DEPARTMENT OF THE ARMY
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND
ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
PICATINNY ARSENAL, NEW JERSEY 07806-5000

9 July 2015

RDAR-EIQ-SF-RPO

MEMORANDUM FOR NUCLEAR REGULATORY COMMISSION (NRC) REGION I
ATTN: MS. LAURIE KAUFFMAN

SUBJECT: Response to NRC Request for Additional Information dtd 10 June 2015; Area 1222 Radiological Release

1. Area 1222, also known as "the Gorge", is presently considered potentially contaminated with depleted uranium. As stated in our SUB 348 source materials license renewal application dated 20 June 2011, limited research and development testing with depleted uranium containing items was conducted in this test area 40 to 45 years ago. A small amount of radium contamination, most likely a fragment of a luminescent gauge or dial, was also found in the area during a survey performed in 2001.

2. The U.S. Army Joint Munitions Command (JMC) has contracted Bering Sea Environmental, LLC (BSEn) doing business as (dba) Aleut World Solutions (AWS) to write a work plan that describes the methods proposed for site remediation, and the performance of final status radiological surveys and sampling in accordance with the guidelines set forth in the Multi Agency Radiation Survey and Site Investigation Manual (MARSSIM).

3. The final objective of the MARSSIM final status survey and sampling in Area 1222 is for final release in accordance with the unrestricted release criteria outlined in 10 CFR Part 20.1402. The final status survey is also considering the unrestricted radiological release criteria issued by the New Jersey Department of Environmental Protection (NJDEP).

4. ARDEC requested NRC review and approval of the original release plan on 23 July 2013. On 10 June 2015, the NRC forwarded a fourth request for additional information (RAI).

5. As a result of the RAI dtd 10 June 2015, The Final Status Survey and Sampling Work Plan has been updated and enclosed as revision 6. Attachment 1; "DandD Version 2.1 Input / Output Files", and Attachment 2;"RESRAD Version 6.5 Code Run" remain unchanged. The enclosed plan also contains updates required as a result the RAI dtd 10 July 2014. In particular, the work plan was updated to include the following:

5.1 Facility Operating History as defined in Section 16.2 of NUREG-1757, to include previous decommissioning activities, spills, prior onsite burials, and prior partial site releases have been added to Section 2.

5.2 Site Information as defined in Section 16.3 of NUREG-1757, to include population distribution, current/future land use, meteorology and climatology, geology and seismology, surface and ground water hydrology, and natural resources have been added to Section 3.

5.3 An estimated schedule as defined in Section 17.1.5 of NUREG-1757 has been added to Section 3.

5.4 Project Management and Organization information as defined in Section 17.2 of NUREG-1757, to include Radiation Safety Officer and Contractor Support have been added to Section 4.

5.5 Radiation Safety and Health Program during Decommissioning information as defined in Section 17.3 of NUREG-1757, to include the respiratory protection program (including declared pregnant workers), internal exposure determination program (including declared pregnant workers), summation of internal or external exposures, and the contamination control program has been added to Section 5.

5.6 Nuclear Criticality Safety information as defined in Section 17.3.2 of NUREG-1757 has been added to Section 5.

5.7 Health Physics Audits and Recordkeeping information, as defined in Section 17.3.3 of NUREG-1757 hs been added to Section 4.

5.8 Environmental Monitoring and Control Program information, as defined in Section 17.4 of NUREG-1757 to include the Environmental ALARA Evaluation Program, and Effluent Monitoring and Control Programs has been added to Section 11.

5.9 Quality Assurance Program information, as defined in Section 17.6 of NUREG-1757 to include organization, quality assurance, document control, control of measuring and test equipment, corrective action, quality assurance records, and audits and surveillance information has been added as Section 10.

5.10 Area factors were reviewed to assure consistency between stated and derived values based on the RESRAD Version 6.5 analysis. Tables 7, 8, 9, and 10 of Section 8.7.3.3 have been updated based on the review.

5.11 The areas associated with the contaminated zones in paragraphs 8.6; "Definition of Study Boundaries" and 8.7.3.2; "Depleted Uranium (U-238)" were reviewed for consistency. Although the first paragraph defines the zones in terms of square feet and second in terms of square meters, the areas are consistent. To clarify, paragraph 8.6 was updated to add units in square meters.

5.12 Facility Radiation Survey information, as defined in Sections 4.3 through 4.5 of NUREG-1757 has been added as Section 9.1.

5.13 A statement regarding Financial Assurance was added as Section 13.

5.14 A statement regarding Restricted Use/Alternate Criteria was added as Section 14.

5.15 A statement regarding Modifications to Decommissioning Programs and Procedures as Section 15.

6. The point of contact regarding this correspondence is Richard Lamoreaux, ARDEC RSO, at (973) 724-8842 or richard.w.lamoreaux.civ@mail.mil.

RICHARD W. LAMOREAUX
Radiation Safety Officer, ARDEC

Encl:
MARSSIM Survey and Sampling Work Plan/Open Detonation Pit & Hillside Areas Picatinny Arsenal, Revision 6

DISTRIBUTION:
RDAR-D; Mr. Hedderich
RDAR-EI; Mr. Sebasto
RDAR-EIQ; Mr. Finno
RDAR-EIQ-S; Ms. Oraby
RDAR-EIQ-SF; Ms. Vo
RDAR-EIQ-SF; Mr. Hamilton
RDAR-CRM; Mr. Glikerdas (acting)
IMPI-ESP; Mr. Morrissey
IMPI-PWE; Mr. Gabel
HQAMC-G1 RSSO, MAJ Myers
AMSRD-SO RSO; Mr. Lee
AMSJM-SF; Mr. Hart
CF:
ARDEC Radiation Protection Office

ALEUT WORLD SOLUTIONS

ALEUT WORLD SOLUTIONS

MARSSIM FINAL STATUS SURVEY AND SAMPLING WORK PLAN

Radiological Surveys and Sampling
Open Detonation Pit Area & Adjacent Hillside in Area 1222 (Gorge)
ARDEC, Picatinny Arsenal, New Jersey

Project No. USA 2013-006

Revision 6
June 29, 2015

Prepared by:

Aleut World Solutions
615 E. 82nd Ave. Suite 200
Anchorage, AK 99518
(907) 278-2311

ALEUT WORLD SOLUTIONS

MARSSIM FINAL STATUS SURVEY AND SAMPLING WORK PLAN

Radiological Surveys and Sampling
Open Detonation Pit Area & Adjacent Hillside in Area 1222 (Gorge)
ARDEC Picatinny Arsenal, New Jersey

