder to describe in words. In any case, roll is meaningless for a target having an axis of symmetry.

Target principal polarizability rate transients: These are three transient decay curves representing the principal polarizability rates (dP(t)/dt) at each of the time gates observed with the data. At APG, we acquired static data at a base frequency of 30 Hz resulting in transient decay lengths of 8,333 μs. These transients were decimated into 42 logarithmically spaced time gates with centers ranging from 106 to 7,912 μs. The transients are ordered so that the largest corresponds with the x-axis of the principal system and the smallest corresponds with the z-axis. The units of polarizability rate is $m^3/s = cm^3/\mu s$.

Integrated target polarizability (P_{0x}, P_{0y}, and P0z): These three parameters represent the numerical integration, respectively, of the three polarizability rate transients' curves (5 above). Because the integration is with respect to time, the resulting units of integrated polarizability will be either m^3 or cm^3 depending on the units of time used. Time units of μs were used in the analyses and therefore, the units of target polarizability are cm^3. These parameters provide a sense of target size. From these three parameters, we can further define a couple of other useful parameters, which are $R = 2P_{0x}/(P_{0y} + P_{0z})$ and $E = (P_{0y} - P_{0z})/P_{0x}$. The R parameter indicates the elongation or aspect of the resulting target. When R > 1, we have an elongated (rod-like) target. The E parameter is a measure of symmetry. When the two minor polarizability curves (dP_{0y}/dt and dP_{0z}/dt) are identical, E = 0.

b. Why have these characteristics been chosen and not others (e.g., empirical evidence of their ability to help discriminate, inclusion in a theoretical tradition, etc.)?

These parameters were chosen because the shape and amplitude of the polarizability rate transients five contain all available characteristics of the targets. The integrated parameters six in fact are very robust metaparameters that can be derived directly from the curves. Based on our experience with the analysis of targets from YPG along with the knowledge that at APG only a maximum of six targets to identify, it is believed that discrimination could best be accomplished through matching curve characteristics of unknown targets with the characteristics of a library of "type" curves generated through analysis of target polarizabilities measured in the calibration lanes.

c. How are these characteristics estimated (e.g., least-mean-squares fit to a dipole model, etc.), include the equations that are used for parameter estimation?

These characteristics are derived from a series of three-step least-squares estimation. The figure shows only a single transmitter loop and a single receiver loop. The data set acquired by the Metal Mapper in fact involves three different transmitter loops and 21 different receiver loops. The three estimation steps are:

Estimate position and composite polarizability tensor using a composite gate on each transient, thereby converting the 63 transients (21 transients for each of three transmitters) to 63 scalar gate values). This is a nonlinear problem in nine unknowns.

Estimate target attitude by doing an eigen analysis of the polarization tensor resulting from the application of step 1. This is a linear problem in three unknowns.

Estimate the principal polarizability transient values at each time gate. This is a linear least squares problem.

d. What tunable parameters (if any) are used in the characterization process (e.g., thresholds on background noise, etc.)?

None. The inversion requires that we provide a background data set that is to be subtracted from the observed data set prior to performing the inversion. This background data set is optional and, in cases, where the SNR of the observed data is large (e.g., 40 dB) there is no practical difference between parameters extracted after background has been removed and parameters extracted without first removing background. However, at lower SNR levels (i.e., <30 dB), the removal of background is important. For that reason, a background is always removed. Moreover, a background data file is acquired at a calibration site 2 to 3 times per day and the most current background data file (i.e., the background file whose acquisition time is closest to the data file under investigation) is used for the inversion. The inversion process also requires a data file that provides an estimate of the RMS noise levels at every time gate and for every receiver channel. These noise levels are used to estimate errors in the parameter estimates. The RMS noise file is not critical for good inversion results. However, in the field procedure data is acquired for a noise estimate every time static background is measured (2 to 3 times per day).

Classification.

a. What algorithm is used for discrimination (e.g., multilayer perception, support vector machine, etc.)?

A library curve matching method to affect discrimination was used. For each of the three blind areas, the library consisted of the relevant target parameters for the three (or six for the blind grid) seeded target types.

b. Why is this algorithm used and not others?

During the analysis of the target data acquired over the calibration lanes at APG, two approaches were evaluated. In the first approach, multivariate statistics were used to identify a set of target features based on two sets of integrated polarizability parameters: the P_0 parameters described in six of the previous section, and a second set (P_{1x}, P_{1y}, P_{1z}) that represent numerically derived values for the first moments in time of the respective polarizability rate transients (five in previous section). The first moments (P_{1x}, P_{1y}, and P1z) weight the late times. It was found that the algorithm worked well on the training data but was unsatisfactory when applied to blind data.

The second method experimented with was curve matching. This method works very well on training data and, based on preliminary results provided by ATC, also worked well on data from the blind areas that were surveyed. Curve matching was chosen because it appeared to work better on blind data as judged when compared to the discrimination result provided by numerical curve matching and a visual inspection polarization curves with the candidate "type" curves (an optical correlation performed by an expert).

c. Which parameters are considered as possible inputs to the algorithm?

Figure of merit (FOM): This parameter is derived from the SNR amplitude characteristic of the data set. It recognizes the fact when the SNR of the data set is greater than 10 (20 dB), the resulting parameters from the inversion estimates are good. At lower SNRs, the results are less reliable. The parameter (SNR = 10) has been established over a period of about 8 years, during which four different algorithms for the estimation of target parameters have been used. While differing somewhat in computational flow, these four algorithms all suggest that reliable results require a SNR > 10. The formula for FOM is:

$$FOM\left[SNR;SNR_{th}\right] = Max\left[0,1+Min\left[0,\log_{10}\left(\frac{SNR}{SNR_{th}}\right)\right]\right]$$

FOM takes the value 1 for all SNR> = 10, and 0 for all SNR $\leq$ 1. It was used as a multiplicative penalty function to derate the discrimination score based on the fact that the data set has a low SNR.

Fit (fit_d): The Fit statistic is an indicator of the quality of the underlying parameters. A desired discrimination metric contain a penalty for poor fits. Therefore, we defined the function:

$$fit_d\left[fit;a,b\right] = \frac{1}{1+e^{\frac{100-fit-b}{a}}}$$

Fitd ≈ 1 for good fits (fit ≈ 100) and Fit_d ≈ 0 for poor fits (fit ≈ 0). The rate of transition is controlled by the parameter a. The point at which $Fit_d = 0.5$ is controlled by the parameter b. For discrimination at APG, a = 7, and b = 28 was used for these parameters. In this function, significant penalties begin to be applied for fits less than 90 percent and at fit = 72 percent, the penalty is 0.5.

Curve Match (log P_x): This operation actually supplies two parameters: K = gain factor; a curve shape factor $shape_x$. Normally, polarizability curves are displayed on a log-log plot. The adopted approach that the curve matching should follow a methodology that is similar to how visually compare two sets of principal polarization curves. Therefore, the polarizability curves were matched after taking their logarithms. Recognizing that it is possible to have two polarization curves with virtually identical shapes but different amplitudes, a relative gain factor between the unknown transient curve and the "type" curve needs to be determined. This is the parameter K. The shape factor ($shape_x$) represents in an RMS sense the difference between the logarithms of the unknown transient and its corresponding "type" transient after first correcting the unknown transient for a gain factor K. An exact match between two transient curves is indicated when K = 1 and $shape_x = 100$.

Curve Match (log R): This operation compares the ratio of the major polarizability transient (dP_x/dt) to the arithmetic (or geometric) average of the two minor polarizabilities (dP_y/dt and dP_z/dt). Since the R parameter represents a ratio, constant gain factors are cancelled out. Therefore, in this curve match, the RMS error is computed between the logarithm of the unknown ratio curve and one of the "type" ratio curves. A return of this parameter ($shape_R$) is a number between 0 and 100, with 100 being a perfect match.

Size and Shape Metric (M): The three parameters defined above were used to define the following metric that reflects a match of both size (i.e., sameness in amplitude) and shape (similarity in logarithmic shape).

$$M\left[K, shape_x, shape_R; \sigma_x, w_x, w_R\right] = w_x e^{-\frac{1}{2}\left[\frac{\log K}{\sigma_x}\right]^2} shape_x + w_R shape_R$$

The third equation above is simply a weighted sum of the two shape factors generated in numbers above. The weighting parameters (w_x and w_R) reflect provided the ability to weight the two shape parameters differently. Lacking any indication of whether one was in some sense better than the other, the value $w_x = w_x = 1/2$ was used. Because the match between the major polarity curve, a corresponding library "type" curve, is a function not only of logarithmic shape but also gain, a multiplicative penalty factor was introduced into the first term in equation three. That term will be recognized by most readers as a Gaussian-shaped curve having a value of 1 when logK = 1 and dropping to a value of 0.61 when $\log K = \sigma_x$. Empirically, it was determined that a value of $\sigma_x = 0.25$ worked well when metric was trained on data from the APG calibration grid.

Eccentricity Factor (1-E): Eccentricity in six of the previous sections was defined. This parameter is important since it reflects the likeness of the two minor principal polarizability transients. When the eccentricity is very low, an axis of symmetry to the target that is directed along the target X axis is ascribed. Likewise, high eccentricity is generally attributed as the most distinguishing feature of a clutter target. This is not always the case, however, since the ability of the physics-based modeling to adequately distinguish symmetry degrades with SNR and also with certain attitude situations (e.g., 45^o pitch angles). So the parameter is applied (1-E) as a penalty function in the metric to downgrade otherwise good scores.

The METRIC (M_d): Equations 1 through 3 were combined along with the eccentricity factor described above to form a metric that provides values ranging from 0 to 100. A metric value was generated for each of the 3/6 target types in our library depending on the area that was analyzed. The target class was identified according to the "type" curves that generated the best (maximum) metric value.

$$M_d = FOM[SNR; SNR_{th}]\, fit_d[fit; a, b]\, M[K, shape_x, shape_R; \sigma_x, w_x, w_R](1 - E)$$

d. What are the outputs of the algorithm (probabilities, confidence levels)?

The output (M_d) of the discrimination metric is scaled to have positive values ranging from $0 \le M_d \le 100$. These values certainly reflect relative confidence, but in no way can they be construed as probabilities (expressed as a percentage). Curve matching often does not produce sharp contrasts between targets of the same general size but belong to different classes (e.g., 25-mm (DF) versus 37-mm (DF); 105-mm (IF) versus 105-mm (DF)). Similarly, on the basis of shape and size alone, there were clutter targets that produced high discrimination metrics. Only by introducing the eccentricity factor (1-E) were we able to move these targets into the clutter class.

e. How is the threshold set to decide where the munitions/nonmunitions line lies in the discrimination process?

A threshold is set by visually examining the resulting metric values (together with the values for their underlying components -FOM, fit_d, M, and E) and the corresponding polarizability curves. At some low value of the metric M_d it became obvious that the target was no longer ordnance. This threshold was different for each of the three areas analyzed, as to why is uncertain. The thresholds for the IF and DF areas were relatively close together (21.0 and 14.6, respectively), so these two target lists were combined without in any way adjusting the thresholds. However, the discrimination threshold in the blind grid was much higher. No explanation for that fact other than to note that the targets in the blind grid were separated by a minimum distance of 2 meters. As a consequence, there was much less interference. The inference is that the fit quality as indicated by such indicators as the fit_d and (1-E) produce consistently better discrimination values in the blind grid.

Training.

a. Which tunable parameters have final values that are optimized over a training set of data and which have values that are set according to geophysical knowledge (i.e., intuition, experience, common sense)?

Of the six tunable parameters identified in equation 4, only the parameter σ_x was determined using the training data. Values for the other five (SNR_{th}, a, b, w_x, and w_R) were set with geophysical knowledge.

(1) For those tunable parameters with final values set according to geophysical knowledge:

(a) What is the reasoning behind choosing these particular values?

SNR_{th} was chosen based on both vendor and published results suggesting that at SNR levels below 10, the quality of the inversion diminishes significantly. The values chosen were of the parameters a and b in fit_d. The parameters were such that there is virtually no penalty for solutions for a fit statistic above 90 percent. Thereafter, the penalty increases rapidly. Inversion parameter sets below a level of between 60 to 70 percent can provide some rough indication of depth and, correspondingly size. This information is sometimes sufficient to exclude a target (based on size and depth) not wanting to totally exclude inversion results with low fit scores. With regard to the shape parameters ($shape_x$, and $shape_R$), the maximum entropy approach was adopted and it was decided that the shape of the primary polarizability (along with its gain) and the shape of the ratio curve were equally important. This gave each of the parameters (w_x, and w_R) equal weights.

(b) Why were the final values not optimized over a training set of data?

In the case of the first three parameters (SNRth, a, and b), the training data are simply not relevant to the setting of these data. The shape parameter weights were varied ($shape_x$ and $shape_R$) about the chosen uniform values using trial and error. The results were relatively insensitive to small changes. Intuitively, it is believed that the ratio curve provides important information about the target. The 25-mm (DF) is an example where the ratio provides a very distinguishing characteristic. In other cases, the ratio is less important. It was decided to weigh the two characteristics equally.

(2) For those tunable parameters with final values optimized over the training set data:

(a) What training data is used (e.g., all data, a randomly chosen portion of data, etc.)?

All data was used from the calibration lanes including grid sites that contained munitions that were not one of the six types of interest.

(b) What error metric is minimized during training (e.g., mean squared error, etc.)?

A simple binary decision (correct ID = 1; incorrect ID = 0) was used, simply minimizing the number of misidentified targets

(c) What learning rule is used during training (e.g., gradient descent, etc.)?

A trial and error to change the parameter (σ_x).

(d) What criterion is used to stop training (e.g., number of iterations exceeds threshold, good generalization over validation set of data, etc.)?

Stopping training when the number of incorrect decisions was minimized.

(e) Are all tunable parameters optimized at once or in sequence (in sequence = parameters 1 is held constant at some common sense values while parameter 2 is optimized, and then parameter 2 is held constant at its optimized value while parameter 1 is optimized)?

This question is not really applicable to what was done. However, to the extent that played a bit with optimizing the shape weights, this optimization was done in sequence holding σ_x constant while varying the weights. Note that since the weights have a constraint (i.e., w_x 2 + w_R 2 = 1), in essence is varying only a single parameter.

b. What are the final values of all tunable parameters for the characterization process?

