FINAL

Depleted Uranium Slug Search

Santa Susana Field Laboratory

Ventura County, California

Contract Number 114579

Prepared for:

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RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION

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Table of Contents

1.0 Introduction ... 1
1.1 Historical Background ... 1
1.2 Site Description ... 2
1.3 Project Action Levels ... 2
2.0 Data Quality Objectives ... 3
2.1 Step 1 – State the Problem ... 3
2.2 Step 2 – Identify the Decision ... 3
2.3 Step 3 – Identify Inputs to the Decision ... 3
2.4 Step 4 – Define the Study Boundaries ... 3
2.5 Step 5 – Develop a Decision Rule ... 4
2.6 Step 6 – Specify Limits on Decision Errors ... 4
2.7 Optimize the Design ... 4
3.0 Summary of Survey activities ... 5
3.1 Geophysical Survey ... 5
3.2 Gamma Walkover Survey ... 5
3.3 Metal Detector ... 5
4.0 Survey results ... 6
4.1 Geophysical Survey Results ... 7
4.2 Gamma Walkover Survey Results ... 8
5.0 Quality Control ... 11
5.1 Precision, Accuracy, Representativeness, Comparability, and Completeness ... 11
5.2 Portable Instrumentation ... 11
5.3 Calibration and Maintenance ... 11
5.4 Instrument Response ... 12
5.5 Minimum Detectable Concentration ... 12
5.6 Data Quality Assessment ... 12
6.0 Conclusion and recommendation ... 15
7.0 References ... 17

List of Figures

Figure 1.2 Aerial View of DU Slug Impact Area ... 20
Figure 4.1-1 Results of the Geophysical Survey with Anomaly Selections ... 21
Figure 4.1-2 Investigated Anomalies With target Response Within 1 Standard Deviation of the Average Seed Response ... 22
Figure 4.1-3 Investigated Anomalies With Target Response Within the Range of Seed Responses ... 23
Figure 4.1-4 Investigated Anomalies With Target Response Outside the Range of Seed Responses ... 24
Figure 4.1-5 Photograph of Metal Wire Removed at Anomaly C1_29 ... 25
Figure 4.1-6 Photograph of Scrap Metal Removed at Anomaly C0_14 ... 25
Figure 4.1-7 Photograph of Nail Removed at Anomaly A0_54 ... 26
Figure 4.1-8 Photograph of Beverage Can Removed at Anomaly B0_065 ... 26
Figure 4.2-1 Gamma Walkover Contour Map of the Impact Area ... 27
Figure 4.2-2 Locations of Radiological Investigations Based on Gamma Walkover Results ... 28

Figure 4.2-3 Cumulative Frequency Distribution of the Radiological Investigation of Geophysical Anomalies 28

List of Tables

Table 2-1 Decision Rules........ 4
Table 5-2 Portable Instrumentation 11

List of Appendices

Appendix A: Instrument QC and Calibration Sheets

Appendix B: Electronic Anomaly Dig Sheets

Appendix C: Electronic Appendix of Photos

Appendix D: Scan MDC Calculations

List of Attachments

Attachment 1: Geophysical Report

List of Acronyms, Abbreviations, and Units of Measurement

bgs	below ground surface
Boeing	The Boeing Company
CABRERA	Cabrera Services, Inc.
cpm	count per minute
DGPS	digital global positioning system
DOE	US Department of Energy
DQO	Data Quality Objective
DU	depleted uranium
EM	electromagnetic
EDA	exploratory data analysis
FSP	Field Sampling Plan
GPS	global positioning system
GWS	Gamma walkover survey
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
NAD	North America Datum
NaI	sodium iodide
NIST	National Institute of Standards and Technology
pCi/g	picocurie per gram
QA	quality assurance
QC	quality control
PVC	polyvinyl chloride
RTK	real time kinetic
SNAP	System for Nuclear Auxiliary Power
SSFL	Santa Susana Field Laboratory
U	Uranium (e.g. ^{238}U)
US	United States

EXECUTIVE SUMMARY

This report presents the results of a comprehensive search for a missing depleted uranium (DU) slug at the Santa Susana Field Laboratory (SSFL) in Ventura County, California. The DU slug was reportedly lost in the 1960s during a test conducted at Area IV. Boeing operates Area IV of the SSFL for the United States (US) Department of Energy (DOE). Cabrera Services, Inc. (CABRERA) has been contracted by The Boeing Company (Boeing) to perform this work.

In the early 1960s a test was performed near the west end of Area IV to simulate a rocket failure during the launch of a System for Nuclear Auxiliary Power (SNAP) reactor. The test is believed to have occurred sometime prior to 1966 and most likely in the spring of 1965. The test was conducted by dropping 20 simulated SNAP fuel elements from a low flying helicopter in order to simulate a launch pad accident. One of the DU slugs was reported as not being recovered.

A radiological survey of surface soil was performed over 100% of the impact area to locate radiation anomalies that indicate potential areas for further investigation. The actual boundaries of the area were established at the time of field mobilization. A geophysical survey was then performed to supplement and corroborate findings from the radiological survey using one or more time-domain electromagnetic systems capable of detecting both ferrous and non-ferrous metals. Hand digging was performed to investigate subsurface anomalies to a depth of approximately 12 inches below grade surface.

The radiological and geophysical data are presented in this technical report. The report includes a narrative of the DU slug search effort, presents and interprets analytical data, and includes figures showing the location of the area searched and pertinent field information. It describes the methods used to collect and analyze data, presents quality assurance/quality control (QA/QC) information, and includes field data sheets, project photographs, and maps of the project area. This report presents conclusions and recommendations regarding the missing DU slug. Report appendices include a complete set of the radiological and geophysical data collected.

Based on the results of the radiological survey there is greater than 95% confidence that the DU slug is not present in the top ten inches of soil in the expected impact area. Based on the results of the geophysical survey there is greater than 90% confidence that the DU slug is not present in the top twelve inches of soil in the expected impact area. There is no reasonable expectation for the DU slug to be present in the expected impact area. No additional investigations of the impact area to locate the DU slug are recommended.

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1.0 INTRODUCTION

This report presents the results of the radiological and geophysical surveys performed at the Santa Susan Field Laboratory (SSFL) in Ventura County, California to locate a missing depleted uranium (DU) slug. The field work was performed from April 29, 2008 to May 22, 2008 by Cabrera Services, Inc (CABRERA) in accordance with the *Final Field Sampling Plan for the Depleted Uranium Slug Search* (CABRERA, 2008).

1.1 Historical Background

Boeing operates Area IV of the SSFL for the United States (US) Department of Energy (DOE). In the early 1960s, sometime prior to 1966, a test was performed near the west end of Area IV to simulate a rocket failure on the launch pad during the launch of a System for Nuclear Auxiliary Power (SNAP) reactor. The test is believed to have occurred sometime prior to 1966 and most likely in the spring of 1965. The test was conducted by dropping 20 simulated SNAP fuel elements from a low flying helicopter in order to simulate a launch pad accident. Historical documentation describes the test as follows:

> "The helicopter was to fly a straight line path over the south light posts of building 20's parking lot through to and on line with the ESADA tower (Building 814) south of the burn pit (Area 886). The altitude was about 300 feet above ground. The speed was not recalled, but it appeared to be relatively slow (20 to 30 miles per hour). [An observer] remembers the soil condition as damp and muddy.
>
> "When the fly-over took place a single depleted uranium fuel slug came out first followed by the remainder in a cluster. The cluster started just south of the designated flight path at the intersect of the road to the water tower. The recovery crew with their Geiger counters and some military mine detectors, along with the test observers, raced out to the site from our vantage point near a telephone pole".
>
> "The majority of the slugs were only half buried and were visible, and all but one were recovered, including the single drop, within 45 minutes. Some had landed end first and left a small target of about a 1.5 inch hole. The metal detectors kept finding pieces of pipe, drum lids, cans, angle iron etc. The search continued for 4 hours. Several searchers returned the next day to continue the search".
>
> "The report back from the helicopter was that all of the elements were dropped as they were viewed by the observers. An element was not stuck in the dropping container or anything else." (Rockwell, 1991)

The object was reported as a DU slug cylindrical in shape approximately 30 centimeters in length and 3 centimeters in diameter. No information is available regarding the composition of the DU encapsulation. Since the reported loss occurred in the 1960s, it is thought that the containment would likely be composed of an aluminum, zirconium or steel alloy. Casting and machining more exotic, non-conductive metals may have been prohibitively expensive or the techniques may not yet have existed at the time of the loss. No documentation has been found to suggest the slug was ever found.

1.2 Site Description

Historical documentation (Rockwell, 1991) describes the location of the drop zone as the "field west of Building 20 and south of Building 9." A terrestrial view of the impact area where the slug was dropped is shown in Figure 1.2-1. It is a relatively flat area covered with surface soil that is estimated to be approximately three acres in size.

1.3 Project Action Levels

The project action level for the gross gamma walkover survey was primarily based on statistical probability and used contours of z-scores (number of standard deviations from the mean). A z-score greater than 3.0 was used as an indicator for investigating the missing DU Slug. The geophysical survey was used to supplement and corroborate the results from the radiological survey using one or more time domain electromagnetic systems capable of detecting both ferrous and non ferrous metals.

2.0 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) were developed to define the purpose of the search, clarify what data should be collected to satisfy the purpose, and specify the performance requirements for the quality of information to be obtained from the data. Quality assurance (QA) measures were implemented throughout the project to ensure data met known and suitable data quality criteria such as precision, accuracy, representativeness, comparability, and completeness. The quality of analytical data was also controlled through the performance of quality control (QC) measurements (see Section 5 for more details).

2.1 Step 1 – State the Problem

A DU slug was reported missing during a test conducted in the mid-1960s. Boeing would like to recover the DU slug as part of their ongoing decontamination and decommissioning efforts at the SSFL.

2.2 Step 2 – Identify the Decision

The principal study question is: "Do radiological and/or geophysical survey results suggest further investigation is warranted?" The following alternative actions will result from resolution of the principle study question:

- If radiological and geophysical survey results do not suggest further investigation is warranted, then the area(s) will be identified as satisfactorily searched with no follow-on action planned.
- If radiological and/or geophysical survey results suggest further investigation is warranted, then the area(s) will be marked and the Boeing Project Manager will be consulted to determine further action.

Based on the principal study question and the alternative actions listed above, the decision statement is: Determine areas where radiological and/or geophysical survey results suggest further investigation is warranted.

2.3 Step 3 – Identify Inputs to the Decision

Radiological and geophysical survey measurement data were used as qualitative inputs to the principal study question.

The radiological survey was based on the detection of low-energy gamma-emitting surface residual radioactivity by scanning. A z-score greater than 3.0 was used to represent a probability greater than 99% that the survey data may not belong to the same population as the rest of the data set (i.e., potentially represents radioactivity other than that due to background).

The geophysical survey was based on the instrument responses to surrogate items of similar size, shape and composition buried in a test strip. The use of a "soft prove-out" allows the geophysicist to determine soil background responses and instrument positioning latencies. The prove-out provided sufficient data to establish a preliminary threshold for anomaly selection based upon actual data that represents responses from the anticipated targets of interest.

2.4 Step 4 – Define the Study Boundaries

For the radiological survey, the target population was the low-energy gamma-emitting by the DU slug and measured by sodium iodide (NaI) gamma scintillation detector. For the geophysical survey, the target population was the electromagnetic signature of the encapsulating metal material surrounding the DU slug, and the density of the slug itself. Only surface soil is included in the study boundaries because the presence of a hardpan layer at a depth of approximately 12 inches below ground surface would prevent the DU slug from penetrating deeper into the subsurface. The other DU slugs were all located on or near the ground surface with portions of the DU slug being visible. Both radiological and geophysical survey data were collected from the surface soil of the search area in Area IV.

2.5 Step 5 – Develop a Decision Rule

The decision statement results in the decision rules, listed in Table 2-1.

Table 2-1 Decision Rules

Parameter	***IF***	***THEN***
Radiological Measurements	Areas identified with z-scores greater than 3.0,	Hand survey area; investigate subsurface anomalies by hand digging to a depth of approximately 12 inches below grade surface; consult Boeing Project Manager to determine further action, if any.
Geophysical Measurements	Areas identified that meet anomaly selection criteria,	

2.6 Step 6 – Specify Limits on Decision Errors

There are no quantitative decision errors rates that were applied due to the qualitative nature of the survey data and their evaluation. The radiological detection limit assumes Type I and Type II decision error rates of 0.05. The detection limit calculation assumes the radioactivity is uniformly distributed throughout a volume of soil rather than a fixed geometry. This assumption is necessary to cover the possibility that the DU slug broke open on impact and was distributed in the environment. The uniform distribution of activity over a large volume of soil is a conservative assumption compared to the intact DU slug and provides the upper limit on decision errors. However, since the DU slug was not located and the DU could be present as an intact slug in a variety of orientations or as discrete pieces of DU if the slug is no longer intact, the decision error rates are qualitative.

2.7 Optimize the Design

The data were evaluated (i.e., against the project action levels and by exploratory data analysis [EDA]) and used to refine the scope of field activities to optimize implementation of the survey design and ensure the DQOs were met. The top six inches of soil in the impact area was tilled to remove vegetation and provide access for performing measurements. The survey area was extended approximately 70 feet beyond the boundary of the expected impact area on the north and south sides, and approximately 150 feet beyond the boundary on the east side to ensure 100% coverage. The fence at the western edge of the expected impact area prevented extending the survey area to the west. Figure 1.2-1 shows the approximate area of the survey relative to the expected impact area. The field instrument for the detection of low-energy radiation (FIDLER) selected for performing gross gamma measurements was replaced with a Ludlum Model 44-20 3-inch by 3-inch sodium iodide (NaI) detector. The calculated detection limit for the Model 44-20 is approximately equal to the detection limit for the FIDLER, but is sufficient to achieve the DQOs (see Section 5.5 and Appendix D). No other changes to the survey design were made.

3.0 SUMMARY OF SURVEY ACTIVITIES

A radiological survey and geophysical survey were performed over 100% of the reasonably accessible search area to locate the missing DU slug as described in the Field Sampling Plan (FSP) (CABRERA, 2008). The gross gamma walkover survey was performed using a Ludlum Model 2221 with Model 44-20 NaI instead of the Bicron G5 FIDLER specified in the survey design. The boundaries of the survey area were extended beyond the boundaries of expected impact area whenever possible to ensure 100% survey coverage (see Figure 1.2-1). The top six inches of soil in the survey area was tilled to remove vegetation and provide access to the surface soil for performing radiological and geophysical measurements.

3.1 Geophysical Survey

Geophysical survey data were collected using the Geonics EM61 MK2 All-metal detector coupled with the Leica 1200 Real Time Kinetics Digital Global Positioning System (RTK/DGPS). The RTK/DGPS was used to establish geographically referenced locations of the survey areas in North American Datum (NAD) 1983 California State Plane Zone 5 with units of US survey feet. Geophysical data were collected using a line spacing of 2.5 to 3.0 feet at a sample rate of 12 times per second. The survey area did not contain any significant obstacles that could not be traversed safely, so 100% of the expected impact area was surveyed. The EM61 was coupled with the Leica GPS in a "cart" configuration. Ruggedized nonmetallic wheels supported the Electromagnetic Coil. The GPS antenna was mounted directly above the center of the coil. A polyvinyl chloride (PVC) carriage was constructed on-site allowing the operator to push or pull the cart. Ropes were extended along the ground at 3 feet spacing which aided the operator in maintaining equal line spacing and attaining 100% coverage.

After each dataset was collected, the data were downloaded onto a flash card and provided to the site geophysicist for analysis. The data were uploaded to a computer and then processed and analyzed. File corrections were made for drifting. Once corrected for drift, the data were gridded and maps were formulated (see Figure 4.1-1).

3.2 Gamma Walkover Survey

Gross gamma walkover survey data were collected using a Ludlum Model 2221 scaler/ratemeter with a Ludlum Model 44-20 3-inch by 3-inch NaI gamma scintillation detector. The detector was suspended at a height of approximately 10 centimeters above the ground and moved in parallel lines about 0.5 meters apart at a speed of roughly 0.5 meters per second. The measurements were position correlated using a GPS. Data were automatically logged at one-second intervals with the measurement coordinates using a Trimble TSCe™ GPS. The GPS linked survey data to spatial locations using state plane coordinates for California, Zone 5, NAD 1983.

3.3 Metal Detector

An Elite Model 2200 metal detector was used to investigate metallic anomalies identified by the geophysical survey. The metal detector consists of a transmitter and receiver, and was used to locate metal objects identified by the geophysical survey. The metal detector was used to verify the presence of metal at each anomaly. If metal was detected, a shovel was used to recover any metallic items to a depth of 12 inches below ground surface (bgs). If no metal was detected, soil was excavated down to hardpan (approximately 12 inches bgs) to investigate the location. A one-minute static measurement of gamma activity was performed at each anomaly investigation.

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4.0 SURVEY RESULTS

4.1 Geophysical Survey Results

A total of 416 anomalies were identified by the geophysical investigation. Of the identified anomalies, 8 were seeded items. All seeded items were readily identified and their positions were consistent with those measured using the RTK/DGPS. See Attachment 1 for the Geophysical Survey results.

The expected impact area was divided into six grids for collecting geophysical data; A0, A1, B0, B1, C0, and C1. Figure 4.1-1 shows an overview of the geophysical anomalies for the entire survey area. Attachment 1 includes figures identifying geophysical anomalies for each of the six survey grids.

An area in the central portion of Grid B0 contained stained soils indicating an old burn area, but did not have substantially larger quantity of anomalies. A large anomaly was identified in the northwest corner of grid C-0 that was consistent with the area where metal culvert pipe was removed from the surface prior to the DU slug search being performed. In general, the density of anomalies appeared to increase toward the southeastern portion of the search area. While several anomalies appeared elongated (for example B1_06 and B0_054), there was no specific attribute that would distinguish between piping and concentrations of wire bundles. None of the 416 anomalies identified the DU slug.

