ENERGYSOLUTIONS

CS-FO-PN-002

LLNL Site 300 Building 812 U-238 Surface Soil Gamma Radiation Survey Work Plan

Livermore, CA

Project No. 313147 **FINAL**

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS/ACRONYMS

μCi/cm^3	microCuries per cubic centimeter
μR/hr	microRoentgen per hour
ASME	American Society of Mechanical Engineers
amsl	above mean sea level
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
CORS	Continuously Operating Reference Station
cpm	counts per minute
cps	counts per second
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQI	data quality indicators
DQO	data quality objectives
DTSC	California Department of Toxic Substances Control
DU	depleted uranium
Energy*Solutions*	Energy*Solutions*, LLC
EPA	U.S. Environmental Protection Agency
FIDLER	Field Instrument for Detection of Low Energy Radiation
g/cm^3	grams per cubic centimeter
GIS	Geographical Information System
GPS	global positioning system
IAEA	International Atomic Energy Agency
IDW	Investigation derived wastes
keV	kilo-electronvolts
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security LLC
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MDER	minimum detectable exposure rate
NAD	North American Datum

ABBREVIATIONS/ACRONYMS (CONTINUED)

NaI	sodium iodide
NIST	National Institute of Standards and Technology
PHP	Project Health Physicist
QA	Quality Assurance
QC	quality control
RCRA	Resource and Conservation and Recovery Act
RemCAT	Remote Controlled All Terrain
RI/FS	Remedial Investigation/Feasibility Study
RWQCB	Regional Water Quality Control Board-Central Valley Region
Pa	protactinium
pCi/g	picoCuries per gram
PRG	U.S. Preliminary Remediation Goal
SBAS	Satellite Based Augmentation System
SOP	standard operating procedure
Th	thorium
U	uranium
WAAS	Wide Area Augmentation System

1. INTRODUCTION

The Environmental Restoration Department at Lawrence Livermore National Laboratory (LLNL) has contracted Energy*Solutions* to perform gamma radiation surveys to define the extent of uranium-238 (U-238) in surface soil surrounding and proximal to the high explosives firing table at LLNL Site 300 Building 812.

1.1. PURPOSE

This work plan describes the survey design and methods to be implemented to bound and quantify the U-238 surface soil contamination at LLNL Site 300 Building 812.

1.2. OBJECTIVES

The objectives of the gamma radiation survey that will be conducted are:

- Provide better definition of the areal extent of surface soil containing total U-238 activity concentrations greater than or equal to 3.1 picoCuries per gram (pCi/g)[1];
- Define the location(s) and extent(s) of areas of elevated total U-238 activity concentrations in surface soil, i.e., "hot spots;" and
- Locate potential sites for follow-on characterization work.

1.3. SCOPE

Energy*Solutions* will perform gamma radiation surveys under the direction of applicable plans and procedures, including this work plan.

2. BACKGROUND

Site 300 is a U.S. Department of Energy (DOE)-owned experimental test facility, currently operated by Lawrence Livermore National Security (LLNS) LLC. As a result of the dispersal of contaminated shrapnel during explosives testing, surface and subsurface soil at the firing table, in an adjacent alluvial channel, and on the surrounding hillsides have become contaminated with depleted uranium (DU) and other metals. DU is termed "depleted" because it is natural uranium from which much of the more radioactive U-235 isotope has been removed for energy and weapons applications. Thus, DU contains a higher proportion of U-238 than does natural uranium.

Because LLNL Site 300 is a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Superfund site, a remedial investigation/feasibility study (RI/FS) is being conducted to: 1) characterize the nature and extent of contamination in environmental media at Building 812, 2) evaluate impacts to human and ecological receptors that could be exposed to contaminated media, and 3) develop and evaluate alternatives for remedial actions.

[1] The information from this survey, along with the borehole subsurface survey results and physical and chemical characterization results will be used to define the nature and extent of uranium contamination in soil.

The gamma radiation survey is being conducted as part of the RI to define the extent of total U-238 in surface soil at Building 812.

2.1. SITE LOCATION AND DESCRIPTION

The site is located in the Altamont Hills about 17 miles east-southeast of Livermore, California, and 8.5 miles southwest of Tracy, California (Figure 2-1). Site topographic elevation ranges from about 900 to 1,200 feet above mean sea level (amsl). The steep topography will present a challenge in conducting the survey and has been considered in the survey designs and methods. There is also thick vegetation in a narrow area of valley fill alluvium where U-238 may have accumulated due to surface water flow and transport.

2.2. PREVIOUS INVESTIGATIONS

Past operations involving the processing, testing, and deactivation of explosive materials resulted in soil contamination at the site. In 1981, DOE began investigation and characterization at Site 300. In 1991, Site 300 was placed on the U.S. Environmental Protection Agency (EPA) National Priorities (Superfund) List. Soil sample analysis has identified U-238 contamination at Building 812.

Soil samples were collected and analyzed through mass spectrometry in the most recent investigations to determine the activity concentrations of uranium isotopes. Maximum detected total activity concentrations of U-235 and U-238 in surface soil were 0.95 and 93 pCi/g, respectively. These data were used to define the extent of U-235 and U-238 contamination in surface and subsurface soil (as shown in Figure 2-2 and Figure 2-3) and to conduct a screening level risk assessment (Taffet et al. 2008). The screening level risk assessment indicated that U-235 and U-238 activities in surface soil exceeded U.S. Preliminary Remediation Goals (PRGs). Uranium-235 exceeds its PRG within the footprint of U-238 exceeding PRGs and background and thus any remedial strategy that targets elevated U-238 will also remediate U-235 (Figure 2-2 and Figure 2-3). The EPA PRGs for U-238 and U-235 are 1.65 and 0.386 pCi/g, respectively. The upper limit for background activity concentrations in Site 300 surface soil are 3.1 and 0.0737 pCi/g, respectively (Taffet et al., 2008). PRGs were used in the screening-level risk assessment to help identify areas, contaminants, and conditions that do not require further attention. Concentrations above a PRG would not automatically trigger a response action, but rather suggest that further evaluation of the potential risks that may be posed by the contaminant is appropriate. PRGs are not to be used, necessarily, as cleanup standards. Modeling also indicated that U-238 activities in soil posed a threat to underlying ground water. The modeling results are presented in the Draft Building 812 RI/FS (Taffet et al., 2008). As a result, the DOE and LLNS have agreed with the EPA, the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board-Central Valley Region (RWQCB) to remediate the soil to mitigate this risk.

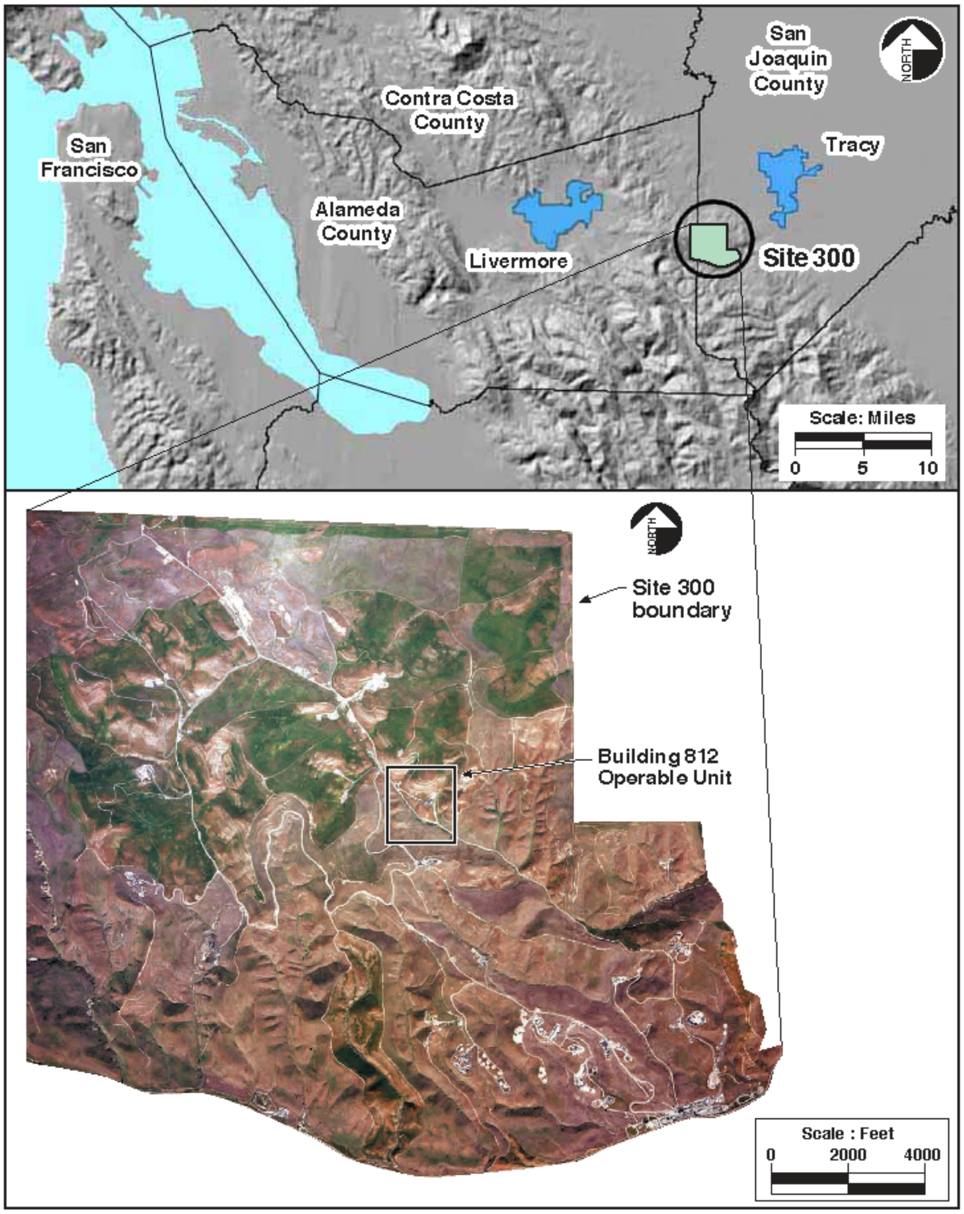

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Figure 2-1: Site Location
(Source: Taffet et al. 2008)