Project No. USA 2013-006

Revision 6
June 29, 2015

Approvals

Prepared by: Daniel M. Spicuzza Date: 06/29/2015 .
Dan Spicuzza, AWS Project Manager

Approved by: WG Haney Digitally signed by WG Haney DN: cn=WG Haney, c=US, o=AWS, LLC, ou=Field Operations, email=bhaney@aleutworldsolutions.com Date: 2015.07.07 10:15:56 -04'00' Date:
Bill Haney, AWS Field Operations Manager

Approved by: [signature] Date: 7/7/2015
Richard Lamoreaux, ARDEC Radiation Safety Officer

Approved by: HART.EARL.J.1098644772 Digitally signed by HART.EARL.J.1098644772 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=HART.EARL.J.1098644772 Date: 2015.07.07 09:54:00 -05'00' Date:
Joe Hart, U.S. Army JMC

TABLE OF CONTENTS

Section **Page**

List of Figures, Tables, and Attachments

Figures

Tables

Attachments

ACRONYMS AND ABBREVIATIONS

α	Alpha
AOC	Areas of concern
ALARA	As Low As Reasonably Achievable
ANSI	American National Standard Institute
AR 11-9	The Army Radiation Safety Program
ARDEC	Armaments Research, Development & Engineering Center
AREA 1222	The Gorge
ARP	Army Radiation Permit
ARPO	Army Radiation Protection Office
β	Beta
AWS	Aleut World Solutions, LLC
Bkgd	Background counts
Bgs	Below grade surface
Bi^{214}	Bismiuth-214 Uranium-238 Series
Bkg	Background
Cal	Calibration
Cm	Centimeter
cm^2	Square centimeter
Cpm	Counts per minute
CRSO	Corporate Radiation Safety Officer
Cs^{137}	Cesium-137 Check Source
DA PAM 385-24	Department of the Army Pamphlet 385-24
DAC	Derived Air Concentration
dba	doing business as
DCGL	Derived Concentration Guideline Limit
$DCGL_W$	Derived Concentration Guideline Limit (Weighted)
$DCGL_{EMC}$	Derived Concentration Guideline Limit (Elevated Measurement Comparison)
Δ	DCGL – LBGR
DOT	Department Of Transportation
Dpm	Disintegrations per minute
$dpm/100cm^2$	Disintegrations per minute per 100 square centimeters
DQO's	Data Quality Objectives
DU	Depleted Uranium
Eff	Efficiency
F	Relative fraction
FSS	Final Status Survey
Ft	Feet
Ft^2	Square feet
G	Gram
H_o	Null Hypothesis
HASP	Health and Safety Plan (HASP).
Inst	Instrument
IAW	In Accordance with
ISO	International Organization for Standardization
JMC	U.S. Army Joint Munitions Command
LBGR	Lower bound of gray region
LLD	Lower Level of Detection

M	Meters
m^2	Square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDCR	Minimum Detectable Count Rate
mCi	Millicurie
Mm	Millimeter
mrem	Millirem
mrem/yr	Millirem per year
N/A	Not applicable
NaI	Sodium iodide
NIST	National Institute of Standards and Technology
NMSS	Nuclear Regulatory Commission Office of Nuclear Material Safety and Safeguards
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Guide
NUREG-1505	Nuclear Regulatory Commission (NRC). 1998. A Nonparametric Statistical Methodology for the Design and Analysis of the Final Status Decommissioning Survey. NUREG-1505, Rev.1
NUREG-1575	MARSSIM
ODPA	open detonation pit area
$ODPA_{INT}$	open detonation pit interior area
$ODPA_{EXT}$	open detonation pit exterior area
OSHA	Occupational Safety and Health Administration
Pb^{214}	Lead-214 Uranium-238 Series
pCi	Picocurie
PM	Project Manager
Ppm	Parts per million
QA/QC	Quality Assurance / Quality Control
Ra^{226}	Radium-226 Uranium-238 Series
RCRA	Resource Conservation and Recovery Act
Δ/σ	Relative shift
RPO	Radiation Protection Officer
RSO	Radiation Safety Officer
RWP	Radiation Work Permit
σ	Standard deviation
S/N	Serial number
Scan	Gamma detector response rate
SOP	Standing Operating Procedure
Surface samples	Defined as 0-15 cm below ground surface
TCLP	Toxicity Characteristic Leaching Procedure
TEDE	Total effective dose equivalent
Th^{234}	Thorium-234 – Uranium-238 Series
U^{234}	Uranium-234
U^{235}	Uranium-235
U^{238}	Uranium-238 (Depleted Uranium)
USACHPPM	US Army Center for Health Promotion Preventive Medicine
USAEHA	US Army Environmental Hygiene Agency
USA	U.S. Army
μR/hr	Microroentgen per hour
μCi	Microcurie
UXO	Unexploded Ordnance

SUXOS	Senior UXO Supervisor
Wilcoxon Rank Sum Test	Used to test the null hypothesis in statistics
WP	Work plan
WRS	Wilcoxon Rank Sum Test
ZnS(Ag)	Silver activated zinc sulfide

RECORD OF REVISIONS

Revision Number	Description	Date
0	Draft Final Status Survey and Sampling Work Plan	12/14/2012
1	Draft Final Status Survey and Sampling Work Plan	2/5/2013
2	Draft Final Status Survey and Sampling Work Plan	3/15/2013
3	Final Status Survey and Sampling Work Plan	4/2/2013
4	Final Status Survey and Sampling Work Plan	1/30/2014
5	Final Status Survey and Sampling Work Plan	3/18/2014
6	Final Status Survey and Sampling Work Plan	6/29/2015

1.0 EXECUTIVE SUMMARY

Bering Sea Environmental, LLC (BSEn) dba Aleut World Solutions (AWS) has been contracted by the U.S. Army Joint Munitions Command (JMC) to write this work plan that describes the methods to perform remediation, and MARSSIM final status radiological surveys and sampling in the open detonation pit area and adjacent hillside located in Area 1222 (The Gorge) at the Armaments Research, Development & Engineering Center (ARDEC), Picatinny Arsenal, NJ. The final status survey and sampling will be done in accordance with the guideline set forth in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

The final objective of the MARSSIM final status survey and sampling in these areas is for the unrestrictive release of the areas in accordance with the Nuclear Regulatory Commission’s (NRC’s) unrestricted release criteria outlined in 10 CFR Part 20.1402 which states a site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent (TEDE) to an average member of the critical group that does not exceed 15 mrem per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). The NRC’s approval and/or review of this plan will be required before commencing work under this plan.