$SNR_{th} = 10$

a = 7; b = 28

$\sigma_x = 0.25$; $w_x = w_R = 1/2$

2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined on the USAEC Web site www.uxotestsites.org. These submitted data are not included in this report in order to protect GT information.

2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) (provided by demonstrator)

Quality Control (QC). The AOL2 DAQ system integrates data acquired from three (optionally 4) sensors into a sample data point. These systems are: position; attitude; EM, and (optionally) MAG. The data from each of the systems are integrated into a single data structure (i.e., an EM3DDataPoint). Performed system checks by returning to a calibration point to acquire data will occur. Typically, the system check consists of a short profile (approximately 10 m) that is surveyed repeatedly two or more times a day. The profile will be set up in an area of typical background response (i.e., no targets). The calibration survey will consist of a dynamic survey run over a calibration target (typically a shot put) centered along the profile. At the start of the calibration survey a static point using both dynamic and static acquisition parameters at the beginning of the calibration line is acquired, the target is surveyed dynamically in one direction, and then the survey is repeated in the opposite direction. Finally, the antenna array is halted directly over the target and acquires a static data point. The static points (static/dynamic parameters) provide base-level background measurements. These measurements are useful in determining whether the background changes significantly over the area of the survey. The calibration survey lines, repeated in opposite directions, provide a check of survey timing latency between the acquisition of the GPS position and the acquisition of the EM data. Position latencies typical of systems where survey positions and data are merged from independent data files based on a time stamp has not been experienced because of the way the GPS position is integrated directly with the data. However, this experiment provides proof-positive that there is no significant timing latency in the acquisition system. The amplitude of the dynamic survey peaks as they cross over the calibration target and also provides a crude measure of the EM drift. A better measure of the drift is provided by the static measurements of the background and the target response. As part of the static background measurement, a precise method for putting the cart into a known and repeatable attitude will be established so that the reliability of the orientation system may be checked. It is notable that the DAQ system constantly monitors the quality of the GPS positions and provides a visual warning to the operator when the GPS quality for any reason degrades below that of real-time kinematic (RTK). Furthermore, the acquisition software includes the ability to graphically display data from any point in any data file. This plotting capability allows data to be checked at anytime while in the field.

Overview of Quality Assurance (QA).

a. Three main objectives for the demonstration at ATC:

(1) Demonstrate that the Metal Mapper system represents a significant advance in the state-of-the-art. This will be done by demonstrating that both hardware and software performs as well as other next generation EMI systems commonly accepted to represent an advance in the art (ALLTEM, BUD, and the NRL TEM Array system).

(2) Demonstrate that the Metal Mapper system is ready to conduct product UXO surveys.

(3) Using dynamic data collected from the APG survey, determine the configuration for a base-level Metal Mapper system. The resulting configuration will be used primarily for mapping and will compete with presently used EMI technology such as the EM61-MKII daily at the start of the field day, at mid-day, and at quitting time.

b. Dynamic Survey. Dynamic surveys over both the calibration grid and the blind test grid will be conducted. These surveys will be conducted using excitation with a single transmitter loop at 1-meter lane intervals. All or part of these surveys may be repeated using different acquisition parameters. The maps that are compiled from these data will be used for target detection.

c. Calibration Checks. Proper functioning of both navigation and EM data acquisition will be assured by conducting periodic calibration surveys as described earlier. These surveys provide a check of the three critical AOL2 subsystems, navigation, attitude, and EM data acquisition, as well as serving as a means to sample long term drift of the instrument response.

d. Static Surveys. Using the target list generated from the dynamic surveys above, each target will be reacquired, and a static data set will be taken that consists of the EMI response from all three transmitter polarizations. For static measurements, DAQ parameters will be changed to allow the acquisition of a longer time transient (e.g., T = 0.3s, N = 9 to provide us with a 8.3 ms transient decay). The acquisition stack-count is generally set so that a data point is acquired in less than 30 sec. Previous experience with this survey mode has demonstrated that it is capable of acquiring up to 200 targets per day. As with the dynamic surveys, a repeat of all or part of the two grids using different acquisition parameters may occur.

e. Calibration Checks. All static surveys will include periodic measurements at a background site and over a calibration target. Furthermore, the intent is to acquire static background points at random locations within the calibration and blind grids that are judged to be background with the objective of determining whether background varies with position. The frequency of the calibration checks will depend on the drift rates that are observed during surveys over the calibration grid. At a minimum, however, these calibration checks will be run two times daily at the start of the field day and at quitting time.

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as MicroSoft Word documents at www.uxotestsites.org.

2.2 APG SITE INFORMATION

2.2.1 Location

The APG Standardized Test Site is located within a secured range area of the Aberdeen Area. The Aberdeen Area of APG is located approximately 30 miles northeast of Baltimore at the northern end of the Chesapeake Bay. The Standardized Test Site encompasses 17 acres of upland and lowland flats, woods, and wetlands.

2.2.2 Soil Type

According to the soils survey conducted for the entire area of APG in 1998, the test site consists primarily of Elkton Series type soil (ref 2). The Elkton Series consist of very deep, slowly permeable, poorly drained soils. These soils formed in silty aeolin sediments and the underlying loamy alluvial and marine sediments. They are on upland and lowland flats and in depressions of the Mid-Atlantic Coastal Plain. Slopes range from 0 to 2 percent.

ERDC conducted a site-specific analysis in May 2002 (ref 3). The results basically matched the soil survey mentioned above. Seventy percent of the samples taken were classified as silty loam. The majority (77 percent) of the soil samples had a measured water content between 15 and 30 percent with the water content decreasing slightly with depth.

For more details concerning the soil properties at the APG test site, go to www.uxotestsites.org on the Web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at APG is presented in Table 1. A test site layout is shown in Figure 2.

TABLE 1.   TEST SITE AREAS

Area	Description
Calibration lanes	Contains 14 standard munitions items buried in six positions, with representation of clutter, at various angles and depths to allow demonstrators to calibrate their equipment.
Blind grid	Contains 400 grid cells in a 0.5-acre site. The center of each grid cell contains either munitions, clutter, or nothing.
Open field	A 10-acre site composed of generally open and flat terrain with minimal clutter and minor navigational obstacles. Vegetation height varies from 15 to 25 cm. This area is subdivided into four subareas (legacy, direct fire, indirect fire, and challenge).
	• *Open field (legacy)* The legacy subarea contains the same wide variety of randomly-placed munitions that were present in the open field prior to the January 2008 general reconfiguration of the site.
	• *Open field (direct fire)* The direct fire subarea contains only three munition types that could be typically found at an impact area of a direct fire weapons range. Munitions and clutter are placed in a pattern typical for these munitions.
	• *Open field (indirect fire)* The indirect fire subarea contains only three munition types that could be typically found at an impact area of an indirect fire weapons range. Munitions and clutter are placed in a pattern typical for these munitions.
	• *Open field (challenge)* The challenge subarea is easily reconfigurable used to meet the specific needs and requirements of the demonstrator or the program sponsor. Any results from this area will not be reported in the standardized scoring record.
Woods	1.34-acre area consisting of cleared woods (tree removal with only stumps remaining), partially cleared woods (including all underbrush and fallen trees), and virgin woods (i.e., woods in natural state with all trees, underbrush, and fallen trees left in place).
Moguls	1.30-acre area consisting of two areas (the rectangular or driving portion of the course and the triangular section with more difficult, nondrivable terrain). A series of craters (as deep as 0.91 m) and mounds (as high as 0.91 m) encompass this section.

2.2.4   STANDARD AND NONSTANDARD INERT MUNITIONS TARGETS

The standard and nonstandard munitions items emplaced in the test areas are presented in Table 2. Standardized targets are members of a set of specific munitions items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are inert munitions items having properties that differ from those in the set of standardized items.

TABLE 2. INERT MUNITIONS TARGETS

Item	Munition Type	Calibration Lanes	Blind Grid	Open Field Direct Fire	Open field Indirect Fire	Open Field Legacy	Moguls	Woods
20-mm Projectile M55	S	X				X	X	X
25-mm Projectile M794	S	X	X	X				
37-mm Projectile M47	S	X	X	X				
40-mm Projectile MKII Bodies	S	X				X	X	X
BDU-28 Submunition	S	X				X	X	X
BLU-26 Submunition	S	X				X	X	X
M42 Submunition	S	X				X	X	X
57-mm Projectile APC M86	S	X				X	X	X
60-mm Mortar M49A3	S	X	X		X			
2.75-in. Rocket M230	S	X				X	X	X
81-mm Mortar M374	S	X	X		X	X	X	X
105-mm HEAT Rounds M456	S					X	X	X
105-mm HEAT Round M490	S	X	X	X				
105-mm Projectile M60	S	X	X		X	X	X	X
155-mm Projectile M483A1	S	X				X	X	X
20-mm Projectile M55	NS					X	X	X
20-mm Projectile M97	NS					X	X	X
40-mm Projectile M813	NS					X	X	X
60-mm Mortar (JPG)	NS					X	X	X
60-mm Mortar M49	NS					X	X	X
2.75-in. Rocket M230	NS					X	X	X
2.75-in. Rocket XM229	NS					X	X	X
81-mm Mortar (JPG)	NS					X	X	X
81-mm Mortar M374	NS					X	X	X
105-mm Projectile M60	NS					X	X	X
155-mm Projectile M483A	NS					X	X	X

S = Standard munition.
NS = Nonstandard munition.
JPG = Jefferson Proving Ground.
HEAT = high-explosive antitank.

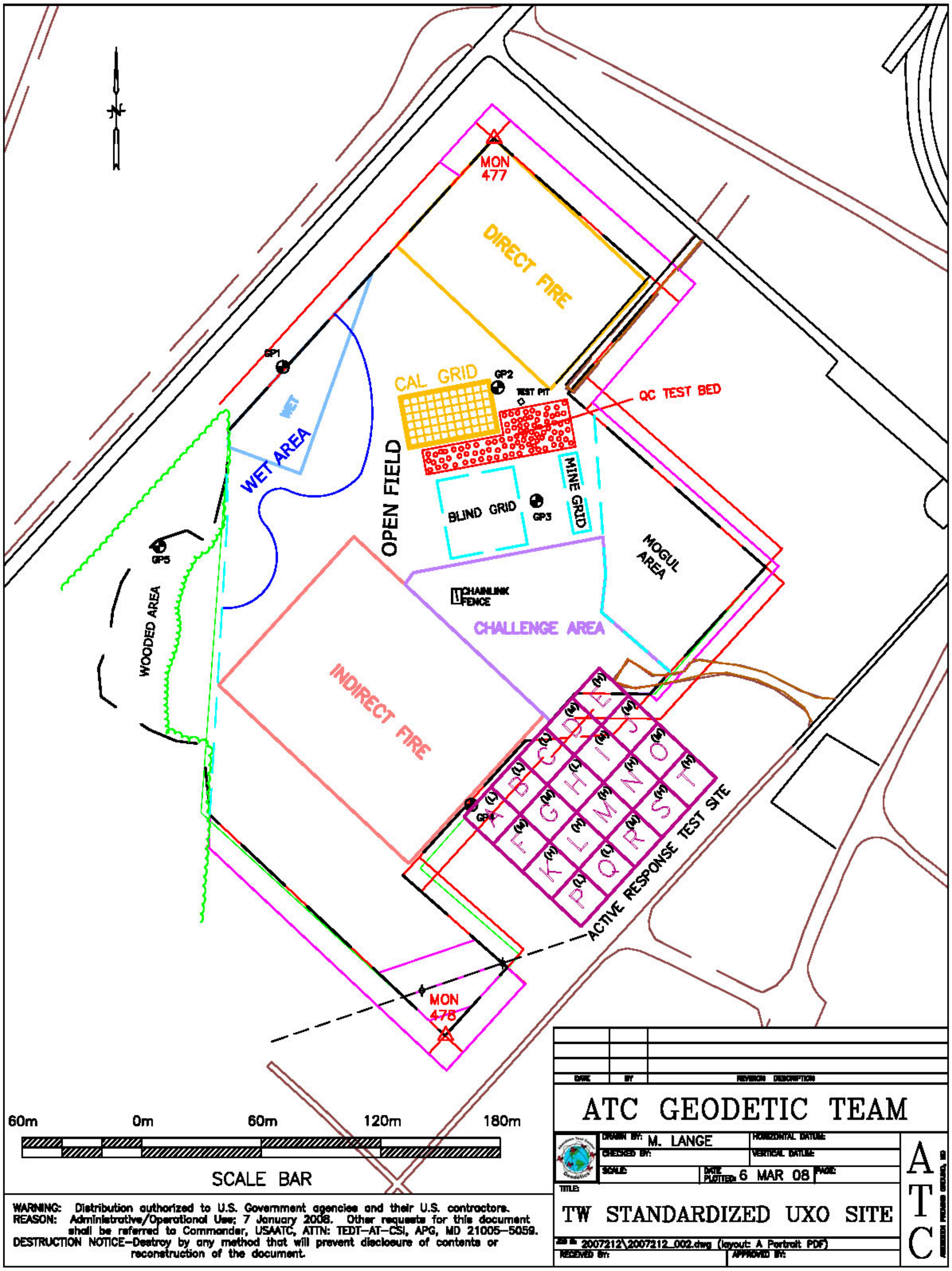


Figure 2. Test site layout.

(Page 26 Blank)

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (15 to 20, 22 to 27, 30 September; 1, 2, and 4 October 2008)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total number of hours operated at each site are presented in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration lanes	12.16
Blind grid	17.75
Open field	94.33
Woods	0.00
Mogul	0.00

Note: Table 3 represents the total time spent in each area.

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

An APG weather station located approximately 1 mile west of the test site was used to record average temperature and precipitation on a half hour basis for each day of operation. The temperatures presented in Table 4 represent the average temperature during field operations from 0700 to 1700 hours, while precipitation data represents a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 08	Average Temperature, °F	Total Daily Precipitation, in.
15 Sep	80.6	0.00
16 Sep	68.4	0.00
17 Sep	69.3	0.00
18 Sep	72.3	0.00
19 Sep	66.6	0.00
20 Sep	65.1	0.00
22 Sep	71.8	0.00
23 Sep	67.8	0.00
24 Sep	67.2	0.00
25 Sep	62.0	0.13
26 Sep	66.4	0.11
27 Sep	71.8	0.55

TABLE 4. (CONT'D)

Date, 08	Average Temperature, °F	Total Daily Precipitation, in.
30 Sep	67.4	0.33
01 Oct	59.6	0.32
02 Oct	64.4	0.00
04 Oct	62.7	0.00

3.3.2 Field Conditions

G&G Sciences, Inc. surveyed from mid-September through early October. The temperatures were seasonable. There were areas of standing water in various places throughout the open field. This did not hinder the survey.

