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FINAL REPORT

Radiological Final Status Survey

Transonic Range – Land Areas

Depleted Uranium Study Area

Aberdeen Proving Ground, Aberdeen, MD

Contract Number

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***Prepared for*:**

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Executive Summary

Cabrera Services, Inc. (CABRERA), under contract to the U.S. Army Field Support Command (FSC), performed remedial activities, characterization, and Final Status Surveys (FSSs) for the Transonic Range Depleted Uranium Study Area (DUSA) located at the Aberdeen Proving Ground (APG), Maryland.

CABRERA conducted decommissioning activities in accordance with the formally approved Nuclear Regulartory Commission (NRC) decommissioning plan prepared by the Allied Technology Group, Inc. (ATG). Deviations from the approved plan were provided to the FSC and APG for coordination with the NRC. CABRERA did request a reduction in what it considered an unnecessarily large number of alpha spectroscopy analyses. To accommodate collection and analysis of additional samples for alpha spectroscopy, CABRERA proposed to reduce the number of samples receiving alpha spectroscopy from 75 to 3 (Appendix B). The NRC reviewed and approved this request. Additionally, upon further review of the work plan, CABRERA decided to reduce the number of Class 2 areas from five to three by increasing Class 1 areas to 15.

The project had several major activities associated with the remediation and FSS including:

- Designation of the DUSA land areas into Multi-Agency Radiation Survey And Site Investigation Manual (MARSSIM) Class 1 and Class 2 divisions.
- Determination that the dose from residual contamination at the site is not greater than the release criterion for each Survey Unit (SU).
- Remediation of soils, debris, and structures within the confines of the DUSA located within the confines of the Transonic Range.
- Removal and shipment of remediated soils and debris to an NRC licensed disposal site.
- FSS of the DUSA soils and structures located within the confines of the Transonic Range.

Final status surveys were performed over a land area of approximately 53,000 square meters and on two structures remaining on the Range. This FSS report addresses only Transonic DUSA land areas; surveys performed on structures are addressed under separate cover. The radiological contaminant of concern was depleted uranium (DU). The derived concentration guideline ($DCGL_w$) for DU was determined to be 230 picocuries per gram (pCi/g) and, based on its isotopic weight ratio, 190 pCi/g for Uranium-238 (^{238}U). An As Low As Reasonably Achievable (ALARA) target and remediation goal of 105 pCi/g DU and 86 pCi/g ^{238}U was established, as described by the ATG 2000 decommissioning plan.

Based on the modifications noted above, the FSS established fifteen Class 1 and three Class 2 SUs. Although MARISSM recommends a gamma walkover survey (GWS) covering 10% to 100% of Class 2 areas, CABRERA judgmentally selected the most conservative approach. The final status survey consisted of a GWS of 100% of reasonably accessible Class 1 and Class 2 areas; and, sample collection and analysis. Soil sample collection was limited to the surface, from 0 to 15 centimeters (cm) below grade surface.

All soil sample results are below the ALARA target of 86 pCi/g ^{238}U. The results of the soil samples areas show the highest ^{238}U soil sample result was 16 pCi/g in a Class 2 SU, 79 pCi/g in a Class 1 SU, and 14 pCi/g from the earthen floor from the X-Ray Building. The FSS gamma walkover survey for the DUSA land area shows all remediated areas are less than 41,000 cpm calculated empirically to be less than the ALARA target of 86 pCi/g ^{238}U. The FSS data indicates that the site is suitable for release for unrestricted use, without regard for former operations with licensed radioactive material.

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Glossary of Acronyms and Abbreviations

ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
APG	Aberdeen Proving Ground
ARL	Army Research Laboratory
ATC	Aberdeen Test Center
bgs	Below ground surface
CABRERA	Cabrera Services, Inc.
cm	Centimeter(s)
cpm	Counts Per Minute
DCGL	Derived Concentration Guideline Level
$DCGL_{emc}$	Derived Concentration Guideline Level - Elevated Measurement Criterion
dpm	Disintegrations Per Minute
DU	Depleted Uranium
DUSA	Depleted Uranium Study Area
FSC	U.S. Army Field Support Command
FSS	Final Status Survey
gmw	Gram molecular weight
GPS	Global Positioning System
GWS	Gamma Walkover Survey
LBGR	Lower Bound of the Grey Region
m^2	Square meters
MARSSIM	Multi-Agency Radiation Survey And Site Investigation Manual
MDC	Minimum Detectable Concentration

MDC_{scan}	Minimum Detectable Concentration for gamma Scanning
mg/k	Milligrams per kilogram
mrem	Millirem
NIST	National Institute of Standards and Technology
NRC	U. S. Nuclear Regulatory Commission
Paragon	Paragon Analytics, Inc.
pCi/g	Picocuries per gram
ppm	Parts per million
QA	Quality Assurance
QC	Quality Control
ROPC	Radionuclides of Potential Concern
SU	Survey Unit
^{234}U	Uranium-234
^{235}U	Uranium-235
^{238}U	Uranium-238
UXO	Unexploded ordnance

1.0 INTRODUCTION

Cabrera Services, Inc. (CABRERA) is under contract to the United States Army Field Support Command (FSC) to provide support to the Aberdeen Test Center (ATC) at the Aberdeen Proving Ground (APG) in Aberdeen, MD. CABRERA performed radiological surveys of the Transonic Range Depleted Uranium Study Area (Transonic Range DUSA) to support consideration for unrestricted release. The Transonic Range consists of approximately 53,000 square meters (m^2) of land. Several support facilities and access roads located on the Transonic Range were used for the testing of Depleted Uranium (DU) munitions. The Final Status Survey (FSS) for the two structures will be addressed under separate cover. This document presents the FSS activities, which are designed in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC 2000) guidance.

1.1 Background

Aberdeen Proving Ground, located in Aberdeen, MD, is an active U.S. Army testing and research facility. The Aberdeen Proving Ground lies along the western shore of the Chesapeake Bay in Harford and Baltimore Counties, MD, approximately 15 miles northeast of Baltimore. The APG covers a total of 72,516 acres (land and water) and consists of two distinct areas: the northern portion of APG, referred to as the Aberdeen Area; and the southern portion of APG, referred to as the Edgewood Area. The Aberdeen Area became a formal military post, designated as the APG, in 1917. The site location map is shown in Figure 1.

The DUSA comprises approximately 12 acres on the southeast end of the Transonic Range. The DUSA can be described as a cleared relatively flat tract, surrounded by woods to the east, south, and west. Swampy areas are found behind the Transonic Range catch basin to the south, along the wooded areas to the west, and in the northeast section of the site.

The DUSA was used for DU testing from 1973 to 1979. Testing consisted of gun launching DU penetrator rounds from two locations on the northern portion of the site at targets mounted adjacent to the X-Ray units to the south. Stripper/deflector plates located in between the launch or shooting locations were designed to strip or deflect the sabot away from the penetrator while in flight to the target. Penetrators were either stopped in the target or penetrated the target and impacted into a backstop located a short distance behind the targets.

As a result of the testing, most of the DU melted into the target and backstops. However, some DU fell onto the soils around the targets or was scattered into the surrounding area. Test technicians wore protective clothing and dosimetry while in the test area and monitored activities for radioactive contamination. Shot targets and other designated materials were maintained on site in a radioactive materials storage area located to the east of the impact zone. While the shot target and other designated materials had been remediated, recycled, and/or disposed of as radioactive waste, this site still contained radioactive materials.

After outdoor testing ceased, the Army Research Laboratory (ARL) health physicist conducted an initial site cleanup to reduce the radioactive waste inventory and to allow other non-radiological testing to be conducted on the site. ARL conducted soil sampling on the site as late as 1991 as a part of their environmental monitoring program. In 1995/96, General Physics Corporation characterized the site as a part of the preparations for decommissioning. The results of this characterization are found in "Transonic Range Depleted Uranium Study Area Radiological Characterization Study Report", General Physics Corporation (GPC 1996). These results are used as the radiological bases for the Decommissioning Plan.

1.2 General Summary of Decommissioning Activities

CABRERA conducted field efforts to implement the NRC approved decommissioning plan for this site including:

- An Unexploded Ordnance (UXO) sweep of the entire range was conducted before field activities began. A UXO scan was conducted during excavation/sampling activities after every bucket/trowel scoop.
- The 12 acres comprising the range was gridded into fifteen Class 1 survey units and three Class 2 survey units. Each survey unit contained 14 randomly selected sampling points. These points were flagged for later sampling.
- Excavation activities included staging and tarping soil on-site. The soil then was loaded into lift liners for shipment to Envirocare of Utah, an NRC licensed disposal facility.
- During the UXO investigation several magnetometer targets were dug up in order to clear the area for remediation and to establish a safe entrance for personnel and equipment. Some of the 30+ small (1foot x 2 foot) steel plates were outside of the areas previously identified as elevated during the characterization survey. Removal of the plates revealed contaminated soil beneath them requiring the excavation of the plate storage area to a depth of two to three feet.
- Based on the contaminants on site, a letter was sent to the NRC requesting a reduction of the number of soil samples requiring alpha spectroscopy analysis. The original plan called for 75 alpha spectroscopy analyses. The NRC approved the request for three samples, although five were ultimately submitted.
- A conservative approach was taken as the number of Class 2 survey units was reduced from five to three while Class 1 survey units were increased to fifteen from thirteen.
- After the completion of the gamma walkover survey, biased soil samples were taken at the highest counts per minute (cpm) locations in each survey unit.
- One minute fixed gamma measurements were performed on the X-Ray 2 structure interior soil floor and randomly selected soil sample locations.

1.3 General Approach to the Transonic Site FSS

The FSS investigations were designed using the approach outlined in MARSSIM (NRC 2000).

- Development of Derived Concentration Guideline Levels (DCGL)
- Selection of instrumentation and measurement techniques
- Identification of survey units and classification areas by contamination potential
- Estimation of the number of measurement locations
- Collection of Data
- Evaluation of Data

1.4 Radionuclides of Potential Concern (ROPCs)

Site Radionuclides of Potential Concern (ROPCs) are limited to DU and short-lived progeny. The uranium ratios are based on isotopic uranium weight ratios used for shipments of routine DU waste from APG (BARG 1995). The activity fractions are calculated from the isotopic weight ratios and the specific activity of each uranium isotope. The result is a Uranium-234 (^{234}U), Uranium-235 (^{235}U), and Uranium-238 (^{238}U) ratio of 8.4%, 1.2%, and 90.4%, respectively. This composition is similar to the 19.0%, 2.1%, and 79.0% average ratio from three DU soil samples described in the APG report (ANL 1999) entitled "Derived Uranium Guideline for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland", Argonne National Laboratory (ANL 1999) See Appendix A for details.

2.0 SITE REFERENCE COORDINATE SYSTEM

The site reference coordinate system was designed to ensure all sample and measurement locations are spatially identified such that each location is reliably reproducible. The basic unit of the coordinate system is meters. Survey unit grids, site boundaries, and other survey reference points related to land areas are described by northing and easting coordinates, in meters, tied to North American Datum 1983 State Plane Maryland.

3.0 DERIVED CONCENTRATION GUIDELINE LEVEL

The cleanup criteria for the Site is established by the approved decommissioning plan with criteria as set forth by NRC 2000, ARMY 1980, and AR 11-9 1999. The site has release criteria established for soil. The soil release criteria DCGLs are based on analysis provided by Argonne National Laboratory (ANL 1999) and NRC 2000 techniques. Soil DCGLs are summarized in Table 3-1.

Table 3-1 DUSA Soil DCGL

Parameter	Depleted Uranium Activity Concentration (pCi/g)	
	Total Uranium	**^{238}U**
DCGL	230	190
ALARA Target	105	86

^{238}U derived from the isotopic activity ratio of 90.4%
ALARA: As Low as Reasonably Achievable
pCi/g: Picocuries per gram

4.0 TRANSONIC FINAL STATUS SURVEY DESIGN

4.1 Survey Unit Classification

Soil sample collection was limited to the surface, from 0 to 15 centimeters (cm) below grade surface (bgs).

Prior to soil remediation, the Transonic DUSA was broken down into Class 1 and Class 2 Survey Units as seen in Figure 2. The original Decommissioning Plan submitted by ATG called for five Class 2 Survey Units and thirteen Class 1 Survey Units. CABRERA judgmentally selected a more conservative approach by establishing fifteen Class 1 and three Class 2 survey units (SU). The survey units were classified according to contamination potential as described by NRC 2000 using MARRSIM as a basis. Each FSS Survey Unit was classified as either a Class 1 or a Class 2 Survey Unit. No Class 3 Survey Units were selected.

The Class 2 Survey Units ranged in size from approximately 8,400 m^2 to 9,800m^2. These Survey Units are on the northern border of the Transonic DUSA. The Class 1 Survey Units ranged in size from 1,287 m^2 to 2,000 m^2 and appear south and down range of the Class 2 Survey Units.

4.2 Systematic Surface Soil Sampling for Sign Test

Surface soil samples (0 to 15 cm, bgs were collected in each of the survey units. The minimum number of systematic soil sample locations required in each of the survey units was established using MARSSIM (NRC 2000) guidance. It was determined that 14 sample locations were required in each of the survey units. No reference area was chosen since the natural occurring level of ^{238}U in the soil, (the primary constituent of DU) is a small fraction of the ALARA DCGL. For purposes of the FSS data evaluation, it is conservatively assumed that the reference area ^{238}U concentration is zero.

Paragon Analytics Laboratory (Paragon) of Ft. Collins, Colorado performed gamma spectroscopy analyses on soil samples via EPA analysis methodology 901.1, Modified. Results are reported in terms of dry weight activity per gram of soil. Appendix D presents the results of the soil samples from the Class 1 and Class 2 Survey Units.

4.2.1 Determination of N (Number of Required Measurement Locations)

The sample variability in each survey unit was estimated using the characterization data. MARSSIM defines the lower bound of the gray region (LBGR) as the activity where the user would like to know the probability of failing to release a "clean" survey unit. For the DUSA, the LBGR was selected to be 70 pCi/gm because this was the cut off for identifying areas that require remediation, so the probability of failing to release a site with activity below this level should be low. This results in a relative shift of greater than 3.0. Therefore, 3.0 was used to determine the number of measurements per survey unit. MARSSIM, Table 5.5, lists 14 measurements for a relative shift of 3.0 and decision error rates of 0.05. This means that 14 samples will be collected in each Class 1 survey unit greater than 100 m^2 and in each Class 2 survey unit.

4.2.2 Reduction in Number of Alpha Spectroscopy Soil Samples

In February 2003, CABRERA requested a reduction from what it considered an unnecessarily large number of alpha spectroscopy analyses. CABRERA proposed to reduce the number of samples receiving alpha spectroscopy from 75 to 3 for reasons outlined in the request seen in Appendix B. Appendix D shows the results of five alpha spectroscopy samples confirming that remedial efforts were indeed removing materials associated with the test firing of DU munitions.

4.2.3 Elevated Measurement Criterion ($DCGL_{EMC}$)

MARSSIM states that, for Class 1 survey units, a dose area factor should be used to evaluate the magnitude by which the concentration within a small area of elevated activity can exceed the DCGL while maintaining compliance with the release criterion. For the purpose of ALARA, the $DCGL_w$ will be used as the $DCGL_{EMC}$ for soil. This corresponds to an area factor of one. Since the soil MDC_{SCAN} values are sensitive enough to identify a concentration that is less than half of their respective DCGL, it is unlikely that small areas of elevated activity exceeding the release criterion would be missed during scanning.

4.2.4 Soil Sample Locations

Soil samples were taken at 14 locations within each Class 1 and Class 2 Survey Unit for a total of 252 samples. The sample collection depths were 0-15 cm. Measurement locations in the survey units were established using a random start point in a systematic triangular grid. The grid spacing for each survey units was determined, based on the measured area of the survey unit, using the following equation (Equation 5-7 from MARSSIM).

$$L = \sqrt{\frac{A}{0.866\,N}}$$

Where:
- L = rectangular grid spacing for survey unit
- A = area of survey unit
- N = number measurement locations

Survey Unit areas, and the associated grid spacing, (L), using the equation above are presented in Table 4-1. A map showing the Transonic DUSA soil sample locations by survey unit based on this spacing are presented in Figures 4 through 6.

Table 4-1 Transonic Soil Grid Spacing

Survey Unit	Class	Area, m^2	Number of Data Points, n	Grid Spacing, L, m
1	2	9698	14	28.3
2	2	9837	14	28.5
3	2	8405	14	26.3
4	1	1775	14	12.1
5	1	2000	14	12.8
6	1	2000	14	12.8
7	1	2000	14	12.8
8	1	2000	14	12.8
9	1	1974	14	12.8
10	1	1990	14	12.8
11	1	2000	14	12.8
12	1	2000	14	12.8
13	1	2000	14	12.8
14	1	2000	14	12.8
15	1	1986	14	12.8
16	1	1936	14	12.6
17	1	1894	14	12.5
18	1	1287	14	10.3

4.3 Gamma Walkover Surveys

The gamma walkover surveys (GWS) were performed following MARSSIM protocol by walking straight parallel lines over an area while moving the detector in a serpentine motion, approximately 10 cm above the ground surface. The walking speed was maintained at approximately 0.5 meters per second. Survey passes were approximately one meter apart in all SUs. Although MARISSM recommends a GWS covering 10% to 100% of Class 2 areas, CABRERA judgmentally selected the most conservative approach. The final status survey consisted of a GWS of 100% of reasonably accessible Class 1 and Class 2 areas; and, sample collection and analysis.

The purpose of the GWS was to identify areas of elevated surface radioactivity. These surveys provide position-correlated instantaneous gross gamma count rates at a collection rate of one record per second. This was accomplished using a GPS with sub-meter accuracy coupled to a 3-inch by 3-inch NaI detector and ratemeter/scaler. Appendix F calculation indicates that the approximate detection sensitivity of the GWS is 38 pCi/gram for surficially deposited (0 to 15 cm) DU in 50-year equilibrium with its radioactive daughter products. The calculation is based on the methodology described by NRC 1997. It should be noted that the original decommissioning plan called for the use of a 2 by 2 NaI detector. To ensure detection of activity well below the ALARA target of 86 pCi/g for ^{238}U a detector capable of providing greater sensitivity was used.

Figure 3 shows the results of the FSS gamma walkover survey for the Transonic DUSA. The GWS is based on approximately 74,000 data points spread over the 18 Survey Units. The upper range of the GWS cpm legend shown on Figure 3 is equivalent to 105 pCi/g DU. The FSS GWS shows smoothed plots based on the final remediated Survey Units. All remediated areas average less than 41,000 cpm calculated empirically to be less than the ALARA target of 86 pCi/g ^{238}U.

The soil area within the perimeter of the X-ray 2 structure could not be surveyed as part of the GWS. This area was gridded and surveyed separately by taking 1-minute fixed gamma counts in each of the 1 square meter (m^2) grid units. The results can be seen in Figure 7.

5.0 RESULTS

5.1 Soil Sample Results

As shown in Figure 2 soil survey areas were divided into three Class 2 SUs (SU-1through SU-3) and fifteen Class 1 SUs (SU-4 through SU-18). Fourteen soil samples were collected from each SU and sent to Paragon Analytics (a division of Data Chem Laboratories, Inc) for gamma spectroscopy analysis. EPA analysis methodology 901.1, Modified, was utilized for the analysis. Results are reported in terms of dry weight activity per gram of soil. Appendix D presents the results of 252 soil samples from the Class 1 and Class 2 survey units. Class 2 sample IDs are 36 through 76 and the Class 1 sample IDs are 77 through 286.

Statistical results for these 18 survey units are presented below. All soil sample results are below the ALARA goal of 86 pCi/g for ^{238}U. Sample activity for ^{238}U is inferred via the direct measurement of Th-234 decay progeny using gamma spectroscopy analysis.

5.1.1 SU-1 Results

The results for the 14 samples (Field IDs 36 through 49) collected and analyzed in this Class 2 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 1.5 pCi/g, with a standard deviation of 1.3 pCi/g, and a maximum of 3.5 pCi/g. See Appendix D for the full list of soil sample results and Figure 4 for soil sample locations.

5.1.2 SU-2 Results

The results for the 14 samples (Field IDs 50 through62) collected and analyzed in this Class 2 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 2.6 pCi/g, with a standard deviation of 2.8 pCi/g, and a maximum of 8.7 pCi/g. See Appendix D for the full list of soil sample results and Figure 4 for soil sample locations.

5.1.3 SU-3 Results

The results for the 14 samples (Field IDs 63 through 76) collected and analyzed in this Class 2 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 4.9 pCi/g, with a standard deviation of 5.5 pCi/g, and a maximum of 16 pCi/g. See Appendix D for the full list of soil sample results and Figure 4 for soil sample locations.

5.1.4 SU-4 Results

The results for the 14 samples (Field IDs 77 through 90) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 1.3 pCi/g, with a standard deviation of 1.0 pCi/g, and a maximum of 3.2 pCi/g. See Appendix D for the full list of soil sample results and Figure 5 for soil sample locations.

5.1.5 SU-5 Results

The results for the 14 samples (Field IDs 91 through 104) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 2.1 pCi/g, with a standard deviation of 2.0 pCi/g, and a maximum of 7.1 pCi/g. See Appendix D for the full list of soil sample results and Figure 5 for soil sample locations.

5.1.6 SU-6 Results

The results for the 14 samples (Field IDs 105 through118) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 6.6 pCi/g, with a standard deviation of 7.3 pCi/g, and a maximum of 26 pCi/g. See Appendix D for the full list of soil sample results and Figure 5 for soil sample locations.

5.1.7 SU-7 Results

The results for the 14 samples (Field IDs 119 through 132) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 8.2 pCi/g, with a standard deviation of 9.9 pCi/g, and a maximum of 29 pCi/g. See Appendix D for the full list of soil sample results and Figure 6 for soil sample locations.

5.1.8 SU-8 Results

The results for the 14 samples (Field IDs 133 through 146) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 5.3 pCi/g, with a standard deviation of 7.4 pCi/g, and a maximum of 26 pCi/g. See Appendix D for the full list of soil sample results and Figure 6 for soil sample locations.

5.1.9 SU-9 Results

The results for the 14 samples (Field IDs 147 through 160) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 1.6 pCi/g, with a standard deviation of 1.5 pCi/g, and a maximum of 5.3 pCi/g. See Appendix D for the full list of soil sample result and Figure 6 for soil sample locations.

5.1.10 SU-10 Results

The results for the 14 samples (Field IDs 161 through 174) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 1.0 pCi/g, with a standard deviation of 1.4 pCi/g, and a maximum of 3.4 pCi/g. See Appendix D for the full list of soil sample results and Figure 6 for soil sample locations.

5.1.11 SU-11 Results

The results for the 14 samples (Field Ids 175 through 188) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 1.7 pCi/g, with a standard deviation of 1.6 pCi/g, and a maximum of 5.3 pCi/g. See Appendix D for the full list of soil sample results and Figure 5 for soil sample locations.

5.1.12 SU-12 Results

The results for the 14 samples (Field IDs 189 through 202) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 14 pCi/g, with a standard deviation of 18 pCi/g, and a maximum of 56 pCi/g. See Appendix D for the full list of soil sample results and Figure 5 for soil sample locations.

5.1.13 SU-13 Results

The results for the 14 samples (Field IDs 203 through 216) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 11 pCi/g, with a standard deviation of 18 pCi/g, and a maximum of 66 pCi/g. See Appendix D for the full list of soil sample results and Figure 6 for soil sample locations.

5.1.14 SU-14 Results

The results for the 14 samples (Field IDs 217 through 230) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 6.5 pCi/g, with a standard deviation of 14 pCi/g, and a maximum of 54 pCi/g. See Appendix D for the full list of soil sample results and Figure 6 for soil sample locations.

5.1.15 SU-15 Results

The results for the 14 samples (Field IDs 231 through 244) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 2.8 pCi/g, with a standard deviation of 1.4 pCi/g, and a maximum of 5.7 pCi/g. See Appendix D for the full list of soil sample results and Figure 5 for soil sample locations.

5.1.16 SU-16 Results

The results for the 14 samples (Field IDs 245 through 258) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 2.5 pCi/g, with a standard deviation of 2.2 pCi/g, and a maximum of 6.4 pCi/g. See Appendix D for the full list of soil sample results and Figure for 6 soil sample locations.

5.1.17 SU-17 Results

The results for the 14 samples (Field IDs 259 through 272) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for^{238}U. The ^{238}U results for this SU average 4.4 pCi/g, with a standard deviation of 8.2 pCi/g, and a maximum of 31 pCi/g. See Appendix D for the full list of soil sample results and Figure 6 for soil sample locations.

5.1.18 SU-18 Results

The results for the 14 samples (Field IDs 273 through 286) collected and analyzed in this Class 1 SU are below the ALARA target of 86 pCi/g for ^{238}U. The ^{238}U results for this SU average 7.4 pCi/g, with a standard deviation of 21 pCi/g, and a maximum of 79 pCi/g. See Appendix D for the full list of soil sample results and Figure 6 for soil sample locations.

5.1.19 Building Soil Sample Results

As discussed previously, there is no "floor" associated with the X-Ray Building 2. Rather, the structure rests directly on soil. Thirteen soil samples were collected utilizing a 1-meter square grid system. The soil samples collected from X-Ray Building 2 show overall low levels of activity in the soil, well below the ALARA goal. Soil sample ^{238}U results for the X-Ray Building 2 average 4.8 pCi/g, with a standard deviation of 4.6 pCi/g, and a maximum of 14 pCi/g. See Appendix D for the full list of soil sample results for the area under the X-ray building and Figure 7 for soil sample locations.

5.2 Alpha Spectroscopy

Alpha spectroscopy analyses were performed in order to verify that uranium activity concentrations were consistent with DU. CABRERA submitted a request to the NRC (See Appendix B) to reduce the required number of samples from 75 to three. That request was approved and five samples were ultimately collected and submitted for analysis.

Appendix D provides the alpha spectroscopy results from the 5 samples. The unadjusted raw alpha spectroscopy results are shown in this table. The low level of DU activity in the Transonic soils may become "masked" by background levels of naturally occurring uranium isotopes in the soil. The raw results may be adjusted for the background level of uranium isotopes so that more meaningful ratios of the DU uranium isotopes may be ascertained.

The background concentration of uranium at the Transonic Range is based on the "U.S. Geological Survey Digital Data Series, DDS-9, 1993." The total concentration of naturally occurring uranium in the Maryland coastal areas is shown in the reference as approximately 2 ppm total uranium. The activity concentration of ^{238}U uranium based on soil ppm levels may be calculated from the equation:

$$pCi/g_{U-238} = \frac{mg/kg}{2.8 \times 10^{-12} \times gmw \times T_{1/2}}$$

where,

mg/kg = ppm of ^{238}U

2.8×10^{-12} = units conversion constant

gmw = gram molecular weight of the ^{238}U isotope, 238.05 and,

$T_{1/2}$ = half life in years of the isotope, 4.47×10^{9}

And,

$pCi/g_{U-238} = 0.67$

The naturally occurring activity of ^{238}U in the soil is about 0.7 pCi/g. The naturally occurring uranium progeny ^{234}U is in secular equilibrium with ^{238}U and is therefore also present at levels of approximately 0.7 pCi/g.

