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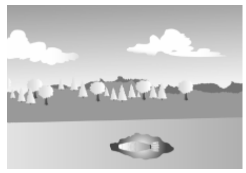
ITRC's Internet-based Training Program

Geophysical Prove-Outs



ITRC Technical and Regulatory Guidance:
Geophysical Prove-Outs for Munitions Response Projects

This training is co-sponsored by the EPA Office of Superfund Remediation and Technology Innovation

Presentation Overview:

Geophysical systems are used to detect surface and subsurface anomalies, (i.e. unexploded ordnance (UXO) and/or discarded military munitions) during geophysical surveys of munitions response sites. These systems are tested, evaluated, and demonstrated by a site-specific geophysical prove-out (GPO). Information collected during the implementation of the prove-out is analyzed and used to select or confirm the selection of a geophysical system that can meet the performance requirements established for the geophysical survey.

This training introduces the purpose and scope of GPOs, provides examples of goals and objectives associated with GPOs, and presents detailed information needed to evaluate the design, construction, implementation, and reporting of GPOs. The course is based on ITRC's **Geophysical Prove-Outs for Munitions Response Projects** (UXO-3, 2004). In addition to the material covered in the training, this document provides additional background information on geophysical surveys, for those readers who may want to review the broader topic of geophysical surveys, equipment, processes and survey methodology to gain a greater understanding of the context of GPOs in the munitions response process.

ITRC (Interstate Technology and Regulatory Council) www.itrcweb.org

Training Co-Sponsored by: EPA Office of Superfund Remediation and Technology Innovation (www.clu-in.org)

ITRC Course Moderator: Mary Yelken (myelken@earthlink.net)

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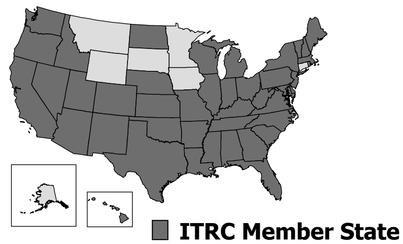

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For a state to be a member of ITRC their environmental agency must designate a State Point of Contact. To find out who your State POC is check out the "contacts" section at www.itrcweb.org. Also, click on "membership" to learn how you can become a member of an ITRC Technical Team.

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- Environmental Manag. at Operational Outdoor Small Arms Ranges
- Guidance for Using Direct-Push Wells
- In Situ Chemical Oxidation – Advanced Course
- Mitigation Wetlands
- Permeable Reactive Barriers: Lessons Learn and New Direction
- Radiation Site Cleanup
- Unexploded Ordinance Site Investigation/Site Remediation
- More in development…….

Popular courses from 2004

- Alternative Landfill Covers
- Characterization and Remediation of Soils at Closed Small Arms Firing Ranges
- Constructed Treatment Wetlands
- Geophysical Prove-Outs
- Performance Assessment of DNAPL Remedies
- Radiation Risk Assessment
- Remediation Process Optimization
- Surfactant/Cosolvent Flushing of DNAPLs
- Triad Approach

Training dates/details at: www.itrcweb.org
Training archives at: http://cluin.org/live/archive.cfm

More details and schedules are available from www.itrcweb.org under "Internet-based Training."

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Geophysical Prove-Outs (GPOs)

Presentation Overview

- Introduction to GPOs
- GPO Design
- Data Quality Objectives and Performance Metrics
- Questions & Answers
- GPO Design, continued
- GPO Construction
- GPO Implementation
- GPO Reporting
- Questions & Answers
- Links to Additional Resources
- Your Feedback

Logistical Reminders

- Phone line audience
  - ✓ Keep phone on mute
  - ✓ *6 to mute, *7 to un-mute to ask question during designated periods
  - ✓ Do NOT put call on hold
- Simulcast audience
  - ✓ Use ? at the top of each slide to submit questions
- Course time = 2¼ hours

No associated notes.

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Meet the ITRC Instructors

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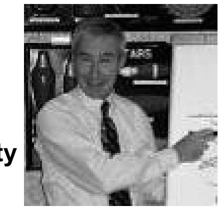

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Gary Moulder received a BA in political science from Villanova University, an MS in environmental engineering from Columbia Southern University and is working toward a master's degree in occupational safety and health. He served with the US Navy on active and reserve duty for 22 years, 4 of which were spent working on environmental restoration projects with the Naval Facilities Engineering Command. Gary is employed by the Pennsylvania Department of Environmental Protection as Chief of the Federal Facilities Section, Division of Remediation Services. He has worked for the Commonwealth for over 24 years in various Departments. He serves as the principal point of contact for Pennsylvania's innovative Cooperative Multi-Site Agreement (CMSA) with the Departments of the Army, Navy, Air Force and Defense Logistics Agency as well as Program Manager for Pennsylvania's Defense-State Memorandum of Agreement (DSMOA). Gary serves on the following national committees and work groups: Association of State and Territorial Solid Waste Management Officials Base Closure Focus Group; National DSMOA Steering Committee; and the ITRC Unexploded Ordinance (UXO) Team.

Jim Pastorick is President of Geophex UXO, Ltd., a consulting firm that specializes in providing technical support to state and foreign governments on ordnance and explosives/unexploded ordnance (OE/UXO) project planning and management. He is a former Navy Explosive Ordnance Disposal (EOD) officer who graduated from the U.S. Naval School of EOD in 1986. Since leaving the Navy he has worked as the Senior UXO Project Manager for UXB International, Inc. and IT Corporation prior to starting Geophex UXO in 1999. Mr. Pastorick is a member of the ITRC UXO Work Team and has participated as a presenter of ITRC's "Basic UXO Training" Course. He has a BA degree in Journalism from the University of South Carolina and worked as a photographer for *The Columbia Record* prior to reentering the Navy. Before attending college he served as a Navy enlisted man in the SEABEES.

Doug Murray is a Senior Ordnance Environmental Scientist at the Ordnance Environmental Support Office (OESO) of the Naval Ordnance Safety and Security Activity (NOSSA), Indian Head, Maryland. He provides Explosive Ordnance Disposal (EOD) technical review and oversight at munitions and explosives of concern (MEC) cleanup sites Navy-wide. Previously he worked for Engineering Field Activity Northwest where he was a MEC Remedial Technical Manager for Naval Facilities Engineering Command. Before joining the Navy, Mr. Murray worked in the private sector, developing, implementing, and overseeing environmental compliance and restoration programs relating to MEC for federal agencies and industry. Prior to that he served for 26 years in the U.S. Air Force, including 16 years as an EOD officer. Mr. Murray holds a Bachelor of Science degree in chemistry from the University of Maryland and a Master of Arts degree from the University of Northern Colorado.

Brian Ambrose is a senior safety specialist who leads the explosives network for DuPont's Corporate Remediation Group. In addition to his health and safety responsibilities for ongoing environmental remediation projects, Brian is the project director at a former ordnance and small arms manufacturing facility in the northeast and is responsible for coordinating the detection and removal of ordnance items on this 450 acre site. Prior to joining the DuPont Corporate Remediation Group in 1991, he served in the United State Marine Corps for twelve years. Brian received his degree from the University of Washington at Bellevue and became a Senior Certified Hazardous Materials Manager (CHMM) in 1992. He has been an active member of the ITRC UXO Team since 2003.

