FINAL

TECHNICAL MEMORANDUM
FOR
MAKUA MILITARY RESERVATION (MMR) AERIAL SURVEYS
OAHU, HAWAII

CONTRACT NUMBER: W52P1J-07-D0041
DELIVERY ORDER: 0003
CABRERA PROJECT NUMBER: 08-3040.03

Prepared for:

Department of the Army
Headquarters, U.S. Army Sustainment Command
Procurement Directorate, Environmental Contracting Division
AMSAS-CCA-I Building 350, 5th Floor
Rock Island, IL 61299-6000

Prepared by:

CABRERA SERVICES
RADIOLOGICAL • ENGINEERING • REMEDIATION

473 Silver Lane
East Hartford, CT 06118

July 24, 2009

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

%	Percent
^{234}Th	Thorium-234
^{234}U, ^{235}U, ^{238} U	Isotopes of uranium: uranium-234, uranium-235, uranium-238
ASR	Archives Search Report
AGL	Above Ground Level
BHHRA	Baseline Human Health Risk Assessment
A-CLASS	Cabrera Large Area Scanning System
C	Celsius
CABRERA	Cabrera Services Inc
COC	Contaminant of Concern
DQO	Data Quality Objective
DU	Depleted Uranium
EPA	U.S. Environmental Protection Agency
ft	Foot
GPS	Global Positioning System
GFS	Gamma Flyover survey
in.	Inch
kg	Kilogram
Lb	Pound
m	Meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Contaminant Level
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MEC	Munitions and explosives of concern
NaI (Tl)	Sodium iodide thallium activated
NRC	U.S. Nuclear Regulatory Commission
pCi/g	Pico Curies per gram
ppm	parts per million
PRG	Preliminary Remedial Goal
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAGS	Risk Assessment Guidance for Superfund
RDL	Reporting detection limit
RESRAD	Residual radioactivity
SAP	Sampling and Analysis Plan
SDAD	Surface Danger Area Diagram
Sec	Second
SOP	Standard Operating Procedure
U	Uranium
U_3O_8	Triuranium octaoxide
UO2	uranium dioxide
USACE	United States Army Corps of Engineers
USAG-HI	United States Army Garrison, Hawaii
USEPA	United States Environmental Protection Agency
UXO	Unexploded Ordnance
µg/l	Micrograms per liter

1.0 INTRODUCTION

Cabrera Services Inc (CABRERA) was contracted by the U.S. Army Joint Munitions Command to perform confirmatory aerial radiation and visual surveys of potential Davy Crocket impact areas at the Makua Military Reservation (MMR), Hawaii (hereafter referred to as “MMR” or “the site”). And to the extent practical, conduct confirmatory ground based gamma walkover surveys (GWS) and soil sampling to correlate measurements taken during aerial surveys for the presence of DU. Due to the potential presence of UXO/MEC, improved conventional munitions (ICM) and ground cover over the MMR range, only limited access for GWS and soil sampling was anticipated to be available.

The methodology for aerial surveys to be performed at MMR was established during June 30, 2008 through July 7, 2008 at Schofield Barracks. The aerial surveys at Schofield Barracks demonstrated the ability of the Aerial Cabrera Large Area Scanning System (A-CLASS) to identify spatial distribution patterns and trends which correlated to ground based GWS surveys taken during characterization of the Schofield Barracks DU impact area in 2007 (CABRERA 2008). This technical memorandum has been prepared to present the findings of the aerial surveys conducted at MMR from December 15, 2008 through December 20, 2008.

2.0 SITE HISTORY

The MMR is located in the western portion of Oahu near Kaena Point (Figure 2-1). The training site extends west from the Waianae Range ridge line to the ocean and is approximately three miles north of Makaha. State Highway 93 extends through the site along the shoreline and ends at the northern boundary of the site. The site is approximately 18 miles from Schofield Barracks via Kolekole Pass Road. The MMR has been used by the U.S. Army and Marine Corps for training since 1943. The area is used as an infantry and artillery range, with some use of the shoreline for amphibious assault training. The area also has several archeological and cultural sites. The facility is currently one of the potential practice areas of the United States Army 25th Infantry Division and the United States Army Garrison, Hawaii (USAG-HI).

According to the *Archives Search Report* (ASR) *On the Use of Cartridge, 20MM Spotting M101 For Davy Crockett Light Weapon M28, Schofield Barracks and Associated Training Areas, Islands of Oahu and Hawaii* (USACE 2007), training on the Davy Crockett weapons system was likely conducted at Schofield Barracks between 1962 and 1968. The ASR did not specifically identify MMR as a location of use for the Davy Crockett system, nor did preliminary aerial reconnaissance identify the presence of pistons indicative of Davy Crockett system use at MMR (CABRERA 2008A).

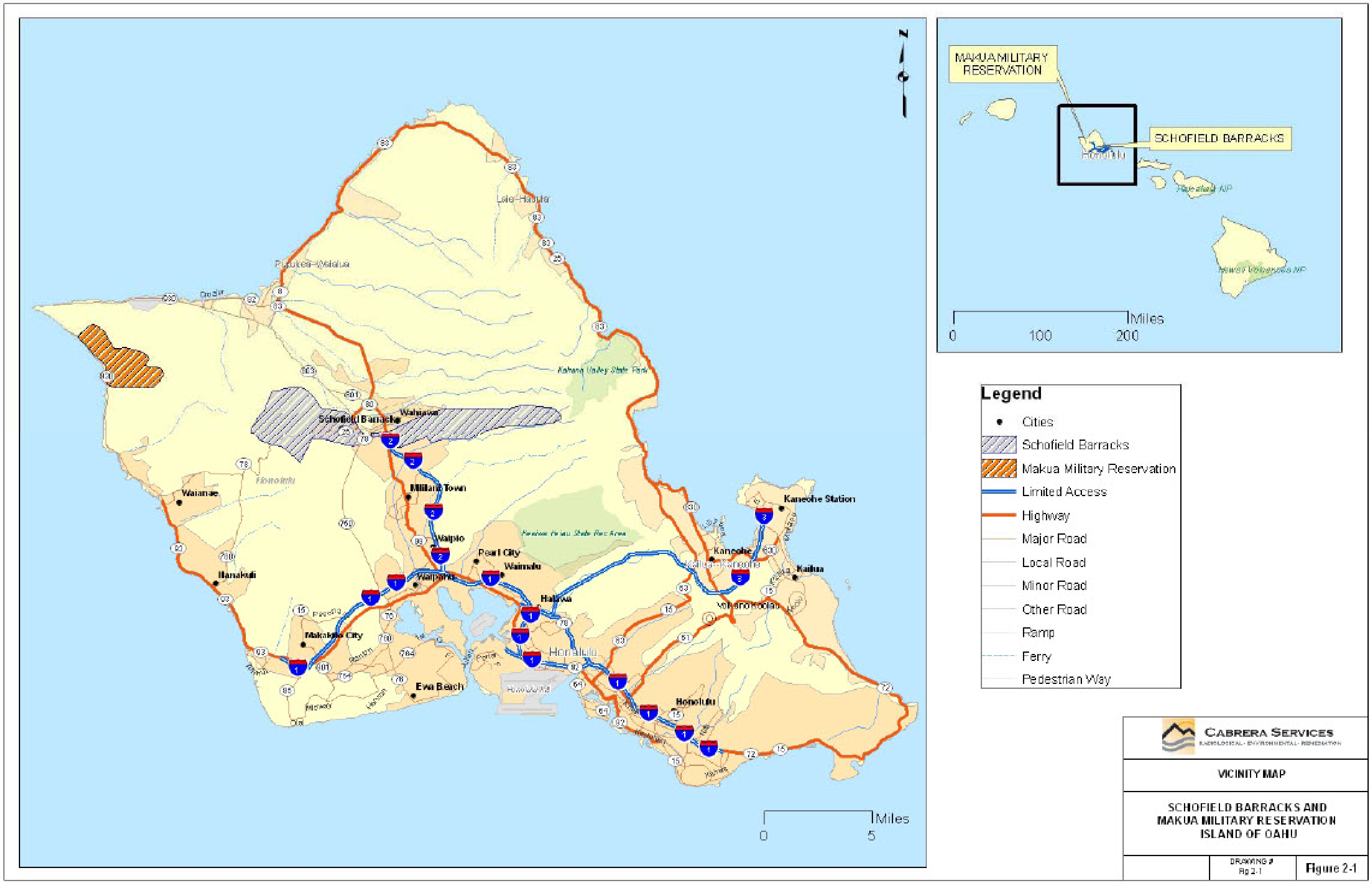

FIGURE 2-1: MAKUA AND SCHOFIELD BARRACKS VICINITY MAP

2.1 Summary of Existing Data

The presence of DU at MMR has been the subject of recent scoping investigations, and Characterization Surveys completed in 2007 by CABRERA and described in *Technical Memorandum, Depleted Uranium Scoping Investigations Makua Military Reservation, Pohakuloa Training* Area, *Schofield Barracks Impact Area, Islands of Oahu and Hawaii* (CABRERA 2008A).