The ^{235}U isotope activity values may be estimated from the natural uranium $^{235}U/^{238}U$ mass ratio of $0.7/99.3 = 7.05 \times 10^{-3}$ and the above equation:

where,

mg/kg = ppm of $^{238}U \times 7.05 \times 10^{-3} = 1.41 \times 10^{-2}$

2.8×10^{-12} = units conversion constant

gmw = gram molecular weight of the ^{235}U isotope, 235.04 and,

$T_{1/2}$ = half life in years of the isotope, 7.05×10^8

And,

$pCi/g_{U\text{-}235} = 0.03$

Table 5-1 provides the background-adjusted values for the Transonic alpha spectroscopy soil samples.

Table 5-1. Alpha Spectroscopy Background Adjusted Uranium Concentrations in Transonic Soil

Sample ID	U-234		(pCi/gram)	U-235		(pCi/gram)	U-238		(pCi/gram)	U-Total		(pCi/gram)
129	3.771	±	0.660	0.469	±	0.120	24.601	±	3.400	28.840	±	3.466
144	1.601	±	0.430	0.149	±	0.740	9.401	±	0.340	11.150	±	0.921
207	4.511	±	0.790	0.479	±	0.140	32.601	±	4.600	37.590	±	4.669
214	0.411	±	0.230	0.196	±	0.081	1.461	±	0.410	2.067	±	0.477
229	0.221	±	0.170	0.051	±	0.038	1.931	±	0.390	2.202	±	0.427

The background adjusted alpha spectroscopy results are converted into activity fractions that may be used to verify that the uranium activity concentrations are consistent with DU. Table 5-2 provides the individual soil sample activity fractions and the average activity fraction. An entry for natural uranium is also included.

Appendix A of this report "Transonic DCGL Summary" provides ranges of soil uranium activity fractions. The range of DU activity values listed in Appendix A are 0.138 to 0.222 for ^{234}U, 0.193 to 0.0234 for ^{235}U, and 0.759 to 0.839 for ^{238}U. Table 5-2 values compare well with the report activity fractions and demonstrate increased ^{238}U activity fractions, decreased ^{234}U fractions in all cases, and decreased ^{235}U fractions in all but one case.

Table 5-2. Alpha Spectroscopy Background Adjusted Activity Fractions In Transonic Soil

Sample ID	U-234	U-235	U-238
129	0.13	0.02	0.85
144	0.14	0.01	0.84
207	0.12	0.01	0.87
214	0.20	0.09	0.71
229	0.10	0.02	0.88
Sample Average	0.14	0.03	0.83
natural uranium	0.49	0.02	0.49

6.0 QUALITY ASSURANCE / QUALITY CONTROL

6.1 Field Replicate Sample Analyses

Replicate analyses were performed on approximately 10% (38 replicates) of the soil samples sent for analysis. This entailed performing separate analyses on a split sample and comparing the results statistically. The samples were numbered using a unique identifier. Field replicate analyses were compared to the initial analytical results by determining a Z-score value for each data set by the following equation:

$$Z = \frac{|S - D|}{\sqrt{\sigma_S^2 + \sigma_D^2}}$$

Where: S, D, ≡ value of (S)ample and (D)uplicate measurements; and,
σ ≡ one sigma error associated with (S)ample and (D)uplicate measurements.

The calculated Z-Score results were compared to a performance criteria of less than or equal to 2.57. The value of 2.57 corresponds to a 99% confidence level, or, 99% of the Z-Score values will be below 2.57, and only 1% of the values will be above this acceptance criteria, if the sample and the duplicate are truly of the same distribution. Calculated Z-values less than 2.57 are considered acceptable and values greater than 2.57 are investigated for possible discrepancies in analytical precision, or for sources of disagreement with the following assumptions of the test:

- the sample measurement and duplicate or replicate measurement are of the same normally distributed population
- the standard deviations, σ_S and σ_D, represent the true standard deviation of the measured population

One sample duplicate pair did not pass the Z-score performance criteria of less than or equal to 2.57. Sixty-two soil samples, or approximately 24% of the total number of samples collected were analyzed as duplicates. One duplicate comparison would be expected to fail due to natural statistical fluctuation in the population of data. The results are presented in Appendix E.

6.2 Field Instrumentation Quality Control Results

Data collection activities were performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. The Project Engineer ensured that individuals were appropriately trained to use project instrumentation and other equipment, and that instrumentation met the required detection sensitivities.

6.2.1 Calibration Requirements

Radiological instruments were used to scan equipment, personnel, and clothing for radiological contamination and for performance of the GWS. This equipment included Geiger-Mueller detectors, alpha-beta scintillation probes, NaI scintillation detectors, and smear count rate instrumentation. Many of these instruments were used for health and safety purposes and to guide remediation activities, while NaI detectors and GPS units were used directly to generate FSS data and establish FSS sample locations.

Current calibration/maintenance records were kept on site for review and inspection (included in Appendix H). The records include, at a minimum, the following:

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

Instrumentation was maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments were maintained. Instruments were calibrated at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using NIST traceable sources.

6.2.2 Sodium Iodide (NaI) Gross Gamma Systems

Sodium iodide detectors were used directly to generate FSS data. Ludlum 44-20 NaI detectors coupled to count rate meters and Digital Global Positioning System were used to perform gamma walk-over surveys. Instruments were calibrated within one year of the FSS at a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using NIST-traceable standards.

Instruments were response checked daily for quality control by comparing the instrument response to a designated cesium-137 (^{137}Cs) source. Response checks consisted of a one-minute integrated count of the ^{137}Cs source positioned in a reproducible geometry (i.e., a jig). The acceptance criterion for these instrument response checks is within +/- 20% of the mean response generated using ten initial source checks. Results of daily response checks are provided, along with calibration certificates, as Appendix G to this report.

6.2.3 Daily Field Checks

GPS units were used directly to generate FSS GWS data and locate FSS sample locations. GPS point features were collected at the beginning and end of the day at a fixed location established at the beginning of the FSS. Results of these feature counts were compared to the mean of a series of sequential initial positions. This data was entered into a spreadsheet and examined to ensure less than one-meter variability. Results of daily field checks are provided as Appendix G this report.

7.0 REFERENCES

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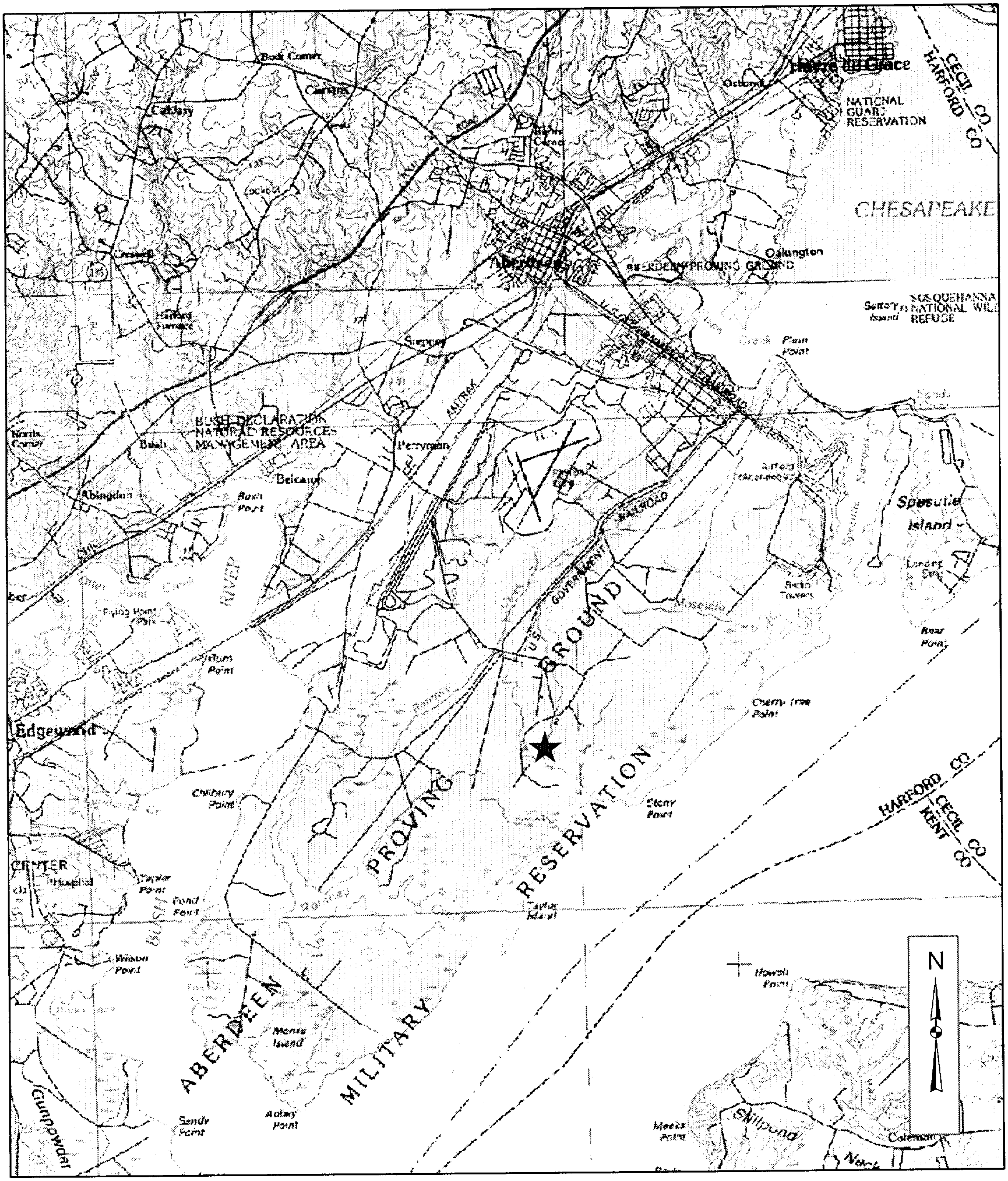
(NRC 1997) NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions,* December 1997.

(NRC 2000) NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM), Revision 1, August 2000.

Figures 1 - 7

Figure 1 - Site Overview



★ APG Transonic Range Location

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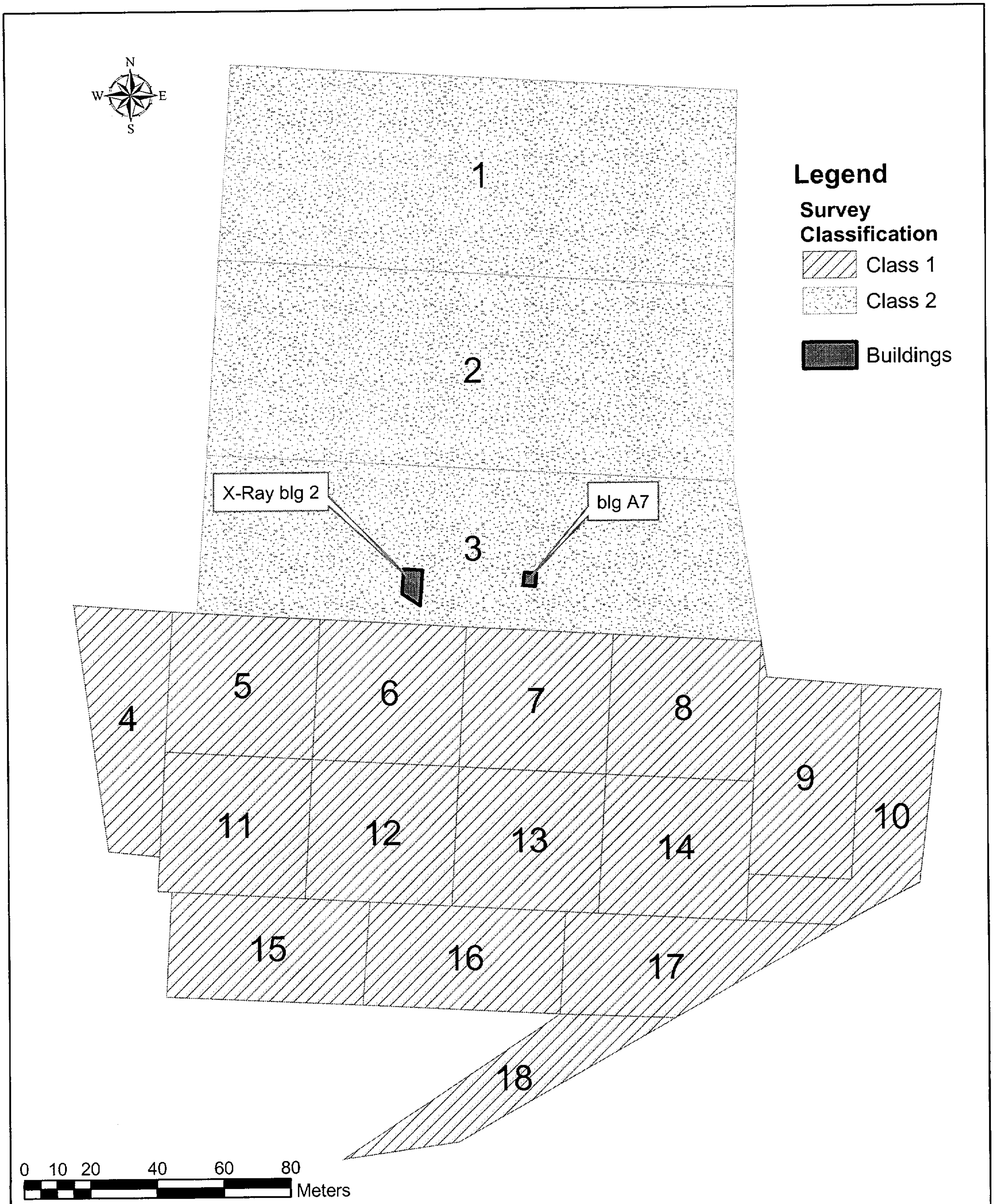
Figure -2 Site Survey Classification and Survey Units-



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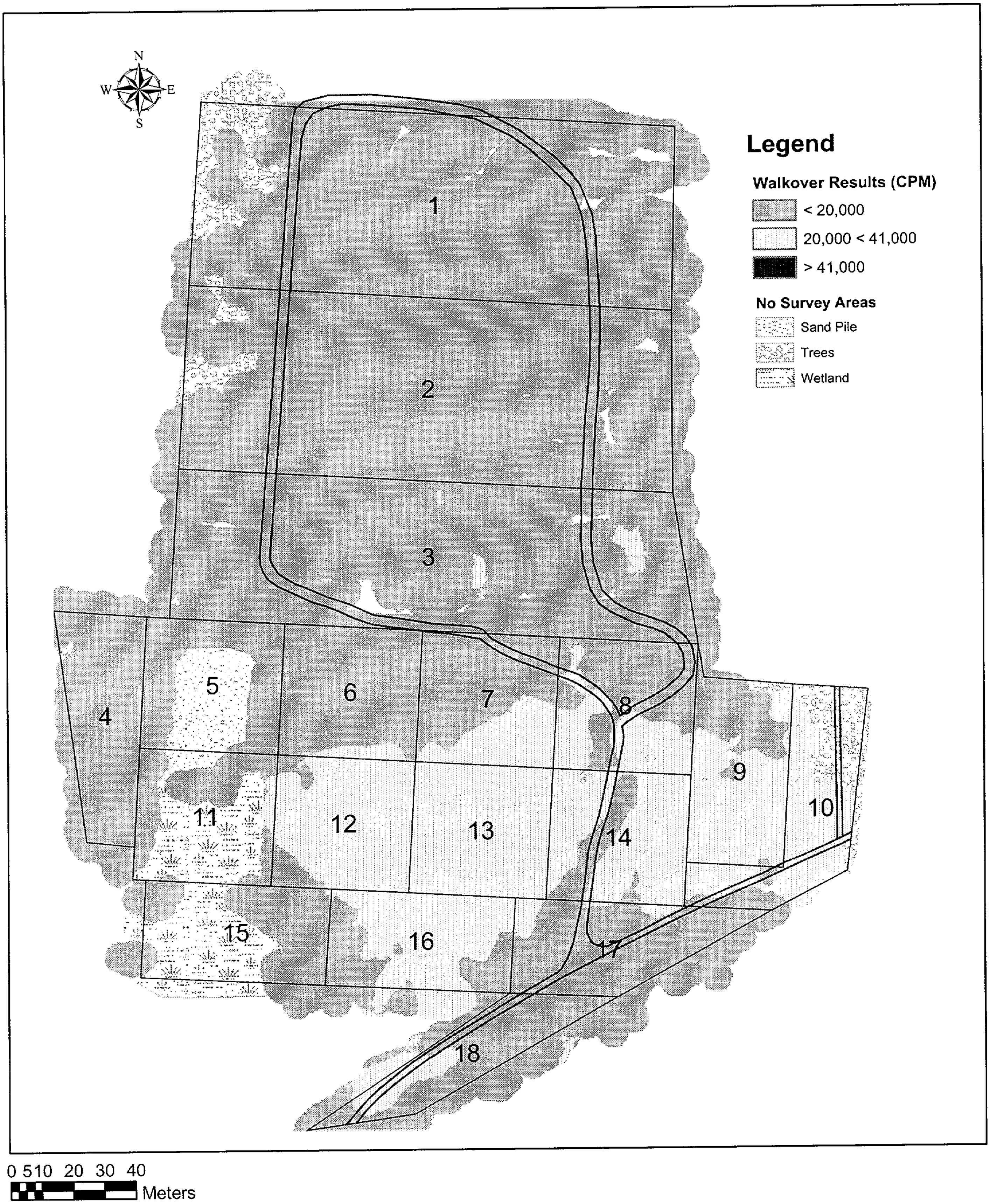
Site Survey Classification and Survey Units

APG Transonic Range

Date: November 2004
Project #: 03-3004.00
File Name: 03-3004-00_Fig2_SurveyClass.mxd
Prepared By: JTM

Figure 2

Figure 3- Gamma Walkover Survey Results



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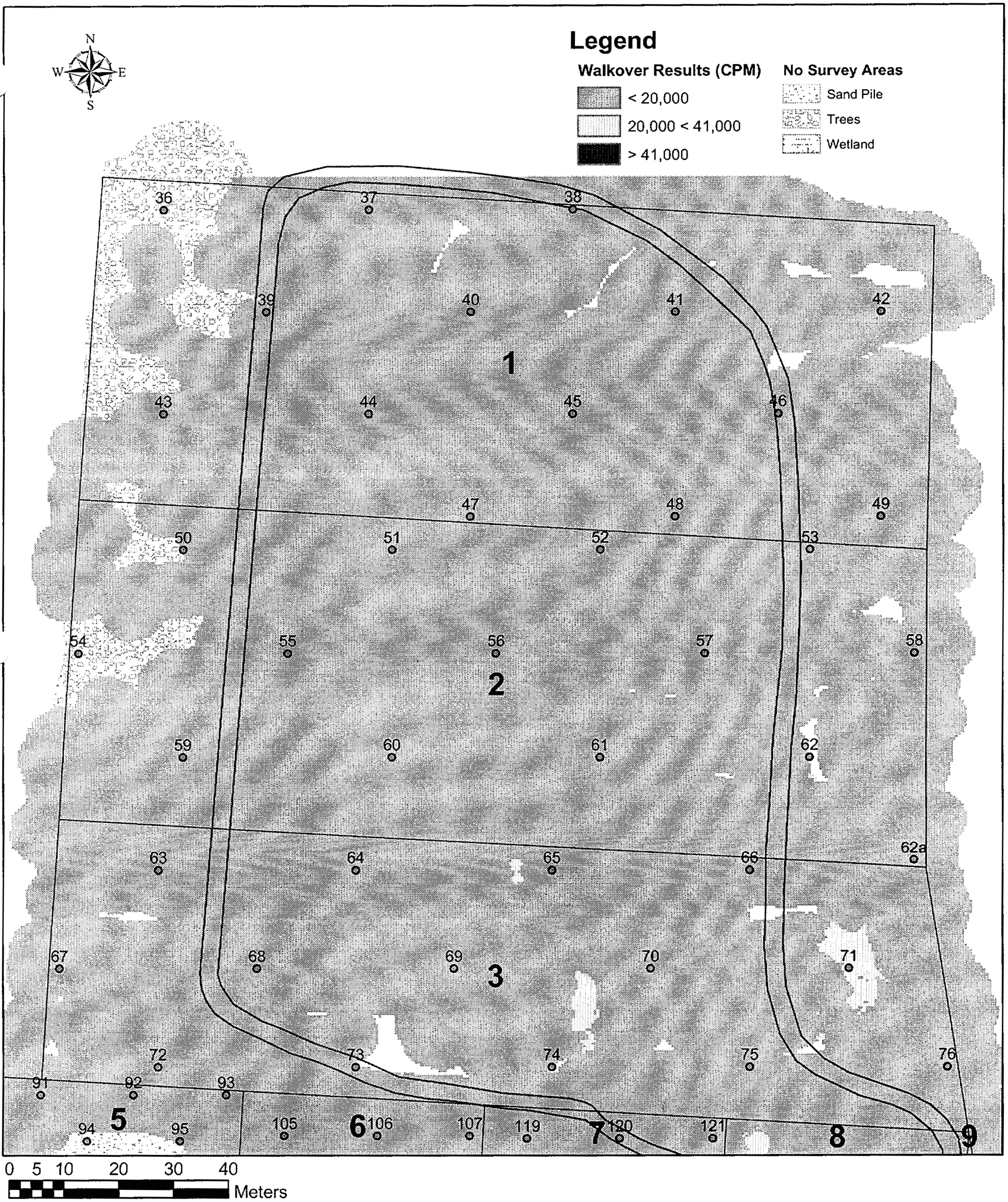
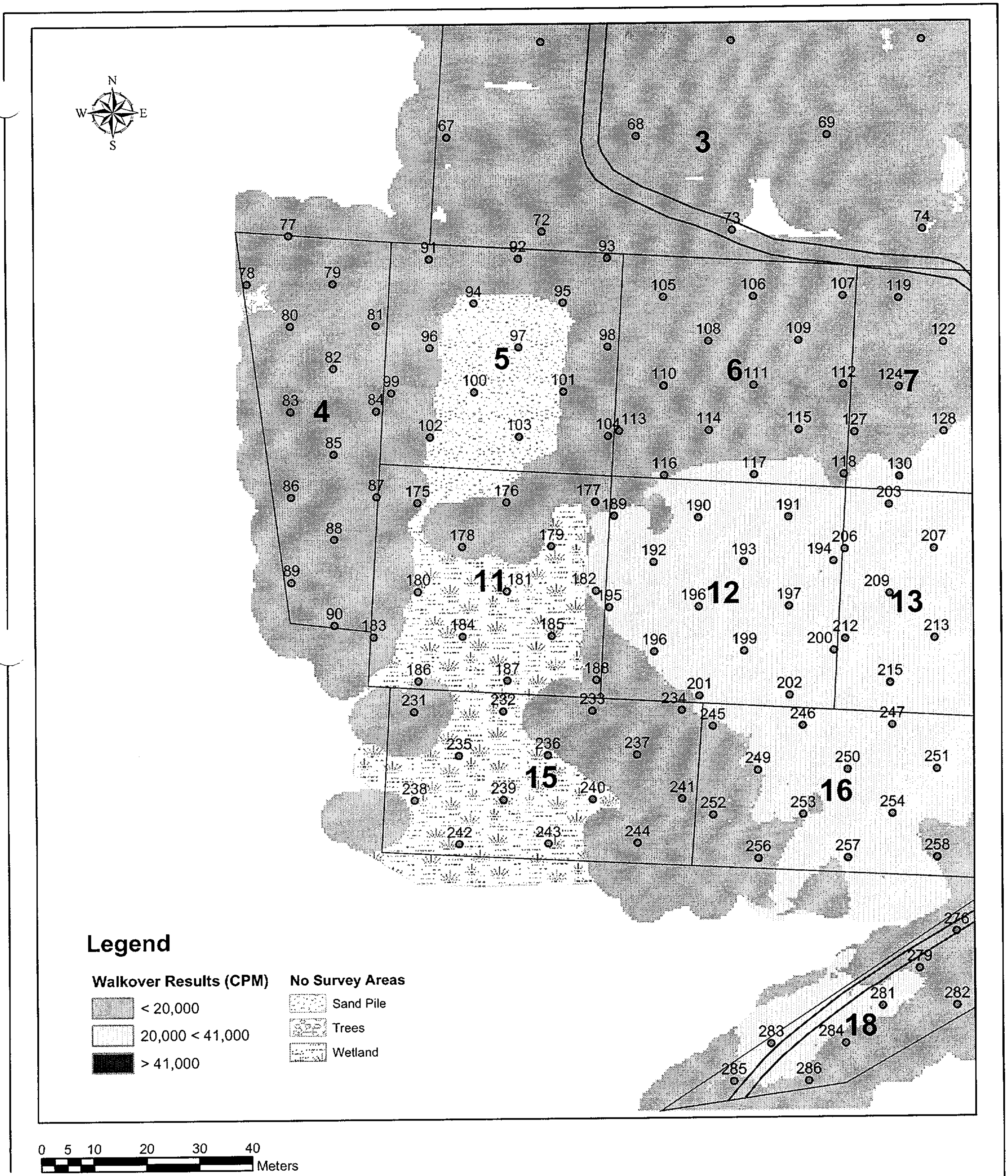
Gamma Walkover Survey Results	Date: November 2004 Project #: 03-3004.00	**Figure 3**
APG Transonic Range	File Name: 03-3004-00_Fig3_GWS.mxd Prepared By: JTM	

Figure 4 - Soil Sample Locations Class 2 Survey Units-



CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	Soil Sample Locations Class 2 Survey Units	Date: November 2004 Project #: 03-3004.00	**Figure 4**
	APG Transonic Range	File Name: 03-3004-00_Fig4.mxd Prepared By: JTM	