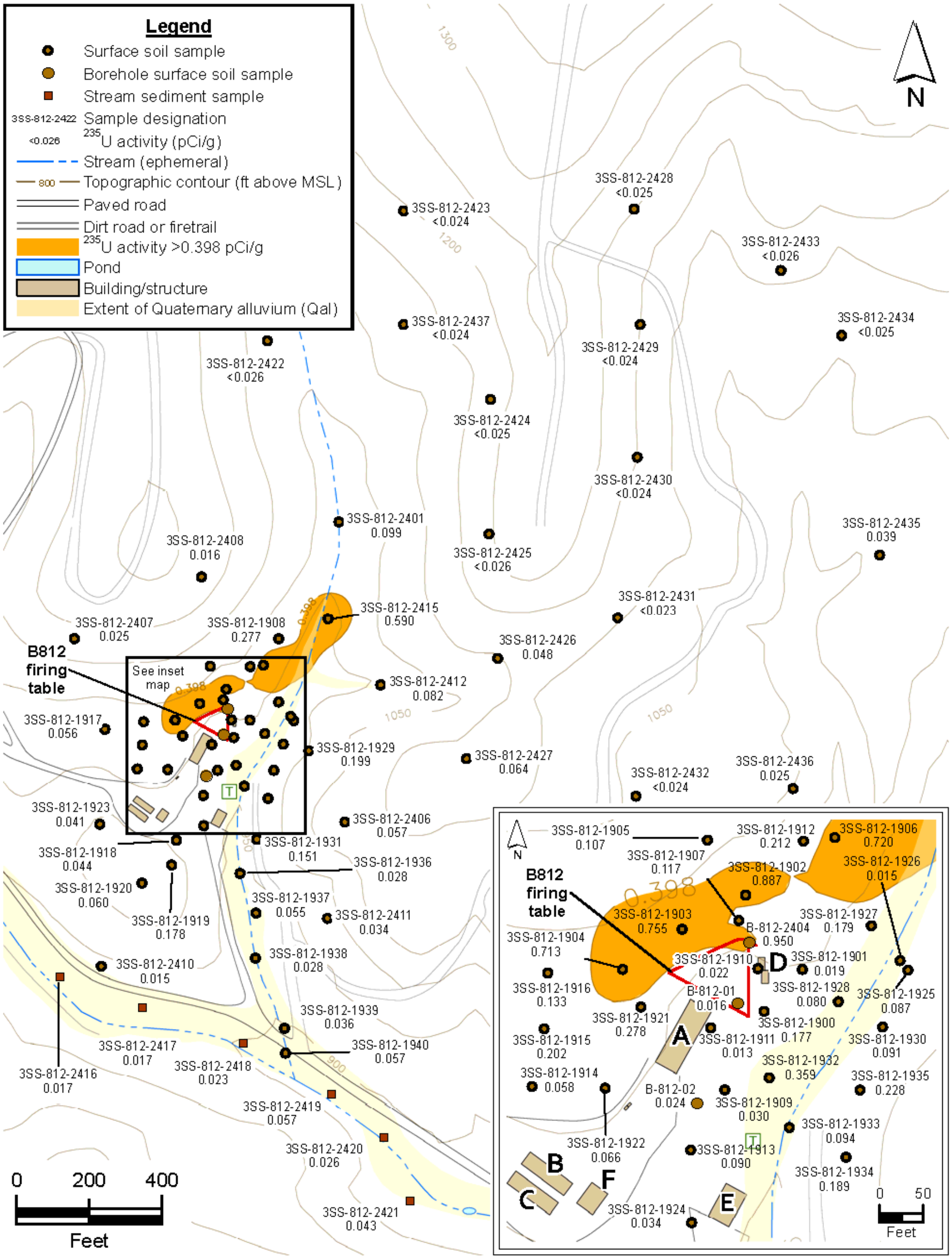

Figure 2-2: Extent of U-235 Activity Concentration Based on Soil Sampling and Analysis
(Source: Taffet et al. 2008)

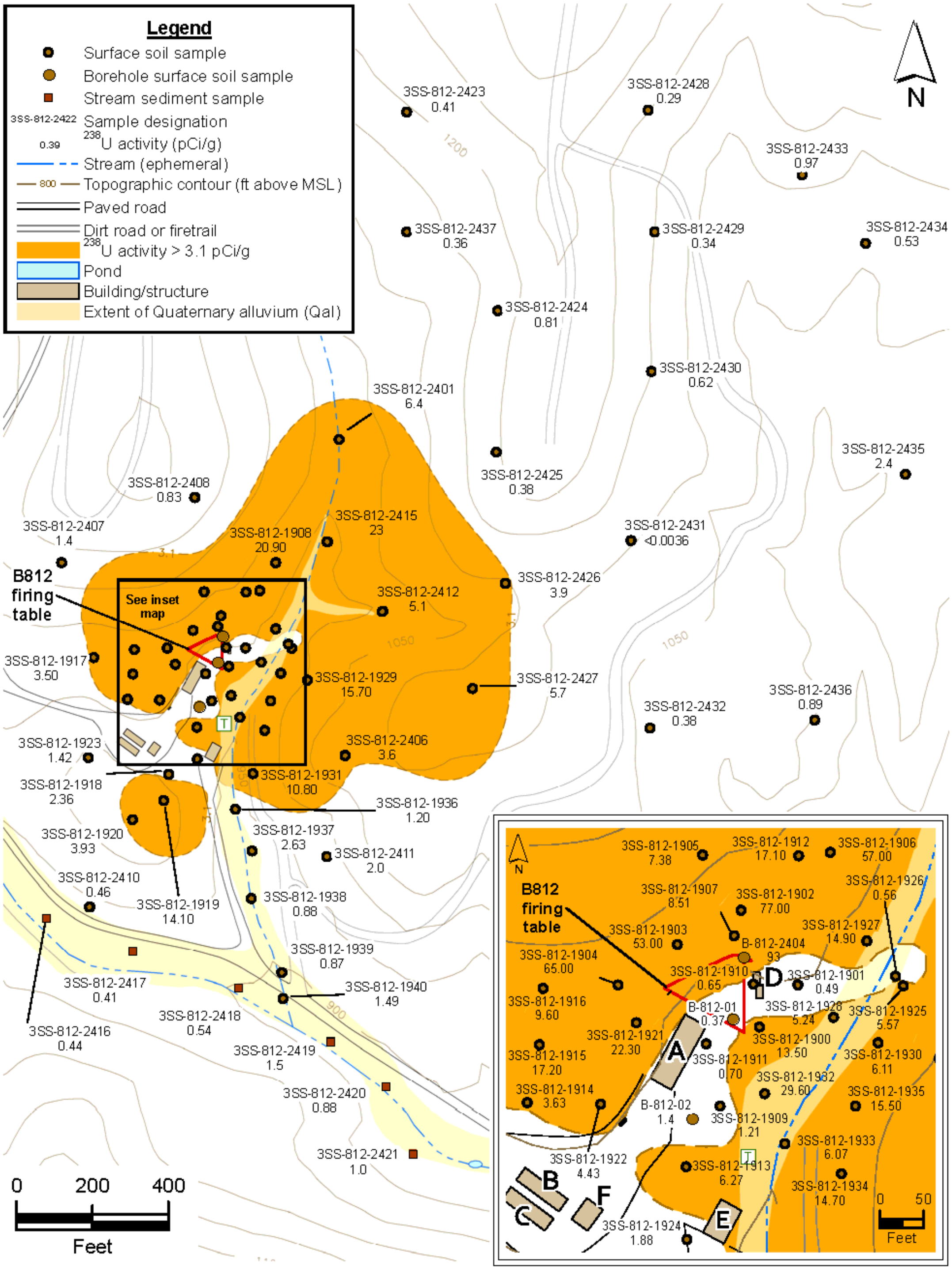

Figure 2-3: Extent of U-238 Activity Concentration Based on Soil Sampling and Analysis
(Source: Taffet et al. 2008)

The draft RI/FS document was submitted to the regulatory agencies in July 2008 (Taffet et al. 2008). The document identified soil excavation and subsequent soil washing, solidification and stabilization, and/or disposal at an onsite landfill, or offsite disposal as potential remedial technologies that could mitigate the risks posed by the contaminated soil. Based on the FS, a soil washing treatability study was planned for 2011-2012. An independent panel of experts from DOE/EM reviewed the RI/FS and determined that additional characterization could be effective in better defining the location of soil requiring cleanup, provide additional data to improve the risk assessment, and better define what soil cleanup technologies might be most effective for the Building 812 soils. The surface soil gamma radiation survey is the first of several characterization efforts to be conducted in 2011-2012. The results will be used to locate sampling locations for uranium mineralogy and grain-size studies, borehole drilling and sampling, and invertebrate and vegetation uranium analysis. After completion of this work, a revised RI/FS, documenting the results, will be submitted to the regulatory agencies. The RI/FS will also include a baseline risk assessment and remedial alternatives for soil. After agreement on a preferred alternative for the uranium contamination in soil and ground water contamination, a Proposed Plan, Record of Decision Amendment, and Remedial Design documents will be submitted to the regulatory agencies for approval.

3. PROJECT DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are qualitative and quantitative statements for establishing criteria for data quality and for developing data collection designs. Planning radiological surveys using the DQO process can improve the survey effectiveness and efficiency and defensibility of the collected data.