None of the anomalies identified by the geophysics survey resulted in a target response expected from the DU slug. All 8 (100%) of the seeds were identified by the geophysical survey. Summary statistics were calculated using the target response for the 8 seeds used in the geophysical survey. The average response was 56 mV with a standard deviation of 20 mV. The response for the seeds ranged from 24.9 mV to 84.5 mV.

There were 416 anomalies identified by the geophysics survey. There were 8 seeds, and location (B0_117) had no target identified. One hundred thirteen locations had a target response within one standard deviation of the mean for the seeds, and 188 locations had target responses in the range of responses for the seeds. In addition, 130 anomalies reported target responses below the range for the seeds and 89 anomalies reported target responses that exceeded the range of responses for the seeds.

While none of the geophysical anomalies was identified as a likely location for the DU slug, the anomalies were prioritized for intrusive investigations based on size, shape, and target response. Anomalies that were similar in size, shape, and expected target response for the DU slug were selected for intrusive investigation. Linear and circular anomalies less than 5 feet long with responses within one standard deviation of the mean response for the seeds were always investigated. Anomalies with target responses outside the range of responses for the seeds that did not match the size or shape of the DU slug were only analyzed for quality control to demonstrate the effectiveness of the geophysical methods.

Intrusive investigations were performed for 111 of the 113 (98%) anomalies with target responses within one standard deviation of the mean response of the seeds. Intrusive investigations were performed at 153 of the 188 (81%) anomalies with target responses within the range of responses for the seeds. Intrusive investigations were performed for quality control at 22 of the 219 (10%) anomalies with target responses that fell outside the range of responses for the seeds. Figure 4.1-2 shows the locations of anomalies with responses within one standard deviation of the mean response for the seeds where intrusive investigations were performed. Figure 4.1-3 shows the locations of the additional anomalies with responses within the range of responses for the seeds where intrusive investigations were performed. Figure 4.1-4 shows the locations of anomalies with responses outside the range of responses for the seeds where intrusive investigations for quality control were performed.

Based on the geophysical survey results, 172 out of 416 anomaly locations were selected for intrusive investigation. The metal detector was used to confirm the presence of metal objects for each location. If the metal detector confirmed the presence of metal, a shovel was used to remove metal objects to a depth of 12 inches bgs. A description of items found during these investigations was recorded on the dig sheet. If the metal detector failed to confirm the presence of metal, soil was excavated down to hardpan (approximately 12 inches bgs) to verify the DU slug was not present.

Metal objects were recovered from 106 of the 175 (60%) anomalies where intrusive investigations were performed. The rate of recovery of metal objects was consistent for anomalies with responses within one standard deviation of the mean response for the seeds (66%), anomalies with responses within the range of responses for the seeds (61%), anomalies with responses below the range of responses for the seeds (60%), and anomalies with responses exceeding the range of responses for the seeds (57%).

None of the metal objects recovered as a result of the intrusive investigations resembled the DU slug. All of the metal objects were surveyed for gamma radiation, and one minute static measurements were performed in each of the 172 holes where the intrusive investigations were performed. All of the gamma radiation measurements were consistent with the instrument background and the gross gamma walkover survey results.

Descriptions of metal objects found during the intrusive investigations were recorded on the dig sheets included in Appendix B. Most of the objects were iron or steel, although there were also pieces of aluminum and copper identified. The most commonly found objects were wire (Figure 4.1-5), scrap metal (Figure 4.1-6), nails (Figure 4.1-7), and beverage cans (Figure 4.1-8). Photographs of metal objects recovered from each of the intrusive investigations are included electronically in Appendix C.

4.2 Gamma Walkover Survey Results

One hundred percent of the accessible surfaces at the search area in SSFL Area IV were surveyed for gross gamma activity using GPS correlated measurements with a 3-inch by 3-inch NaI. Approximately 0.17% of the measurements (97 out of 55908 measurements) exceed the mean by more then three standard deviations (i.e., z-score greater than 3), with a maximum z-score of 4.26 (37,809 counts per minute [cpm]) (see Figure 4.2-1). The average background at the search area was at 32,508 cpm. Locations 1 through 7 (see Figure 4.2-2) were investigated based on the gamma walkover survey (GWS) results. A one minute static measurement was performed at each location and all of the results were consistent with the instrument background and the gamma walkover survey results.

One minute static measurements were performed for each of the 172 anomaly locations based on the geophysical survey as described in Section 4.1. The cumulative frequency distribution of the results shows the data are approximately normally distributed and are consistent with the instrument background and the results of the gamma walkover survey (see Figure 4.2-3). The highest reading was at 41,102 cpm at location B0-028 (see Figure 4.1-3). No metal objects were recovered at this location.

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5.0 QUALITY CONTROL

Activities performed in the completion of this project were performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. Instrumentation was operated in accordance with approved CABRERA procedures and the manufacturers' operation manuals. The following records were maintained for each instrument used to complete this project:

- name of the equipment
- equipment identification (model and serial number)
- manufacturer
- date of calibration
- calibration due date

5.1 Precision, Accuracy, Representativeness, Comparability, and Completeness

Quality control measures were implemented to ensure data met known and suitable data quality criteria, i.e., precision, accuracy, representativeness, comparability, and completeness. Variables related to data precision and accuracy were monitored by instrument response checks designed to monitor the performance of the instrumentation used to collect the data. The type and quantity of collected data were reviewed against project DQOs (see Section 2.0) to ensure data completeness.

5.2 Portable Instrumentation

The following table lists the types of portable instrumentation used for this project.

Table 5-2 Portable Instrumentation

Instrument	***Model/Detector***	***Detector Type***	***Radiation Type***
Ludlum Model 2221	Ludlum Model 44-20	3-inch by 3-inch Scintillation	gamma
Trimble TSCe™ GPS	NA	NA	NA
Time-domain electromagnetics	Geonics EM61 MK2 metal detector	NA	NA
Leica 1200 Series real time kinetic, differential GPS	NA	NA	NA
Metal Detector	Elite 2200	NA	NA

5.3 Calibration and Maintenance

Survey instruments were calibrated prior to use. Radiation detection instruments were calibrated for the radiation types and energies of interest. Radioactive sources used for calibration purposes are traceable to the National Institute of Standards and Technology (NIST). Instrumentation was inspected prior to use to ensure its proper working condition, and properly protected against inclement weather conditions in the operation. Instrument calibration certificates and quality control results are presented in Appendix A.

5.4 Instrument Response

Instrument response checks were conducted to assure constancy in instrument response, to verify the detector was operating properly, and to demonstrate that measurement results were not the result of detector contamination. Instrument response was checked daily. A check source was used that emits the same type of radiation (i.e., gamma) as the radiation being measured and that gives a similar instrument response. The response check was performed at a set location using a specified source-detector alignment that could easily be repeated.

Prior to initial instrument use, at least 10 measurements were made using a source representative of the radiation types and energies of interest. At least 10 one-minute measurements were also made with the source removed to determine the instrument's expected response to ambient background. Background was monitored qualitatively to assess daily variations that may have impacted instrument minimum detectable concentrations (MDCs). From the initial source measurements, the mean of the observed count rate was calculated. The acceptance criterion was ± 20% of the mean of the initial source counts. Source check was monitored using a control chart, with control limits set at ± 20% of the average count rate. In addition, these instruments were checked daily for:

- Current calibration
- Physical damage or defects
- Battery level
- ambient background

For this project, all QC response checks were within the established performance criteria and are included in Appendix A.

5.5 Minimum Detectable Concentration

The MDC was determined using the methods described in MARSSIM for instruments used to perform the gross gamma walkover survey. The scan speed, distance above ground surface, radionuclides of concern, and detector characteristics were considered in the calculation. The anticipated scan MDC for the gross gamma walkover survey was 1 picocurie per gram (pCi/g) for DU. Since DU contains approximately 330,000 pCi/g of Uranium-238 (^{238}U) the scan MDC is adequate to achieve the DQOs.

The MDC calculation assumes the DU slug was intact, positioned horizontally, and buried 10 inches bgs. Other orientations would decrease the horizontal cross section but move one end of the DU slug closer to ground surface. The MDC calculations for the NaI detector and the FIDLER are included in Appendix D.

5.6 Data Quality Assessment

Survey data were verified to be reliable, appropriately documented, and technically defensible. Specifically, the following conclusions were made:

- The instruments used to collect the data were capable of detecting the radiation types and energies of interest at or below the action levels.
- The calibration of the instruments used to collect the data was current and radioactive sources used for calibration were NIST traceable.

- Instrument response was checked daily for each day data were collected.
- The MDCs and the assumptions used to develop them were appropriate for the instruments and the survey methods used to collect the data.
- The survey methods used to collect the data were appropriate for the media and types of radiation being measured.
- The survey data consist of qualified measurement results that are representative of the area of interest and collected as prescribed by the survey design.

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6.0 CONCLUSION AND RECOMMENDATION

A radiological and geophysical survey of surface soil was performed over 100% of the impact area to locate radiological and geophysical anomalies that indicated potential areas for further investigation. The boundary of the area to be searched was established by extending the boundaries beyond the boundaries of the expected impact area as shown in Figure 1.2-1. Radiological walkover surveys did not identify any areas of elevated gross gamma activity. Geophysical surveys identified 416 anomalies. Hand digging was performed to investigate 172 subsurface anomalies to a depth of approximately 12 inches below grade surface. The missing DU slug was not recovered in the first foot of dirt within the DU impact area boundaries.

The results of the radiological survey failed to identify any locations where the gross gamma activity exceeded the scan MDC. The decision error rates used to calculate the scan MDC were 5% for both Type I and Type II decision errors. Therefore, there is greater than 95% confidence that the DU slug is not located in the top 10 inches of soil in the expected impact area.

The results of the geophysical investigation did not identify any anomalies that resembled the DU slug. Intrusive investigations were performed at 172 locations to demonstrate the effectiveness of the geophysical method and demonstrate the DU slug was not present. Geophysics is primarily a qualitative search technique. However, a confidence level of 90% that the DU slug is not present in the top 12 inches of soil in the expected impact area has been assigned based on the results of the geophysical investigation. The confidence level is based on the effectiveness of the geophysical method which identified 100% of the seeds and geophysical prove out items, intrusive investigations of 98% of the anomalies with responses within one standard deviation of the average response expected from the DU slug, intrusive investigations of 81% of all anomalies with responses within the range expected from the DU slug, and intrusive investigations of 10% of other anomalies.

Based on the results of the radiological survey there is greater than 95% confidence that the DU slug is not present in the top ten inches of soil in the expected impact area. Based on the results of the geophysical survey there is greater than 90% confidence that the DU slug is not present in the top twelve inches of soil in the expected impact area. There is no reasonable expectation for the DU slug to be present in the expected impact area. No additional investigations of the impact area to locate the DU slug are recommended.

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7.0 REFERENCES

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Figures

Figure 1.2-1 Aerial View of DU Slug Impact Area

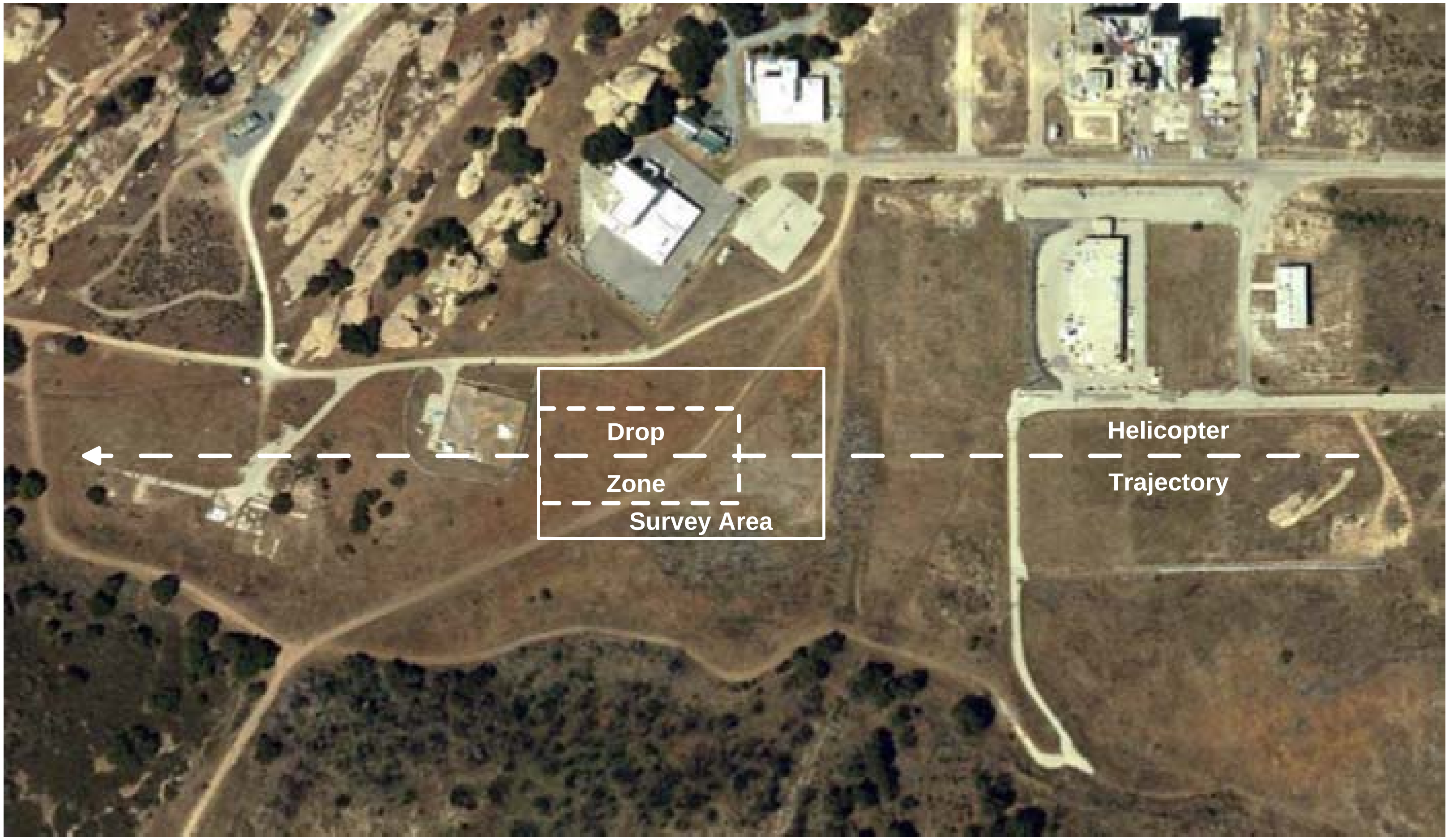


Figure 4.1-1 Results of the Geophysical Survey with Anomaly Selections

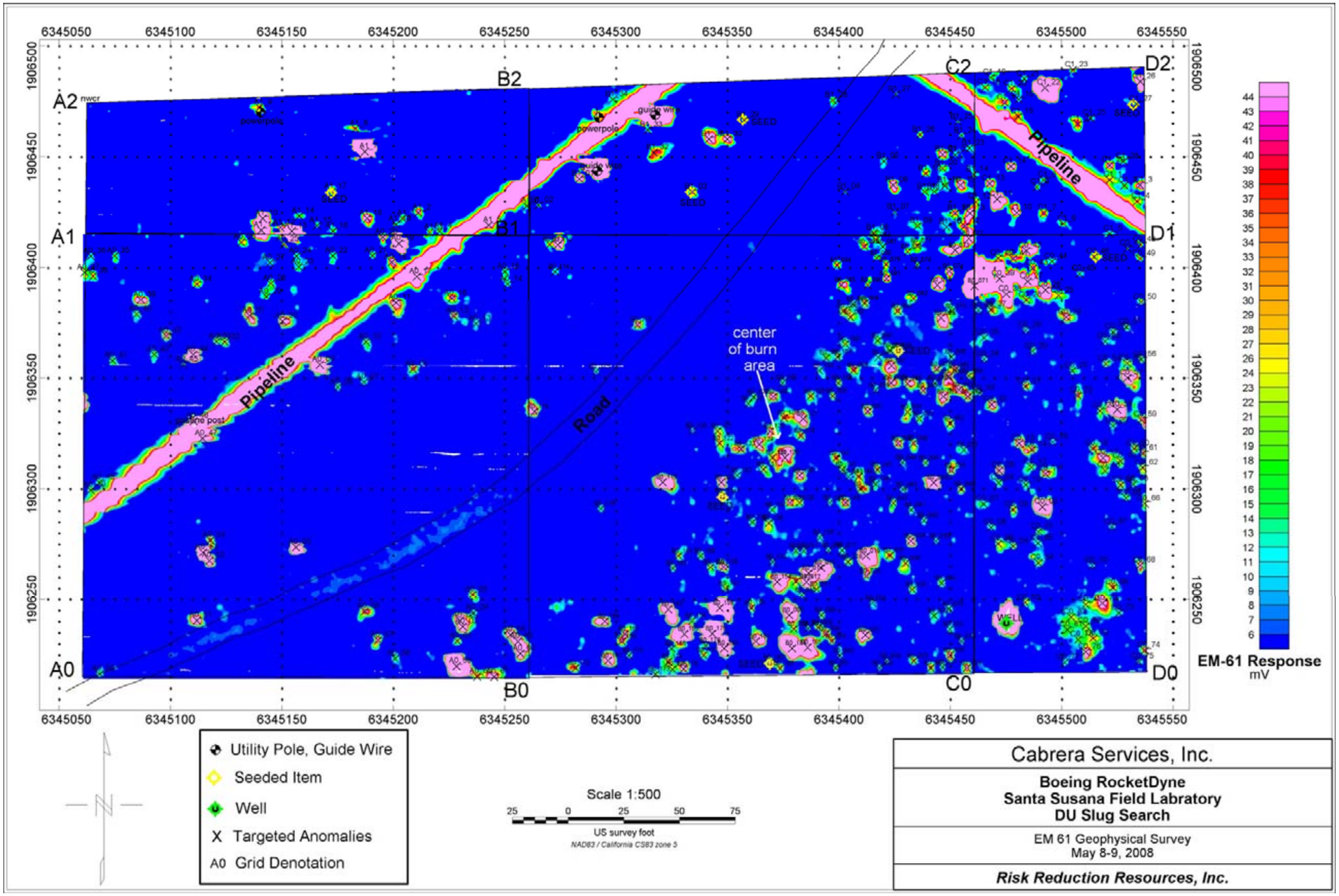


Figure 4.1-2 Investigated Anomalies With target Response Within 1 Standard Deviation of the Average Seed Response

