Appendix I

Final

Geophysical Prove-Out Work Plan

Final
Geophysical Prove-Out Work Plan

for

MEC Removal Action
Bains Gap
Fort McClellan, Alabama

Task Order 0004

Contract Number: W912DY-04-D-0011

Prepared For:

U.S. Army Engineering and Support Center
Huntsville, Alabama

Prepared By:
Tetra Tech EC INC.

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LIST OF ACRONYMS

CEHNC	United States Army Engineering and Support Center, Huntsville
EM	Electromagnetic
Ft	Feet
DGPS	Differential Global Positioning System
DID	Data Item Description
GPO	Geophysical Prove-Out
Mv	Millivolts
OE	Ordnance and Explosives
PCMCIA	P.C. Memory Card International Association
PLS	Professional land surveyor
QA	Quality Assurance
QC	Quality Control
RTS	Robotic Total Station
TDEM	Time Domain Electromagnetic
UXO	Unexploded Ordnance

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Arthur B. Holcomb P.E.
Program Manager

1.0 GPO PLAN

The United States Army Engineering and Support Center Huntsville (CEHNC) has contracted Tetra Tech EC Inc. (TtEC), under Contract W912DY-04-D-0011, to perform a Geophysical Prove-Out (GPO) at Fort McClellan located in Anniston, Alabama. It is anticipated that the GPO task will be performed in November of 2005 in order to support the Bains Gap Removal Action (RA).

The objective of the GPO is to demonstrate and document the performance of the data acquisition methodology and spatial sampling protocols, sensor(s) and positioning equipment, data analysis and management systems, data transfer procedures, and the geophysical Quality Control (QC) and Quality Assurance (QA) system. The following components of the geophysical system will be evaluated during the GPO field program to ensure the program objectives will be met:

- Spatial sample density (i.e., line and station spacing)
- Navigation and positioning methodologies
- Sensor and positioning system platform (stability, noise characteristics and ergonomics)
- Data processing, analysis and interpretation, management and transfer system
- Quality Assurance (QA) Control, documentation protocol for data acquisition, processing and analysis and data management and transfer
- The personnel that are going to perform the production geophysical surveyto ensure their ability to meet the data quality objectives.

1.1 TEST PLOT DESIGN

TtEC constructed a test area at Fort McClellan in August of 2002. This test area has been modified several times, as it has served as a testing area for over three years. In addition to performing GPO's at the test area, TtEC has used the test area to perform quality control and assurance functions following changes in equipment, changes in field personnel, and operational procedures. The following document will refer to the construction of the existing GPO plot and summarize the actions to be performed during the upcoming GPO for the Bains Gap RA.

1.1.1 Prove-out Size and Location

The existing GPO area is located near the scrap yard off Bains Gap Road (Appendix B Figure B-1). The site is representative of the physical environment to be encountered during geophysical operations during the RA. The area contains two separate test areas; one area is "open" (Test Grid 1) and a dense, wooded area with foliage characterizes Test Grid 2. The wooded area obstructions, trees, and foliage in Test Grid 2 are similar to those to be found in the area of concern near Bains Gap.

Test Grid 1 (center) and Test Grid 2 (right edge of photo)

Fence near Test Grid 1

A fence is located approximately 30 feet from the northern side of the GPO test plot, as seen in the photo above. This will allow our geophysicist to determine if signal interference from this cultural feature adversely affects the geophysical sensors or positioning equipment.

1.1.2 Seed Items

The seed items buried at the existing GPO are presented in Appendix A, Table A-1. The seed items are representative of the items that might be encountered during the Bains Gap project. There are fifty inert MEC items buried at depths that range from several inches to several feet (ft). The corner points of Test Grid 1 and Test Grid 2 are demarcated with rebar.

Representative GPO seed items

1.2 SITE PREPARATION

1.3 LOCATION SURVEYING

TtEC constructed Test Grids 1 and 2 near Bains Gap in August 2002 to meet the requirements of Data Item Description (DID) OE-005-05A.01. The existing GPO remains in accordance with DID Munitions Response (MR) 005-05A. The grid corners for each test grid were located using a high resolution Leica Robotic Total Station (RTS) survey instrument. The control points used for the RTS location survey were developed from pre-existing site monuments, which were established using a Differential Global Positioning System (DGPS) operated by a professional land surveyor (PLS). The PLS was used to determine and/or verify the position of all Test Grid corner points and seed items. Measurements of the seeded items were performed in accordance with DID MR-005-05A.

1.4 BACKGROUND GEOPHYSICAL MAPPING

The background geophysical survey data for the existing GPO are presented in Appendix B, Figure B-2.