Research conducted by the Army into training records did not discover any documentation of requests for Davy Crockett sections to use the range facilities at MMR. However, these types of records are not long-term and may no longer exist. Research also did not find any maps from the 1960s with Davy Crockett ranges specifically noted. The majority of the MMR is identified on maps as an impact area. Based on a review of maps and range regulations, one possible area for a Davy Crockett Range was located. Figure 2-1 shows an area originally suspected for potential contamination from Cartridge, 20mm Spotting 101. Later research by the Army showed that this area does not meet all the criteria for a Davy Crockett range and is no longer suspect as a Davy Crockett impact area. The entire MMR was considered a potential Davy Crockett range impact area and field observations at the range were recommended.

The 2007 scoping survey and characterization efforts consisted of site visits, surface soil and debris sampling and analysis, and radiological scanning. Laboratory analyses of the samples included gamma spectroscopy, alpha spectroscopy for uranium (U) isotopes, total metals, and herbicides. Results of the scoping and characterization survey relevant to an aerial survey are summarized as follows:

- The visual and scanning surveys identified no distinct surface areas with yellow, oxidized metal fragments consistent with DU.
- During the scoping survey, ten soil samples were collected around the perimeter of MMR at locations areas where sediment had or may have collected from past runoff/erosion. These analysis of these soil samples showed no indication of DU.

The soil sample locations are shown in Figure 2-2. All of the samples were analyzed for isotopic uranium by alpha spectrometry. The results of the analyses are provided in Table 2-1. All of the results are consistent with naturally occurring concentrations and ratios of uranium in Hawaiian soils/basalt (Rubin 2008). None of the results indicate uranium depletion, where the ^{234}U activity concentration is significantly lower than the ^{238}U activity concentration.

Aerial site reconnaissance was conducted at MMR using a Bell Long Ranger helicopter to look for pistons and other visually identifiable indicators of the Davy Crockett weapons system. The aerial team included two personnel, one situated on each side of the aircraft. Due to limits on prescribed burns in the Makua valley to keep the range clear, the vegetation was very dense, and the 2007 aerial survey was limited to ravines and dry stream beds. No pistons were spotted during the aerial reconnaissance survey of MMR. Physical entry in to range areas was precluded by safety concerns, including the likely presence of Unexploded Ordnance (UXO) and Improved Conventional Munitions (ICM). No DU fragments or Davy Crockett system components were identified at the MMR.

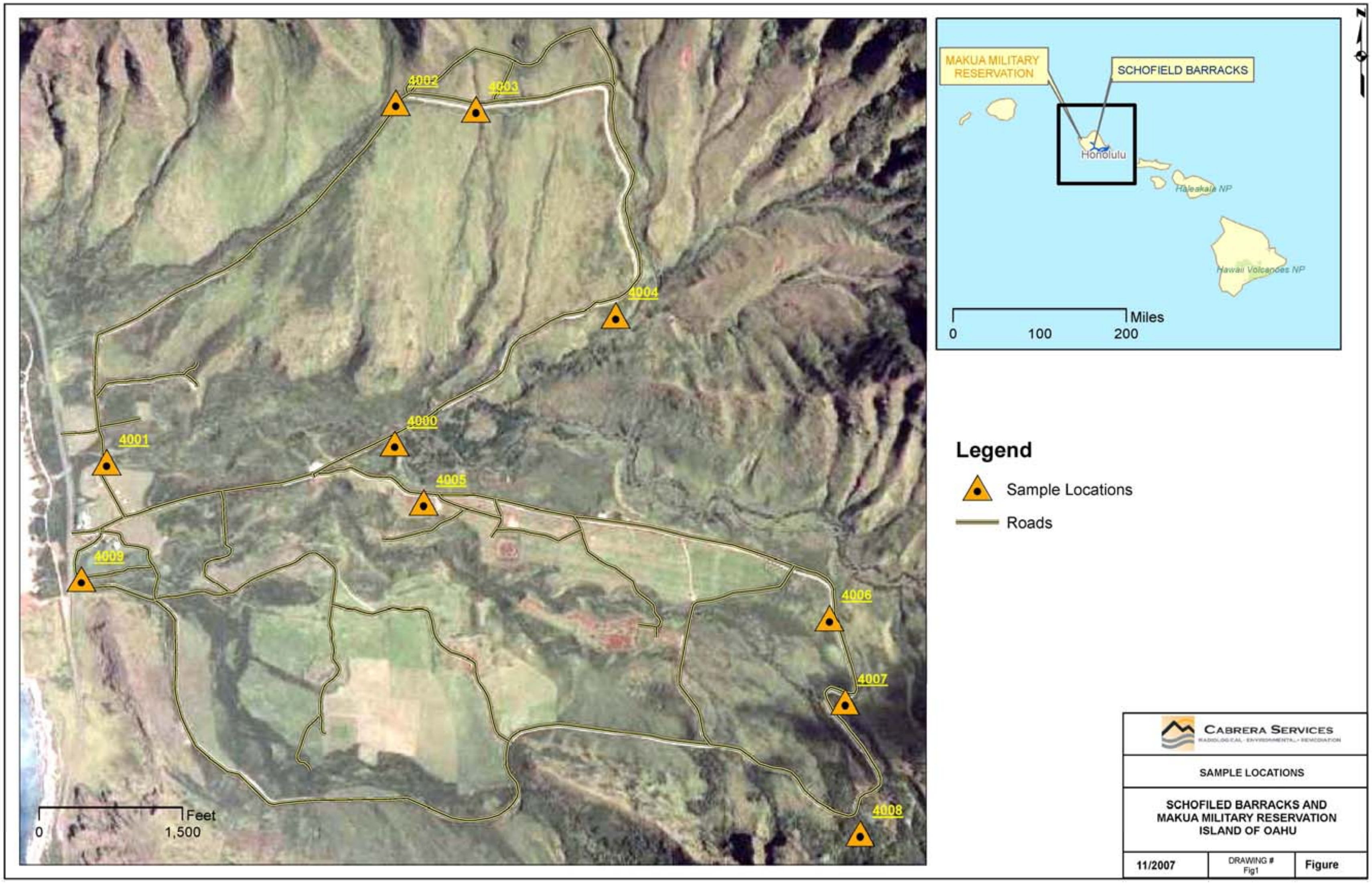

FIGURE 2-2: MAKUA 2007 SCOPING SURVEY SOIL SAMPLING LOCATIONS

TABLE 2-1: 2007 MMR SOIL SAMPLE RESULTS

Sample	Analyte*	Activity (pCi/g)	2σ Counting Error (pCi/g)	Total Error (pCi/g)	MDA (pCi/g)
4000	U-233/234	0.086	0.05	0.053	0.019
	U-235	0	0	0	0.024
	U-238	0.131	0.064	0.069	0.037
4001	U-233/234	0.069	0.048	0.05	0.044
	U-235	0	0	0	0.023
	U-238	0.1	0.056	0.059	0.036
4002	U-233/234	0.239	0.089	0.101	0.02
	U-235	0.018	0.026	0.027	0.025
	U-238	0.234	0.089	0.1	0.039
4003	U-233/234	0.326	0.103	0.122	0.019
	U-235	0.004	0.02	0.02	0.046
	U-238	0.325	0.103	0.122	0.019
4004	U-233/234	0.272	0.091	0.106	0.018
	U-235	0.034	0.034	0.035	0.023
	U-238	0.339	0.103	0.123	0.018
4005	U-233/234	0.461	0.135	0.164	0.043
	U-235	0.05	0.045	0.048	0.027
	U-238	0.512	0.142	0.175	0.022
4006	U-233/234	0.216	0.085	0.096	0.021
	U-235	0.01	0.019	0.019	0.026
	U-238	0.23	0.088	0.1	0.021
4007	U-233/234	0.344	0.109	0.129	0.039
	U-235	0.009	0.018	0.019	0.025
	U-238	0.398	0.117	0.142	0.02
4008	U-233/234	0.136	0.06	0.066	0.017
	U-235	0.034	0.035	0.037	0.04
	U-238	0.12	0.057	0.062	0.032
4009	U-233/234	0.225	0.084	0.095	0.036
	U-235	0.034	0.034	0.036	0.023
	U-238	0.251	0.089	0.102	0.036