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What you will learn…

- The regulator's role in the GPO process
- GPO principles and associated terminology
- Goals and objectives of a GPO
- Overview of the GPO process
- GPO data quality objectives and performance metrics
- Elements of GPO reporting

Points to be considered in this training include:

- The state may be the lead regulator in the GPO process and must understand the purposes and limitations of a GPO
- Regulators must understand and appreciate the inherent limitations of a GPO
- An understanding of the performance metrics is necessary to determine whether a regulatory agency or a regulated entity has achieved its goals and objectives in the GPO
- Reporting requirements associated with a GPO

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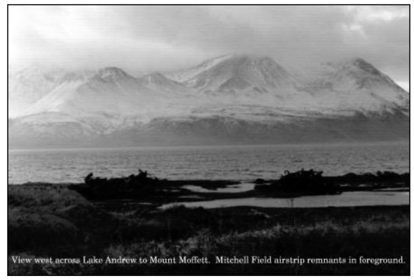
Diversity of Munitions Response Sites

Lowry Bombing Range, Colorado



Adak, Alaska

Massachusetts Military Reservation, Cape Cod, Massachusetts

The Department of Defense's Defense Science Board (DDSB) Task Force estimates that there are 1,400 munitions response sites in every state of the U.S. on approximately 10 million acres (*Report of the Defense Science Board Task Force on Unexploded Ordnance*, November 2003).

The Department of Defense's Military Munitions Response Program is currently creating an inventory of munitions response sites. See www.denix.osd.mil for more information on this inventory.

Document Overview

- Chapter 1: Introduction
  - State Regulator Role
  - Geophysics in Munitions Response
  - DoD Munitions Response Terminology
- Chapter 2: Introduction to Geophysical Surveys
  - Equipment
  - Methods
- Chapter 3: GPO Goals and Objectives
  - Example GPO Objectives
- Chapter 4: Technical GPO Process
  - Design, Construction, Implementation, and Reporting
- Chapter 5: Data Quality Objectives and Performance Metrics
- Chapter 6: Issues, Concerns, and Recommendations
  - FAQ-style format
- Chapter 7: References


Technical/Regulatory Guideline

Geophysical Prove-Outs for Munitions Response Projects

November 2004

Prepared by
The Interstate Technology & Regulatory Council
Unexploded Ordnance Team

The GPO document is organized into 7 chapters that walk the regulator or other interested party through the GPO process. Where possible, pictures of actual munitions response field operations, charts and diagrams are used to provide better clarity and give better definition of the subject matter. Chapter 6 contains frequently asked questions and responses to them which may be helpful in addressing questions concerning a GPO. Chapter 7 contains additional reference sources in print and available through the Internet from the US Department of Defense, EPA, and other areas of expertise.

This training covers the technical process and considerations involved in planning, designing, implementing and reporting geophysical prove-outs. In addition to providing this information, the document also provides background information on geophysical equipment and the geophysical survey process in general in Chapter 2, to assist readers who may not be familiar with geophysics as used for munitions response.

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Importance of GPOs to Regulators

- Basic understanding of GPO principles
- Contractor oversight
- Expectations for design, execution, and reporting of GPOs
- Early "buy-in" to the munitions response project
- Communication of state/federal cleanup standards

State regulators should:

- Understand the purpose and limitations of GPOs in general;
- Evaluate whether or not the goals and objectives or the overall objectives of a GPO are appropriate for the planned geophysical survey;
- Understand performance metrics and how they are determined;
- Perform field oversight to ensure the GPO construction and implementation are consistent with the sampling design as documented in the work plan, as possible;
- Evaluate whether or not the quality assurance/quality control protocol established for the GPO has been followed;
- Review the GPO report for completeness; and
- Evaluate whether or not the GPO objectives have been achieved and documented.

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Basic Terminology

- Mag and flag
- Digital geophysical mapping (DGM)
- Seed item
- Clutter
- Munitions and explosives of concern (MEC)

Mag and flag survey

In many cases, the regulator may learn “a new language” when dealing with munitions response sites. The terminology listed on this slide is commonly used in describing the various elements associated with a GPO. It is important to understand these terms as well as their overall significance in the GPO.

Mag and flag – the process of using handheld magnetometers that alert the operator to anomalies with a visible or audio signal to survey an area. The operator records the anomaly location with a pin and flag.

Digital geophysical mapping – the method of acquiring (“mapping”) geophysical data from an area using self-recording instruments and processing the data to allow for the selection of anomalies for further investigation.

Seed item: Inert military munitions (or their surrogates) and clutter emplaced (“seeded”) in a GPO.

Clutter: Clutter items may include fragments of military munitions (also called “munitions debris”) or non-munitions-related, manmade metallic objects (also called “cultural debris”) or magnetic rock.

Munitions and explosives of concern (MEC) - this term, which distinguishes specific categories of military munitions that may pose unique explosives safety risks means (A) UXO, as defined in 10 U.S.C. 2710 (e)(9); (B) discarded military munitions (DMM), as defined in 10 U.S.C. 2710 (e)(2); or (C) explosive munitions constituents (e.g., TNT, RDX) present in high enough concentrations to pose an explosive hazard.

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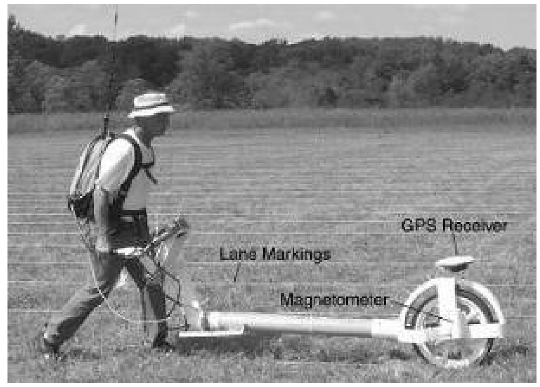
Basic Terminology (continued)

- Dig sheet
- Anomaly reacquisition
- Data quality objectives (DQOs)



Digital geophysical mapping survey

Dig sheet: A summary of the instrument responses and excavation results (often referred to as a “dig sheet”) resulting from a survey (either mag and flag or digital geophysical mapping.

Anomaly reacquisition: For digital geophysical mapping surveys, anomaly reacquisition is the process of navigating back to the recorded location of a selected anomaly and determining the precise anomaly location using a geophysical sensor.

Data quality objectives (DQOs) - DQOs are quantitative and qualitative statements that specify the type and quality of the data needed to support an investigative activity. They are developed before data are collected as part of sampling program design.

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Geophysical Prove-Outs (GPOs)

- Test
- Evaluate
- Demonstrate

Towed array survey on a GPO test site

…the site-specific capabilities of one or several geophysical systems in order to select or confirm the capabilities of the most appropriate technology for a geophysical survey

No associated notes.

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Why are GPOs Important?

- GPOs help establish the adequacy of a technology selected for a geophysical survey
- Inadequate surveys result in additional costs in terms of time and money
- Also, munitions and explosives of concern that are not detected will not be removed

The GPO establishes the basis for the field production surveys conducted on a munitions response site. This “base line” will be used to determine both the detection equipment’s and the positioning system’s ability to detect and discriminate actual and suspected unexploded ordnance and discarded military munitions.

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Example of the Importance of GPOs in the Geophysical Survey Process

- Colorado experience
- First attempt at GPO failed
  - The geophysical sensor used in the GPO had been modified for use at a different site, and did not perform as expected
- Second attempt at GPO failed
  - Transmissions from a nearby aircraft control tower were interfering with the GPS signal from the contractor's ground base station and corrupting the positioning data
- Third attempt at GPO successful

The use of a GPO on this project resulted in a significant time and cost savings by avoiding the collection of inadequate geophysical and positioning data during the geophysical survey.

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GPO Objectives

- Specific objectives of GPOs differ with the unique issues and challenges present at every munitions response site
- Examples of objectives
  - Document the consideration given to various geophysical detection instruments, the criteria used to identify geophysical instruments for consideration, and the causes for their respective selection or rejection
  - Document the capabilities and limitations of each geophysical detection instrument selected for consideration at the site-specific GPO
  - Confirm the achievable probability of detection and confidence levels or confidence intervals to support decision making at the site

Clearly defined objectives are important for a successful GPO as well as a munitions response. Several examples are given here to illustrate importance of clear and well-defined objectives.