1.5 QUALITY CONTROL

TtEC-specific instrument and functional checks will be performed at the beginning and end of every data acquisition session for the GPO survey. The TtEC test regimen includes the following:

- Acquisition personnel metal check (ensure no metal on acquisition personnel);
- Static position system check (accuracy and repeatability of position – 0.25 ft tolerance);
- Static “background” geophysical sensor check (repeatability of geophysical sensor measurements, influence of ambient noise – +- 2.5 mV tolerance, c2_660 time gate (timegate 3));
- Static “spike” geophysical sensor check (repeatability of geophysical sensor measurements when metal object (i.e. trailer hitch ball) is present – within 20 % of standard response, c2_660 time gate);
- Kinematic geophysical sensor check with test item (repeatability and comparability of measurements with sensor in motion) – aka TtEC “cloverleaf” or “rebar” test – align samples to 0.5 ft tolerance;
- Repeatability of overall data (re-survey of portion of the survey area during each data acquisition session - ensure background removal is within +-2 mV, and repeatability of peak anomaly intensity within 20 % when position within 0.25 ft); and

- Occupation (kinematic) of known survey control (e.g., grid corners) during the acquisition session to ensure comparability, accuracy, and repeatability of the positioning systems (1 ft tolerance).

In addition to the above tests, an array of required tests will be performed at the commencement of the GPO program. The specific tests and their intervals are specified in DID MR-005-05. The tests include an equipment warm up, verification of sensor offset, personnel test, vibration (cable shake) test, static background and static spike test, height of sensor optimization, six line test, and collection of repeat data. As a quality control function, the GPO area will be used to validate significant changes in operational procedures, as well as changes in equipment, personnel or objectives. The test procedures outlined will be digitally documented and delivered to the client.

All field team members involved in data collection during the RA will be involved with data collection during the GPO to document their ability and efficiency to collect geophysical data as per the standards set forth in DID MR-005-05.

1.5.1 Equipment Warm-up

The geophysical sensor will be turned on and allowed to run for a minimum of five minutes prior to collecting data.

1.5.2 Record Sensor Position

The distance between the geophysical sensor and ground surface will be measured and recorded, as well as the offset between the positioning system detector and the geophysical sensor.

1.5.3 Personnel Test

Field team leaders will be accountable for and ensure that there is no metal (e.g., rings, chains, earrings, knives, wallets, belt buckles, et.) residing on personnel immediately prior to data acquisition activities.

1.5.4 Vibration Test (Cable Shake)

All cables will be shook in a manner simulating walking in rough terrain. Excessive noise induced from this test will be recorded and the appropriate corrective action(s) implemented (e.g., replace equipment cable, tighten connector, use tension relief device, etc.).

1.5.5 Static Background and Static Spike

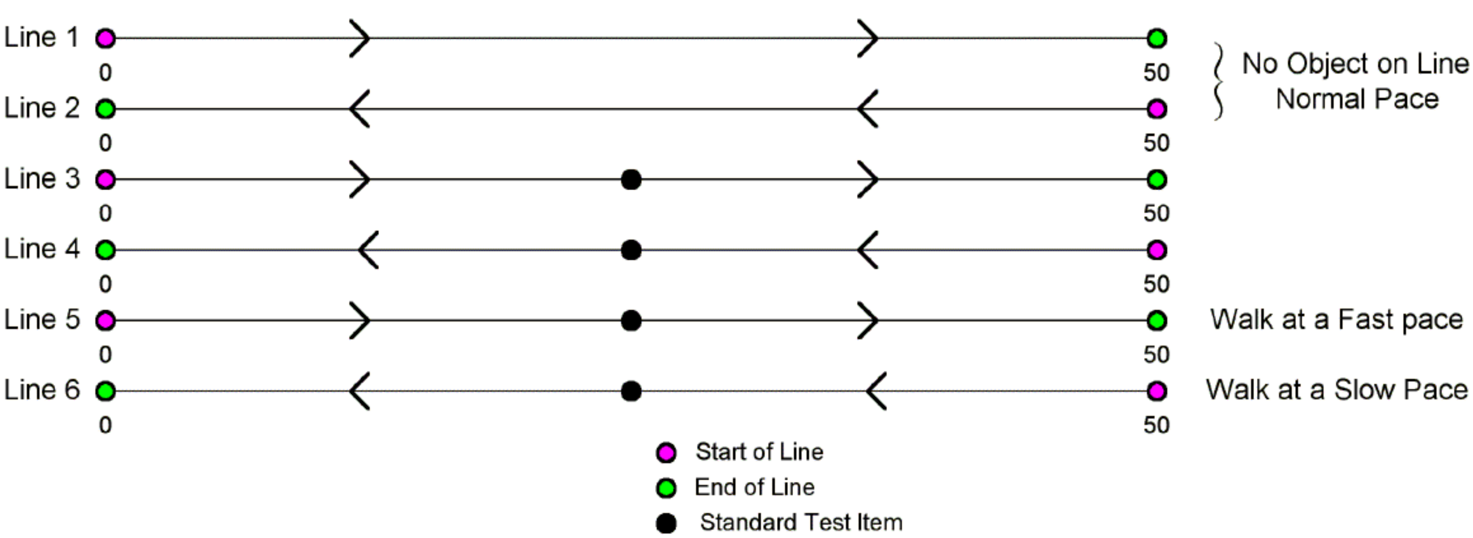
The static test involves locating the instrument over a "geophysically quiet" area and recording data for a minimum of three minutes, then placing a steel ball under the instrument and recording an additional three minutes of data.