Work will be performed under reciprocity with the Nuclear Regulatory Commission (NRC) or equivalent agreement state regulatory agency under AWS's NRC Broad Scope Radioactive Materials License.

Figure 1 below presents a diagram of the open detonation pit interior and exterior areas in Area 1222 that will be surveyed and sampled for unrestricted release.

Figure 2 below presents a map of the adjacent hillside area in Area 1222 that will be surveyed and sampled for unrestricted release.

Figure 1 Open Detonation Pit Area Map

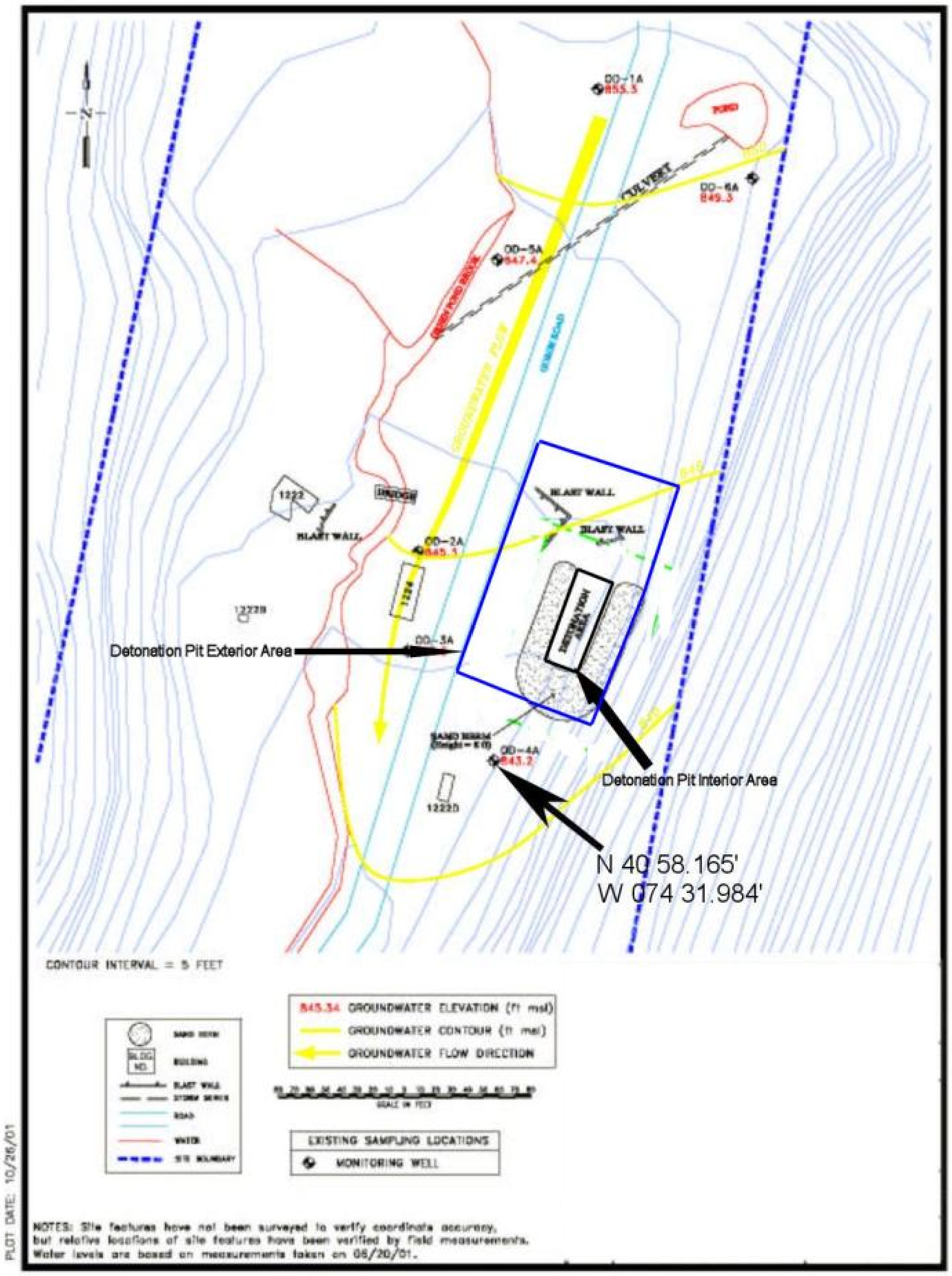
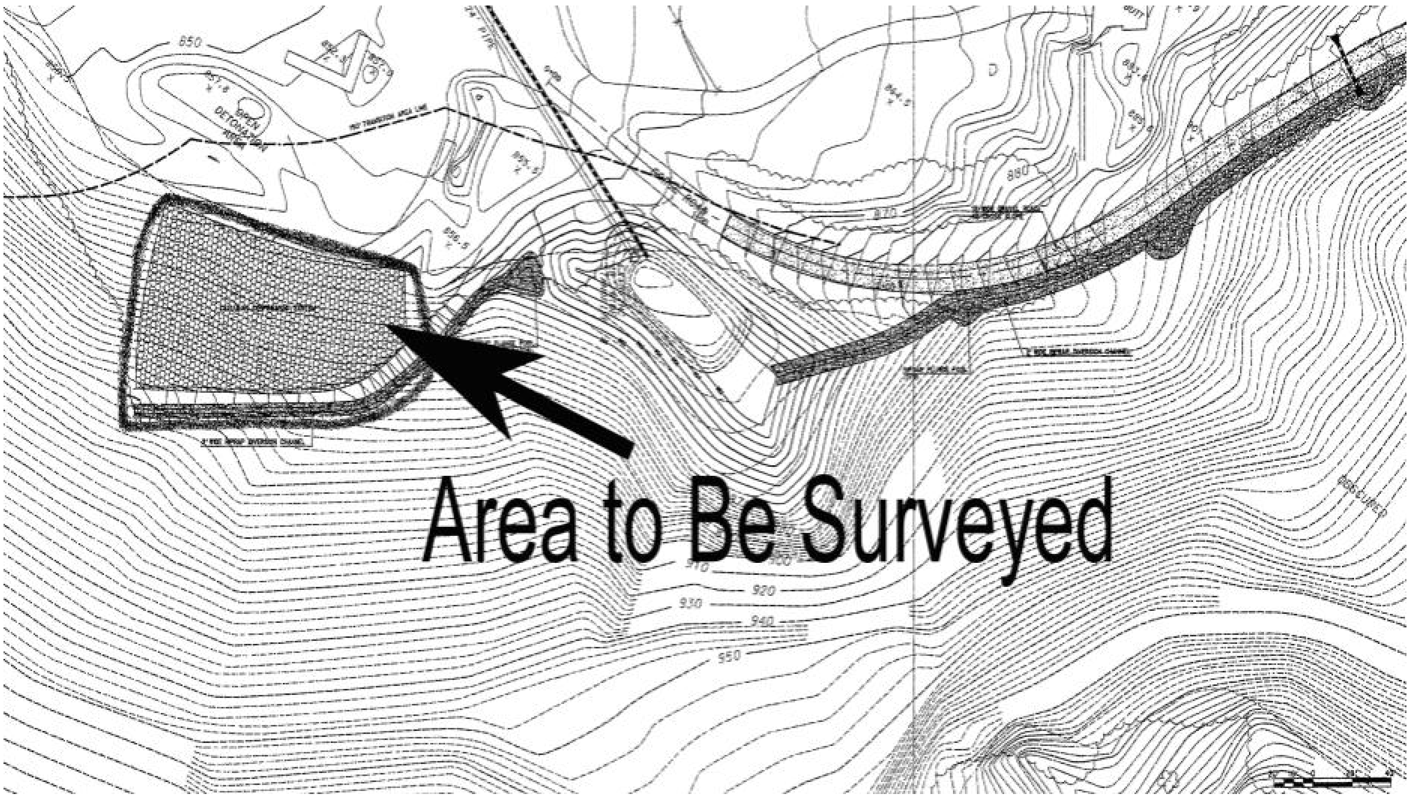