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GPO Objectives (continued)

- Examples of objectives, continued
  - Observe each geophysical detection instrument operating in the contractor's configuration, using the contractor's personnel and methodologies.
  - Evaluate the contractor's data collection, data transfer quality and data QC method(s)
  - Evaluate the contractor's method(s) of data analysis and evaluation
  - Evaluate estimated field production rates and estimated false positive ratios, as related to project cost
  - Establish anomaly selection criteria
  - Document system reliability

Here are some additional examples of GPO objectives.

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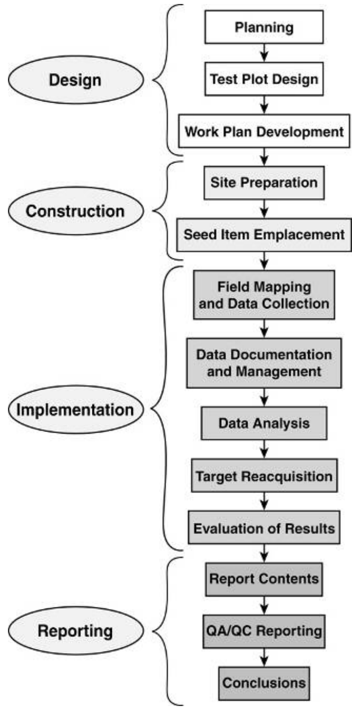

GPO Technical Process

Four Phases of a GPO

- Design
- Construction
- Implementation
- Reporting

This slide presents the four major phases of the overall GPO process (design, construction, implementation, and reporting) and the more detailed functions that occur during the various phases. First we will discuss designing the GPO.

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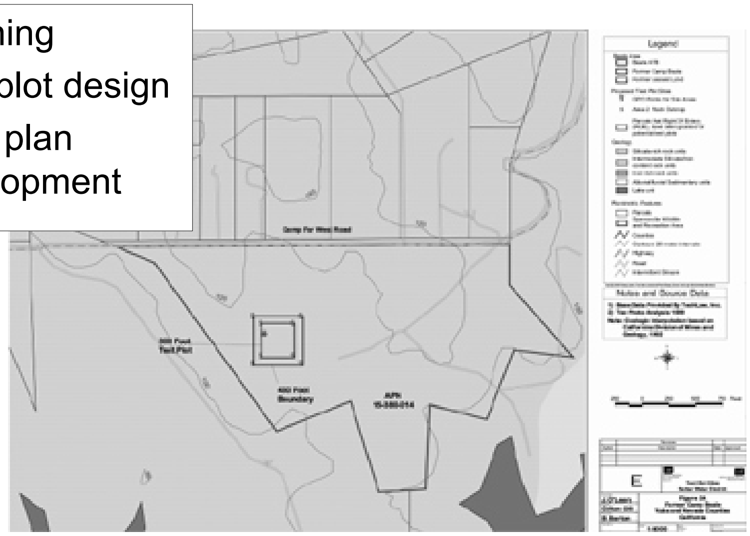
GPO Design

- ▶ Planning
- ▶ Test plot design
- ▶ GPO plan development



Map of Former Camp Beale showing GPO test plot site, geologic and cultural features, and parcel and property boundaries

The three components of the overall GPO design are:

•Planning the GPO

•Designing the test plot

•Developing the GPO plan

Discuss the graphic which shows an overall view of a munitions response site and the location of the GPO and other relevant features.

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GPO Design: Planning

- Type, scope, and complexity must be consistent with the goals and objectives of the production geophysical survey
- GPO can range from simple (single type of munitions and explosives of concern, well-defined depth range) to complex (multiple types of munitions and explosives of concern, wide depth range)
- More than one GPO may be required
- GPO data quality objectives and performance metrics must be identified and tested

1. Type, scope and complexity of the GPO must be consistent with the goals and complexity of the planned geophysical survey.
2. The GPO can range from small and simple to large and complex. Give example scenarios.

- Small and simple - The munitions response site is the kick-out area of an open burning/open detonation (OB/OD) pit and all of the munitions and explosives of concern are expected to be found on or within six inches of the surface.
- Large and complex - A large area of unidentified combat training ranges used during World War II was used for live firing for everything from 20-mm projectiles to shoulder-fired anti-tank rockets to heavy artillery projectiles and bombs. The GPO must demonstrate the ability of the geophysical equipment to detect munitions and explosives of concern from small to very large across a wide depth spectrum from the surface to six-feet over varying terrain, vegetation, and geological conditions.

3. A large site with varying types of geology, terrain, vegetation or contamination may require more than one GPO because the GPO should mirror the conditions in the production survey area as closely as possible.
4. Data quality objectives and performance metrics are critical parts of the GPO because they allow the specific requirements of the geophysical program to be identified and measured. The next presenter will now discuss data quality objectives and performance metrics in more detail.

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Data Quality Objectives Overview

- Data quality objectives are quantitative and qualitative statements that specify the type and quality of the data needed to support an investigative activity
  - Statements describe specific objectives of performance criteria related to precision, representativeness, sensitivity, accuracy, and completeness
- Data quality objectives are statements that
  - Clarify objectives of GPO data collection effort
  - Specify how data will be used to support risk management decision
  - Define most appropriate type, quantity, and quality of data to collect
  - Specify acceptable levels of decision errors

- Explain what data quality objectives are and are not
- Discuss the performance criteria of data quality objectives that may apply to a GPO (precision, representativeness, sensitivity, accuracy, and completeness)
- Review the purpose statements listed

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Data Quality Objectives

- Data quality objectives developed before data are collected as part of sampling program design
- Data quality objectives developed using EPA's 7-step process
  1. State the problem
  2. Identify decisions
  3. Identify inputs
  4. Define study boundaries
  5. Develop decision rules
  6. Specify tolerance limits
  7. Optimize sampling design
- Output of each development step is a data quality objective

3-inch Stokes mortar
Photo courtesy of U.S. Army

Discuss who develops data quality objectives and when they are developed

Review the EPA 7-step process for determining data quality objectives:

1. Problem statement should originate with project objectives (see Section 3.1 of the GPO document);
2. Identifying decisions means what data are necessary to collect;
3. Determining input decisions means finding the most appropriate conditions in which to collect the data;
4. Defining study boundaries means setting the limits to the data that must be collected;
5. GPO team establishes if-then decision rules;
6. Decision errors are a reality, it's establishing acceptable limits that's the challenge; and lastly
7. The six previous steps lead to optimizing sampling design

Sample Data Quality Objectives:
Geophysical Sensor Data for Anomaly Identification

Data Quality Indicator	Sample Measurement Performance Criteria
Precision	▶ Response to standardized item will not vary more than ±10%
Representativeness	▶ Survey to achieve 0.85 probability of detection at 90% confidence level for all 60-mm mortars within 2 ft bgs ▶ Sensor to identify at least 90% of all munitions seed items or their surrogates
Sensitivity	▶ Sensor to identify 60-mm mortars at a minimum of 2 ft bgs ▶ Sensor to identify 20-mm projectiles to a depth of 12 in bgs ▶ Signal-to-noise variance $\leq$ lesser of 5% or 5mV
Accuracy	▶ Percent false positives not to exceed 15% of all identified anomalies
Completeness	▶ At least 98% of possible sensor readings will be captured in the GPO

- Discuss data quality indicator categories shown.
- Explain how data quality objective process may use these same indicators and corresponding sample performance criteria
- Remind audience that the output of this process is data needed to make a sound decision regarding the technology employed
- Discuss how and where data quality objectives are documented in the work plan
- Discuss how data quality objectives become integral to the QA/QC program

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Performance Metrics

- Performance metrics are aspects of the various types of data required by the data quality objectives
  - Both definable and measurable
- There are two types of metrics: counting or judgment
  - Judgment metrics must be based on ratings established using specific criteria

Munitions field survey operations, Adak Island. Photo courtesy of U.S. Navy

- Explain how performance metrics can be thought of as the measurable criteria from the GPO data that are scored to determine whether seeded anomalies were successfully detected, identified, and relocated
- Remind the audience that, like data quality objectives, performance metrics are site specific and therefore can vary from GPO to GPO