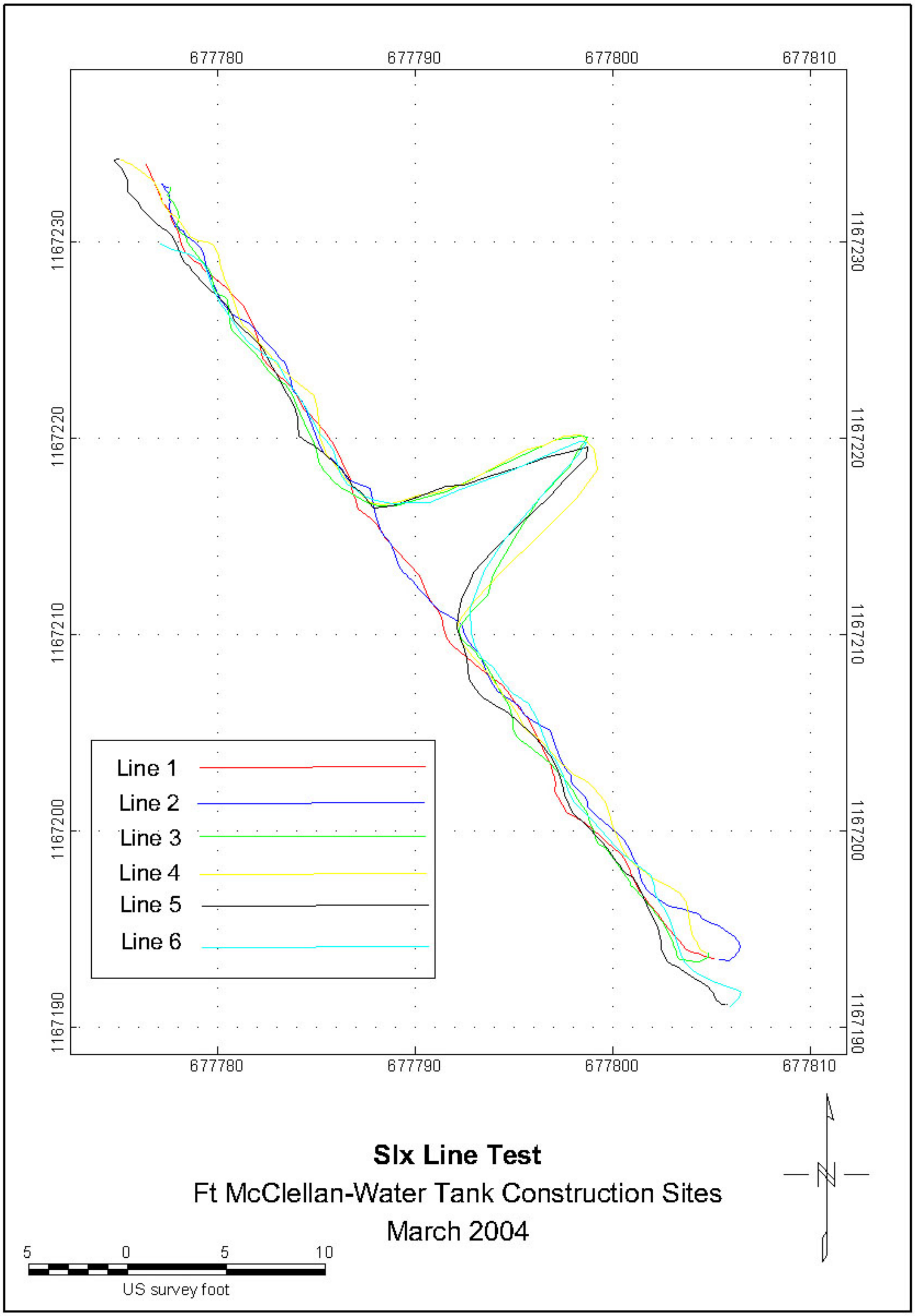
1.5.6 Height Optimization

The data acquired at the GPO area will be used to ensure the sensor can reliably detect the smallest MEC item at the required depth. If necessary, the sensor distance above the ground will be decreased in order to meet this objective, while still maintaining an acceptable level of "noise" in the data.

1.5.7 Six Line Test

The six-line test involves collecting data along a one dimensional profile line six times. The purpose of the line test is to determine "noise" due to system movement/motion as well as potential location errors due to factors associated with system timing. For the first two line paths (1 and 2), data are collected along the line in opposite directions at a normal walking pace with no test item present. A steel ball (or equivalent) is then placed a known location on the path, and data collected along the line in equivalent manner to the first two lines (3 and 4). For the last two line paths, data are collected in one direction at a slow pace, and in the opposite direction at a faster pace (5 and 6). An example of the six-line test is presented in the following.