3.1. PROJECT TASK AND PROBLEM DEFINITION

The project task is to conduct a total U-238 surface soil gamma radiation survey of the surface soils surrounding and proximal to the high explosives firing table at Site 300 Building 812 to meet the objectives discussed in Section 1.2.

3.2. DATA QUALITY OBJECTIVES (DQOS)

Because this is a small project with a limited scope, defining action levels and data quality indicators (DQIs) for the field measurements are considered to be sufficient. However, simplified DQOs were also established to improve the survey effectiveness and efficiency and defensibility of the collected data. Development of the DQOs followed guidance described in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM; NUREG-1575, Rev. 1) Appendix D, which references EPA QA/G-4, *Guidance for the Data Quality Objectives Process*. The DQO process consists of seven steps, evaluated in the following subsections.

3.2.1. Step 1: State the Problem

The extent of total U-238 activity concentrations in surface soil surrounding and proximal to the explosives firing table at LLNL Site 300 Building 812 is known only based on conventional surface soil sampling results. A more areally-extensive and discretized survey sampling approach would provide more detailed information on the U-238 distribution in surface soil.

3.2.2. Step 2: Identify the Decision

Determine the extent of surface soil containing activity concentrations greater than or equal to 3.1 pCi/g total U-238; specify locations of elevated total U-238, i.e. "hot spots," and the areal extent of each; and, identify potential sites for follow-on characterization work.

3.2.3. Step 3: Identify the Inputs to the Decision

Perform gamma radiation surveys using specialized detectors to: 1) measure the low-energy gamma radiation from U-238 and its short-lived progeny thorium-234 (Th-234) and protactinium-234m (Pa-234m) to determine the total activity concentration of U-238, and 2) document the extent of U-238 with total activity concentrations greater than or equal to 3.1 pCi/g in surface soil.

3.2.4. Step 4: Define the Boundaries of the Study

The survey area is shown in Figure 4-2. The gamma radiation survey will cover a minimum of 90% of the exposed surface soil within the survey area. The boundaries of the survey area may be altered by LLNL based on findings as the surveys are conducted. Specifically, if based on preliminary survey results, the extent of U-238 in excess of the MDC for Survey Areas 2, 3, or 5 is not defined within the original boundaries (depicted on Figure 4-2), these survey area boundaries may be extended. In that case, the boundaries of some of the other Survey Areas, such as 6 and 7, may be reduced to reflect the increase in the size of the Survey Area 2, 3, or 5.

3.2.5. Step 5: Develop a Decision Rule

All gamma radiation survey results that exceed the action levels developed in Section 4.1.6 will be considered to represent total U-238 contamination greater than or equal to 3.1 pCi/g, with contour plots defining the extent of varying activity concentrations as well as the areal extent of "hot spot" locations. The action level is dependent upon the background radiation count rate, scan speed, index of sensitivity (d′), and surveyor efficiency. Based on these inputs a minimum detectable count rate (MDCR), above background, is established. The $MDCR_{surveyor}$ is a modification of the MDCR to account for the fact that the signal is not processed by the ideal observer. The $MDCR_{surveyor}$ plus the background count rate, both assessed in counts per minute (cpm), are used to derive the Scan minimum detectable concentration (MDC) and associated action level.

3.2.6. Step 6: Specify Limits on Decision Errors

For gamma radiation surveys, the true positive proportion will be set to 95% and the false positive proportion will be set at 60%. This provides a d′ of 1.38 for Scan MDC calculations (discussed in Section 4.1.6). If background count rates permit (less than the *a priori* background), d′ may be modified to reduce the false positive proportion as long as the survey sensitivity meets the survey objectives.

3.2.7. Step 7: Optimize the Design for Collecting Data

Detector geometry, survey speed, and other factors affecting the survey sensitivity have been optimized to most efficiently provide the required survey sensitivity. Final selection of all factors affecting the survey sensitivity is discussed in Section 4.1.6. Remote-operated droids will be used on all inclined and steep terrain in the survey area to optimize the data collection of U-238 and short-lived progeny gamma emissions over surface soils. The design of the RemCAT (see Section 4.1) places the detectors 3.5 inches above the ground surface, predominantly due to mechanical considerations. To conservatively account for field conditions that could cause changes in the detector geometry, in this case height above the soil surface, the detector geometry was modeled at a height of 6 inches above the ground surface (discussed in Section 4.1.6). This approach is conservative because the 6-inch model underestimates the exposure rate that the detector will measure compared to the actual height of 3.5 inches.

3.3. DATA QUALITY INDICATORS (DQIS)

DQIs are used to monitor and ensure that the data generated are adequate for their intended use. In order to assess the quality of field data generated during this project, six measurement performance criteria or DQIs, will be evaluated including: precision, accuracy, representativeness, completeness, comparability, and sensitivity. These six performance criteria indicate the qualitative and quantitative degree of quality associated with measurement data.

3.3.1. Precision

The definition of precision is taken from International Organization of Standardization (ISO) 3534-1 "… the closeness of agreement between independent test results obtained under stipulated conditions." Precision will be qualitatively documented for each survey area listed in Figure 4-2 by resurveying up to 5% of the area using one of two methods: 1) same survey equipment with a different surveyor or 2) different survey equipment with the same surveyor. Each survey area will be divided into similarly sized sub-areas such that all areas are at least 5% of the total area. The sub-areas will be numbered and the sub-area to be resurveyed will be chosen randomly by the PHP.

The results of the two surveys will be reviewed by the PHP to determine, using professional judgment, if the same conclusions can be reached from each survey, such as the number and extent of areas of elevated gamma radiation. The data from the original survey (limited to the extent of the randomly-selected sub-area) will be statistically compared to the re-survey data. The average and standard deviation of each data set will be determined and used to calculate the 95% confidence range (±2-sigma of the average) of each data set. If the two confidence ranges overlap, the averages between the two surveys will be considered statistically similar.

3.3.2. Accuracy

Accuracy is defined as the closeness of agreement between a "true" or reference value and an associated measurement result. Data logging instruments and associated detectors will be calibrated using National Institute of Standards and Technology (NIST) traceable sources and calibration equipment. Source checks, using NIST traceable sources when practical, will be used daily to verify instrument response.

A qualitative review of post-processed and plotted survey data (discussed in Section 3.5.4) will be completed by the surveyor that collected the data. The review will ensure that the totality of the data was recorded and was consistent with the field evaluation using visible or audible output of the survey mode. Documentation of the review will be recorded in the site log book (discussed in Section 3.5.1).

3.3.3. Representativeness

Representativeness is defined as a measure of the degree to which data accurately and precisely represent a characteristic of a population. Representativeness will be satisfied by the Energy*Solutions* Site Manager documenting in the site logbook that proper survey techniques were employed and procedures were followed as directed by this plan and applicable procedures.

3.3.4. Completeness

Completeness is defined as the percentage of valid data points relative to total possible data points. With respect to the gamma radiation survey, completeness is alternatively defined as the percentage of area surveyed divided by the total area to be surveyed. The project goal for this DQI is 90% or greater. Since the boundaries of the survey are captured using Global Positioning System (GPS) equipment, this percentage can be determined.

3.3.5. Comparability

Comparability is defined as a qualitative term that expresses the confidence that two data sets can contribute to a common analysis and interpolation—whether two data sets can be considered equivalent in regard to the measurement of a specific variable or groups of variables. Comparability is established via the same qualitative methods used for ensuring representativeness (Section 3.3.3) plus the use of conventional and standard units for reporting.

3.3.6. Sensitivity

Survey sensitivity for the two modes of gamma radiation surveying is defined in Section 4.1.6.

3.4. Data Review and Validation

During the survey of each area, the Energy*Solutions* Site Manager will conduct daily Quality Control (QC) reviews of all generated data with a final QC review completed by the Project Health Physicist (PHP). The QC review will ensure that all applicable QC measurements were collected and evaluated properly—Section 7 outlines the QC process and applicable procedures. When the final QC review is completed and contour figures generated, the survey area results and contour plots will be submitted to LLNL to ensure project DQOs are met and to plan follow-on activities.

3.5. DATA MANAGEMENT

Data pertinent to site activities will be recorded in site logbooks, on data forms, as photographs, and/or in electronic data files as directed in CS-AD-PR-002, *Commercial Services Project Records*. Data will be managed as discussed in the following subsections.

Project records and documents will be stored on site and off site (backup) for the duration of site activities performed by Energy*Solutions*. Energy*Solutions* will then provide all project records and documents to LLNL for archival on LLNL's servers. LLNL will maintain and store the project records throughout the lifetime of the LLNL Site 300 Environmental Restoration Program.

3.5.1. Site Logbooks

Information pertinent to the field activities, including field instrumentation calibration data, will be recorded in field logbooks. Each logbook will document the site name and project name and number. Sufficient information will be recorded to permit reconstruction of field activities when necessary. The logbooks will be bound and the pages will be consecutively numbered and water resistant. Entries in the logbooks will be made in waterproof ink and will include, at a minimum, a description of all accomplished activities; names of individuals involved in field investigative activities; date, times, and locations of surveys; weather conditions; and a description of any problems encountered.

If any recorded information is noticed to be in error, the original entry will be crossed out so that the original entry is still legible or readable and will be replaced with the new entry. Logbook changes will be initialed by the Energy*Solutions* Site Manager.

Information recorded on forms or in electronic files will not be repeated in the logbooks (e.g., daily responses tests), although summaries and/or conclusions will be included where deemed necessary. Entries will include, but not be limited, to the following information:

- Name and title of author and Energy*Solutions* Site Manager;
- Date and times of arrival and departure from site;
- Name and address of the field contact(s);
- Names and responsibilities of field members;
- Names, affiliations, and purpose of any site visitors;
- Level of personal protective equipment worn at the site;
- Weather conditions on the day of site activities and any additional environmental conditions or observations relevant to the field activities;
- Description of the daily activities;
- Field instrumentation or equipment used, and purpose of use;
- Location, description, and log of photographs taken (see Section 3.5.3);

- Deviations from written plans and/or procedures with justifications;
- Record a summary of field results and QC information; and,
- Listing of all forms created or updated (see Section 3.5.2).