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Performance Metrics: Probability of Detection

- Probability of detection not the same as percent detected
  - Percent detected + confidence level = probability of detection
- Probability of detection
  - Captures random processes effecting detectability
  - Requires statistically significant population
- GPOs can use array of expected munitions
  - Emplaced at range of depths and orientations
  - Probability of detection calculated on a single sample
- GPO probability of detection ≠ production survey probability of detection
- Probability of detection linked to confidence level and false alarm rate

- Discuss how percent detected is calculated and how it is not the same as the probability of detection
- Describe what probability of detection is meant to measure
- Explain how probability of detection is measured at a GPO
- Warn the listener that the probability of detection calculated at the GPO can only suggest the probability of detection in the production survey
- Mention that probability of detection is linked to both confidence level and false-alarm rate

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Performance Metrics: Confidence Level

- Confidence level is the statistical confidence that the probability of detection measured on the GPO is representative of the true probability of detection of the system on the GPO
- The number of targets will determine the lower bound on the true probability of detection at a specified confidence level
  - Sample size (i.e., the number of emplaced items) must be large enough to ensure the required statistical significance

Targets Detected	Percent Detected	95% Lower Confidence Level
9 out of 10	90%	Confidence Level = 0.55
90 out of 100	90%	Confidence Level = 0.82

- Explain how confidence level is a measurement of the uncertainty (or confidence) that the probability of detection estimated by the GPO is representative of the actual probability of detection of the system at the GPO
- Discuss the positive statistical correlation between the number of seeded items and the confidence level
- Take-home message: the sample size (i.e. number of seeded items) must be large enough to ensure statistical significance
- Note: The confidence level statistic from the GPO is not an estimate of the uncertainty (or confidence) that the probability of detection estimated by the GPO is representative of the probability of detection of the system during the field survey

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Performance Metrics: Signal-to-Noise Ratio

- Signal-to-noise ratio is ratio of signal strength to system noise
  - Sensor noise is the fluctuation in sensor output in the absence of an external signal and is generally dominated by noise in the sensor electronics
  - Determines the level at which a threshold must be set in order to detect a target of interest and thus governs the false alarm rate
- In general, signal-to-noise ratios of a minimum of 2 to 3 are required for reliable detection

- Use the simile of what happens to the favorite radio station while driving away from the transmission tower to signal-to-noise ratio at a GPO
- Discuss sources of sensor and environmental noise
- Explain why signal-to-noise ratio determines the level at which a threshold must be set in order to detect a target of interest and thus governs the false alarm rate
- Explain why the signal from the item of interest must exceed by 2 or 3 times the sum of the sensor noise and the environmental noise

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Performance Metrics: False Negative

- Failure of the geophysical instrument or the geophysicist to select a UXO anomaly as UXO
- Results in omission of UXO from the dig sheet
  - Explosive hazard remains following completion of munitions response action
- Causes include low signal-to-noise ratio and personnel error

Hand-held magnetometers in use at Fort Ord, CA. Photo courtesy of U.S. Army

- Share the Easter egg hunting story
- Explain how I was like the geophysical survey team and the geophysicist and the egg was like a UXO
- Discuss the potential of false negatives on remaining risks at the munitions response site following the completion of the munitions response action

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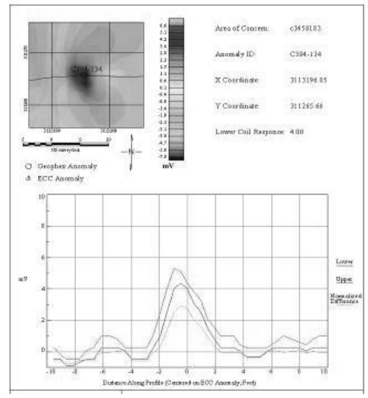
Performance Metrics: False Positive / False Alarm

- Identifying a signal as originating from UXO when no UXO is present
- Results in unnecessary digging
- Causes include low signal-to-noise ratio and personnel error



Electromagnetic induction (EMI) survey sample of Adak, AK
Graphic courtesy of U.S. Navy

- Discuss the terms: false positive; Type I error; and dry hole
- Give examples and explain possible causes

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Performance Metrics: False Alarm Rate

- A measure of the number of incorrect target anomalies selected
  - False positives divided by number of declared targets

False Alarms	Declared Targets	False Alarm Rate
5	50	10%
10	50	20%

- High false alarm rates
  - Decrease field efficiency
  - Increase data, thereby increasing likelihood of processing errors
  - Result from increasing probability of detection

- Explain how the false alarm rate is a measured
- Discuss implications of a high false alarm rate, to include how increasing sensitivity increases false alarms
- Share some contractual approaches to false alarm rate ($\leq$15%)

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Performance Metrics: Positional Accuracy

- Positional accuracy is measured by comparing the known location of the emplaced targets to the reported location of the anomalies detected, selected, and reacquired by the GPO demonstrator
- Positional accuracy error in a GPO simulates positional accuracy error in the production survey

Photos courtesy of U.S. Navy

- Failure of the geophysical instrument or the geophysicist to select a UXO anomaly as a UXO results in omission of UXO from the dig sheet
- Explosive hazard remains following completion of munitions response action
- Causes include low signal-to-noise ratio and personnel error

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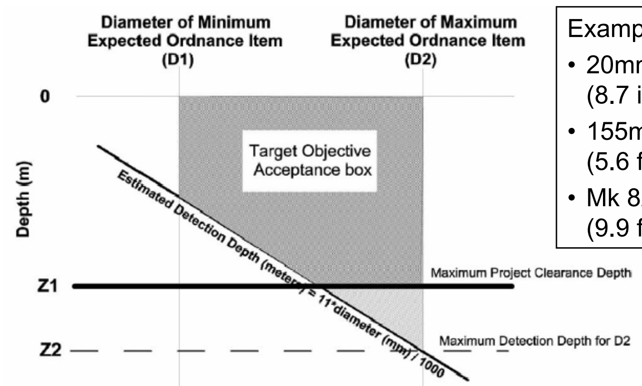
Performance Metrics: Object Depth vs. Diameter

- In general, larger objects may be detected at greater depths than smaller objects



Examples:
- 20mm detection depth = 0.22m (8.7 in)
- 155mm detection depth = 1.7m (5.6 ft)
- Mk 82 detection depth = 3 m (9.9 ft)

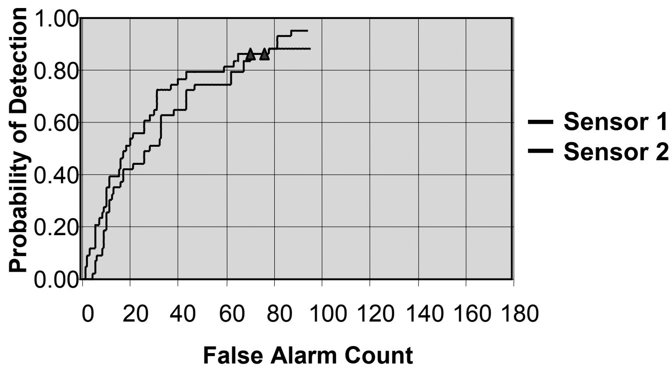
Source: U.S. Army Ordnance and Explosives Mandatory Center of Expertise and Design Center, Huntsville

- Discuss geophysical principle of magnetic flux as a function of object mass and distance
- Explain the USACE rule-of-thumb formula: estimated detection depth (m) = 11*object diameter (mm)/1000
  - This may be used as a level of performance standard
  - May also be a contractual standard
  - Failure to find all munitions and explosives of concern or ferrous items in the box could result in QA/QC failure

32

Performance Metrics: Receiver Operator Characteristics Curve

- A method of comparing the probability of detection and false alarm rate metrics
- Can be used to characterize the performance of sensors



Last metric

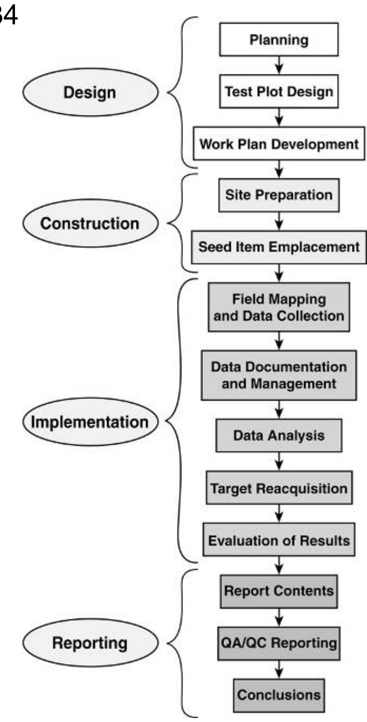
- Explain how it is that as probability of detection increases, so does false alarm rate
- Discuss why that information is useful
- Discuss why understanding the efficiency with which these two parameters trade off is critical to making optimal project decisions

33

Questions & Answers

No associated notes.