Six-line test data

1.5.8 Repeat Lines

At the end of each data acquisition session, the first line path will be repeated, or a diagonal path will be traversed across the grid that terminates at the start or end of the first line path.

1.6 ANOMALY AVOIDANCE

Anomaly avoidance techniques were used prior to placing wooden stakes and rebar at each corner and mid point of the test grids at the GPO area.

1.7 SEEDING

The inert MEC items presently located in Test Grid 1 at the GPO area are specified in Table A-1. These items were provided by CEHNC and were buried by TtEC personnel. All of the seeded items are inert MEC and painted blue and tagged with a non-biodegradable label identifying the item as inert and providing a reference of contact information. The following procedures were performed to seed Test Grid 1:

1. Inert items were labeled and photographed prior to burial.

2. Holes were dug with a shovel and/or a small backhoe.

3. The seed items were placed in the respective hole and the depth measured to the top of each item using a metal bar placed across the hole at ground level for reference. For larger seed items (e.g., 2.36 inch rocket) the depth was measured at the nose, tail and center point.

4. The location of the centroid of each item was then determined by using a high-resolution laser-based positioning system (Arc Second Constellation).

Location survey of a seed item in the open hole (Constellation)

5. The items were buried with one end of the metal bar on the item, and the dirt replaced in the hole. The metal bar was then removed..

1.8 DATA COLLECTION VARIABLES

Based on our previous experience at numerous UXO sites including Ft. McClellan, the EM61 MK2 TDEM geophysical sensor exhibits the greatest potential to meet the project objectives. Based on the physical features present at the area of interest, laser-based positioning methods (RTS and Constellation) have the highest probability of providing accurate coordinate locations for the geophysical measurements.

1.8.1 EM61 MK2

The Geonics Limited EM61 MK2 utilizes two coaxial receiver coils to measure the residual magnetic field generated by conductive and/or magnetic materials. The sensor electronics are designed to measure the residual magnetic field at a time when the response from conductive and/or magnetic objects is maximized, compared to the response from most earth materials. The use of two receiver coils also makes it possible to differentiate, in a simplistic fashion, shallow versus deep objects. An additional benefit of the specific design of the EM61 MK2 system is that it permits a more focused observation of the subsurface in areas of cultural interference, as well as in areas characterized by a high spatial density of subsurface metal objects. This is due to the mechanical design and operational parameters of the instrument, as well as the inherent nature of active electro-magnetic (EM) fields, which diminish in magnitude at a much higher rate than other sensor technologies such as magnetometry.

The EM61 MK2 utilizes multiple time-gates centered at 216, 366, 660, and 1,266 µs. The signal intensity for a given ferrous target recorded by the earlier time-gates is generally a factor of 2 to 4 times that recorded by the standard EM61 MK1 time-gate. This feature facilitates a more reliable and repeatable interpretation of smaller targets such as 37mm projectiles.

1.8.2 RTS

The Leica Geosystems 1105 or 1200 RTS is a laser-based positioning system that utilizes line-of-site to accurately determine the position of a 360-degree prism that is mounted at a known offset from the geophysical sensor. The RTS continuously records the position of the prism at a rate of approximately 3-4 Hz as it is transported across the area of interest. Coordinate and time of measurement data are stored on a PCMCIA device on the RTS, and uploaded to the processing computer a minimum of once per day.

1.8.3 Constellation

The Arc Second Constellation is a laser-based positioning system that consists of four laser transmitters and a field computer for logging the position data via wireless modem. Four

Trimble Spectra Precision LS920 Laser Transmitters are positioned in a diamond or square geometry over 1/4 to 1 acre depending upon the density of obstacles present (e.g., trees). The transmitters are leveled, and an automatic routine calculates the relative x-y-z- plane between the transmitters to a tolerance of one inch or less. A laser detector "wand" (i.e., receiver) is centered over the EMII MK2 coils on a TtEC-designed fiberglass "doghouse" (or equivalent). The detector wand receives the laser pulses from the four transmitters simultaneously, and computes a position based on the known position of the laser transmitters. Only two of the laser transmitters are necessary to compute a reliable position to a relative accuracy of approximately one inch. The position data are updated at 2-3 Hz and sent via wireless modem to the field computer for storage and display.

1.8.4 Sensor Configurations

Due to the physical features present in the area of interest, the EM61 MK2 geophysical sensor will be integrated with the RTS and Constellation positioning systems. Based on our past site-specific experience at Fort McClellan, the RTS is the preferred positioning system in generally "open" areas, and the Constellation will provide positioning in the parcels at the site that are moderate to densely wooded. Based on past testing performed in the Bains Gap area by TtEC in 2001, DGPS is not the preferred positioning method (even in generally "open" areas) due to the presence of tall trees at the borders of the survey area, which degrade the GPS satellite signals.