Figure 2 Adjacent Hillside Area To Be Surveyed



2.0 FACILITY OPERATING HISTORY

2.1 PREVIOUS DECOMMISSIONING ACTIVITIES

There have not been any previous decommissioning activities at the Gorge, however characterization and remediation efforts are described in paragraph 3.3.

2.2 SPILLS

There are not any written records of spills or uncontrolled releases at the Gorge.

2.3 PRIOR ONSITE BURIALS

There are not any written records of onsite burials at the Gorge.

2.4 PRIOR PARTIAL SITE RELEASES

There are not any written records of any partial site releases at the Gorge.

3.0 FACILITY DESCRIPTION

3.1 SITE LOCATION AND DESCRIPTION

Area 1222, known as the Gorge, is located in the valley toward the northern end of the arsenal. It lies at the base of Copperas Mountain and is bounded by an unnamed mountain to the southeast. The areas to be surveyed and sampled for unrestricted release; the open detonation pit and the adjacent hillside area are located within Area 1222. The open detonation pit is also commonly referred to as the “open detonation/demilitarization pit”.

Area 1222 is still operational. Picatinny demilitarization personnel use the open detonation pit area and other detonation areas in Area 1222 on a regular basis, and it is the only RCRA approved site available. Minimizing time in the interior areas of the open detonation pit and the development of a detailed schedule and coordination procedures will be crucial to the successful completion of the final status surveys in the area.

3.2 SITE HISTORY

The open detonation pit area (ODPA) was used for open detonation of munitions and as a demilitarization area. Records indicate that it was used to detonate a limited number of mines containing small quantities of depleted uranium (DU) approximately 40 years ago.

3.3 GORGE AREA

Records and correspondences indicate that the open detonation pit in the gorge area was used to detonate a limited number of mines containing small quantities of DU. AWS must coordinate with the personnel at Picatinny Arsenal so that all pertinent standing operating procedures (SOPs) dealing with unexploded ordnance (UXO) are adhered to.

> **NOTE: THE DETONATION PIT WAS USED TO DETONATE A VERY LIMITED NUMBER OF MINES CONTAINING SMALL QUANTITIES OF DU. AWS PERSONNEL WILL COORDINATE WITH THE PROPER PERSONNEL AT PICATINNY ARSENAL SO THAT ALL PERTINENT STANDING OPERATING PROCEDURES (SOPS) DEALING WITH UNEXPLODED ORDNANCE (UXO) ARE ADHERED TO. AWS UXO PERSONNEL MUST BE PRESENT DURING ALL TIMES WHEN WORK IS BEING PERFORMED IN THIS AREA.**

AWS will be required to obtain a Demo Permit for the area. Picatinny Arsenal UXO personnel will be required to review the credentials of the of the AWS personnel to ensure they are certified UXO Tech 2 or Tech 3's, and provide them with a Demo Permit.

Items of note:

- A U.S. Army Environmental Hygiene Agency (USAEHA) survey completed of the area (U.S. AEHA Report No. 27-43-EQ86-93) detected no concentrations of DU exceeding the minimum detectable activity (MDA). (USAEHA, 1993)

- A survey was performed by New World Technology, Inc. (NWT) in October/November of 2001 in the Open Detonation Pit area. Radium contamination (most likely a fragment of a luminescent gauge or dial) was found in Grid #27 located at the bottom of the hill. Radium contamination was found in Grid #24 and depleted uranium contamination was found in Grids #4 and #6 in the open detonation pit area. (NWT, 2006a)

  Figure 3 show the grids and locations where contamination was found and remediated during the above mentioned survey.

- A survey was performed by NWT in May of 2004 on the hill adjacent to the eastern boundary of the Open Detonation Pit area. The entire surface of the hill area forming the eastern boundary of the open detonation pit area was 100 % gamma scan surveyed. Five areas exceeded the gamma scan action level of 2,800 net-cpm or 14,800 cpm-gross. All other areas ranged between 11,000 cpm and 14,000 cpm.