Figure -5- Soil Sample Locations Class 1 Survey Units SW Areas



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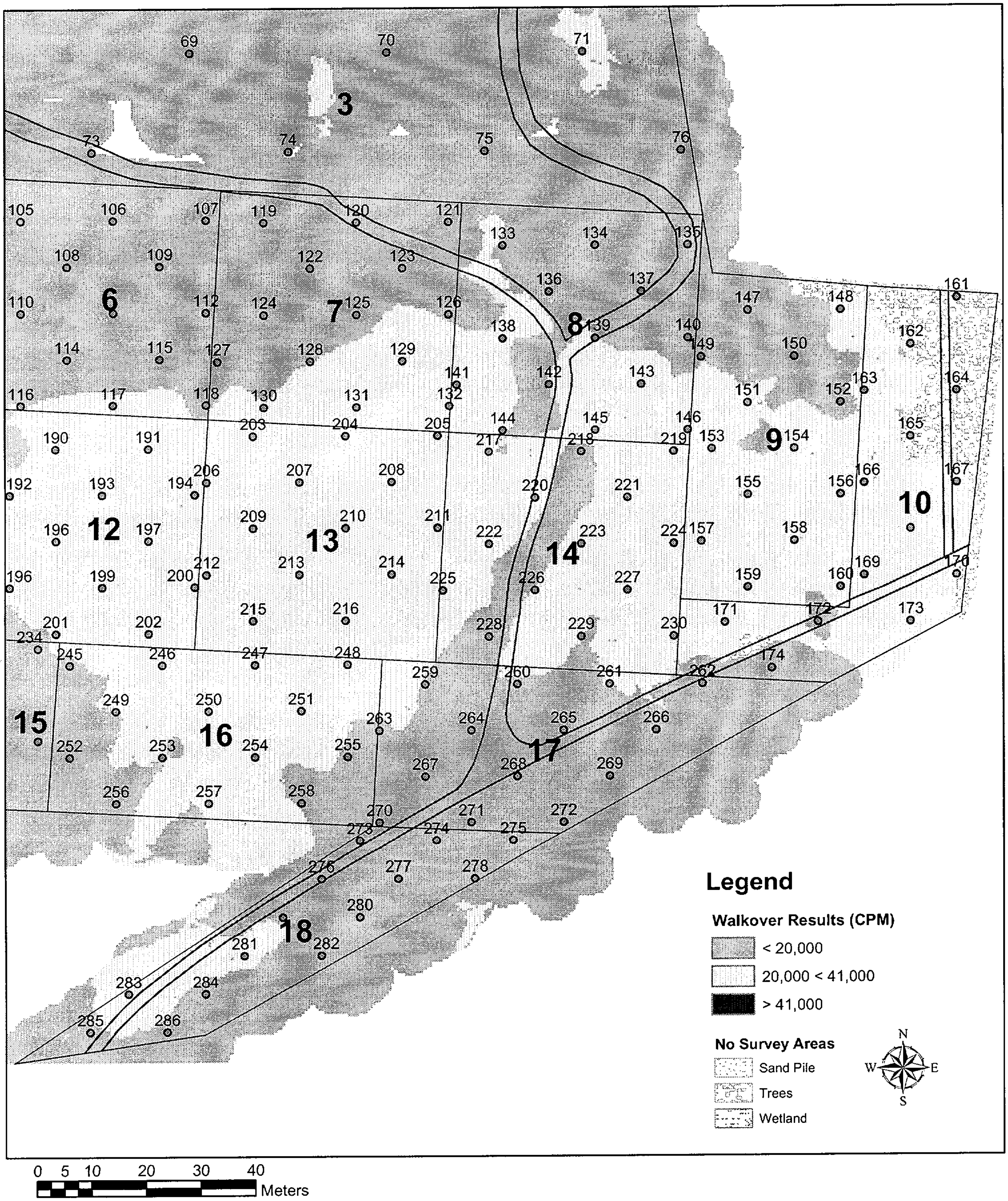
Soil Sample Locations Class 1 Survey Units South West Areas	Date: November 2004		Figure 5
	Project #: 03-3004.00		
APG Transonic Range	File Name: 03-3004-00_Fig5.mxd		
	Prepared By: JTM		

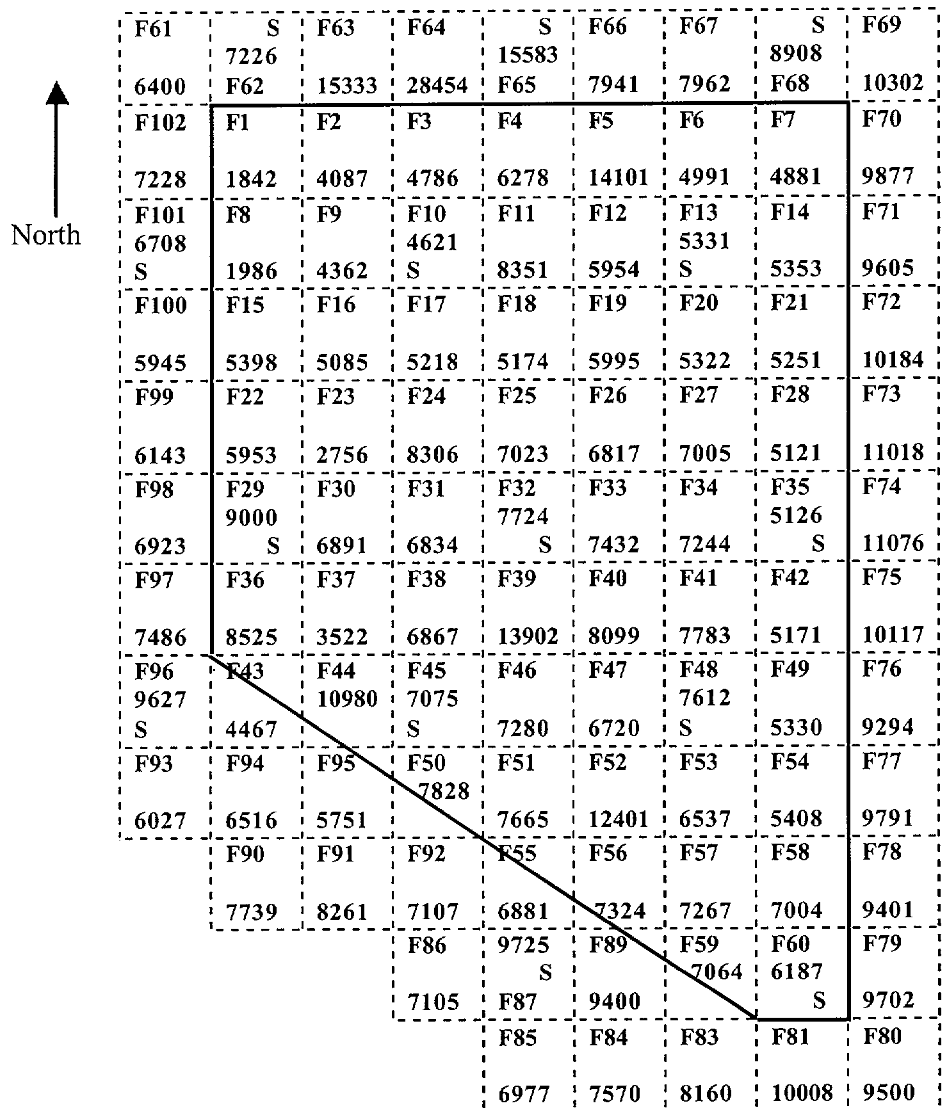
Figure - 6- Soil Sample Locations Class 1 Survey Units SE Areas



CABRERA SERVICES RADIOLOGICAL · ENVIRONMENTAL · REMEDIATION WWW.CABRERASERVICES.COM	Soil Sample Locations Class 1 Survey Units South East Areas **APG Transonic Range**	Date: November 2004 Project #: 03-3004.00 File Name: 03-3004-00_Fig6.mxd Prepared By: JTM	**Figure 6**

Figure 7 - X- Ray 2 Building Floor and Grounds Scan

Figure 7 – X-Ray 2 Floor and Grounds Scan



Notes:

- - - - - - - - - - 1 meter grid lines

———— Structural Walls;

S Soil Sample Locations (Random Start Triangular Grid)

NNNN 1 minute fixed count

Grid F1,F8,F15,F22,F29, and F36 are on a steel plate

1 inch thick metal plate on ground at grids F23, F30, and F37

Some wood and trash on ground on grids F90 and F91

Appendix A

Transonic DCGL Summary

Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range Aberdeen Proving Ground, Maryland

April 1999

prepared by

CONTENTS

TABLES

NOTATION

The following is a list of the acronyms, initialisms, and abbreviations (including units of measure) used in this document.

ACRONYMS, INITIALISMS, AND UNITS OF MEASURE

APG	Aberdeen Proving Ground
cm	centimeter(s)
DOE	U.S. Department of Energy
DU	depleted uranium
g	gram(s)
ha	hectare(s)
in.	inch(es)
km	kilometer(s)
mi	mile(s)
mrem	millirem(s)
pCi	picocurie(s)
yr	year(s)

DERIVED URANIUM GUIDELINES FOR THE DEPLETED URANIUM STUDY AREA OF THE TRANSONIC RANGE, ABERDEEN PROVING GROUND, MARYLAND

by

M. Picel and S. Kamboj

SUMMARY

Guidelines for depleted uranium (DU) residual radioactive material in soil were derived for the Depleted Uranium Study Area of the Transonic Range at the Aberdeen Proving Ground (APG), Maryland.

The Depleted Uranium Study Area (the site) is located within the boundaries of the Transonic Range in the Aberdeen Area of the APG. The APG lies along the western shore of the Chesapeake Bay in Harford and Baltimore Counties, Maryland, approximately 24 km (15 mi) northeast of Baltimore. The site occupies approximately 5 ha (12 acres) on the southeast end of the Transonic Range; the site became contaminated as a result of DU testing activities that were performed at the site between 1973 and 1979.

Single-nuclide and total-uranium guidelines were derived on the basis of the requirement that following remedial action, the 50-year committed effective dose equivalent to a hypothetical individual living or working in the immediate vicinity of the site should not exceed a dose constraint of 25 mrem/yr. The U.S. Department of Energy (DOE) RESidual RADioactive material guideline computer code, RESRAD (Yu et al. 1993), was used in this evaluation. RESRAD implements the methodology described in the DOE manual for establishing residual radioactive material guidelines.

Two scenarios were considered; both assumed that for a period of 1,000 years following remedial action, the site would be used without radiological restrictions. The two scenarios varied with regard to the type of site use, time spent at the site by the exposed individual, and sources of food and water consumed. The evaluation indicated that the dose constraint of 25 mrem/yr would not be exceeded for DU within 1,000 years, provided that the soil concentration of DU at the Study Area of the Transonic Range did not exceed 800 pCi/g for the industrial-worker scenario or 230 pCi/g for the resident-farmer scenario. For this evaluation, uranium activity ratios were calculated from the soil sampling data; three cases were formulated in which sampling data were grouped differently.

The uranium guidelines derived in this analysis apply to the total activity concentration of uranium isotopes (i.e., uranium-234, uranium-235, and uranium-238) present in their mean activity concentration ratios of 0.21:0.021:0.77, 0.14:0.023:0.84, and 0.22:0.019:0.76, respectively, in the three cases (i.e., DU activity ratios in three cases). Consequently, if uranium-238 was measured as the indicator radionuclide for DU, the soil concentration limits would be 660 to 670 pCi/g for the industrial-worker scenario and 190 pCi/g for the resident-farmer scenario.

These derived guidelines were calculated on the basis of a dose constraint of 25 mrem/yr for both scenarios. In establishing the actual guidelines to be used for cleanup of the site, the as-low-as-reasonably-achievable (ALARA) approach could be incorporated into the decision-making process, along with such other factors as whether a particular scenario is reasonable and appropriate.

1 DERIVATION OF CLEANUP GUIDELINES

The purpose of this analysis was to derive the residual radioactive material guidelines for uranium (i.e., uranium-234, uranium-235, uranium-238, and depleted uranium [DU]) in soil that would be applicable for the cleanup at the Depleted Uranium Study Area of the Transonic Range at the Aberdeen Proving Ground (APG), Maryland. The derived guidelines represent the residual concentration of DU in soil in a homogeneously contaminated area that must not be exceeded if the site is to be released for use without radiological restrictions. The uranium guideline is derived for natural uranium by assuming that uranium-234, uranium-235, and uranium-238 are present in their natural activity concentration ratio of 0.49:0.022:0.49. For DU, three cases were analyzed in which activity was present in mean concentration ratios of 0.211:0.0205:0.768, 0.222:0.0193:0.759, and 0.138:0.234:0.839. These cases varied in that the soil sampling data were evaluated in three different ways (groupings).

Site-specific uranium guidelines for the Depleted Uranium Study Area of the Transonic Range were derived on the basis of a dose constraint of 25 mrem/yr. Version 5.82 of the RESRAD computer code (Yu et al. 1993) was used to derive these guidelines. RESRAD implements the methodology described in the U.S. Department of Energy (DOE) manual for establishing residual radioactive material guidelines (Yu et al. 1993).

1.1 DEPLETED URANIUM ACTIVITY CONCENTRATION RATIO DETERMINATION

A comprehensive radiological characterization of the site was performed from December 1995 through May 1996 (General Physics Corp. 1996). The soil samples were collected at 45 biased and 5 random locations. For each sampling location, soil was collected from 1- to 3-in. (3- to 8-cm) and 3- to 6-in. (8- to 15-cm) depth intervals. Samples were analyzed for uranium-234, uranium-235, and uranium-238. A total of 100 samples were analyzed as presented in Table 1. Soil data from this radiological characterization were used in deriving the uranium isotope's activity concentration ratio. The sample data were analyzed in three different ways in order to arrive at the most representative ratio for the three uranium isotopes. This approach would also provide the possible range of guideline values appropriate for the site. In the first case, all 100 samples were evaluated together; in the second case, only those samples that had uranium-235 activity concentrations greater than 1 pCi/g were grouped (35 samples):

TABLE 1 Soil Sampling Results for the Depleted Uranium Study Area[a]

		Concentration in Soil (pCi/g)		
Grid	Sample[b]	Uranium-234	Uranium-235	Uranium-238
A1	TRB27A	17	3.1	120
	TRB27B	2.2	0.18	10
	TRB47A	1.1	0.16	7.5
	TRB47B	0.74	0.10	4.6
	TRB48A	1.6	0.30	11
	TRB48B	1.12	0.10	3.5
A2	TRB28A	49,000	8,300	370,000
	TRB28B	1.4	0.12	5.5
	TRB29A	220	49	1,500
	TRB29B	16,000	2,800	87,000
	TRB31A	0.94	0.065	1.4
	TRB31B	0.74	0.037	0.96
	TRQ02A	0.75	0.091	2.6
	TRQ02B	23	6.2	180
A3	TRQ03A	1.7	0.30	12
	TRQ03B	0.89	0.075	3.8
	TRB32A	0.60	0.015	1.6
	TRB32B	0.36	0.058	1.5
	TRB33A	0.85	0.0055	1.1
	TRB33B	0.67	0.041	1.0
A4	TRB52A	3.7	0.74	26
	TRB52B	1.4	0.22	6.9
	TRB53A	9.6	1.4	66
	TRB53B	2.7	0.39	17
	TRB54A	2.1	0.32	13
	TRB54B	5.9	0.86	44
A5	TRB34A	1.4	0.14	4.6
	TRB34B	1.1	0.043	2.0
	TRB35A	0.33	0.0022	0.33
	TRB35B	0.19	0.0093	0.19
	TRB36A	0.50	0.027	1.3
	TRB36B	0.57	0.028	1.1
	TRB50A	0.95	0.099	3.8
	TRB50B	0.86	0.061	2.1
	TRB51A	0.87	0.092	2.7
	TRB51B	1.7	0.19	7.8
B1	TRB12A	5.0	0.70	30
	TRB12B	2.0	0.13	4.6
	TRB13A	2.3	0.34	11
	TRB13B	0.83	0.026	1.5
	TRQ05A	1.8	0.27	9.2
	TRQ05B	4.2	0.71	27

TABLE 1 (Cont.)

		Concentration in Soil (pCi/g)		
Grid	Sample[b]	Uranium-234	Uranium-235	Uranium-238
B2	TRB08A	8,100	2,400	40,000
	TRB08B	36	7.1	230
	TRB09A	9,700	1,800	49,000
	TRB09B	10	1.6	63
	TRB10A	13,000	1,400	88,000
	TRB10B	40	4.9	250
	TRB11A	220	33	1,600
	TRB11B	16	2.9	120
B3	TRB03A	9.4	1.6	61
	TRB03B	4.0	0.86	30
	TRB04A	17	2.6	120
	TRB04B	21	2.9	140
	TRB05A	11	1.8	76
	TRB05B	12	1.8	96
	TRB06A	110	23	840
	TRB06B	72	8.6	590
B4	TRB00A	39,000	4,900	260,000
	TRB00B	3.0	0.34	16
	TRB01A	9.4	1.7	67
	TRB01B	3.3	0.46	22
	TRB02A	0.36	0.0067	0.91
	TRB02B	0.32	0.0034	1.7
B5	TRB14A	0.57	0.012	2.2
	TRB14B	0.5	0.0047	1.2
C1	TRB26A	1.0	0.13	2.7
	TRB26B	1.2	0.11	1.3
	TRB45A	1.4	0.18	5.0
	TRB45B	1.1	0.091	1.7
	TRB46A	11	1.7	77
	TRB46B	1.3	0.064	1.5
C2	TRQ10A	1.5	0.18	10
	TRQ10B	0.32	0.011	1.4
	TRB22A	28	4.4	190
	TRB22B	10	1.6	65
	TRB23A	4,400	520	3,300
	TRB23A[c]	17	2.4	140
	TRB24A	200	26	1,500
	TRB24B	160	41	900
	TRB25A	5,800	1,000	44,000
	TRB25B	6.7	1.2	45

TABLE 1 (Cont.)

		Concentration in Soil (pCi/g)		
Grid	Sample[b]	Uranium-234	Uranium-235	Uranium-238
C3	TRB21A	3.6	0.74	22
	TRB21B	1.2	0.026	2.5
	TRQ11A	4.3	0.75	21
	TRQ11B	0.66	0.025	1.1
C4	TRB18A	0.87	0.12	1.8
	TRB18B	0.94	0.0010	1.6
	TRB19A	46	6.3	290
	TRB19B	0.87	0.028	2.1
C5	TRB16A	0.51	0.027	0.80
	TRB16B	0.56	0.027	0.62
	TRB17A	5.6	0.91	41
	TRB17B	0.82	0.095	3.5
	TRB49A	0.94	0.10	2.5
	TRB49B	3.0	0.39	19
Z2	TRB39A	20,000	3,000	130,000
	TRB39B	10,000	3,100	63,000
	TRQ14A	1.1	0.083	2.2
	TRQ14B	0.62	0.0019	0.90

[a] Source: General Physics Corporation (1996). Activity concentrations are rounded to two significant figures.

[b] Samples ending with "A" are from the 0- to 3-in. sampling depth; samples ending with "B" are from the 3- to 6-in. sampling depth.

[c] A steel plate prevented collection from the 3- to 6-in. sampling depth at location TRB23. An additional sample was collected from the 0- to 3-in. depth 1 ft west of the first location.

and in the third case, 13 samples considered to be "hot spots" were excluded and only the remaining 87 samples were evaluated.

Table 2 gives the activity and weight range and the activity and weight percentages of each uranium isotope for all three cases. For comparison, Table 2 also includes activity and weight percentages for natural uranium. In all three cases, Table 2 shows that the weight percentages for uranium-235 are less than those for natural uranium, which indicates that the soil has DU. For one of the samples (TRB 28A), the uranium-238 activity (370,000 pCi/g) is greater than the uranium-238 specific activity of 336,000 pCi/g. This data point is suspect because the

TABLE 2 Statistical Analysis Based on Soil Data for Calculating the Activity Ratios

Case No.		Uranium-234	Uranium-235	Uranium-238
1[a]	Activity Range, pCi/g	0.19 – 49,000	0.001 – 8,300	0.19 – 370,000
	Weight Range, g/g-soil	3.1E-11 – 7.87E-6	4.63E-10 – 3.84E-3	5.65E-7 – 1.1
	Mean Activity (%)	21.1 ± 11.1	2.05 ± 0.97	76.8 ± 11.4
	Mean Weight (%)	0.00167 ± 0.00132	0.431 ± 0.286	99.6 ± 0.287
2[b]	Activity Range, pCi/g	6.7 – 49,000	1.2 – 8,300	45 – 370,000
	Weight Range, g/g-soil	1.08E-9 – 7.87E-6	5.56E-7 – 3.84E-3	1.34E-4 – 1.1
	Mean Activity (%)	13.8 ± 7.03	2.34 ± 1.02	83.9 ± 7.83
	Mean Weight (%)	0.000977 ± 0.00106	0.463 ± 0.366	99.5 ± 0.367
3[c]	Activity Range, pCi/g	0.19 – 46	0.001 – 6.3	0.19 – 290
	Weight Range, g/g-soil	3.1E-11 – 7.38E-9	4.63E-10 – 2.92E-6	5.65E-7 – 8.63E-4
	Mean Activity (%)	22.2 ± 11.3	1.93 ± 0.82	75.9 ± 11.2
	Mean Weight (%)	0.00175 ± 0.00126	0.404 ± 0.208	99.6 ± 0.208
Natural uranium	Activity (%)	48.9	2.25	48.9
	Weight (%)	≈0	0.7	99.3

[a] For case 1, all (total 100) samples were grouped together.

[b] For case 2, only samples with uranium-235 activity greater than 1 pCi/g (35 in all) were grouped together.

[c] For case 3, 13 hot samples were removed, and the remaining 87 samples were grouped together.

reported concentration implies that there is more mass of uranium-238 than the soil. For the three cases, mean activity percentages of uranium-234, uranium-235, and uranium-238 varied from 0.138:0.0234:0.839 to 0.222:0.0193:0.759. For comparison, the guideline values were derived for these three cases and also for natural uranium.

1.2 SCENARIO DEFINITIONS

Two potential exposure scenarios were considered for this assessment. For both scenarios, it was assumed that at some time within 1,000 years, the site would be released for use without radiological restrictions following the cleanup.

Consistent with U.S. Environmental Protection Agency (EPA) and U.S. Nuclear Regulatory Commission (NRC) protocols, potential radiation doses resulting from nine exposure pathways were considered in this evaluation: (1) direct exposure to external radiation from decontaminated soil material, (2) internal radiation from inhalation of contaminated dust, (3) internal radiation from inhalation of emanating radon-222, (4) internal radiation from ingestion of plant foods grown in the decontaminated area and irrigated with water drawn from a well located at the downgradient edge of the decontaminated area, (5) internal radiation from ingestion of meat from livestock fed with fodder grown in the decontaminated area and irrigated with water drawn from an on-site well, (6) internal radiation from ingestion of milk obtained from livestock fed with fodder grown in the decontaminated area and irrigated with water drawn from an on-site well, (7) internal radiation from ingestion of fish from a pond downgradient from the decontaminated area, (8) internal radiation from incidental ingestion of on-site soil, and (9) internal radiation from drinking water drawn from an on-site well. Table 3 summarizes the applicability of these exposure pathways to the three scenarios evaluated.

The industrial-worker scenario (the current and likely future use scenario) assumed continued industrial use of the site. Under this scenario, a hypothetical individual was assumed to work 8 hours per day at the site (6 hours working outdoors and 2 hours indoors), 5 days per week, 50 weeks per year. It was also assumed that the worker would not ingest water, plant foods, or fish obtained from the decontaminated area or meat or milk from livestock raised in the decontaminated area. The dose to the worker was assumed to be only from the decontaminated soil.

TABLE 3 Summary of Applicable Exposure Pathways for the Industrial-Worker and Resident-Farmer Scenarios at the Depleted Uranium Study Area of the Transonic Range

	Applicable Pathways for Two Scenarios	
Pathway	Industrial-Worker[a]	Resident-Farmer[b]
External gamma exposure	Yes	Yes
Inhalation of dust	Yes	Yes
Inhalation of radon	Yes	Yes
Ingestion of soil	Yes	Yes
Ingestion of plant foods	No	Yes
Ingestion of meat	No	Yes
Ingestion of milk	No	Yes
Ingestion of fish	No	Yes
Ingestion of water	No	Yes

[a] Industrial-worker: no consumption of water or food obtained on the site.

[b] Resident-farmer: water used for drinking, household purposes, livestock watering, and irrigation assumed to be from an on-site well.

In the resident-farmer scenario (a plausible but unlikely future use scenario), in which a subsistence farmer was assumed to ingest plant foods grown in an on-site garden, the resident was also assumed to ingest meat and milk from livestock fed with forage grown on-site and to catch and consume 50% of fish and other aquatic organisms from an on-site pond. For this scenario, the groundwater drawn from a well located on-site would be the only water source for drinking, household use, livestock watering, and irrigation. Currently, no agricultural activity occurs at the site, and production of livestock in the decontaminated area is considered extremely unlikely.

1.3 DOSE/SOURCE CONCENTRATION RATIOS

The RESRAD computer code, Version 5.82 (Yu et al. 1993), was used to calculate the dose/source concentration ratio $DSR_{ip}(t)$ for uranium isotope i and pathway p at time t after remedial action for each of the two scenarios. The time frame considered in this analysis was 1,000 years. Radioactive decay and ingrowth were considered in deriving the dose/source concentration ratios. The various parameters used in the RESRAD code for this analysis were taken from the dose assessment study performed for this site (ANL 1998). The calculated maximum dose/source concentration ratios for all pathways are presented in Tables 4 and 5 for the industrial-worker and resident-farmer scenarios, respectively. For both scenarios, the maximum dose/source concentration ratios would occur immediately following remedial action for uranium-238, uranium-234, and uranium-235. For the industrial-worker scenario, the external exposure and inhalation (dust) pathways are the primary contributors to the dose from DU in soil. For the resident-farmer scenario, the external exposure, plant ingestion, and inhalation (dust) pathways are the primary contributors to the dose from DU. Because the maximum dose occurs immediately after remediation, the dose from the inhalation of radon, water ingestion, and fish ingestion pathways is zero.

The summation of $DSR_{ip}(t)$ for all pathways p is the $DSR_i(t)$ for the ith isotope,

$$DSR_i(t) = \sum_p DSR_{ip}(t) .$$

The total dose/source concentration ratio for total uranium can be calculated as

TABLE 4 Maximum Dose/Source Concentration Ratios for the Industrial-Worker Scenario at the Depleted Uranium Study Area of the Transonic Range

	Maximum Dose/Source Concentration Ratios[a] (mrem/yr)/(pCi/g)		
Pathway	Uranium-234	Uranium-235	Uranium-238
External gamma exposure	8.3E-5	1.5E-1	2.6E-2
Inhalation of dust	4.3E-3	4.0E-3	3.8E-3
Inhalation of radon	0	0	0
Ingestion of soil	2.4E-3	2.2E-3	2.3E-3
Total	6.7E-3	1.6E-1	3.2E-2

[a] All values are reported to two significant figures. Maximum dose/source concentration ratios would occur immediately following remedial action for all uranium isotopes.

TABLE 5 Maximum Dose/Source Concentration Ratios for the Resident-Farmer Scenario at the Depleted Uranium Study Area of the Transonic Range

	Maximum Dose/Source Concentration Ratios[a] (mrem/yr)/(pCi/g)		
Pathway	Uranium-234	Uranium-235	Uranium-238
External gamma exposure	2.4E-4	4.3E-1	7.2E-2
Inhalation of dust	9.9E-3	9.2E-3	8.9E-3
Inhalation of radon	0	0	0
Ingestion of plant foods	1.0E-2	9.7E-3	9.8E-3
Ingestion of meat	3.2E-3	3.0E-3	3.0E-3
Ingestion of water	0	0	0
Ingestion of milk	8.2E-3	7.7E-3	7.8E-3
Ingestion of fish	0	0	0
Ingestion of soil	7.7E-3	7.3E-3	7.4E-3
Total	4.0E-2	4.7E-1	1.1E-1

[a] All values are reported to two significant figures. Maximum dose/source concentration ratios would occur immediately following remedial action for all uranium isotopes.

where W_i is the existing activity concentration fraction in soil at the site for uranium-234, uranium-235, and uranium-238.

For this analysis, W_i was assumed to represent the mean activity concentration fractions given in Table 2 for uranium-234, uranium-235, and uranium-238, respectively, for the three DU cases and for natural uranium. Table 6 gives the total dose/source concentration ratios for single radionuclides, natural uranium, and depleted uranium. These ratios were used to determine the allowable residual radioactivity for uranium in soil at the Depleted Uranium Study Area of the Transonic Range.