The specific system configurations that will be tested at the existing GPO grid include the following:

GPO Instrument Configurations

Instrument	Coils	Time Gates	Positioning	Line Spacing (ft.)
EM61 MK2	1m by 1m	216 µs, 366 µs, 660 µs	Constellation	~2.5
EM61 MK2	1m by 1m	216 µs, 366 µs, 660 µs	RTS	~2.5

The physical features present at Test Grid 1 are representative of the "open" areas at the Bains Gap area of interest, and this area will be used to prove-out the EM61 MK2 and the RTS positioning system. A Juniper Allegro data recorder will be used to record the EM61 MK2 measurements at a rate of 12-15 Hz, and the RTS will be configured to record position measurements at a rate of approximately 3-4 Hz. The spacing between adjacent data acquisition transects will be ~ 2.5 ft.

The physical features present at Test Grid 2 (i.e., woods) will be used to validate the positioning accuracy of the Constellation system; a secondary objective at Test Grid 2 is to ensure that the data acquisition platform (i.e., integrated EM61 MK2 and Constellation system electronics) are integrated to record measurements that can meet the project objectives. Placing several metal items on the ground surface at known locations, and collecting geophysical data over the entire area will validate the Constellation positioning system for project use. A Juniper Allegro data recorder will be used to record the EM61 MK2 measurements at a rate of 12-15 Hz, and the Constellation will be configured to record position measurements at a rate of approximately 3-4 Hz. The spacing between adjacent data acquisition transects will be ~ 2.5 ft.

The EM61 MK2 lower coil height will be adjusted so that it remains at a height of 16 inches (+-1 inch) above the ground surface. The height of the lower coil will be measured prior to each data acquisition session to ensure repeatability between different team members and different data acquisition sessions.

The man-portable (MP) “skirt” mode will be used during the GPO. In the TtEC man-portable configuration, two operators will be used to collect the geophysical data. One person transports the EM61 MK2 coils and positioning system detector while the other person, walking approximately ten ft behind, carries the EM61 MK2 electronics, Juniper Allegro data recorder, and the positioning system electronics (there are no electronics for the RTS configuration). The positioning system detector will be centered above the EM61 MK2 coils for both the RTS and Constellation system configurations.

1.9 DATA ANALYSIS AND INTERPRETATION

Geophysical measurements and position data will be stored on digital media during data acquisition. After acquisition over the test grid is complete, data will be transferred to the site-processing center for initial data processing and evaluation. A TtEC geophysicist will perform preliminary geophysical and position data processing and QC checks in the field. The final analysis and interpretation of the data will be performed at a centralized processing center located at the TtEC Lakewood, Colorado or at the on-site TtEC field office. Processing, QC, analysis and interpretation of the data will be performed with internally developed software that has been specifically produced to integrate and assess digital geophysical data acquired with the RTS and Constellation positioning systems. These processed data are output to Geosoft Oasis Montaj Mapping software (version 6.2) to create color-coded images of sensor intensity for interpretation. All data channels of the EM61 MK2 will be analyzed to ensure the most comprehensive data interpretation.

In general, the post processing that will be performed includes removal of instrument bias, removal of timing errors (i.e., lag), and removal of geophysical sensor drift. Data will be recorded or transferred into the requested coordinate system (State plane zone Alabama North, NAD83). All data processing parameters are stored in digital files (*.chk) or in the Oasis Montaj log file (*.log).

Data will be interpreted at the processing center and a Microsoft Excel digsheet generated that is compatible with DID MR-005-05. This digsheet will be provided to the client project team for evaluation and scoring. The digsheet will also be provided to reacquisition personnel along with a color-coded image of sensor intensity for the target reacquisition phase of the GPO.

1.10 REACQUISITION

The TtEC reacquisition team will perform reacquisition of the interpreted geophysical anomalies using the digsheet. The RTS and Constellation positioning systems will be used by reacquisition personnel to validate both of these systems for project use. A hand held sensor (Vallon VMH3C, Minelab Explorer) or equivalent will be used by personnel to pinpoint the target specified on the digsheet, and these coordinates will be stored by the respective positioning system and/or recorded on the digsheet. The coordinates of the reacquired position will be compared to the interpreted coordinates on the digsheet to ensure the requirements in DID MR-005-005 are achieved; the requirement states that 95% of the reacquired locations shall fall within 1 meter of the target location as specified by the interpreter on the digsheet.

The Vallon and Minelab hand held TDEM systems use the same electronic technology as the EM61 MK2 system.

1.11 DATA EVALUATION

Data will be evaluated with respect to the number of seed items detected by each instrument configuration, production rate, and equipment reliability, functionality overall ease of use. The spatial sample density and "noise" level of each instrument configuration will be evaluated to ensure the data are of sufficient quantity and quality to meet the project objectives. Based on our past experience and the project objectives, the distance between adjacent acquisition tracks should not exceed 3.3 ft, and the kinematic "noise" level for the c2_660 time gate (time gate 3) should be less than 4 mV (peak to peak) in "background" areas.