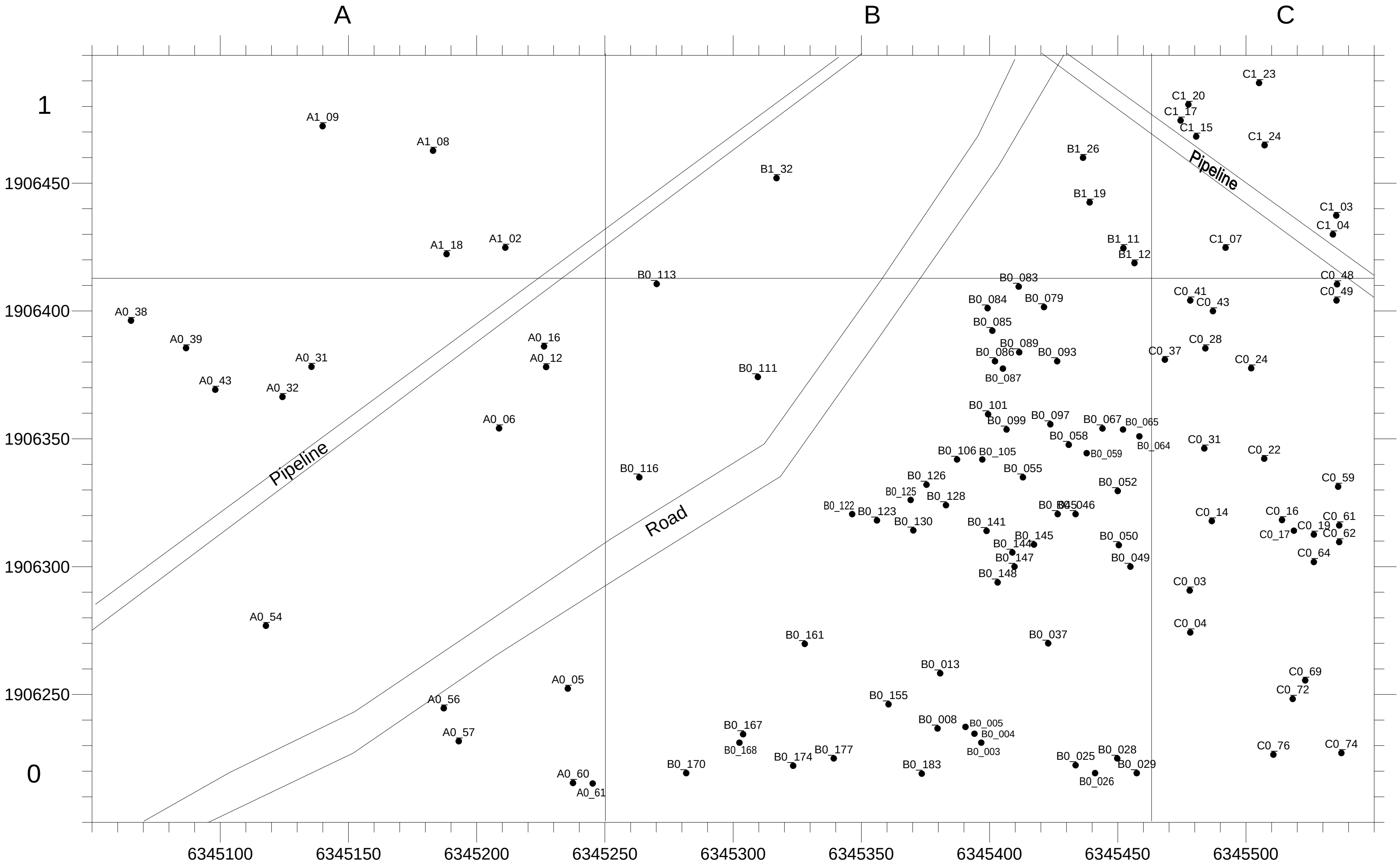


Figure 4.1-3 Investigated Anomalies With Target Response Within the Range of Seed Responses

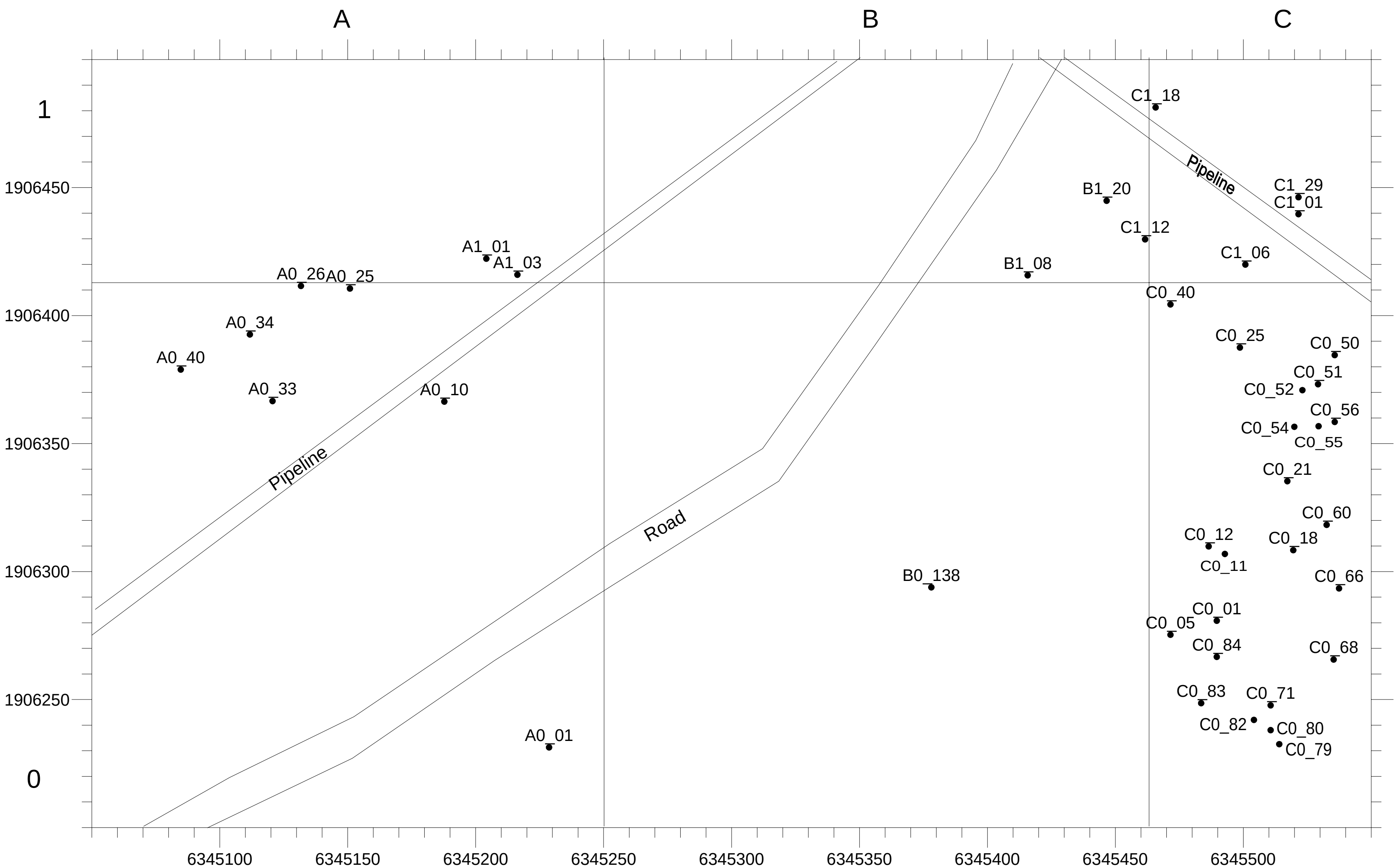


Figure 4.1-4 Investigated Anomalies With Target Response Outside the Range of Seed Responses

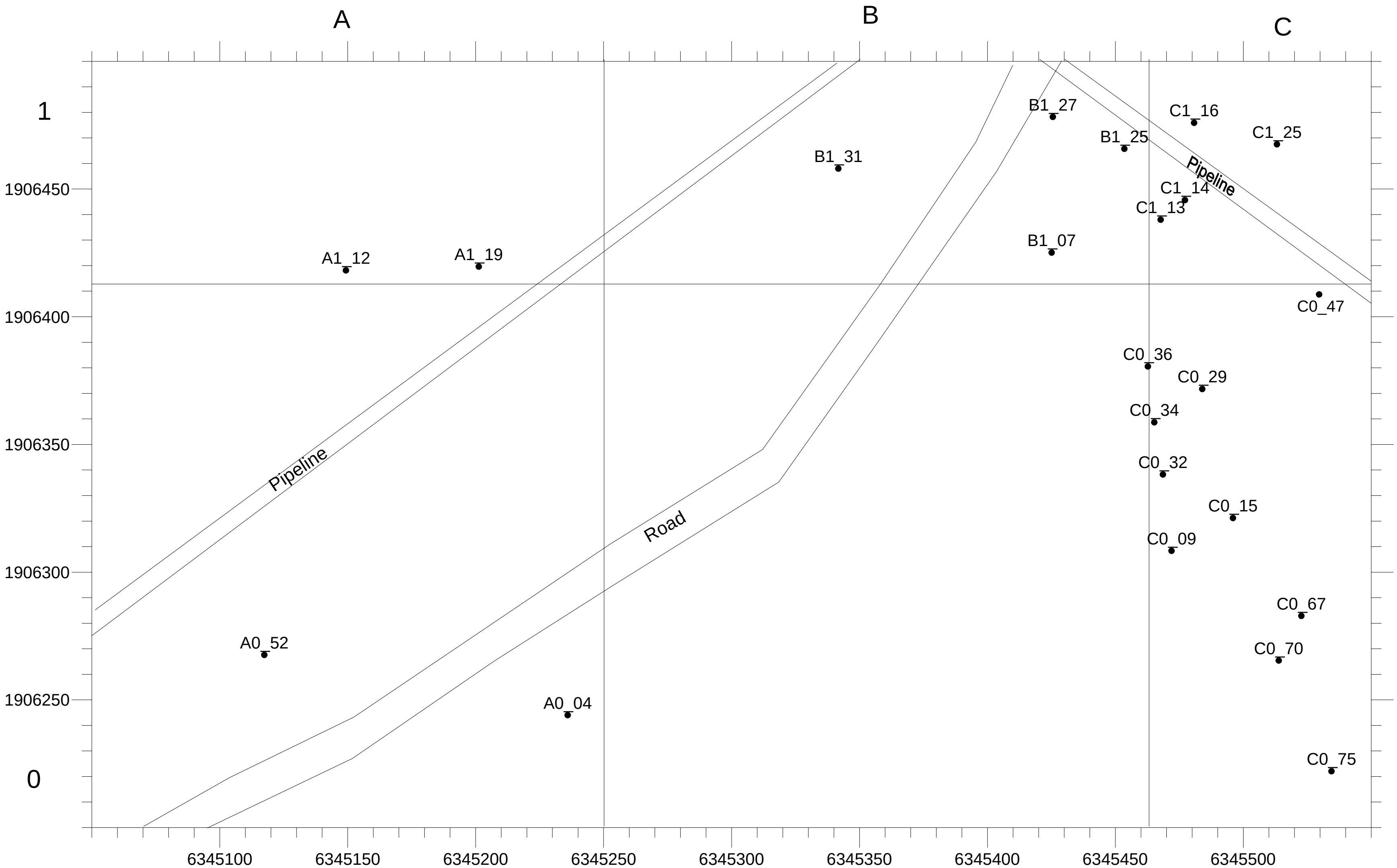


Figure 4.1-5 Photograph of Metal Wire Removed at Anomaly C1_29

Figure 4.1-6 Photograph of Scrap Metal Removed at Anomaly C0_14

Figure 4.1-7 Photograph of Nail Removed at Anomaly A0_54

Figure 4.1-8 Photograph of Beverage Can Removed at Anomaly B0_065

Figure 4.2-1 Gamma Walkover Contour Map of the Impact Area

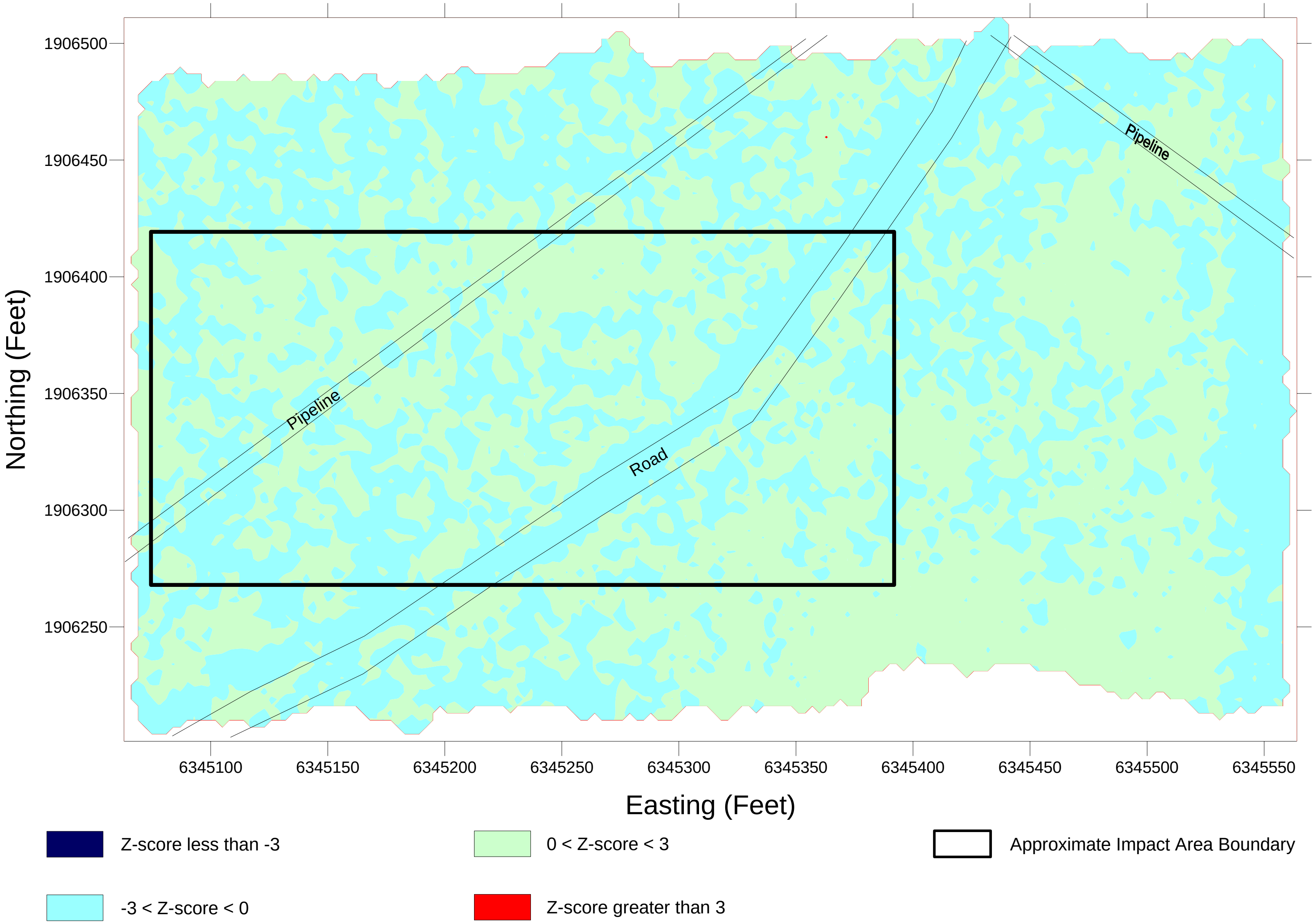


Figure 4.2-2 Locations of Radiological Investigations Based on Gamma Walkover Results