  Figure 4 presents a map of the locations of the elevated activity areas found during the gamma scan survey of the open detonation pit area adjacent hillside. (NWT, 2006b)

- The five elevated areas of activity were remediated using hand tools. The depth required to remove the elevated areas was between six-inches and 18-inches. It was discovered during the investigation that discrete pieces of debris were the source of the elevated readings. The areas were re-surveyed following remediation, and found to be at background radiation levels. (NWT, 2006b)

Figure 3 Area Open Detonation Pit Survey Grid Map

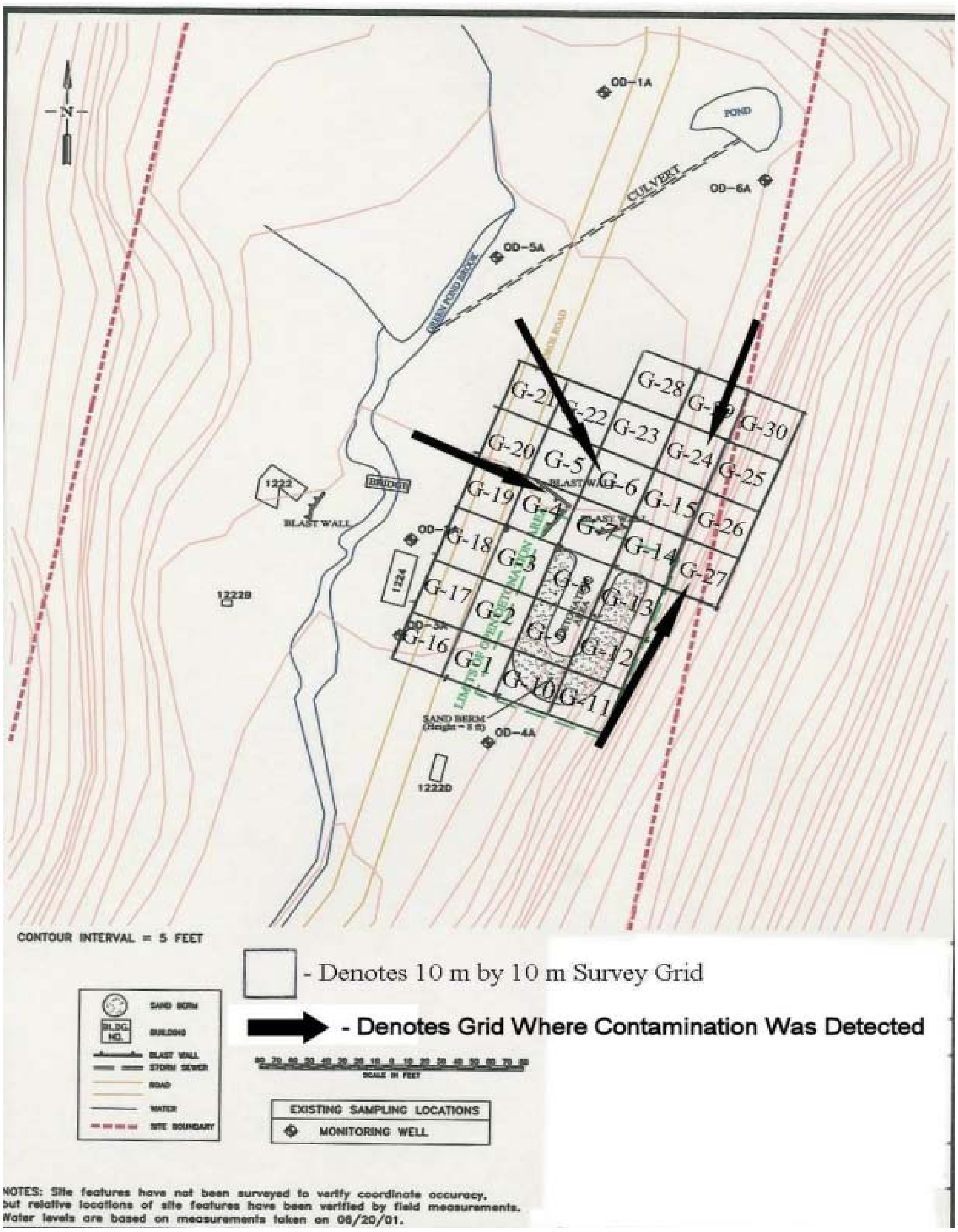
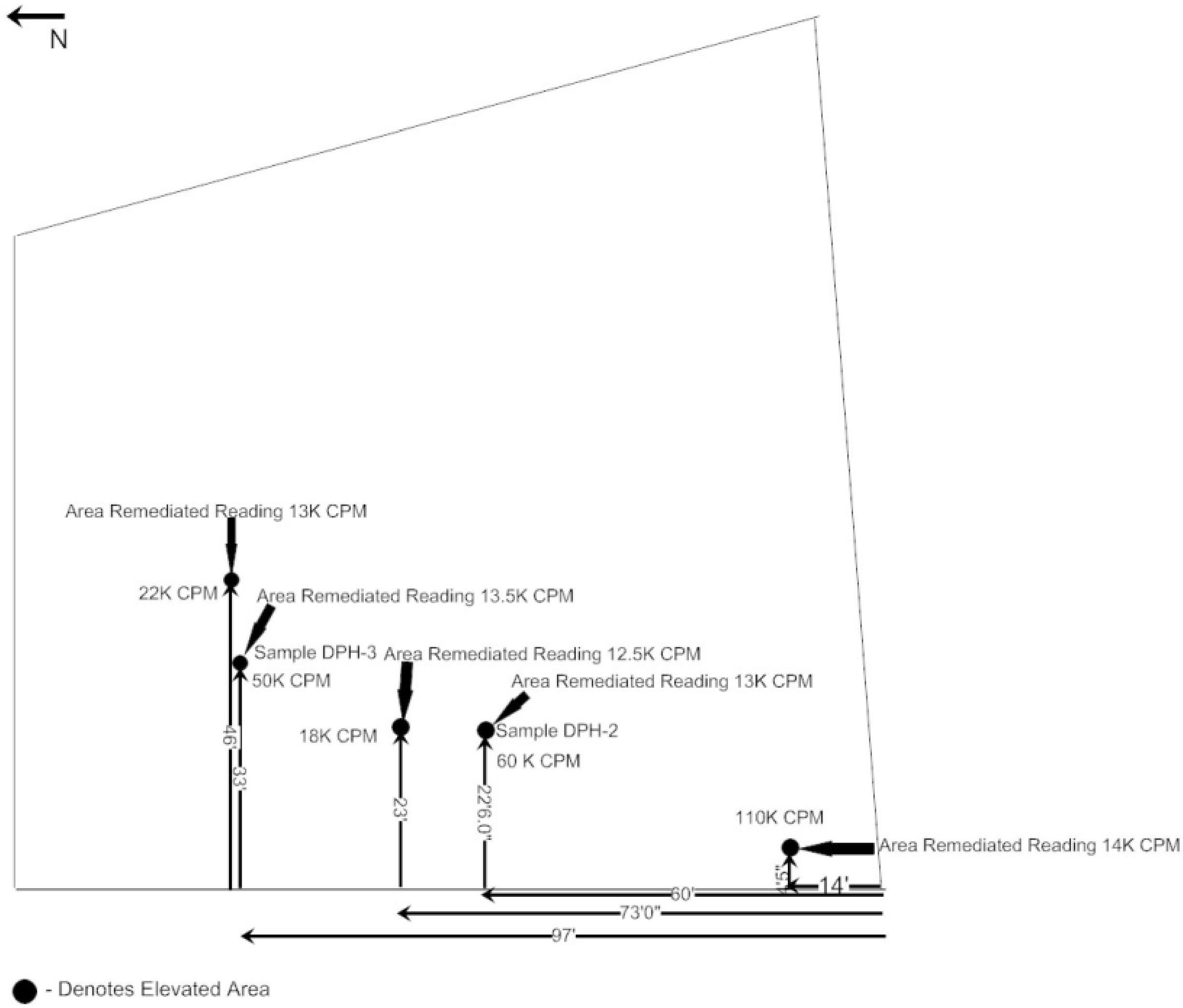