2.0 GPO LETTER REPORT

2.1 DELIVERABLES

The results of the GPO will be submitted in the GPO letter report in tabular and graphical form. The GPO Letter report will include, at a minimum, the following information:

- As-built drawing of the GPO plot;
- Pictures of the seed items;
- Color maps of the geophysical data;
- Summary of the GPO results;
- Proposed geophysical equipment, techniques, and methodologies; and
- Sufficient supporting information to justify the project team's recommendations, including manufacturer specifications for all recommended geophysical equipment, a definition of the expected target anomalies based upon the Archives Search Report, Site Inspection Report, Remedial Investigation/Feasibility Study or Engineering Evaluation/Cost Analysis results, or any other pertinent data/information used in decision making.

A CD shall be delivered with the letter report containing the following files:

- The GPO Letter Report (Microsoft Word format);
- All raw and processed geophysical data. All data, except raw instrument data, shall be provided in column delineated ASCII files in the format x, y, z, v1, v2, etc., where x and y are State Grid Plane Coordinates in Easting (meters) and Northing (meters) directions, z (elevation) is an optional field in meters, and v1, v2, v3, etc., are the instrument readings. The last data field will be a time stamp. Each data field will be separated by a comma or tab.
- Geophysical maps in their native format (Surfur®, Geosoft Oasis montaj™, Intergraph, or ESRI ArcView format) and/or as raster bit-map images such as BMP, JPEG, TIFF or GIF;
- Seed item location spreadsheet (Microsoft Excel format);
- Spreadsheet (Microsoft Excel format) of contractor picks for each sensor type, including reacquisition; and
- Spreadsheet (Microsoft Excel format) of all control points, survey points and benchmarks established or used during the Location Surveying task.

- The GPO Letter Report and Contracting Officer Approval Letter shall be included in geophysical reports and work plans associated with the survey area.

APPENDIX A
TABLES

TABLE A-1: GEOPHYSICAL PROVE-OUT SEED ITEMS - Test Grid 1

X	Y	Target ID	Item	Depth(in)	Inclination
677699.94	1167164.58	a1	37mm	4.00	Horizontal
677708.37	1167173.14	a2	37mm	4.00	Vertical
677719.73	1167188.12	a3	81mm	34.00	Horizontal
677721.10	1167175.99	a4	2.36" rocket	26.00	Horizontal
677730.10	1167179.32	a5	rocket motor	12.00	Horizontal
677723.37	1167167.69	a6	37mm	16.00	Horizontal
677735.00	1167169.03	a7	60mm	12.00	Vertical
677735.62	1167156.66	a8	MKII HG	8.00	Vertical
677745.30	1167155.03	a9	2.36" rocket	6.00	Vertical
677743.41	1167136.92	a10	Anti Tank Mine	6.00	Horizontal
677726.67	1167132.67	a11	60mm	6.00	Vertical
677718.25	1167118.37	a12	MKII HG	4.00	Horizontal
677719.58	1167146.36	a13	37mm	0.00	Horizontal
677688.23	1167097.99	a14	3 "stokes	20.00	Horizontal
677704.27	1167108.58	a15	3 "stokes	32.00	Horizontal
677694.61	1167113.24	a16	75mm	30.00	Horizontal
677709.18	1167133.61	a17	60mm	25.00	45 degrees
677691.87	1167128.25	a18	75mm	12.00	Vertical
677681.35	1167118.85	a19	MKII HG	14.00	Horizontal
677673.49	1167132.86	a20	75mm	18.00	45 degrees
677666.45	1167141.88	a21	37mm	4.00	45 degrees
677680.90	1167152.03	a22	slap flare	4.00	45 degrees
677706.20	1167151.98	a23	105mm	45.00	45 degrees
677753.84	1167216.57	a24	37mm	4.00	Horizontal
677765.13	1167208.06	a25	37mm	4.00	Vertical
677771.70	1167196.19	a26	81mm	17.00	Horizontal
677771.95	1167190.79	a27	2.36" rocket	26.00	Horizontal
677781.41	1167187.60	a28	rocket motor	12.00	Horizontal
677794.28	1167178.14	a29	37mm	16.00	Horizontal
677775.16	1167162.11	a30	60mm	12.00	Vertical
677767.82	1167173.71	a31	MKII HG	8.00	Vertical
677763.33	1167167.94	a32	2.36" rocket	6.00	Vertical
677750.42	1167179.97	a33	60mm	6.00	Horizontal
677756.51	1167195.77	a34	60mm	6.00	Vertical
677740.94	1167197.48	a35	MKII HG	4.00	Horizontal
677741.04	1167180.67	a36	37mm	0.00	Horizontal
677728.58	1167178.52	a37	3 "stokes	20.00	Horizontal
677733.40	1167171.79	a38	3 "stokes	32.00	Horizontal
677743.27	1167161.79	a39	75mm	30.00	Horizontal
677758.76	1167148.27	a40	81mm	25.00	45 degrees
677697.46	1167163.21	a41	75mm	12.00	Vertical
677699.23	1167155.70	a42	MKII HG	0.00	Horizontal
677700.11	1167144.91	a43	75mm	18.00	45 degrees
677715.77	1167137.08	a44	37mm	4.00	45 degrees
677715.85	1167112.69	a45	slap flare	4.00	Vertical