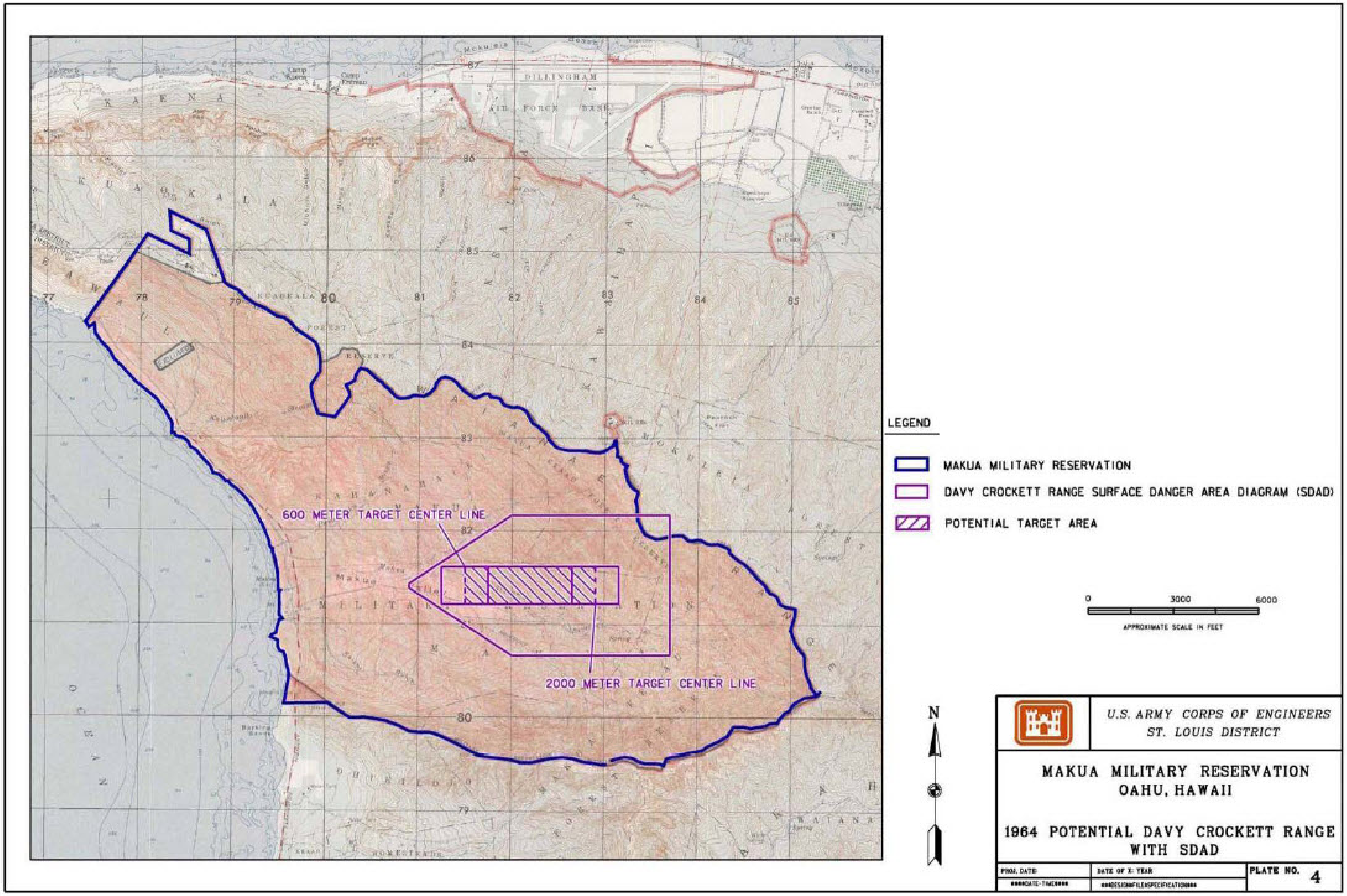

FIGURE 2-3: LOCATION OF SUSPECTED DAVY CROCKETT RANGE-MMR

3.0 MMR 2008 AERIAL SURVEY PROJECT DESCRIPTION

3.1 Scope and Objectives

The scope of this project encompasses: a) Aerial collection and analysis of gamma spectroscopic data over defined areas of interest (Figure 3-1) of potential Davy Crockett impact areas using the CABRERA A-CLASS system consisting of a large volume energy stabilized thallium activated sodium iodide NaI(Tl) detector system over areas of interest outlined in red on Figure 3-1; b) Visual inspection/observation from both the ground and air of the defined areas of interest for the presence of the following Davy Crockett system components:

- Aluminum shrapnel/pieces from the rear body assembly and plastic fiberglass from the fins and windscreen of the Projectile, Atomic Supercaliber 279 millimeter (mm) Practice M390,
- Aluminum fin assemblies and projectile body pieces from the Cartridge, 20 mm spotting M101,
- Pistons from either the light or heavy Davy Crockett weapon, or,
- Bright yellow (oxidized) and non-oxidized fragments from uranium alloy components.

c) Ground based GWS for the confirmation/correlation of indications of DU presence and/or absence as well as entry into potential areas not accessible by aerial survey, and, d) Collection of soil samples (where available) from areas identified as potential locations of SRBs, fragments, DU contaminated soil, and Davy Crockett debris.

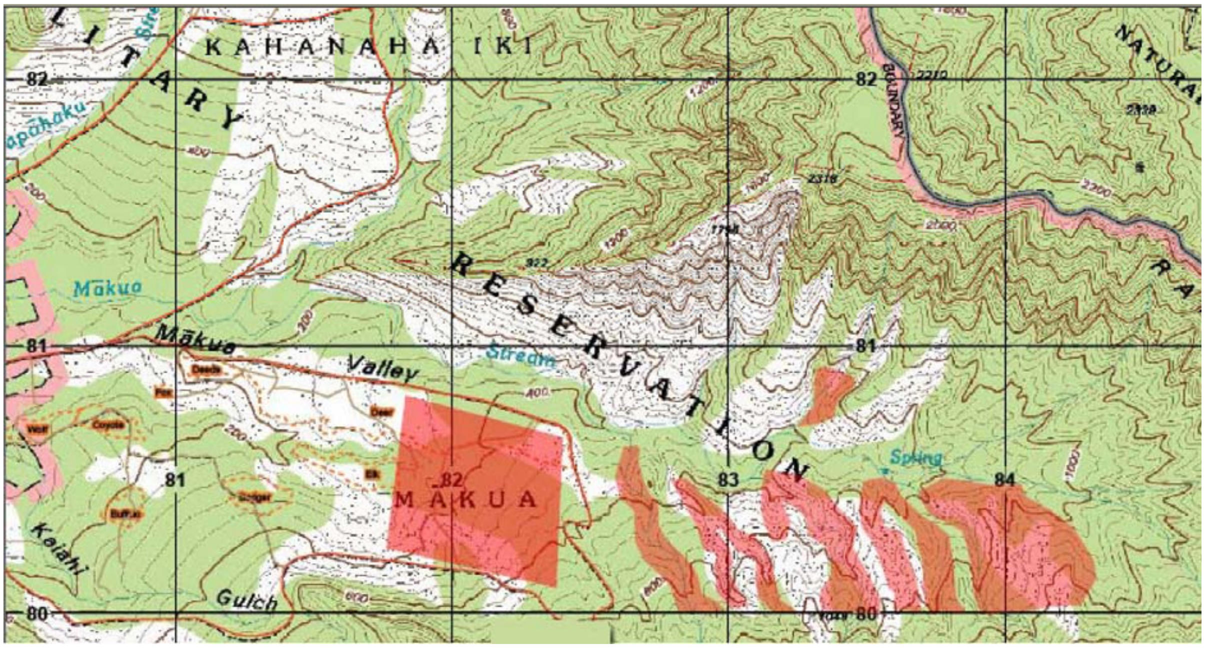

FIGURE 3-1: MMR AREAS OF INTEREST

4.0 SAMPLE COLLECTION AND ANALYSIS METHODS

4.1 Soil Collection/Sampling

A total of ten surface soil samples were collected in areas surrounding and adjacent to areas of interest along the range access roadway (Figure 4-1) as well as three (3) biased locations in the GWS area (also Figure 4-1) based on GWS survey data and professional judgment. Small hand tools (trowels) and either nitrile or vinyl gloves were used for sample collection. Samples were collected and stored in double re-sealable plastic bags. Soil was collected from approximately the top 2 to 4 inches of the ground, in area that was generally six by six inches in size. Approximately 200-250 grams of soil was collected at each sample location. Tools were rinsed with potable water and surveyed for contamination between samples. Field personnel removed all visible vegetation and rocks from the soil. All samples were scanned before and after being collected and, as were all sample containers prior to packaging for shipment to the laboratory.