The field logbooks will be kept in the possession of the Energy*Solutions* Site Manager, or in a secure place when not being utilized for field work. Upon completion of the field activities, the logbooks will become part of the final project file.

3.5.2. Data Forms

Written entries on data forms will be made in waterproof ink. If any recorded information is noticed to be in error, the original written entry will be crossed out so that the original entry is still legible and will be replaced with the new entry. All such changes will be initialed by the Energy*Solutions* Site Manager. Data forms will be kept in the possession of the Energy*Solutions* Site Manager, or in a secure place when not being utilized for field work. Electronic data forms are acceptable. Upon completion of the field activities, the data forms will become part of the final project file.

3.5.3. Photographs

LLNL will take photographs when requested by the Energy*Solutions* Site Manager or at LLNL's discretion to document visual information such as field conditions, indications of visual contamination, etc. All photographs will be digitized images with descriptive captions and unique identifiers. The GPS location and bearing where the photograph was taken will be recorded when possible. If necessary, LLNL will process all photographs through its Information Management process prior to release for external use to ensure that confidentiality of sensitive information is maintained. For each photograph, field logbook or electronic entries will include the following items:

- Date and time;
- Photographer (name and signature);
- Description of photograph;
- General position and direction faced (not required when GPS position and bearing is electronically recorded); and,
- Unique identifier in sequential order for each photograph.

3.5.4. Electronic Data Files

Electronic data files will be created during survey activities and some of the data will be stored in the file format native to the software application (e.g. Trimble TerraSync SSF format). GPS data will be geo-referenced to North American Datum (NAD) 1983 California State Plane Zone III Coordinates unless otherwise directed by LLNL. Data files will be copied from the device for backup purposes at a frequency of at least daily and the files will also be uploaded to Oak Ridge, TN servers for archive and post-processing.

Post-processing of data will begin with differentially correcting GPS positions as necessary. The data will then be migrated from the native software applications file format to a Geographical Information System (GIS) database format where conversion factors will be applied as necessary (e.g. count rate to U-238 activity concentration) and survey results will be graphically plotted and statistically analyzed.

3.6. ASSESSMENT OVERSIGHT

Energy*Solutions* will implement a quality program that sets forth requirements for the establishment, execution, assessment, and documentation of project-specific Quality Assurance (QA) programs on all our projects involving commercial and Federal agencies, including DOE. The program encompasses all phases of a project, including the approval of submittals of plans and reports, procurement, storage of materials and equipment, coordination of subcontractor activities, and inspections and tests to ensure project specifications are met.

The QA/QC programs are routinely evaluated by various key personnel/corporate support personnel to ensure that Energy*Solutions* is consistently meeting high industry standards and expectations to support the work performed for its clients. The quality program is discussed in more detail in Section 7.

4. FIELD METHODS AND PROCEDURES

4.1. FIELD EQUIPMENT

The U-238 surface soil gamma radiation survey will be performed using field instruments described in Sections 4.1.1 and 4.1.2 below. Scan MDCs for the Remote Controlled All Terrain (RemCAT) and Backpack Mode are calculated as being 1.7 pCi/g and 1.8 pCi/g net U-238, respectively. Assuming a nominal background U-238 activity concentration of 1 pCi/g, the RemCAT and Backpack Modes will be capable of evaluating total U-238 activity concentrations of 2.7 pCi/g and 2.8 pCi/g total U-238, respectively. Scan MDC calculations are described in Section 4.1.6. Survey areas have been developed to encompass the entire impacted area and are identified in Section 4.2.

4.1.1. Description of Radiation Survey Equipment

Energy*Solutions* will use Field Instrument for Detection of Low Energy Radiation (FIDLER) detectors coupled to Ludlum 2350-1 data logging digital rate meters. This radiation survey detection equipment combination is configured in two survey modes as described below. Both survey modes will be accompanied with GPS instruments to collect GPS location coordinates associated with each radiological gamma measurement interval collected with the individual FIDLER.

The RemCAT survey mode consists of a droid base platform with track-driven drive train that can climb difficult and/or steep terrains. The design of the platform chassis is approximately 1.2 meters in width to accommodate the GPS system, FIDLER detectors, instrumentation, and motor. The weight of the system fully equipped is approximately 100 pounds. The FIDLER detectors are configured at a height of 6 inches above the soil surface.

With all equipment and electronics attached, the RemCAT maintains a low center of gravity and is low geared to maintain a relatively constant survey speed and torque, allowing for surveying on inclines exceeding 60 degrees, which is the maximum angle of slope expected to be encountered in the Building 812 area. As mounted, the FIDLER detectors encompass a gamma emission solid angle of detection area of 0.25 square meters. With the width of the platform being approximately 1.2 meters and using four FIDLER detectors that are placed equidistant apart, approximately 40% overlap is obtained to ensure the required 90% coverage of the surveyed area while producing six measurements per square meter over a planar cube. Exposed soil coverage is expected to be close to 100% with this method. Each FIDLER detector in the array is pulsed to collect the gamma signal every second with the count tagged to an x, y, and z coordinate from the GPS unit. In addition, the velocity of the RemCAT is also monitored to allow for Scan MDC validation of survey speed during post-processing of the data.

The backpack survey mode is used for areas that are readily accessible by a human and/or where the RemCAT is unable to survey effectively, such as the bottom of the streams and/or ditches, gravel mounds, and debris piles. This mode consists of the same instrumentation with the FIDLER detector coupled to a Ludlum 2350-1 data logging digital rate meter and weighs about 10 pounds. However, the mode of movement is the human surveyor rather than a remote operated droid. The same data will be collected, achieving the same DQOs for the radiation survey. The surveyor efficiency for Backpack Mode is half of the RemCAT based on variable detector height and speed variability as described in NUREG-6364, *Human Performance in Radiological Survey Scanning*.

4.1.2. GPS Equipment

RemCAT Mode

Energy*Solutions* will use a Trimble GPS Pathfinder ProXRT Model 2 receiver with external Trimble Tornado antenna to record the GPS location of the RemCAT. With the ProXRT's GLONASS option, computing the current location is potentially improved by utilizing available Russian satellites. This will be a significant advantage given the limited view of the sky while surveying steep hillsides. The ProXRT receiver is capable of determining the GPS location with better than 20 centimeter (cm) accuracy in real-time, utilizing the OmniSTAR XP/G2 satellite-based differential correction service. No post-processing for differential correction of the GPS data will be required. The differentially corrected position will be exported in NMEA-0183 data format to a customized data acquisition board that will simultaneously collect each one-second integrated FIDLER detector count.

Backpack Mode

A Trimble GeoExplorer 2008 series GeoXH handheld GPS unit with backpack-mounted antenna and Trimble's TerraSync Professional software will be used to record the GPS location for each one-second integrated FIDLER detector count. The GPS data collection will provide sub-meter accuracy in the field, utilizing the Satellite Based Augmentation System (SBAS) to receive differential correction information in real-time from the Wide Area Augmentation System (WAAS). WAAS is an air navigation aid developed by the Federal Aviation Administration to augment GPS with the goal of improving its accuracy, integrity, and availability. Trimble's

Pathfinder Office software will be used to post-process field collected data, utilizing the Continuously Operating Reference Station (CORS) network to improve GPS location accuracy from submeter to subfoot accuracy, with a high percentage of locations being corrected to decimeter accuracy.

4.1.3. Background Reference Area Determination

A background reference area is an area similar to that of the remediation site from which representative reference measurements are performed for comparison with measurements obtained in specific survey areas. Therefore, a background reference area or areas will be selected at Site 300. The background reference area will be used for gamma radiation survey-specific measurements only. The data generated by gamma radiation survey-specific measurements are different from those that were previously used to develop the U-238 soil background calculation by virtue of the data collection method: discrete soil sampling with mass and alpha spectroscopy analyses versus near complete areal gamma radiation survey coverage with conversion of gross detector counts recorded in an approximate 1-second observation interval to activity concentration.

The background reference area(s) shall meet the following requirements.

1. Similar physical, chemical, radiological, geological, and biological characteristics as the Building 812 area.
2. Not contaminated by site activities.

Before mobilization to the site, several candidate reference areas, if available, will be established. Upon mobilization to the site, gamma radiation surveys in the background reference area will be performed to establish the background mean. The gamma radiation survey will encompass a large enough area to collect greater than 1,000 unique measurements.

Following the collection of background reference area measurements, the theoretical mean background count rate of the reference area will be determined and used to calculate the actual $MDCR_{surveyor}$ as opposed to the *a priori* $MDCR_{surveyor}$ calculated in the following section.

If the initial background reference area is determined not to be adequate by Energy*Solutions* (e.g. not enough variability), then multiple background reference areas may be surveyed.
Section A.3.4 of NUREG-1757 Vol. 2 Rev. 1, *Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria*, discusses that the Kruskal-Wallis test can be conducted should significant variations within multiple background reference areas be encountered to determine that there are no significant differences in the mean background level among the areas. The Kruskal-Wallis test and/or other statistical guidance options may be used in the evaluation of apparent significant variations in background reference areas.

4.1.4. Calibration of Field Equipment

All calibrations will be performed using NIST-traceable standards according to Energy*Solutions*' procedure CS-FO-PR-002, *Calibration and Maintenance of Radiological Survey Instruments*.