TABLE 6 Total Dose/Source Concentration Ratios for Uranium at the Depleted Uranium Study Area of the Transonic Range

	Maximum Dose/Source Concentration Ratios[a] (mrem/yr)/(pCi/g)	
Radionuclide	Industrial-Worker[b]	Resident-Farmer[c]
Uranium-234	6.7E-3	4.0E-2
Uranium-235	1.6E-1	4.7E-1
Uranium-238	3.2E-2	1.1E-1
Natural uranium	2.2E-2	8.3E-2
Depleted uranium[d]	2.9E-2	1.0E-1
Depleted uranium[e]	3.1E-2	1.1E-1
Depleted uranium[f]	2.9E-2	1.0E-1

[a] All values are reported to two significant figures. For all uranium isotopes (uranium-234, uranium-235, and uranium-238), maximum dose/source concentration ratios will occur at time zero after remediation for both scenarios.

[b] Industrial-worker: no consumption of water or food obtained on the site (current use scenario).

[c] Resident-farmer: water used for drinking, household purposes, livestock watering, and irrigation assumed to be from an on-site well (an unlikely but plausible future use scenario).

[d] The uranium isotopes (uranium-238, uranium-234, and uranium-235) are present in the activity ratio of 0.768:0.211:0.0205.

[e] The uranium isotopes (uranium-238, uranium-234, and uranium-235) are present in the activity ratio of 0.839:0.138:0.0234.

Uncertainty in the derivation of dose/source concentration ratios arises from (the variability in the activity ratios) the distribution of possible input parameter values, as well as from the conceptual model used to represent the site. Because the maximum dose would occur immediately following the remedial action for both scenarios, the results are not affected by uncertainties in the parameters for the leaching of uranium from the contaminated zone. The breakthrough time (i.e., the time it takes the uranium to reach the water table) does not occur within 1,000 years.

1.4 RESIDUAL RADIOACTIVE MATERIAL GUIDELINES

The residual radioactive material guideline is the concentration of residual radioactive material that can remain in the soil in a decontaminated area and still allow use of the area without radiological restrictions. Given a dose limit, *DL*, for an individual, the residual radioactive material guideline *G* for uranium at the Depleted Uranium Study Area of the Transonic Range can be calculated as

$$G = DL / DSR ,$$

where *DSR* is the total dose/source concentration ratio listed in Table 6. The dose limit, *DL*, used to derive the residual radioactive material guideline is 25 mrem/yr for both scenarios. Table 7 gives the residual radioactive material guidelines for single radionuclides (uranium-234, uranium-235, and uranium-238), natural uranium, and depleted uranium calculated for the Depleted Uranium Study Area of the Transonic Range for both scenarios.

For the calculations of the natural uranium guidelines, it was assumed that the activity concentration ratio of uranium-234, uranium-235, and uranium-238 is 0.49:0.022:0.49. The derived guidelines for natural uranium for two scenarios (industrial-worker and resident-farmer) are 1,100 and 300 pCi/g, respectively. If uranium-238 is measured as the indicator radionuclide, the uranium-238 limits for total uranium can be calculated by multiplying the total uranium guidelines by 0.49. The resulting uranium-238 limits for the industrial-worker and resident-farmer scenarios are 540 and 150 pCi/g, respectively.

TABLE 7 Residual Radioactive Material Guidelines for the Depleted Uranium Study Area of the Transonic Range

	Guideline (pCi/g)[a]	
Radionuclide	Industrial-Worker[b]	Resident-Farmer[c]
Uranium-234	3,700	630
Uranium-235	160	54
Uranium-238	790	230
Natural uranium	1,100	300
Depleted uranium[d]	860	250
Depleted uranium[e]	800	230
Depleted uranium[f]	880	250

[a] All values are reported to two significant figures.

[b] Industrial worker: no consumption of water or food obtained on the site (current use scenario, dose constraint 25 mrem/yr).

[c] Resident-farmer: water used for drinking, household purposes, livestock watering, and irrigation assumed to be from an on-site well (an unlikely but plausible future use scenario, dose constraint = 25 mrem/yr).

[d] The uranium isotopes (uranium-238, uranium-234, and uranium-235) are present in the activity ratio of 0.768:0.211:0.0205.

[e] The uranium isotopes (uranium-238, uranium-234, and uranium-235) are present in the activity ratio of 0.839:0.138:0.0234.

[f] The uranium isotopes (uranium-238, uranium-234, and uranium-235) are present in the activity ratio of 0.759:0.222:0.0193.

For the calculations of the DU guidelines, it was assumed that the activity concentration ratios of uranium-234, uranium-235, and uranium-238 are 0.211:0.0205:0.768, 0.138:0.0234: 0.839, and 0.222:0.0193:0.759 (in three cases). The derived guidelines for depleted uranium in the three cases for the industrial-worker scenario are 860, 800, and 880 pCi/g, respectively; for the resident farmer scenario, the derived guidelines are 250, 230, and 250 pCi/g, respectively. If uranium-238 is measured as the indicator radionuclide, the uranium-238 limits for total uranium can be calculated by multiplying the total uranium guidelines by 0.768, 0.839, and 0.759 in the three cases. The resulting uranium-238 limits for the industrial-worker and resident-farmer scenarios are 660 to 670 pCi/g and 190 pCi/g, respectively.

The sum-of-fractions rule applies when the derived radionuclide guidelines for decontamination of a site are implemented. The summation of the radionuclide concentrations, S_i, remaining on-site (averaged over an area of 100 m^2 and a depth of 15 cm) and divided by their guidelines, G_i, should not be greater than unity, that is,

$$\sum_i S_i / G_i \leq 1 .$$

The derived guidelines listed in Table 7 are for a large homogeneously contaminated area. For a small, isolated area of contamination (a hot spot), the allowable concentration that can remain on-site may be higher than the homogeneous guideline, depending on the size of the contaminated area, and in accordance with the ranges given in Table 8.

TABLE 8 Ranges for Hot Spot Multiplication Factors

Hot Spot Area Range (m^2)	Factor (multiple of authorized limit)
<1	10[a]
1 – <3	6
3 – <10	3
10 – 25	2

[a] Areas less than 1 m^2 are averaged over a 1-m^2 area; average shall not exceed 10 times the authorized limit.

The sum-of-fractions rule applies when the derived radionuclide guidelines for decontamination of a site are implemented. The summation of the radionuclide concentrations, S_i, remaining on-site (averaged over an area of 100 m^2 and a depth of 15 cm) and divided by their guidelines, G_i, should not be greater than unity, that is,

$$\sum_i S_i / G_i \leq 1 .$$

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10 – 25	2

[a] Areas less than 1 m^2 are averaged over a 1-m^2 area; average shall not exceed 10 times the authorized limit.

2 REFERENCES

Argonne National Laboratory, 1998, *Dose Assessment for the Depleted Uranium Study Area of the Transonic Range Aberdeen Proving Ground, Maryland*, prepared by Environmental Assessment Division, Argonne National Laboratory, Argonne, IL.

General Physics Corporation, 1996, *Transonic Range Depleted Uranium Study Area, Radiological Characterization Report*, prepared by General Physics Corporation, Columbia, MD, for Aberdeen Proving Ground Directorate of Safety, Health and Environment, Aberdeen Proving Ground, MD, Oct.

Yu, C., et al., 1993, *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0*, ANL/EAD/LD-2, prepared by Argonne National Laboratory, Environmental Assessment Division, Argonne, IL, for U.S. Department of Energy, Office of Environmental Restoration, Washington, DC, Sept.

Appendix B:

NRC Request for Reduction in number of Alpha Spectroscopy Samples

February 10, 2003

Aberdeen Proving Ground
U.S. Army Research Laboratory
Aberdeen, MD 21005
ATTN: Richard A. Markland, ARL RSO

Subject: *Aberdeen Proving Ground Transonic Range Depleted Uranium Study Area Work Plan*

Mr. Markland:

Cabrera Services Inc. (CABRERA) is providing Decontamination and Decommissioning (D&D) services to Aberdeen Proving Ground (APG) at the Transonic Range located on the grounds of APG. The range provided an outdoor test area for Depleted Uranium (DU) ammunitions. CABRERA is providing these D&D services utilizing an NRC approved work plan. CABRERA is requesting relief from certain aspects of this approved plan.

The work plan, "Aberdeen Proving Ground Transonic Range Depleted Uranium Study Area Detailed Work Plan", contains requirements to perform gamma and alpha spectroscopy on soil samples and other solid materials (concrete, sheet metal, etc.) present in the various survey areas on the site to support MARSSIM final status survey. The sample analysis includes the performance of gamma spectroscopy on 100 percent of the samples and alpha spectroscopy on 15 percent of the samples. Table 5.4 of the work plan entitled "DUSA Sample and Analysis Recap" provides for 75 alpha spectroscopy samples on soils, QA samples, investigative samples, and structural samples.

CABRERA requests relief from what it considers an unnecessarily large number of alpha spectroscopy analyses. CABRERA proposes to reduce the number of samples receiving alpha spectroscopy from 75 to 3 for the following reasons:

- Examination of the DCGL development document as detailed in "*Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range Aberdeen Proving Ground, Maryland*", Argonne National Laboratory, 1999, shows that the guideline is controlled by ^{235}U and ^{238}U components of the DU. The ^{234}U component of the DU comprises only 5 percent of the DCGL guideline. Therefore, additional alpha spectroscopy analyses on 75 samples will provide only a small additional confidence level to the remediation process. The ^{235}U and ^{238}U components, comprising 95 percent of the guideline soil concentration DCGL, are readily determined by gamma spectroscopy and may be considered to be the primary isotopic indicators associated with a successful MARSSIM final status survey for this work evolution. No changes to the number of gamma spectroscopy samples as described in the work plan will be made.

- One hundred (100) uranium alpha spectroscopy analyses of soil samples as detailed in "*Transonic Range Depleted Uranium Study Area Radiological Characterization Report*", General Physics Corporation, October 1996, were performed for this site. The report shows elevated activity levels of ^{238}U and lower activity levels of ^{235}U and ^{234}U as compared to natural uranium, indicating that the uranium components present in the soil are due to DU. No testing of uranium containing munitions has occurred on this outdoor range since 1979, therefore there are no expected changes to the soil uranium contamination levels.

- Derivation of the APG Transonic Range soil cleanup guidelines are based upon the RESRAD computer model and isotopic uranium activities typical of DU as detailed in "*Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range Aberdeen Proving Ground, Maryland*", Argonne National Laboratory, 1999. The RESRAD model was run with isotopic inputs derived from the 1996 General Physics characterization report.

- A description of the past work activities taking place at Transonic Range details the use of DU ammunition at the site. This information is discussed in "*Aberdeen Proving Ground Transonic Range Depleted Uranium Study Area Detailed Work Plan*", Allied Technology Group Inc., September 1999. This work plan has been approved by the NRC and provides the basis for the D&D work and cleanup levels that CABRERA will follow. The Allied report further states that soil data does not show the presence of radionuclides above ambient levels other than uranium.

- The Department of the Army U.S. Army Research Laboratory Material License that provides for uranium munitions testing and APG user process knowledge regarding use of DU in these munitions reflects the fact that radioactive soil contamination on the Transonic range is due to DU. No other radioisotopes are involved.

The analysis of three (3) samples by alpha spectroscopy is sufficient to ascertain that the remediation and sampling program is in fact removing materials associated with the test firing of DU munitions on the Transonic Range. The three alpha spectroscopy samples chosen for analysis will come from three separate Class 1 or Class 2 area locations showing the highest walkover scan counts. The performance of gamma spectroscopy on 100 percent of the soil samples as described in the Transonic Range Work Plan will not be altered by this request.

If you should have any questions regarding this request, please contact either Henry W. Siegrist or David J. Watters at CABRERA (860) 285-1885.

Sincerely,

Henry W. Siegrist, CHP, P.E.
Corporate Health Physicist
Cabrera Services, Inc.

Appendix C

APG Transonic DUSA Decommissioning Plan

ABERDEEN PROVING GROUND

TRANSONIC RANGE
DEPLETED URANIUM STUDY AREA

DECOMMISSIONING PLAN

conducted under

Army Research Laboratory
NRC License No.:

SMB-141

Revision 1
March 1, 2000

Allied Technology Group, Inc.
669 Emory Valley Road
Oak Ridge, TN 37830

ABERDEEN PROVING GROUND

TRANSONIC RANGE
DEPLETED URANIUM STUDY AREA

DETAILED DECOMMISSIONING PLAN

Revision 1
March 24, 2000

Approval Page

Submitted by:	______________________ Lee Young, ATG Project Manager	Date
Concurrence:	______________________ Arthur J. Palmer, III, ATG QA/QC Manager	Date
Recommended for Approval:	______________________ Mike Styvaert, IOC Project Officer	Date
Approved:	______________________ Nuclear Regulatory Commission	Date

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1. BACKGROUND

Allied Technology Group, Inc. (ATG) has been contracted by the U.S. Army Industrial Operations Command (IOC) for the remediation and decommissioning of the Depleted Uranium Study Area (DUSA) of the Transonic Range located at Aberdeen Proving Grounds, MD. In addition, the contract requires ATG to provide a final release survey of the grounds and structures to show that they meet the release criterion and to provide for packaging, shipment, and disposal of the resulting waste. All decommissioning activities will be conducted under the requirements of Army Research Laboratory's NRC license (No. SMB-141). In addition, the ARL RSO will oversee all related activities and has the authority to suspend any operations deemed to be unsafe to workers and public or detrimental to the environment.

The release criterion can be found in the facility license provisions and "Radiological Criteria for License Termination", 10 CFR 20, Subpart E, (Reference 1). The corresponding release limit for the affected outdoor area, 230 pCi/gm, was derived by Argonne National Laboratory (ANL) using the unrestricted release criterion, for the resident-farmer scenario, of 25 mRem/yr. The report, "Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, MD", Argonne National Laboratory, 1999, (Reference 2) is the basis for the volumetric DCGLs of this Work Plan. The release limit for the structures are derived in accordance with the "Federal Register/Volume 62, Number 222/Wednesday, November 18, 1998", (Reference 3), and its associated Regulatory Guide, "Demonstrating Compliance with the Radiological Criteria for License Termination", Draft Regulatory Guide DG-4006, (Reference 4). This corresponds to Table 6.4 of "Army Regulation EM 385-1-80, Radiation Protection Manual" (Reference 5) for the material of interest, Depleted Uranium (DU).

1.1 REASON FOR REMEDIATION

DU penetrator ammunition rounds were tested at the DUSA between 1973 and 1979. In 1979 outdoor testing of the penetrators ceased, however the site continues to be listed as a radiation test facility in the U.S. Army Research Laboratory's (ARL) Nuclear Regulatory Commission (NRC) License. The determination was made in 1995 to cease licensed activities at the DUSA. To support this determination, IOC and ARL desire to terminate the license conditions and provisions associated with the DUSA. The need to perform remediation to support this termination is found in the NRC Branch Technical Position (BTP), "When to Remediate Inadvertent Contamination of the Terrestrial Environment", (Reference 6). According to the BTP, licensee sites which are no longer used to conduct licensed activities should be remediated to unrestricted use levels to preclude migration of the radioactivity.

1.2 MANAGEMENT APPROACH

The ATG approach to the Decontamination and Decommissioning of the DUSA is designed to provide the customer (IOC) with a top quality service at a reasonable price. We have provided environmental / radiological remediation and waste management services since ATG was founded in 1976, and have performed these services for the IOC since 1989. ATG will provide all aspects of on-site project management and work direction. To provide the best possible service to the IOC, we have teamed with Sanford Cohen & Associates, Inc. (SC&A) and MHF Logistical Services, Inc. (MHF-LS). SC&A will provide laboratory and data analysis services under the direction of the ATG Project Manager. MHF-LS will provide for transportation arrangements, also under the direction of the ATG Project Manager.

NOTE: The project organization chart and resumes of key personnel are included in the document "Specification for the Decommissioning Plan, Transonic Range - Aberdeen Proving Ground", Appendix 1 to this work plan.

The ATG Project Manager will oversee all on-site activities. The Project Manager is responsible for the safe progress of the job, oversight of the quality assurance aspects, field remediation activities, data/sample collection, and packaging/shipping of radioactive waste. The Project Manager will also be the on-site Radiation Safety Officer (RSO). The Project Manager will report directly to the IOC Point of Contact/Project Officer. All on-site activities will require working in conjunction with scheduled range activities as this facility is an active military testing facility. It is anticipated that this work will be performed on weekends and early morning hours when the range is inactive. Scheduling will be coordinated with the IOC Project Officer and the APG Point of Contact.

The work force for the setup, remediation activities, data/sample collection, on-site analysis, packaging and shipping of samples, and packaging, loading and shipping of radioactive waste will be under the direction of the ATG Project Supervisor. The Project Supervisor will also serve as the on-site health and safety officer and the health physics supervisor. The Project Supervisor will report to the ATG Project Manager.

The ATG QA/QC Manager will ensure that all work is performed in accordance with applicable Federal, State, and local regulations and requirements; the Decommissioning Work Plan; the provisions of the Project Quality Assurance (QA) Plan (Appendix 2); and the ATG Field Operating Procedures (Appendix 3). The QA/QC Manager will report to the ATG Project Manager, however, he will also report to the ATG Corporate QA/QA Manager who has a direct reporting chain to the IOC Project Officer.

The ATG Health, Safety, and Environmental Compliance Manager will ensure that all project personnel are trained and qualified in accordance with applicable Federal, State, and local regulations and requirements and that work is performed in compliance with the Project Health and Safety Plan (Appendix 4). The HS&E Manager will report to the ATG Project Manager.

The ATG UXO Supervisor will be ensure that the provisions of the Project UXO Avoidance Plan, (Appendix 5), are implemented in the field, as applicable. He will provide technical direction to the UXO specialist(s) assigned as part of the project workforce. The ATG UXO Supervisor will report to the ATG Project Manager.

Individuals assigned to this project will be trained and qualified in accordance with the provisions of 10 CFR 19.13 "Radiation Worker Training (Reference 7), 29 CFR 1910.120 "OSHA Construction Standards" (Reference 8), and applicable license provisions. Training records will be supplied and maintained as part of the project records in accordance with the Project QA Plan. Training specific to the project will be performed prior to the start of field work by or under the direction of the ATG HS&E Manager and APG personnel, as applicable. On-site training will be documented on ATG Form 027 (Training Record) in accordance with ATG Field Operating Procedures.

Daily briefing/training meetings will be conducted, prior to the start of field work, to discuss activities that will be performed that day. Radiological and Industrial safety concerns will be discussed , as well as proper Personnel Protective Equipment (PPE) and contamination controls. Compliance with state, local, and facility motor vehicle laws will also be covered in these briefings. These meetings will be conducted by the Project Manager and Project Supervisor and will be documented on ATG Form 027 (Training Record). These briefings will also be documented on the Pre-Job Briefing for Health Physics (ATG Form 026) and the Pre-Job Briefing for Industrial Hygiene/Safety (ATG Form 025), if applicable. Visitors who request access into the exclusion zone will be required to attend the daily briefing (or an equivalent briefing) and document attendance on the appropriate forms.

2. SITE DESCRIPTION

2.1 TYPE AND LOCATION OF FACILITY

Aberdeen Proving Ground (APG) located at Aberdeen, MD is an active U.S. Army testing and research facility. The APG lies along the western shore of the Chesapeake Bay in Harford and Baltimore Counties, MD, approximately 15 miles northeast of Baltimore, MD. The APG covers a total of 72,516 acres (land and water) and consists of two distinct areas: the northern portion of APG, referred to as the Aberdeen Area (AA); and the southern portion of APG, referred to as the Edgewood Area (EA). The AA became a formal military post, designated as APG, in 1917. The EA (formerly Edgewood Arsenal) was appropriated by Presidential Proclamation in 1918. The Depleted Uranium Study Area (DUSA) is located within the boundaries of the Transonic Range in the AA of APG.

2.2 OWNERSHIP

As an active military installation, APG is the property of the U.S. Government, Department of Defense. It is operated and maintained by the U.S. Army.

2.3 FACILITY DESCRIPTION

The DUSA comprises approximately 12 acres on the southeast end of the Transonic Range. The gun locations were located on the northern portion of the site and fired at targets to the south. The DUSA can be described as a cleared relatively flat tract, surrounded by woods to the east, south, and west. Swampy areas are found behind the Transonic Range catchbasin to the south, along the wooded areas to the west, and in the northeast section of the site.

The east side of the site was stabilized approximately ten years ago when a layer of landscaping plastic was laid north of building A-7 to the tree line to the east and west toward X-Ray 1. A 4 to 8 inch layer of gravel was laid over the plastic. At about the same time, the small swampy area to the north of the firing positions was covered with 2 to 4 feet of soil so that guns could be moved further away from the targets.

DU penetrator round testing was conducted on the site from 1973 to 1979. After outdoor testing ceased the Army Research Laboratory (ARL) health physicist conducted an initial site cleanup to reduce the radioactive waste inventory and to allow other non-radiological testing to be conducted on the site. ARL conducted soil sampling on the site as late as 1991 as a part of their environmental monitoring program. In 1995/96, the site was characterized by General Physics Corporation as a part of the preparations for decommissioning. The results of this characterization are found in "Transonic Range Depleted Uranium Study Area Radiological Characterization Study Report", General Physics Corporation, 1996 (Reference 9). These results are used as the radiological bases for this work plan.

2.4 STRUCTURES

The DUSA did contain five small industrial type structures. One building (X-Ray 1) has been removed since the characterization survey was conducted.

2.4.1 BUILDING A-7

Building A-7 is located on the southeast side of the DUSA and is constructed of concrete. The building covers approximately 20 m^2 and is approximately 3 meters high. The northern face of the building is covered by an earthen berm. There are no known drains from the building and no ventilation system. The interior does contain work tables and storage shelves. The installation used A-7 to store electronics equipment.

The west wall has an outer wall of three inch steel plate attached to the concrete and a single metal box penetrating the wall. The east wall contains a single metal door, the only access to the structure. The concrete roof is covered with three inch thick steel plates, approximately 6 ft. long and 41 in. wide, held in place by anchor bolts imbedded in the concrete.

Building A-7 meets the release guidelines with the exception of the joints between the steel plates on the roof and the east exterior wall. The area between the roof and the walls, the north exterior wall, and the west exterior wall could not be accessed for characterization and are therefore assumed to be contaminated.

2.4.2 X-RAY 2

X-Ray 2 is located on the southern portion of the DUSA and covers approximately 58 m^2 with a nominal wall height of approximately 3.5 meters. There are no known drains associated with X-Ray 2. The structure contains a US Army Field Electronics Trailer. The trailer is constructed of aluminum and rests on a raised platform above the ground.

The walls of X-Ray 2 consist of fitted 2.5 in. steel plate. The upper roof, over the trailer, is 1 in. thick steel. The lower roof, west side of the structure, is 2.5 in steel. The south wall contains the access door and the west wall has a slit cut into it for X-Ray passage.

Significant portions of X-Ray 2 were either inaccessible (therefore, considered contaminated) or showed fixed contamination above the guidelines. These areas include the west end of the south exterior wall, the west exterior wall, the lower roof, the upper roof, and the interior floor.

2.4.3 SECURITY BOXES

Security Box 1 covers approximately 50 m^2 and is located northwest of X-Ray 2 along the access road. Security Box 2 occupies approximately 26 m^2 and is located north of the affected area of the DUSA. Both are constructed of 1 in. steel, have 4 vents in the roof, and have a door and an equipment hatch in the south facing wall. There are no known drains from these structures.

The Security Boxes meet the release guidelines on the exterior portions of the structures. The interiors were inaccessible during the characterization and are therefore considered to be contaminated.

2.5 Grounds and Soils

The soil composition of the affected area of the DUSA is primarily a sandy loam with gravel added in certain areas.

ARL conducted soil sampling from 1973 to 1978, and again in 1991, as a part of their environmental monitoring program. Analytical results for soil samples collected from several areas around the radioactive waste storage area and behind the backstops showed levels in excess of the guideline values for unrestricted use. Most of the soil contamination was found in the radioactive waste storage area. Concentrations in this area ranged from 10 to 520 pCi/g.

During the characterization surveys of the DUSA (1995/96), numerous soil samples were taken and analyzed for radioactive and other hazardous components. The characterization report (Reference 9) concluded that all areas showed soil concentrations in excess of the guideline level of 35 pCi/g for depleted uranium developed for the characterization study (Reference 9). The highest average concentrations were reported in characterization grids C1, C2, B2, B3, A1, and A4. Small areas of elevated activity were reported in characterization grids A2, B4, C4, and Z2. The highest activity reported (4.23 E5 pCi/g) was found in characterization grid A2. It should be noted that this reported DU concentration will be evaluated to determine the source of the error, given that the specific activity of DU is less than 370,000 pCi/g. Much of the contamination is limited to the top three inches of soil. Also it appears that much of the contamination is localized to well defined areas.

The characterization data also indicates the potential for subsurface UXO, particularly in characterization grids A1, C1, and C2.

The characterization samples were also analyzed and compared to the disposal site criteria. This data indicated no hazardous material component in the soil that would cause the remediation waste to be classified as a mixed waste. These samples will be verified prior to packaging and shipment of waste generated in the remediation process.

3. OPERATING HISTORY

3.1 LICENSING STATUS

The Depleted Uranium Study Area (DUSA) is located within the boundaries of the Transonic Range in the AA of APG. The DUSA of the Transonic Range at Aberdeen Proving Ground (APG) is listed as a radiation test facility in the U.S. Army Research Laboratory's (ARL) Nuclear Regulatory Commission (NRC) license (No. SMB-141). The facility has been involved in testing of DU penetrator rounds from 1973 to 1979. Outdoor testing of the DU rounds ceased in 1979; however, the area continues to be listed as a radiation test facility. In 1995 a determination was made to cease all licensed activities at the DUSA and remove it from the list of radiation test facilities at APG.

After outdoor testing ceased in 1979, ARL conducted an initial site cleanup to reduce the radioactive waste inventory and allow other non-radiological testing to be conducted at the DUSA. This effort included removing shot target and other materials from the radioactive material storage area. This initial effort also included surveying and removing contaminated soil, sand, and other materials. Based on these "scoping" surveys and site history, it was estimated that approximately 12 acres should be considered suspect areas for DU contamination.

When the decision was made to cease licensed activities and remove the DUSA from the list of radiation test facilities, General Physics Corporation was contracted to perform a radiological "characterization" survey of the site. The report of this characterization, "Transonic Range Depleted Uranium Study Area Radiological Characterization Report", General Physics Corporation, 1996, (Reference 9) reached the following conclusions:

- Based on the radiation surveys no removable contamination was found on the structures surveyed at DUSA. However, fixed radiation levels in A-7, X-Ray 1 and 2 are in excess of the guideline values.

- Soil data does not show the presence of radionuclides other than isotopes of U-238 and U-235 above ambient levels. The approximate distribution of the uranium isotopes is that of depleted uranium.

- All areas showed soil concentrations in excess of guideline values for depleted uranium with the highest concentrations in grids C1, C2, B2, B3, A1, and A4. Much of the contamination is limited to the top three inches of soil. Also it appears that much of the contamination is localized to well defined areas. Any remedial actions will require careful planning and implementation as it is likely that subsurface UXO will be encountered. In particular, grids A1, C1, and C2 showed high concentrations of ferrous and non-ferrous metal from the magnetometry survey.

- The soil does not contain hazardous materials, pesticides, herbicides, or explosives above the regulatory limit.