Soil samples were analyzed for uranium via alpha spectroscopy by a NELAP accredited laboratory using method ATSM-D3972. The sample results are consistent with the presence of natural uranium in which the activities of both ^{238}U and ^{234}U are essentially equivalent. Samples containing DU would have ^{234}U activity significantly below that of ^{238}U. The results of the sample analysis can be seen in Table 4-1.

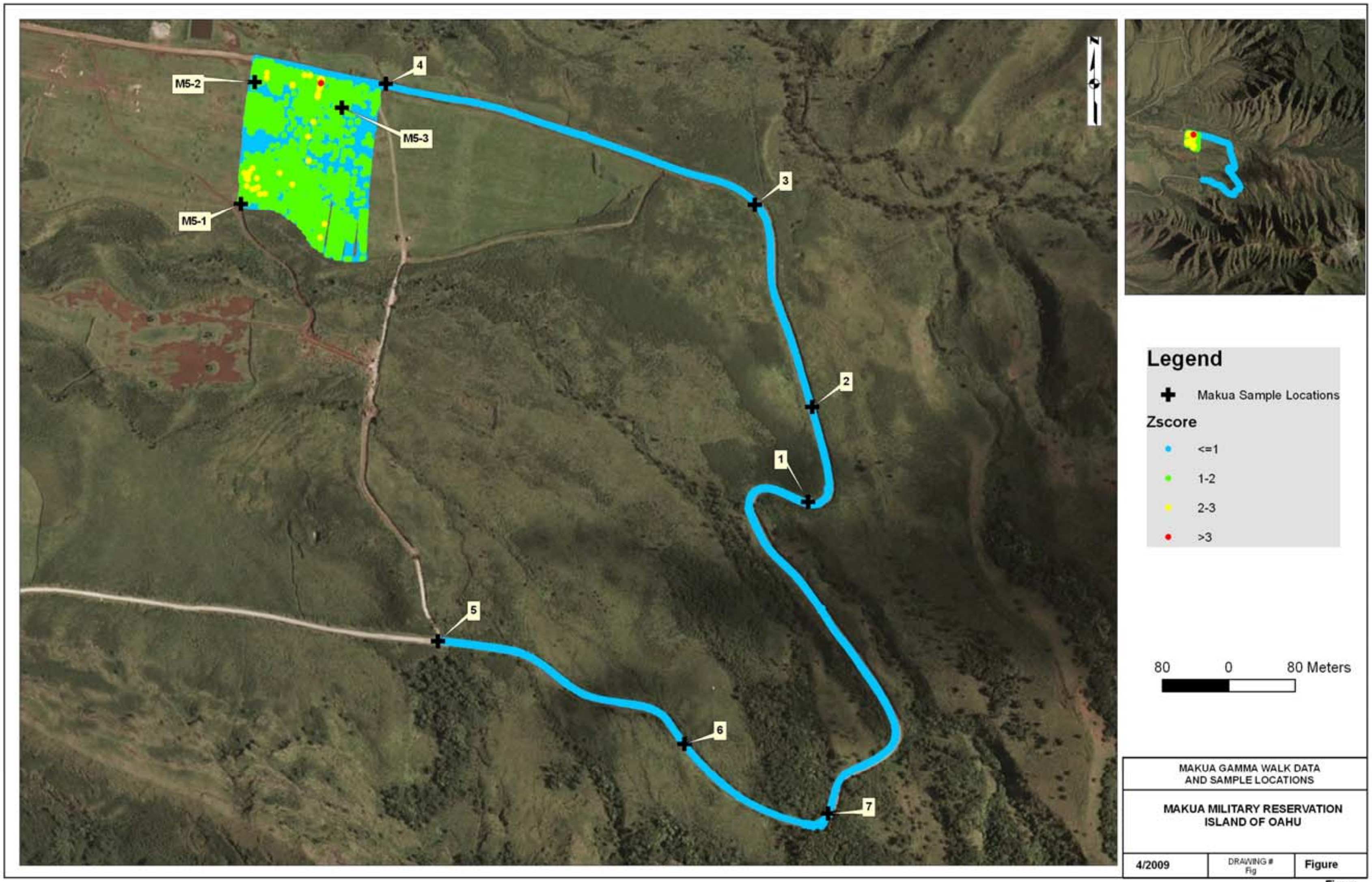

FIGURE 4-1: MMR GWS PLOT AND SOIL SAMPLE LOCATIONS

TABLE 4-1: 2008 MMR ALPHA SPECTROSCOPY ANALYSIS RESULTS

Sample	Analyte	Activity (pCi/g)	Total Error (pCi/g)	MDC (pCi/g)
MMR01	U-234	0.39	0.12	0.04
	U-235	0.031	0.033	0.044
	U-238	0.297	0.097	0.016
MMR02	U-234	0.19	0.072	0.034
	U-235	0.018	0.028	0.049
	U-238	0.206	0.075	0.034
MMR03	U-234	0.62	0.15	0.03
	U-235	0.034	0.032	0.04
	U-238	0.6	0.15	0.03
MMR04	U-234	0.56	0.14	0.04
	U-235	0.041	0.032	0.016
	U-238	0.49	0.13	0.04
MMR05	U-234	0.43	0.12	0.05
	U-235	0.012	0.027	0.053
	U-238	0.48	0.13	0.04
MMR06	U-234	0.67	0.17	0.05
	U-235	0.025	0.031	0.047
	U-238	0.61	0.16	0.04
MMR07	U-234	0.44	0.12	0.06
	U-235	0.028	0.029	0.04
	U-238	0.5	0.13	0.05
MMR08* (M5-1)	U-234	0.49	0.13	0.06
	U-235	0.046	0.035	0.018
	U-238	0.44	0.13	0.07
MMR09* (M5-2)	U-234	0.9	0.21	0.06
	U-235	0.022	0.034	0.061
	U-238	0.87	0.2	0.04
MMR10* (M5-3)	U-234	0.79	0.19	0.09
	U-235	0.037	0.041	0.063
	U-238	0.65	0.16	0.02

* M5-1, 2, 3 on Figure 4-1

4.2 Gamma Walkover Surveys

GWS surveys were conducted on the access road surrounding on of the main areas of interest as well as a cleared range area which comprised approximately 10 acres. Due to safety considerations with the presence of ICM and UXO, GWS were not performed in any other areas of the range.

The purpose of the GWS was to locate radiation anomalies that indicate potential areas with relatively elevated radioactivity where biased soil sampling, and/or further investigations may be warranted. The GWS was performed using a thin crystal sodium iodide (NaI) Field Instruments for the Detection of Low Energy Radiation (FIDLER) detector with a Ludlum Model 2221 scaler/rate meter. The detector was suspended a few inches above the ground while the surveyor walked over the area at a speed of approximately 0.5 meters per second, spacing each pass one meter from the previous pass. Each pass was spaced using GPS coordinates, and/or flags/marking tape, or other appropriate method to ensure straight survey paths. Measurement data were position correlated using a Trimble Pathfinder® global positioning system (GPS) receiver mated with a Trimble TSC™ graphical interface system (GIS) field device.

The GPS was used to link survey data to spatial locations (northing and easting) using state plane coordinates for Hawaii Zone 1 (island of Hawaii) and Zone 3 (island of Oahu), North American Datum 1983. By design, the GPS unit is self-checking, using data received from the satellite constellation to determine the precision and accuracy of its readings. Measurement and position data were automatically logged at one-second intervals.