Figure 4 Open Detonation Pit Hill Elevated Area Location Map



3.4 POPULATION DISTRIBUTION

Located about 35 miles west of New York City, Picatinny has more than 1,010 permanent structures, including 64 laboratories, situated on the installation's nearly 6,500 acres. As one of the largest employers in Morris County, there are about 3,907 civilians, approximately 93 military personnel and about 1,035 contractors employed there (PA, 2015).

The Census 2010 population for Rockaway Township, NJ which is the nearest town to the Picatinny Arsenal is 24,156. It has a mean age of 47 years and a median household income of $95,530 (USCB, 2015).

3.5 CURRENT/FUTURE LAND USE

The Open Detonation Pit provides for the demilitarization of excess, unserviceable, or obsolete conventional munitions and explosives. Materials which are treated by Open Detonation at Picatinny Arsenal includes such items as small arms ammunition, land mines, mortars, bombs, fuses, detonators and other types of ordnance. The area will perform the same function following radiological release for the foreseeable future.

3.6 METEOROLOGY AND CLIMATOLOGY

Northern New Jersey is characterized by a temperate, continental climate with warm summers and cold winters. Some areas of the Arsenal have microclimatic conditions, which could be classified as “cool temperate” due to the particular topographic relief, aspect, and geology. Examples of such areas are north-facing exposures, “shadowed” slopes, and cold air sinks in certain ravines, the Gorge, and talus slopes.

3.6.1 TEMPERATURE

The average annual high temperature is 60 degrees Fahrenheit (F) and the Average Annual Low is 40 F. Overnight low temperature ranges from an average daily low of 18 F in January to an average daily low of 62 F in July. Daytime high temperature ranges from an average daily high of 35 F in January to an average daily high of 83 F in July. Based on these averages, the coldest month tends to be January and the hottest to be July. The lowest recorded temperature occurred in 1961 when the thermometer registered 15 degrees below zero (-15F). In 1953, the highest temperature, 104 F, was recorded (PA, 2001).

3.6.2 PRECIPITATION

Rainfall averages 48 inches and is evenly distributed throughout the year. The average monthly rainfall totals range from 3.00 inches in February to 4.59 inches in July, the rainiest month. The highest rainfall in any 24-hour period was in September 1966 with 5.53 inches. Thunderstorms account for most of the summer rain. Precipitation is generally not considered limiting to tree growth in the region (PA, 2001)

The average yearly snowfall is 31.4 inches. Snow accumulation can begin as early as October and remain as late as April. On average, snow cover of 1 inch or more can be expected for 44 days during this period (PA,2001).

3.7 GEOLOGY AND SEISMOLOGY

The eastern and southeastern areas of the installation consist of older Precambrian bedrock (granite gneiss). The western and northwestern areas consist mainly of younger Paleozoic bedrocks (quartz conglomerate and sandstone). This latter bedrock is known as the Green Pond Formation and dates back to the Silurian age. This formation dips northwesterly, giving rise to many prominent outcrops, resistant cliffs, and talus slopes along the truncated southeastern aspect. An inactive geologic fault is associated with Green Pond (a large lake north of the Arsenal). It follows Upper GPB through the Gorge and the base of Green Pond Mountain to the south. The fault tends to divide the older bedrocks to the east from the younger deposits to the west. The Cambrian age Leihsville Formation (dolomite) lies south of Picatinny Lake between GPB and Green Pond Mountain. Surficial geology throughout the Arsenal is mostly glacial till of Wisconsin age derived from the aforementioned bedrocks. Large glacial erratic are scattered throughout the Arsenal. The northern edge of the Wisconsin terminal moraine just touches the southwest corner of the installation. This geology results in the topography being marked by an abundance of stones, boulders, and bedrock outcroppings (PA, 2001).

3.8 SURFACE WATER HYDROLOGY

3.8.1 DRAINAGE BED GRADIENTS

The Arsenal is comprised of five main drainages:

1. Green Pond Wetlands and Gorge.
2. Denmark Lake and Wetlands.
3. Middle Green Brook and Picatinny Lake.
4. Lower Green Pond Brook.
5. Beaver Brook Sub-watershed.

From the uppermost reaches, water steps down through Picatinny Valley in three main drainage beds (2-4 above). The Gorge, as well as Bear Swamp Brook are parallel drainages originating at higher elevations which also flow into Picatinny Valley. The Upper GPB falls 300 feet through the Gorge from Green Pond and its associated wetlands at elevation 1,046 feet to the confluence with Lower Burnt Meadow Brook at 750 feet. Upper Burnt Meadow Brook is the source stream for Denmark Lake at elevation 821 feet. Water drops about 10 feet at Denmark Dam Spillway to the tailrace. Lower Burnt Meadow Brook falls 60 feet from this tailrace to the confluence with Upper GPB out of the Gorge. From this confluence Middle GPB grades 40 feet into Picatinny Lake at elevation 711 feet. The steep gradient from Green Pond Wetlands and Gorge to Picatinny Lake is about 339 feet. In contrast the step from Denmark Lake to Picatinny Lake is nearly 110 feet. Water drops 10 feet also at Picatinny Dam Spillway to its tailrace. The Lower GPB grades only 26 feet to its exit point at elevation 685 feet, near the main entrance to the Arsenal. With such gradients and several smaller tributaries, runoff can be rapid during

periods of extreme precipitation or snowmelt. Fortunately, the major portion of the watershed is in dense tree and grass cover retarding and reducing flood frequency (PA, 2001).