Calibration of field equipment is performed in two stages. First, the instrument is electronically calibrated. The electronic calibration includes, but is not limited to, instrument range checks using an electronic pulser, high voltage and threshold verification, and function settings. Appendix A provides an example instrument calibration. Second, the FIDLER source calibration includes determination of, but is not limited to, operating high voltage and count rate to exposure rate conversion. Appendix B provides an example instrument calibration (using a 2-inch by 2-inch NaI detector but the same process will be used for a FIDLER detector). This calibration ensures that detector operation is acceptable. Instrument records, including dates of use, efficiencies, calibration due dates and source traceability will be maintained in accordance with established Energy*Solutions* procedures. If the detection equipment fails during any stage of the calibration, the equipment will not be put into service and thus not used during field activities.

4.1.5. Daily Field Checks

Instruments and FIDLER detectors will be checked at the beginning of each day to ensure they are operating properly and reassuring the validity of the previous day's measurements according to Energy*Solutions*' procedure CS-FO-PR-004, *QA/QC of Portable Radiological Survey Instruments*. Instrument control logs/charts will be maintained. The daily checks will include a background measurement used to ensure that FIDLER detector has not become contaminated and a source check to confirm the continuing satisfactory operation of the instrument and FIDLER detector combination. The source check is performed using a check source which is a radioactive source, not necessarily traceable to NIST, with the same type of radiation emissions as the contaminant of concern, in this case low-energy gamma emissions. Control charts of background and source check measurements will be established. Background control chart limits will be set to ±50% of the baseline background measurement. Source check control chart limits will be set to ±20% of the net baseline source reading. The same instruments will be used each day unless an instrument does not respond within the expected range or needs recalibration.

If detection equipment fails during daily QC checks, any data collected since the last daily QC check passed will be considered suspect and not used. The detection equipment will be taken out of service until the failure is resolved with resolution demonstrated by an acceptable daily QC result. The area(s) where the survey QC check failed will be re-surveyed with acceptable QC-checked detection equipment.

4.1.6. Gamma Radiation Survey Sensitivity

The Scan MDC for the gamma radiation survey was developed *a priori* following the guidance in Section 9.3.5 of NUREG-1507 and Section 6.8.2 of MARSSIM. By definition, the Scan MDC represents the activity concentration that can be detected above the underlying background distribution. The technical basis and supporting information for this development are discussed below. Energy*Solutions* will re-evaluate values chosen for *a priori* parameters during site activities to ensure survey sensitivity requirements are met for site-specific conditions. Energy*Solutions* employed similar FIDLER technology earlier in 2010 during a DU survey project at Whittaker-Bermite in California. During this project, a high level of confidence was identified in the *a priori* assessment.

Calculation of MDCR

To calculate the U-238 Scan MDC, it was first necessary to determine the MDCR above background using the following equations:

$$s_i = d'\sqrt{b_i} \qquad \text{(Eq. 1)}$$

$$MDCR = s_i\left(\frac{60}{i}\right) \qquad \text{(Eq. 2)}$$

where

s_i	=	Minimum detectable source counts per counting interval;
d'	=	Index of sensitivity (Table 6.5 of MARSSIM);
b_i	=	Background counts per observation interval; and
i	=	Observation interval (seconds).

The index of sensitivity (d') value was set to 1.38, as recommended in MARSSIM, for a true positive proportion of 95% and a false positive proportion of 60%. The observation interval, i, was calculated based on the amount of time for the FIDLER to pass completely over a postulated hot spot of radius 28 cm (as described in NUREG-1507). Using a MARSSIM-recommended and typical survey speed of 0.5 m/s, the observation interval equals 1.1 seconds. Assuming a background count rate of 12,000 gross cpm and using i equal to 1.1 seconds, the MDCR was calculated to be 1,106 net cpm.

The $MDCR_{surveyor}$ for the detector was calculated using Eq. 2 above, then dividing by the square root of the surveyor efficiency. For gamma radiation surveys performed in the Backpack Mode, the surveyor efficiency was set to 0.5 per MARSSIM guidance and the RemCAT was set to one (1)–consistent with the fact that the RemCAT represents an ideal observer as described in NUREG-6364. Therefore, the $MDCR_{surveyor}$ for the Backpack Mode was calculated to be 1,565 net cpm and for the RemCAT was 1,106 net cpm.

MicroShield® Modeling

Next, the exposure rate from the postulated hot spot was modeled using MicroShield®. The model was setup with the following inputs and options consistent with the information provided on Page 6-21 of NUREG-1507:

- Cylinder volume–end shields;
- Height of 15 centimeters (cm) and radius of 28 cm;
- Dose point #1 at x=0 cm, y=25 cm, and z=0 cm for Backpack Mode;
- Source material of concrete (used per the standard MicroShield® model and conservative for this soil application) with a density of 1.6 grams per cubic centimeter (g/cm^3);
- Air gap with density of 0.00122 g/cm^3;

- All source activities equal to 8E-6 microCuries per cubic centimeter (µCi/cm^3) per Equation 6-19 of NUREG-1507, which is equivalent to 5 pCi/g; and
- Source input grouping method of standard indices.

For RemCAT, Dose Point #1 was altered to have y=30.25 cm, which is a ground to detector distance equal to 6 inches. In addition, a ¼-inch Plexiglas® plate that will protect the FIDLERs was added to the model. The model created for U-238 included its short-lived progeny Th-234 and Pa-234m.

Table 4-1 provides the gamma energies, in kilo-electronvolts (keV), and the associated photons per second for each modeled radionuclide (5 pCi/g) as listed in MicroShield®. However, it is typical to group multiple gamma emissions into simple energy groups. The MicroShield® standard indices grouping method was selected for the energy groups, as shown in Table 4-2.

Table 4-1: MicroShield® Gamma Energies per Radionuclide

Radionuclide	Energy (keV)	Source Activity (5 pCi/g) per Radionuclide	
		Photons per Second	Percent of Activity
U-238	13	965.77	98.9%
	66.4	10.608	1.1%
Th-234	13.3	1,046.1	49.9%
	63.3	416.83	19.9%
	76.8	14.043	0.7%
	92.4	297.98	14.2%
	92.8	294	14.0%
	112.8	26.443	1.3%
Pa-234m	13.3	6.5289	2.9%
	13.6	48.478	21.3%
	73.9	1.482	0.7%
	94.7	12.648	5.6%
	98.4	20.5	9.0%
	111	9.5467	4.2%
	766.4	22.601	10.0%
	926.2	40.894	18.0%
	1001	64.418	28.4%

Table 4-2: MicroShield® Grouped Gamma Energies

Energy (keV)	Source Activity for 5 pCi/g (U-238, Th-234, & Pa-234m)	
	Photons per Second	Percent of Activity
15	206.68	62.7%
60	42.744	13.0%
80	15.525	0.5%
100	661.11	20.0%
800	22.601	0.7%
1000	105.31	3.2%

The FIDLER response in cpm per μR/hr versus gamma energy (keV) is shown in Figure 4-1. As can be seen, the response is maximized for energies less than 100 keV and since more than 95% of the activity is less than or equal to 100 keV in the MicroShield® model (Table 4-2), the FIDLER is an appropriate detector.

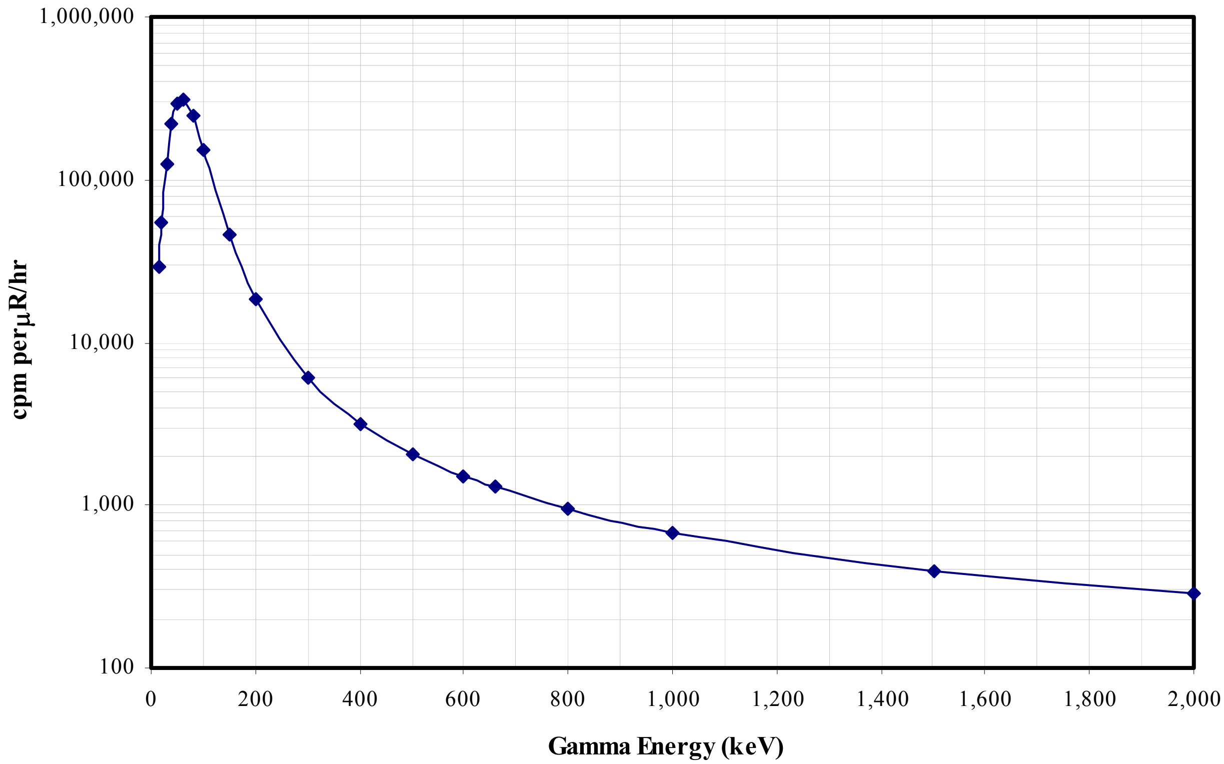

Figure 4-1: FIDLER Detector Response

<u>Calculation of the MDER</u>

The MicroShield® results were independently tabulated by grouped gamma energies and exposure rates for each uranium isotope. The exposure rate for each gamma energy group was then multiplied by the count rate versus exposure rate (based on manufacturer reported conversion factors for exposure rates to count rate for a FIDLER detector) to determine the weighted count rate versus exposure rate for each gamma energy, and the results were summed.