The survey team also had a Ludlum Model 3 rate meter with a Ludlum Model 44-9 GM Pancake Probe and Ludlum Model 19 µR meter, which accompanied the field team for measurement of possible DU fragments and/or contaminated soil.

GWS data was post processed and analyzed and sorted by Z-Score and the data is plotted in Figure 4-1. Two locations were identified with Z scores slightly above 3 (actual scores of approximately 3.5 and 3.6). These two locations were re-investigated and no anomalous materials or additional readings were noted in the immediate or surrounding areas.

No anomalous readings were identified during a survey of the road area surrounding the selected areas of interest and there were no visual indications of depleted uranium (oxidized yellow fragments), or Davy Crockett system components. The ground survey team did identify other pieces of UXO and MEC just off the roadway, one of which had moved onto/near the access road. Range control was notified of this item and an ordinance team was called to investigate.

4.3 Aerial Gamma Flyover Surveys

The project included the advanced configuration platform for function and increased stability in flight conditions of the A-CLASS system on a helicopter platform. The platform was modified specifically for a Hughes 500 helicopter to include padded standoffs and a central adjustable lifting shackle/turnbuckle system which stabilized the platform from movement as compared to the nylon lifting straps used on the original system. In addition a large helicopter inverter system provided AC current. The system included a RSI-701 Controller Console digital gamma ray spectrometer/multi-channel analyzer (MCA)/data controller, four (4) RSX-256 4-liter (256 cubic inch) sodium-iodide (thallium activated) (NaI(Tl)) gamma scintillation detectors, internal Trimble Lassen SQ embedded GPS module, and a software integrated externally mounted Contour XLR laser range finder. The CLASS is designed as a turn-key system to rapidly measure, spatially correlate, and GIS map radioactivity concentrations in support of environmental characterization, remediation, and site closure activities.

The A-CLASS is an aerial design of the CLASS system mountable on a variety of helicopter models via cargo hook. It is ruggedized to operate in a variety of environmental conditions (Photo 4-1) and is equipped with a cloned video display to enable pilot navigation and altitude feedback data over the desired flight paths. A handheld Garmin GPS60cx system was also used in the helicopter to mark the locations over range targets, pistons, and debris from the Davy Crockett system during over-flights.

PHOTO 4-1: A-CLASS SYSTEM MOUNTED ON HUGHES 500

Radiation and location information is collected by the system at a very high data transfer rate (nominally one data point every second), and stored in a non-corruptible data file for real-time feedback and data validation/post-processing. The system operator receives real-time feedback using "waterfall" plots of total and radioisotope specific response and geo-referenced mapping of relative radiation concentrations. The data can also be transferred through a wireless network back to our data management center for real-time processing, and for conversion into GIS maps and data presentation formats.

The A-CLASS digital interface enables the user to pre-set multiple regions of interest (ROIs) within the energy spectrum to identify and track specific gamma radiation emissions from radioactive contaminants of concern (RCOCs). Using an ROI for field scanning is advantageous as it greatly reduces the detector background, which in turn reduces the scan minimum detectable concentration (MDC). The CLASS also utilizes internal energy gain stabilization to ensure the ROIs remain centered on the corresponding energy peaks. The A-CLASS operates with four (4) large volume (4L) NaI detectors and can be set up to collect data independently from each detector or in a serial collection mode. The independent data collection allows for better spatial sensitivity while the serial or summed collection mode allows for overall maximum detection sensitivity. The serial collection mode can operate effectively due to the digital gain stabilization which maintains consistent response over the survey interval.

Two regions of interest to corresponding to the approximately 766 and 1001 keV photons emitted by ^{234m}Pa (a decay product in the ^{238}U decay chain) as a surrogate for the presence of ^{238}U. In addition the CLASS system tracks contributions to the spectrum from naturally occurring ^{40}K and Thorium for stabilization purposes. These two naturally occurring radionuclides may contribute background interference which can be subtracted from the spectrum. The RSI system is essentially continuously stabilized. Automatic Stabilization occurs approximately every 1 to 5 minutes. The RSI-701 controller uses three naturally occurring elements to achieve stabilization ^{40}K, ^{238}Uranium and ^{232}Th are combined with a least squares fit and compared to the accumulated spectral data. The system holds three "reference" spectrums in memory. An accumulated spectrum for each crystal is maintained in memory and when the count total exceeds a preset total the system then compares the individual crystal's spectrum to the reference spectrum and adjusts the gain accordingly to maintain the proper gain in each detector.

Data density during aerial surveys at MMR was controlled by using custom generated RGM virtual areas of interest (Figure 4-2) and by maintaining spacing manually by using spacing provided by the RSI system display on both the laptop and the cloned pilot’s display. At MMR it was possible to use innate spacing provided within RSI system itself due to the increased maneuverability with the helicopter at, or near, sea level such that power and torque limits are much less of a concern as compared to flights at altitude. Data was collected at intervals between passes of the helicopter at a spacing interval of approximately 10 meters and at a speed of approximately 2 to 3 meters per second, or less. Altitude above ground level (AGL) is determined by a laser range finder and the data display in the helicopter is color coded to give the system operator and the pilot immediate feedback on system AGL. The pilot can appropriately adjust altitude, in accordance with safety protocols, obstacles, flight conditions and the presence of foreign object debris (FOD). The target range for AGL is 10 to 12 feet or lower. Processing of the spectral data is performed within ESRI /ARCGIS which enables the variable radius wide area averaging of radiation data within individual ROIs.