Table A-1: Geophysical Prove-Out Seed Items (Continued)

X	Y	Target ID	Item	Depth (in)	Orientation
677706.94	1167104.36	a46	105mm	10.00	Vertical
677693.62	1167134.69	a47	81mm	34.00	Vertical
677683.47	1167133.54	a48	rocket motor	12.00	Vertical
677680.56	1167145.54	a49	3 "stokes	20.00	Vertical
677674.37	1167119.69	a50	37mm	2.00	Horizontal

TABLE A-2: GEOPHYSICAL PROVE-OUT CORNER POINTS and MIDPOINTS
Test Grid 1 (ft)

Corner Point	X ft	Y ft
SW	677693.96	1167088.76
SE	677796.54	1167176.86
NE	677753.19	1167226.71
NW	677651.45	1167138.05
M1	677762.26	1167147.30
M2	677728.18	1167117.92
M3	677685.25	1167167.49
M4	677719.52	1167196.53

Test Grid 2 (ft)

Corner Point	X ft	Y ft
SW	677825.1	1167325.0
SE	677868.1	1167300.0
NE	677911.9	1167375.0
NW	677869.0	1167401.0

TtEC proposes placing four inert 37mm projectiles (or larger) items on the surface at the following locations in Test Grid 2:

Item	X ft	Y ft
37mm	677846.0	1167337.0
37mm	677877.0	1167362.0
37mm	677885.0	1167330.0
37mm	677871.0	1167393.0