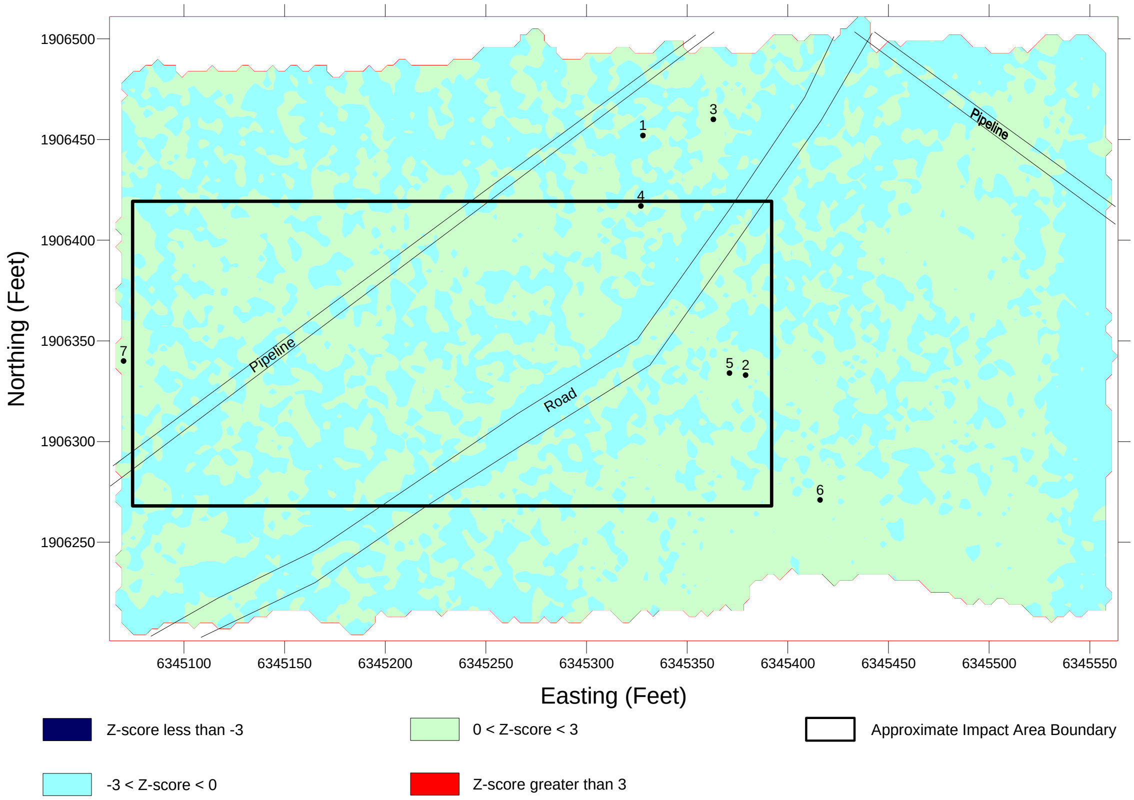
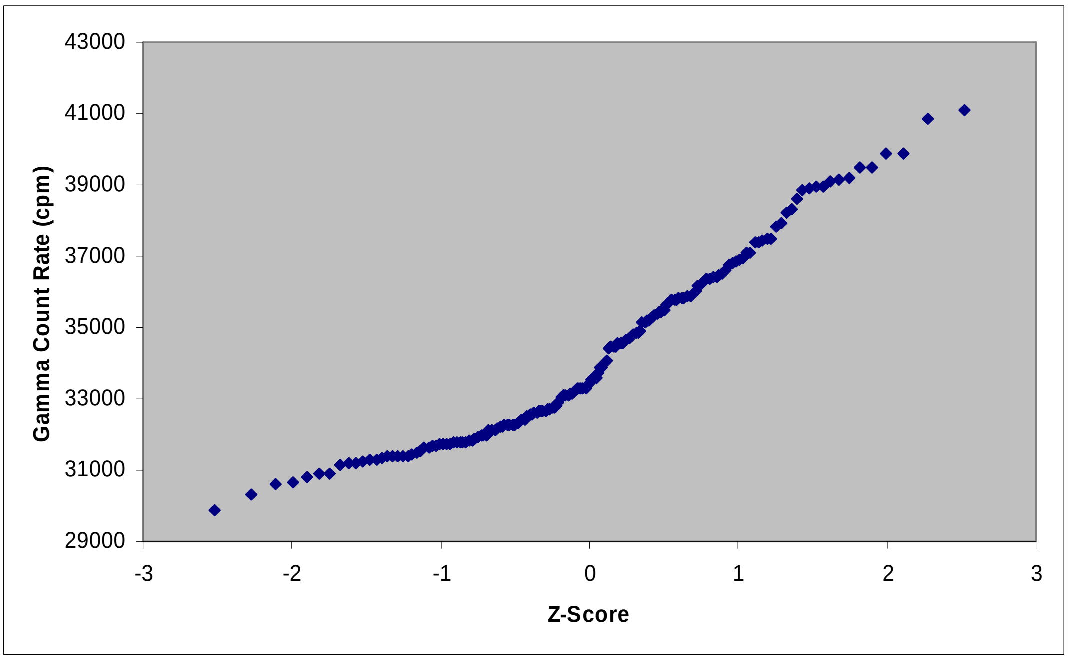


Figure 4.2-3 Cumulative Frequency Distribution of the Radiological Investigation of Geophysical Anomalies



Appendix A
Instrument QC and Calibration Sheets

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Inst.# 149942		
QC Daily Source		
Date	Result (cpm)	P/F
4/30/2008	20318	Pass
5/1/2008	22083	Pass
5/2/2008	21088	Pass
5/5/2008	22112	Pass
5/6/2008	23113	Pass
5/7/2008	21300	Pass
5/8/2008	23757	Pass
5/9/2008	23783	Pass
5/12/2008	24941	Pass
5/13/2008	24672	Pass
5/14/2008	24931	Pass
5/15/2008	24511	Pass
5/16/2008	23997	Pass
5/19/2008	23121	Pass
5/20/2008	21538	Pass
5/21/2008	22678	Pass

Inst.# 149942		Source Ser. #	Bkg
Initial Source Readings		Nuclide	
Date	Result (cpm)		
4/30/2008	21099		
4/30/2008	20946		
4/30/2008	21877		
4/30/2008	20703		
4/30/2008	20701		
4/30/2008	20479		
4/30/2008	20676		
4/30/2008	20463		
4/30/2008	20742		
4/30/2008	20340		
	Average		
	20803		

Inst.# 149942		
QC Daily Source		
Date	Result (cpm)	P/F
4/30/2008	353242	Pass
5/1/2008	343424	Pass
5/2/2008	337573	Pass
5/5/2008	334552	Pass
5/6/2008	339412	Pass
5/7/2008	340709	Pass
5/8/2008	344956	Pass
5/9/2008	358129	Pass
5/12/2008	352640	Pass
5/13/2008	347386	Pass
5/14/2008	350489	Pass
5/15/2008	346392	Pass
5/16/2008	338628	Pass
5/19/2008	345265	Pass
5/20/2008	341452	Pass
5/21/2008	347864	Pass

Inst.# 149942		Source Ser. #	Cs-137
Initial Source Readings		Nuclide	1698-03
Date	Result (cpm)		
4/30/2008	354483		
4/30/2008	357946		
4/30/2008	352928		
4/30/2008	351832		
4/30/2008	352579		
4/30/2008	351604		
4/30/2008	352462		
4/30/2008	351735		
4/30/2008	351874		
4/30/2008	351999		
	Average		
	352944		

Inst.# 105934		
QC Daily Source		
Date	Result (cpm)	P/F
4/30/2008	7603	Pass
5/1/2008	7918	Pass
5/2/2008	8378	Pass
5/5/2008	8227	Pass
5/6/2008	7841	Pass
5/7/2008	8132	Pass
5/8/2008	8180	Pass
5/9/2008	8695	Pass
5/12/2008	9303	Pass
5/13/2008	9163	Pass
5/14/2008	9124	Pass
5/15/2008	9100	Pass
5/16/2008	9183	Pass
5/19/2008	9364	Pass
5/20/2008	7828	Pass

Inst.# 105934		Source Ser. #	Bkg
Initial Source Readings		Nuclide	
Date	Result (cpm)		
4/30/2008	7849		
4/30/2008	7912		
4/30/2008	7850		
4/30/2008	7761		
4/30/2008	7774		
4/30/2008	7641		
4/30/2008	7792		
4/30/2008	7794		
4/30/2008	7876		
4/30/2008	7789		
	Average		
	7804		

Inst.# 105934		
QC Daily Source		
Date	Result (cpm)	P/F
4/30/2008	134190	Pass
5/1/2008	135109	Pass
5/2/2008	142302	Pass
5/5/2008	143137	Pass
5/6/2008	137317	Pass
5/7/2008	132695	Pass
5/8/2008	133188	Pass
5/9/2008	132756	Pass
5/12/2008	135229	Pass
5/13/2008	135584	Pass
5/14/2008	143597	Pass
5/15/2008	138523	Pass
5/16/2008	139320	Pass
5/19/2008	136110	Pass
5/20/2008	137472	Pass

Inst.# 105934		Source Ser. #	Cs-137
Initial Source Readings		Nuclide	1698-03
Date	Result (cpm)		
4/30/2008	136119		
4/30/2008	133989		
4/30/2008	133782		
4/30/2008	134103		
4/30/2008	134801		
4/30/2008	134283		
4/30/2008	134015		
4/30/2008	132858		
4/30/2008	133819		
4/30/2008	133820		
	Average		
	134159		

Certificate of Calibration

Ratemeter / Scaler Certificate of Calibration

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Manufacturer: Ludlum Model: 2221r Serial No.: 149942

All Ranges Calibrated Electronically; Ludlum Pulser Generator Serial No.: ☐ 97743 ☑ 201932

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997.
NMRCB Registration No. 481-3 • Calibration of Radiation Detection Instruments & Devices

☑ Mechanical ck. ☑ Meter Zeroed ☑ Geotropism ck. ☑ F/S Response ck. ☑ Audio ck.

☑ THR/WIN ck. High Voltage ck.: ☑ 500v ☑ 1000v ☑ 1500v ☑ Battery ck. (min 4.4 vdc)

Threshold Setting: 10 mV

Instrument found within tolerance (+/- 10%) ☑ Yes ☐ No

Reference Calibration Point	Instrument "As Found Reading"	Instrument Meter Reading
400 Kcpm	400 Kcpm	400 Kcpm
100 Kcpm	100 Kcpm	100 Kcpm
40 Kcpm	40 Kcpm	40 Kcpm
10 Kcpm	10 Kcpm	10 Kcpm
4 Kcpm	4 Kcpm	4 Kcpm
1 Kcpm	1 Kcpm	1 Kcpm
400 cpm	400 cpm	400 cpm
100 cpm	100 cpm	100 cpm

Reference Calibration Point	Instrument "As Found Reading"	Log Scale Count Rate	Integrated Counts (1-minute count)
400 Kcpm	398806	400 Kcpm	398806
40 Kcpm	39881	40 Kcpm	39881
4 Kcpm	3987	4 Kcpm	3987
400 cpm	400	400 cpm	400

Calibrated By: [signature] Calibration Date: 4-29-08

Calibration Due: 4-29-09

Reviewed By: [signature] Date: 4/29/08

Certificate of Calibration

Ratemeter / Scaler Certificate of Calibration

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Manufacturer: Ludlum Model: 2221r Serial No.: 149942

All Ranges Calibrated Electronically; Ludlum Pulser Generator Serial No.: ☐ 97743 ☑ 201932

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997.
NMRCB Registration No. 481-3 • Calibration of Radiation Detection Instruments & Devices

☑ Mechanical ck. ☑ Meter Zeroed ☑ Geotropism ck. ☑ F/S Response ck. ☑ Audio ck.

☑ THR/WIN ck. High Voltage ck.: ☑ 500v ☑ 1000v ☑ 1500v ☑ Battery ck. (min 4.4 vdc)

Threshold Setting: 10 mV

Instrument found within tolerance (+/- 10%) ☑ Yes ☐ No

Reference Calibration Point	Instrument "As Found Reading"	Instrument Meter Reading
400 Kcpm	400 Kcpm	400 Kcpm
100 Kcpm	100 Kcpm	100 Kcpm
40 Kcpm	40 Kcpm	40 Kcpm
10 Kcpm	10 Kcpm	10 Kcpm
4 Kcpm	4 Kcpm	4 Kcpm
1 Kcpm	1 Kcpm	1 Kcpm
400 cpm	400 cpm	400 cpm
100 cpm	100 cpm	100 cpm

Reference Calibration Point	Instrument "As Found Reading"	Log Scale Count Rate	Integrated Counts (1-minute count)
400 Kcpm	398806	400 Kcpm	398806
40 Kcpm	39881	40 Kcpm	39881
4 Kcpm	3987	4 Kcpm	3987
400 cpm	400	400 cpm	400

Calibrated By: [signature] Calibration Date: 4-29-08

Calibration Due: 4-29-09

Reviewed By: [signature] Date: 4/29/08

ERG Form 1.02B

Certificate of Calibration

Voltage Plateau Form

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Detector Mfg.: Ludlum Model: 44-10 Serial No.: PR170271

Counter Mfg.: Ludlum Model: 2221r Serial No.: 105934 DX2

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997.
NMRCB Registration No. 481-3 • Calibration of Radiation Detection Instruments & Devices

Counter Threshold Setting: 10 mV Cable Length: ☑ 39 inch, ☐ 5 foot, ☐ Other:

Detector geometry to source: ☐ Face, ☑ Side, ☐ Below, ☐ Other:

Distance to source: ☐ Contact, ☑ 6-Inches, ☐ Other:

Gamma Source :☑Cs-137 @ 5.7μCi (2/18/08) sn: 4097-03 ☐Other:

Count Time: 1 Minute

High Voltage	Gross Source Counts	Background Counts
700	2544	
800	32632	
900	54412	
1000	64961	
1050	67963	
1100	69886	8548
1150	71801	
1200	74530	

Comments: Recommended Operating High Voltage: 1100 volts

Calibrated By: [signature] Calibration Date: 4-29-08

Calibration Due: 4-29-09

Reviewed By: [signature] Date: 4/29/08

ERG Form 1.03A1

Certificate of Calibration

Voltage Plateau Form

ERG
Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

Detector Mfg.: Ludlum Model: 44-20 Serial No.: PR201774

Counter Mfg.: Ludlum Model: 2221r Serial No.: 149942

This calibration conforms to the requirements and acceptable calibration conditions of ANSI N323A - 1997.
NMRCB Registration No. 481-3 • Calibration of Radiation Detection Instruments & Devices

Counter Threshold Setting: 10 mV Cable Length: ☑ 39 inch, ☐ 5 foot, ☐ Other:

Detector geometry to source: ☐ Face, ☑ Side, ☐ Below, ☐ Other:

Distance to source: ☐ Contact, ☑ 6-Inches, ☐ Other:

Gamma Source :☑Cs-137 @ 5.7μCi (2/18/08) sn: 4097-03 ☐Other:

Count Time: 1 Minute

High Voltage	Gross Source Counts	Background Counts
700	54093	
800	124215	
900	174447	
1000	195211	
1050	199324	
1100	203302	24055
1150	209325	
1200	212038	

Comments: Recommended Operating High Voltage: 1100 volts

Calibrated By: [signature] Calibration Date: 4-29-08

Calibration Due: 4-29-09

Reviewed By: [signature] Date: 4-29-08

ERG Form 1.03A1

Appendix B

Anomaly Dig Sheets (Electronic)

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Cabrera Services, Inc

Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid A0

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct reading cpm	Item Description Comment
A0_01	35.9	6345228.7	1906231.3	0	4	1	37443	Wire
A0_02	171.3	6345231.1	1906237.8					
A0_03	142.9	6345229.9	1906240.4					
A0_04	16.8	6345235.9	1906244.0	4	1	1	35762	Piece of Aluminum
A0_05	40.2	6345235.5	1906252.3	0	0	0	36502	No metal detected, nothing found
A0_06	47.5	6345208.7	1906354.1	0	0	0	38961	No metal detected, nothing found
A0_07	18.6	6345186.7	1906348.3					
A0_08	19.8	6345175.1	1906345.8					
A0_09	556.4	6345167.0	1906356.1					
A0_10	27.4	6345187.8	1906366.4	0	3	1	32425	Tire Wire
A0_11	125.8	6345201.3	1906384.1					
A0_12	72.9	6345227.1	1906378.1	12	1	1	31630	Nut
A0_13	19.0	6345237.1	1906374.7					
A0_14	16.4	6345251.3	1906392.6					
A0_15	18.5	6345250.1	1906398.3					
A0_16	56.4	6345226.3	1906386.2	24	1	1	32152	Scrap metal
A0_17	382.8	6345210.5	1906396.0					
A0_18	90.8	6345199.2	1906402.5					
A0_19	3683.1	6345202.5	1906411.0					
A0_20	122.5	6345195.2	1906413.8					
A0_21	24.1	6345190.6	1906405.5					
A0_22	18.4	6345172.8	1906405.5					
A0_23	14.8	6345157.5	1906400.5					
A0_24	20.2	6345156.5	1906405.3					
A0_25	35.5	6345150.9	1906410.5	0	0	0	36897	Nothing Found

Cabrera Services, Inc

Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid A0

Target ID	Target Response *(mV)*	*NAD83-CA CS83 Z-5* ***X*** US Survey Foot	*NAD83-CA CS83 Z-5* ***Y*** US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct reading cpm	Item Description Comment
A0_26	33.2	6345131.7	1906411.6	0	0	0	31627	Nothing Found
A0_27	16.8	6345144.6	1906402.3					
A0_28	25.0	6345145.0	1906393.0					
A0_29	20.8	6345143.0	1906387.0					
A0_30	141.6	6345150.3	1906375.7					
A0_31	48.7	6345135.6	1906378.2	12	4	1	38887	Metal Plate 2"x1"
A0_32	37.4	6345124.3	1906366.4	0	7	1	31946	Metal Scrap
A0_33	27.7	6345120.6	1906366.6	0	0	1	35755	Large tin in ground
A0_34	32.3	6345111.8	1906392.6	0	0	0	37383	Nothing Found
A0_35	25.7	6345074.9	1906405.5					
A0_36	15.7	6345064.2	1906405.3					
A0_37	20.5	6345061.3	1906397.9					
A0_38	37.2	6345065.2	1906396.2	6	6	1	38616	Aluminum sheet metal 1"x1"
A0_39	57.6	6345086.6	1906385.5	0	0	0	34711	Nothing Found
A0_40	26.1	6345084.7	1906378.9	0	0	0	34432	Nothing Found
A0_41	22.1	6345073.9	1906357.9					
A0_42	25.0	6345092.6	1906360.8					
A0_43	73.6	6345098.0	1906369.2	0	0	0	36974	Nothing Found
A0_44	685.0	6345110.1	1906360.8					
A0_45	19.5	6345105.7	1906356.1					
A0_46	1439.7	6345110.3	1906330.7					
A0_47	120.0	6345114.4	1906322.9					
A0_48	21.0	6345068.0	1906302.9					
A0_49	25.4	6345064.2	1906299.5					
A0_50	18.1	6345068.0	1906216.6					

Cabrera Services, Inc

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Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid A0