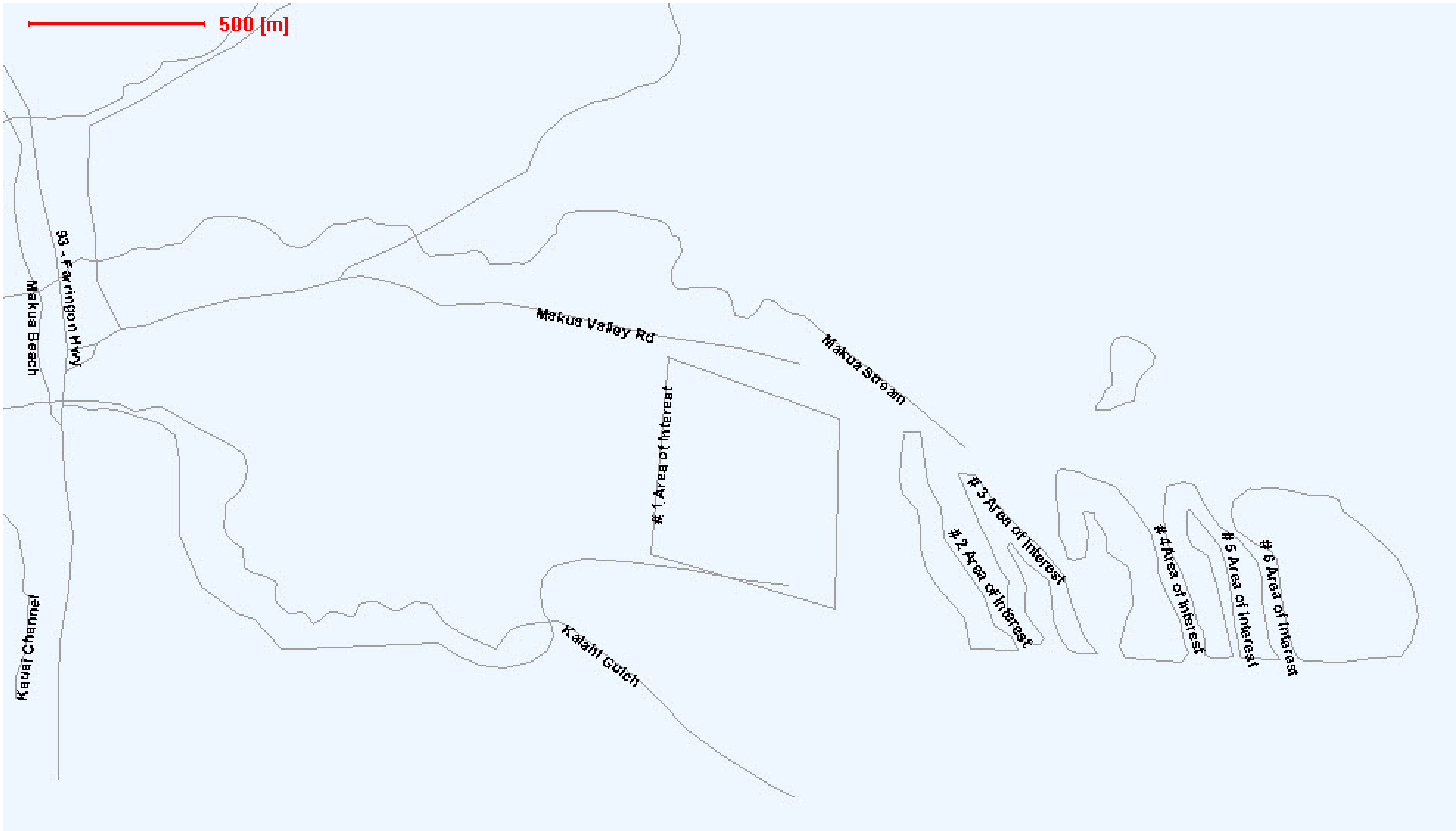

FIGURE 4-2: VIRTUAL AREA OF INTEREST OVERLAY OF MAKUA

4.4 Aerial Gamma Flyover Survey Results

Approximately 204 acres were surveyed using the A-CLASS system and the results are shown in Figures 4-3. In the outlined areas of interest, surveys concentrated on the plateau areas due to the sheer drop-off and erosion which had occurred over the years and as a result of the very recent rains on Oahu which had occurred the week prior to the MMR surveys (Photo 4-3). The steep angle of the plateau sides also precluded aerial surveys due to the helicopter rotor diameter to approach the ravines from the side, as well as the increased distance from the detector array to the ravine surfaces when approached head on. In these areas special attention was taken to make visual observations for potential Davy Crockett system components.

PHOTO 4-3: PLATEAU AND EROSION AT MMR

Z-scores throughout the MMR survey area did not indicate a significant departure from background distributions over the Aerial survey area with no Z-scores of data in the Uranium regions of interest exceeding three. Within survey areas where Z-scores indicated a potential pattern of increase or distribution, the gamma ray spectrum in these areas (the green and yellow highlighted areas) was reviewed for consistent ratios of Thorium, Uranium, Radium and Potassium to see if increases were related to geometric conditions, increases in normal background radiation due to rock out cropping and/or indicated an increase in regions of interest for the ^{232}Th decay chain (notably the 2.6 MeV photon from Tl-208) which may influenced the entire photon spectrum. Review of the integrated gamma-ray spectrum from these individual areas did not indicate an increase in ^{238}U activity indicative of the presence of DU. GWS data in similar areas of slightly elevated, but within statistical norms, on the main valley floor also did not indicate the presence of DU.

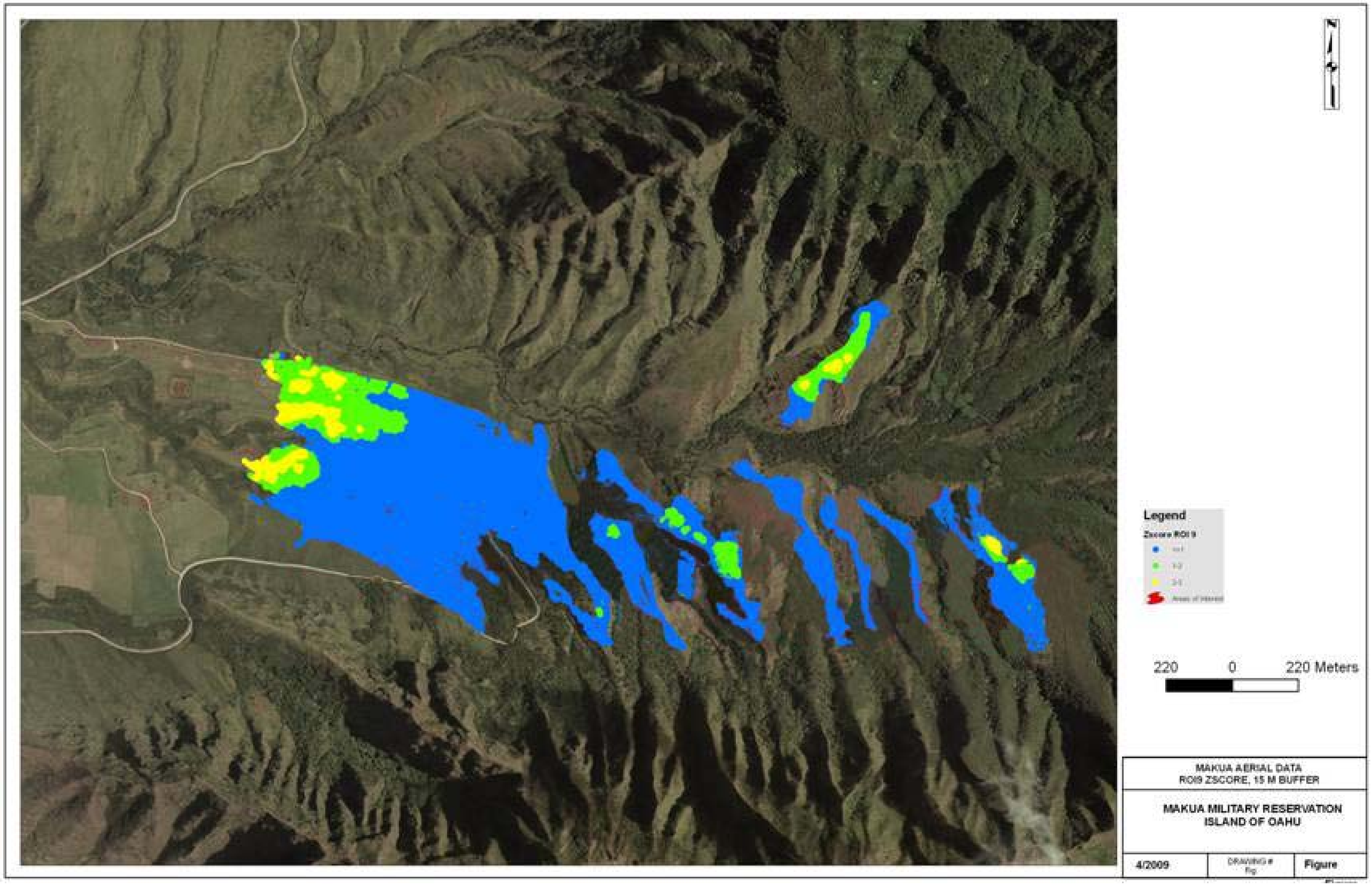

FIGURE 4-3: AERIAL SURVEY DATA Z-SCORES SHOWING FLYOVER AND AREAS OF INTEREST

4.5 Aerial Visual Reconnaissance Survey Results

A visual aerial survey from the Hughes 500 was also conducted to look for pistons and other visually identifiable indicators of the Davy Crockett system while radiological data was being collected. Due to the very low altitude of flight and obstacles (Trees, branches, bushes) the A-CLASS system operator assisted the pilot in the identification of FOD and object avoidance. During flyovers it was not uncommon for large sections of grass and ground cover to be lifted up in sections and come loose in large mat like objects. While this presented an excellent opportunity for ground and object visualization, it presented a potentially significant hazard for the helicopter. At times vegetation presented difficulties with main rotor balance and it was necessary for the helicopter to land and clean grass from the rotor blades.

In area A, outlined on the flyover coverage map (figure 4-3), because of the very low flight altitude, flowering vegetation required that the helicopter return to the landing zone to clear materials from the main windshield area (Photo 4-3).

PHOTO 4-3: VEGETATION ON HELICOPTER WINDSHIELD AT MMR

No pistons, back plates, windscreens, spotter round bodies, or aluminum tail fins were identified during the surveys at MMR. The components of the Davy Crockett system particularly back plate assemblies and windscreens have a very distinct coloring as seen in photos 4-4 and 4-5 and are readily observable from the air (Photos from PTA). All photographs taken during the MMR surveys are included in appendix E. The largest contiguous area of the survey is shown in photos 4-6, through 4-9 and comprises a relatively flat short grassy area with the remainder being heavily vegetated with short brush and tall grass. Areas within the upper valley area are characterized by small raised plateaus surround by steep drop offs and ravines. Typical plateaus in the upper regions of the Makua Valley are shown in photos 4-8 through 4-10.