NOTE: The guideline values referred to in the characterization report are not necessarily the guidelines used in this work plan. The guidelines used in this work plan were derived in accordance with the most current guidance, i.e., "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM), NUREG-1575 (Reference 10) for soil and "Demonstrating Compliance with the Radiological Criteria for License Termination", Draft Regulatory Guide DG-4006 (Reference 4) for structures.

Based on the scoping and characterization data IOC contracted Argonne National Laboratory (ANL) to provide the volumetric Derived Concentration Guideline Levels (DCGL) applicable to DUSA in accordance with the guidance contained in MARSSIM. The report, "Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, MD", Argonne National Laboratory, 1999, (Reference 2) is the basis for the volumetric DCGLs of this Work Plan.

The remediation and final survey documentation developed in the implementation of this work plan, along with the referenced reports, will form the bases for the NR Form 314 required as a part of the decommissioning and license termination of the DUSA.

3.2 PROCESSES

The DUSA is located on the southeast end of the Transonic Range and was used for DU testing from 1973 to 1979. Testing consisted of gun launching DU penetrator rounds from two locations on the northern portion of the site at targets mounted adjacent to the X-Ray units to the south. Stripper/deflector plates located in between the launch or shooting locations were designed to strip or deflect the sabot away from the penetrator while in flight to the target. Penetrators were either stopped in the target or penetrated the target and impacted into a backstop located a short distance behind the targets.

As a result of the testing, most of the DU melted into the target and backstops. However, some DU fell onto the soils around the targets or was scattered into the surrounding area. Test technicians wore protective clothing and dosimetry while in the test area and monitored activities for radioactive contamination. Shot targets and other designated materials were maintained on site in a radioactive materials storage area located to the east of the impact zone. While the shot target and other designated materials have been remediated, recycled, and/or disposed of as radioactive waste, the wooded storage site is still posted "Radioactive Materials Area".

3.3 WASTE DISPOSAL PRACTICES

During operation of the DUSA as a DU test range, radioactive wastes, except for shot targets and other designated materials, were handled through established radioactive waste disposal channels, i.e., packaged and shipped to a licensed disposal site. Shot targets and other designated materials were maintained on site in a radioactive waste storage area. After testing ceased, the ARL health physicist conducted an initial site cleanup to reduce the radioactive waste inventory and allow other non-radiological testing to be conducted at the DUSA. This effort included removing shot target and other materials from the radioactive material storage area. The shot target and other designated materials have been remediated, recycled, and/or disposed of as radioactive waste at a licensed disposal site.

4. REMEDIATION ACTIVITIES

4.1 OBJECTIVES

The objective of this project is the decontamination/remediation of the Depleted Uranium Study Area (DUSA) of the Transonic Range at Aberdeen Proving Grounds, including facilities and equipment, to acceptable ALARA (as low as is reasonably achievable) levels for unrestricted release. The criteria for this release shall be the Derived Concentration Guideline Levels (DCGLs) developed in compliance with the "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM), NUREG-1575, (Reference 10) for the soil and Army Regulation EM 385-1-80, "Radiation Protection Manual", Table 6-4 (Reference 5) for facilities and equipment. This objective will be accomplished by performing the following activities and tasks:

NOTE 1: It is estimated that the waste volume from this activity will be 2,500 ft^3.

NOTE 2: All work activities will be performed in accordance with this Decommissioning Work Plan, ATG Field Operating Procedures, and the requirements of the Site License.

4.1.1 Site Mobilization and Preparation

Mobilize personnel and equipment
Provide on-site training
Collect bioassay samples and issue dosimetry
Establish work schedule
Obtain necessary work permits
Establish UXO protocol for range activities
Establish Air Sampling protocol for range activities

4.1.2 Establish Characterization Grid Reference System

Preliminary UXO Sweep
Re-establish the grid boundaries used during the characterization
Verify the grid boundaries through radiation surveys
Post area boundaries (Radiological, HAZMAT, UXO)

4.1.3 Survey of Surfaces/Areas Inaccessible during Characterization

UXO Survey
Laydown area survey and establishment
Obstruction removal

4.1.4 Testing of Contaminated Structural Surfaces

Identification of Representative Contaminated Surfaces
Determination of Contamination Depth
Approximation of Background

4.1.5 REMEDIATION
UXO Support
Segregation/Excavation

4.1.6 EQUIPMENT AND DEMOBILIZATION
Surveys and Samples
Equipment Release
Demobilization

Note: The activities, including grid layout and surveys/samples, associated with the final release of the DUSA are discussed in Section 5 of this work plan.

4.2 RESULTS OF PREVIOUS SURVEYS

Environmental and work area surveys were conducted in the area of the Transonic Range during the full time operation of the range and during the interim period, i.e., prior to the decision to cease licensed activities. In late 1995 and early 1996 the site was characterized ("Transonic Range Depleted Uranium Study Area Radiological Characterization Study Report", General Physics, 1996, Reference 9) to determine the extent of radioactive contamination and other hazards. The results of this characterization is the basis for the remediation and decommissioning activities in this work plan. As part of the decommissioning activities these results will be verified and used to focus specific remediation tasks.

4.2.1 STRUCTURES
There are four structures remaining on the Transonic Range, Depleted Uranium Study Area (DUSA). None of the accessible areas of these structures showed loose surface contamination in excess of the guidelines contained in Army Regulation EM 385-1-80, "Radiation Protection Manual", Table 6-4. For purposes of planning the inaccessible areas are assumed to contain loose surface contamination above the guidelines. In addition fixed contamination above the guidelines was detected or assumed to be present as outlined below.

4.2.1.1 Building A-7
Building A-7 meets the release guidelines with the exception of the joints between the steel plates on the roof and the east exterior wall. The area between the roof and the walls, the north exterior wall, and the west exterior wall could not be accessed for characterization and are therefore assumed to be contaminated.

4.2.1.2 X-Ray 2
Significant portions of X-Ray 2 were either inaccessible (therefore, considered contaminated) or showed fixed contamination above the guidelines. These areas include the west end of the south exterior wall, the west exterior wall, the lower roof, the upper roof, and the interior floor.

4.2.1.3 Security Box 1

Security Box 1 meets the release guidelines on the exterior portions of the building. The interior was inaccessible during the characterization and is therefore considered to be contaminated.

4.2.1.4 Security Box 2

Security Box 2 meets the release guidelines on the exterior portions of the building. The interior was inaccessible during the characterization and is therefore considered to be contaminated.

4.2.2 Soil

The 1996 Characterization of the DUSA showed thirteen (13) soil areas with depleted uranium (DU) concentrations that exceed the ALARA target of 105 pCi/g (see Table 5.1 and Section 5.1 of this work plan). Twelve (12) of these locations are relatively small, with areas ranging from 4 to 10 m^2. The final location is a large area of elevated activity of about 250 m^2.

The grids of concern are A-1, A-2, A-4, B-2, B-3, B-4, C-1, C-2, C-4, and Z-2. The large area of elevated activity extends over the juncture of grids C-1/2, with small areas of elevated activity spotted over the remaining grids. The highest exposure rates and corresponding soil activity appear in grids A-2 and Z-2.

4.2.3 Unexploded Ordinance

As a preliminary phase of the characterization of the DUSA, the site was surveyed for and cleared of surface unexploded ordinance (UXO). Additional subsurface magnetometry scans were conducted during the characterization. The results of these sweeps and surveys indicate that encountering subsurface UXO is likely, particularly in grids A-2 and C1/2.

4.2.4 Other Hazards

In the characterization process the collected soils were analyzed for compatibility with disposal site criteria. This evaluation included analyses for the presence of materials regulated under 40 CFR 261, Reference 11 (Hazardous Materials) as well as an evaluation of physical properties. The characterization shows that the soil on the DUSA does not contain hazardous materials, pesticides, herbicides, or explosives above the regulatory limits. In those instances where hazardous materials were detected, only trace levels were found, which were well below the component limit. If additional information were to show that other hazardous materials (e.g., metals, semi-volatiles, and volatiles) were present, specific steps will be taken in conducting additional characterization for H&S purposes and waste disposal. The USA-IOC Project Officer and ARL RSO will be notified of such findings and any additional characterization efforts will be conducted only with IOC and ARL approval.

4.3 REMEDIATION PROCEDURES

4.3.1 Mobilization and Preparation

4.3.1.1 Mobilization

ATG will physically mobilize upon the receipt of the Notice to Proceed. Necessary equipment and material will be assembled and shipped/transported to APG. The necessary staff will mobilize and assemble at a pre-designated location in the area of APG to facilitate access.

Personnel: All personnel assigned to this project shall have completed the 40 hour Basic Hazardous Waste Training Program and, if needed, the 8 hour refresher Training in accordance with 29 CFR 1910.120, "OSHA Standards", Reference 8.

- Supervisors shall have completed the 8 hour Supervisors Training Program in accordance with 29 CFR 1910.120.
- All personnel will be required to provide evidence of training in accordance with 29 CFR 1910.120 e.6.
- All personnel will be required to provide evidence of Medical Certification in accordance with 29 CFR 1910.120 f.
- All respirator wearers will be trained and have documentation required for respirator use in accordance with 29 CFR 1910.134

Equipment: Tools and equipment necessary for the completion of this project shall be mobilized as needed. This is expected to include:

- Radiation Survey Instruments
- Radiation Counting Equipment
- Air Sampling Instruments
- Excavation Equipment, e.g., Backhoe, Front End Loader
- Sampling Equipment (including concrete boring tools)
- Hand Tools
- Cutting Torch
- Ventilation Equipment
- Scabbling Equipment
- Air Compressor
- Generator

Facilities: APG will provide office facilities and supplies, i.e., office space, restroom, telephone lines, fax equipment, and access to a copy machine. ATG will establish a field office in this location. Copies of all project records will be maintained at this location for field use, Base, IOC, and regulatory review.

4.3.1.2 Training

In addition to the training specified above all personnel shall receive the following training as a preliminary to field work. All on site training will be documented on a Training Record (ATG Form 027) and be kept as a part of the permanent project file.

Site Specific OSHA (29 CFR 1910.120) Training, including:

- Work Plan and Associated Documents
- Site Health and Safety Plan
- Site Specifics (APG)

Radiation Worker (10 CFR 19.13, Reference 7) Training, including:

- Radiation Worker Rights
- Sources of Radiation and Contamination
- Types of Radiation and Contamination
- Units of Radiation and Radioactivity
- Prenatal Exposure (Reg. Guide 8.13, "Prenatal Exposure", Reference 12)
- Biological Effects of Radiation
- Radioactive Contamination Control
- Use of Anti-C Clothing
- ALARA Concepts
- Emergency Procedures
- Use of Radiation and Contamination Detection Instruments

4.3.1.3 Monitoring

Performance of decommissioning activities on the Transonic Range is not expected to result in measurable dose equivalent to the workers. Personnel dosimetry (TLDs) and bioassay shall be used to verify that this condition is, in fact, true. TLDs will be issued and baseline bioassays will be collected during the mobilization phase.

Personnel monitoring methods will include:

- Dosimetry - Work crews will be required to wear TLDs during work activities at the site, visitors will be issued self-reading dosimetry (SRDs) during inspection or briefing tours.
- Bioassay - All workers will be required to provide a urine specimen for analysis prior to start of work (baseline) and at the completion of the project.

4.3.1.4 Scheduling

During mobilization, crew work schedules will be established based on the needs of the site. It is understood that the Transonic Range is an active firing range and that the mission of the base is paramount. Consequently, the schedule will have the necessary flexibility to maintain a minimum forty (40) hour work week during the hours the range is down.

Arrangements and schedules for surveys of the Security Box interiors will be established during the mobilization phase.

4.3.1.5 Site Permits

During the mobilization phase base required permits will be obtained (or arrangements made to expedite "as needed" receipt). Anticipated base permits are:

DARP - A Department of the Army Radiation Permit is required for the instrument check sources that will be needed for day-to-day activities.

Radiation Work Permit - A site issued Radiation Work Permit (RWP) is required for work on the Transonic Range. An ATG RWP (ATGF-002) will also be prepared and issued in accordance with ATG Field Operating Procedures, Appendix 3.

Safety Work Permit - A site issued Safety Work Permit (SWP) is required for work on the Transonic Range.

Cutting, Burning, Grinding Permit - Certain decontamination activities may require a "Hot" Work Permit, i.e., cutting, burning, and grinding. Base requirements will be ascertained during the mobilization phase.

Excavation Permit - Remediation activities may require the issuance of a base Excavation Permit. Base requirements will be ascertained during the mobilization phase.

Other - Other permits and authorizations may be required for certain remediation activities on the Transonic Range. Base requirements will be ascertained during the mobilization phase.

4.3.1.6 UXO Procedures

During the characterization of the DUSA, conducted in 1996, surface UXO was detected and properly disposed of. The characterization indicated that encountering sub-surface UXO is highly likely, particularly in grids A1 and C1/2. It is the policy of ATG and the Department of Defense (DoD) to provide the maximum possible protection to personnel and property from the damaging effects of potential accidents involving ammunition and explosives. Consequently, all activities conducted during the remediation of the Transonic Range will be preceded by the corresponding level of UXO Avoidance Activity (Project UXO Avoidance Plan, Appendix 5).

Work Site Establishment - UXO personnel shall assist in the establishment of the work site boundaries and control zones.

UXO Sweeps and Surveys - Prior to initial work area entry and any excavation activities UXO personnel shall perform the appropriate sweep or survey for the activity.

UXO Support - A UXO qualified individual shall be present during and monitor all excavation/soil disturbance activities.

UXO Qualifications - A UXO Technician is a graduate of the US Naval EOD School, Indian Head, MD, and has a minimum of 5 years of combined active duty EOD and commercial UXO experience.

4.3.1.7 Air Sampling Procedures

Sampling and analysis of the air in work areas containing radioactive contamination is required to ensure that workers and the general public do not receive an uptake of radioactive material or that any such uptake is accounted for and documented.

Air samples will be collected in the general area and breathing zone of workers during evolutions that have the potential for producing airborne radioactivity (e.g., soil or surface disturbing activities, container loading, etc.).

At a minimum two low volume (nominal flow rate 1 CFM) air samplers will be positioned down wind of the work area. One will be positioned as close to the work area as possible, while maintaining enough distance to prevent cross contamination from the work. The second will be placed at the closest downwind boundary of the work area.

A lapel sampler will be placed on at least one crew member to represent the breathing zone of the workers.

These air samples will be collected and analyzed in accordance with ATG Field Operations Procedure HP-OP-010, "Air Sampling and Analysis". Although no airborne radioactivity is anticipated from this remediation and decommissioning activity, these samples provide representative and reproducible data and will serve to quantify any release of radioactive materials or worker uptake of radioactive materials should airborne transport occur.

The general area air samples will be collected at 3 to 6 feet off the ground. The lapel samples will be collected as close to the individuals face as possible.

The health physics technician obtaining the samples will be responsible for ensuring that while the samples are being obtained they are maintained in a representative sample zone.

The *a priori* calculation with the below parameters shows that an air sample drawn for eight hours at a flow rate of 1 CFM will have a Lower Limit of Detection (LLD) of less than 2×10^{-12} uCi/ml or 0.1 Derived Air Concentration (DAC) for U-238 (or 2.0×10^{-11} uCi/ml, Class Y Compounds). The basis and calculation, using beta counting, assume:

LLD =

B_f = 1.89 ß/dis (DU)
C_e = beta counter efficiency, 12%
t_s = sample counting time, 5 min.
t_b = background counting time, 10 min.
R_b = background count-rate, 40 cpm
F_r = sample flow rate, 1 CFM or 28,317 mL/min.
S_t = sample duration, 8 hr
S_v = sample volume, 1.36×10^7 ml

2.22E+06 = Number of dpm per uCi

The LLD for a sample taken and evaluated under these conditions is about 2.0×10^{-12} uCi/ml, i.e., less than 10% of the DAC for U-238. The investigative limit for airborne activity will be 0.5 DAC for DU or 1×10^{-11} uCi/ml.

- If this limit is approached or exceeded the cause will be investigated and corrective actions identified.
- If this limit is exceeded work will be stopped until corrective actions have been taken.
- If 0.5 DAC is exceeded inhalation doses will be calculated and assigned to individuals as appropriate.
- If this limit is exceeded the base contact, the IOC Point of Contact/Project Manager, the ATG Project Manager/RSO, and the NRC will be notified as soon as possible of the occurrence.
- In the event of a second occurrence, work causing the elevated activity will be ceased, an investigation will be initiated to identify the cause of the elevated readings, institute the appropriate corrective actions, and determine if perimeter monitoring (Transonic Range Boundaries) need to be established. All resulting findings will be fully documented and notifications will be made to the ARL RSO.
- All events of elevated airborne activity will be thoroughly documented in the project logs and on the procedural forms.

Air samples will be collected every working shift (8 hours) and analyzed to ensure that elevated activity events are documented as soon as possible.

All personnel performing work in the area will submit a urine sample for analysis prior to the commencement of work (baseline) and upon completion of work, as a verification of the accuracy of the air sampling program.

Respiratory protection will be required in areas that exceed 0.5 DAC.

DAC-hour tracking will be required for all personnel wearing respiratory protection.

4.3.2 Establish Characterization Grid Reference System

Note 1: Prior to any range activities or change in range activities, e.g., change from surface work to excavation, the requirements of the ATG "UXO Avoidance Plan" will be implemented and met.

Note 2: All on site work will be done in accordance with the Project Health and Safety Plan, the Project Quality Assurance Plan, and the ATG Field Operating Procedures, which are an integral part of this plan, and are submitted as Appendix 4, Appendix 2, and Appendix 3. All stop work conditions, radiological and hazardous material, safety and industrial hygiene analysis are discussed in the Site Health and Safety Plan.

Note 3: All personnel with unescorted access to the work area will be required to wear TLDs during work activities at the site. Exposure Rate information from the characterization of the Transonic Range indicates that personnel exposure during remediation and decommissioning will be minimal. The highest indicated exposure rate is less than 0.1 mrem/ hr. A conservative estimate of individual exposure is: 12 hours per day for 20 days, yielding 12 * 20 * 0.1 or 24 mrem (TEDE).

Note 4: All material, tools, equipment, and personnel exiting the posted radiological work area must be surveyed to prevent the spread of contamination.

Note 5: Air samples will be collected in the general area and breathing zone of workers during evolutions that have the potential for producing airborne radioactivity (e.g., soil or surface disturbing activities, container loading, etc.). See Section 4.3.1.7 'Air Sampling Procedures" and Appendix 3 "ATG Field Operations Procedures".

Note 6: Protective clothing will be required, as per the RWP, in areas or during activities where the potential for personnel contamination exists (e.g., soil intrusion/excavation, decontamination).

Note 7: During excavation or other intrusive action of contaminated soils a source of water (e.g., spray tank) will be maintained in the area to minimize dusty conditions that could spread contamination.

The work area will be barriered and posted as "Radioactive Materials Area" and "Authorized Entry Only" based on visual assessment of identifiable landmarks. Access to these areas during work activities is as follows:

Table 4.1 Posting and Access Controls

POSTING	UNESCORTED ACCESS REQUIREMENTS
Radioactive Materials Area (10 CFR 20, Reference 13)	Rad Worker Training Dosimetry (TLD)Signed on RWP(s)
Authorized Entry Only (29 CFR 1910, Reference 8)	HAZMAT Training Project Document Training (Work Plan and Appendices)

Brush and other vegetation which would interfere with the identification of the original grids and/or surveys will be cleared with hand operated equipment (e.g., weed wackers, chain saws). The use of a bush hog or similar piece of equipment may be required depending on the thickness of the brush and vegetation. Removed materials will be surveyed, to ensure the radioactivity levels are below the guidelines, and removed from the immediate work area.

Establish a preliminary original grid pattern based on physical landmarks or other identifiable points of reference. One of the objectives when establishing this grid will be to correlate grid locations with the characterization grids. A GPS (Global Positioning Satellite) tracking system may be used during the gridding process to assist in identifying grid locations. Based on survey data and other available information re-establish, if necessary, the original characterization grids for reference.

Conduct a remedial action support and verification survey of the identified grids using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent). The objective of the remedial action support and verification survey will be to verify locations of areas requiring remediation identified in the 1996 characterization report (Reference 9) and ensure that these locations are remediated to levels below the site-specific ALARA level of 105 pCi/g. Table 4.2 lists areas at the site that may require remediation based on the results of the characterization survey. All data will be documented on ATGF-001, "Radiological Survey Report" in accordance with ATG Field Operations Procedures. Mark (red surveyors flag or equivalent) any areas exceeding the site-specific ALARA level for further investigation or remediation.

Table 4.2 Areas of the DUSA Potentially Requiring Remediation

Characterization Grid	Description
C1 and C2	Large area of elevated activity near the dirt road
Z2	One debris pile
A2	One area southeast of the sandpile near a detonation crater
A4 and A5	Several small isolated areas with elevated beta readings
B3	Area between buildings X-Ray 1 and X-Ray 2
B3	Area surrounding dirt hill that covers the electronics building A-7
B4	Area in the vicinity of X=250', Y=575' (southeast corner of grid)

Developed using data from "Transonic Range Depleted Uranium Study Area" (Reference 9), Appendix A, pages 16 and 17.

Conduct a remedial action support and verification survey of the accessible areas of the range structures using a Ludlum Model 2221 with a Model 43-69 Gas Flow Proportional Detector (or equivalent). Particular attention should be paid to areas found to be above the site-specific DCGLs during the characterization surveys. All data will be documented on ATGF-001, "Radiological Survey Report" in accordance with ATG Field Operations Procedures. Mark (red paint or equivalent) any areas exceeding the site-specific DCGL for further investigation or decontamination.

Based on survey data and other available information re-establish, if necessary, the work area boundaries (Radiological, HAZMAT, and Exclusion Areas).

4.3.3 SURVEY OF INACCESSIBLE SURFACES

Note 1: Prior to any range activities or change in range activities, e.g., change from surface work to excavation, the requirements of the ATG "UXO Avoidance Plan" will be implemented and met.

Note 2: All on site work will be done in accordance with the Site Health and Safety Plan, the Project Quality Assurance Plan, and the ATG Field Operating Procedures, which are an integral part of this plan. All stop work conditions, radiological and hazardous material, safety and industrial hygiene analysis are discussed in the Site Health and Safety Plan.

Note 3: All personnel with unescorted access to the work area will be required to wear TLDs during work activities at the site. Exposure Rate information from the characterization of the Transonic Range indicates that personnel exposure during remediation and decommissioning will be minimal. The highest indicated exposure rate is less than 0.1 mrem/ hr, as a conservative assumption. For scoping purposes, the dose to a hypothetical individual is estimated to be:

12 hrs/day x 20 days x 0.1 mrem/hr = 24 mrem (TEDE)

Once initial radiation survey evaluations are conducted in each area scheduled for remediation, the above estimate will be updated using actual measurement results.

Note 4: All material, tools, equipment, and personnel exiting the posted radiological work area must be surveyed to prevent the spread of contamination.

Note 5: Air samples will be collected in the general area and breathing zone of workers during evolutions that have the potential for producing airborne radioactivity (e.g., soil or surface disturbing activities, container loading, etc.).

Note 6: Protective clothing will be required, as per the RWP, in areas or during activities where the potential for personnel contamination exists (e.g., soil intrusion/excavation, decontamination).

Note 7: During excavation of contaminated soils a source of water (e.g., spray tank) will be maintained in the area to minimize dusty conditions that could spread contamination.

Based on survey data and other available information establish lay-down areas for clean, contaminated, and potentially contaminated materials in preparation for accessing unexposed or inaccessible areas of the range structures.

Using the least intrusive means available, remove any access interference to allow surveys of all portions of the range structures.

Areas known to have been inaccessible during characterization include:

Table 4.3 Areas Inaccessible During Characterization

STRUCTURE	LOCATION
Building A-7	eaves (i.e., area between the walls and roof)
Building A-7	roof under the steel plate
Building A-7	north exterior wall
Building A-7	west exterior wall
X-Ray 2	interior floor
Security Box 1	interior
Security Box 2	interior

Building materials removed to gain access will be surveyed to determine status. Materials above the DCGLs will be marked (e.g., red paint) held for decontamination or disposed of as Low Level Radioactive Waste (LLRW). All data will be documented on ATGF-001, "Radiological Survey Report" in accordance with ATG Field Operations Procedures.

If the method used to gain access has the potential to cause airborne radioactivity (e.g., grinding or chipping on contaminated structures), a containment will be built around the structure or area prior to commencing the aggressive activity.

Soil removed to gain access to building exteriors will be surveyed using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent) to determine status. If the indicated activity is above the DCGL, move it away from the building and resurvey. All data will be documented on ATGF-001, "Radiological Survey Report" in accordance with ATG Field Operations Procedures.

The newly exposed surfaces will be surveyed using a Ludlum Model 2221 with a Model 43-68 Gas Flow Proportional Detector (or equivalent) for fixed contamination and representative 100 cm^2 swipes for loose surface contamination. The swipes will be field counted using a Ludlum Model 2221 with a Model 44-9 GM Detector (or equivalent) and returned to the office area for laboratory counting with a Ludlum Model 2929 Scaler with a Model 43-10-1 ZnS(Ag)/plastic Scintillation Detector (or equivalent). All data will be documented on ATGF-001, "Radiological Survey Report" in accordance with ATG Field Operations Procedures.

4.3.4 Structural Test Area(s)

Note 1: Prior to any range activities or change in range activities, e.g., change from surface work to excavation, the requirements of the ATG "UXO Avoidance Plan" will be implemented and met.

Note 2: All on site work will be done in accordance with the Site Health and Safety Plan, the Project Quality Assurance Plan, and the ATG Field Operating Procedures, which are an integral part of this plan. All stop work conditions, radiological and hazardous material, safety and industrial hygiene analysis are discussed in the Site Health and Safety Plan.

Note 3: All personnel with unescorted access to the work area will be required to wear TLDs during work activities at the site. Exposure Rate information from the characterization of the Transonic Range indicates that personnel exposure during remediation and decommissioning will be minimal. The highest indicated exposure rate is less than 0.1 mrem/ hr, as a conservative assumption. For scoping purposes, the dose to a hypothetical individual is estimated to be:

12 hrs/day x 20 days x 0.1 mrem/hr = 24 mrem (TEDE)

Once initial radiation survey evaluations are conducted in each area scheduled for remediation, the above estimate will be updated using actual measurement results.

Note 4: All material, tools, equipment, and personnel exiting the posted radiological work area must be surveyed to prevent the spread of contamination.

Note 5: Air samples will be collected in the general area and breathing zone of workers during evolutions that have the potential for producing airborne radioactivity (e.g., soil or surface disturbing activities, container loading, etc.).

Note 6: Protective clothing will be required, as per the RWP, in areas or during activities where the potential for personnel contamination exists (e.g., soil intrusion/excavation, decontamination).

Note 7: During excavation of contaminated soils a source of water (e.g., spray tank) will be maintained in the area to minimize dusty conditions that could spread contamination.

The depth of contamination on concrete and steel surfaces are of concern in identifying an appropriate background reference area for the structures. To address these concerns small test areas will be decontaminated to determine the depth of the contamination.

An area of about one meter by one meter will be selected on the interior of building A-7. This area should be representative of the levels of fixed contamination found on the interior.

This area will be enclosed to prevent excessive airborne contamination during the decontamination process.