Target ID	Target Response *(mV)*	*NAD83-CA CS83 Z-5* ***X*** US Survey Foot	*NAD83-CA CS83 Z-5* ***Y*** US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct reading cpm	Item Description Comment
A0_51	120.4	6345111.8	1906240.6					
A0_52	198.2	6345117.4	1906267.6	12	4	1	31300	Nail
A0_53	1177.2	6345114.6	1906271.4					
A0_54	51.3	6345117.8	1906276.9	0	2	1	31384	Nail
A0_55	909.2	6345156.3	1906273.7					
A0_56	47.4	6345187.2	1906244.6	0	3	1	34053	Bolt
A0_57	63.2	6345193.0	1906231.7	0	0	0	33738	Nothing Found
A0_58	19.8	6345200.7	1906223.5					
A0_59	1386.6	6345228.3	1906220.0					
A0_60	42.4	6345237.6	1906215.4	0	1	1	33117	Copper wire
A0_61	55.2	6345245.2	1906215.2	0	4	3	34481	Bolt, Nail, Metal Strap
A0_62	157.4	6345256.9	1906225.7					
A0_63	146.2	6345255.9	1906231.1					
A0_64	130.8	6345252.5	1906234.1					

Cabrera Services, Inc

Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid A1

Target ID	Target Response *(mV)*	*NAD83-CA CS83 Z-5* ***X*** US Survey Foot	*NAD83-CA CS83 Z-5* ***Y*** US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct Reading cpm	Item Description Comment
A1_01	27.1	6345204.2	1906422.2	0	3	1	32525	Metal Scrap
A1_02	70.2	6345211.1	1906424.8	0	0	0	39202	No metal detected, Nothing Found
A1_03	32.0	6345216.3	1906415.9	4	4	1	31968	Metal Cylinder, 1/2 inch
A1_04	22.5	6345220.7	1906416.5					
A1_05	90.1	6345242.8	1906419.3					
A1_06	23.3	6345259.9	1906427.9					
A1_07	11372.5	6345187.2	1906452.4					
A1_08	36.1	6345183.0	1906462.7	0	0	0	34841	No metal detected, Nothing Found
A1_09	42.1	6345139.9	1906472.3					Power Pole
A1_10	637.3	6345141.4	1906422.2					
A1_11	261.7	6345140.6	1906417.0					
A1_12	93.2	6345149.3	1906418.2	0	0	0	39875	No metal detected, Nothing Found
A1_13	6672.7	6345154.4	1906416.5					
A1_14	20.2	6345157.8	1906423.3					
A1_15	20.4	6345165.7	1906419.1					
A1_16	20.1	6345172.9	1906416.5					
A1_17	61.7	6345172.3	1906434.4					Seed
A1_18	62.9	6345188.3	1906422.2	0	0	0	39507	No metal detected, Nothing Found
A1_19	17.0	6345201.2	1906419.6	0	0	0	31792	No metal detected, Nothing Found

Cabrera Services, Inc

Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B0

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
B0_001	25.6	6345398.4	1906219.2					
B0_002	17.0	6345400.5	1906224.8					
B0_003	49.6	6345396.8	1906231.2	0	1	1	33053	Striker
B0_004	59.7	6345394.1	1906234.7	0	2	1	35816	Metal Band
B0_005	39.0	6345390.6	1906237.3	0	1	1	33173	Wire, Iron
B0_006	31.3	6345392.0	1906242.9					
B0_007	19.3	6345386.1	1906236.9					
B0_008	38.3	6345379.7	1906236.7	36	3	1	37117	Aluminum sheet metal
B0_009	271.0	6345377.7	1906242.9					
B0_010	21.4	6345383.4	1906251.9					
B0_011	27.6	6345390.0	1906254.8					
B0_012	330.8	6345385.5	1906258.1					
B0_013	43.9	6345380.7	1906258.3	0	0	0	31714	Nothing found
B0_014	493.8	6345386.5	1906262.0					
B0_015	361.8	6345392.0	1906264.5					
B0_016	18.2	6345395.3	1906272.3					
B0_017	20.2	6345401.5	1906272.3					
B0_018	35.2	6345404.2	1906267.1					
B0_019	855.5	6345412.2	1906269.8					
B0_020	80.8	6345412.4	1906260.8					
B0_021	16.0	6345414.8	1906248.4					
B0_022	173.5	6345411.8	1906234.0					
B0_023	15.5	6345418.1	1906219.2					
B0_024	17.2	6345421.4	1906222.3					
B0_025	47.3	6345433.5	1906222.3	0	0	0	36778	Nothing found

Cabrera Services, Inc

Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B0

Target ID	Target Response *(mV)*	*NAD83-CA CS83 Z-5* ***X*** US Survey Foot	*NAD83-CA CS83 Z-5* ***Y*** US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct Reading cpm	Item Description Comment
B0_026	44.7	6345441.1	1906219.2	0	0	0	38307	Nothing found
B0_027	19.2	6345446.5	1906219.5					
B0_028	69.7	6345449.8	1906225.0	0	0	0	41102	Nothing found
B0_029	66.2	6345457.4	1906219.2	0	0	0	35842	Nothing found
B0_030	15.4	6345454.9	1906231.2					
B0_031	16.7	6345449.8	1906236.5					
B0_032	20.9	6345442.6	1906242.7					
B0_033	18.8	6345449.4	1906245.8					
B0_034	26.2	6345446.1	1906257.5					
B0_035	34.5	6345432.9	1906254.6					
B0_036	34.2	6345430.1	1906266.5					
B0_037	42.5	6345422.9	1906270.0	0	0	0	37848	Nothing found
B0_038	149.9	6345432.3	1906276.6					
B0_039	16.2	6345443.6	1906276.6					
B0_040	17.5	6345438.3	1906285.8					
B0_041	19.9	6345432.5	1906290.6					
B0_042	35.3	6345424.5	1906293.6					
B0_043	16.1	6345428.8	1906299.8					
B0_044	19.8	6345428.6	1906311.9					
B0_045	66.6	6345426.6	1906320.6	0	0	1	32762	Nothing Found, dispersed while digging
B0_046	56.5	6345433.5	1906320.6	0	0	1	32122	Can top
B0_047	27.7	6345438.9	1906311.7					
B0_048	865.4	6345442.6	1906302.9					
B0_049	56.6	6345454.9	1906300.0	0	unknown	multiple	35372	Lots of signal, nothing found
B0_050	63.8	6345450.4	1906308.4	0	unknown	multiple	34584	Lots of signal, nothing found

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Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B0

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
B0_051	18.5	6345456.1	1906317.7					
B0_052	49.2	6345450.0	1906329.6	0	4	1	31512	6" rebar
B0_053	27.8	6345436.0	1906331.6					
B0_054	30.9	6345430.9	1906334.7					
B0_055	74.9	6345413.0	1906334.9	0	0	0	31684	Nothing found
B0_056	16.4	6345416.5	1906344.6					
B0_057	84.1	6345423.5	1906347.9					
B0_058	72.2	6345430.9	1906347.7	36	0	1	30621	Metal strap, possibly stuck in grass & moved
B0_059	74.9	6345437.9	1906344.4	6	unknown	many	32260	Lots of signals all around, nothing found
B0_060	18.6	6345443.2	1906347.9					
B0_061	109.5	6345446.9	1906341.7					
B0_062	99.4	6345453.9	1906344.8					
B0_063	84.9	6345458.0	1906341.7					
B0_064	39.2	6345458.4	1906351.0	0	0	0	36437	Lots of signals all around, nothing found
B0_065	60.0	6345452.0	1906353.6	12	0	1	34754	Beverage can
B0_066	90.2	6345449.2	1906350.6					
B0_067	63.1	6345444.0	1906354.0	0	0	1	36376	Beverage can
B0_068	16.8	6345450.6	1906359.6					
B0_069	96.4	6345445.9	1906377.3					
B0_070	23.3	6345450.8	1906380.3					
B0_071	5922.0	6345460.9	1906391.9					
B0_072	91.1	6345458.4	1906413.2					
B0_073	180.5	6345452.2	1906407.9					
B0_074	108.6	6345449.6	1906398.4					
B0_075	209.7	6345444.2	1906392.3					

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Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B0

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
B0_076	28.7	6345435.2	1906401.3					
B0_077	31.2	6345435.2	1906409.9					
B0_078	30.7	6345430.9	1906407.3					
B0_079	37.7	6345421.2	1906401.5	3	3	1	31459	Scrap metal
B0_080	23.8	6345417.1	1906404.4					
B0_081	18.7	6345419.8	1906409.5					
B0_082	30.8	6345416.7	1906412.6					
B0_083	48.9	6345411.4	1906409.5	0	0	0	39108	No metal detected, nothing found
B0_084	43.8	6345399.2	1906401.1	0	8	0	35459	No item found, respond to metal detector
B0_085	72.0	6345401.1	1906392.3	1	1	1	31404	Scrap metal
B0_086	40.9	6345402.1	1906380.3	6	6	1	35197	Scrap metal
B0_087	38.0	6345405.2	1906377.5	4	4	1	32223	Scrap metal
B0_088	19.6	6345406.4	1906383.4					
B0_089	38.3	6345411.6	1906383.8	12	0	1	34885	Wire
B0_090	35.4	6345413.0	1906392.3					
B0_091	94.7	6345421.4	1906395.1					
B0_092	36.3	6345433.5	1906386.1					
B0_093	50.2	6345426.4	1906380.3	1	1	1	31787	Scrap metal
B0_094	21.4	6345417.5	1906367.0					
B0_095	22.5	6345422.9	1906362.7					
B0_096	56.5	6345426.6	1906362.3					Seed
B0_097	65.0	6345423.7	1906355.7	0	0	1	33387	Wire
B0_098	15.7	6345417.7	1906359.4					
B0_099	47.5	6345406.6	1906353.6	6	6	1	37469	Scrap aluminum
B0_100	29.4	6345402.9	1906365.3					

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Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B0

Target ID	Target Response *(mV)*	NAD83-CA CS83 Z-5 **X** US Survey Foot	NAD83-CA CS83 Z-5 **Y** US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct Reading cpm	Item Description Comment
B0_101	37.2	6345399.4	1906359.6	0	0	0	36306	No metal, nothing found
B0_102	28.0	6345394.3	1906359.2					
B0_103	18.3	6345391.2	1906353.4					
B0_104	34.2	6345399.8	1906347.9					
B0_105	37.1	6345397.2	1906341.9	6	6	1	31775	Metal strap
B0_106	41.4	6345387.3	1906341.9	0	1	1	33149	Scrap metal
B0_107	19.6	6345374.8	1906347.9					
B0_108	79.1	6345370.7	1906341.7					
B0_109	22.8	6345361.8	1906341.5					
B0_110	22.4	6345359.4	1906338.6					
B0_111	72.2	6345309.6	1906374.2	0	0	0	34477	No metal detected, nothing found
B0_112	331.5	6345273.9	1906410.4					
B0_113	37.7	6345270.2	1906410.6	41	6	1	32567	Alumimun chunk
B0_114	15.5	6345272.7	1906398.2					
B0_115	17.3	6345290.9	1906353.0					
B0_116	62.6	6345263.4	1906334.9	0	0	0	32258	Nothing found
B0_117	**NO TARGET SELECTED**							
B0_118	18.3	6345293.2	1906291.2					
B0_119	259.1	6345320.9	1906303.1					
B0_120	15.8	6345334.3	1906326.3					
B0_121	31.9	6345345.6	1906326.1					
B0_122	37.2	6345346.4	1906320.6	0	0	0	34591	Nothing found
B0_123	58.3	6345356.1	1906318.1	6	6	1	31403	Scrap metal
B0_124	132.8	6345364.3	1906320.1					
B0_125	75.2	6345369.2	1906326.1	7	7	1	31744	Wire

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Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B0

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
B0_126	44.7	6345375.4	1906332.1	8	8	1	33281	Scrap metal
B0_127	85.4	6345384.0	1906331.6					
B0_128	48.8	6345383.0	1906324.0	4	4	1	31761	Scrap metal
B0_129	90.6	6345375.8	1906314.2					
B0_130	36.3	6345370.3	1906314.2	0	8	multiple	32780	Chain (lots of broken links)
B0_131	36.3	6345366.1	1906308.8					
B0_132	15.5	6345354.4	1906306.2					
B0_133	305.8	6345347.2	1906303.1					
B0_134	81.3	6345347.7	1906296.7					Seed
B0_135	24.7	6345361.2	1906285.0					
B0_136	29.3	6345368.6	1906284.6					
B0_137	17.9	6345370.1	1906290.6					
B0_138	76.3	6345378.1	1906293.8	12	2	1	33117	Scrap iron
B0_139	33.9	6345382.4	1906293.8					
B0_140	92.9	6345382.4	1906306.2					
B0_141	43.7	6345398.8	1906314.0	3	3	1	33606	Wire
B0_142	27.3	6345401.5	1906308.8					
B0_143	16.0	6345404.4	1906305.6					
B0_144	38.8	6345408.9	1906305.6	0	0	0	32680	Nothing Found
B0_145	47.4	6345417.3	1906308.6	0	1	multiple	30795	Wire, fence pieces
B0_146	23.3	6345416.5	1906302.3					
B0_147	42.2	6345409.7	1906300.0	0	0	1	29859	Metal strap
B0_148	70.6	6345403.1	1906293.8	0	0	1	32233	Wire cable, 2 ft long
B0_149	17.6	6345395.9	1906293.8					
B0_150	16.2	6345391.4	1906278.0					

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Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B0

Target ID	Target Response *(mV)*	*NAD83-CA CS83 Z-5* ***X*** US Survey Foot	*NAD83-CA CS83 Z-5* ***Y*** US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct Reading cpm	Item Description Comment
B0_151	19.4	6345384.2	1906272.1					
B0_152	24.0	6345380.7	1906272.1					
B0_153	20.2	6345370.3	1906267.1					
B0_154	225.4	6345372.3	1906258.1					
B0_155	54.3	6345360.6	1906246.2	0	0	1	39890	Metal Strap
B0_156	4543.2	6345346.4	1906246.2					
B0_157	27.0	6345349.1	1906255.0					
B0_158	111.6	6345348.3	1906264.9					
B0_159	34.9	6345342.3	1906264.7					
B0_160	25.4	6345338.0	1906269.8					
B0_161	42.5	6345327.9	1906269.8	0	0	0	35936	Nothing found
B0_162	28.5	6345325.5	1906264.3					
B0_163	291.9	6345323.4	1906245.6					
B0_164	26.7	6345334.1	1906240.4					
B0_165	546.9	6345330.6	1906234.5					
B0_166	17.3	6345324.8	1906227.9					
B0_167	73.8	6345303.9	1906234.5	0	5	1	38202	Metal washer
B0_168	46.4	6345302.4	1906231.2	0	2	1	35128	Extension cord
B0_169	107.1	6345294.8	1906240.2					
B0_170	39.1	6345281.7	1906219.2	0	1	1	31958	Copper wire
B0_171	319.8	6345296.3	1906222.5					
B0_172	22.0	6345305.7	1906224.8					
B0_173	27.0	6345317.7	1906216.4					
B0_174	49.7	6345323.4	1906222.1	24	1	1	32571	12" wire
B0_175	24.5	6345325.3	1906218.6					

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Santa Susana Field Laboratory
Anomaly Digsheet

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Grid B0

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
B0_176	103.8	6345330.2	1906218.8					
B0_177	37.4	6345339.2	1906225.0	6	2	1	33302	Wire
B0_178	22.4	6345340.3	1906229.3					
B0_179	1370.5	6345343.1	1906234.7					
B0_180	742.4	6345348.5	1906228.1					
B0_181	141.2	6345362.7	1906231.2					
B0_182	84.5	6345369.0	1906221.7					Seed
B0_183	39.1	6345373.5	1906219.0	0	1	1	35337	Metal banding
B0_184	566.8	6345378.9	1906228.1					
B0_185	209.2	6345385.9	1906228.5					

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Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B1

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
B1_01	181.9	6345283.5	1906440.1					
B1_02	21.8	6345265.1	1906428.2					
B1_03	57.7	6345334.2	1906434.3					Seed
B1_04	10.2	6345402.8	1906434.4					
B1_05	17.2	6345420.3	1906448.1					
B1_06	99.8	6345424.4	1906437.3					
B1_07	10.3	6345425.1	1906425.1	0	0	2	31327	Wires
B1_08	29.0	6345415.7	1906415.7	6	6	1	31386	Scrap metal
B1_09	24.1	6345435.4	1906419.0					
B1_10	9.8	6345448.4	1906418.3					
B1_11	65.4	6345452.2	1906424.6	12	1	1	35757	Wire
B1_12	53.0	6345456.5	1906418.7	0	2	1	31845	Washer
B1_13	96.4	6345458.9	1906424.6					
B1_14	18.0	6345460.4	1906442.1					
B1_15	116.4	6345454.6	1906437.3					
B1_16	21.7	6345447.7	1906437.1					
B1_17	19.0	6345442.9	1906434.3					
B1_18	21.7	6345438.6	1906434.3					
B1_19	37.4	6345439.0	1906442.5	12	6	1	35506	Metal scrap
B1_20	25.3	6345446.6	1906444.8	0	0	0	35138	Nothing found
B1_21	95.8	6345446.6	1906451.1					
B1_22	15.5	6345452.2	1906450.9					
B1_23	16.6	6345458.7	1906453.9					
B1_24	17.7	6345455.0	1906459.5					
B1_25	15.0	6345453.5	1906465.8	8	6	1	31513	Scrap metal

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Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid B1

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
B1_26	37.1	6345436.4	1906459.9	3	2	1	30896	Aluminum sheet metal
B1_27	12.0	6345425.5	1906478.2	0	0	0	33284	Nothing found
B1_28	24.3	6345397.2	1906475.5					
B1_29	36.4	6345357.5	1906466.6					Seed
B1_30	104.2	6345349.9	1906458.0					
B1_31	111.4	6345341.7	1906458.0	0	0	1	31391	Metal strap
B1_32	41.9	6345316.9	1906452.0	0	0	0	39493	Nothing found
B1_33	18.5	6345314.1	1906462.1					
B1_34	16.5	6345298.6	1906475.9					

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Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid C0