PHOTO 4-5: PART OF DAVY CROCKETT REAR PLATE ASSEMBLY

PHOTO 4-5: PART OF DAVY CROCKETT REAR PLATE ASSEMBLY

PHOTO 4-6: MAIN VALLEY FLOOR SURVEY AREA

PHOTO 4-7: BOUNDARY OF ICM AREA AT GRASS LINE

PHOTO 4-8: BEGINNING OF ICM AREA

PHOTO 4-9: UPPER END (EASTERN MOST) MAIN CONTIGUOUS AREA BOUNDED BY ROAD

4.6 Quality Control Measures

Data collection activities were performed in a controlled and deliberate manner. Data were collected by trained individuals with calibrated instruments following written procedures and/or protocols. Data were recorded and reviewed, and documentation is auditable. Instrumentation capable of detecting the radiation types and energies of interest were selected, calibrated, and maintained for survey data collection and sample analysis. All equipment used in the field was checked using either a thorium-230 (^{230}Th) alpha check source, a technetium-99 (^{99}Tc) beta check source, or a cesium-137 (^{137}Cs) beta/gamma check source and/or in accordance with manufacturer recommendations. Operational checks were performed for each instrument before and after each use. All instruments used in the field met data quality requirements.[1] Samples were collected in the field using clean tools and gloves. All samples were scanned All samples were scanned before and after being collected and, as were all sample containers prior to packaging for shipment to the laboratory. Sample tools were cleaned between each sample collection.

4.7 Data Quality Objectives

The Data Quality Objectives (DQOs) specify the type, quality, quantity, and uses of data needed to support decisions and are the basis for designing data collection activities. To determine the project DQOs, a series of planning steps were used as specified in QA/G4, *Environmental Protection Agency (EPA) Guidance for Data Quality Process* (USEPA 2006). The DQO development process was used to optimize the data collection necessary to meet the applicable decision criteria. The seven (7) steps of the DQO process are presented in the following subsections along with summary answers addressing each DOQ step.

4.7.1 Step 1 – State the Problem

The problem is that due to both the nature of the UXO, and the extremely rugged terrain of some of the firing ranges, it is impractical to perform ground based surveys either efficiently or safely to gather data about the nature and extent of DU contamination in the impact areas of PTA or Makua.

4.7.2 Step 2 – Identify the Decision

The principal study question and decision statement is whether the DU present on the ranges that cannot be accessed effectively or safely can be adequately detected and quantified using an aerial platform (in this case a helicopter) equipped with a large area sodium iodide (NaI) gamma spectroscopy system. From a comparison of GWS data of an area known to contain DU from the Davy Crockett System at Schofield Barracks, to flyover data gathered by the A-CLASS system, it can be seen that the aerial system can identify the presence of DU which correlates well to distributions of DU found during GWS surveys at on ground level.

4.7.3 Step 3 – Identify Inputs to the Decision

4.7.3.1 Contaminants of Concern

The only known source of radionuclides is DU contained in the spotter round bodies of training rounds found during previous investigations at Schofield Barracks. Depleted uranium is the waste product of U enrichment processes and is defined as U containing less than 0.711 percent (%) ^{235}U. Depleted uranium consists primarily of 238U with smaller amounts of uranium-234 (^{234}U) and ^{235}U from both a mass and activity perspective. Natural U that is present in the environment consists of approximately equal activities of ^{234}U and ^{238}U.

The DU was a U metal-molybdenum alloy when it was released to the environment. The DU fragments identified at Schofield Barracks are largely intact; however some of the metal has oxidized and is present as uranium oxide in the surface soils. The DU is expected to be intact or present as large chunks of U metal, and some oxides in surface soils at MMR very similar to the distributions at Schofield Barracks, if it is present.

Uranium and its decay products emit characteristic energy photons which can be detected by gamma spectroscopic methods and distinguished from other gamma emitting radionuclides. It is by the detection of specific energy photons discrimination from other radionuclides and natural background that the presence of elevated levels of DU will be determined.

Two regions of interest (ROI) were established for collection of data which correspond to the 766 keV and 1001 keV energy photons of protactinium (^{234}Pa) which provide distinct indications of the presence of ^{238}U. ^{234}Pa is a decay product in the decay chain of ^{238}U. Elevated levels of ^{234}Pa indicate elevated uranium levels and thus the potential presence of DU on the ranges.

4.7.3.2 Potentially Affected Media

The media of concern for the aerial surveys are surface soil and shallow subsurface soil (i.e., to a depth of approximately 6 inches).

4.7.3.3 Natural Background Variations

Due to the presence and variation of naturally occurring radionuclides in the environment, including natural U, Th and potassium 40 (^{40}K), elevated areas of naturally occurring radioactive materials may be present. By establishing ROIs which are specific to the decay products of uranium, the background variations can be minimized and accounted for since contributions from other radionuclides are minimized. Spectral analysis capabilities can assist in identifying increases within areas of interest.

4.7.4 Step 4 – Define the Study Boundaries

The area to be investigated will be a portion of the range where the Davy Crockett Spotting rounds containing DU may have been used. The study boundaries for the aerial survey was chosen and marked on topographical maps by USAG-HI based on possible range layout and locations for target areas. Aerial surveys will be conducted over the plateaus and valley floors based on both visual and GPS reference points. During the actual surveys, emphasis was placed on confirming the boundaries and plotting data immediately as it was gathered to ensure that the appropriate areas were covered.

4.7.5 Step 5 – Develop a Decision Rule

Preliminary specific decision rules regarding presence of DU from the aerial platform was established during system evaluation at Schofield Barracks. Applicable decision rules and goals for the evaluation of gamma flyover data during the characterization survey are in Table 4-2 and may be modified and refined based on the results and changes made in system configurations during aerial surveys, if required.

TABLE 4-2: DECISION RULES

Parameter of Interest	IF	THEN	Comments
Aerial Gamma Flyover Data			
Elevation Above Ground Level	Elevation is outside of operating parameters/tolerances	Discard data associated with measurements outside of tolerance or scale measurements if appropriate.	Laser Detection and Ranging will be used. Elevation above ground level is a parameter stored with each accumulated data point.
GIS Area Integration Radius	Data shows concentrations at/below detectable levels	Adjust radius to attempt to achieve enhanced sensitivity/detection levels	Enables increases sensitivity over larger areas of interest.
Gamma Spectroscopy Nuclide ID (NID)/ Elevated ROI counts	Data shows potential presence of increased activity	Perform ground based GWS, if possible. Perform NID and spectral examination to identify the source of increase	NID if possible, confirm with soil sampling and/or ground based surveys.

Elevation above ground level: The elevation above ground level was determined by using laser ranging during the survey to direct the pilot to adjust altitude, if possible. Due to the presence of trees, large rocks and ravines, safety considerations were often the primary determinate of elevation during the survey. The use of the laser range finder enabled the classification and separation of data based on elevation above ground.

A potential complicating factor with laser data is the fact that objects such as high grass, large rocks, and trees, as well as range debris cause the laser range finder to be recorded as elevations closer to the ground than they actually are. Helicopter rotor wash reduces this effect in tall grassy areas by compressing/flattening the grass. These factors were observed and tested during static platform testing by transiting over the flat and mowed areas as well as high grasses and vegetation. Rotor wash also separated brush/small trees and also allowed the laser to penetrate to the ground surface.

Another critical use of altitude data enables the analysis of data to ensure that altitude is not a factor in the development of potential DU distribution patterns. If increased count rate patterns were the result of altitude influence the plotting of altitude data would mirror the plot of potentially elevated Z scores. As can be seen from a comparison of Figure 4-4 with data plotted in Figure 4-3 these distinct patterns are not readily observed. The slight increase in count rates in the survey data do not appear to be attributable to altitude alone.

4.7.6 Step 6 – Specify Tolerable Limits on Decision Errors

The collection and analysis of data is designed as a graded approach using a combination of gross aerial gamma data, processed data, peak search and radionuclide identification, energy defined regions of interest, as well as the application of GIS data analysis and screening.

Analytical uncertainty is controlled by use of appropriate instruments, methods, techniques, and Quality Control (QC) procedures to ensure the proper function and calibration of the instrumentation to be used. Minimum detectable levels for individual radionuclides using specific gamma spectroscopic and analytical methods have been established for ground based application of the CLASS system which is primarily based on constant surface to detector distance. Detector ground distances for aerial based surveys are dependent on elevation above ground level which is influenced by variations in terrain and helicopter altitude. To qualify data for inclusion LADAR (*Laser Detection and Ranging*) will be used to classify data based on elevation for acceptance. Specifying values for the operating parameters controls the uncertainty associated with individual analytical results, which limits decision errors and improves data quality.