The minimum detectable exposure rate (MDER) was then calculated by dividing the $MDCR_{surveyor}$ by the summed weighted count rate versus exposure rate per Equation 6-21 of NUREG-1507.

Calculation of Scan MDC

The Scan MDC for U-238 was calculated using Equation 6-22 of NUREG-1507. Scan MDCs for the RemCAT and Backpack Mode are calculated as being 1.7 pCi/g and 1.8 pCi/g net U-238, respectively. Assuming a nominal background U-238 activity concentration of 1 pCi/g, the RemCAT and Backpack Modes will be capable of evaluating total U-238 activity concentrations of 2.7 pCi/g and 2.8 pCi/g, respectively. For both the RemCAT and Backpack Mode, the requirement to define activity concentrations greater than or equal to 3.1 pCi/g total U-238 is achieved.

Action Level

Because the decision rule is to identify U-238 activity concentrations greater than or equal to 3.1 pCi/g total U-238 (Section 3.2.5), the action level will be set to the $MDCR_{surveyor}$ (which represents the FIDLER net cpm measurement distinguishable from the *a prior* background of 12,000 gross cpm) plus the net $MDCR_{surveyor}$ values calculated above. The action levels (which include background) for total U-238 will be 13,106 gross cpm (RemCAT mode) and 13,565 gross cpm (Backpack Mode). Therefore, the action levels are set to evaluate activity concentrations in excess of 2.7 pCi/g and 2.8 pCi/g total U-238 for the RemCAT and Backpack Modes, respectively, meeting the greater than or equal to 3.1 pCi/g total U-238 requirement.

Field Efficiency

Using the MicroShield® modeling results, the FIDLER detector response in cpm per unit concentration in pCi/g was calculated for each gamma energy group by dividing the modeled exposure rate by the arbitrary input concentration of U-238 and then multiplying by the count rate to exposure rate conversion factor (based on manufacturer reported conversion factors for exposure rates to count rate for a FIDLER detector). The results were summed to calculate the field efficiency. The field efficiency for U-238 was 647 net cpm per net pCi/g (RemCAT mode) and 883 net cpm per net pCi/g (Backpack Mode).

FIDLER gross cpm measurements collected in the survey areas will be first corrected by subtracting the average background reference area gross cpm (*a priori* assumed to be 12,000 cpm for the calculations in this section) to determine the net cpm attributable to U-238 activity distinguishable from background. Next, the FIDLER net cpm will be divided by the appropriate field efficiency for the mode used to collect the FIDLER measurement, resulting in net U-238 activity concentration above background. Finally, net U-238 activity concentration above background will be summed with the nominal U-238 background of 1 pCi/g to estimate the total U-238 activity concentration at each FIDLER gross cpm measurement location.

4.2. SOIL GAMMA RADIATION SURVEYS

With the exception of Survey Area 1B, the gamma radiation survey will begin starting with Survey Area 1A (see Figure 4-2) and chronologically advance to the next survey area. Because of thick vegetation in a narrow area of valley fill alluvium within an area of potential red-legged frog and tiger salamander habitat, Survey Area 1B will be completed after LLNL receives approval from the U.S. Fish and Wildlife Service to clear the survey area of vegetation that would adversely impact the radiological survey. Equipment concerns/problems will be documented on field discrepancy reports which will be made available to LLNL project personnel.

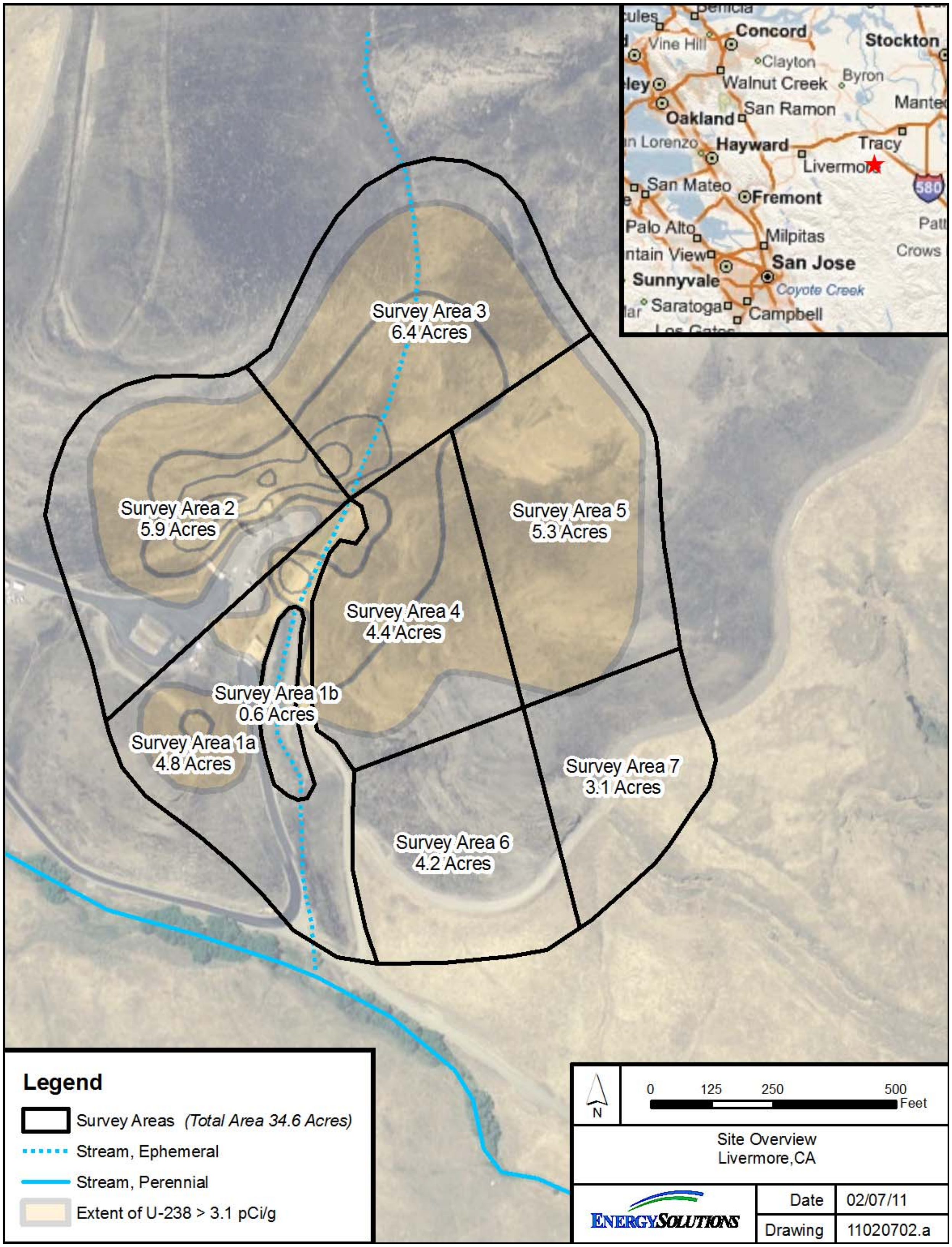

Figure 4-2: LLNL Site 300 Survey Areas

5. CONTAMINATION CONTROL

Based on site experience, when the soil is dry, equipment and personnel will not become contaminated. To demonstrate that cross-contamination between survey areas is not occurring, the treads of the RemCAT(s) and soles of the shoes of the surveyor(s) will be wiped with a large area swipe whenever leaving the survey area or moving to a new survey area. The large area swipe will then be frisked with a Geiger-Mueller detector. Areas with count rates exceeding 100 gross cpm (assuming a nominal 50 cpm background response), will be subject to decontamination.

If the soil becomes damp or wet due to precipitation, before leaving a survey area, clumped soil or mud will be removed from equipment and personnel (predominantly foot wear) and left in the survey area. Equipment or personnel that were cleaned of clumped soil or mud will be frisked with a Geiger-Mueller detector. Count rates exceeding 100 gross cpm (assuming a nominal 50 cpm background response), will be subject to decontamination. Tools or equipment decontamination activities will follow Energy*Solutions* procedure CS-FO-PR-010, *Decontamination of Tools, Equipment and Areas*. Any personnel contamination will be reported to LLNL and decontamination activities will follow Energy*Solutions* procedure CS-RS-PR-002, *Personnel Survey and Decontamination Procedure*.

All tools and equipment will be unconditionally released per LLNL requirements and Energy*Solutions* procedure CS-RS-PR-006, *Unconditional Release of Tools, Equipment, and Waste Materials from Projects*, before shipment off site for repair or end of site activities. The procedure provides methodology for survey and limits applicable to unconditional release.

6. DISPOSAL OF RESIDUAL MATERIAL

Investigation derived wastes (IDW) are not expected to be generated for this project. However, should IDW be generated, it will be collected and provided to LLNL for proper disposal.

7. QUALITY CONTROL

The Energy*Solutions* quality program defined in ES-QA-PG-001, *Quality Assurance Program*, is consistent with American Society of Mechanical Engineers (ASME) NQA-1-2004, *Quality Assurance Requirements for Nuclear Facility Applications*, as the consensus standard. The program is also consistent with select documents from other federal agencies and industry groups. The QC methods for implementing the program focus on the following key elements:

- All materials are inspected to ensure that they meet quality and performance specifications—we ensure that the proper materials are used for the scope of work being performed.
- Calibration and operational checkout of instrumentation.
- Survey area completion status will be tracked and reviewed to ensure that the survey is progressing as planned.