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
C0_01	25.4	6345489.6	1906280.8	0	0	1	32252	Metal strap
C0_02	347.0	6345491.3	1906292.0					
C0_03	41.3	6345478.0	1906290.7	0	0	1	33525	6" wire, aluminum can
C0_04	37.1	6345478.2	1906274.3	0	0	0	32282	No response, 3 ft away pipe clamp 3" deep
C0_05	32.9	6345471.5	1906275.3	0	0	0	37093	Nothing found
C0_06	18.7	6345468.4	1906282.7					
C0_07	16.3	6345465.0	1906293.2					
C0_08	20.0	6345471.7	1906302.9					
C0_09	168.4	6345471.9	1906308.4	0	0	1	35829	Tie wire
C0_10	24.6	6345483.9	1906302.0					
C0_11	82.1	6345492.8	1906306.9	0	0	1	32617	Piece of soda can
C0_12	27.5	6345486.5	1906309.8	0	0	1	34563	Beverage Can
C0_13	124.1	6345481.0	1906320.6					
C0_14	59.3	6345486.7	1906317.8	0	0	1	32103	Metal strap
C0_15	15.7	6345495.9	1906321.2	0	0	1	30672	Beverage Can
C0_16	43.6	6345514.0	1906318.2	0	0	1	32907	Wire
C0_17	53.7	6345518.7	1906314.1	0	0	0	36227	Nothing found
C0_18	28.7	6345519.5	1906308.4	0	0	0	36184	Nothing found
C0_19	37.2	6345526.4	1906312.6	0	0	multiple	36029	Lots of metal detected, nothing identified
C0_20	22.7	6345523.1	1906328.6					
C0_21	31.8	6345517.2	1906335.3	0	5	1	35795	Scrap metal
C0_22	49.7	6345507.1	1906342.2	0	0	0	35864	Some signals, nothing found
C0_23	16.3	6345504.8	1906353.4					
C0_24	62.1	6345502.0	1906377.6	6	3	1	33864	Can lid
C0_25	26.5	6345498.7	1906387.5	0	1	1	31716	Tie wire

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Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid C0

Target ID	Target Response *(mV)*	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct Reading cpm	Item Description Comment
C0_26	223.2	6345492.8	1906390.0					
C0_27	177.5	6345484.8	1906393.8					
C0_28	36.5	6345484.1	1906385.4	0	2	1	32789	Tie wire
C0_29	15.7	6345483.9	1906371.7	0	0	0	32661	Nothing found
C0_30	20.9	6345486.9	1906362.2					
C0_31	48.9	6345483.7	1906346.2	0	0	multiple	31809	Pieces of metal strap, aluminum can
C0_32	88.3	6345468.6	1906338.2	0	0	0	31686	Nothing found
C0_33	17.1	6345463.1	1906343.3					
C0_34	17.0	6345465.2	1906358.7	0	3	1	32719	Tie wire
C0_35	16.0	6345465.2	1906368.3					
C0_36	17.0	6345462.7	1906380.6	0	3	1	33284	Tie wire
C0_37	44.1	6345468.4	1906381.0	0	>18	0	40836	Dug18", signal was still present
C0_38	145.0	6345475.1	1906388.1					
C0_39	252.2	6345472.1	1906395.1					
C0_40	28.4	6345471.5	1906404.3	0	0	0	37387	Nothing Found
C0_41	54.7	6345478.2	1906404.1	0	0	1	30340	Piece of corrugated pipe
C0_42	206.8	6345484.1	1906407.7					
C0_43	51.4	6345487.1	1906399.9	12	1	2	33284	Metal strap, wire
C0_44	19.8	6345495.7	1906402.9					
C0_45	16.3	6345508.1	1906397.4					
C0_46	48.3	6345514.7	1906405.0					Seed
C0_47	19.9	6345529.6	1906408.8	0	0	0	33870	Nothing found
C0_48	40.4	6345535.5	1906410.4	0	4	1	34009	Scrap metal
C0_49	39.9	6345535.3	1906404.1	0	3	1	36474	Scrap metal
C0_50	31.2	6345535.7	1906384.5	0	0	0	32420	Nothing found

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Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid C0

Target ID	Target Response *(mV)*	*NAD83-CA CS83 Z-5* ***X*** US Survey Foot	*NAD83-CA CS83 Z-5* ***Y*** US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct Reading cpm	Item Description Comment
C0_51	25.7	6345529.2	1906373.2	0	0	0	31782	Wire
C0_52	25.8	6345523.1	1906370.9	0	0	0	34781	Nothing found
C0_53	17.1	6345519.5	1906366.7					
C0_54	31.9	6345519.9	1906356.6	0	0	0	36435	Nothing found
C0_55	33.8	6345529.4	1906356.8	0	0	0	35614	Nothing found
C0_56	27.1	6345535.7	1906358.4	0	0	0	35860	Nothing found
C0_57	248.1	6345529.6	1906350.2					
C0_58	268.6	6345525.0	1906335.8					
C0_59	57.6	6345535.9	1906331.3	0	1	1	32680	3" metal strap
C0_60	30.3	6345532.6	1906318.2	0	0	2	31311	Scrap metal, strap, 6" bracket
C0_61	59.8	6345536.3	1906316.1	0	1	1	32250	Aluminum band
C0_62	44.3	6345536.3	1906309.6	0	0	1	33567	Wire
C0_63	18.4	6345532.1	1906302.3					
C0_64	43.0	6345526.4	1906301.8	0	0	1	32701	1" metal
C0_65	24.5	6345529.0	1906295.9					
C0_66	25.3	6345537.4	1906293.4	0	0	1	36878	Beverage Can
C0_67	17.2	6345522.7	1906282.9	0	0	0	36620	Nothing found
C0_68	77.8	6345535.3	1906265.6	0	0	0	39168	Nothing found
C0_69	43.5	6345523.1	1906255.5	12	2	1	35272	Nail
C0_70	15.5	6345513.8	1906265.4	0	0	1	35434	Gum wrapper
C0_71	28.2	6345510.7	1906247.7	0	0	1	32609	3" rusty nail
C0_72	56.9	6345518.2	1906248.3	0	0	0	36797	Nothing found
C0_73	16.9	6345525.6	1906243.9					
C0_74	52.3	6345537.2	1906227.1	0	0	1	37467	Piece of soda can, some signal still present
C0_75	20.0	6345534.4	1906222.1	0	0	1	32302	10" aluminum band

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Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid C0

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
C0_76	75.0	6345510.7	1906226.5	24	2	1	31258	Beverage Can
C0_77	17.0	6345501.2	1906221.6					
C0_78	22.1	6345507.3	1906232.0					
C0_79	35.2	6345514.0	1906232.6	0	0	1	31892	3" scrap metal
C0_80	26.2	6345510.7	1906238.1	0	0	0	37951	Nothing found
C0_81	19.0	6345502.5	1906236.4					
C0_82	26.7	6345504.1	1906242.1	0	0	1	32383	3" rusty nail
C0_83	33.0	6345483.5	1906248.6	0	0	0	34831	Nothing found
C0_84	33.5	6345489.6	1906266.7	0	0	1	33127	Wire
C0_85	15.9	6345489.4	1906275.5					

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Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid C1

Target ID	Target Response (mV)	NAD83-CA CS83 Z-5 X US Survey Foot	NAD83-CA CS83 Z-5 Y US Survey Foot	Target Offset (in)	Depth to item (in)	Number of Items	Direct Reading cpm	Item Description Comment
C1_01	33.3	6345521.5	1906439.6	0	1	1	31159	Scrap wire
C1_02	22.6	6345528.2	1906437.1					
C1_03	56.3	6345535.2	1906437.3	0	1	1	31212	Scrap wire
C1_04	39.5	6345533.9	1906429.9	0	2	1	33106	Scrap wire
C1_05	19.1	6345521.5	1906415.3					
C1_06	26.3	6345500.8	1906419.9	0	0	0	36376	Nothing found
C1_07	46.1	6345492.0	1906424.7	36	0	0	38842	Lots of signals, nothing found
C1_08	21.2	6345492.0	1906439.6					
C1_09	23.2	6345488.8	1906436.4					
C1_10	113.4	6345479.9	1906424.9					
C1_11	402.0	6345471.1	1906431.0					
C1_12	30.1	6345461.6	1906429.8	3	3	1	34465	Wire
C1_13	122.4	6345467.7	1906438.0	0	0	0	31739	Nothing found
C1_14	163.4	6345477.2	1906445.7	2	2	1	31958	Scrap metal
C1_15	40.2	6345480.6	1906468.2	0	0	0	35209	Nothing found
C1_16	15.4	6345480.7	1906475.9	0	4	1	33456	Wire cotter pin
C1_17	52.0	6345474.5	1906474.5	1	1	1	30906	Scrap metal
C1_18	28.6	6345465.7	1906481.3	2	2	1	31212	Metal valve
C1_19	21.8	6345468.2	1906485.8					
C1_20	42.4	6345477.5	1906480.8	0	0	0	38933	Nothing found
C1_21	19.1	6345483.3	1906485.2					
C1_22	1912.2	6345492.6	1906481.1					
C1_23	40.0	6345505.1	1906489.2	6	6	1	34538	Fence post
C1_24	42.9	6345507.2	1906464.8	0	1	1	32671	Metal clip, curtain rod
C1_25	17.5	6345513.1	1906467.5	0	5	1	34651	Beverage can

Cabrera Services, Inc

Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

RISK REDUCTION RESOURCES, INCORPORATED

Grid C1

Target ID	Target Response *(mV)*	*NAD83-CA CS83 Z-5* ***X*** US Survey Foot	*NAD83-CA CS83 Z-5* ***Y*** US Survey Foot	Target Offset *(in)*	Depth to item *(in)*	Number of Items	Direct Reading cpm	Item Description Comment
C1_26	354.0	6345535.4	1906484.0					
C1_27	24.9	6345533.7	1906473.8					Seed
C1_28	23.3	6345527.8	1906448.0					
C1_29	77.2	6345521.5	1906446.2	3	1	1	32129	Steel plate 1" x 3" sheet metal

Appendix C
Photos (Electronic)

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A0-10

A0_31

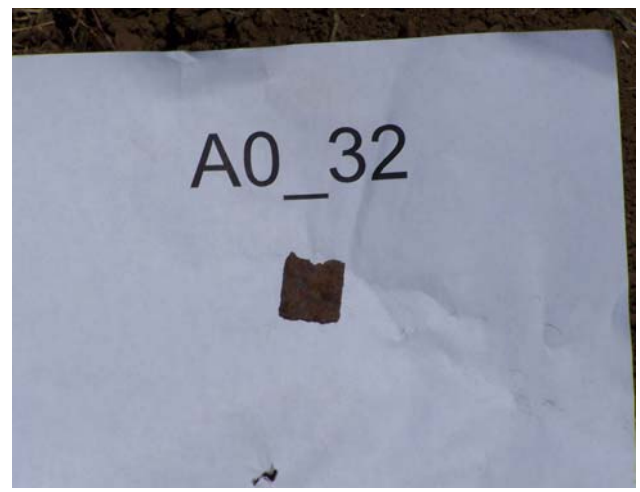
A0_38

A0_04

A0_16

A0-33

A001

A0_12

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B0-003
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B0_008

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B0-79

B0-005

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B0-67

B0-004

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BO-87

BO-97

B0_106

BO-86

BO- 93

B0_105

BO-85

B0_089

BO-99


B0-125

B0_130

B0_145

B0-123

B0-128

B0-141

B0_113

B0-126

B0_138


B0-155

B0-170

B1_07

B0_148

B0-168

B0-183

B0_147

0-167

B0_177


B1-25


C0-01


C0-09


B1_12
?


B1-031


C0_04


B1-08


B1_26


C0_03


C0_14


CO 21


CO-28


CO-12


C0_16


CO-25


CO- 11


C0_15


C0_24


C0_41

CO-49

CO-60

CO-34

CO-48

C0_59

C0_31

C0_43

CO-51


CO-64


CO-70


CO-79


CO-62


C0_69


C0_76


C0_61


CO-66


CO-75


C1-01

C1-12

C1-17

CO-84

C1-04

C1_16

CO-82

C1-03

C1-14


C1_24


C1-23


C1_29


C1-18

Appendix D
Scan MDC Calculations

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2x2 NaI Scan @ DU slug 50 year decay, DU 30 cm x 3 cm Al clad 10 mils, under 30 FGR 12 soil composition with density 1.6

Fluence rate to exposure rate (FRER, no units) = ~ (1 uR/h)/(Eγ)(u_{en}/ρ)air

TABLE 1		
Energy$_{\gamma}$, keV	**(u_{en}/ρ)$_{air}$, cm^2/g**	**FRER**
15	1.29	0.0517
20	0.516	0.0969
30	0.147	0.2268
40	0.064	0.3906
50	0.0384	0.5208
60	0.0292	0.5708
80	0.0236	0.5297
100	0.0231	0.4329
150	0.0251	0.2656
200	0.0268	0.1866
300	0.0288	0.1157
400	0.0296	0.0845
500	0.0297	0.0673
600	0.0296	0.0563
800	0.0289	0.0433
1,000	0.0280	0.0357
1,500	0.0255	0.0261
2,000	0.0234	0.0214

Probability of interaction (P) through end of detector for given energy is

Probability = $1-e^{-(\mu/\rho)NaI\ (x)\ (\rho NaI)}$

TABLE 2		
Energy$_{\gamma}$, keV	(μ/ρ)$_{NaI}$, cm^2/g	P
15	47.4	1.00
20	22.3	1.00
30	7.45	1.00
40	19.3	1.00
50	10.7	1.00
60	6.62	1.00
80	3.12	1.00
100	1.72	1.00
150	0.625	1.00
200	0.334	1.00
300	0.167	0.96
400	0.117	0.89
500	0.0955	0.83

600	0.0826	0.79
800	0.0676	0.72
1,000	0.0586	0.67
1,500	0.0469	0.58
2,000	0.0413	0.54

for Ludlum 44-10   5.1cm dia x 5.1 cm thick NaI crystal   use aluminum window per Ludlum ~0.05 inch thick

x = 5.1 cm

ρ = 3.67 g/cm^3

Relative Detector Response (RDR) = relative fluence-to-exposure rate (FRER) times probability (P) of interaction

TABLE 3			
Energy$_\gamma$, keV	FRER	P	RDR
15	0.0517	1.00	0.0517
20	0.0969	1.00	0.0969
30	0.2268	1.00	0.2268
40	0.3906	1.00	0.3906
50	0.5208	1.00	0.5208
60	0.5708	1.00	0.5708
80	0.5297	1.00	0.5297
100	0.4329	1.00	0.4329
150	0.2656	1.00	0.2656
200	0.1866	1.00	0.1862
300	0.1157	0.96	0.1107
400	0.0845	0.89	0.0750
500	0.0673	0.83	0.0561
600	0.0563	0.79	0.0443
800	0.0433	0.72	0.0310
1,000	0.0357	0.67	0.0238
1,500	0.0261	0.58	0.0153
2,000	0.0214	0.54	0.0115

Estimated Ludlum 44-10   5.1 cm dia x 5.1 cm thick NaI response for Cs-137 is   900   cpm/μR/hr

Use same methodology and interpolating for Cs-137 response have:

Energy$_\gamma$, keV	$(u_{en}/\rho)_{air}$, cm^2/g		
662	0.0294	FRER ~	0.0514
Energy$_\gamma$, keV	$(\mu/\rho)_{NaI}$, cm^2/g		
662	0.0780	Probability =	0.77
		RDR =	0.0394

For this detector the response to another energy is based on the ratio of the relative detector response, RDR, to the Cs-137 energy
cpm/μR/h, E_i = $(cpm_{cs-137})*(RDR_{Ei})/(RDR_{Cs-137})$

TABLE 4		
Energy$_\gamma$, keV	RDR_{Ei}	Ludlum 44-10 2x2 NaI Detector, E_i, cpm per μR/hr
15	0.0517	1179
20	0.0969	2211
30	0.2268	5175
40	0.3906	8915
50	0.5208	11886
60	0.5708	13026
80	0.5297	12088
100	0.4329	9880
150	0.2656	6062
200	0.1862	4250
300	0.1107	2525
400	0.0750	1712
500	0.0561	1280
600	0.0443	1011
662	0.0394	900
800	0.0310	709
1,000	0.0238	543
1,500	0.0153	349
2,000	0.0115	263

MDC for Cs-137 energy

Assume 10 μR/hr bkg then have 9,000 cpm

b_i =	150	counts
MDCR =	1863.000	cpm
$MDCR_{surveyor}$ =	2635	cpm

Utilize a 15% bkg variability instead of SQRT of 150 counts in 1 sec interval for MDCR; more realistic

minimum detectable exposure rate = 2.93 μR/hr

Table 5				
keV	MicroShield Exposure Rate, μR/hr (with buildup)	cpm/μR/hr	cpm/μR/hr (weighted)	Percent of NaI detector response
15	6.229E-28	1179	0	0.0%
20	1.121E-30	2211	0	0.0%
30	2.497E-26	5175	0	0.0%
40	1.110E-19	8915	0	0.0%

50	3.848E-12	11886	0	0.0%
60	2.914E-07	13026	0	0.0%
80	5.809E-06	12088	0	0.0%
100	1.851E-03	9880	4	0.7%
150	4.683E-04	6062	1	0.1%
200	8.395E-03	4250	8	1.4%
300	8.644E-04	2525	1	0.1%
400	2.292E-03	1712	1	0.2%
500	7.281E-03	1280	2	0.4%
600	5.245E-02	1011	12	2.1%
800	6.355E-01	709	104	18.1%
1000	3.417E+00	543	430	74.4%
1500	1.550E-01	349	13	2.2%
2000	3.071E-02	263	2	0.3%
Total	4.312E+00		578	100%

Minimum Detectable Exposure Rate =

MDCR surveyor/(cpm/μr/hr)
4.56 μr/hr

and MDC for DU Slug based on a 1 pCi/g DU in slug

Scan MDC = (Assumed MDC DU_{Conc}) x (Exposure Rate $MDCR_{Surveyor}$)/(Exposure $Rate_{assumed\ DU\ Conc}$)

Scan MDC = 1.06 pCi/g assuming DU slug at bottom center of soil with long axis oriented horizontally

3963 g DU Slug mass for dimensions 30cm long x 3 cm diameter

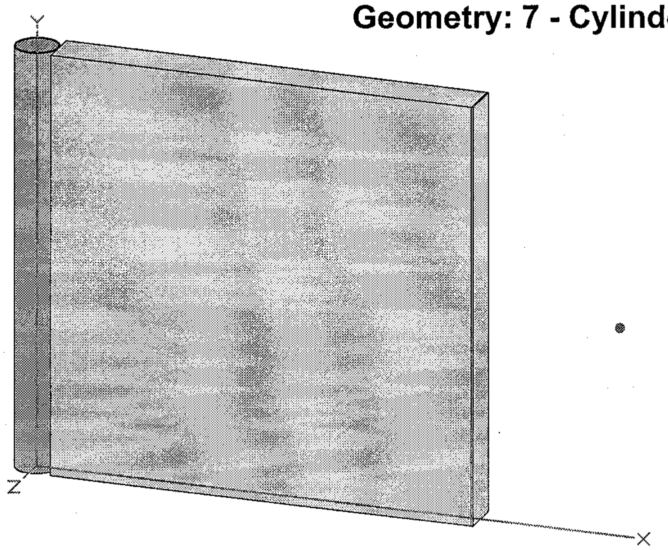
MDA 0.004 uCi

MicroShield v5.05 (5.05-00136)
Cabrera Services, Inc.