The A-CLASS system’s minimal detection limit was calculated using a NIST traceable Uranium Slab of 0.3 cm thickness and an area of approximately 250 cm^2, at various distances from the face of the system’s detectors to determine system efficiency. Assuming DU metal fragments lying on the surface/near surface at a depth of 1” to 2” of the soil and using an observation interval of 5 seconds (representing an integration averaging radius of approximately meters) an approximate MDA of 3 to 5 Davy Crockett Spotter Rounds (DCSR) in an area of approximately 150 ft^2 (14 m^2 at a distance of 10-12 feet at 1 to 2 meters per second (3 to 6 knots) helicopter speed.

Laser ranging data enabled both the classification and sorting of data by altitude (Figure 4-4) and the exclusion of data from the data set. Daily QA/QC of the detector system assured proper energy calibration and detector response prior to collection of survey data.

4.7.7 Step 7 – Optimize the Design for Collecting Data

Review and analysis of observations and collected gamma flyover data from the static testing and reference areas will be performed to optimize the flight parameters (helicopter speed, height above ground level, regions of interest, survey density) for use in the impact areas. Static testing will confirm the assumptions made with regard to regions of interest for peaks, background subtraction, and Minimum Detectable activities.

Data and flight parameters gathered during static testing and platform configuration targeted a height above ground of approximately 10 to 12 feet as a level which could be consistently and safely maintained. Helicopter speeds over the ground of approximately 2-3 knots or less also appeared to be easily obtained during system trials. Actual conditions on the range increased the altitude which could be maintained while maneuvering in the 10-14 foot range and increased the airspeed to 3-6 knots due to wind conditions and the need to be able to maneuver over and around objects and the slope of the range. Lowering the speed would increase residence time of the detectors over the ground but would increase survey time by a factor of approximately 1.6 based on speed alone. The decrease in maneuverability may impact the ability to hold straight transit lines and increase repeat flyovers to achieve coverage, and safety.

The regions of interest, approximately 30-36 channels of data appear appropriate and the ability to perform variable area averaging enable the detection of DU. Post processing of data will examine the adjustment of peak channel width for each of the two ROIs selected. Processing time for the variable area averaging performed at a 20 to 30 foot radius requires optimization to reduce processing times to reasonable levels.

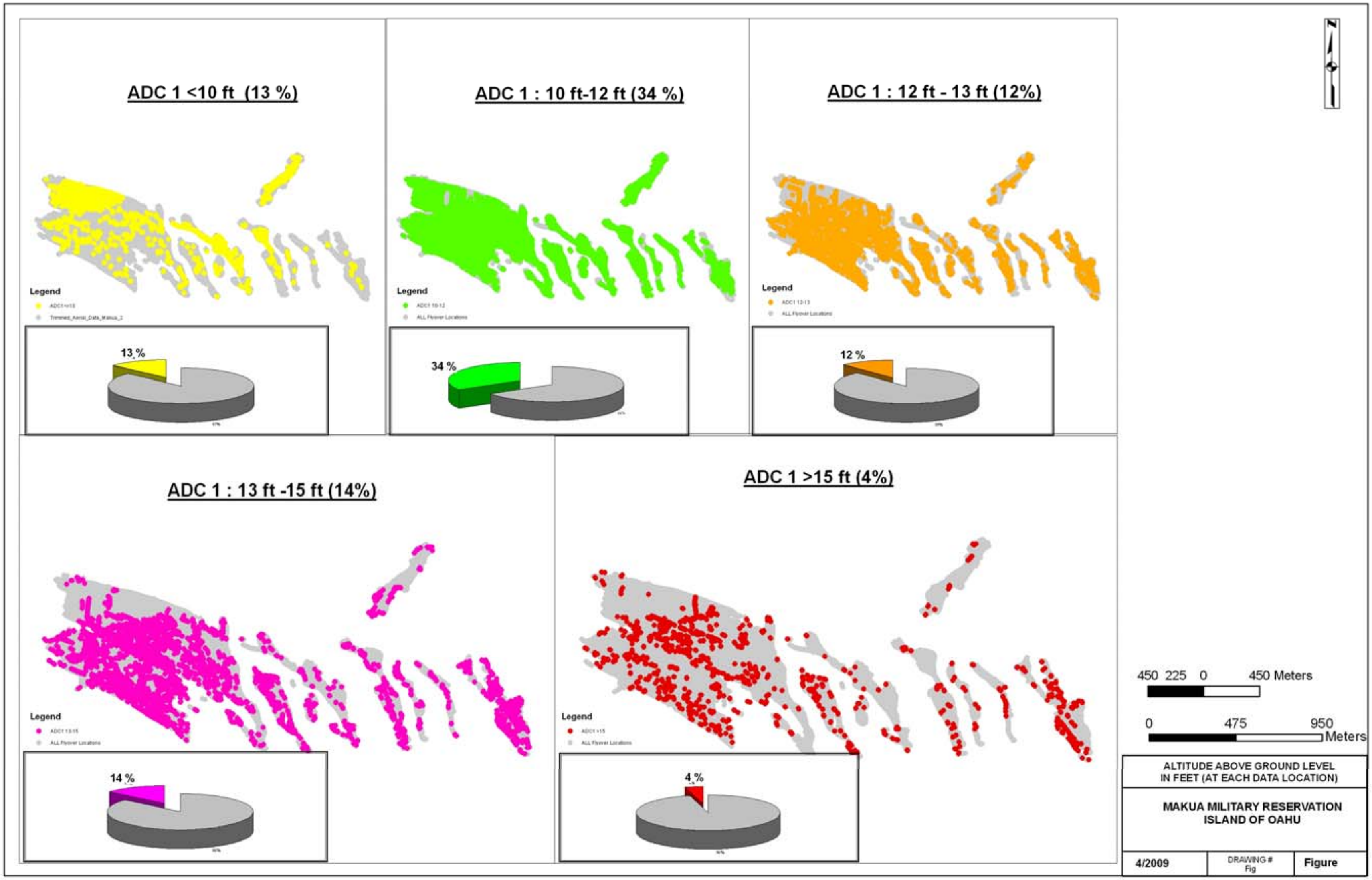

FIGURE 4-4: BREAKDOWN OF SURVEY ELEVATION ABOVE GROUND LEVEL

5.0 SUMMARY AND CONCLUSIONS

Aerial surveys conducted at MMR did not visually or radiologically identify Davy Crockett systems components, pistons, back plate assemblies, or spotter round pieces or fragments. There appears to be no evidence linking the use of the MMR firing range with Davy Crockett practice.

Examination of radiological data including soil sample results, GWS data and Aerial gamma ray spectrums indicates normal background distributions of radioactivity and radiation associated with that radioactivity.

6.0 REFERENCES

CABRERA 2007. Schofield Barracks Firing Range Phase I, Depleted Uranium Investigation. Prepared for U.S. Army Joint Munitions Command. January.

CABRERA 2008A, Technical Memorandum, Depleted Uranium Scoping Investigations Makua Military Reservation Pohakuloa Training Area Schofield Barracks Impact Area, Islands of Oahu and Hawaii.

OER 2007b. Accident Prevention Plan for UXO Escort and Avoidance Services in Support of Depleted Uranium Investigation at Schofield Barracks.

Rubin 2008. Depleted Uranium, Natural Uranium and Other Naturally Occurring Radioactive Elements in Hawaiian Environments, Kenneth H. Rubin, Ph.D., Professor and Chair of the Volcanology, Geochemistry and Petrology Division Department of Geology and Geophysics School of Ocean and Earth Science and Technology University of Hawaii, May 2008.

USACE 2007. Archives Search Report On the Use of Cartridge, 20MM Spotting M101 For Davy Crockett Light Weapon M28, Schofield Barracks and Associated Training Areas, Islands of Oahu and Hawaii, Prepared by USACE St. Louis District.

USEPA 2000. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), EPA 402-R-97-016, Rev. 1, August.

USEPA 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4. February.

APPENDIX A

GAMMA WALKOVER SURVEY DATA

(Provided electronically on CD)

APPENDIX B

SOIL ANALYSIS DATA AND COC
(Provided electronically on CD)

APPENDIX C

Flyover Data
(Provided electronically on CD)

APPENDIX D

INSTRUMENT QA/QC DATA

(Provided electronically on CD)

APPENDIX E

PHOTOS
(Provided electronically on CD)