- Proper QC documentation will be maintained for all activities, calibrations, survey results, and materials received.
- Successes and/or deficiencies will be tracked in the field logbook and reviewed for corrective action.

Only qualified and trained personnel will operate the survey equipment and instrumentation. Personnel will be trained in the technical and QA/QC aspects as required by LLNL of the project as well as in the calibration, maintenance, and standard operating procedures (SOP) for their assigned equipment. For the duration of on-site activities, daily tailgate meetings will provide supplemental training and ensure that personnel are given clear direction and the proper tools for performing their respective tasks. These meetings will also provide a forum for field personnel to relate any potential quality concerns. Tailgate meeting notes and attendance sheets will be maintained on-site and included in the project file.

The applicable SOPs for field operations are listed below.

- CS-FO-PR-001, *Performance of Radiological Surveys*
- CS-FO-PR-002, *Calibration and Maintenance of Radiological Survey Instruments*
- CS-FO-PR-004, *QA/QC of Portable Radiological Survey Instruments*
- CS-FO-PR-005, *General Operations of Radiological Survey Instruments*

8. FIELD VARIANCES

As conditions in the field may vary, it may become necessary to implement minor modifications to the survey as presented in this plan. When appropriate, the Energy*Solutions* Project Manager and the LLNL Technical Manager will be notified and written approval documenting how these changes continue to meet the gamma radiation survey objectives will be obtained before implementing the changes. Modifications to the approved work plan, including how these changes meet survey objectives, will be documented in the sampling project report.

9. PROJECT ORGANIZATION

Energy*Solutions* will provide four on-site and four off-site professionals for implementation of this work plan. The technical team will provide project and site management, data review, assessment, and analysis. The organization[2] is shown in Figure 9-1.

[2] A Health Physics (HP) technician is an individual with specialized training and experience in performing radiological monitoring tasks. The individual is trained on instrument setup and operation, performance verification and calibration requirements of the instrument and data collection system. The individual has a minimum of 2 years of similar radiological monitoring experience.

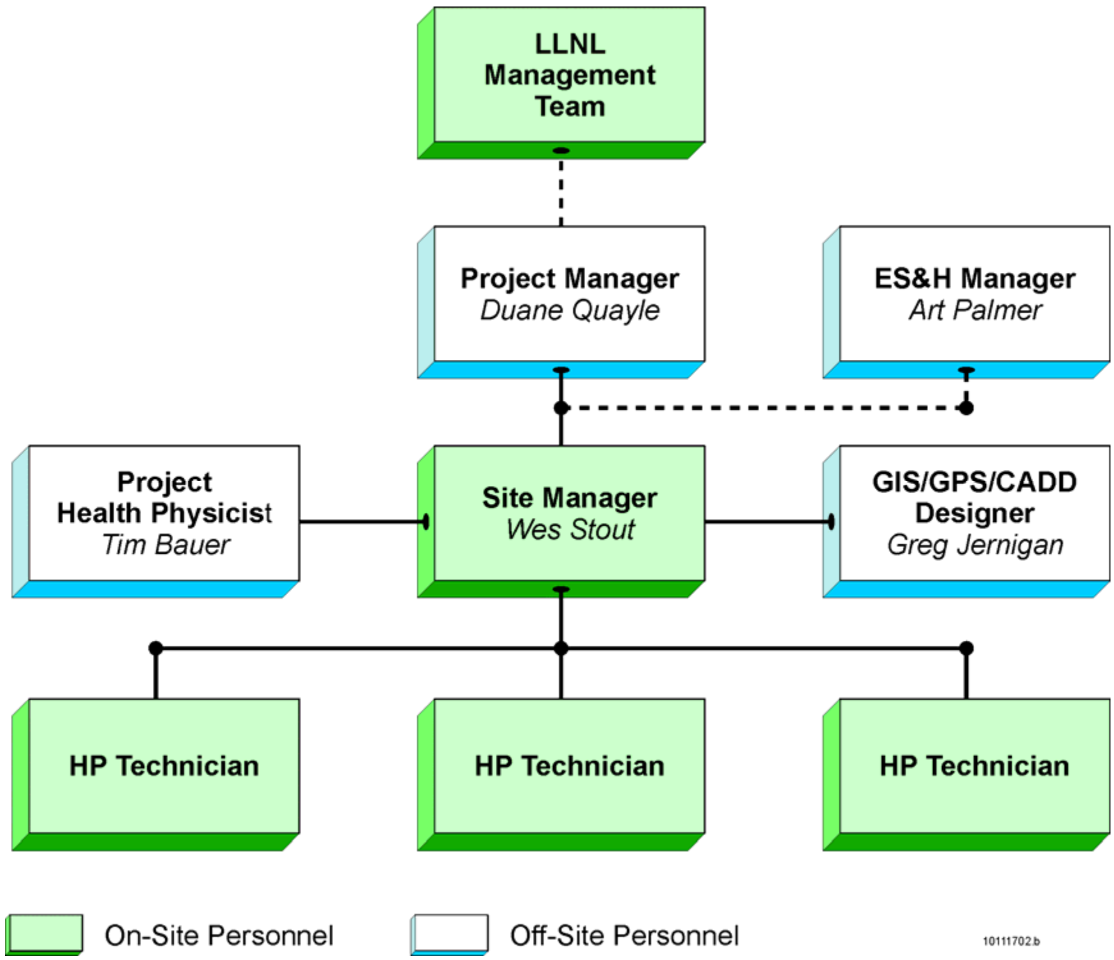

Figure 9-1: Project Organization

10. SURVEY REPORT

A survey report will be developed documenting the results of the soil gamma radiation survey and an analysis of the data collected. The report will include a table displaying analytical and QA/QC data and map(s) depicting the data, associated activity (pCi/g) contours to detection limits, and all regions of elevated U-238 activity defined by the gamma survey. Calibration, data determination, and data analysis methods and calibration logs will be provided in an appendix. The report will also indicate any problems that were identified during the survey and how these were corrected.

11. PROJECT SCHEDULE

Gamma radiation survey field work will commence in early July 2011 and be completed by October 15, 2011. The Draft and Final Gamma Radiation Survey Reports will be completed and submitted to the regulatory agencies in December 2011.

12. REFERENCES

Energy*Solutions*, LLC, CS-AD-PR-002, Rev. 2, *Commercial Services Project Records*, March 5, 2009.

Energy*Solutions*, LLC, CS-FO-PR-001, Rev. 1, *Performance of Radiological Surveys*, November 18, 2008.

Energy*Solutions*, LLC, CS-FO-PR-002, Rev. 1, *Calibration and Maintenance of Radiological Survey Instruments*, November 18, 2008.

Energy*Solutions*, LLC, CS-FO-PR-004, Rev. 0, *QA/QC of Portable Radiological Survey Instruments*, November 18, 2008.

Energy*Solutions*, LLC, CS-FO-PR-005, Rev. 0, *General Operations of Radiological Survey Instruments*, November 18, 2008.

Energy*Solutions*, LLC, *Task Identification Process (TIP) List for the Lawrence Livermore National Laboratory Site 300 Building 812 Gamma Radiation Survey of Surface Soil*, 2011.

Grove Software, Inc., MicroShield® Version 8.01, 2008.

ISO 3534-1, *Statistics -- Vocabulary and symbols -- Part 1: General statistical terms and terms used in probability*, 2006.

Lawrence Livermore National Laboratory, *Integrated Worksheet for LLNL Site 300 Building 812 Gamma Radiation Survey*, Livermore, Calif, 2011 (IWS 15869).

Taffet, M.,V. Dibley, T. Carlsen, V. Madrid, Z. Demir, B. Daily, and L. Ferry (2008), *Draft Building 812 Remedial Investigation/Feasibility Study*, *Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif., July 2008 (LLNL-AR-404981-DRAFT).

U.S. EPA QA/G-4, *Guidance on Systematic Planning Using the Data Quality Objectives Process*, Washington, DC, February 2006.

U.S. NRC, U.S. EPA, U.S. DOE, and U.S. DOD (2000), *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Revision 1*, U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency, U.S. Department of Energy, and U.S. Department of Defense, Washington, DC, August 2000 (NUREG-1575, Rev.1, EPA 402-R-97-016, Rev.1, DOE/EH-0624, Rev.1).

APPENDIX A

Example Instrument Calibration

EXAMPLE

Duratek

CALIBRATION CERTIFICATE

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION		INSTRUMENT INFORMATION	
Customer Name: Duratek Inc. - Instrument Services Facility		Manufacturer: Ludlum	
Address: 628 Gallaher Road, Kingston, TN 37763		Model: 2350-1	Serial Number: 117023
Contact Name: Tony Riggs		Probe: N/A	Serial Number: N/A
Customer Purchase Order Number: N/A	Work Order Number: 2010-10637	Calibration Method: Electronic	

INSTRUMENT CALIBRATION INFORMATION

Instrument Range (CPM)	Calibration Standard Value (CPM)	Instrument Response: Before Calibration	Instrument Response: After Calibration	Comments	
				Calibrated in accordance with CP-IN-WI-239 Rev 1	
400	400	397	397	Pulser: 120935	Cal Due: 08/30/10
4,000	4,000	3,974	3,974	DVM: 88020324	Cal Due: 11/12/10
40,000	40,000	39,733	39,733	D-814: 3590	Cal Due: 07/09/10
400,000	400,000	397,345	397,345	Humidity: 958670	Cal Due: 05/13/10
HV Cal Values (M2350 HV Entry)	**Desired HV (Voltmeter) (VDC)**	**As Found (VDC)**	**As Left (VDC)**	EPPROM Version: 37122N28	
600 (540-660)	600	602	602	Temp: 23.5°C Pressure: 743 mmHg Humidity: 20%	
1,200 (1,080-1,320)	1,200	1,208	1,208		
1,800 (1,620-1,980)	1,800	1,812	1,812		
Parameter	**Tolerance (±10%)**	**As Found**	**As Left**		
Threshold T = 100	10 ± (9 to 11) mVDC	10.2	10.2	Geotropism: SAT	ACK/Scroll: SAT
Threshold T = 500	50 ± (45 to 55) mVDC	46.9	46.9	BAT>4.5: SAT	Volume: SAT
Threshold T =1000	100 ± (90 to 110) mVDC	96	96	Count: SAT	Audio Divide: SAT
Window Width W = 100	10 ± (9 to 11) mVDC	10	10	Alarms: SAT	Lamp: SAT
Display-to-mV ratio:	100 to 10 mV			Overload Test: SAT	Physical cond: SAT

STATEMENT OF CERTIFICATION

We Certify that the instrument listed above was calibrated and inspected prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this instrument).