3.3.3 Soil Moisture

Three soil probes were placed at various locations within the site to capture soil moisture data: blind grid, calibration, open field, and wooded areas. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil depths (1 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in., and 36 to 48 in.) from each probe. Soil moisture logs are included in Appendix C.

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and breakdown. A three-person crew took 2 hours and 45 minutes to perform the initial setup and mobilization. There were 10 hours and 50 minutes of daily equipment preparation, and end of the day equipment breakdown lasted 5 hours and 15 minutes.

3.4.2 Calibration

G&G Sciences, Inc. spent a total of 12 hours and 10 minutes in the calibration lanes, of which 6 hours and 30 minutes was spent collecting data. Numberous calibration activities occurred while surveying the open field and blind grid. Total amount of time was 6 hours and 45 minutes.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, demonstration site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor requirements (section 5) except for downtime due to demonstration site issues. Demonstration site issues, while noted in the daily log, are considered nonchargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are discussed in this section and billed to the total site survey area.

3.4.3.1 Equipment/data checks, maintenance. Equipment data checks and maintenance activities accounted for 3 hours and 25 minutes of site usage time. These activities included changing out batteries and performing routine data checks to ensure the data were being properly recorded/collected. G&G Sciences, Inc. spent an additional 5 hours and 15 minutes for breaks and lunches.

3.4.3.2 Equipment failure or repair. No time was needed to resolve equipment failures that occurred while surveying.

3.4.3.3 Weather. No weather delays occurred during the survey.

3.4.4 Data Collection

TABLE 5. TOTAL TIME G&G SCIENCES, INC. SPENT PER AREA

AREA	Time, hr/min
Blind grid	17 hours/45 minutes
Open field	94 hours/20 minutes
Legacy	N/A
Direct fire	46 hours/15 minutes
Indirect fire	48 hours/5 minutes
Challenge	N/A
Wooded	N/A
Moguls	N/A

Note: Table 5 represents the total time spent in each area collecting data.

3.4.5 Demobilization

The G&G Sciences, Inc. survey crew went on to conduct a full demonstration of the site. Therefore, demobilization did not occur until 4 October 2008. On that day, it took the crew 55 minutes to break down and pack up their equipment.

3.5 PROCESSING TIME

G&G Sciences, Inc. submitted the raw data from the demonstration activities on the last day of the demonstration, as required. The scoring submittal data were also provided within the required 30-day time frame.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Thomas S. King
Donald D. Snyder
David C. George

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

G&G Sciences, Inc. surveyed the direct fire, indirect fire, and blind grid in a linear fashion with 3/4-meter line spacing. G&G Sciences, Inc. then went to each point in the areas where they believed something was buried and did further investigation of these individual points.

3.8 SUMMARY OF DAILY LOGS

Daily logs capture all field activities during this demonstration and are located in Appendix D. Activities pertinent to this specific demonstration are indicated in highlighted text.

SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL MUNITIONS CATEGORIES

The probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of clutter detection or probability of false positive within each area are shown in Figures 3 through 8. The probabilities plotted against their respective background alarm rate within each area are shown in Figures 9 through 14. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the GT.

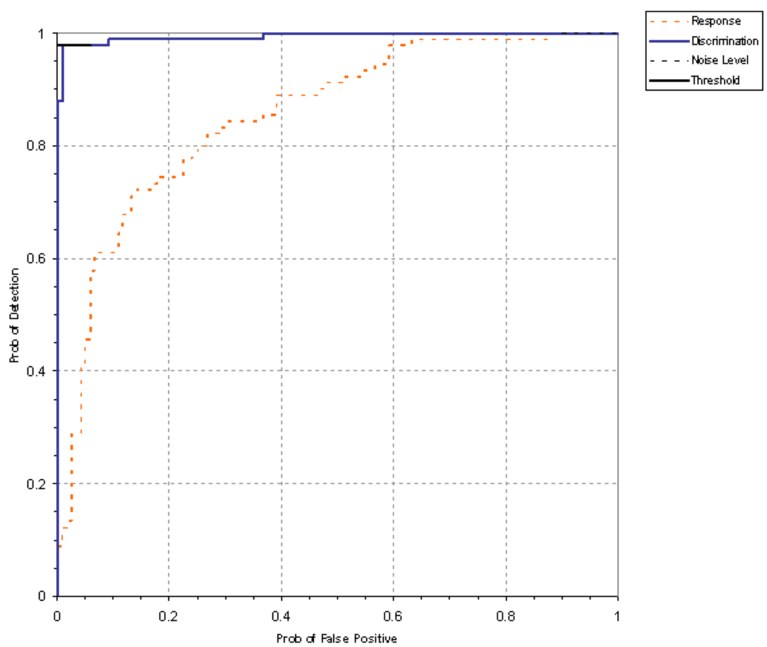


Figure 3. Metal Mapper/dual mode blind grid probability of detection for response and discrimination stages versus their respective probability of false positive.

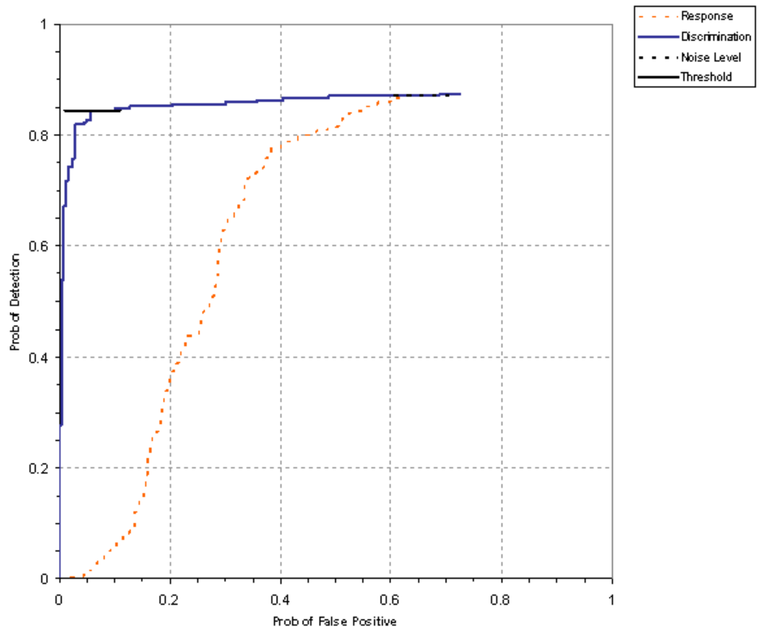


Figure 4. Metal Mapper/dual mode open field (direct fire) probability of detection for response and discrimination stages versus their respective probability of false positive.

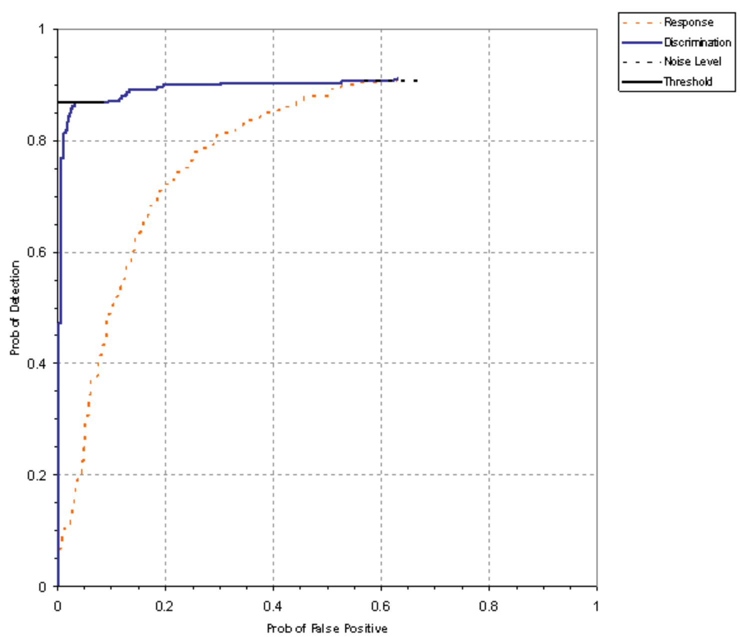


Figure 5. Metal Mapper/dual mode open field (indirect fire) probability of detection for response and discrimination stages versus their respective probability of false positive.

Not covered

Figure 6. Metal Mapper/dual mode open field (legacy) probability of detection for response and discrimination stages versus their respective probability of false positive.

Not covered

Figure 7. Metal Mapper/dual mode wooded probability of detection for response and discrimination stages versus their respective probability of false positive.

Not covered

Figure 8. Metal Mapper/dual mode mogul probability of detection for response and discrimination stages versus their respective probability of false positive.

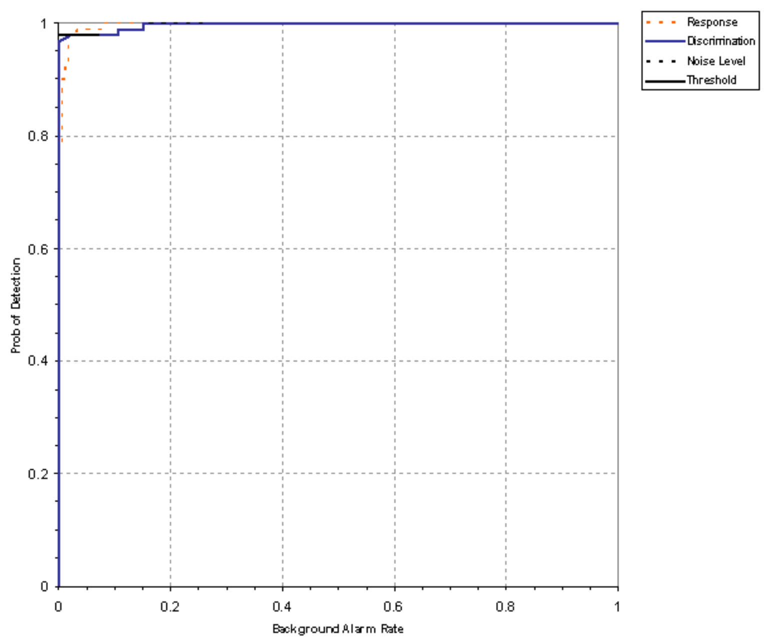


Figure 9. Metal Mapper/dual mode blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm.

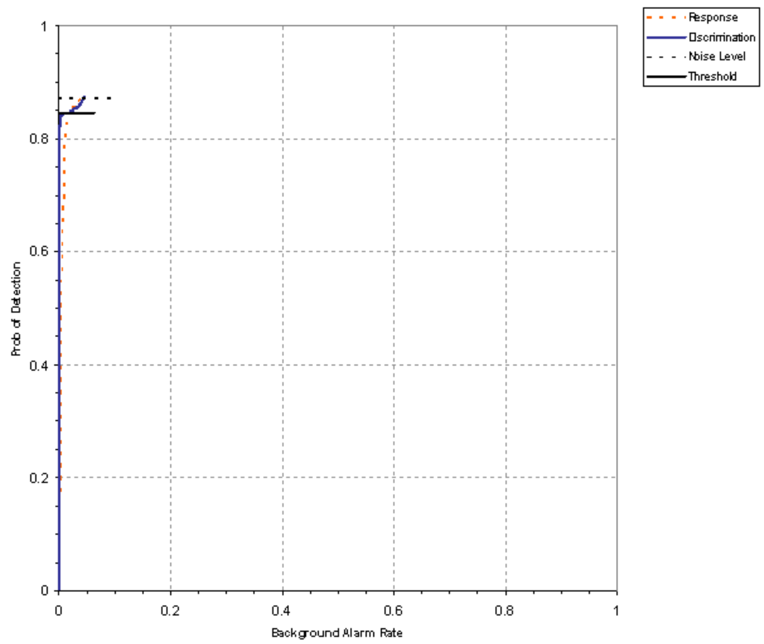


Figure 10. Metal Mapper/dual mode open field (direct fire) probability of detection for response and discrimination stages versus their respective background alarm rate.

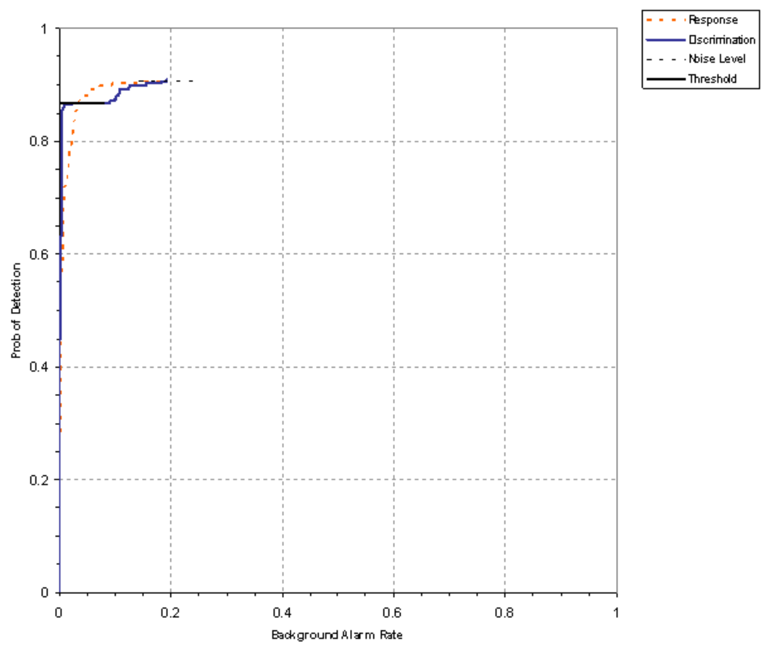


Figure 11. Metal Mapper/dual mode open field (indirect fire) probability of detection for response and discrimination stages versus their respective background alarm rate.

Not covered

Figure 12. Metal Mapper/dual mode open field (legacy) probability of detection for response and discrimination stages versus their respective background alarm rate.

Not covered

Figure 13. Metal Mapper/dual mode wooded probability of detection for response and discrimination stages versus their respective background alarm rate.