The existing conditions will be documented with at least 5 direct measurements using a Ludlum Model 2221 with a Model 43-68 Gas Flow Proportional Detector (or equivalent). All data will be documented on ATGF-001, "Radiological Survey Report" in accordance with ATG Field Operations Procedures.

A thin layer will be removed by scabbling (or other surface removal method) and the measurements will be repeated and documented.

This decontamination process will be repeated until all five measurements are less than 500 cpm (i.e., the estimated background plus 1.5 standard deviations).

If necessary to establish the contamination depth, core samples will be obtained of the concrete surfaces.

The process will be repeated for the exterior surface of building A-7.

At least 30 measurements will be obtained and documented in the decontaminated areas to provide an estimate of background for evaluating the remediation/decontamination data.

If the contamination depth appears to vary significantly (more than +50%) in X-Ray 2, then this process will be repeated in that structure.

4.3.5 REMEDIATION

Note 1: Prior to any range activities or change in range activities, e.g., change from surface work to excavation, the requirements of the ATG "UXO Avoidance Plan" will be implemented and met.

Note 2: All on site work will be done in accordance with the Site Health and Safety Plan, the Project Quality Assurance Plan, and the ATG Field Operating Procedures, which are an integral part of this plan. All stop work conditions, radiological and hazardous material, safety and industrial hygiene analysis are discussed in the Site Health and Safety Plan.

Note 3: All personnel with unescorted access to the work area will be required to wear TLDs during work activities at the site. Exposure Rate information from the characterization of the Transonic Range indicates that personnel exposure during remediation and decommissioning will be minimal. The highest indicated exposure rate is less than 0.1 mrem/ hr, as a conservative assumption. For scoping purposes, the dose to a hypothetical individual is estimated to be:

12 hrs/day x 20 days x 0.1 mrem/hr = 24 mrem (TEDE)

Once initial radiation survey evaluations are conducted in each area scheduled for remediation, the above estimate will be updated using actual measurement results.

Note 4: All material, tools, equipment, and personnel exiting the posted radiological work area must be surveyed to prevent the spread of contamination.

Note 5: Air samples will be collected in the general area and breathing zone of workers during evolutions that have the potential for producing airborne radioactivity (e.g., soil or surface disturbing activities, container loading, etc.).

Note 6: Protective clothing will be required, as per the RWP, in areas or during activities where the potential for personnel contamination exists (e.g., soil intrusion/excavation, decontamination).

Note 7: During excavation of contaminated soils a source of water (e.g., spray tank) will be maintained in the area to minimize dusty conditions that could spread contamination.

Based on verification survey data and anticipated area volumes, lay down area(s) will be established for the roll-off containers to be used for low level radioactive waste (LLRW).

Locate the appropriate number of hard cover roll-off containers, with 6 mil liners, in the lay down area(s).

4.3.5.1 Structures

The contaminated areas identified in the verification surveys of the DUSA structures will be decontaminated using the least intrusive means that is effective.

All contaminated materials removed and decontamination supplies will be contained for disposal as LLRW.
In-process surveys, using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent), of the area(s) being decontaminated will be taken to determine the end point of the decontamination effort.

If the method used for decontamination has the potential to cause airborne radioactivity (e.g., grinding or chipping on contaminated structures), a containment will be built around the structure or area prior to commencing the aggressive activity.

In cases where decontamination of small items and structural pieces is not cost effective, these items may be disposed of as LLRW.

Upon completion of decontamination, the last in-process survey will be documented. The documentation will be noted that the area is ready for final release survey.

4.3.5.2 Small Areas

The remediation method used in the small areas will depend on the extent of contamination found during the verification surveys.

For small, isolated spots, hand remediation using a shovel and pail or wheelbarrow is the preferred method. Hand remediation minimizes the chance of UXO encounters and minimizes LLRW.

For more extensive spots, heavy equipment (e.g., back-hoe, front-end loader), cutting approximately 1 foot of material per pass is more effective and expedient.

All removed material will be placed into the staged roll-off containers.

In-process surveys, using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent), of the area(s) being remediated will be taken to determine the end point of the remediation/decontamination effort.

Upon completion of remediation/decontamination, the last in-process survey will be documented. The documentation will be noted that the area is ready for final release survey.

4.3.5.3 Large Area

The large affected area will be bounded based on the verification surveys and other pertinent data.

A silt trench will be established around the area to prevent additional environmental contamination and/or cross contamination of additional areas.

Given appropriate UXO clearance to proceed, this area will be excavated, using heavy equipment (e.g., back-hoe, front-end loader) to a depth of approximately one foot.

The excavated material will be placed in the staged roll-off containers for disposal as LLRW.

During and upon completion of excavation an in-process survey, using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent), will be taken to determine the effectiveness of the remediation and the area status.

Any areas found to be above the site-specific ALARA level of 105 pCi/g will be flagged (red surveyors flag or equivalent) for additional remediation.

Depending on the extent of any remaining areas, hand or mechanical remediation will be continued until no additional areas exceeding the site-specific ALARA level are identified.

Upon completion of remediation/decontamination, the last in-process survey will be documented. The documentation will be noted that the area is ready for final release survey.

4.3.6 EQUIPMENT RELEASE AND DEMOBILIZATION

Prior to release from the site, all tools and equipment shall be surveyed for loose and fixed radioactive material.

All data will be documented on ATGF-001, "Radiological Survey Report" in accordance with ATG Field Operations Procedures.

Release of material from the site will be noted in the project logs with reference to the survey number for tracking purposes.

4.4 REMEDIATION WASTE

4.4.1 RADIOACTIVE WASTE VOLUME ESTIMATES AND HANDLING

Contaminated soils will be excavated using a backhoe and front end loader, while for some areas, waste removals will be done manually depending UXO clearance requirements. Contaminated structures (i.e., Building A-7, X-Ray 2, and both Security Boxes) will be decontaminated using scabblers, cut using oxyacetylene torches, or otherwise dismantled.

The waste generated from these activities will be packaged in hard covered roll-off intermodal transport containers (ITC) using a 6-mil thick insert liner. ITC containers meet the DOT definition of a strong tight container. Each container will be inspected for damages before use, including overall integrity, cracks, damaged gasket seals, and fitness of top cover. Once loaded, the top cover will be put in place and bolted down to ensure a tight-gasketed seal. The containers will be staged in the loading area on transport trucks or on cleared ground. All partially full containers will be covered at the end of the work day, or if work is suspended for more than 2 hours. The exact staging locations will be determined jointly with the Range Control Officer and ARL RSO. During on-site storage and until shipment, the storage area will be posted as a "Radioactive Materials Storage Area" and "Authorized Entry Only". An emergency call list will be developed to identify organizations and individuals to contact in the event of emergencies or unusual conditions. The call list will be coordinated with the Firing Range Officer and ARL RSO.

All exterior surfaces of the containers and transport vehicles will be verified to be free of loose surface contamination prior to shipment from the DUSA. All containers will be surveyed prior to shipment in accordance with ATG Field Operating Procedures and in compliance with 49 CFR Part 171-179. Maximum external dose rates containers are expected to be less than 1,000 uR/hr. The general area (30 cm) dose rate is anticipated to be between 20 and 100 uR/hr, depending on the distribution of DU in the containers and packages. Radiation levels from contaminated items and PPEs discarded as radioactive waste are expected to be non-distinguishable from ambient background radiation exposure rates.

The highest waste activity levels are expected to be less than the specific activity of DU, about 3.7 E+5 pCi/g. While lower DU concentrations are expected to range from non-detectable levels to about 520 pCi/g. The amounts of waste with higher DU concentrations are expected to be a fraction of the total volume of waste. It is expected that all shipments will be less than 0.05% by weight of source material. Waste will be sampled and analyzed onsite using an MCA as it is being generated. A composite sample will be prepared from each of the nine ITC containers and analyzed by an offsite laboratory for isotopic U by alpha spectroscopy and for U and Th decay products by gamma spectroscopy. The analysis will be used to confirm that only DU is present and that U and Th decay product concentrations are associated with naturally occurring radioactivity, including K-40. The same samples will be used for TCLP analysis. In both cases, the analyses will be conducted by laboratories certified by disposal sites or listed by USA-IOC.

Approximately 2,500 ft^3 of solid radioactive waste will be generated during remediation activities. The total amount shipped for disposal is estimated to be higher, about 3,125 ft^3 assuming growth factor of about 1.25, applied to the base estimate of 2,500 ft^3. Waste will be packaged in nine ITC containers. Expected waste forms are expected to include soils, concrete, wood, steel, and miscellaneous waste and debris. Contaminated soils are expected to make up most of the waste volume. Any natural moisture contained in soils generated during remediation activities will be absorbed with an approved desiccant prior to shipment for disposal. If excessive amounts of liquids are found in the waste, sampling and analysis will be performed in accordance with the ATG Field Operating Procedures. Arrangements for the processing and disposal of liquids wastes will be coordinated with the USA-IOC Project Officer and ARL RSO.

Based on prior characterization data, no other types of hazardous materials are expected that would result in the waste being classified as a mixed waste. However, should the presence of other types of hazardous materials be found (e.g., lead), ATG will immediately inform the USA-IOC Project Officer and ARL RSO. Any subsequent characterization efforts will be conducted under USA-IOC and ARL RSO approved methods. In addition, specific arrangements will be made for the disposal of such wastes, as needed.

All data generated in support of waste characterization and packaging will be recorded to later prepare the required shipping manifests (NRC Form 541 - Uniform Low-Level Radioactive Waste Manifest) and demonstrate compliance with the waste acceptance criteria of the disposal facilities (Envirocare and/or WCS). The data recorded will include external surface radiation exposure rates, container surface contamination levels, type, weight and volume of container, DU concentration, total DU inventory, RQ, waste class, physical and chemical form, type of absorbents if used, transport index, and shipment methods.

The full containers will be transported from APG to a local rail spur for trans-shipment (or directly on the transport truck) to Envirocare or WCS of Texas. MHF-Logical Solutions, Inc. (or an equally qualified company) will provide transportation services to the disposal sites. All shipments will meet the DOT requirements and comply with the IOC Standard Operating Procedures - "Shipping Procedures for Unwanted Radioactive Material". In addition, all activities associated with packaging, loading, survey, and shipment will be conducted in accordance with the ATG Field Operating Procedures. The drivers will be qualified and trained in accordance with DOT regulations under 49 CFR Part 172.700.

The broker used for the waste shipments will be USA-IOC certified in accordance with the IOC Standard Operating Procedure - "Shipping Procedures for Unwanted Radioactive Material". It is anticipated that waste generated during remediation activities will be shipped on a continual basis, thereby, leaving only small amounts of waste to be shipped at the end of the project.

4.4.2 Miscellaneous and Investigation-Derived Wastes

All equipment, supplies, and materials leaving site will be surveyed in accordance with protocol established for the project (see Table 5.1). Release limits will be those established in DG-4006, Demonstrating Compliance With the Radiological Criteria for License Termination and with Army Regulation EM 385-1-80. Equipment, tools, and materials not meeting the free release criteria will be decontaminated or disposed of as radioactive waste. Used PPE and other related wastes will be managed and disposed of with contaminated soils.

Liquid wastes are not expected during the conduct of remediation activities, nor are any liquid effluents. Any natural moisture contained in soils generated during remediation activities will be absorbed with desiccant prior to shipment for disposal. If liquids are found, sampling and analysis will be performed in accordance with the ATG Field Operating Procedures, which are based on the requirements of 10 CFR Part 20, Table 2, Col. 2. Compliance with these requirements will be documented.

Similarly, airborne effluents are not expected as a result of project activities. An air sampling program will be established in accordance with Section 4.3 of the Decommissioning Plan following the requirements of 10 CFR Part 20, Table 2, Col.1. Compliance with these requirements will be documented.

5. FINAL SURVEY PROCEDURES

5.1 MARSSIM ASSUMPTIONS AND PARAMETERS

The surveys and samples collected to demonstrate compliance with the release criterion have been designed using the guidance provided in the "Multi-Agency Radiation Survey and Site Investigation Manual", MARSSIM, NUREG-1575, (Reference 10) for the soil, Army Regulation EM 385-1-80, "Radiation Protection Manual", (Reference 5) for facilities and equipment, and "Demonstrating Compliance with the Radiological Criteria for License Termination" Draft Regulatory Guide DG-4006, (Reference 4). The release criterion for this site is found in "Radiological Criteria for License Termination", 10 CFR 20, Subpart E, (Reference 1).

Derived Concentration Guideline Limits (DCGLs) are radionuclide and site specific activity concentrations within a survey unit that correspond to the release criterion. DCGLs are required for volumetric (i.e., soil) contamination and structural surface contamination as an average activity level ($DCGL_W$) and for small areas of elevated activity ($DCGL_{EMC}$). The volumetric DCGLs for the Depleted Uranium Study Area (DUSA) of the Aberdeen Proving Ground (APG) Transonic Range were derived by Argonne National Laboratory (ANL) using the unrestricted release criterion, for the resident-farmer scenario, of 25 mRem/yr. The DCGLs are summarized here in Table 5.1. The report, "Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, MD", (Reference 2) is the basis for the volumetric DCGLs of this Work Plan. The ALARA target in Table 5.1 was selected based on the characterization results (Reference 9).[1] The Non-Detectable target is taken from Table 6 "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminates and Field Conditions" (Reference 17). Army Regulation EM 385-1-80 provides the basis for the surface DCGLs - see Table 5.2. Depending on NRC requirements, site-specific surface contamination limits may be developed using other tools, such as RESBUILD and DandD.

Table 5.1 DUSA Volumetric $DGCL_W$

CONDITION	$DCGL_W$ pCi/g
ANL (Ref. X) U-238 DCGL	230
ANL (Ref. X) U-238 DCGL (adjusted for DU and daughters)	190

[1] The results of the characterization study provide drawings identifying areas of the DUSA that exceed 35 pCi/g, 70 pCi/g, and 105 pCi/g. 35 pCi/g is below the detection limit for the field measurements, and 70 pCi/g is essentially equal to the detection limit. 105 pCi/g was selected as the ALARA limit and remediation goal because areas exceeding this concentrations are identified by the characterization survey results, can be detected using field measurement techniques, and this concentration is approximately half of the $DCGL_W$.

ALARA Target	105
Non-Detectable Target	60

Table 5.2 DUSA Structural DCGLs

CONDITION	LIMIT	
Loose Surface Contamination	< 1,000 dpm/100 cm^2 (a, ß)	$DCGL_L$
Fixed Contamination, Average	< 5,000 dpm/100 cm^2 (a, ß)	$DCGL_W$
Fixed Contamination, Maximum	< 15,000 dpm/100 cm^2 (a, ß)	$DCGL_{EMC}$

The $DCGL_{EMC}$ is not a single value, but a family of values developed for the site using the same modeling assumptions and parameter values but reducing the size of the area containing the activity. MARSSIM defines the ratio of the $DCGL_{EMC}$ to the $DCGL_W$ as the area factor. Since the scan MDC is less than the $DCGL_W$, the area factors do not affect the development and design of the release survey. In the event that small areas of elevated contamination are evident after remediation of the DUSA, conservative $DCGL_{EMC}$s will be developed based on the relative size of the areas and the guidance provided in "Manual for Conducting Radiological Surveys in Support of License Termination", NUREG-5849 (Reference 14) to determine the need for additional remediation.

The DUSA occupies approximately 50,000 m^2. Areas with DU activity greater than 105 pCi/gm, as identified in the characterization report and redefined in the confirmation surveys will be remediated (See Section 6, Remediation Activities). MARSSIM recommends that remediated areas receive a survey unit designation of Class 1. Areas of the DUSA that are remediated will be designated as Class 1 areas. Areas of the DUSA that do not require remediation will be designated as Class 2 areas. The results of the characterization survey indicate that the majority of the DUSA has the potential to contain concentrations of DU greater than 35 pCi/gm, therefore, no areas were designated as Class 3 or non-impacted areas.

Survey units are areas of specified size and shape for which a separate decision will be made whether the unit attains the site-specific $DCGL_W$. Survey units are formed by grouping contiguous site areas with a similar use history and the same classification. It is expected, based on the characterization results, that most of the DUSA will be classified as Class 2.

The sample variability in the DUSA was estimated to be approximately 26 pCi/g using the expected range of the data following remediation (0 pCi/g to 105 pCi/g) divided by four. The standard deviation for the characterization data less than 105 pCi/g for the five rows on the characterization grid ranged from 11 pCi/g for row 5 (grids A5, B5, and C5) to 30 pCi/g for row 2 (grids Z2, A2, B2, and C2). The estimated variability of 26 pCi/g is consistent with these values. MARSSIM defines the lower bound of the gray region (LBGR) as the activity where the user would like to know the probability of failing to release a "clean" survey unit For the DUSA the LBGR was selected to be 105 pCi/gm because this was the cut off for identifying areas that require remediation, so the probability of failing to release a site with activity below this level should be low. The relative shift is defined as the $DCGL_W$ minus the LBGR, divided by the variability. This results in a relative shift of 3.2 ([190-105]/26). MARSSIM recommends rounding down to 3.0 when the relative shift exceeds 3. Therefore, 3.0 was used to determine the number of measurements per survey unit. The acceptable Type I and Type II decision error rates were selected as 0.05. This means there is a 5% chance that a survey unit with an actual concentration of 190 pCi/g of DU would be determined to have a concentration less than 190 pCi/g. It also means that there is a 5% chance that a survey unit with an actual concentration of 105 pCi/g would be determined to have a concentration greater than 190 pCi/g. MARSSIM, Table 5.5, lists 14 measurements for a relative shift of 3.0 and decision error rates of 0.05. This means that 14 samples will be collected in each Class 1 survey unit greater than 140 m^2 and in each Class 2 survey unit.

5.1.1 Delineation and Layout of Class 1/Class 2 Survey and Sample Areas

5.1.1.1 Soil Survey Units

The DUSA is too large to be considered a single Class 2 survey unit. MARSSIM recommends that the survey unit size match the modeling assumptions used to develop the DCGLs. Since the ANL report does not list the area of exposure used, the RESRAD default value of 10,000 m^2 was used to divide the site into 5 Class 2 survey units of approximately 60 x 180 meters. This value (10,000 m^2) is consistent with the guidance found in MARSSIM. These survey units will roughly correspond to the rows (i.e., 1 through 5) of the characterization maps, adjusted to keep the areas approximately equal in size. The survey units will be designated and marked for identification (e.g., color coded metal stakes) in the north-west corner. (The DUSA does not lay perfectly aligned north and south. The perpendicular from the east-west axis will be designated as "Survey North".) Each survey unit will be subdivided and marked (e.g., color coded wood steaks) at ten meter intervals for reference and establishment of sampling and measurement locations. Two 400 m^2 areas will be identified and marked, in each Class 2 survey unit, as verification areas. These areas will be randomly selected, but skewed to not coincide with Class 1 survey units (including the "buffer") or structures. A GPS (Global Positioning Satellite) tracking system may be used during the gridding process to assist in identifying grid locations. Example sample locations have been determined and placed on the figures using a random-start triangular grid system. Sample locations that fall within structures or within Class 1 survey units (including the "buffer") will be eliminated and replaced, if necessary, with additional randomly selected locations to maintain the correct number of measurements.

Figure 5.1 shows the expected boundaries of the five Class 2 survey units. Figure 5.2 depicts the expected locations of the Verification Areas within the Class 2 survey units. Figures 5.3 through 5.7 show examples of sample locations on a random-start triangular grid in Class 2 survey units 1 through 5, respectively. The actual survey unit boundaries, areas, and sample locations cannot be finalized until after the remedial action support survey when the area classifications are finalized.

For remediation purposes, there were thirteen areas of concern (Class 1 areas), i.e., one large area and twelve small areas. Due to proximity and orientation, for final survey planning purposes these areas correspond to three Class 1 survey units of greater than 100m^2. The exact dimensions of the units will be determined by field surveys (remedial action support surveys). For work planning purposes the large area is expected to be approximately 250 m^2 with two smaller areas of approximately 120 m^2 each. If, based on field conditions, isolated small areas exist outside the bounds of these three areas, they will be marked and bounded as described below. While the Class 1 survey unit boundaries cross over individual Class 2 survey unit boundaries, all of the Class 1 survey units are fully contained within Class 2 survey units. The area surrounding each Class 1 survey unit, in Class 2 survey units, will receive 100% scan coverage. The width of this "buffer" will be dependent upon the relative size of the Class 1 survey unit. At a minimum, the width of this area will be 10 % of the maximum dimension of the remediated area. The perimeter and interior of the Class 1 survey units (including the "buffer") will be delineated and marked, as they fall within the Class 2 survey units, using the same system as the Class 2 survey units. The Class 1 survey units and the associated "buffer" will be differentiated from the Class 2 survey units using different color boundary indicators (e.g., green stakes - Class 2, yellow stakes - buffer, red stakes - Class 1). The sample locations will be field determined and placed using a random-start triangular grid system. It is likely that some small areas of elevated activity will be identified and remediated during the remedial action support and verification survey with areas less than 140 m^2. MARSSIM guidance states that special considerations may be necessary for land areas less than approximately 100 m^2. Remediated areas smaller than 140 m^2 and larger than 1 m^2 will have one sample collected for every 10 m^2. The number of samples will not be sufficient to support the assumptions of the statistical tests so these results will be compared directly to the $DCGL_W$. Areas less than 1 m^2 will not have any samples collected, but will receive a 1-minute direct count with the NaI(Tl) detector. All Class 1 survey units will receive 100% scan coverage. The 1 m^2 area is selected to correspond with the area of elevated activity used to develop the scanning sensitivity. A scan speed of 0.5 m/sec is expected to be able to identify a 1 m^2 area with a concentration of 60 pCi/g 95% of the time.

Figure 5.8 depicts the expected Class 1 survey units and their relationship to the Class 2 survey units.

5.1.1.2 Structural Survey Units

There are ten structural survey units based on the characterization survey data. (Two additional survey units may be necessary based on the results of the inaccessible area surveys of the security box interiors.) Survey units that exceeded the characterization criteria are identified as Class 1 survey units, the remaining surfaces are identified as Class 2 survey units.

Building A-7 will be divided into two survey units. The entire interior of the structure will be considered as one Class 2 survey unit. The entire exterior of the building and those areas considered inaccessible during the characterization survey will be designated as one Class 1 survey unit. Figures 5.9 and 5.10 depict the survey units for building A-7.

Building X-Ray 2 will be divided into six survey units. The interior and exterior of the north wall will be designated as one Class 2 survey unit, as will the interior and exterior of the east wall. The interior and exterior of the south wall will be designated as one Class 1 survey unit, as will the interior and exterior of the west wall. The ceiling and roof will be designated as a Class 1 survey unit. The final survey unit (Class 1) will be comprised of the floor and the ground immediately (approximately 1 meter or the width of the excavation necessary to expose inaccessible surfaces) outside of the walls. Figures 5.11 through 5.16 depict the survey units for building X-Ray 2. Figure 5.17 shows the Class 1, floor and ground, survey unit with the sample locations marked.

The exterior (and interior) surfaces of each Security Box will be designated as a Class 2 survey unit. If contamination is detected during the survey of inaccessible areas, the interiors will be designated as Class 1 survey units. Figures 5.18 and 5.19 depict the survey units for the Security Boxes.

The structural surfaces will be gridded at 1 meter intervals for survey purposes. The grid lines will be marked using a readily identifiable and repeatable system (e.g., paint or chalk lines). The floor and exterior ground of X-Ray 2 will be gridded using 1 meter grid intervals, but treated for sampling location purposes as a Class 1 soil survey unit, i.e., 14 locations placed using a random-start triangular grid system.

Table 5.3 Structural Survey Units

BUILDING	SURVEY UNIT	SURVEY CLASS
A-7	All interior surfaces	2
A-7	All exterior and inaccessible surfaces	1
X-Ray 2	South wall - interior and exterior	1
X-Ray 2	West wall - interior and exterior	1
X-Ray 2	North wall - interior and exterior	2
X-Ray 2	East wall - interior and exterior	2
X-Ray 2	Ceiling and roof	1
X-Ray 2	Floor (soil) and ground outside the walls	1
Security Box 1	Exterior	2
Security Box 1	Interior	*
Security Box 2	Exterior	2
Security Box 2	Interior	*

* The classification of the interior surfaces of the Security Boxes will be determined during the verification surveys taken during the Remediation Phase. If no contamination is detected during the verification, they will be combined with the exterior surfaces as a Class 2 survey unit. If contamination is detected, they will be considered as individual Class 1 survey units.

5.1.2 SURVEYS/SCANS OF CLASS 1 AREAS

5.1.2.1 Soil Survey Units

The scan coverage for each Class 1 survey unit will be 100%. This will be documented based on the sub-grids established in the field layouts. This scan will be conducted using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent) with a scan speed of less than 0.5 m/sec.

Direct measurements using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent) will be taken at each sample location prior to collecting the surface soil sample. These direct measurements will be integrated one minute counts.

Dose rates will be obtained at each sample location using a Ludlum Model 19 μR meter (or equivalent). Dose rates will be obtained at contact with the surface prior to collecting the soil sample and at waist level (1 meter).

If, based on field conditions, isolated small areas exist outside the bounds of the three anticipated Class 1 survey units of greater than 100 m^2, one direct measurement and dose rate point will be marked for each 10 m^2 of surface area. These direct measurement results will be compared directly to the $DCGL_W$ and will not use the statistical tests to demonstrate compliance and eligibility for release. A minimum of three measurements and dose rates will be obtained in each limited area identified.

5.1.2.2 Structural Survey Units

The scan coverage for each Class 1 survey unit will be 100% using a Ludlum Model 2221 with a Model 43-69 Gas Flow Proportional Detector (or equivalent). This scan will be conducted at a scan speed not to exceed ½ probe width per second (approximately 2" per second).

A direct measurement will be obtained from each 1 meter square grid, at the point of the highest scan count rate, using a Ludlum Model 2221 with a Model 43-69 Gas Flow Proportional Detector (or equivalent). These direct measurements will be integrated one minute counts.

5.1.3 SAMPLES FROM CLASS 1 AREAS

5.1.3.1 Soil Survey Units

Surface soil samples will be collected from each of the 14 locations in each Class 1 survey units greater than 100 m^2.

These samples will be approximately 1 kg (2.2 lb) from the top six inches of soil at the sampling location.

The sampling tool (e.g., garden trowel) will be cleaned between samples to prevent cross contamination of samples.

Chain-of-Custody (COC) will be established and maintained in accordance with ATG Field Operating Procedures (Appendix 3).

Samples analysis will include gamma spectroscopy on all samples (42) and alpha spectroscopy on 15% of the samples (7).

5.1.3.2 Structural Survey Units

A 100 cm^2 smear (swipe) sample will be obtained from each square meter grid for structural Class 1 survey units.

Smear samples will be field counted using a Ludlum Model 2221 with a Model 44-9 GM Detector (or equivalent) and returned to the office area for analysis with a Ludlum Model 2929 Scaler with a Model 43-10-1 ZnS(Ag)/plastic Scintillation Detector (or equivalent).

Media samples will be obtained from each Class 1 survey unit including: core bore samples and/or chips from the concrete surfaces, pieces of steel (approximately 100 cm^2 samples), and soil from the soil surfaces of X-Ray 2. Anticipated distribution of samples is: soil 14, concrete 4, and steel 2).