34



GPO Technical Process

Four Phases of a GPO

- Design
- Construction
- Implementation
- Reporting

This slide presents the four major phases of the overall GPO process (design, construction, implementation, and reporting) and the more detailed functions that occur during the various phases.

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GPO Design: Test Plots

There are usually two main areas of a GPO Test Plot

- Function check area (also called “known area”)
  - Used to ensure that equipment, operators, software, and models work under general site conditions with known seed item types, locations, and depths
- Field test area (also called “blind test” or “test grid”)
  - “Blind” test because the seed items types, locations, and depths are unknown
  - Representative of field conditions at the munitions response site

Function check area - used to allow demonstrators to test and calibrate their equipment under actual geological conditions prior to demonstrating in the blind test area.

Blind test area - should simulate the actual field conditions as closely as possible. Examples of types of field conditions that are relevant are shown on the next slide.

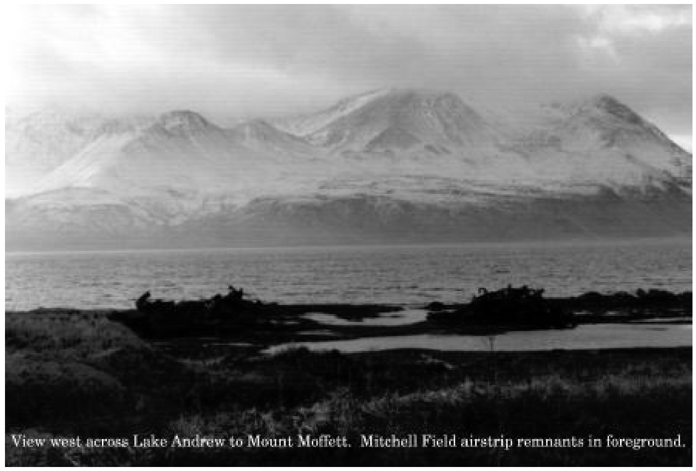
36

GPO Design: Site Selection

- Considerations
  - Terrain
  - Vegetation
  - Geological noise
  - Size
  - Accessibility
  - Proximity to actual survey site

The photo is part of the actual GPO from the Adak, Alaska munitions response project. Note the steep hillside and tundra vegetation that is typical of the project site. Other types of terrain were also included in the GPO including flat areas, rocky areas, and areas of tall tundra grass.

GPO Design: Tailoring the GPO Area to Specific Site Requirements



Adak, Alaska

This photo of the Adak, Alaska project site shows the range of terrain types that had to be duplicated in the GPO.

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GPO Design: Basic Design Criteria

Know what you are looking for (Table 4.1 of GPO document lists GPO design criteria)

- Munitions of interest
- Maximum depth for each munition
- Size of smallest munition(s)
- Quantity of munitions
- Composition of munitions
- Objectives (characterization, removal, remediation)
- Acceptable geophysical survey confidence and uncertainty levels
- Survey coverage and geometry

Rifle grenades

This slide presents other elements of the GPO design. A valid and successful GPO duplicates site conditions in these areas.

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GPO Design: Seed Item Selection and Placement

- Inert munitions vs. simulants
- Clutter
- Types of seed items
- Number of each type of seed item
- Placement

Projectiles

81-mm mortars

Inert vs. Simulants - When selecting target items, it is important to consider these criteria. Note that inert munitions are usually considered to be superior to simulated munitions and explosives of concern because actual inert munitions are more likely to closely duplicate the geophysical anomaly response of the actual munitions and explosives of concern. Such geophysical properties as conductivity and magnetic permeability are not likely to be duplicated by simulants. Simulants also may possess additional characteristics such as residual magnetism from being cut and shaped on a lathe. However, in the absence of inert ordnance, the use of simulated munitions and explosives of concern can provide a good general idea of the detection capabilities of a geophysical system. Inert munitions and explosives of concern may not be available or it may not be possible to provide adequate site security for buried munitions and explosives of concern on a GPO. The Army Corps of Engineers is considering implementing a policy on the security implications of using inert munitions and explosives of concern on GPOs.

The other factors listed above (clutter within the GPO, the type, ratio of different types of ordnance, and the depth and orientation of placement) should duplicate, as much as possible, the conditions that are expected to be found in the production geophysical survey.

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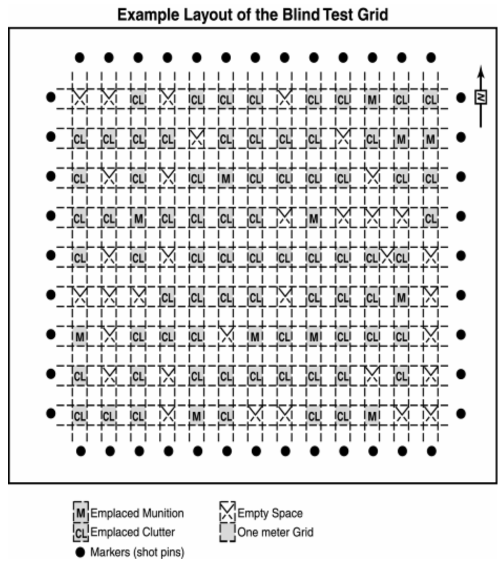
GPO Design: Seed Item Placement

- Plan where you are going to place your seeded targets and, possibly, clutter



This diagram shows a blind test grid divided into 1-meter by 1-meter areas with the locations of ordnance and explosive items, clutter, and empty areas identified. The GPO plan can also identify which type of munitions and explosives of concern targets are emplaced at each location.

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GPO Design: Quantity of Seed Items

- Sufficient number of seeded items should be used to evaluate and document system detection performance with respect to
  - Munition type
  - Orientation
  - Depth of detection
  - Random factors
  - Site-specific performance metrics
  - Clutter
  - Required confidence level

Deciding on the number of targets is a complex decision. The required confidence level is a statistical evaluation that can dictate the number of targets required. Other factors may be more flexible and based on site-specific considerations such as the munitions and explosives of concern type, detection depth requirements, and type of clutter emplaced in the GPO.

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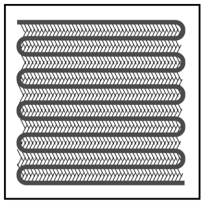
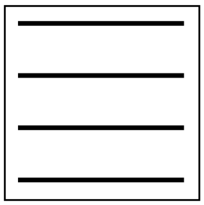
GPO Design: Test Plot Search Patterns



Full Coverage



Transect

- Must be consistent with the search pattern and/or coverage scheme for the production survey
- Search pattern parameters vary depending on the search pattern, coverage scheme, and data quality objectives

The search pattern used in the GPO should duplicate the pattern or patterns that will be used in the field production survey. This is especially important when using transect surveys in the field. If transect surveys are going to be used in the field they should also be used in the GPO instead of a full coverage “grid” type survey. This is because the full coverage allows the possibility that the geophysical instrument will get additional data from each target due to detecting the target on multiple adjacent survey lanes. In the transect type survey it is assumed that the transects are separated by sufficient distance to prevent this additional geophysical data to be acquired on each anomaly.