Not covered

Figure 14. Metal Mapper/dual mode mogul probability of detection for response and discrimination stages versus their respective background alarm rate.

4.2 PERFORMANCE SUMMARIES

Results for each of the testing areas are presented in Tables 6 (for labor requirements, see section 5). The response stage results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the discrimination stage are derived from the demonstrator’s recommended threshold for optimizing munitions related cleanup by minimizing false alarm digs and maximizing munitions recovery. The lower and upper 90-percent confidence limits on P_d, P_{cd}, and P_{fp} were calculated assuming that the number of detections and false positives are binomially distributed random variables.

TABLE 6a. BLIND GRID TEST AREA RESULTS

	Response Stage				Discrimination Stage			
Munitions[a] Scores	***P_d^{res}: by type***				***P_d^{disc}: by type***			
	All Types	**105-mm**	**81/60-mm**	**37/25-mm**	**All Types**	**105-mm**	**81/60-mm**	**37/25-mm**
	1.00 1.00 0.98	1.00 1.00 0.93	1.00 1.00 0.93	1.00 1.00 0.93	0.99 0.98 0.94	0.98 0.93 0.83	1.00 1.00 0.93	1.00 1.00 0.93
	By Depth[b]							
0 to 4D	1.00	1.00	1.00	1.00	0.96	1.00	0.92	1.00
4D to 8D	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8D to 12D	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Clutter Scores	***P_{cd}***				***P_{fp}***			
	By Mass							
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**
All Depth	0.97 0.95 0.91	0.90	1.00	1.00	0.03 0.01 0.00	0.00	0.00	0.10
0 to 0.15 m	0.96	0.93	1.00	1.00	0.01	0.00	0.00	0.17
0.15 to 0.3 m	0.88	0.60	1.00	1.00	0.00	0.00	0.00	0.00
0.3 to 0.6 m	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Background Alarm Rates							
	P_{ba}^{res}: 0.21				**P_{ba}^{disc}:** 0.02			

[a]The two numbers to the right of the all types munitions result are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

TABLE 6b. OPEN FIELD DIRECT FIRE TEST AREA RESULTS

	Response Stage				Discrimination Stage			
Munitions[a] Scores	***P_d^{res}: by type***				***P_d^{disc}: by type***			
	All Types	**105-mm**	**37-mm**	**25-mm**	**All Types**	**105-mm**	**37-mm**	**25-mm**
	0.90 0.87 0.84	0.88 0.83 0.77	0.91 0.87 0.81	0.95 0.91 0.86	0.87 0.85 0.81	0.84 0.78 0.71	0.89 0.84 0.78	0.94 0.90 0.85
By Density								
High	0.86	0.92	0.82	0.85	0.83	0.84	0.82	0.85
Medium	0.83	0.76	0.79	0.94	0.80	0.76	0.72	0.91
Low	0.92	0.83	0.97	0.94	0.90	0.76	0.97	0.94
By Depth[b]								
0 to 4D	0.91	1.00	0.86	1.00	0.88	0.95	0.83	1.00
4D to 8D	0.91	0.93	0.88	0.91	0.90	0.91	0.88	0.91
8D to 12D	0.68	0.39	N/A	0.88	0.61	0.28	N/A	0.85
Clutter Scores	***P_{cd}***				***P_{fp}***			
By Mass								
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**
All Depth	0.69 0.65 0.61	0.47	0.80	0.92	0.08 0.06 0.04	0.02	0.08	0.14
0 to 0.15 m	0.65	0.49	0.80	0.90	0.05	0.03	0.09	0.05
0.15 to 0.3 m	0.62	0.39	0.75	0.88	0.07	0.00	0.00	0.25
0.3 to 0.6 m	0.80	0.00	1.00	1.00	0.20	0.00	0.00	0.29
Background Alarm Rates								
	BAR^{res}: 0.07				**BAR^{disc}:** 0.02			
Groups								
Found	0.85				0.52			
Identified	0.03				0.00			
Coverage	0.44				0.26			

[a]The two numbers to the right of the all types munitions result are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

TABLE 6c. OPEN FIELD INDIRECT FIRE TEST AREA RESULTS

	Response Stage				Discrimination Stage			
Munitions[a] Scores	P_d^{res}: *by type*				P_d^{disc}: *by type*			
	All Types	**105-mm**	**81-mm**	**60-mm**	**All Types**	**105-mm**	**81-mm**	**60-mm**
	0.93 0.91 0.88	0.96 0.93 0.88	0.92 0.88 0.82	0.95 0.91 0.86	0.90 0.87 0.84	0.96 0.92 0.87	0.83 0.77 0.70	0.95 0.91 0.86
By Density								
High	0.86	0.85	0.96	0.80	0.85	0.85	0.91	0.80
Medium	0.89	0.93	0.82	0.90	0.84	0.90	0.71	0.90
Low	0.96	1.00	0.88	1.00	0.91	1.00	0.73	1.00
By Depth[b]								
0 to 4D	0.96	0.98	1.00	0.92	0.94	0.98	0.91	0.92
4D to 8D	0.91	0.87	0.92	0.93	0.82	0.84	0.77	0.93
8D to 12D	0.60	0.75	0.22	0.83	0.60	0.75	0.22	0.83
Clutter Scores	P_{cd}				P_{fp}			
By Mass								
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**
All Depth	0.65 0.62 0.59	0.47	0.75	0.87	0.05 0.04 0.02	0.03	0.02	0.11
0 to 0.15 m	0.61	0.47	0.76	0.88	0.03	0.03	0.02	0.13
0.15 to 0.3 m	0.65	0.38	0.75	0.82	0.02	0.00	0.00	0.06
0.3 to 0.6 m	0.83	1.00	0.67	1.00	0.17	1.00	0.00	0.20
Background Alarm Rates								
	BAR[res]**:** 0.19				**BAR**[disc]**:** 0.03			
Groups								
Found	0.95				0.80			
Identified	0.00				0.00			
Coverage	0.47				0.40			

[a]The two numbers to the right of the all types munitions result are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

TABLE 6d. OPEN FIELD LEGACY TEST AREA RESULTS (not covered)

	Response Stage				Discrimination Stage			
Munitions[a] Scores	***P_d^{res}: by type***				***P_d^{disc}: by type***			
	All Types	**Small**	**Medium**	**Large**	**All Types**	**Small**	**Medium**	**Large**
	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
By Depth[b]								
0 to 4D	--	--	--	--	--	--	--	--
4D to 8D	--	--	--	--	--	--	--	--
8D to 12D	--	--	--	--	--	--	--	--
> 12D	--	--	--	--	--	--	--	--

Clutter Scores	***P_{cd}***					***P_{fp}***				
	By Mass									
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 10 kg**	**> 10 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**< 10kg**
All Depth	-- -- --	--	--	--	--	-- -- --	--	--	--	--
0 to 0.15 m	--	--	--	--	--	--	--	--	--	--
0.15 to 0.3 m	--	--	--	--	--	--	--	--	--	--
0.3 to 0.6 m	--	--	--	--	--	--	--	--	--	--
> 0.6 m	--	--	--	--	--	--	--	--	--	--

Background Alarm Rates		
	BAR^{res}:	**BAR^{disc}:**

Groups								
Found	--				--			
Identified	--				--			
Coverage	--				--			

[a]The two numbers to the right of the all types munitions result are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

TABLE 6e. WOODED TEST AREA RESULTS (not covered)

	Response Stage				Discrimination Stage			
Munitions[a] Scores	***P_d^{res}: by type***				***P_d^{disc}: by type***			
	All Types	**Small**	**Medium**	**Large**	**All Types**	**Small**	**Medium**	**Large**
	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
	By Depth[b]							
0 to 4D	--	--	--	--	--	--	--	--
4D to 8D	--	--	--	--	--	--	--	--
8D to 12D	--	--	--	--	--	--	--	--
> 12D	--	--	--	--	--	--	--	--

Clutter Scores	***P_{cd}***					***P_{fp}***				
	By Mass									
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 10 kg**	**> 10 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**< 10kg**
All Depth	-- -- --	--	--	--	--	-- -- --	--	--	--	--
0 to 0.15 m	--	--	--	--	--	--	--	--	--	--
0.15 to 0.3 m	--	--	--	--	--	--	--	--	--	--
0.3 to 0.6 m	--	--	--	--	--	--	--	--	--	--
> 0.6 m	--	--	--	--	--	--	--	--	--	--

	Background Alarm Rates							
	BAR^{res}:				**BAR^{disc}:**			
	Groups							
Found	--				--			
Identified	--				--			
Coverage	--				--			

[a]The two numbers to the right of the all types munitions result are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

TABLE 6f. MOGUL TEST AREA RESULTS (not covered)

	Response Stage				Discrimination Stage			
Munitions[a] Scores	P_d^{res}: *by type*				P_d^{disc}: *by type*			
	All Types	Small	Medium	Large	All Types	Small	Medium	Large
	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
	By Depth[b]							
0 to 4D	--	--	--	--	--	--	--	--
4D to 8D	--	--	--	--	--	--	--	--
8D to 12D	--	--	--	--	--	--	--	--
> 12D	--	--	--	--	--	--	--	--

Clutter Scores	P_{cd}				P_{fp}				
	By Mass								
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 10 kg**	**> 10 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**< 10kg**
All Depth	-- -- --	--	--	--	--	-- -- --	--	--	--	--
0 to 0.15 m	--	--	--	--	--	--	--	--	--	--
0.15 to 0.3 m	--	--	--	--	--	--	--	--	--	--
0.3 to 0.6 m	--	--	--	--	--	--	--	--	--	--
> 0.6 m	--	--	--	--	--	--	--	--	--	--
	Background Alarm Rates									
	BAR^{res}:					**BAR^{disc}:**				
	Groups									
Found	--					--				
Identified	--					--				
Coverage	--					--				

[a]The two numbers to the right of the all types munitions result are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

4.3 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are presented in Tables 7a through 7d.

TABLE 7a. BLIND GRID EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.98	0.99	0.90
With No Loss of P_d	1.00	0.61	0.28

TABLE 7b. OPEN FIELD (DIRECT) EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.97	0.92	0.72
With No Loss of P_d	1.00	0.23	0.06

TABLE 7c. OPEN FIELD (INDIRECT) EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.96	0.94	0.85
With No Loss of P_d	1.00	0.14	0.05

TABLE 7d. OPEN FIELD (LEGACY) EFFICIENCY AND REJECTION RATES (not covered)

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	--	--	--
With No Loss of P_d	--	--	--

TABLE 7e. WOODED EFFICIENCY AND REJECTION RATES (not covered)

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	--	--	--
With No Loss of P_d	--	--	--

TABLE 7f. MOGUL EFFICIENCY AND REJECTION RATES (not covered)

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	--	--	--
With No Loss of P_d	--	--	--

At the demonstrator's recommended setting, the munitions items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 8a through 8f). Correct type examples include 20-mm projectile, 105-mm HEAT projectile, and 2.75-inch Rocket. A list of the standard type declaration required for each munitions item was provided to demonstrators prior to testing. The standard types for the three example items are 20-mmP, 105H, and 2.75-inch.

TABLE 8a. BLIND GRID CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS

Size	Percentage Correct
25mm	100%
37mm	100%
60mm	100%
81mm	67%
105mm	7%
105 artillery	93%
Overall	78%

Note: The demonstrator did not attempt to provide type classification (if applicable).

TABLE 8b. OPEN FIELD DIRECT FIRE CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS

Size	Percentage Correct
60mm	84%
81mm	74%
105mm	78%
Overall	79%

TABLE 8c. OPEN FIELD INDIRECT FIRE CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS

Size	Percentage Correct
25-mm	89%
37-mm	74%
105-mm	91%
Overall	85%

TABLE 8d. OPEN FIELD LEGACY CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS (not covered)

Size	Percentage Correct
Small	--
Medium	--
Large	--
Overall	--

TABLE 8e. WOODED CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS (not covered)

Size	Percentage Correct
Small	--
Medium	--
Large	--
Overall	--

TABLE 8f. MOGUL CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS (not covered)

Size	Percentage Correct
Small	--
Medium	--
Large	--
Overall	--

4.4 LOCATION ACCURACY

The mean location error and standard deviations appear in Tables 9a through 9f. These calculations are based on average missed distance for munitions correctly identified during the response stage. Depths are measured from the center of the munitions to the surface. For the blind grid, only depth errors are calculated because (X, Y) positions are known to be the centers of the grid square.

TABLE 9a. BLIND GRID MEAN LOCATION ERROR AND STANDARD DEVIATION

	Mean	Standard Deviation
Northing	N/A	N/A
Easting	N/A	N/A
Depth	0.05	0.06

TABLE 9b. OPEN FIELD DIRECT FIRE MEAN LOCATION ERROR AND STANDARD DEVIATION

	Mean	Standard Deviation
Northing	0.01	0.08
Easting	-0.01	0.07
Depth	0.03	0.05

TABLE 9c. OPEN FIELD INDIRECT FIRE MEAN LOCATION ERROR AND STANDARD DEVIATION

	Mean	Standard Deviation
Northing	0.00	0.07
Easting	0.01	0.07
Depth	0.03	0.06

TABLE 9d. OPEN FIELD LEGACY MEAN LOCATION ERROR AND STANDARD DEVIATION (not covered)

	Mean	Standard Deviation
Northing	--	--
Easting	--	--
Depth	--	--

TABLE 9e. WOODED MEAN LOCATION ERROR AND STANDARD DEVIATION (not covered)

	Mean	Standard Deviation
Northing	--	--
Easting	--	--
Depth	--	--

TABLE 9f. MOGUL MEAN LOCATION ERROR AND STANDARD DEVIATION (not covered)

	Mean	Standard Deviation
Northing	--	--
Easting	--	--
Depth	--	--

SECTION 5. ON-SITE LABOR REQUIREMENTS

A standardized estimate for labor associated with this effort was calculated as follows: the first person at the test site was designated supervisor, the second person was designated data analyst, and the third and following personnel were considered field support.

Government representatives monitored on-site activity. All on-site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, collecting data, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. The daily activity log is provided in Appendix D. A summary of field activities is provided in Section 3.4.