Page : 1
DOS File : DU30X3.MS5
Run Date: April 25, 2008
Run Time: 3:17:47 PM
Duration : 00:03:39

File Ref: ___________
Date: ___________
By: ___________
Checked: ___________

Case Title: DU Slug 30 cm deep
Description: NBS soil 50 year decay DU slug 3963 g
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	30.0 cm	11.8 in
Radius	1.5 cm	0.6 in

Dose Points

	X	Y	Z
# 1	41.65 cm	15 cm	0 cm
	1 ft 4.4 in	5.9 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	212.058 cm³	Uranium	18.7
Transition		Air	0.00122
Shield 2	30.0 cm	FGR 12 Soil	1.6
Shield 3	.127 cm	Aluminum	2.7
Air Gap		Air	0.00122
Wall Clad	.025 cm	Aluminum	2.7

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Ac-227	8.9602e-009	3.3153e+002	4.2253e-005	1.5634e+000
Bi-210	4.3697e-010	1.6168e+001	2.0606e-006	7.6244e-002
Bi-211	8.9264e-009	3.3028e+002	4.2094e-005	1.5575e+000
Bi-214	1.1921e-009	4.4107e+001	5.6216e-006	2.0800e-001
Fr-223	1.2365e-010	4.5751e+000	5.8310e-007	2.1575e-002
Pa-231	1.7931e-008	6.6346e+002	8.4559e-005	3.1287e+000
Pa-234	2.1152e-006	7.8262e+004	9.9747e-003	3.6906e+002
Pa-234m	1.3220e-003	4.8914e+007	6.2342e+000	2.3066e+005
Pb-210	4.3744e-010	1.6185e+001	2.0628e-006	7.6325e-002
Pb-211	8.9264e-009	3.3028e+002	4.2094e-005	1.5575e+000
Pb-214	1.1921e-009	4.4108e+001	5.6216e-006	2.0800e-001
Po-210	4.2436e-010	1.5701e+001	2.0012e-006	7.4043e-002
Po-211	2.4369e-011	9.0166e-001	1.1492e-007	4.2519e-003
Po-214	1.1918e-009	4.4098e+001	5.6204e-006	2.0795e-001
Po-215	8.9265e-009	3.3028e+002	4.2095e-005	1.5575e+000

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Po-218	1.1923e-009	4.4116e+001	5.6227e-006	2.0804e-001
Ra-223	8.9265e-009	3.3028e+002	4.2095e-005	1.5575e+000
Ra-226	1.1931e-009	4.4143e+001	5.6261e-006	2.0817e-001
Rn-219	8.9265e-009	3.3028e+002	4.2095e-005	1.5575e+000
Rn-222	1.1923e-009	4.4117e+001	5.6227e-006	2.0804e-001
Th-227	8.8157e-009	3.2618e+002	4.1572e-005	1.5382e+000
Th-230	1.1096e-007	4.1054e+003	5.2324e-004	1.9360e+001
Th-231	1.6960e-005	6.2752e+005	7.9978e-002	2.9592e+003
Th-234	1.3220e-003	4.8914e+007	6.2342e+000	2.3066e+005
Tl-207	8.9020e-009	3.2938e+002	4.1979e-005	1.5532e+000
U-234	2.4665e-004	9.1261e+006	1.1631e+000	4.3036e+004
U-235	1.6960e-005	6.2752e+005	7.9978e-002	2.9592e+003
U-238	1.3220e-003	4.8914e+007	6.2342e+000	2.3066e+005

Buildup
The material reference is : Shield 2

Integration Parameters

Radial	69
Circumferential	69
Y Direction (axial)	69

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.180e+03	1.063e-204	7.263e-30	9.116e-206	6.229e-31
0.02	3.009e+00	6.155e-96	3.237e-32	2.132e-97	1.121e-33
0.03	9.201e+04	8.225e-33	2.519e-27	8.151e-35	2.497e-29
0.04	9.753e+01	4.569e-21	2.511e-20	2.021e-23	1.110e-22
0.05	1.080e+04	1.389e-13	1.445e-12	3.699e-16	3.848e-15
0.06	1.918e+06	8.699e-09	1.467e-07	1.728e-11	2.914e-10
0.08	1.433e+05	1.317e-07	3.671e-06	2.084e-10	5.809e-09
0.1	3.072e+06	3.372e-05	1.210e-03	5.159e-08	1.851e-06
0.15	1.224e+05	7.334e-06	2.844e-04	1.208e-08	4.683e-07
0.2	4.038e+05	1.390e-04	4.757e-03	2.453e-07	8.395e-06
0.3	5.918e+03	1.863e-05	4.557e-04	3.534e-08	8.644e-07
0.4	4.909e+03	6.463e-05	1.176e-03	1.259e-07	2.292e-06
0.5	7.139e+03	2.610e-04	3.709e-03	5.124e-07	7.281e-06
0.6	2.918e+04	2.319e-03	2.687e-02	4.527e-06	5.245e-05
0.8	1.624e+05	3.963e-02	3.341e-01	7.538e-05	6.355e-04
1.0	5.192e+05	2.796e-01	1.854e+00	5.153e-04	3.417e-03
1.5	1.096e+04	2.066e-02	9.211e-02	3.475e-05	1.550e-04
2.0	1.425e+03	5.573e-03	1.986e-02	8.617e-06	3.071e-05

Page : 3
DOS File : DU30X3.MS5
Run Date : April 25, 2008
Run Time: 3:17:47 PM
Duration : 00:03:39

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	6.504e+06	3.483e-01	2.338e+00	6.396e-04	4.311e-03

Santa Susana Fidler Scan for Large DU Slug (3963 g) 30 cm long x 3 cm diameter with 30 cm soil cover
FGR 12 Soil density 1.6
Fluence rate to exposure rate (FRER, no units) = ~ (1 uR/h)/(Eγ)(u_{en}/ρ)air

TABLE 1

Energy$_\gamma$, keV	$(u_{en}/\rho)_{air}$, cm^2/g	FRER
15	1.29	0.0517
20	0.516	0.0969
30	0.147	0.2268
40	0.064	0.3906
50	0.0384	0.5208
60	0.0292	0.5708
80	0.0236	0.5297
100	0.0231	0.4329
150	0.0251	0.2656
200	0.0268	0.1866
300	0.0288	0.1157
400	0.0296	0.0845
500	0.0297	0.0673
600	0.0296	0.0563
800	0.0289	0.0433
1,000	0.0280	0.0357
1,500	0.0255	0.0261
2,000	0.0234	0.0214

Probability of interaction (P) through end of detector for given energy is

Probability = $1-e^{-(\mu/\rho)NaI\ (x)\ (\rho NaI)}$

TABLE 2

Energy$_\gamma$, keV	$(\mu/\rho)_{NaI}$, cm^2/g	P
15	47.4	1.00
20	22.3	1.00
30	7.45	0.99
40	19.3	1.00
50	10.7	1.00
60	6.62	0.98
80	3.12	0.84
100	1.72	0.64
150	0.625	0.31
200	0.334	0.18
300	0.167	0.09
400	0.117	0.07
500	0.0955	0.05
600	0.0826	0.05

800	0.0676	0.04
1,000	0.0586	0.03
1,500	0.0469	0.03
2,000	0.0413	0.02

for Fidler G-5 12.7cm dia x 0.16 cm thick NaI crystal

beryllium window per Fidler catalog 0.010 inch

x = 0.16 cm

ρ = 3.67 g/cm^3

Relative Detector Response (RDR) = relative fluence-to-exposure rate (FRER) times probability (P) of interaction

TABLE 3

Energy$_\gamma$, keV	FRER	P	RDR
15	0.0517	1.00	0.0517
20	0.0969	1.00	0.0969
30	0.2268	0.99	0.2239
40	0.3906	1.00	0.3906
50	0.5208	1.00	0.5199
60	0.5708	0.98	0.5591
80	0.5297	0.84	0.4449
100	0.4329	0.64	0.2752
150	0.2656	0.31	0.0816
200	0.1866	0.18	0.0332
300	0.1157	0.09	0.0108
400	0.0845	0.07	0.0056
500	0.0673	0.05	0.0037
600	0.0563	0.05	0.0027
800	0.0433	0.04	0.0017
1,000	0.0357	0.03	0.0012
1,500	0.0261	0.03	0.0007
2,000	0.0214	0.02	0.0005

Estimated Fidler G-5 12.7cm dia x 0.16cm thick NaI response for Cs-137 is 1287 cpm/uR/hr

Use same methodology and interpolating for Cs-137 response have:

Energy$_\gamma$, keV	$(u_{en}/\rho)_{air}$, cm^2/g		
662	0.0294	FRER ~	0.0514

Energy$_\gamma$, keV	$(\mu/\rho)_{NaI}$, cm^2/g		
662	0.0780	Probability =	0.04
		RDR =	0.0023

For this detector the response to another energy is based on the ratio of the relative detector response, RDR to the Cs-137 energy cpm/μR/h, E_i = $(cpm_{cs\text{-}137})*(RDR_{Ei})/(RDR_{Cs\text{-}137})$

TABLE 4

Energy$_\gamma$, keV	RDR_{Ei}	Fidler NaI Detector, E_i, cpm per μR/hr
15	0.0517	28934
20	0.0969	54250
30	0.2239	125355
40	0.3906	218695
50	0.5199	291052
60	0.5591	313006
80	0.4449	249068
100	0.2752	154090
150	0.0816	45680
200	0.0332	18602
300	0.0108	6053
400	0.0056	3140
500	0.0037	2056
600	0.0027	1493
662	0.0023	1287
800	0.0017	942
1,000	0.0012	676
1,500	0.0007	398
2,000	0.0005	287

MDC for Cs-137 energy

Assume 10 μR/hr bkg then have 12,870 cpm

b_i =	214.5	counts
MDCR =	2664.09	cpm
$MDCR_{surveyor}$ =	3768	cpm

minimum detectable exposure rate = 2.93 μR/hr

Table 5

keV	MicroShield Exposure Rate, μR/hr (with buildup)	cpm/μR/hr	cpm/μR/hr (weighted)	Percent of NaI detector response
15	6.229E-28	28934	0	0.0%
20	1.210E-30	54250	0	0.0%
30	2.497E-26	125355	0	0.0%
40	1.317E-19	218695	0	0.0%
50	4.277E-12	291052	0	0.0%
60	3.146E-07	313006	0	0.0%

80	6.122E-06	249068	0	0.0%
100	1.931E-03	154090	68	8.2%
150	4.837E-04	45680	5	0.6%
200	8.632E-03	18602	37	4.4%
300	8.847E-04	6053	1	0.1%
400	2.339E-03	3140	2	0.2%
500	7.417E-03	2056	3	0.4%
600	5.336E-02	1493	18	2.2%
800	6.451E-01	942	139	16.8%
1000	3.463E+00	676	536	64.9%
1500	1.567E-01	398	14	1.7%
2000	3.100E-02	287	2	0.2%
Total	4.371E+00		826	100%

Minimum Detectable Exposure Rate =

MDCR surveyor/(cpm/μr/hr)
4.56 μr/hr

and MDC for DU Slug based on a 1 pCi/g DU in slug

Scan MDC = (Assumed MDC DU_{Conc}) x (Exposure Rate $MDCR_{Surveyor}$)/(Exposure $Rate_{assumed\ DU\ Conc}$)

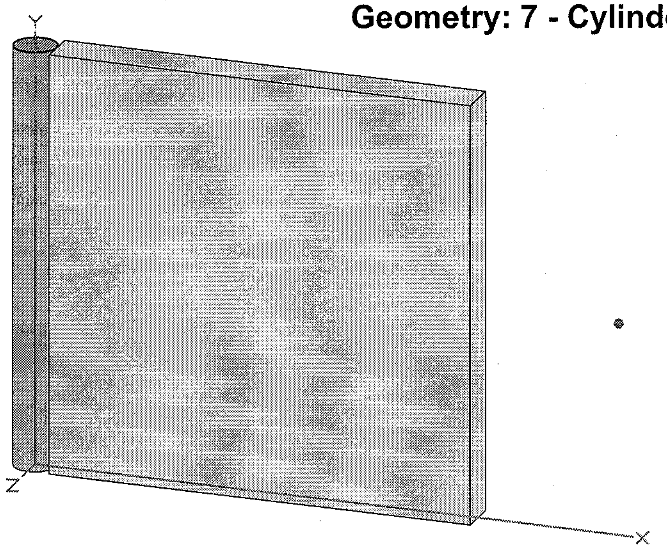
Scan MDC =	1.04	pCi/g	assuming DU slug at bottom center of soil with long axis oriented horizontally
	3963	g	DU Slug mass for dimensions 30cm long x 3 cm diameter
MDA	0.004	uCi	

MicroShield v5.05 (5.05-00136)
Cabrera Services, Inc.

Page : 1
DOS File : DU30X3A.MS5
Run Date : April 25, 2008
Run Time : 5:42:32 PM
Duration : 00:03:40

File Ref: ___________
Date: ___________
By: ___________
Checked: ___________

Case Title: DU Slug 30 cm deep
Description: NBS soil 50 year decay DU slug 3963 g w fidler Be
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	30.0 cm	11.8 in
Radius	1.5 cm	0.6 in

Dose Points

	X	Y	Z
# 1	41.65 cm	15 cm	0 cm
	1 ft 4.4 in	5.9 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	212.058 cm³	Uranium	18.7
Transition		Air	0.00122
Shield 2	30.0 cm	FGR 12 Soil	1.6
Shield 3	.025 cm	Beryllium	1.85
Air Gap		Air	0.00122
Wall Clad	.025 cm	Aluminum	2.7

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : Grove

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Ac-227	8.9602e-009	3.3153e+002	4.2253e-005	1.5634e+000
Bi-210	4.3697e-010	1.6168e+001	2.0606e-006	7.6244e-002
Bi-211	8.9264e-009	3.3028e+002	4.2094e-005	1.5575e+000
Bi-214	1.1921e-009	4.4107e+001	5.6216e-006	2.0800e-001
Fr-223	1.2365e-010	4.5751e+000	5.8310e-007	2.1575e-002
Pa-231	1.7931e-008	6.6346e+002	8.4559e-005	3.1287e+000
Pa-234	2.1152e-006	7.8262e+004	9.9747e-003	3.6906e+002
Pa-234m	1.3220e-003	4.8914e+007	6.2342e+000	2.3066e+005
Pb-210	4.3744e-010	1.6185e+001	2.0628e-006	7.6325e-002
Pb-211	8.9264e-009	3.3028e+002	4.2094e-005	1.5575e+000
Pb-214	1.1921e-009	4.4108e+001	5.6216e-006	2.0800e-001
Po-210	4.2436e-010	1.5701e+001	2.0012e-006	7.4043e-002
Po-211	2.4369e-011	9.0166e-001	1.1492e-007	4.2519e-003
Po-214	1.1918e-009	4.4098e+001	5.6204e-006	2.0795e-001
Po-215	8.9265e-009	3.3028e+002	4.2095e-005	1.5575e+000

Page : 2
DOS File : DU30X3A.MS5
Run Date: April 25, 2008
Run Time: 5:42:32 PM
Duration : 00:03:40

Nuclide	curies	becquerels	μCi/cm³	Bq/cm³
Po-218	1.1923e-009	4.4116e+001	5.6227e-006	2.0804e-001
Ra-223	8.9265e-009	3.3028e+002	4.2095e-005	1.5575e+000
Ra-226	1.1931e-009	4.4143e+001	5.6261e-006	2.0817e-001
Rn-219	8.9265e-009	3.3028e+002	4.2095e-005	1.5575e+000
Rn-222	1.1923e-009	4.4117e+001	5.6227e-006	2.0804e-001
Th-227	8.8157e-009	3.2618e+002	4.1572e-005	1.5382e+000
Th-230	1.1096e-007	4.1054e+003	5.2324e-004	1.9360e+001
Th-231	1.6960e-005	6.2752e+005	7.9978e-002	2.9592e+003
Th-234	1.3220e-003	4.8914e+007	6.2342e+000	2.3066e+005
Tl-207	8.9020e-009	3.2938e+002	4.1979e-005	1.5532e+000
U-234	2.4665e-004	9.1261e+006	1.1631e+000	4.3036e+004
U-235	1.6960e-005	6.2752e+005	7.9978e-002	2.9592e+003
U-238	1.3220e-003	4.8914e+007	6.2342e+000	2.3066e+005

Buildup
The material reference is : Shield 2

Integration Parameters

Radial	69
Circumferential	69
Y Direction (axial)	69

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.180e+03	1.474e-203	7.263e-30	1.264e-204	6.229e-31
0.02	3.009e+00	1.882e-95	3.237e-32	6.518e-97	1.121e-33
0.03	9.201e+04	1.171e-32	2.519e-27	1.160e-34	2.497e-29
0.04	9.753e+01	5.429e-21	2.977e-20	2.401e-23	1.317e-22
0.05	1.080e+04	1.549e-13	1.605e-12	4.126e-16	4.277e-15
0.06	1.918e+06	9.437e-09	1.584e-07	1.875e-11	3.146e-10
0.08	1.433e+05	1.397e-07	3.869e-06	2.210e-10	6.122e-09
0.1	3.072e+06	3.545e-05	1.262e-03	5.423e-08	1.931e-06
0.15	1.224e+05	7.641e-06	2.937e-04	1.258e-08	4.837e-07
0.2	4.038e+05	1.442e-04	4.891e-03	2.545e-07	8.632e-06
0.3	5.918e+03	1.923e-05	4.664e-04	3.647e-08	8.847e-07
0.4	4.909e+03	6.647e-05	1.201e-03	1.295e-07	2.339e-06
0.5	7.139e+03	2.678e-04	3.779e-03	5.257e-07	7.417e-06
0.6	2.918e+04	2.375e-03	2.734e-02	4.636e-06	5.336e-05
0.8	1.624e+05	4.046e-02	3.392e-01	7.697e-05	6.451e-04
1.0	5.192e+05	2.849e-01	1.879e+00	5.251e-04	3.463e-03
1.5	1.096e+04	2.097e-02	9.313e-02	3.529e-05	1.567e-04
2.0	1.425e+03	5.647e-03	2.005e-02	8.732e-06	3.100e-05

Page : 3
DOS File : DU30X3A.MS5
Run Date: April 25, 2008
Run Time: 5:42:32 PM
Duration : 00:03:40

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
TOTALS:	6.504e+06	3.549e-01	2.370e+00	6.517e-04	4.371e-03

Attachment 1
Geophysical Report

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Final Report for:
Santa Susana Field Laboratories
DU Slug Geophysical Survey

Prepared by: Risk Reduction Resources, Inc.