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GPO Design: Work Plan

- Documents
  - GPO goals and objectives
  - Specific data quality objectives
  - GPO area design
  - Scoring criteria
- Stand alone document OR
- Part of the geophysical investigation or removal work plan

The GPO plan should state what is going to be achieved, how the GPO will be constructed, and how the demonstrator will be scored (what is a hit and what is a miss).

44

GPO Design: Work Plan Elements

- Test area layout
- Site preparation
- Survey specifications
- Baseline geophysical survey
- Quality control
- Anomaly avoidance
- Seeding
- Data collection procedures and variables
- Data analysis and interpretation
- Reacquisition
- Data evaluation

Table 4.2 shows each of the elements above and how they relate to the Work Plan

There is additional discussion of each of these topics that are typically described in the GPO plan in the GPO document.

45

GPO Construction

- Site preparation
  - Establish site boundaries
  - Surface removal
  - Vegetation clearance
  - Baseline survey
- Seed item emplacement
  - Acquisition and selection
  - Emplacement
  - Clutter
  - Documentation

- The boundaries should include terrain which is consistent with the terrain topography which is across the site
- Surface removal may be a two step process, one by UXO tech to remove ordnance items and one simply to remove cultural clutter etc.
- Should replicate or include the various types of vegetation which may occur on site
- Ideally this should be accomplished with the same instrument/crew/line spacing etc. which will be used on the site
- Seeded items should represent all the various items which are suspected to be present
- Items should be placed at varying depths and orientations
- Clutter may include cultural items as well as munitions and explosives of concern components
- This simply can't be over emphasized. This will be the "answer key" on which a lot of decisions will ride

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GPO Construction: Site Boundaries

- Terrain, topography, and vegetation should be representative of site

No associated notes.

GPO Construction: Surface Removal

- May be a two step process
- May decide to leave some behind

No associated notes.

48

GPO Construction: Vegetation Removal

- Similar to amount of vegetation removal planned for production site

Trimming vines after mechanical vegetation removal.

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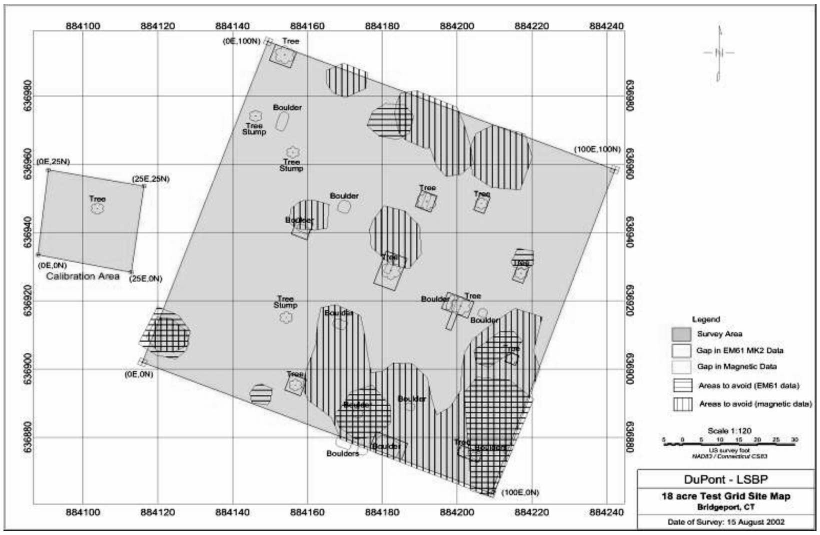
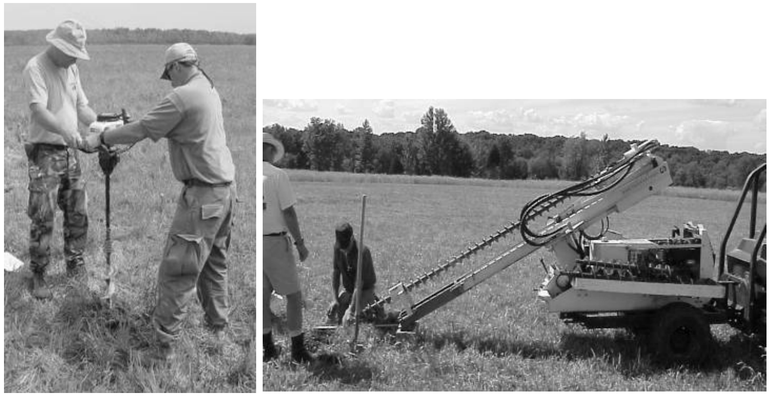
GPO Construction: Establishing Baseline



It is important to know what might be present before selecting location to emplace items. This example shows the results of a mag and electromagnetic survey conducted prior to selecting locations.

50

GPO Construction: Seed Item Emplacement



Using an auger and a post hole digger to emplace seed items on a test plot

This is usually accomplished by a third or independent party to maintain the integrity of the GPO. Angle auger placement is used to remove any clues related to the disturbed soil. Overlapping target signatures could influence the performance of the survey instruments.

- Placement methodologies will vary and is largely dependent on site geology, consideration must be given to post placement restoration to mask item location

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GPO Construction: Seed Item Emplacement

Measuring seed item dip using an inclination protractor

Measuring seed item depth using the depth measuring T

- All the details of the placement to must be recorded for use and reference.
- All future questions about target placement/location/depth/geology/orientation etc should be considered
- Measurements will include depth, dip (inclination) orientation.

A sample log sheet is included ahead.

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GPO Construction: Clutter

- Clutter items may include fragments of military munitions or non-munitions related, manmade metallic objects, or magnetic rock

- If items were removed in the baseline survey to facilitate placement of items, re-use them as cultural clutter. Whatever is used it should be representative of what is actually on site. Placement considerations should include depth and concentration densities if this can be estimated. Clutter should be emplaced so that orientation to true north is the same as when it was originally removed or the items may stand out when surveyed with many instruments.

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GPO Construction: Documentation

- Map of test plot location
- Diagram showing seed item locations
- Photographs of all seed items
- Survey data
- Names of people constructing test plot
- Date of construction

Depending on the complexity of the project and GPO, the documentation can vary from a letter report acknowledging that the site was constructed per the work plan, to a construction report and as-built drawings. Expectations for the content need to be communicated up front

This is the living record for the project (which may last many years) you only get one chance to get this right

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GPO Construction:

Daily Construction Log

DAILY CONSTRUCTION LOG

1. DATE:

2. LOCATION:

3. PREPARED BY:

4. WEATHER CONDITIONS:

5. CONSTRUCTION SITE AND ACTIVITY:

A. **SITE:** [ ] CALIBRATION LANES [ ] GROUND TRUTH TEST PIT

[ ] BLIND TEST GRID [ ] OPEN FIELD SITE

[ ] ALL SITES

B. **ACTIVITY:** [ ] INTIAL UXO CLEARANCE [ ] GROUND PREPARATION

[ ] SOIL CHARACTERIZATION [ ] SECONDARY UXO CLEARANCE

[ ] POST SURVEY DIG [ ] BASELINE SURVEY

[ ] LANE/GRID LAYOUT [ ] TARGET/CLUTTER EMPLACEMENT

[ ] SITE/FIELD MAINTENANCE

OBSERVATIONS: (Record progress, displays, who is performing work, etc.)

ISSUES AND REMARKS: (Problems, or any observations not covered above.)

Here is a sample for the daily log. Again, communicate documentation deliverables up front to ensure expectations are met.