The standardized estimate of the labor needed to perform the field activities is presented in Table 10. Note that calibration time includes time spent in the calibration lanes as well as field calibrations. Site survey includes daily setup/stop time, collecting data, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 10. ON-SITE LABOR REQUIREMENTS

	No. of People	Hours
	Initial setup	
Supervisor	1	2.75
Data analyst	1	2.75
Field support	1	2.75
Subtotal		
	Calibration site survey	
Supervisor	1	18.92
Data analyst	1	18.92
Field support	1	18.92
Subtotal		
	Blind grid site survey	
Supervisor	1	17.75
Data analyst	1	17.75
Field support	1	17.75
Subtotal		

See notes at end of table.

TABLE 10. (CONT'D)

	No. of People	Hours
	Open field site survey	
Supervisor	1	94.33
Data analyst	1	94.33
Field support	1	94.33
Subtotal		
	Wooded site survey	
Supervisor	0	0.00
Data analyst	0	0.00
Field support	0	0.00
Subtotal	0	0.00
	Mogul site survey	
Supervisor	0	0.00
Data analyst	0	0.00
Field support	0	0.00
Subtotal	0	0.00
	Demobilization	
Supervisor	1	0.92
Data analyst	1	0.92
Field support	1	0.92
Subtotal		

Notes: Calibration time includes time spent in the calibration lanes as well as calibration before each data run.
Site survey time includes daily setup/stop time, collecting data, breaks/lunch, downtime due to system maintenance, failure, and weather.

SECTION 6. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced munitions item.

Detection: An anomaly location that is within R_{halo} of an emplaced munitions item.

Military Munitions (MM): Specific categories of MM that may pose unique explosive safety risks, including UXO as defined in 10 USC 101(e)(5), DMM as defined in 10 USC 2710(e)(2) and/or munitions constituents (e.g. TNT, RDX) as defined in 10 USC 2710(e)(3) that are present in high enough concentrations to pose an explosive hazard.

Emplaced Munitions: A munitions item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., nonmunitions item) buried by the government at a specified location in the test site.

R_{halo}: A predetermined radius about an emplaced item (clutter or munitions) within which an anomaly identified by the demonstrator as being of interest is considered to be a detection of that item. For the purpose of this program, a circular halo 0.5 meters in radius is placed around the center of the object for all clutter and munitions items.

Small Munitions: Caliber of munitions less than or equal to 40 mm (includes 20-mm projectile, 25-mm projectile, 37-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Munitions: Caliber of munitions greater than 40 mm and less than or equal to 81 mm (includes 57-mm projectile, 60-mm mortar, 2.75-inch rocket, and 81-mm mortar).

Large Munitions: Caliber of munitions greater than 81 mm (includes 105-mm HEAT, 105-mm projectile, and 155-mm projectile).

Group: Two or more adjacent GT items with overlapping halos.

GT: Ground truth

Response Stage Noise Level: The level that represents the signal level below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the blind grid test area.

Discrimination Stage Threshold: The demonstrator-selected threshold level that is expected to provide optimum performance of the system by retaining all detectable munitions and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for *n* independent trials with the probability *p* of success and the probability *1-p* of failure being the same for each trial. The number of successes *x* observed in the *n* trials is an estimate of *p* and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages: response stage and discrimination stage. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of clutter detection (P_{cd}) or probability of false positive (P_{fp}). Those that do not correspond to any known item are termed background alarms.

The response stage is a measure of whether the sensor can detect an object of interest. For a channel instrument, this value should be closely related to the amplitude of the signal. The demonstrator must report the response level (threshold) below which target responses are deemed insufficient to warrant further investigation. At this stage, minimal processing may be done. This includes filtering long- and short-scale variations, bias removal, and scaling. This processing should be detailed in the data submission.

For a multichannel instrument, the demonstrator must construct a quantity analogous to amplitude. The demonstrator should consider what combination of channels provides the best test for detecting any object that the sensor can detect. The average amplitude across a set of channels is an example of an acceptable response stage quantity. Other methods may be more appropriate for a given sensor. Again, minimal processing can be done, and the demonstrator should explain how this quantity was constructed in their data submission.

The discrimination stage evaluates the demonstrator's ability to correctly identify munitions as such, and to reject clutter. For the same locations as in the response stage anomaly list, the discrimination stage list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain munitions. Thus, higher output values are indicative of higher confidence that a munitions item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide optimum system performance, (i.e., that retains all the detected munitions and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

GROUP SCORING FACTORS

Based on configuration of the GT at the standardized sites and the defined scoring methodology, there exists munitions groups defined as having overlapping halos. In these cases, the following scoring logic is implemented (fig. A-1 through A-9):

a. Overall site scores (i.e., P_d) will consider only isolated munitions and clutter items.

b. GT items that have overlapping halos (both munitions and clutter) will form a group and groups may form chains.

c. Groups will have a complex halos composed of all the composite halos of all its GT items.

d. Groups will have three scoring factors: groups found groups identified and group coverage. Scores will be based on 1:1 matches of anomalies and GT.

(1) Groups Found (Found): the number of groups that have one or more GT items matched divided by the total number of groups. Demonstrators will be credited with detecting a group if any item within the group is matched to an anomaly in their list.

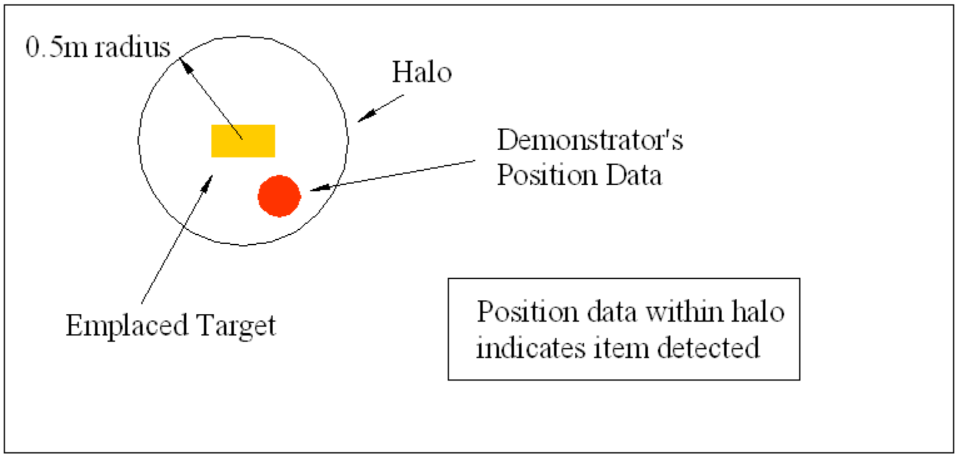
(2) Groups Identified (ID): the number of groups that have two or more GT items matched divided by the total number of groups. Demonstrators will be credited with identifying that a group is present if multiple items within the composite halo are matched to anomalies in their list.

(3) Group Coverage (Coverage): the number of GT items matched within groups divided by the total number of GT items within groups. This metric measures the demonstrator accuracy in determining the number of anomalies within a group. If five items are present and only two anomalies are matched, the demonstrator will score 0.4. If all five are matched the demonstrator will score 1.0.

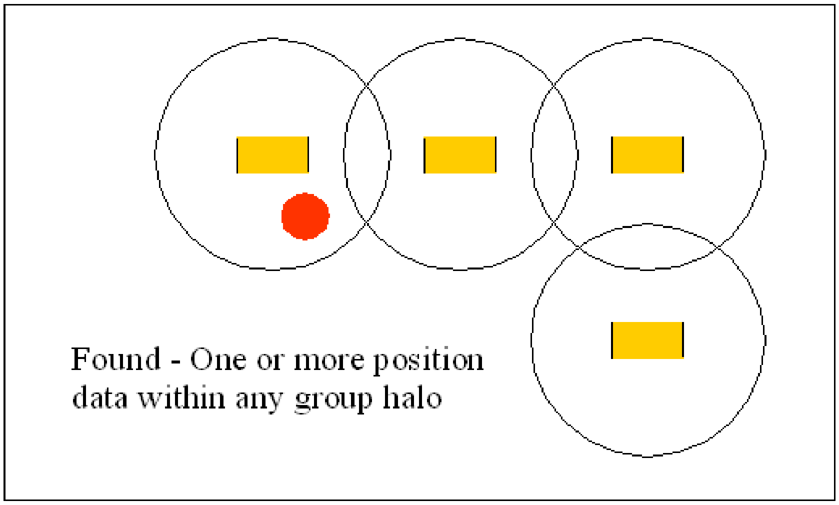
e. Location error will not be reported for groups.

f. Demonstrators will not be asked to call out groups in their scoring submissions. If multiple anomalies are indicated in a small area, the demonstrator will report all individual anomalies.

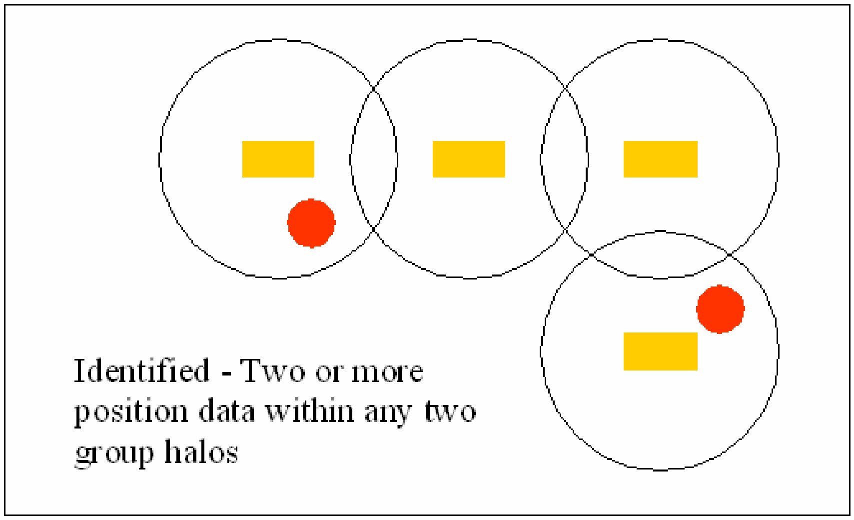
g. Excess alarms within a halo will be disregarded.



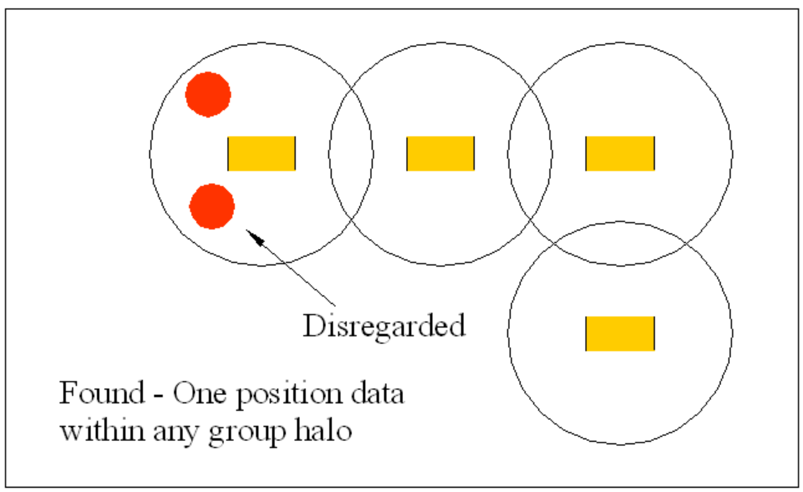
A-1. Example of detected item.



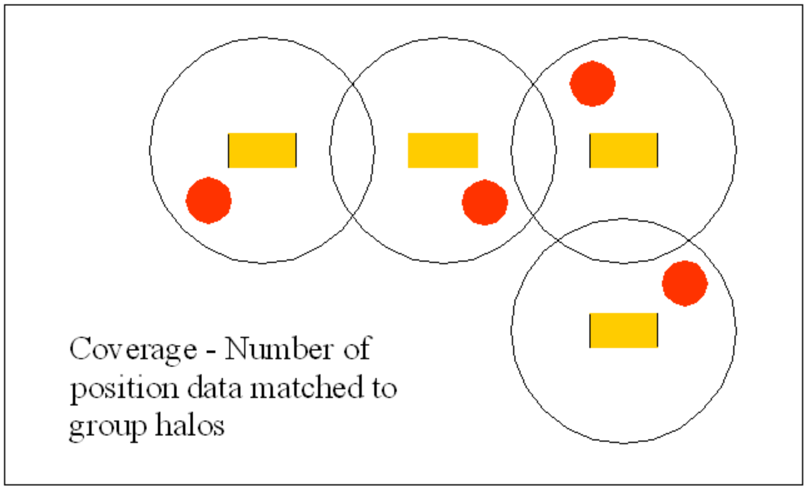
A-2. Example of group found (found).



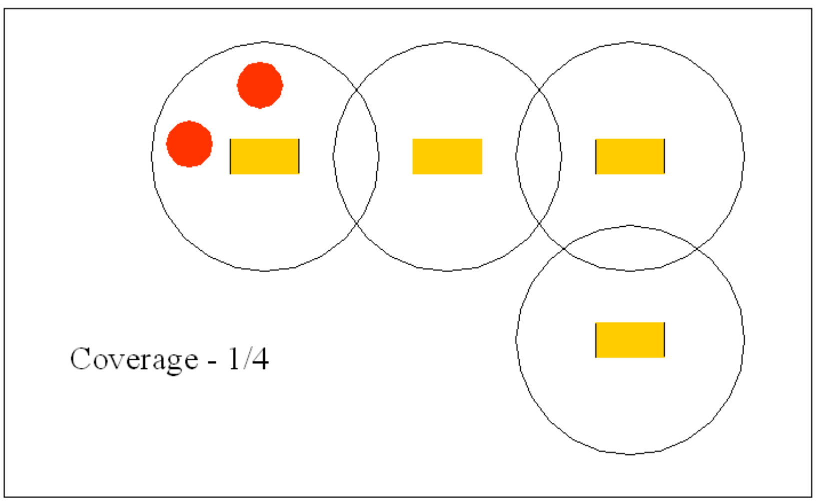
A-3. Example of group identified (ID).