Prepared for: Cabrera Services, Inc.

June / 2008

Risk Reduction Resources, Incorporated

Geophysical Investigations

Environmental Restoration Geographic Information Systems (GIS)

Final Report for:
Santa Susana Field Laboratories
DU Slug Geophysical Survey

Objective

The objective of the project was to geophysically map 2.89 acres of open ground in Area 4 of the Santa Susana Field Laboratories with the intent of identifying conductive metal anomalies that may have represented an encased slug of depleted uranium thought to have been dropped from a helicopter. The deliverables include:

- Results of the survey presented in both digital and hard copy (maps) formats.
- Digsheets with target locations of items that may represent the DU Slug location.
- A description of the survey.

Pre-Survey Instrument Verification

The Geonics EM61 MK2 (EM61) All-metal detector was coupled with the Leica 1200 series Real Time Kinetics Differentially Corrected Global Positioning System (RTK/DGPS). Both the detection and positioning technology have proven successful on a number of similar projects and are referred to as the industry standard. Both systems have factory calibrations which are set periodically by the manufacture; however pre- survey system performance verifications were required. The DGPS system was checked by verifying the value at a calculated location derived from the United States National Oceanographic and Atmospheric OPUS system which calculated the base station location to within two centimeters horizontally. A copy of the OPUS report is included as part of this report. Risk Reduction Resources, Inc. (RRR) then checked the consistency of the survey control daily by measuring the locations of established survey corners. All points were reacquired to within 0.1-ft of the initially surveyed locations which complies with typical quality control standards. In addition to validating the positional accuracy of the unit, the range of the differential correction radio transmission was also tested.

EM61 data was collected statically for no less then 90 seconds as part of the pre survey tests. Data was collected over a metal object for 30 seconds (Static Source Response) and with no item (Static Response) for 30-seconds. No major drift was detected in the data and the response to the known source was consistent day-to-day. All static tests were recorded in digit format. A shake test was also performed during static data collection. The electronics and positioning equipment were shaken vigorously (to simulate field data collection) while the data was being monitored. No significant fluctuations were observed in the data.

Establishment of Work Area and Cultural Features

The work area had been previously prepared for the survey by tilling the soils, thereby removing all vegetation. The open, survey area was marked at its corners by metal stands having traffic cones on top for greater visibility. RRR used the Leica 1200 RTK/DGPS to establish geographically referenced locations of the survey areas in NAD83 California State Plane Zone 5, US Survey Foot coordinates. Once the corners of the study area were established, the area was divided into 200-foot by 200-foot grids starting in the southwest corner. Only two such grids were established with an additional five grids of smaller size (see Figure 1). In addition to the grids, several cultural features were surveyed that would be identifiable from the geophysical survey. Those features included one metal-cased monitoring well, two power line pole with support wires, an unpaved road that traversed the area, and an area of stained soils that contained several pieces of burnt metal debris.

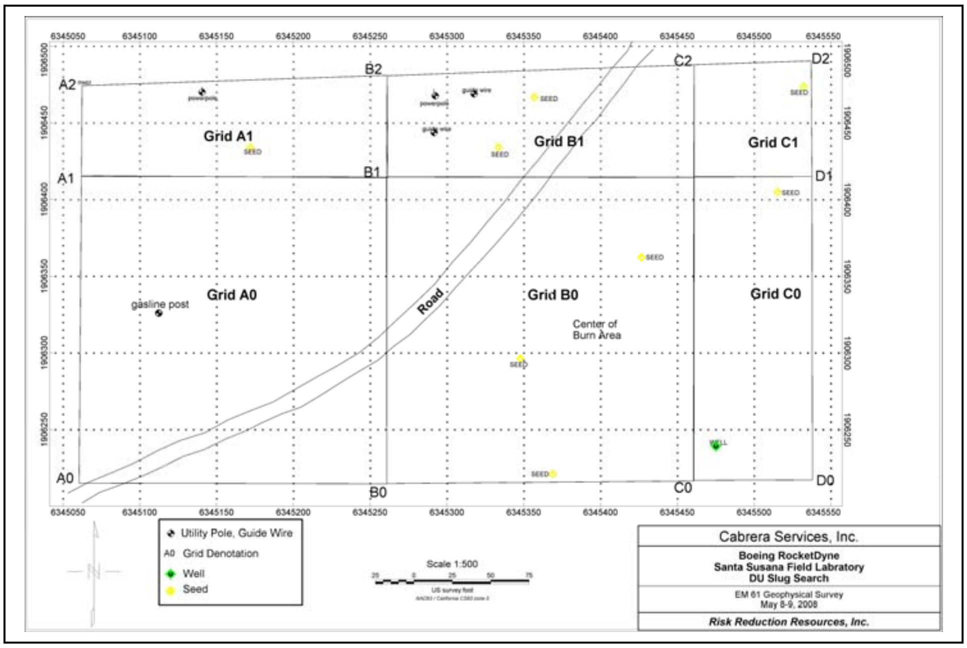


Figure 1 – Base Map

Surface Clearance

After the study area had been delineated, the RRR Project Team formed lines at arms' length apart to collect metallic debris from the surface of the study area. By removing the debris, fewer surface anomalies would be identified in the geophysical data that would be of little interest. The debris was piled at several locations outside of the study area. Most of the surface debris collected was composed of wire and scrap metal. No items of significance were identified.

Finally, crushed metal culvert pipe and a large, collapsed metal sign were removed by Boeing employees from the work area.

Geophysical Survey

The geophysical survey was conducted over a three-day period in two phases. The first phase included a Geophysical Prove-out (GPO), and the second phase included the actual geophysical survey across the study area.

Geophysical Prove-out

A geophysical prove-out was conducted to demonstrate the response of the EM61 to seeded targets meant to replicate the DU slug reported to have been lost. An area measuring 50 feet long by six feet wide was selected immediately to the north of the study area for the GPO. The location was selected since it was close to the study area and contained soil conditions similar to those within the study area. The GPO area was first mapped to identify any metallic objects that could interfere with seeded items that were to be placed in the GPO area. Once the area was cleared of all metallic objects, five objects were buried along the centerline of the GPO area. The following table displays the characteristics of each object.

Object	Northing	Easting	Depth	Orientation
1”x10” Aluminum Pipe	1906541.62	6345526.38	6 inches	Horizontal
1” x 6” Iron Rod	1906536.45	6345526.60	6 inches	Vertical
1”x10” Aluminum Pipe	1906526.50	6345526.67	6 inches	Vertical
1”x10” Aluminum Pipe	1906516.64	6345526.45	9 inches	45 degrees off Vertical
1”x10” Aluminum Pipe	1906506.52	6345526.32	12 inches	Vertical

The depths of the seeded objects in the GPO was significant because it was noted that the top six to eight inches of soil was relatively loose; whereas underlying soils appeared saprolitic (bedrock altered to soil in situ) or hardpan which would have required a significant impact to penetrate. These soil conditions appeared to be present across the study area.

Once the GPO was prepared, it was traversed longitudinally in two lanes spread three feet apart while collecting data. The data logger was then downloaded and the data was processed and interpreted.

The results of the analysis of data collected from the GPO indicated that all of the buried objects were readily detected by the EM61. Additionally, the data indicated that there was no appreciable latency between the time stamps for the positioning system (RTK/DGPS) and the EM61 responses.

Based upon the instrument responses during the GPO, a threshold value of 20 mV on Channel 2 was used for the anomaly selection process during the geophysical survey.

Geophysical Survey

Geophysical data was collected at a line spacing of 2.5-3.0-ft at a sample rate of 12 times per second. The survey locations did not contain any significant obstacles that could not be traversed safely

The EM61 was coupled with the Leica DGPS in a "cart" configuration. Ruggedized non-metallic wheels supported the Electromagnetic Coil (Figure 2 shows an example of the configuration). The GPS antenna was mounted directly above the center of the coil.

A PVC carriage was constructed on site allowing the operator to push or pull the cart. Ropes were extended along the ground at 3.0-ft spacing which aided the operator to maintain equal line spacing and attain 100% coverage.

Figure 2: Example of an EM61 coupled with a Leica 1200 DGPS.

Data file names were determined by the name of the grid stake at the Southwest corner of the data collection area.

As a quality assurance measure, seeded items composed of ¼-inch x 6-inch steel bolts were inserted into the ground in each grid. The items were surveyed in using the RTK/DGPS and their positions were relayed to the Site Geophysicist. Seeded items are generally targets inserted into the ground that mimic the size and shape of targets of interest. This is more of a quality assurance measure than anything else in that it demonstrates that the technology is capable of detecting the targets of interest and that they are in the correct positions. The seeded items were buried vertically with one end even with the ground surface. All seeded items were removed at the end of the survey. As long as the geophysicist can identify the seeded items in the data and they are in the correct position, then we know that the dataset is of acceptable quality.

After each dataset was collected, the data was downloaded onto a flash memory device and provided to the site geophysicist for analysis. The data was uploaded into a computer where Trackmaker MG software was used to merge the EM61 and RTK/DGPS files to create a .xyz file used for detailed analysis. The .xyz file was then uploaded into Geosoft Oasis Montage software for processing and analysis. File corrections were minimal - requiring only leveling of the EM data which displayed a tendency to drift slightly over the long period of data collection (up to 60 minutes per dataset). Once the data was corrected for drift, it was gridded and maps were formulated. Color scheming was applied in a linear distribution to highlight anomalies and features of interest. Once the data had been optimally displayed, anomaly selection was completed.

The process of anomaly selection is one that has been refined over years of experience. While the anticipated shape of the DU slug was elongated, it was also recognized that it could have been masked by larger shapes surrounding it as well as being atop or under debris. Therefore, anomalies were selected for investigation that did not represent the anticipated shape. Anomalies that were of smaller size or having responses that were below the set instrument threshold were also selected in the event that the DU slug broke, was deformed on impact, or did somehow penetrate deeper into the ground.

Quality control anomalies or "QC Picks" are anomaly selections whose instrument responses are outside of the expected responses for the targets of interest. By selecting anomalies lower than the threshold value established during the GPO, we demonstrate that we are selecting anomalies that would represent the minimum instrument response of the anticipated targets of interest (see Figure 3). If we are looking to detect a 1"x10" item and our low end QC picks are small nails, then we have some assurance that we selected instrument responses that were low enough to detect the targets of interest. The same holds true for high value QC picks. QC picks are a tool used by the geophysicist to ensure that they have selected intelligently. The feedback (results) submitted by the intrusive investigation teams to the geophysicist are an integral part of the geophysical investigation. If the QC picks are improper, then the geophysicist would re-analyze the data and adjust selections accordingly.

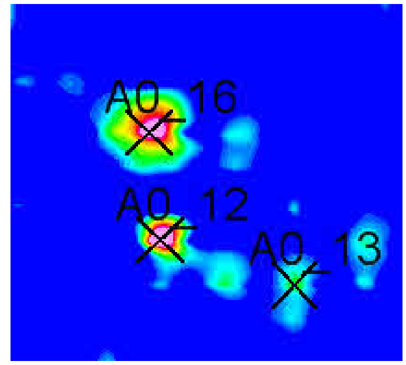
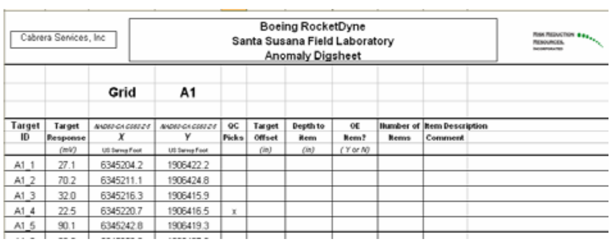


Figure 3- A0-13 is an example of a QC Pick.


Cabrera Services, Inc

Boeing RocketDyne
Santa Susana Field Laboratory
Anomaly Digsheet

Grid A1

Target ID	Target Response (mV)	X US Survey Foot	Y US Survey Foot	QC Picks	Target Offset (in)	Depth to Item (in)	OE Item? (Y or N)	Number of Items	Item Description Comment
A1_1	27.1	6345204.2	1906422.2						
A1_2	70.2	6345211.1	1906424.8						
A1_3	32.0	6345216.3	1906415.9						
A1_4	22.5	6345220.7	1906416.5	x					
A1_5	90.1	6345242.8	1906419.3						

Figure 4 – Dig sheet example.

Once anomaly selection was completed, the anomaly locations were plotted on the total site map. A review of anomaly locations was then completed to ensure that multiple anomalies did not overwrite one another. Final maps displaying anomaly locations were then created along with dig sheets describing the individual anomalies locations and instrument responses. The dig sheets (see Figure 4) also contained areas for the intrusive investigation teams to enter in information as to what the anomaly consisted of as well as depth and location information.

Finally, the maps and dig sheets along with an electronic comma delimited (.csv) file of anomaly locations were delivered to the Client.

Geophysical Survey Results

A total of 416 anomalies were selected for investigation (see Figure 5). Of the selected anomalies, eight (8) were seeded items. All seeded items were readily identified and their positions were consistent with those measured using the RTK/DGPS. An additional 40 anomalies were QC picks.

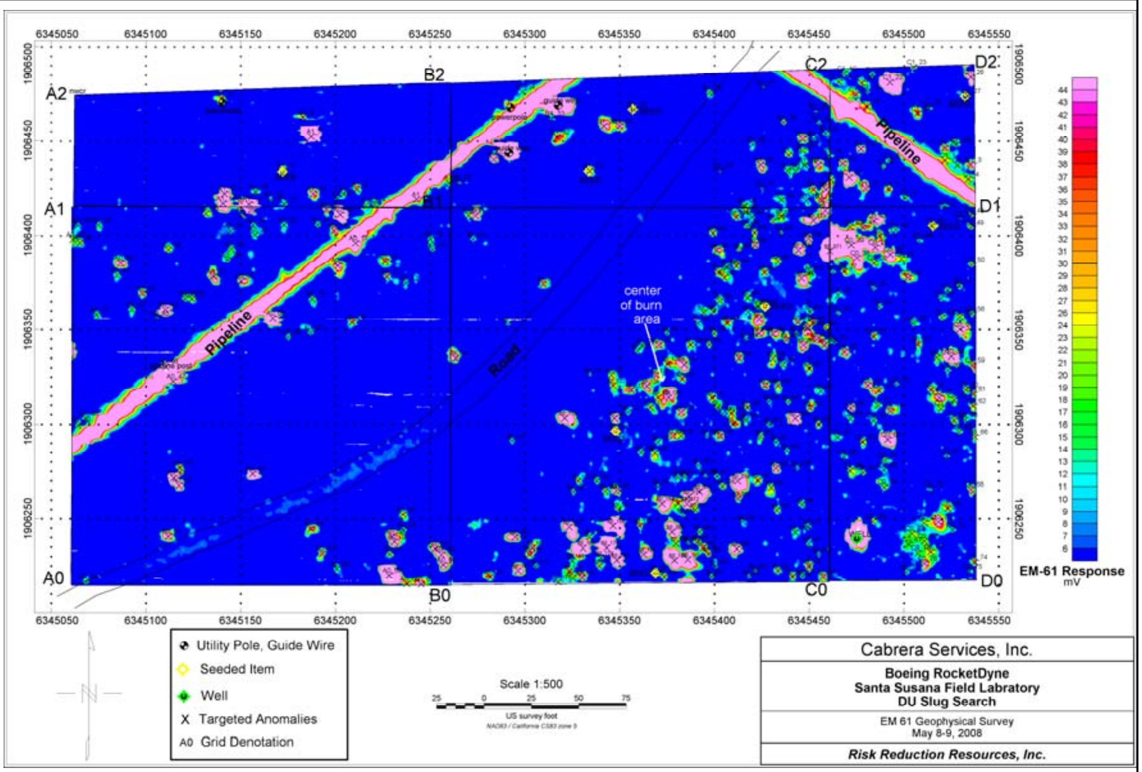


Figure 5- Results of the geophysical survey with anomaly selections.

One location within the central portion of Grid B-0 contained stained soils but did not have any substantially larger quantity of anomalies. Another large anomaly was identified in the northwest corner of grid C-0, that was consistent with the area where metal culvert pipe was removed from the surface prior to the survey being completed.

In general, the density of anomalies appeared to increase toward the southeastern portion of the study area. While several anomalies appeared elongated (for example B1_06 and B0_054), there was no specific attribute that would distinguish between piping and concentrations of wire bundles, and the suspected DU slug.