Ames Brook carries headwaters off of 250 acres of the installation downstream into Beaver Brook (PA, 2001).

3.8.2 LAKES AND PONDS

There are 621 acres of lakes, ponds, and their associated scrub-shrub wetlands on the Arsenal. Picatinny Lake is designated by as an open water wetland. Denmark and Picatinny Lakes comprise 360 acres of open water. There are eighteen ponds/sloughs on the Arsenal; ten medium sized (>1 acre) and eight smaller (<0.5) (PA, 2001).

3.8.3 STREAMS

There are two main brooks that flow into the installation from the north. These are Green Pond Brook that originates from Green Pond and Burnt Meadow Brook, which arises from Egbert Lake. There are several small brooks and springs that originate from the installation that add to the flowage. All lotic corridors comprise 24 miles on post (see Appendix E2). Two brooks discharge from the Arsenal. Green Pond Brook (7.3 miles) is the primary discharge and exits the southern boundary of the installation. Ames Brook exits the installation along the eastern boundary. There are nine high quality waterways in the Highlands Region. Green Pond Brook is cold and clean enough to support self-sustaining brook trout populations. The Rockaway River is currently considered by the NJ Department of Environmental Protection to be of good or excellent water quality. The Picatinny Arsenal is one of the watersheds that flow into the Rockaway River (PA, 2001).

3.9 GROUNDWATER HYDROLOGY

The Arsenal is an important recharge area within New Jersey Watershed Management Area #6 comprising the Upper Passaic, Whippany, and Rockaway Watersheds. Watershed Management Area #6 serves as the primary water supply for northern New Jersey (PA, 2001).

The Farny Highlands Watershed, named for Farny State Park three miles northeast of Picatinny Arsenal, comprises five sub-watersheds in northern Morris County. Comprising a substantive portion of The Green Pond drainage basin and a small part of the Beaver Brook sub-watershed, the installation represents 18 percent of the Farny Highlands Watershed, and more significantly, 33 percent of all public or conservation lands within the watershed (PA, 2001).

Picatinny Arsenal comprises 61 percent of the 9,600-acre Green Pond third order watershed draining nearly 7,700 acres through the installation. The headwaters of this watershed originate from a 500-acre spring-fed lake known as Green Pond. Green Pond is north and adjacent to the installation. The Green Pond Watershed drains into the Rockaway River, which then drains to the Passaic River. The New Jersey Department of Environmental Protection recognizes the Rockway River as a high quality waterway (PA, 2001).

Groundwater monitoring well and surface water sample results from the area in the past have indicated that groundwater and surface water in the area have not been impacted by radioactive materials. Results of the environmental sampling program will be addressed by the Picatinny Environmental Affairs group.

3.10 NATURAL RESOURCES

There are not any known significant mineral deposits, water resources, coal deposits or other natural resources which, if exploited would affect the licensee.

At this time, project activities are not anticipated to create any traffic impacts.

Noise generation from site activities may require the use of hearing protection in the immediate area. Due to the location of the site, it is not anticipated that noise associated with the site work will adversely impact personnel outside the work area.

No ecosystems or habitats that may provide refuge for sensitive, threatened, or endangered species located within a one-kilometer radius of the work site will be affected.

The hours for the issuance and return of the keys for the padlock on the entrance gate to the area are confined at the earliest to 0700 hours and at the latest to 1630 hours (M-T) and 0700 hours to 1520 hours on Friday.

Any survey and sampling interruptions will be contingent on the availability of the key custodians in Building 611 and the presence of the SUXOS.

3.11 SCHEDULE

The proposed schedule to accomplish the decommissioning activities, as outlined in this plan is as follows:

- Decommissioning Activities (including FSS, mob/demob) – 21 days
- Submit Draft Final Status Survey Report – Within 30 days of completion of decommissioning activities

A detailed schedule of planned decommissioning activities will be provided to NRC, the U.S. Army JMC, and Picatinny Arsenal representatives, once this plan has been approved.

4.0 PROJECT MANAGEMENT AND ORGANIZATION

This project has been initiated by and all decommissioning activities will be coordinated through the authorized representative of the license holder for this facility:

Mr. Richard Lamoreaux
ARDEC Radiation Safety Officer
richard.w.lamoreaux.civ@us.army.mil

Aleut World Solutions, LLC (AWS) has been contracted by the U.S. Army JMC to develop this plan, as well as conduct all decommissioning, disposal, and final status survey activities as outlined herein. All work performed by this plan will be performed under and in accordance with the AWS NRC license. The AWS on site Radiation Safety Officer will be:

Mr. Daniel Spicuzza
Aleut World Solutions, LLC
radconpro@verizon.net

4.1 DECOMMISSIONING TASK MANAGEMENT

Safety guidelines for work in radiologically controlled areas have been established in this Work Plan. These guidelines will be amended by RWPs, as necessary, to provide administrative control of all activity within areas that may have radiological hazards, in order to maintain exposure ALARA. The radiation work described in this Work Plan will be considered when specific procedures are developed for work in radiologically controlled areas.

These RWPs will be reviewed and approved by the AWS RSO and prior to implementation. The RSO will ensure that ambient radiation, surface radioactivity, and airborne radioactivity surveys are performed, as required to define and document the radiological conditions for each job. RWPs will describe the job to be performed, outline tasks with elevated dose potentials and significant radiological hazards, define protective clothing and equipment to be used, and identify personnel monitoring requirements. RWPs will also specify any special instructions or precautions pertinent to radiation hazards in the area, including listing the radiological hazards present; the area dose rates, and the presence and intensity of hot spots; removable surface radioactivity; and other hazards as appropriate.

The subsections below describe AWS oversight of the decommissioning operations. This arrangement serves to minimize administrative functions, keep overhead costs to a practical minimum, and provide maximum flexibility for resource allocation.

4.2 CONTRACTOR RADIATION SAFETY OFFICER

The Project Manager (PM) will serve as the onsite RSO and will provide direct supervision of field staff ensuring that personnel adhere to the requirements of this Work Plan. The RSO will have the following additional responsibilities:

- Coordinate with the CRSO in developing the HASP for additional site-specific project modifications.
- Coordinate with field crew personnel for field implementation and enforcement of this Work Plan
- Ensure compliance with applicable regulations concerning the handling and transportation of radioactive material.
- Provide training to on-site personnel who may be exposed to ionizing radiation, and for other site-specific hazards.
- Verify that subcontractors (as on-site personnel) implement the requirements of the Work Plan in an acceptable manner.
- Implement the Work Plan for the Gorge work.
- Review the results of surveys, sampling, and environmental monitoring to identify trends and potential for personnel exposure
- Recognize potential radiological hazards and modifying the Work Plan to protect against these hazards.
- Specify proper levels of PPE and resources necessary for full implementation of the Work Plan.
- Develop additional health and safety procedures, as required.
- Conduct daily safety briefings.
- Observe work in progress to verify adherence to day-to-day radiation safety operations.
- Assist the CRSO in the investigation of accidents/incidents and "near misses".
- Termination of any work activities that could or do violate regulatory requirements for radiological protection pursuant to "Stop Work Authority."