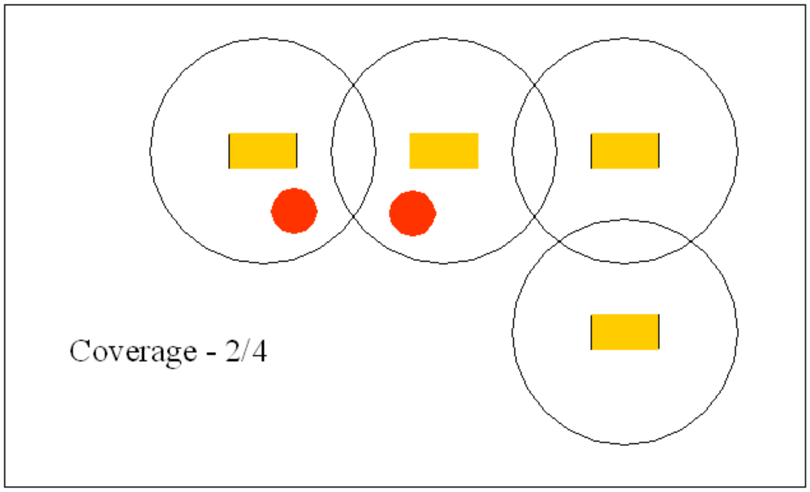
A-4. Example of excess alarms disregarded.



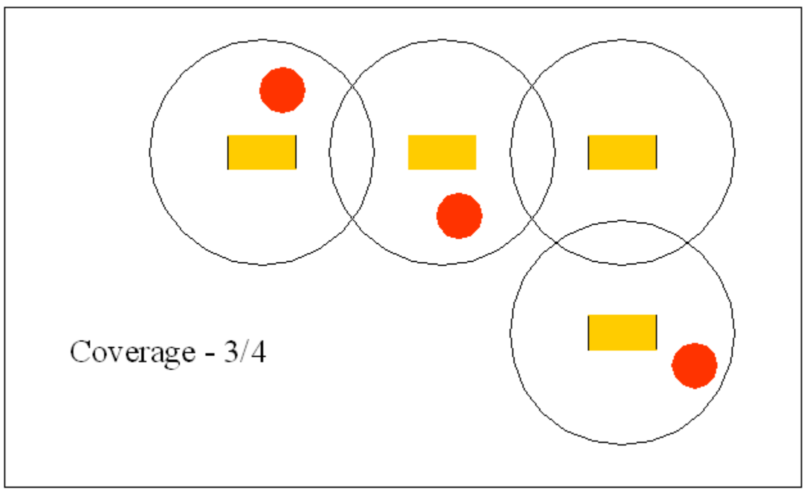
A-5. Example of a group.



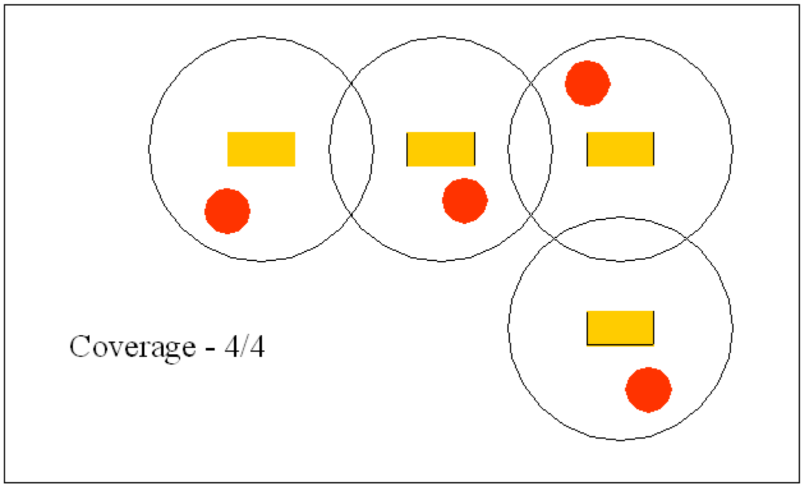
A-6. Example of group (1/4 = 0.25).



A-7. Example of group (2/4 = 0.5).



A-8. Example of group (3/4 = 0.75).



A-9. Example of group (4/4 = 1.0).

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/(No. of emplaced munitions in the test site).

Response Stage Clutter Detection (cd^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of Clutter Detection (P_{cd}^{res}): P_{cd}^{res} = (No. of response-stage clutter detections)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced munitions nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced munitions or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open field any challenge area (including the direct and indirect firing sub areas) only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{cd}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{cd}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to sensor data to discriminate munitions from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to munitions, as well as those that the demonstrator has high confidence correspond to nonmunitions or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced munitions in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced munitions nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced munitions or emplaced clutter item.

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d versus P_{cd} or P_{fp} and P_d versus BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] P_d versus P_{fp} and P_d versus BAR being combined into ROC curves is shown in Figure A-10. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

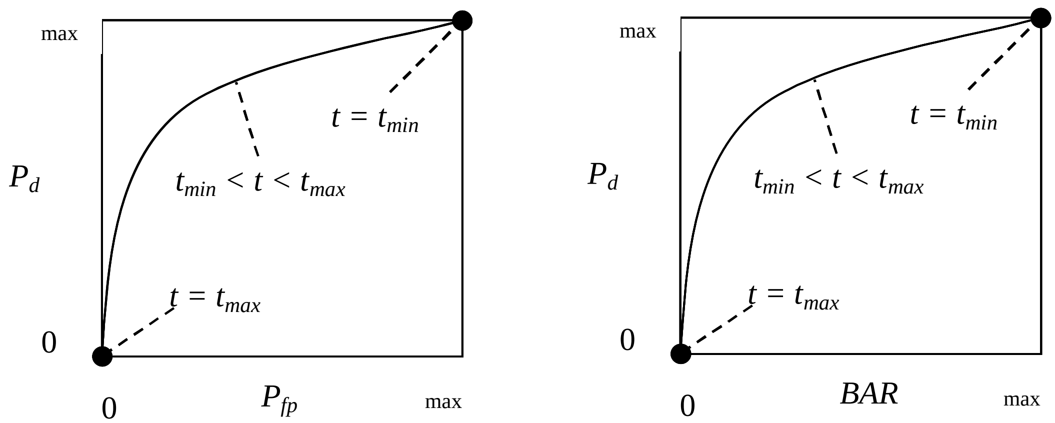


Figure A-10. ROC curves for open field testing. Each curve applies to both the response and discrimination stages.

METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of munitions detections from the anomaly list while rejecting the maximum number of anomalies arising from nonmunitions items. The efficiency measures the fraction of detected munitions retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum munitions detectable by the sensor and its accompanying clutter detection rate/false positive rate or background alarm rate.

---

[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a predetermined and fixed number of detection opportunities (some of the opportunities are located over munitions and others are located over clutter or blank spots). In an open field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the blind grid test sites are true ROC curves.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$: Measures (at a threshold of interest) the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage tmin) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the munitions initially detected in the response stage were retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{cd}^{res}(t_{min}^{res})]$: Measures (at a threshold of interest) the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

Blind grid: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$.
Open field: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})])$.

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

CHI-SQUARE COMPARISON

The Chi-square test for differences in probabilities (or 2 by 2 contingency table) is used to analyze two samples drawn from two different populations to see if both populations have the same or different proportions of elements in a certain category. More specifically, two random samples are drawn, one from each population, to test the null hypothesis that the probability of event A (some specified event) is the same for both populations (ref 3).

The test statistic of the 2 by 2 contingency table is the Chi-square distribution with one degree of freedom. When an association between a more challenging terrain feature and relatively degraded performance is sought, a one-sided test is performed. A two-sided 2 by 2 contingency table is used in the Standardized UXO Technology Demonstration Site Program to compare performance between any two areas or subareas when the direction of degradation cannot be predetermined.

For a one-sided test, a significance level of 0.05 is used to set the critical decision limit. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, then the lower proportion tested will be considered significantly less than the greater one (degraded). If the test statistic calculated from the data is less than this value, then no degradation can be said to exist because of the terrain feature introduced.

For a two-sided test, a significance level of 0.10 is used to allow .05 on either side of the decision. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, then the two proportions tested will be considered significantly different. If the test statistic calculated from the data is less than this value, then the two proportions tested will be considered not significantly different.

An exception must be applied when either a 0 or 100 percent success rate occurs in the sample data. The Chi-square test cannot be used in these instances. Instead, Fischer's test is used, and the critical decision limit for one-sided tests is the chosen significance level, which in this case is 0.05. With Fischer's test, if the test statistic is less than the critical value, then the proportions are considered to be significantly different.

An example follows that illustrates Standardized UXO Technology Demonstration Site blind grid results compared to those from the open field legacy. It should be noted that a significant result does not prove a cause-and-effect relationship exists between the two populations of interest; however, it does serve as a tool to indicate that one data set has experienced a degradation or change in system performance at a large enough level than can be accounted for merely by chance or random variation. Note also that a result that is not significant indicates that there is not enough evidence to declare that anything more than chance or random variation within the same population is at work between the two data sets being compared.

Demonstrator X achieves the following overall results after surveying the blind grid and open field (legacy) using the same system (results indicate the number of munitions detected divided by the number of munitions emplaced):

	Blind grid	Open field
P_d^{res}	100/100 = 1.0	8/10 = .80

P_d^{res}: BLIND GRID versus OPEN FIELD (legacy). Using the example data above to compare probabilities of detection in the response stage, all 100 munitions out of 100 emplaced munitions items were detected in the blind grid while 8 munitions out of 10 emplaced were detected in the open field. Fischer's test must be used since a 100 percent success rate occurs in the data. Fischer's test uses the four input values to calculate a test statistic of 0.0075 that is compared against the critical value of 0.05. Since the test statistic is less than the critical value, the smaller response stage detection rate (0.80) is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause-and-effect relationship exists between the change in survey area and degradation in performance, it does indicate that the detection ability of demonstrator X's system seems to have been degraded in the open field relative to results from the blind grid using the same system. This is an example of a one-sided Chi-squared test.