APPENDIX B
FIGURES

FIGURE B-1: TEST GRID LOCATION

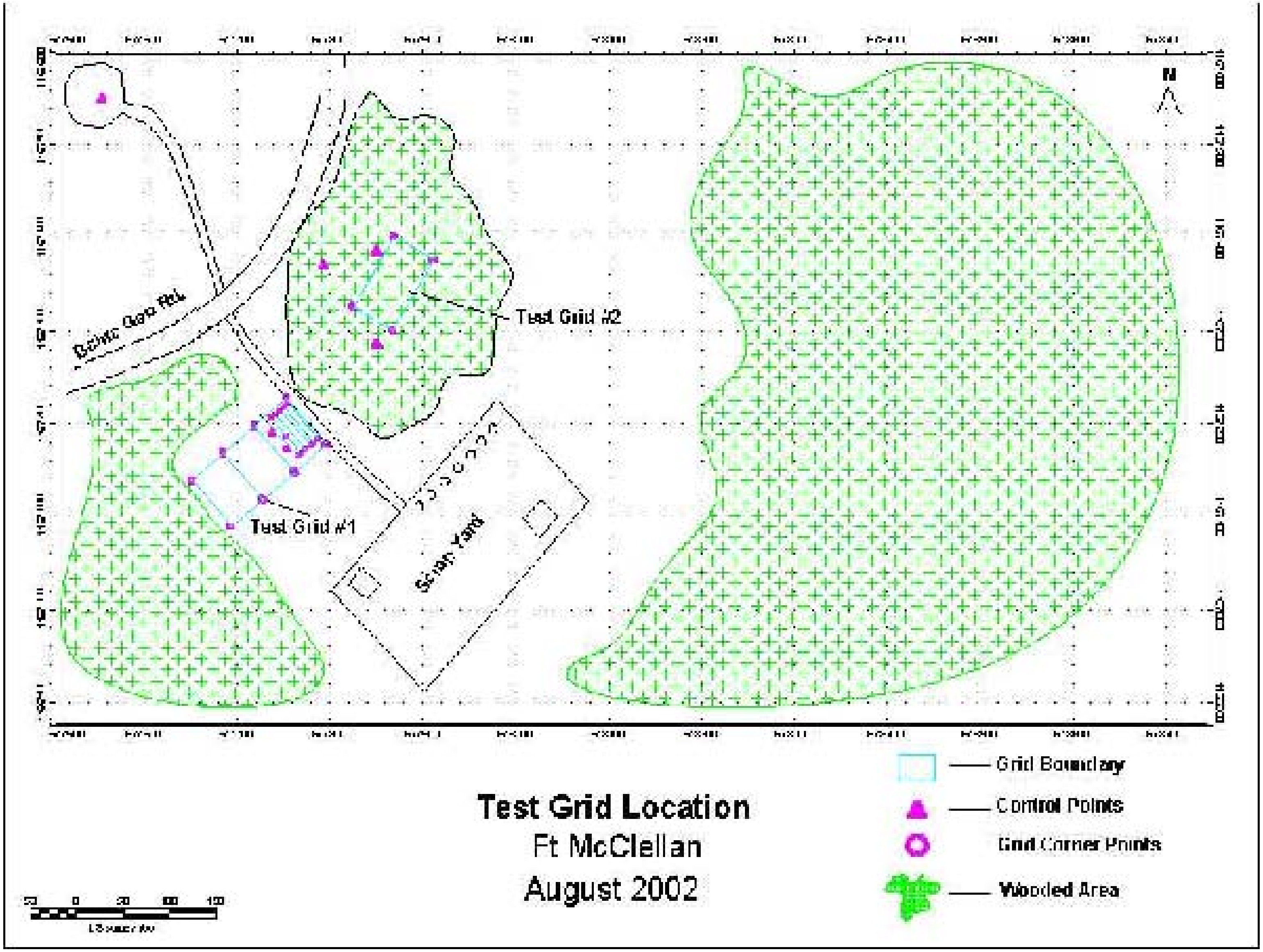
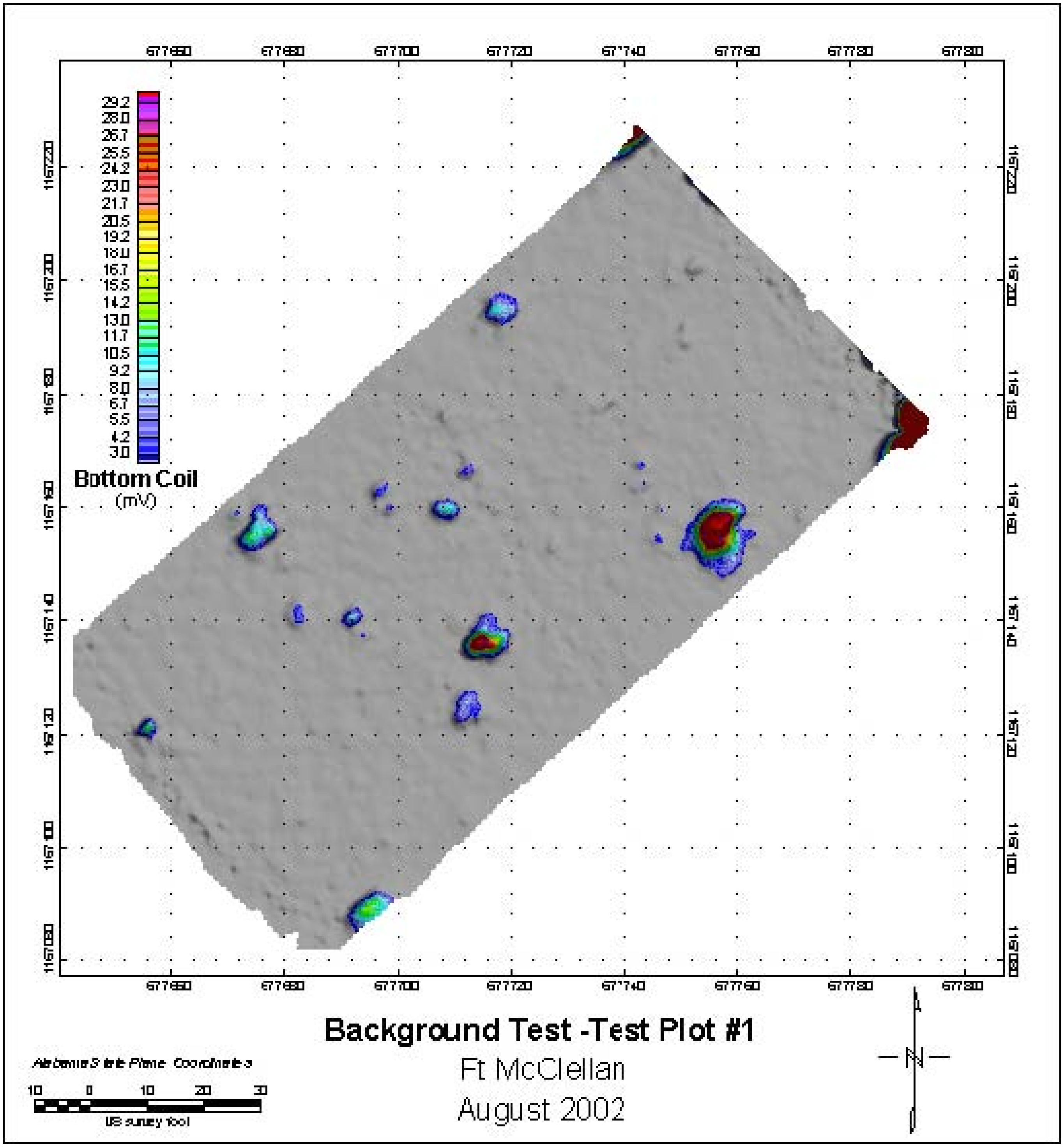


FIGURE B-2: BACKGROUND TEST (Test Grid 1)



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