The floor and exterior grounds of X-Ray 2 will be gridded using 1 meter grids and sampled using the protocol established for the Class 1 soil survey units, i.e., 14 soil samples from locations field determined and placed using a random-start triangular grid system.

Chain-of-Custody (COC) will be established and maintained for media samples in accordance with ATG Field Operating Procedures.

Samples analysis will include alpha and gamma spectroscopy on all samples (20).

The release limits identified in Table 5.2 will be used for the purpose of disposing of materials cleared by the above noted survey methods. Depending on NRC requirements, site-specific surface contamination limits may be developed using other tools, such as RESBUILD and DandD.

5.1.4 SURVEYS/SCANS OF CLASS 2 AREAS

5.1.4.1 Soil Survey Units

The scan coverage of each Class 2 survey unit (exclusive of: area taken up by structures, Class 1 survey units, and verification areas), will be a minimum of 10%. The minimum scan coverage of 10% is expected to be adequate for the Class 2 areas because a scan survey with 100% coverage was performed as part of the characterization. The 10% scan coverage in the Class 2 survey units and the 100% scan coverage in the verification areas will be performed to verify the results of the characterization survey and provide an additional level of confidence that all areas of concern have been identified and addressed. This will be documented based on the sub-grids established in the field layouts. This scan will be conducted using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent) with a scan speed of less than 0.5 m/sec.

The scan coverage for each verification area (2 ea. 400 m^2 areas per Class 2 survey unit) will be 100%. This will be documented based on the sub-grids established in the field layouts. This scan will be conducted using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent) with a scan speed of less than 0.5 m/sec. Suspect areas, i.e., readings greater than the field action level, will be flagged for further investigation.

Direct measurements using a Ludlum Model 2221 with a Model 44-10 2 x 2 NaI(Tl) Detector (or equivalent) will be taken at each sample location prior to collecting the surface soil sample. These direct measurements will be integrated one minute counts.

Dose rates will be obtained at each sample location (including suspect spots identified in the verification areas) using a Ludlum Model 19 μR meter (or equivalent). Dose rates will be obtained at contact with the surface prior to collecting the soil sample and at waist level (1 meter).

5.1.4.2 Structural Survey Units

The scan coverage for each Class 2 survey unit will be 100% using a Ludlum Model 2221 with a Model 43-69 Gas Flow Proportional Detector (or equivalent). This scan will be conducted at a scan speed not to exceed ½ probe width per second (approximately 2" per second).

NOTE: The scan coverage for unrestricted release, in accordance with References 4 and 5, is intended to encompass 100% of the surface. If the documentation of the verification of characterization and remedial action support surveys encompasses 100% of the surface, a 10% scan and reference to those surveys will be considered to meet the intent of the regulations.

A direct measurement will be obtained from each 1 meter square grid, at the point of the highest scan count rate, using a Ludlum Model 2221 with a Model 43-69 Gas Flow Proportional Detector (or equivalent). These direct measurements will be integrated one minute counts.

5.1.5 Samples from Class 2 Areas

5.1.5.1 Soil Survey Units

Surface soil samples will be collected from each of the 14 locations in each of the 5 Class 2 survey units.
Surface soil samples will also be collected, for investigative purposes, from any suspect spots identified in the verification areas.

These samples will be approximately 1 kg (2.2 lb) from the top six inches of soil at the sampling location.

The sampling tool (e.g., garden trowel) will be cleaned between samples to prevent cross contamination of samples.

Chain-of-Custody (COC) will be established and maintained in accordance with ATG Field Operating Procedures.

Samples analysis will include gamma spectroscopy on all samples (70) and alpha spectroscopy on 15% of the samples (11). The total number of samples submitted for alpha spectroscopy may be revised if it can be shown that a lesser number of samples will not impact the quality of the data and interpretation of the results in confirming that D&D objectives have been met.

Samples analysis will include gamma spectroscopy on all samples and alpha spectroscopy on 15% of the samples collected for investigative purposes.

5.1.5.2 Structural Survey Units

A 100 cm^2 smear (swipe) sample will be obtained from each square meter grid for structural Class 2 survey units.

Smear samples will be field counted using a Ludlum Model 2221 with a Model 44-9 GM Detector (or equivalent) and returned to the office area for analysis with a Ludlum Model 2929 Scaler with a Model 43-10-1 ZnS(Ag)/plastic Scintillation Detector (or equivalent).

5.2 BACKGROUND AND QUALITY ASSURANCE SURVEYS

In order to ensure quality, measures will be instituted to evaluate all field measurements and corresponding analyses for samples sent out to an off site laboratory. In addition, instrument responses will be bench-marked during mobilization to determine background counting rates, and to develop instrument specific relationships, e.g., cpm vs. pCi/g, uR/hr vs. pCi/gm. These relationships will be used to develop and establish "field action levels" to guide the D&D and the final status surveys.

These instrument relationships will be developed relating the response (cpm or uR/hr) to known soil contamination levels (pCi/g). A series of regression analyses will be developed to express the response to specific measurement geometry, soil matrix, and surface condition. Instrument response may be expressed as a power function in the form:

C_{DU} = a (cpm or uR/hr)^b, where:

C_{DU} = Lab derived DU soil concentration, pCi/g, cpm, uR/hr = Instrument response, net cpm or uR/hr, corresponding to sampling location,

a, b = Regression coefficients, qualified with coefficients of determination, r^2.

These relationships will take into account that the associated uncertainty between field and laboratory analyses will increase as radioactivity levels decrease. A total of 25 samples will be collected for this purpose and sent out for gamma and alpha spectroscopy analysis. In addressing this aspect, the method will identify ways to compensate for these uncertainties, e.g., increasing counting times for fixed integrated measurements or decreasing scan rate. These relationships between soil activity levels and instrument response will be full documented to withstand technical and regulatory scrutiny.

The performance of the scanning and direct measurement instruments will be monitored in the field using daily performance checks and background plotted on control charts. The performance of the measurement system will be evaluated by replicating 5% of the direct measurements and scans.

The depth of contamination on concrete and steel surfaces and identifying an appropriate background under field conditions will be addressed as a part of the D&D/ER process. Small test areas (i.e., 1 m^2) will be identified on the interior and exterior of Building A-7. The existing conditions will be documented with 5 direct readings from the surface(s). A thin layer will be removed by scabbling (or other surface removal technique) and the measurements will be repeated. This process will be repeated until all 5 readings are less than 500 cpm (i.e., the estimated background plus 1.5 standard deviations). Once the depth of contamination has been determined for each area, these areas will provide a background reference area. At least 30 direct measurements will be performed in the reference areas to estimate the background for reference and data evaluation.

The analytical laboratory will provide information on the historical performance of the alpha and gamma spectroscopy procedures and demonstrate that the measuring systems were operating within these historical parameters during the analysis of surface soil samples. In addition, 25 collocated surface soil samples will be collected and sent to the laboratory for analysis. These samples locations will be randomly selected from the Class 1 and Class 2 final status survey locations. (Analysis will replicate the analysis of the original sample.) These collocated samples will be used to provide an estimate of the overall precision associated with the survey design for the exterior survey units. The results of these analyses will be used to evaluate the overall uncertainty associated with the decisions made based on the survey results.

5.3 SAMPLE ANALYSIS

Table 5.4 provides a recap of the analysis required on the soil samples taken to demonstrate compliance with the DCGLs. These samples include final status survey samples, investigative samples, survey design precision estimation, and instrument relationships.

Table 5.4 DUSA Sample and Analysis Recap

SAMPLE TYPE/LOCATION	APPROXIMATE NUMBER *	ANALYSIS REQUIRED
Class 1 Survey Units	42	Gamma Spec - 100% (42) Alpha Spec - 15% (7)
Class 2 Survey Units	70	Gamma Spec - 100% (70) Alpha Spec - 15% (11)
QA Collocated	25	Gamma Spec - 100% (25) Alpha Spec - 15% (4)
QA Relationship	25	Gamma Spec - 100% (25) Alpha Spec - 100% (25)
Investigative	50	Gamma Spec - 100% (50) Alpha Spec - 15% (8)
Structural (Includes Soil)	20	Gamma Spec - 100% (20) Alpha Spec - 100% (20)

NOTE: In some cases one sample may serve 2 functions, i.e., a collocated sample may also serve as a relationship sample or a survey unit sample may also serve as relationship sample.

5.4 IDENTIFICATION OF MAJOR CONTAMINANT

Based upon available information and historic assessment of site operations and on the results of the 1996 characterization surveys and sampling the significant radiological contaminate in the Transonic Range Depleted Uranium Study Area (DUSA) has been determined to be Depleted Uranium (DU). The isotopic distributions of U-234, U-235, and U-238 appear to be those described for DU since the U-238 activity is greater than 80% with U-234 at less than 20%. If the activity were natural uranium the U-238 and U-234 activities would be equal, since the daughter, U-234, would be in natural equilibrium with the parent, U-238.

For this effort, the radionuclides of concern from the DU are U-238, U-234, Th-234, Pr-234, and Pr-234m. The Thorium and Protactinium isotopes are short lived daughter products from the decay of U-238.

Characterization samples were also analyzed for gamma emitting radionuclides and Technecium 99 (Tc-99). No other significant gamma emitting radionuclides were detected. Tc-99 was not detected in the sample.

On the basis of the combination of contaminates, the DCGLs for building, equipment, and material surfaces are considered to be equivalent to the acceptable surface contamination levels for Uranium listed in Table 6-4 of Reference 5. These levels are recapped in Table 5.5.

Table 5.5 DUSA Surface DCGLs

CONDITION	LIMIT	
Loose Surface Contamination	< 1,000 dpm/100cm^2 (a, ß)	$DCGL_L$
Fixed Contamination, Average	< 5,000 dpm/100cm^2 (a, ß)	$DCGL_W$
Fixed Contamination, Maximum	< 15,000 dpm/100cm^2 (a, ß)	$DCGL_{EMC}$

6.0 RADIOACTIVE WASTE MANAGEMENT

All equipment, supplies, and materials leaving the site will be surveyed in accordance with the protocol established in ATG Field Operating Procedures (Appendix 3). Release limits will be those established in DG 4006, Demonstrating Compliance with the Radiological Criteria for License Termination (Reference 4) and Army Regulation EM 385-1-80. Equipment, supplies, and materials not meeting the free release criteria will be decontaminated or disposed or as radioactive waste.

No liquid wastes are expected to be generated as a result of this project, nor are any liquid effluents expected to be recovered or sampled during this project. Any moisture derived from the soil remediation will be absorbed with desicant prior to shipment of the remediated material for disposal. If liquid samples are required, they will be performed in accordance with ATG field Operating Procedures which are based on the regulations and limitations of 10 CFR 20 (Reference 13).

No airborne effluents are expected to be generated as a result of this project. However, an Air Sampling Program will be established in accordance with Section 4 of this Work Plan and Appendix 3. The results of the samples will be used to document compliance with 10 CFR 20.

Approximately 2,500 ft3 of solid radioactive waste (soil and debris) is anticipated to be generated as a result of this project. Based on the characterization data, there are no other hazardous components that would result in the waste being classified as a mixed waste. This data will be verified prior to packaging and disposal of the waste generated in the remediation process. This waste will be handled, packaged, stored, and disposed of as follows.

The highest sample activity, recorded in the characterization data, was 4.23 E5 pCi.g. While the anticipated average concentration is much lower, this activity will be used for planning purposes.

The waste generated from this project will be packaged in hard covered roll-off containers with a 6 mil liner. These containers will be staged in the loading area on transport trucks or on cleared ground. Staging will be based on field conditions.

Containers will be covered and sealed upon completion of loading. All partially full containers will be covered at the end of the work day, or if work is suspended for more than 2 hours.

All exterior surfaces of the containers, and the transport vehicles, will be verified to be free of loose surface contamination prior to removal from the DUSA.

If on-site storage is necessary prior to shipment, the storage area will be barriered and posted "Radioactive Materials Storage Area" and Authorized Entry Only".

All containers will be surveyed prior to shipment in accordance with ATG Field Operating Procedures and in compliance with 49 CFR 171 - 179 (Reference 15). Maximum expected dose rates on the exterior of the containers is 1,000 uR/hr. The general area (30 cm) dose rate is anticipated to be between 20 and 100 uR/hr, depending on the distribution of DU inside the container.

- The full containers will be transported from APG to a rail spur for trans-shipment (or directly on the transport truck) to WCS of Texas or other licensed and approved disposal site. The final mode of transportation will be field determined.

- All shipments will meet the DOT requirements of Reference 15 and comply with the IOC Standard Operating Procedure - Shipping Procedure for Unwanted Radioactive Material, (Reference 16). In addition, all activities associated with packaging, loading, survey, and shipment will be conducted in accordance with the ATG Field Operating Procedures.

- The broker for this waste will be IOC approved in accordance with Reference 16.

- It is anticipated that all waste generated during this project will be shipped before the end of the project.

7.0 SELECTED PROCEDURES AND EQUIPMENT

7.1 INSTRUMENTATION

7.1.1 CALIBRATION

Electronic and source calibrations of field instruments used for decommissioning and unrestricted release of facilities and sites will be performed by the manufacturer or by another approved vendor laboratory.

Third party analytical laboratories will provide information on the calibration and historical performance of analytical equipment and demonstrate that the measurement system was operating within these parameters during the analysis of project samples.

Copies of the calibration data will be maintained in the field office as a part of the field instrument control data file.

7.1.2 CORRELATION

Instrument responses will be benchmarked, on a project specific basis during mobilization and setup, to determine background rates and establish instrument specific relationships (e.g., cpm vs. pCi/gm and/or uR/hr vs. pCi/gm) used to establish field action levels and end points.

These responses will be documented as a part of the field instrument control data file.

7.1.3 DAILY RESPONSE

All field instruments will be response checked on a daily basis. The minimum checks will include: a visual survey for physical damage, a verification that the calibration and performance check stickers are intact, verification that the instrument is in calibration, i.e., the calibration due date has not passed, a battery check, and response check to a known source.

The response check data will be recorded in accordance with ATG Field Operating Procedures, Appendix 3, on ATGF-003.

The background and source check data for field and laboratory instruments will be plotted on control charts as a measure of performance reliability.

As an additional measure of reliability, a minimum of 5 percent of the direct measurements and scans will be replicated. The locations of replicate measurements will be determined on a biased random basis.

7.1.4 Operation

Field instruments will be operated in accordance with the ATG Field Operating Procedures.

Instruments obtained for use on a specific project, (e.g., leased, borrowed) that are not a part of the ATG inventory, will be operated in accordance with the operating procedure provided by the vendor/owner.

7.2 INSTRUMENT SELECTION

To ensure quality of measurements and that the measurements meet the intent of the applicable guidelines and regulations (i.e., can detect the levels of radioactivity required for release), instruments for the DUSA project have been selected using the relevant guidelines of "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM), NUREG-1575, (Reference 10) and "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminates and Field Conditions", NUREG-1507, (Reference 17).

Table 6.1 lists the instruments to be used for the DUSA survey activities along with typical operating parameters. While specific Types/Models of instruments and detectors are listed, this does not preclude the use of equivalent meters or detectors. Substitution may be made for a variety of reasons including equipment availability and operational considerations.

Table 6.1 Instrument Selection

Indicated Use	Meter	Detector	Detector Type	Efficiency	Minimum Detectable Concentration
Alpha Survey	Ludlum Model 3	Ludlum 43-65	Scintillator ZnS(Ag)	15 %	90 dpm/100 cm^2
Alpha Survey	Ludlum Model 2221	Ludlum 43-68	Gas Flow Proportional	15 %	50 dpm/100 cm^2
Beta Survey	Ludlum Model 3	Ludlum 44-9	G-M	20 %	1080 dpm/100 cm^2
Beta Survey	Ludlum Model 2221	Ludlum 43-68	Gas Flow Proportional	20 %	420 dpm/100 cm^2
Alpha Surface Activity	Ludlum Model 2929	Ludlum 43-10-1	Scintillator ZnS(Ag)/Plast.	35 %	150 dpm/100 cm^2
Beta Surface Activity	Ludlum Model 2929	Ludlum 43-10-1	Scintillator ZnS(Ag)/Plast.	30 %	727 dpm/100 cm^2
Gamma Scan	Ludlum Model 2221	Ludlum 44-10	Scintillator 2 x 2 NaI(Tl)	N/A	56 pCi/gm
Gamma Dose Rate	Ludlum Model 19	Integral	Scintillator 1 x 1 NaI(Tl)	N/A	1 uR/hr

8.0 REFERENCES

1 Radiological Criteria for License Termination, 10 CFR 20, Subpart E, USNRC

2 Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, MD, ANL, 1999

3 Federal Register/Volume 62, Number 222/Wednesday, November 18, 1998

4 Demonstrating Compliance with the Radiological Criteria for License Termination, Draft Regulatory Guide DG-4006, USNRC, 1998

5 Army Regulation EM 385-1-80, Radiation Protection Manual

6 When to Remediate Inadvertent Contamination of the Terrestrial Environment, USNRC, Branch Technical Position, 1995

7 Radiation Worker Training, 10 CFR 19.13, USNRC

8 OSHA Construction Standards, 29 CFR 1910.120, USDOL

9 Transonic Range Depleted Uranium Study Area Radiological Characterization Study Report, General Physics Corporation, 1996

10 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575

11 Hazardous Materials, 40 CFR 261

12 Prenatal Exposure, Reg. Guide 8.13, USNRC

13 Standards for Protection Against Radiation, 10 CFR 20, USNRC

14 Manual for Conducting Radiological Surveys in Support of License Termination, NUREG-5849

15 49 CFR 171 - 179, DOT

16 IOC, AMSIO-DMW. Standard Operating Procedure - Shipping Procedure for Unwanted Radioactive Material, 1999

17 Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminates and Field Conditions, NUREG-1507

9.0 APPENDICES

NO	TITLE
1	Specification for the Decommissioning Plan Transonic Range - Aberdeen Proving Ground
2	Project Quality Assurance Plan
3	ATG Field Operating Procedures
4	Project Health and Safety Plan
5	Project UXO Avoidance Plan

Appendix D

APG Transonic DUSA Soil Sample Results

APPENDIX D

APG TRANSONIC DUSA FSS SOIL SAMPLE

Survey Unit	Field ID	U-238 Result[2] (pCi/g)	Flag[1]	TPU[3,4] (+/-)	MDC[5]	SU Statistics (pCi/g)	
SU-1 Class 2	36	-0.7	U	2.7	4.8	avg	1.5
	37	0.5	U	1	1.8	stdev	1.3
	38	3.5	U	4.5	7.3	max	3.5
	39	0.7	U	2.1	3.5	min	-0.7
	40	1.5	U	1.9	3		
	41	0.3	U	1.4	2.4		
	42	2.1	U	3.7	6.2		
	43	2.9	U	3.4	5.5		
	44	2.8		1.2	1.5		
	45	-0.15	U	0.65	1.2		
	46	0.9	U	3.6	6.3		
	47	3.3	U	4.3	7		
	48	2.1	U	3.4	5.7		
	49	0.75	U	0.78	1.3		
SU-2 Class 2	50	1.5	U	2.8	4.7	avg	2.6
	51	3.9		2	2.7	stdev	2.8
	52	2.7	U	2.9	4.5	max	8.7
	53	2		1.2	1.7	min	-0.2
	54	0.1	U	1	1.8		
	55	0.6	U	1.7	2.9		
	56	-0.2	U	3	5.5		
	57	3.8	U	3.6	5.7		
	58	0	U	5.4	9.6		
	59	0.9	U	1.2	2		
	60	8.7		4.5	6.2		
	61	4.8	U	4	6.1		
	62	7.5		4.8	7		
	62a[6]	0.5	U	3.4	5.8		
SU-3 Class 2	63	1.2	U	3	5	avg	4.9
	64	0	U	2.8	4.9	stdev	5.5
	65	12		4.6	5.4	max	16
	66	-2.1	U	4.1	7.9	min	-2.1
	67	1.3	U	1.8	3		
	68	14		3.1	2.2		
	69	16		6	7		
	70	7.3		2.2	2.2		
	71	1.5	U	4.4	7.5		
	72	1.6	U	4.6	7.9		
	73	5.3		1.8	1.9		
	74	2.5	U	4.4	7.5		
	75	5.3	U	4.8	7.6		
	76	3.3	U	4.4	7.2		

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APG TRANSONIC DUSA FSS SOIL SAMPLE

Survey Unit	Field ID	U-238 Result(2) (pCi/g)	Flag(1)	TPU(3,4) (+/-)	MDC(5)	SU Statistics (pCi/g)	
SU-4 Class 1	77	2.5	U	1.8	2.7	avg	1.3
	78	1.9	U	1.6	2.4	stdev	1.0
	79	0.5	U	3	5.3	max	3.2
	80	0.7	U	1.4	2.4	min	-1
	81	2.4	U	1.9	2.9		
	82	1.6	U	1.7	2.8		
	83	3.2	U	4.3	7		
	84	1.4	U	1.3	2.1		
	85	1.1	U	1.4	2.2		
	86	1.5	U	1.6	2.5		
	87	-1	U	4.7	8.8		
	88	0.4	U	4	6.9		
	89	1.1	U	1.1	1.8		
	90	1.4	U	2.4	3.9		
SU-5 Class 1	91	1.3	U	3.1	5.3	avg	2.1
	92	7.1	LT	3.1	4.4	stdev	2.0
	93	2.6	U	3.8	6.3	max	7.1
	94	2.5	U	4	6.7	min	0
	95	1.8	U	2.4	3.9		
	96	0	U	3.2	5.9		
	97	2.5	U	2.9	4.7		
	98	0.2	U	3.4	6.2		
	99	4	U	3.1	4.6		
	100	0	U	1.7	3.2		
	101	1.2	U	2	3.3		
	102	4.1	U	3.2	4.9		
	103	0.4	U	2.1	3.7		
	104	1.1	LT	0.7	1.03		
SU-6 Class 1	105	0.65	U	0.68	1.1	avg	6.6
	106	26		6.6	6.3	stdev	7.3
	107	14		4.8	5.2	max	26
	108	0.7	U	1.7	3	min	0.65
	109	3.2		1.1	1.3		
	110	3.2	U	4	6.5		
	111	1.4	U	1.3	2.1		
	112	2	U	4.5	7.7		
	113	2.3		1.1	1.5		
	114	6.6		4	5.8		
	115	6.6	LT	4	6		
	116	13		5.1	6.5		
	117	12		2.4	1.8		
	118	0.94	U	0.64	0.95		

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APG TRANSONIC DUSA FSS SOIL SAMPLE

Survey Unit	Field ID	U-238 Result(2) (pCi/g)	Flag(1)	TPU(3,4) (+/-)	MDC(5)	SU Statistics (pCi/g)	
SU-7 Class 1	119	29		7.3	6.9	avg	8.2
	120	21		5.6	4.9	stdev	9.9
	121	2.3		1.1	1.6	max	29
	122	-1.6	U	2.4	4.5	min	-1.6
	123	5		2.8	4		
	124	0.8	U	2.7	4.7		
	125	-0.1	U	2.7	4.9		
	126	13		2.7	2.8		
	127	1.3	U	0.94	1.4		
	128	13		2.4	2.2		
	129	23		6.8	7.5		
	130	0.1	U	1.6	2.7		
	131	4.3	LT	1.7	2.3		
	132	3.7		2.4	3.6		
SU-8 Class 1	133	0.6	U	2.1	3.6	avg	5.3
	134	2.3	U	3.2	5.3	stdev	7.4
	135	0.2	U	2.5	4.3	max	26
	136	-2.2	U	2.8	5.2	min	-2.2
	137	0.5	U	1.4	2.3		
	138	7	LT	4.4	6.8		
	139	2.5	U	1.6	2.6		
	140	14		4.2	4.7		
	141	4.7	U	3.4	5.2		
	142	26		4.8	2.2		
	143	2.5	LT	1.4	2.2		
	144	11		4.8	6.9		
	145	4		2.2	3		
	146	1.6	U	1.9	3.1		
SU-9 Class 1	147	-0.2	U	3	5.5	avg	1.6
	148	0.7	U	3.1	5.4	stdev	1.5
	149	-0.4	U	4.2	7.5	max	5.3
	150	1.3	U	1.6	2.5	min	-0.4
	151	2.9	U	3.8	6.2		
	152	1.5	U	1.2	1.8		
	153	1.5	U	1.6	2.6		
	154	0.62	U	0.8	1.3		
	155	2.7		1.8	2.7		
	156	1.1	U	3.1	5.2		
	157	1.1	U	2.1	3.6		
	158	3.1	U	4	6.6		
	159	1	U	4	6.9		
	160	5.3		3.4	5		

APPENDIX D

APG TRANSONIC DUSA FSS SOIL SAMPLE

Survey Unit	Field ID	U-238 Result(2) (pCi/g)	Flag(1)	TPU(3,4) (+/-)	MDC(5)	SU Statistics (pCi/g)	
SU-10 Class 1	161	-1.7	U	3.5	6.3	avg	1.0
	162	0.1	U	3.6	6.3	stdev	1.4
	163	1.4	U	1.7	2.8	max	3.4
	164	1	U	1	1.6	min	-1.7
	165	0.6	U	1.3	2.3		
	166	0.4	U	1.6	2.8		
	167	1.5	U	1.8	2.9		
	168	3.4	U	3.5	5.6		
	169	2.6	U	3.5	5.8		
	170	-1	U	3.4	6		
	171	1.6	U	1.8	2.9		
	172	2.6	U	4	6.6		
	173	0.9	U	2.1	3.5		
	174	0.8	U	1.9	3.2		
SU-11 Class 1	175	2.3	U	3.7	6.1	avg	1.7
	176	0.4	U	1.1	1.8	stdev	1.6
	177	0.5	U	2.2	3.7	max	5.3
	178	1.3	U	1.6	2.6	min	-0.2
	179	-0.2	U	1.9	3.4		
	180	0.9	U	1.7	2.8		
	181	4.9		2.8	4.1		
	182	1.9	U	3.9	6.5		
	183	1.5	U	1.5	2.4		
	184	1.9	U	3.1	5.1		
	185	5.3		2.2	2.8		
	186	2.2	U	2.3	3.8		
	187	0.1	U	3.2	5.6		
	188	1	U	2	3.3		
SU-12 Class 1	189	2.8	U	4.2	7	avg	14
	190	56		10	4	stdev	18
	191	25		5.3	4.2	max	56
	192	5.5		3.3	5.1	min	1.6
	193	48		9.5	4.4		
	194	3.8	U	4.3	7		
	195	3	U	4.4	7.3		
	196	6.1	LT	1.7	2		
	197	9.1		3	3.3		
	198	2.1	U	3.1	5.1		
	199	3.7	U	3.6	5.7		
	200	27		7.1	7.1		
	201	6.7		3.1	4		
	202	1.6	U	2.5	4.2		