APPENDIX B. DAILY WEATHER LOGS

Date, 08	Time, EST	Avg Temperature, °F	Total Precipitation, in.
15 Sep	0100	81.1	0.00
	0200	82.0	0.00
	0300	80.8	0.00
	0400	79.5	0.00
	0500	77.5	0.00
	0600	77.4	0.00
	0700	76.6	0.00
	0800	77.7	0.00
	0900	79.3	0.00
	1000	80.4	0.00
	1100	81.1	0.00
	1200	81.3	0.00
	1300	82.2	0.00
	1400	82.2	0.00
	1500	82.6	0.00
	1600	82.6	0.00
	1700	81.0	0.00
	1800	77.9	0.00
	1900	74.5	0.00
	2000	72.3	0.00
	2100	72.3	0.00
	2200	72.1	0.00
	2300	71.6	0.00
	2359	70.7	0.00
16 Sep	0100	69.1	0.00
	0200	67.3	0.00
	0300	65.5	0.00
	0400	63.7	0.00
	0500	63.0	0.00
	0600	62.6	0.00
	0700	62.8	0.00
	0800	63.9	0.00
	0900	65.3	0.00
	1000	66.2	0.00
	1100	67.8	0.00
	1200	69.1	0.00
	1300	70.3	0.00
	1400	72.3	0.00
	1500	72.5	0.00
	1600	71.4	0.00
	1700	70.7	0.00
	1800	69.1	0.00
	1900	66.2	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
16 Sep	2000	62.6	0.00
	2100	60.3	0.00
	2200	58.5	0.00
	2300	57.2	0.00
	2359	56.3	0.00
17 Sep	0100	55.4	0.00
	0200	55.9	0.00
	0300	56.8	0.00
	0400	54.7	0.00
	0500	54.0	0.00
	0600	53.8	0.00
	0700	56.8	0.00
	0800	63.1	0.00
	0900	64.8	0.00
	1000	66.9	0.00
	1100	68.2	0.00
	1200	70.7	0.00
	1300	72.0	0.00
	1400	73.9	0.00
	1500	75.0	0.00
	1600	75.7	0.00
	1700	74.7	0.00
	1800	71.2	0.00
	1900	66.6	0.00
	2000	63.0	0.00
	2100	60.3	0.00
	2200	58.5	0.00
	2300	57.6	0.00
	2359	57.2	0.00
18 Sep	0100	56.8	0.00
	0200	56.1	0.00
	0300	55.0	0.00
	0400	54.3	0.00
	0500	53.8	0.00
	0600	54.0	0.00
	0700	55.4	0.00
	0800	64.2	0.00
	0900	69.4	0.00
	1000	72.1	0.00
	1100	74.5	0.00
	1200	76.1	0.00
	1300	76.8	0.00
	1400	77.0	0.00
	1500	77.5	0.00
	1600	76.6	0.00
	1700	75.4	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
18 Sep	1800	73.4	0.00
	1900	69.3	0.00
	2000	67.3	0.00
	2100	68.7	0.00
	2200	67.3	0.00
	2300	66.4	0.00
	2359	64.6	0.00
19 Sep	0100	64.0	0.00
	0200	62.2	0.00
	0300	60.8	0.00
	0400	60.1	0.00
	0500	59.2	0.00
	0600	58.1	0.00
	0700	58.5	0.00
	0800	61.3	0.00
	0900	63.1	0.00
	1000	65.7	0.00
	1100	67.5	0.00
	1200	68.5	0.00
	1300	69.4	0.00
	1400	70.0	0.00
	1500	70.2	0.00
	1600	70.3	0.00
	1700	68.2	0.00
	1800	66.9	0.00
	1900	63.3	0.00
	2000	61.9	0.00
	2100	61.2	0.00
	2200	59.9	0.00
	2300	58.3	0.00
	2359	57.4	0.00
20 Sep	0100	55.4	0.00
	0200	53.4	0.00
	0300	51.8	0.00
	0400	51.3	0.00
	0500	50.4	0.00
	0600	50.0	0.00
	0700	50.5	0.00
	0800	56.1	0.00
	0900	61.3	0.00
	1000	64.6	0.00
	1100	66.6	0.00
	1200	67.5	0.00
	1300	68.9	0.00
	1400	69.4	0.00
	1500	70.7	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
20 Sep	1600	71.2	0.00
	1700	69.4	0.00
	1800	67.3	0.00
	1900	62.4	0.00
	2000	59.5	0.00
	2100	57.7	0.00
	2200	55.6	0.00
	2300	54.1	0.00
	2359	53.2	0.00
21 Sep	0100	52.5	0.00
	0200	51.4	0.00
	0300	50.2	0.00
	0400	49.5	0.00
	0500	48.9	0.00
	0600	49.1	0.00
	0700	50.4	0.00
	0800	58.1	0.00
	0900	64.4	0.00
	1000	69.6	0.00
	1100	72.9	0.00
	1200	75.6	0.00
	1300	77.2	0.00
	1400	78.8	0.00
	1500	78.3	0.00
	1600	78.1	0.00
	1700	77.0	0.00
	1800	74.1	0.00
	1900	67.6	0.00
	2000	64.6	0.00
	2100	62.1	0.00
	2200	60.8	0.00
	2300	59.7	0.00
	2359	58.5	0.00
22 Sep	0100	57.6	0.00
	0200	57.0	0.00
	0300	56.7	0.00
	0400	56.1	0.00
	0500	59.0	0.00
	0600	59.2	0.00
	0700	59.7	0.00
	0800	63.5	0.00
	0900	67.6	0.00
	1000	69.8	0.00
	1100	72.3	0.00
	1200	74.5	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
22 Sep	1300	75.9	0.00
	1400	77.0	0.00
	1500	77.7	0.00
	1600	76.5	0.00
	1700	75.7	0.00
	1800	74.3	0.00
	1900	73.2	0.00
	2000	72.1	0.00
	2100	71.6	0.00
	2200	70.2	0.00
	2300	67.8	0.00
	2359	65.8	0.00
23 Sep	0100	65.3	0.00
	0200	64.6	0.00
	0300	63.7	0.00
	0400	61.9	0.00
	0500	60.4	0.00
	0600	59.4	0.00
	0700	59.5	0.00
	0800	61.9	0.00
	0900	64.0	0.00
	1000	66.2	0.00
	1100	67.8	0.00
	1200	69.1	0.00
	1300	70.3	0.00
	1400	71.4	0.00
	1500	72.1	0.00
	1600	72.3	0.00
	1700	71.4	0.00
	1800	68.9	0.00
	1900	64.2	0.00
	2000	59.7	0.00
	2100	56.8	0.00
	2200	57.7	0.00
	2300	59.0	0.00
	2359	55.4	0.00
24 Sep	0100	55.0	0.00
	0200	55.6	0.00
	0300	55.0	0.00
	0400	54.7	0.00
	0500	53.2	0.00
	0600	53.8	0.00
	0700	55.8	0.00
	0800	60.3	0.00
	0900	64.0	0.00
	1000	65.5	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
24 Sep	1100	68.0	0.00
	1200	69.4	0.00
	1300	70.9	0.00
	1400	72.0	0.00
	1500	71.6	0.00
	1600	71.4	0.00
	1700	70.5	0.00
	1800	68.5	0.00
	1900	67.1	0.00
	2000	65.7	0.00
	2100	64.0	0.00
	2200	62.4	0.00
	2300	61.7	0.00
	2359	60.8	0.00
25 Sep	0100	59.4	0.00
	0200	58.8	0.00
	0300	57.9	0.00
	0400	57.9	0.00
	0500	57.2	0.00
	0600	56.5	0.00
	0700	56.7	0.00
	0800	58.5	0.00
	0900	59.9	0.00
	1000	61.9	0.00
	1100	63.3	0.00
	1200	64.8	0.00
	1300	64.8	0.00
	1400	63.0	0.02
	1500	62.6	0.01
	1600	63.5	0.00
	1700	63.5	0.01
	1800	61.9	0.01
	1900	61.3	0.01
	2000	60.8	0.03
	2100	60.6	0.01
	2200	59.5	0.03
	2300	59.9	0.00
	2359	60.4	0.00
26 Sep	0100	60.6	0.00
	0200	61.0	0.00
	0300	61.7	0.00
	0400	62.2	0.00
	0500	62.4	0.02
	0600	62.1	0.01
	0700	62.4	0.00
	0800	63.1	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
26 Sep	0900	64.0	0.00
	1000	65.1	0.00
	1100	66.4	0.00
	1200	67.8	0.00
	1300	68.2	0.00
	1400	67.6	0.00
	1500	67.8	0.00
	1600	68.9	0.00
	1700	68.9	0.00
	1800	68.5	0.00
	1900	68.7	0.00
	2000	68.9	0.00
	2100	68.7	0.00
	2200	68.9	0.01
	2300	68.7	0.01
	2359	68.5	0.06
27 Sep	0100	68.7	0.00
	0200	68.9	0.00
	0300	69.1	0.00
	0400	69.3	0.05
	0500	69.3	0.01
	0600	69.4	0.00
	0700	70.2	0.00
	0800	70.5	0.05
	0900	71.2	0.00
	1000	72.0	0.00
	1100	72.1	0.15
	1200	70.3	0.12
	1300	71.4	0.00
	1400	72.0	0.01
	1500	72.7	0.00
	1600	73.8	0.00
	1700	73.8	0.00
	1800	72.3	0.00
	1900	72.0	0.00
	2000	71.2	0.00
	2100	70.5	0.00
	2200	70.0	0.05
	2300	69.4	0.02
	2359	69.4	0.09
28 Sep	0100	69.3	0.00
	0200	69.3	0.00
	0300	69.1	0.00
	0400	68.9	0.00
	0500	68.7	0.00
	0600	68.7	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
28 Sep	0700	68.9	0.00
	0800	69.6	0.00
	0900	70.2	0.00
	1000	72.0	0.00
	1100	73.4	0.00
	1200	76.3	0.00
	1300	76.8	0.01
	1400	73.9	0.05
	1500	74.8	0.00
	1600	72.9	0.10
	1700	71.2	0.01
	1800	70.2	0.00
	1900	68.7	0.00
	2000	68.7	0.00
	2100	68.5	0.00
	2200	68.0	0.00
	2300	67.5	0.00
	2359	67.5	0.00
29 Sep	0100	66.9	0.00
	0200	66.4	0.00
	0300	65.8	0.00
	0400	64.9	0.00
	0500	64.2	0.00
	0600	63.0	0.00
	0700	63.0	0.00
	0800	66.9	0.00
	0900	69.8	0.00
	1000	71.6	0.00
	1100	72.3	0.00
	1200	72.0	0.00
	1300	72.0	0.00
	1400	71.8	0.00
	1500	72.7	0.00
	1600	73.8	0.00
	1700	72.5	0.00
	1800	69.6	0.00
	1900	66.0	0.00
	2000	63.0	0.00
	2100	60.8	0.00
	2200	59.7	0.00
	2300	59.5	0.00
	2359	57.7	0.00
30 Sep	0100	55.6	0.00
	0200	54.3	0.00
	0300	53.2	0.00
	0400	53.1	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
30 Sep	0500	52.3	0.00
	0600	51.6	0.00
	0700	52.5	0.00
	0800	58.6	0.00
	0900	63.9	0.00
	1000	65.8	0.00
	1100	68.4	0.00
	1200	71.2	0.00
	1300	72.0	0.00
	1400	72.7	0.00
	1500	72.7	0.00
	1600	72.7	0.00
	1700	71.2	0.00
	1800	69.1	0.00
	1900	68.2	0.14
	2000	62.2	0.13
	2100	61.2	0.01
	2200	61.3	0.05
	2300	60.8	0.00
	2359	60.3	0.00
1 Oct	0100	60.1	0.00
	0200	59.7	0.01
	0300	59.2	0.00
	0400	58.5	0.00
	0500	57.2	0.00
	0600	55.4	0.00
	0700	54.9	0.00
	0800	57.6	0.00
	0900	59.9	0.00
	1000	63.3	0.00
	1100	68.0	0.00
	1200	70.9	0.00
	1300	72.1	0.00
	1400	66.4	0.17
	1500	63.3	0.06
	1600	62.1	0.02
	1700	61.2	0.00
	1800	60.4	0.00
	1900	59.7	0.00
	2000	59.2	0.01
	2100	58.3	0.02
	2200	57.4	0.03
	2300	55.9	0.00
	2359	53.6	0.00
2 Oct	0100	52.5	0.00
	0200	51.4	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
2 Oct	0300	50.4	0.00
	0400	50.0	0.00
	0500	49.5	0.00
	0600	49.6	0.00
	0700	50.2	0.00
	0800	54.1	0.00
	0900	57.0	0.00
	1000	59.0	0.00
	1100	60.8	0.00
	1200	61.2	0.00
	1300	62.2	0.00
	1400	62.8	0.00
	1500	63.0	0.00
	1600	62.8	0.00
	1700	62.2	0.00
	1800	59.0	0.00
	1900	55.6	0.00
	2000	50.2	0.00
	2100	47.8	0.00
	2200	47.3	0.00
	2300	46.6	0.00
	2359	45.5	0.00
3 Oct	0100	45.0	0.00
	0200	44.6	0.00
	0300	44.8	0.00
	0400	46.4	0.00
	0500	48.9	0.00
	0600	49.5	0.00
	0700	50.2	0.00
	0800	55.2	0.00
	0900	59.4	0.00
	1000	63.7	0.00
	1100	66.4	0.00
	1200	68.7	0.00
	1300	69.4	0.00
	1400	69.4	0.00
	1500	69.6	0.00
	1600	69.3	0.00
	1700	67.6	0.00
	1800	64.6	0.00
	1900	60.1	0.00
	2000	57.0	0.00
	2100	54.1	0.00
	2200	53.4	0.00
	2300	53.1	0.00

Date	Time, EST	Avg Temperature, °F	Total Precipitation, in.
3 Oct	2359	53.6	0.00
4 Oct	0100	54.5	0.00
	0200	54.7	0.00
	0300	54.7	0.00
	0400	54.1	0.00
	0500	53.6	0.00
	0600	52.2	0.00
	0700	50.9	0.00
	0800	54.7	0.00
	0900	58.6	0.00
	1000	60.8	0.00
	1100	63.0	0.00
	1200	64.8	0.00
	1300	66.0	0.00
	1400	66.6	0.00
	1500	68.0	0.00
	1600	68.2	0.00
	1700	67.6	0.00
	1800	62.6	0.00
	1900	57.4	0.00
	2000	55.4	0.00
	2100	54.9	0.00
	2200	54.3	0.00
	2300	54.0	0.00
	2359	53.2	0.00

APPENDIX C.   SOIL MOISTURE

Date: 15 Sep 08			
Times: N/A through 1415			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Calibration lanes	0 to 6	N/A	1.7
	6 to 12	N/A	3.4
	12 to 24	N/A	5.4
	24 to 36	N/A	3.7
	36 to 48	N/A	3.7
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 16 Sep 08			
Times: 0700 through 1700			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Calibration lanes	0 to 6	1.7	N/A
	6 to 12	3.4	N/A
	12 to 24	5.3	N/A
	24 to 36	3.7	N/A
	36 to 48	8.4	N/A
Blind grid/moguls	0 to 6	N/A	1.7
	6 to 12	N/A	3.7
	12 to 24	N/A	3.7
	24 to 36	N/A	3.7
	36 to 48	N/A	3.7

Date: 17 Sep 08			
Times: 1000 through 1500			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Calibration lanes	0 to 6	1.7	N/A
	6 to 12	3.1	N/A
	12 to 24	5.4	N/A
	24 to 36	3.7	N/A
	36 to 48	3.7	N/A
Blind grid/moguls	0 to 6	1.6	1.6
	6 to 12	3.7	3.7
	12 to 24	3.7	3.7
	24 to 36	3.7	3.7
	36 to 48	3.7	3.7

Date: 18 Sep 08			
Times: 0700 through 1500			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	1.6	1.6
	6 to 12	3.7	3.7
	12 to 24	3.7	3.7
	24 to 36	3.7	3.7
	36 to 48	3.7	3.7

Date: 19 Sep 08			
Times: 0700 through 1800			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	5.6	5.4
	6 to 12	8.2	8.1
	12 to 24	11.9	11.8
	24 to 36	21.4	21.3
	36 to 48	21.9	21.7
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	1.5	N/A
	6 to 12	3.6	N/A
	12 to 24	3.7	N/A
	24 to 36	3.7	N/A
	36 to 48	3.7	N/A

Date: 20 Sep 08			
Times: 0700 through 1500			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	5.4	5.4
	6 to 12	8.0	7.8
	12 to 24	11.7	11.5
	24 to 36	21.3	21.2
	36 to 48	21.5	21.6
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 22 Sep 08			
Times: 0700 through 1800			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	5.4	5.4
	6 to 12	7.8	7.8
	12 to 24	11.5	11.5
	24 to 36	21.2	21.2
	36 to 48	21.6	21.6
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 23 Sep 08			
Times: 0700 through 1700			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	5.3	5.3
	6 to 12	7.7	7.6
	12 to 24	11.3	11.3
	24 to 36	21.1	21.0
	36 to 48	21.5	21.7
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 24 Sep 08			
Times: 0700 through 1700			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	5.2	5.1
	6 to 12	7.8	7.7
	12 to 24	11.2	11.1
	24 to 36	20.9	20.9
	36 to 48	21.5	21.6
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 25 Sep 08			
Times: 0700 through 1700			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	5.0	5.2
	6 to 12	7.8	7.9
	12 to 24	11.1	11.8
	24 to 36	20.8	21.6
	36 to 48	21.5	21.6
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 26 Sep 08			
Times: 0700 through 1700			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	5.9	5.8
	6 to 12	8.6	8.8
	12 to 24	11.9	12.4
	24 to 36	21.9	21.9
	36 to 48	22.6	22.5
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 27 Sep 08			
Times: 0700 through 1400			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	5.9	5.8
	6 to 12	9.6	9.7
	12 to 24	12.8	12.9
	24 to 36	22.6	22.7
	36 to 48	23.9	23.8
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 29 Sep 08			
Times: 0700 through 1730			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Calibration lanes	0 to 6	3.8	3.7
	6 to 12	3.9	3.9
	12 to 24	6.8	6.7
	24 to 36	5.5	5.4
	36 to 48	4.9	4.9
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 30 Sep 08			
Times: 0700 through 1730			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Calibration lanes	0 to 6	3.6	3.6
	6 to 12	3.7	3.8
	12 to 24	6.6	6.5
	24 to 36	5.3	5.2
	36 to 48	4.8	4.7
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 1 Oct 08			
Times: 0700 through 1730			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	6.8	6.7
	6 to 12	10.8	10.7
	12 to 24	13.7	13.6
	24 to 36	22.5	22.8
	36 to 48	23.6	23.9
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 2 Oct 08			
Times: 0700 through 1730			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	6.9	6.8
	6 to 12	10.8	10.6
	12 to 24	13.9	13.8
	24 to 36	22.7	22.8
	36 to 48	23.6	23.9
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