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GPO Construction:

Target Placement Sheet

FIELD TARGET PLACEMENT SHEET

Location: **Aberdeen Proving Ground**

Date: **03/25/01**

Item Classification: **OR** (OR - Inert Ordnance, CL- Clutter item)

Description: **20 mm Projectile.**

ID Number for Munition or Clutter **20MM-ATC-001**

Field Test Area **B** (OF - Open Field, B - Blind Test Grid, CAL - Calibration Lanes)

Grid Location: Grid lane (X-axis number) **14**

Grid lane (Y-axis letter) **A**

Depth from surface **023** m

Dip **90** deg Length mm

Azimuth **50** deg Width mm

Northing (UTM) **677854** Thickness mm

Easting (UTM) **453537** Weight gram

Type of material

Lat (WGS84)

Long (WGS84)

Target Photographed: (Y or N)

- As discussed earlier, just a sample but note the detail
- Documentation needs may vary by project
- A photo of each item as placed may prove useful down the road, alternatively a photo of each ordnance type may suffice.

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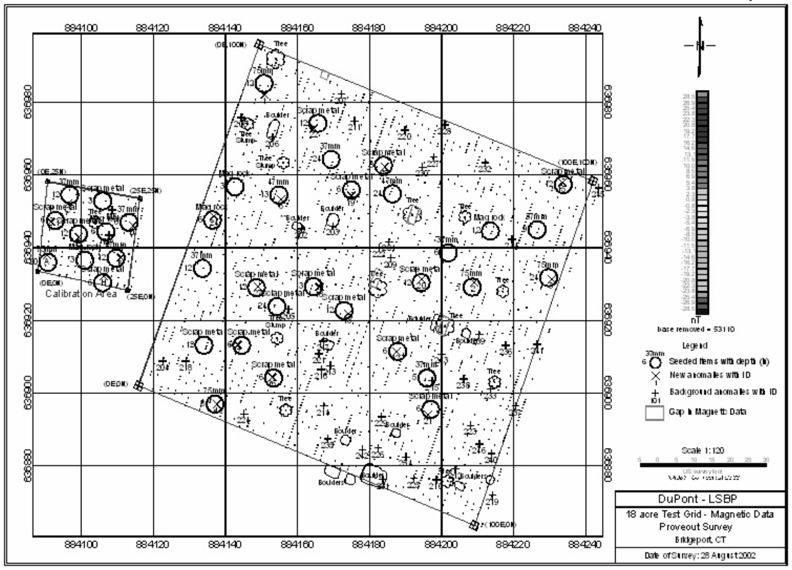
GPO Construction: GPO As-Built Map



No associated notes.

57

GPO Implementation

- Field mapping and data collection
- Data documentation and management
- Data analysis
- Target selection
- Target reacquisition
- Evaluation

Typically includes:

using key geophysical personnel
equipment types and configurations
survey procedures
data analysis
anomaly identification and reacquisition

IN THE SAME MANNER AS WILL BE IMPLEMENTED IN THE PRODUCTION SURVEY

This will help maintain the integrity of the GPO and adds validity to the GPO process and the data collected.

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GPO Implementation: Field Mapping and Data Collection

- Implementation should follow work plan
- Daily logbook should be kept

Multi-frequency Electromagnetic Induction System

Electromagnetic Survey

Daily logbook is typically used to record all on-site activities and field notes. This would include any deviations to the process as identified in the work plan.

This is a good point for regulators to get out in the field to verify all is going as planned.

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GPO Implementation: Data Collection

- Mag and flag survey
  - Sensor operator interprets signals real time
  - Maps are produced that show the locations of the picked targets

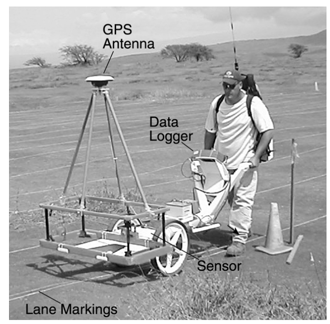
In mag and flag data analysis is completed virtually real time by the UXO technician based on interpretation of the audio and visual signal from the instrument. This will mainly be an X-Y location but some info relative to z (depth) may be noted. The resulting flags are surveyed in to produce a map.

Document search patterns for future duplication.

60

GPO Implementation: Data Collection

- Digital geophysical mapping surveys
  - Data is collected in field
  - A geophysicist processes the raw data
  - Data analyzed and interpreted
  - Anomalies selected
  - Maps produced



This is probably the most common method currently employed

May be mag or electromagnetic

Uses a data logger to collect and store the instrument response and, as pictured here, a GPS system is used to track the motion of the sensor through the area. The two data sets are than combined so the geophysicist can tell where an anomaly was present and what the instrument response was at that position.

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GPO Implementation: Data Collection and QC Procedures

- Standard response tests
- Static tests
- Shake test
- Repeat data test
- Positioning accuracy

Static test stand to check function of an electromagnetic sensor

The standard response tests use a steel sphere to standardize responses.

Can identify instrument problems PRIOR to collecting the data

May be accomplished in morning and afternoon to document instrument response degradation curves

Very important for later post processing of the data

Any deviance in function checks and setup procedures should also be noted in the report

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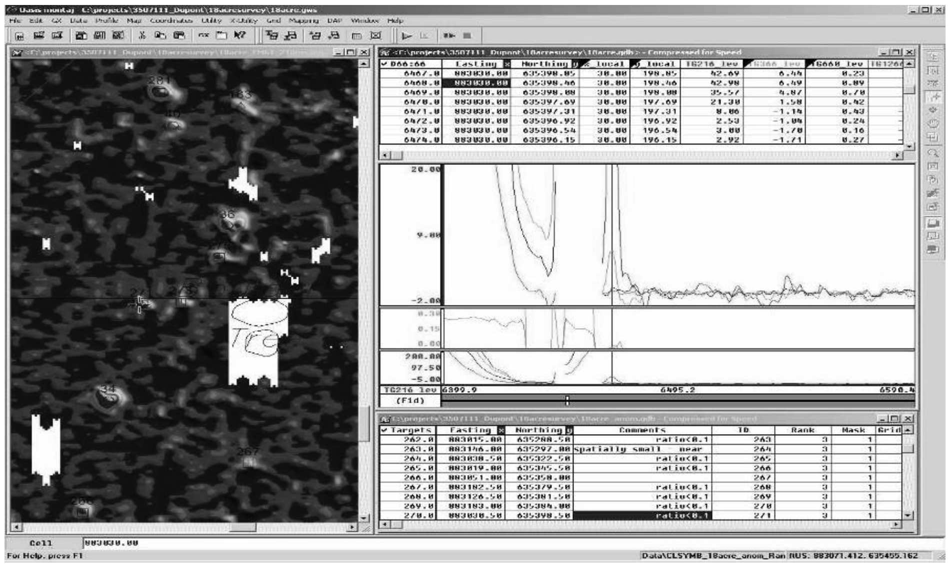
GPO Implementation: Documentation

- Implementation information documented in the GPO report
  - Equipment used
  - Survey speed
  - Survey coverage
  - Data acquisition rates (for digital geophysical mapping surveys)
  - Function checks and setup procedures

All this information will end up in the final report, but the information is generated and collected daily…keep accurate records

63

GPO Implementation: Data Analysis



Based on the analysis of the data (whether mag and flag or digital geophysical mapping) the data is then analyzed. The product of which will be dig sheets maps etc.