Instrument Calibrated By: M. Paul	Reviewed By: [signature]	Date: 3/8/10
Calibration Date: 03/08/2010	*Certification Due (6mo): 09/08/2010	
	*Certification Due (12mo): 03/08/2011	

* Calibration due date is dependant on users regulatory requirements.

Page 1 of 1

EXAMPLE

DETECTOR SETUP CHECK LIST REPORT

The following list is stored as detector setup D2 in the Model 2350.
Today's date is 03/08/2010.
The current time of day is: 10:25:20.

I have verified the list below
has NO discrepancies with the DETECTOR SETTINGS TABLE: MP

Comments:

Model 2350 Serial # =	117023.
User I.D. =	.
High Voltage =	1100 volts.
Threshold =	100.
Window =	1000,Off.
Overload Current =	40.0 micro amperes.
Scaler Count Time =	60 seconds.
Readout Units =	counts.
Readout Time Base =	min.
Readout Range Multiplier =	auto.
Detector Dead Time =	1.710000E-05.
Detector Calibration Constant =	1.000000E+00.
Detector Model =	44-10CPM.
Detector Serial # =	230081.
Ratemeter Alarm Setting =	1.000000E+09.
Scaler Alarm Setting =	1000000.
Integrated Dose Alarm Setting =	1.000000E+09.
Low Count Alarm Setting =	X.
Operating Battery Voltage =	6.3 volts.

EXAMPLE

det2 Generated: 03/08/2010 10:24:02.

Model 2350 Serial #117023

H1100$F
Set High Voltage: 1100

T100$Q
Set Threshold: 100

W1000$WOFF$P
Set Window: 1000,OFF

O400$OOFF$C
Set Overload: 400,OFF

F60$H
Set Scaler Count Time: 60

SU7$I
Set Readout Units = counts

SB1$-
Set Readout Time Base = min

SM0$3
Set Readout Range Multiplier = auto

SL1.710000E-05$H
Set Dead Time: 1.710000E-05

SC1.000000E+00$0
Set Calibration Constant: 1.000000E+00

M44-10CPM$-
Set Detector Model: 44-10CPM

N230081$X
Set Detector Serial #: 230081

J1.000000E+09$V
Set Ratemeter Alarm: 1.000000E+09

K1000000$H
Set Scaler Alarm: 1000000

P1.000000E+09$.
Set Dose Alarm: 1.000000E+09

SP2$8
SAVE PARAMETERS AS D2

APPENDIX B

Example Detector Calibration

EXAMPLE

Duratek

CALIBRATION CERTIFICATE

Duratek Instrument Services
628 Gallaher Road
Kingston, TN 37763
Phone: (865) 376-8337
Fax: (865) 376-8331

This Certificate will be accompanied by Calibration Charts or Readings where applicable

CUSTOMER INFORMATION				DETECTOR INFORMATION	
Customer Name: Duratek Instrument Services				Manufacturer: Ludlum	
Address: 628 Gallaher Rd Kingston, TN 37763				Detector Model: 44-10	
Contact Name: Tony Riggs				Serial Number: 230081	
Customer Purchase Order Number: N/A		Work Order Number: 2010- 10637		Evaluation Method: Source	
DETECTOR EFFICIENCY/RESPONSE/PRECISION INFORMATION					
1) Source Nuclide: Cs^{137}	Serial Number: 019454	Activity: 5µCi nominal		Certification Date: N/A (Used for Plateau Only)	
2) Source Nuclide: Cs^{137}	Serial Number: 049711	Activity: Variable		Certification Date: 07/17/09	
Scaler Information		Precision Test		mR/Hr (Source #2)	
2350-1	#117023	Count 1		1.97	
Due Date	03/08/2011	Count 2		2.00	
Threshold	T=100 (10mV)	Count 3		2.01	
Cable Length	5ft.	Average		1.99	
D-814: 3590	Cal Due: 07/09/10	Tolerance ±10%		All counts within ±10% of Average	
Humidity Pen: 958670	Cal Due: 05/13/10	Pass/Fail		Pass	
Temp: 23.5 °C		Humidity: 20%		Press: 743 mmHg	
Low Sample Activity (400uR/hr): Using Source #2 = 81,700	High Sample Activity (2mR/hr) Using Source #2 = 278,704		Dead Time (DT): 1.710085E-05	Calibration Constant (CC): 6.934921E+10	
ATTACHMENTS		DETECTOR DATA: DOSE RATE PROBES (mR/Hr)			
Detector Setup Report	YES √ NO	Desired Exposure	Tolerance ±10%	As Found	As Left
Barcode Report	YES √ NO	0.400	0.360-0.440	0.408	0.393
Voltage Plateau:	YES √ NO	1	0.90-1.10	1.04	1.08
High Voltage: 1100V		2	1.8-2.2	2.00	2.00

COMMENTS

Detectors set up with a 2350-1 may be used with any 2350-1 provided that the setup parameters are scanned into the 2350-1 prior to use with that specific detector

STATEMENT OF CERTIFICATION

We Certify that the detector listed above was evaluated for proper operation prior to shipment and that it met all the Manufacturers published operating specifications. We further certify that our Calibration Measurements are traceable to the National Institute of Standards and Technology. (We are not responsible for damage incurred during shipment or use of this detector).

Detector Certified By: M. Paul   Reviewed By: Jeff Dickinson   Date: 3/8/10

Certification Date: 03/08/2010

*Certification Due (6mo): 09/08/2010

*certification Due (12mo): 03/08/2011

* Calibration due date is dependant on users regulatory requirements.

Page 1 of 1

EXAMPLE

background plateau 44-10 #230081 3/8/2010

700	147
750	244
800	444
850	582
900	606
950	710
1000	668
1050	645
1100	666
1150	678
1200	683
1250	666
1300	733
1350	711

source plateau Cs137 #019454 5uCi button

700	3412
750	4702
800	5514
850	5970
900	6360
950	6354
1000	6618
1050	6685
1100	6699
1150	6632
1200	6783
1250	6833
1300	6828
1350	7008

EXAMPLE

DETECTOR SETUP CHECK LIST REPORT

The following list is stored as detector setup D1 in the Model 2350.
Today's date is 03/08/2010.
The current time of day is: 10:24:57.

I have verified the list below
has NO discrepancies with the DETECTOR SETTINGS TABLE: MP

Comments:

Model 2350 Serial # =	117023.
User I.D. =	.
High Voltage =	1100 volts.
Threshold =	100.
Window =	1000,Off.
Overload Current =	40.0 micro amperes.
Scaler Count Time =	12 seconds.
Readout Units =	R.
Readout Time Base =	hr.
Readout Range Multiplier =	auto.
Detector Dead Time =	1.710085E-05.
Detector Calibration Constant =	6.934921E+10.
Detector Model =	44-10DOSE.
Detector Serial # =	230081.
Ratemeter Alarm Setting =	1.000000E+09.
Scaler Alarm Setting =	1000000.
Integrated Dose Alarm Setting =	1.000000E+09.
Low Count Alarm Setting =	X.
Operating Battery Voltage =	6.3 volts.

EXAMPLE

det1 Generated: 03/08/2010 10:23:13.

Model 2350 Serial #117023

H1100$F
Set High Voltage: 1100

T100$Q
Set Threshold: 100

W1000$WOFF$P
Set Window: 1000,OFF

O400$OOFF$C
Set Overload: 400,OFF

F12$E
Set Scaler Count Time: 12

SU4$F
Set Readout Units = R

SB2$.
Set Readout Time Base = hr

SM0$3
Set Readout Range Multiplier = auto

SL1.710085E-05$U
Set Dead Time: 1.710085E-05

SC6.934921E+10$Y
Set Calibration Constant: 6.934921E+10

M44-10DOSE$D
Set Detector Model: 44-10DOSE

N230081$X
Set Detector Serial #: 230081

J1.000000E+09$V
Set Ratemeter Alarm: 1.000000E+09

K1000000$H
Set Scaler Alarm: 1000000

P1.000000E+09$.
Set Dose Alarm: 1.000000E+09

SP1$7
SAVE PARAMETERS AS D1

FIELD HEALTH AND SAFETY PROCEDURES

The concept that all accidents, injuries, uptakes, and non-permitted discharges or releases are preventable shall be communicated to project personnel through training, safety meetings, and the continuous improvement process. All employees will be empowered to implement and consistently strive for the "zero accident" goal. As safety is the top priority for our company, Energy*Solutions* project personnel will follow our corporate health and safety guidelines defined in ES-SH-PG-100, *Safety and Health Program*, and CS-SH-PN-004, *Commercial Services Division Health & Safety Plan*. In addition, if there are any health and safety guidelines stated in the LLNL ES&H Manual that are more protective or restrictive, the LLNL ES&H Manual will be followed for those specific guidelines. Additionally, an Activity Hazards Analysis will be developed to identify tasks, associated hazards, and actions to mitigate hazards for the project activities. Individual employees will be responsible for conducting project tasks safely. All safety related issues will be addressed by and through the Site Manager.