Date: 3 Oct 08			
Times: 0700 through 1730			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	2.3	2.3
	6 to 12	3.8	3.7
	12 to 24	3.9	3.9
	24 to 36	5.2	5.1
	36 to 48	5.7	5.9

Date: 4 Oct 08			
Times: 0700 through 1330			
Probe Location:	**Layer, in.**	**AM Reading, %**	**PM Reading, %**
Wet area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Wooded area	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Open area	0 to 6	6.5	6.5
	6 to 12	10.8	10.7
	12 to 24	13.6	13.6
	24 to 36	22.4	22.2
	36 to 48	23.7	23.6
Calibration lanes	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A
Blind grid/moguls	0 to 6	N/A	N/A
	6 to 12	N/A	N/A
	12 to 24	N/A	N/A
	24 to 36	N/A	N/A
	36 to 48	N/A	N/A

APPENDIX D. DAILY ACTIVITY LOGS

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status - Comments	Track Method	Pattern	Field Conditions	
9/15/2008	3	CALIBRATION LANES	915	1200	165	INITIAL SET-UP	INITIAL MOBILIZATION	GPS	LINEAR	SUNNY	MUDDY
9/15/2008	3	CALIBRATION LANES	1200	1240	40	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/15/2008	3	CALIBRATION LANES	1240	1300	20	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHANGE BATTERY	GPS	LINEAR	SUNNY	MUDDY
9/15/2008	3	CALIBRATION LANES	1300	1505	125	COLLECTING DATA	COLLECT DATA 1 METER LINE SPACING	GPS	LINEAR	SUNNY	MUDDY
9/15/2008	3	CALIBRATION LANES	1505	1520	15	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/15/2008	3	CALIBRATION LANES	1520	1530	10	DOWNTIME	DOWNLOAD DATA	GPS	LINEAR	SUNNY	MUDDY
9/15/2008	3	CALIBRATION LANES	1530	1600	30	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	CALIBRATION LANES	750	900	70	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	CALIBRATION LANES	900	910	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	CALIBRATION LANES	910	1120	130	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	CALIBRATION LANES	1120	1140	20	DOWNTIME DUE TO EQUIP MAINT/CHECK	DATA CHECK	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	BLIND TEST GRID	1140	1205	25	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	BLIND TEST GRID	1205	1215	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	BLIND TEST GRID	1215	1325	70	COLLECTING DATA	COLLECT DATA 3/4 METER LINE SPACING	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	BLIND TEST GRID	1325	1350	25	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHANGE BATTERY	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	BLIND TEST GRID	1350	1405	15	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	BLIND TEST GRID	1405	1535	90	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	BLIND TEST GRID	1535	1550	15	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	CALIBRATION LANES	1550	1640	50	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status - Comments	Track Method	Pattern	Field Conditions	
9/16/2008	3	CALIBRATION LANES	1640	1650	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/16/2008	3	CALIBRATION LANES	1650	1705	15	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	CALIBRATION LANES	750	830	40	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	CALIBRATION LANES	830	840	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	CALIBRATION LANES	840	935	55	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	CALIBRATION LANES	935	955	20	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	955	1220	145	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	1220	1235	15	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHANGE BATTERY	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	1235	1310	35	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	1310	1330	20	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	1330	1515	105	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	1515	1535	20	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHANGE BATTERY	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	1535	1630	55	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	1630	1645	15	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/17/2008	3	BLIND TEST GRID	1645	1710	25	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	BLIND TEST GRID	745	815	30	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	BLIND TEST GRID	815	830	15	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	BLIND TEST GRID	830	1125	175	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	BLIND TEST GRID	1125	1135	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DATA CHECK	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	BLIND TEST GRID	1135	1215	40	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status - Comments	Track Method	Pattern	Field Conditions	
9/18/2008	3	BLIND TEST GRID	1215	1235	20	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	BLIND TEST GRID	1235	1245	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	BLIND TEST GRID	1245	1435	110	COLLECTING DATA	COLLECT DATA	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	BLIND TEST GRID	1435	1450	15	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	CALIBRATION LANES	1450	1520	30	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	CALIBRATION LANES	1520	1530	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/18/2008	3	CALIBRATION LANES	1530	1550	20	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	BLIND TEST GRID	740	825	45	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	BLIND TEST GRID	825	835	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	BLIND TEST GRID	835	900	25	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	OPEN FIELD	900	910	10	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	OPEN FIELD	910	1250	220	COLLECTING DATA	COLLECTING DATA, INDIRECT FIRE 3/4 METER LINESPACING	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	OPEN FIELD	1250	1300	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	OPEN FIELD	1300	1325	25	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHANGE BATTERY	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	OPEN FIELD	1325	1335	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	OPEN FIELD	1335	1530	115	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	OPEN FIELD	1530	1540	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/19/2008	3	OPEN FIELD	1540	1605	25	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/20/2008	3	OPEN FIELD	745	825	40	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/20/2008	3	OPEN FIELD	825	835	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status - Comments	Track Method	Pattern	Field Conditions	
9/20/2008	3	OPEN FIELD	835	1330	295	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/20/2008	3	OPEN FIELD	1330	1350	20	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/22/2008	3	OPEN FIELD	745	850	65	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/22/2008	3	OPEN FIELD	850	900	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/22/2008	3	OPEN FIELD	900	1250	230	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/22/2008	3	OPEN FIELD	1250	1300	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/22/2008	3	OPEN FIELD	1300	1340	40	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
9/22/2008	3	OPEN FIELD	1340	1420	40	DOWNTIME DUE TO EQUIP MAINT/CHECK	DATA CHECK	GPS	LINEAR	SUNNY	MUDDY
9/22/2008	3	OPEN FIELD	1420	1640	140	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/22/2008	3	OPEN FIELD	1640	1700	20	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/23/2008	3	OPEN FIELD	740	820	40	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/23/2008	3	OPEN FIELD	820	840	20	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/23/2008	3	OPEN FIELD	840	1255	255	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/23/2008	3	OPEN FIELD	1255	1325	30	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
9/23/2008	3	OPEN FIELD	1325	1330	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHANGE BATTERY	GPS	LINEAR	SUNNY	MUDDY
9/23/2008	3	OPEN FIELD	1330	1645	195	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/23/2008	3	OPEN FIELD	1645	1650	5	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/23/2008	3	OPEN FIELD	1650	1705	15	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/24/2008	3	OPEN FIELD	740	825	45	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/24/2008	3	OPEN FIELD	825	835	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status - Comments	Track Method	Pattern	Field Conditions	
9/24/2008	3	OPEN FIELD	835	1200	205	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/24/2008	3	OPEN FIELD	1200	1210	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/24/2008	3	OPEN FIELD	1210	1220	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHANGE BATTERY	GPS	LINEAR	SUNNY	MUDDY
9/24/2008	3	OPEN FIELD	1220	1250	30	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
9/24/2008	3	OPEN FIELD	1250	1640	230	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/24/2008	3	OPEN FIELD	1640	1645	5	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/24/2008	3	OPEN FIELD	1645	1700	15	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	740	800	20	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	800	810	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	810	1005	5	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	1005	1015	10	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	1015	1225	130	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	1225	1230	5	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	1230	1235	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	CHANGE BATTERY	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	1235	1250	15	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
9/25/2008	3	OPEN FIELD	1250	1555	185	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	RAINY	MUDDY
9/25/2008	3	OPEN FIELD	1555	1605	10	CALIBRATION	CALIBRATION	GPS	LINEAR	RAINY	MUDDY
9/25/2008	3	OPEN FIELD	1605	1625	20	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	RAINY	MUDDY
9/26/2008	3	OPEN FIELD	750	820	30	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	RAINY	MUDDY
9/26/2008	3	OPEN FIELD	820	830	10	CALIBRATION	CALIBRATION	GPS	LINEAR	RAINY	MUDDY
9/26/2008	3	OPEN FIELD	830	1200	210	COLLECTING DATA	COLLECTING DATA	GPS	LINEAR	RAINY	MUDDY
9/26/2008	3	OPEN FIELD	1200	1225	25	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	RAINY	MUDDY
9/26/2008	3	OPEN FIELD	1225	1250	25	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	RAINY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status - Comments	Track Method	Pattern	Field Conditions	
9/26/2008	3	OPEN FIELD	1250	1300	10	CALIBRATION	CALIBRATION	GPS	LINEAR	RAINY	MUDDY
9/26/2008	3	OPEN FIELD	1300	1600	180	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	RAINY	MUDDY
9/26/2008	3	OPEN FIELD	1600	1610	10	CALIBRATION	CALIBRATION	GPS	LINEAR	RAINY	MUDDY
9/26/2008	3	OPEN FIELD	1610	1625	15	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	745	820	35	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	820	830	10	CALIBRATION	CALIBRATION	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	830	1150	200	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	1150	1205	15	CALIBRATION	CALIBRATION	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	1205	1235	30	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	1235	1240	5	CALIBRATION	CALIBRATION	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	1240	1420	100	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	1420	1425	5	CALIBRATION	CALIBRATION	GPS	LINEAR	RAINY	MUDDY
9/27/2008	3	OPEN FIELD	1425	1435	10	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	RAINY	MUDDY
09/30/08	3	OPEN FIELD	1430	1610	100	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
09/30/08	3	OPEN FIELD	1610	1630	20	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	SUNNY	MUDDY
09/30/08	3	OPEN FIELD	1630	1640	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
09/30/08	3	OPEN FIELD	1640	1700	20	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
10/01/08	3	OPEN FIELD	750	820	30	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
10/01/08	3	OPEN FIELD	820	825	5	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
10/01/08	3	OPEN FIELD	825	1200	215	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	SUNNY	MUDDY
10/01/08	3	OPEN FIELD	1200	1210	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status - Comments	Track Method	Pattern	Field Conditions	
10/01/08	3	OPEN FIELD	1210	1245	35	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
10/01/08	3	OPEN FIELD	1245	1505	140	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	SUNNY	MUDDY
10/01/08	3	OPEN FIELD	1505	1510	5	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
10/01/08	3	OPEN FIELD	1510	1550	40	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
10/02/08	3	OPEN FIELD	750	805	15	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
10/02/08	3	OPEN FIELD	805	815	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
10/02/08	3	OPEN FIELD	815	1310	295	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	SUNNY	MUDDY
10/02/08	3	OPEN FIELD	1310	1330	20	BREAK/LUNCH	BREAK/LUNCH	GPS	LINEAR	SUNNY	MUDDY
10/02/08	3	OPEN FIELD	1330	1340	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
10/02/08	3	OPEN FIELD	1340	1635	175	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	SUNNY	MUDDY
10/02/08	3	OPEN FIELD	1635	1645	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
10/02/08	3	OPEN FIELD	1645	1710	25	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	LINEAR	SUNNY	MUDDY
10/04/08	3	OPEN FIELD	750	810	815	DAILY START, STOP	SET UP EQUIPMENT	GPS	LINEAR	SUNNY	MUDDY
10/04/08	3	OPEN FIELD	810	820	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
10/04/08	3	OPEN FIELD	820	1240	260	COLLECTING DATA	COLLECTING DATA DIRECT FIRE	GPS	LINEAR	SUNNY	MUDDY
10/04/08	3	OPEN FIELD	1240	1250	10	CALIBRATION	CALIBRATION	GPS	LINEAR	SUNNY	MUDDY
10/04/08	3	OPEN FIELD	1250	1345	55	DEMOBILIZATI ON	DEMOBILIZATI ON	GPS	LINEAR	SUNNY	MUDDY

APPENDIX E.   REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

4. Yuma Proving Ground Soil Survey Report, May 2003.

APPENDIX F. ABBREVIATIONS

AOL	=	advanced ordnance locator
APG	=	Aberdeen Proving Ground
ATC	=	U.S. Army Aberdeen Test Center
BAH	=	Booz Allen Hamilton
BAR	=	background alarm rate
BUD	=	Berkeley UXO discriminator
DAQ	=	data acquisition
DMM	=	discarded military munitions
DPRT	=	Duke Pattern Recognition Toolbox
EM	=	electromagnetic
EM/MAG	=	electromagnetic/magnetometer
EMI	=	electromagnetic induction
EQT	=	Army Environmental Quality Technology Program
EQT	=	Environmental Quality Technology Program
ERDC	=	U.S. Army Corps of Engineers Engineering Research and Development Center
ESTCP	=	Environmental Security Technology Certification Program
FOM	=	figure of merit
GPS	=	Global Positioning System
GS	=	Geosoft Script
GT	=	ground truth
GX	=	Geosoft Executable
HEAT	=	high-explosive antitank
IDA	=	Institute for Defense Analysis
JPG	=	Jefferson Proving Ground
MM	=	military munitions
NAVSEA	=	Naval Sea Systems Command
NS	=	nonstandard munition
POC	=	point of contact
QA	=	quality assurance
QC	=	quality control
ROC	=	receiver-operating characteristic
RTK	=	real-time kinematic
S	=	standard munition
SERDP	=	Strategic Environmental Research and Development Program
SNR	=	signal-to-noise ratio
TEM	=	time-gated electromagnetic
USAEC	=	U.S. Army Environmental Command
UXO	=	unexploded ordnance
YPG	=	U.S. Army Yuma Proving Ground

APPENDIX G.   DISTRIBUTION LIST

DTC Project No. 8-CO-160-UXO-021

Addressee	No. of Copies
Commander U.S. Army Aberdeen Test Center ATTN: TEDT-AT-SLE (Mr. J. Stephen McClung) 400 Colleran Road Aberdeen Proving Ground, MD 21005-5059	1
Commander U.S. Army Environmental Command ATTN: IMAE-RTA (Ms. Kimberly Watts) 314 Longs Corner Road Aberdeen Proving Ground, MD 21010-5401	1
Booz Allen Hamilton ATTN: Mr. Patrick McDonnell 4692 Millennium Drive, Suite 200 Belcamp, MD 21017-1535	1
G&G Sciences, Inc. ATTN: Mr. Skip Snyder 1 23 Road Grand Junction, CO 81505	
Defense Technical Information Center 8725 John J. Kingman Road, Suite 0944 Fort Belvoir, VA 22060-6218	PDF

Secondary distribution is controlled by Commander, U.S. Army Environmental Command, ATTN: IMAE-RTA.