This is an example of a widely used post processing tool. It is a software platform that allows the geophysicist to look at the heading information and coil information simultaneously

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GPO Implementation: Prioritized "Dig List"

Anomaly ID	Easting (feet)	Northing (feet)	WGS84 Latitude	WGS84 Longitutde	0.216ms amplitude	Priority	Comments
1a	883120.0	635179.5	41.203551	-73.174738	5.9	1	
11	883062.0	635227.3	41.203681	-73.174950	342.0	1	
13	883154.0	635234.5	41.203702	-73.174615	24.3	1	
15	883063.0	635239.0	41.203713	-73.174946	8.0	2	
17	883032.0	635252.0	41.203748	-73.175059	111.3	3	line break
21	883016.0	635268.5	41.203794	-73.175118	13.3	3	

A sample dig sheet will include an anomaly ID, location information, usually signal strength and some comments to assist the field team

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GPO Implementation: Anomaly Reacquisition

						Dig Results			Offset				
Target ID	Northing	Easting	Amplitude (mv)	Date	Date Reacquired	Anomaly Type	# of Contacts	Weight (lbs)	Distance (ft)	Direction	Depth to Top	Date	Team Lead Initials

The actual proof of principal

This is what may be used by the field to go out and demonstrate the anomalies were in fact where they said they were

The additional information (offset, weight, etc.) can later be used by the geophysicist to improve the model used to pick the target.

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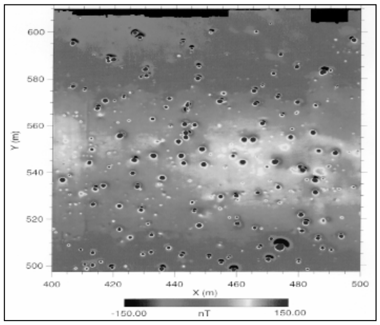
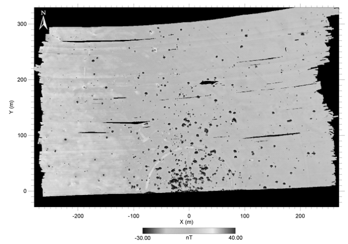
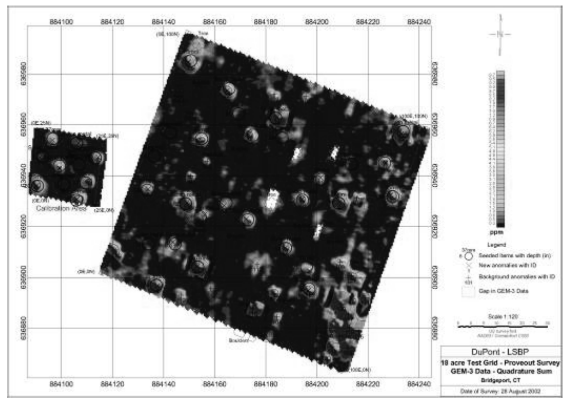
GPO Implementation: Digital Geophysical Mapping Survey Maps







This may be the final product of a GPO survey. The map indicates the location and signal strength for the picked anomalies. Accompanied by a completed dig sheet this would be proof that the selected sensor (when used by the prescribed team and deployed in the prescribed method) can, in fact, detect and reacquire the items in the GPO.

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GPO Reporting: Example Report Table of Contents

1. Introduction
2. GPO Objectives
3. Test Grid Locations and Design
4. Equipment
5. Procedures
6. Data Processing and Management
7. Results
8. Quality Control
9. Conclusion

Appendix A: GPO Seed Item Pictures
Appendix B: Raw and Processed Data
Appendix C: Dig Sheets
Appendix D: Field Notes

Accurate and precise reporting of data collected in the GPO is very important since this information will be used to structure and perform the munitions response field production survey. Report contents may vary as a function of project complexity and will be determined by the data quality objectives established at the beginning of the project. For example, a report on the application of a sophisticated digital geophysical electromagnetic survey will differ markedly from one on a “mag and flag” technology. In general, the report should discuss site conditions, methods, procedures, instruments employed, data collection and processing methods, and the QA/QC process. Certain elements, such as accurate to-scale drawings of the GPO plot, pictures of seeded items and summary of the GPO results should be included in all GPO documents. The report should include all associated maps as well as photos of instruments and equipment used. QA/QC procedures used throughout the GPO should be detailed and documented. Finally, specific findings and conclusions of the GPO should indicate whether the GPO goals and objectives were reached, if the selected equipment was appropriate for the site, and if the selected system will meet the objectives of the munitions response action.

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GPO Reporting: Electronic Data Reporting

- Electronic submittal of all GPO data files
  - Raw data files
  - Processed data files
  - Processing logs
  - Any other intermediate data sets critical to the data processing and analysis

Electronic submittals of GPO data files are in addition to the written report. Data sets should be submitted in “industry standard” formats with sufficient descriptions to allow for audits and reprocessing.

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GPO Reporting: QA/QC Reporting

- The QA/QC procedures used throughout the GPO process should be detailed to include discussions on the following
  - Equipment function checks
  - Personnel qualifications
  - Data collection operations procedures
  - Target parameters
  - Positioning system operations/limitations/accuracy
  - Data management/processing

QA/QC procedures MUST be documented. The level and degree of quality assurance is decided by the appropriate accepting agency. Inspections for quality assurance may include observation of field personnel, independent and confirmatory sampling, and reporting and documentation.

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GPO Report: Conclusions

- Should address
  - Detection capability
  - Positioning system capabilities
  - Data quality
- GPO report should answer the following questions
  - Did this GPO meet its goals and objectives?
  - Is the selected geophysical survey system appropriate for this site?
  - Will the selected system meet the objectives of the munitions response action?

Again, every GPO report should answer the following questions:

Did this GPO meet its goals and objectives?

Is the selected geophysical survey system appropriate for this site?

Will the selected system meet the objectives of the munitions response action?

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Summary Slide

- GPOs test, evaluate, and demonstrate geophysical systems and equipment on a specific site
- State regulator should be provided with necessary information to perform oversight
- Documentation of a GPO through a work plan and reporting is critical
- The GPO document provides technical guidance for reviewing the design, execution, and reporting of GPOs

Remember, the purpose of a GPO is to test and evaluate geophysical systems before performing a production survey on the munitions response site. Information collected during the GPO is then used to analyze and select or confirm the specific geophysical system that will be used to meet the performance requirements established by the interested parties. This document has discussed GPO goals and objectives as well as information needed to design, construct and implement a GPO. Since state regulators will often be the lead approval agency at these sites, it is important for them, as well as other interested parties, to have a working knowledge of all the elements of a GPO.

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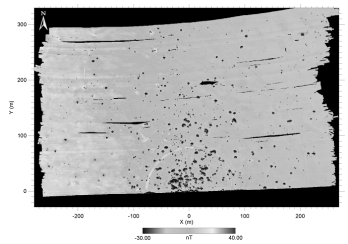
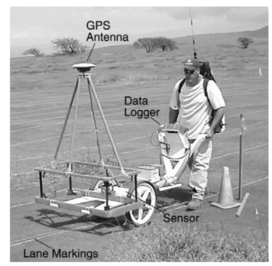
Questions & Answers





No associated notes.

73

Thank you for participating

Links to additional resources

For more information on ITRC training opportunities and to provide feedback visit:
www.itrcweb.org

Links to additional resources:
http://www.clu-in.org/conf/itrc/gpo/resource.cfm

Your feedback is important – please fill out the form at:
http://www.clu-in.org/conf/itrc/gpo

The benefits that ITRC offers to state regulators and technology developers, vendors, and consultants include:

- ✓ Helping regulators build their knowledge base and raise their confidence about new environmental technologies
- ✓ Helping regulators save time and money when evaluating environmental technologies
- ✓ Guiding technology developers in the collection of performance data to satisfy the requirements of multiple states
- ✓ Helping technology vendors avoid the time and expense of conducting duplicative and costly demonstrations
- ✓ Providing a reliable network among members of the environmental community to focus on innovative environmental technologies

How you can get involved with ITRC:

- ✓ Join an ITRC Team – with just 10% of your time you can have a positive impact on the regulatory process and acceptance of innovative technologies and approaches
- ✓ Sponsor ITRC's technical team and other activities
- ✓ Be an official state member by appointing a POC (State Point of Contact) to the State Engagement Team
- ✓ Use ITRC products and attend training courses
- ✓ Submit proposals for new technical teams and projects