APPENDIX D
APG TRANSONIC DUSA FSS SOIL SAMPLE

Survey Unit	Field ID	U-238 Result(2) (pCi/g)	Flag(1)	TPU(3,4) (+/-)	MDC(5)	SU Statistics (pCi/g)	
	203	3	LT	1.5	2.2	avg	11
	204	9.6		4.9	7	stdev	18
	205	3.6		1.7	2.5	max	66
	206	3.9	U	4.7	7.6	min	0.3
	207	35		7	3.2		
	208	3.8	U	4	6.5		
SU-13	209	1.2	U	4	7		
Class 1	210	7.2		2.7	3.2		
	211	66		12	5.5		
	212	6.2		2.3	2.5		
	213	5.4	LT	1.5	1.8		
	214	2.3	U	2.1	3.4		
	215	0.3	U	1.8	3.1		
	216	5.9		2.4	3.2		
	217	2.2	U	1.6	2.4	avg	6.5
	218	2.8	U	2.4	3.8	stdev	14
	219	2.8	U	3.6	5.9	max	54
	220	54		11	7.2	min	0.9
	221	0.9	U	2.6	4.4		
	222	5.3		2	2.4		
SU-14	223	2.4	U	1.7	2.5		
Class 1	224	1.2	U	1.4	2.3		
	225	3.6		1.8	2.6		
	226	3.3	U	4	6.4		
	227	4.3	U	4.4	6.9		
	228	4.3	LT	1.3	1.6		
	229	2.7		1.8	2.6		
	230	1.8	U	1.8	2.8		
	231	5.7	U	4.7	7.3	avg	2.8
	232	1.5	U	4.3	7.4	stdev	1.4
	233	1.6	U	2.3	3.8	max	5.7
	234	3.1		1.7	2.4	min	0.9
	235	0.9	U	1.5	2.6		
	236	1.1	U	0.94	1.5		
SU-15	237	3.8	U	2.8	4.3		
Class 1	238	3.7	U	4.1	6.5		
	239	3	U	3.7	6.1		
	240	4.1	U	2.9	4.4		
	241	2.1		1.3	1.8		
	242	4.3		2.1	2.8		
	243	2.2		1.3	1.9		
	244	1.5	U	2.5	4.1		

APPENDIX D

APG TRANSONIC DUSA FSS SOIL SAMPLE

Survey Unit	Field ID	U-238 Result(2) (pCi/g)	Flag(1)	TPU(3,4) (+/-)	MDC(5)	SU Statistics (pCi/g)	
SU-16 Class 1	245	6.4	U	4.8	7.3	avg	2.5
	246	1.6	U	2.7	4.4	stdev	2.2
	247	1.4	U	3.1	5.4	max	6.4
	248	1.3	U	3.7	6.4	min	-1.3
	249	2.5	U	1.8	2.7		
	250	4.5	U	3.6	5.5		
	251	-0.2	U	2.6	4.6		
	252	3.2	LT	1.3	1.9		
	253	5	U	3.8	6		
	254	-1.3	U	3.1	5.5		
	255	1.3	U	2.9	4.9		
	256	1.9	U	3.4	5.7		
	257	1.4	U	4.2	7.1		
	258	5.6	U	4	5.9		
SU-17 Class 1	259	2.9		1.7	2.5	avg	4.4
	260	0.9	U	1.6	2.6	stdev	8.2
	261	-0.1	U	1.7	2.9	max	31
	262	8.7		4.7	6.7	min	-0.1
	263	8.7		4	5.3		
	264	1.5	U	1.8	2.9		
	265	3.2	U	2.9	4.5		
	266	0.5	U	1	1.8		
	267	31		8.1	7.6		
	268	0	U	4	7.2		
	269	0.5	U	3.4	6		
	270	1.1	U	2	3.3		
	271	0.4	U	2	3.4		
	272	2.3	U	2.4	3.8		
SU-18 Class 1	273	4.4		2	2.5	avg	7.4
	274	2.3	U	2.6	4.2	stdev	21
	275	1.6	U	1.6	2.6	max	79
	276	1.3	U	3.4	5.8	min	-0.1
	277	1.1	U	1.4	2.3		
	278	3.1		1.5	1.9		
	279	-0.1	U	3.1	5.5		
	280	0.4	U	4.2	7.3		
	281	1.2	U	1.3	2		
	282	79		14	3.8		
	283	0.7	U	3.8	6.6		
	284	2.5	U	2	3		
	285	4.3		1.6	2.1		
	286	1.2	U	1.3	2.1		

APPENDIX D
APG TRANSONIC DUSA FSS SOIL SAMPLE

Survey Unit	Field ID	U-238 Result[2] (pCi/g)	Flag[1]	TPU[3,4] (+/-)	MDC[5]	SU Statistics (pCi/g)	
X-Ray 2 Building Class 2	XRAY 2-10	1.5	U	1.4	2.2	avg	4.9
	XRAY 2-13	3.6	U	4	6.4	stdev	4.7
	XRAY 2-29	14		3.7	4.4	max	14
	XRAY 2-32	0.6	U	1.2	2	min	0.5
	XRAY 2-35	1.1	U	2.4	4		
	XRAY 2-45	0.5	U	3	5.4		
	XRAY 2-48	7		3.6	4.8		
	XRAY 2-60	8.5		3.9	5.1		
	XRAY 2-62	1	U	2.9	5.1		
	XRAY 2-65	5.4	LT	1.4	1.6		
	XRAY 2-68	13		4.2	4.3		
	XRAY 2-87	0.8	U	3.8	6.6		
	XRAY 2-96	6.6	U	4.8	7.1		

Notes:

(1) "U" result is less than the sample specific MDC or less than the associated TPU
"LT" result is less than the requested MDC; greater than the sample specific MDC

(2) U-238 results are inferred via measurement of Th-234 progeny, assuming full equilibrium

(3) Total Propagated Uncertainty

(4) TPU reported at the 95% confidence level

(5) Minimum Detectable Concentration

(6) Sample Field ID 287 was renamed 62a; results unchanged

Appendix D
APG - Transonic DUSA
Alpha Spectroscopy Results

SU	Sample ID	U-238 Result[2] (pCi/g)	TPU[3,4] (+/-)	MDC[5]	U-235[1] Result (pCi/g)	TPU[3,4] (+/-)	MDC[5]	U-234 Result (pCi/g)	TPU[3,4] (+/-)	MDC[5]
8	144	10.1	0.34	0.03	0.18	0.74	0.044	2.3	0.43	0.01
13	214	2.16	0.41	0.04	0.227	0.081	0.016	1.11	0.23	0.03
7	129	25.3	3.4	0.034	0.5	0.12	0.035	4.47	0.66	0.025
13	207	33.3	4.6	0.032	0.51	0.14	0.05	5.21	0.79	0.059
14	229	2.63	0.39	0.034	0.082	0.038	0.013	0.92	0.17	0.03

Notes:

(1) "LT" result is less than the requested MDC; greater than the sample specific MDC in sample ID 229
(2) U-238 results are inferred via measurement of Th-234 progeny, assuming full equilibrium
(3) Total Propagated Uncertainty
(4) Errors reported at the 95% confidence level
(5) Minimum Detectable Concentration

Appendix E

Duplicate Soil Sample Analysis Z-Score Results

APPENDIX E

APG Transonic DUSA Replicate Soil Sample Analysis Z-Score Results

Sample ID	Paragon Initial Sample Value 234Th, pCi/g	Two s Error of Sample	Paragon Duplicate Sample Value 234Th, pCi/g	Two s Error of Duplicate	Z-Score	Fail if Z-score > 2.57
42	2.10E+00	3.70	-3.00E-01	2.90	1.02	Pass
66	-2.10E+00	4.10	9.00E-01	1.40	1.38	Pass
73	5.30E+00	1.80	2.30E+00	4.50	1.24	Pass
76	3.30E+00	4.40	1.20E+00	2.90	0.80	Pass
99	4.00E+00	3.10	1.00E+00	1.10	1.82	Pass
100	0.00E+00	1.70	-1.20E+00	1.60	1.03	Pass
109	3.20E+00	1.10	2.70E+00	1.70	0.49	Pass
118	9.40E-01	0.64	-6.00E-01	2.20	1.34	Pass
132	3.70E+00	2.40	4.00E+00	4.00	0.13	Pass
136	-2.20E+00	2.80	2.30E+00	1.60	2.79	Fail
138	7.00E+00	4.40	8.10E+00	2.00	0.46	Pass
138	7.00E+00	4.40	8.10E+00	2.00	0.46	Pass
158	3.10E+00	4.00	9.00E-01	3.90	0.79	Pass
160	5.30E+00	3.40	2.20E+00	2.50	1.47	Pass
165	6.00E-01	1.30	6.00E-01	1.20	0.00	Pass
171	1.60E+00	1.80	9.00E-01	3.30	0.37	Pass
186	2.20E+00	2.30	1.30E+00	1.00	0.72	Pass
186	2.20E+00	2.30	1.30E+00	1.00	0.72	Pass
192	5.50E+00	3.30	7.80E+00	3.70	0.93	Pass
194	3.80E+00	4.30	7.10E+00	2.60	1.31	Pass
219	2.80E+00	3.60	1.00E+00	3.50	0.72	Pass
222	5.30E+00	2.00	6.00E+00	3.30	0.36	Pass
226	3.30E+00	4.00	8.90E+00	5.20	1.71	Pass
237	3.80E+00	2.80	4.00E+00	2.70	0.10	Pass
240	4.10E+00	2.90	2.20E+00	4.10	0.76	Pass
246	1.60E+00	2.70	2.50E+00	3.80	0.39	Pass
263	8.70E+00	4.00	8.50E+00	2.90	0.08	Pass
267	3.12E+01	8.10	3.47E+01	7.00	0.65	Pass
268	0.00E+00	4.00	-1.10E+00	3.20	0.43	Pass
270	1.10E+00	2.00	-3.00E-01	3.70	0.67	Pass
276	1.30E+00	3.40	4.50E+00	3.70	1.27	Pass
125 dupp	9.00E-01	4.20	1.70E+00	3.50	0.29	Pass
252 DUP	3.00E+00	1.60	5.10E+00	1.40	1.98	Pass
37 offset	5.00E-01	1.00	-1.50E+00	3.80	1.02	Pass
X-RAY 2-29	1.35E+01	3.70	1.45E+01	2.40	0.45	Pass
XRAY 2-60	8.50E+00	3.90	4.60E+00	3.60	1.47	Pass
XRAY 2-96	6.60E+00	4.80	1.00E+00	2.80	2.02	Pass

Appendix F

APG Transonic NaI 3 x 3 Scan for DU

Tables 1 through 5

APPENDIX F

APG Transonic NaI 3 x 3 Scan for DU

Transonic 3x3 NaI Scan for DU @ 1pCi/g total U NO SOIL COVER 15 cm thick x 28 cm RADIUS
Fluence rate to exposure rate (FRER, no units) = ~ (1 uR/h)/(Eγ)(u_{en}/ρ)air

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

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

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

TABLE 2		
Energy$_\gamma$, keV	(μ/ρ)$_{NaI}$, cm^2/g	P
15	47.4	1.00
20	22.3	1.00
30	7.45	1.00
40	19.3	1.00
50	10.7	1.00
60	6.62	1.00
80	3.12	1.00
100	1.72	1.00
150	0.625	1.00
200	0.334	1.00
300	0.167	0.99
400	0.117	0.96
500	0.0955	0.93
600	0.0826	0.90
800	0.0676	0.85
1,000	0.0586	0.80
1,500	0.0469	0.73
2,000	0.0413	0.68

APPENDIX F

APG Transonic NaI 3 x 3 Scan for DU

for Ludlum 3x3 Model 44-20 7.6 cm dia x 7.6 cm thick NaI crystal

$x = 7.6$ cm

$\rho = 3.67$ g/cm^3

use aluminum window per Ludlum ~0.05 inch thick

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

TABLE 3

Energy$_\gamma$, keV	FRER	P	RDR
15	0.0517	1.00	0.0517
20	0.0969	1.00	0.0969
30	0.2268	1.00	0.2268
40	0.3906	1.00	0.3906
50	0.5208	1.00	0.5208
60	0.5708	1.00	0.5708
80	0.5297	1.00	0.5297
100	0.4329	1.00	0.4329
150	0.2656	1.00	0.2656
200	0.1866	1.00	0.1866
300	0.1157	0.99	0.1146
400	0.0845	0.96	0.0812
500	0.0673	0.93	0.0626
600	0.0563	0.90	0.0507
800	0.0433	0.85	0.0367
1,000	0.0357	0.80	0.0287
1,500	0.0261	0.73	0.0191
2,000	0.0214	0.68	0.0146

Estimated Ludlum 44-20 7.6 cm dia x 7.6 cm thick NaI response for Cs-137 is 2700 cpm/uR/hr

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

Energy$_\gamma$, keV	$(u_{en}/\rho)_{air}$, cm^2/g		
662	0.0294	FRER ~	0.0514
Energy$_\gamma$, keV	$(\mu/\rho)_{NaI}$, cm^2/g		
662	0.0780	Probability =	0.89
		RDR =	0.0455

APG Transonic NaI 3 x 3 Scan for DU

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

TABLE 4		
Energy$_{\gamma}$, keV	RDR_{Ei}	Ludlum 44-20 3x3 NaI Detector, E_i, cpm per μR/hr
15	0.0517	3064
20	0.0969	5745
30	0.2268	13445
40	0.3906	23161
50	0.5208	30881
60	0.5708	33842
80	0.5297	31404
100	0.4329	25667
150	0.2656	15748
200	0.1866	11061
300	0.1146	6797
400	0.0812	4816
500	0.0626	3714
600	0.0507	3005
662	0.0455	2700
800	0.0367	2175
1,000	0.0287	1704
1,500	0.0191	1131
2,000	0.0146	867

MDC for Cs-137 energy

Assume 10 μR/hr bkg then have 27,000 cpm	b_i =	450	counts
	MDCR =	1756	cpm
	$MDCR_{surveyor}$ =	2484	cpm

minimum detectable exposure rate = 0.92 μR/hr

APPENDIX F

APG Transonic NaI 3 x 3 Scan for DU

Table 5				
keV	MicroShield Exposure Rate, µR/hr (with buildup)	cpm/µR/hr	cpm/µR/hr (weighted)	Percent of NaI detector response
15	8.274E-09	3064	0	0.0%
20	6.657E-11	5745	0	0.0%
30	4.852E-06	13445	9	0.1%
40	7.972E-09	23161	0	0.0%
50	1.133E-06	30881	5	0.1%
60	3.234E-04	33842	1483	16.8%
80	4.275E-05	31404	182	2.1%
100	1.398E-03	25667	4863	55.0%
150	1.108E-04	15748	236	2.7%
200	5.489E-04	11061	823	9.3%
300	1.301E-05	6797	12	0.1%
400	1.473E-05	4816	10	0.1%
500	2.694E-05	3714	14	0.2%
600	1.309E-04	3005	53	0.6%
800	9.470E-04	2175	279	3.2%
1000	3.690E-03	1704	852	9.6%
1500	1.083E-04	1131	17	0.2%
2000	1.755E-05	867	2	0.0%
Total	7.378E-03		8840	100%

Minimum Detectable Exposure Rate =

MDCR surveyor/(cpm/µr/hr)
0.281 µr/hr

and MDC for DU and 50-year equilibrium progeny based on a normalized 1 pCi/g total uranium

Scan MDC = (Assumed MDC U_{TOTAL} Conc) x (Exposure Rate $MDCR_{Surveyor}$)/(Exposure $Rate_{assumed\ U\ Conc}$)

Scan MDC = 38.08 pCi/g

Appendix G

Instrument Calibration Control Data

Appendix G
QC Data

Inst.#176952		
QC Daily Source		
Date	Result (cpm)	P/F
3/28/2003	44507	Pass
3/31/2003	43740	Pass

Inst.#176952		Source Ser. #	1127
Initial Source Readings		Nuclide	Cs 137
Date	Result (cpm)		
3/27/2003	44909		
3/27/2003	45084		
3/27/2003	44799		
3/27/2003	44477		
3/27/2003	44426		
3/27/2003	44668		
3/27/2003	44778		
3/27/2003	44616		
3/27/2003	44220		
3/27/2003	44677		
	Average		
	44665		

Appendix G
QC Data

Inst.#174945		
QC Daily Source		
Date	Result (cpm)	P/F
3/26/2003	43090	Pass
3/27/2003	43654	Pass
3/28/2003	44010	Pass
3/28/2003	45300	Pass
3/31/2003	45703	Pass
4/8/2003	50630	Pass
4/10/2003	48781	Pass
4/11/2003	49370	Pass
4/14/2003	51220	Pass
4/15/2003	50402	Pass
4/16/2003	49782	Pass
4/17/2003	50251	Pass

Inst.#174945		Source Ser. #	1127
Initial Source Readings		Nuclide	Cs137
Date	Result (cpm)		
3/26/2003	48564		
3/26/2003	45962		
3/26/2003	42920		
3/26/2003	43391		
3/26/2003	42872		
3/26/2003	43179		
3/26/2003	42953		
3/26/2003	43124		
3/26/2003	42944		
3/26/2003	42681		
	Average		
	43859		

Appendix G
QC Data

Inst.#161581		
QC Daily Source		
Date	Result (cpm)	P/F
3/26/2003	42441	Pass
3/27/2003	46415	Pass
3/28/2003	49429	Pass
3/28/2003	42891	Pass
3/31/2003	42904	Pass
4/8/2003	48815	Pass
4/10/2003	47378	Pass
4/11/2003	49544	Pass
4/14/2003	50731	Pass
4/15/2003	47616	Pass
4/16/2003	47576	Pass
4/17/2003	46973	Pass

Inst.#161581		Source Ser. #	1127
Initial Source Readings		Nuclide	Cs 137
Date	Result (cpm)		
4/2/2003	42265		
4/2/2003	42138		
4/2/2003	42269		
4/2/2003	41940		
4/2/2003	42181		
4/2/2003	42472		
4/2/2003	42224		
4/2/2003	42617		
4/2/2003	42414		
4/2/2003	42484		
	Average		
	42300		

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABRERA SERVICES ORDER NO. 285193/266468

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 161581

Mfg. Ludlum Measurements, Inc. Model 44-20 Serial No. PR172518

Cal. Date 5-Sep-02 Cal Due Date 5-Sep-03 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 37 % Alt 703.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 5.0 VDC
☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set 1250 V Input Sens. 10 mV Det. Oper. 1250 V at 10 mV Threshold Dial Ratio 100 = 10 mV

☑ HV Readout (2 points) Ref./Inst. 500 / 500 V Ref./Inst. 2009 / 2000 V

COMMENTS:
Firmware:26-10-27

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400K cpm	400	400
X 1000	100 K cpm	100	100
X 100	40 K cpm	400	400
X 100	10 K cpm	100	100
X 10	4 K cpm	400	400
X 10	1 K cpm	100	100
X 1	400 cpm	400	400
X 1	100 cpm	100	100

*Uncertainty within ± 10% C.F. within ± 20% ALL Range(s) Calibrated Electronically

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*	Log Scale REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 K cpm	400389	400389	500 K cpm		
40 K cpm	40054	40054	50 K cpm		
4 K cpm	4006	4006	5 K cpm		
400 cpm	400	400	500 cpm		
40 cpm	40	40	50 cpm		

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☑ Other Am-241 ~0.92 µCi

☑ m 500 S/N 132899 ☐ Oscilloscope S/N ☑ Multimeter S/N 75460209

Calibrated By: Domingo Garza Date 5 Sep 02

Reviewed By: [signature] Date 6 Sep 02

FORM C22A 10/31/2001

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 44-20 Serial No. PR172518

Customer CABRERA SERVICES Order #. 285193/266468

Counter 2221 Serial No. 161581 Counter Input Sensitivity 10 mV

Count Time 6 sec Distance Source to Detector Surface

Other

High Voltage	Background	Isotope Am-241 Size 50.92 µCi	Isotope Size	Isotope Size	Isotope Size
1150	1481	16911			
1200	1629	17575			
1250	1589	17896			
1300	1680	17898			
1350	1689	18221			
1400	1898	18327			
1450	2221	19110			

Signature Domingo Garza Date 5 Sep 02

FORM C4A 02/23/94

of Scientific and Industrial Instruments

POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CERTIFICATE OF CALIBRATION

CUSTOMER CABRERA SERVICES ORDER NO. 286149/266913

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 174945

Mfg. Ludlum Measurements, Inc. Model 44-20 Serial No. PR183404

Cal. Date 24-Sep-02 Cal Due Date 24-Sep-03 Cal. Interval 1 Year Meterface 202-159

heck mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 72 °F RH 37 % Alt 705.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 5.0 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

nstrument Volt Set 1150 V Input Sens. 10 mV Det. Oper. 1150 V at 10 mV Threshold Dial Ratio 100 = 10 mV

☑ HV Readout (2 points) Ref./Inst. 499 / 500 V Ref./Inst. 2003 / 2000 V

COMMENTS:

	Peak settings	Gross Counts
High Voltage:	780	1150
Threshold dial:	642	100(10mv)
Window dial:	40	n/a
Window Position:	"IN"	"OUT"
Resolution for Cs137:	≈ 11.9 %	n/a

Model 2221 currently set for Gross Counts
High voltage set with detector connected.

Firmware: 26 10 27

alibrated w/5 ft cable

amma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	400	400
X 1000	100 Kcpm	100	100
X 100	40 Kcpm	400	400
X 100	10 Kcpm	100	100
X 10	4 Kcpm	400	400
X 10	1 Kcpm	100	100
X 1	400 cpm	400	400
X 1	100 cpm	100	100

*Uncertainty within ± 10% C.F. within ± 20%

ALL Range(s) Calibrated Electronically

	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*		REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
Digital Readout	400 K cpm	39771(0)	39771(0)	Log Scale	500 K cpm	490	490
	40 K cpm	3969(0)	3969(0)		50 K cpm	50	50
	4 K cpm	394(0)	394(0)		5 K cpm	5	5
	400 cpm	39(0)	39(0)		500 cpm	500	500
	40 cpm	4(0)	4(0)		50 cpm	55	55

udlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of her International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. e calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978

State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☐ Other

☑ m 500 S/N 81084 ☐ Oscilloscope S/N ☑ Multimeter S/N 80040300

Calibrated By: Michael S Thome Date 24-Sep-02

Reviewed By: Rhonda Harmir Date 25 Sep 02

FORM C22A 10/31/2001

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 44-20 Serial No. PR183404

Customer CABRERA SERVICES Order #. 286149/266913

Counter 2221 Serial No. 174945 Counter Input Sensitivity 10 mV

Count Time 6sec Distance Source to Detector Surface

Other

High Voltage	Background	Isotope Am-241 Size ≅ 0.774uCi	Isotope Size	Isotope Size	Isotope Size
600	629	642			
650	1054	1117			
700	1638	1646			
750	2399	2397			
800	2998	3186			
850	3222	14418			
900	3206	16111			
950	3214	18348			
1000	3388	19640			
~~00~~ 1050	3243	20060			
1100	3365	20532			
→ 1150	3295	20173			
1200	3356	20086			
1250	3445	20552			
1300	3558	20919			
1350	5172	22275			

Signature Michael T Thomas Date 24-Sep-02

FORM C4A 02/23/94

• *Serving The Nuclear Industry Since 1962* •

Designer and Manufacturer of Scientific and Industrial Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

CUSTOMER CABERA SERVICES ORDER NO. 287245/267454

Mfg. Ludlum Measurements, Inc. Model 2221 Serial No. 176952

Mfg. Ludlum Measurements, Inc. Model 44-20 Serial No PR183405

Cal. Date 18-Oct-02 Cal Due Date 18-Oct-03 Cal. Interval 1 Year Meterface 202-159

Check mark ☑ applies to applicable instr. and/or detector IAW mfg. spec. T. 78 °F RH 39 % Alt 699.8 mm Hg

☐ New Instrument Instrument Received ☑ Within Toler. +-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☑ Mechanical ck. ☑ Meter Zeroed ☐ Background Subtract ☑ Input Sens. Linearity
☑ F/S Resp. ck ☑ Reset ck. ☑ Window Operation ☑ Geotropism
☑ Audio ck. ☐ Alarm Setting ck. ☑ Batt. ck. (Min. Volt) 5.0 VDC

☑ Calibrated in accordance with LMI SOP 14.8 rev 12/05/89. ☐ Calibrated in accordance with LMI SOP 14.9 rev 02/07/97.

Instrument Volt Set Comments V Input Sens. Comments mV Det. Oper Comments V at Comments mV Threshold Dial Ratio 100 = 10 mV

☑ HV Readout (2 points) Ref./Inst. 499 / 500 V Ref./Inst. 1996 / 2000 V

COMMENTS:

	Peak settings	Gross Counts
High Voltage:	73V	1150V
Threshold dial:	642	100(10mv)
Window dial:	40	n/a
Window Position:	"IN"	"OUT"
Resolution for Cs137:	≈ 12.5%	n/a

Model 2221 currently set for Gross Counts
High voltage set with detector connected.

Firmware: 26 10 27

Calibrated w/ 10 foot calibrated

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE/MULTIPLIER	REFERENCE CAL. POINT	INSTRUMENT REC'D "AS FOUND READING"	INSTRUMENT METER READING*
X 1000	400 Kcpm	400	400
X 1000	100 Kcpm	100	100
X 100	40 Kcpm	400	400
X 100	10 Kcpm	100	100
X 10	4 Kcpm	400	400
X 10	1 Kcpm	100	100
X 1	400 cpm	400	400
X 1	100 cpm	100	100

*Uncertainty within ± 10% C.F. within ± 20%

ALL Range(s) Calibrated Electronically

Digital Readout REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
400 K cpm	39851(0)	39851(0)
40 K cpm	39773(0)	39773(0)
4 K cpm	3969(0)	3969(0)
400 cpm	39(0)	39(0)
40 cpm	4(0)	4(0)

Log Scale REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING*
500 K cpm	450K	450K
50 K cpm	50K	50K
5 K cpm	5K	5K
500 cpm	500	500
50 cpm	50	50

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323-1978 State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources:

Cs-137 Gamma S/N ☐ 1162 ☐ G112 ☐ M565 ☐ 5105 ☐ T1008 ☐ T879 ☐ E552 ☐ E551 ☐ Neutron Am-241 Be S/N T-304

☐ Alpha S/N ☐ Beta S/N ☐ Other

☑ m 500 S/N 81084 ☐ Oscilloscope S/N ☑ Multimeter S/N 80040300

Calibrated By: Michael S Thomas Date 18-Oct-02

Reviewed By: Rhonda Harris Date 22 Oct 02

FORM C22A 10/31/2001

AC Inst. Only ☐ Passed Dielectric (Hi-Pot) and Continuity Test ☐ Failed:

Designer and Manufacturer of Scientific and Industrial Instruments

LUDLUM MEASUREMENTS, INC.
POST OFFICE BOX 810 PH. 915-235-5494
501 OAK STREET FAX NO. 915-235-4672
SWEETWATER, TEXAS 79556, U.S.A.

Bench Test Data For Detector

Detector 44-20 Serial No. PR 183405

Customer CABERA SERVICES Order #. 287245/267454

Counter 2221 Serial No. 176952 Counter Input Sensitivity 10 mV

Count Time 6 sec Distance Source to Detector Surface

Other

High Voltage	Background	Isotope Am-241 Size ≈ 0.77uCi	Isotope Size	Isotope Size	Isotope Size
750	2800	3082			
800	3183	15905			
850	3196	16657			
900	3266	18959			
950	3275	19992			
1000	3249	20626			
1050	3355	20481			
1100	3381	20615			
→ 1150	3425	20662			
1200	3365	20172			
1250	3325	20753			
1300	3829	20960			
1350	4471	21386			
1400	6262	22066			

Signature Michael J Thomas Date 18-Oct-02

FORM C4A 02/23/94