- Coordinate with the field crew personnel regarding the control of existing and potential industrial, chemical, and radiological hazards.

The Project Manager is the primary point of contact and AWS interface. The minimum requirements for the Project Manager are 5-10 years of health physics experience including prior management experience.

He/she will be responsible for the supervision and coordinate the daily activities including the overview of the free release surveys. In order to ensure regulatory compliance, he/she will be qualified in the use of the survey instruments used and be familiar with the aspects of surveying as described in NUREG-1575 and this Work Plan.

4.3 TRAINING

Personnel working on the Gorge decommissioning activities with unescorted access to the facility will be trained in regard to the type and magnitude of the radiological, chemical, and physical hazards they might face (all visitors to the site will be escorted). The following subsections briefly describe the various training programs that will be implemented by the CRSO or his/her designee as part of this Work Plan.

4.3.1 VISITOR TRAINING

Visitors to the work zone will be escorted while in the Gorge work area. Visitors shall not be allowed to enter potential airborne areas where exposure to internal dosage may occur without proper training.

4.3.2 GENERAL EMPLOYEE TRAINING

General Employee Training (GET) in radiation protection will be administered to onsite project personnel who will provide support during implementation of this Work Plan. GET, to be provided at the start of fieldwork, will consist of a computer sideshow presentation by the PM, handout materials, and completion of a form acknowledging receipt of training. GET will address the following topics:

- The type and form of radioactive material present at the facility
- The location of the contractor's radiation protection policies and procedures
- Employee and management responsibilities for radiation safety
- Identification of radiation postings and barriers
- Protective equipment and procedures
- Work zone setup and decontamination procedures

- Emergency procedures
- Directions on how to contact contractor representatives and project radiation safety staff

4.3.3 HAZARDOUS WASTE OPERATIONS TRAINING

Project personnel who work in controlled areas with the potential for exposure to hazardous materials are required to undergo Hazardous Waste Site Operations (HAZWOPER) training in accordance with 10 CFR 1910.120 and contractor requirements. Although not planned, it may be necessary for workers to enter an excavated pit. Therefore, site workers will be properly trained according to the Permit-Required Confined Spaces standard, 29 CFR 1910.146.

4.3.4 RADIATION WORKER TRAINING

Project personnel who will work in radiologically controlled areas are required to undergo annual Radiation Worker Training (RWT) prior to arrival at the site. The contractor RWT will include the following topics at a minimum:

- Radioactivity and radioactive decay
- Characteristics of ionizing radiation
- Man made radiation sources
- Effects of exposure to radiation
- Risks associated with occupational radiation exposures
- Special considerations with respect to exposure of women of reproductive age
- Dose-equivalent limits
- Modes of exposure (internal and external)
- Dose-equivalent determinations \
- Basic protective measures (time, distance, and shielding)
- Specific procedures for maintaining exposures ALARA
- Radiation survey instrumentation (calibration, use, and limitations)
- Radiation monitoring programs and procedures
- Contamination control, including protective clothing, equipment, and workplace design
- Personnel decontamination
- Emergency procedures
- Warning signs, labels, and alarms
- Responsibilities of employees and management

RWT will consist of a computer slideshow and procedure review, a question/answer period, and a handout. The duration of training is approximately two hours. A graded exam to test employee proficiency in the class subject matter shall be administered. A passing score of 76 percent is required. A challenge test may be administered in lieu of a formal classroom training session for individuals previously trained by the contractor or demonstrating knowledge regarding radiological hazards expected to be present onsite.

4.3.5 TAILGATE SAFETY TRAINING

A tailgate safety meeting will be conducted at the beginning of each work shift, whenever significant changes in job scope are made, whenever significant changes in site conditions (physical or radiological) occur, or whenever new personnel arrive at the job site. Health and safety procedures and issues for the day, any unique hazards associated with an activity, and a review of any significant topics from previous activities will be presented at this meeting. The information discussed will be recorded, which will serve as confirmation that the information was presented to those persons whose signatures are on the form. There will be at least one signed form for each work shift. Tailgate safety training forms will be incorporated into the decommissioning records.

4.3.6 TRAINING RECORDS

A form will be developed to demonstrate that training commitments have been met. This form will include the following information: the facility name; the date; the time; the task number; the type of work; the hazardous/radioactive materials used; the protective clothing/equipment used; the chemical, radiological, and physical hazards; emergency procedures; the hospital's/clinic's telephone numbers; the hospital's/clinics address; any special equipment needed; and any other safety topics that may be relevant. All training records will be incorporated into the decommissioning records.

A copy of the NRC Form 3 Notice to Employees, and a copy of the AWS NRC Radioactive Materials License will be posted in plain view at the worksite.

An NRC Form 4 will be requested for all individuals requiring radiation-monitoring dosimetry.

4.4 CONTRACTOR SUPPORT

Contractor efforts will be focused on nuclear, health and safety, regulatory compliance, and project management matters. Specialty services necessary to complete certain aspects of the Plan (disposal, treatment, transportation, and laboratory analyses) may be subcontracted to firms with the appropriate skills and experience.

At all times, the contractor will remain responsible for the scope, quality, and timeliness of services provided by all subcontractors. The PM will verify that the subcontractor personnel are adequately informed of the hazards, the preventive measures, and the procedures associated with performing each decommissioning task. The PM will verify that subcontractor personnel perform decommissioning activities in accordance with all license commitments and NRC requirements.

4.5 HEALTH PHYSICS (HP) TECHNICIAN (S)

The HP Technicians will be responsible for performing the release surveys and collecting samples as necessary. They will be qualified in the use of the survey instruments and the performance of surveys in accordance with NUREG-1575 (MARSSIM) as well as this Survey and Sampling Work Plan.

4.6 HEAVY EQUIPMENT OPERATOR(S)

The heavy equipment operators will be responsible for the safe operation of any heavy equipment used at the site.

4.7 UXO PERSONNEL/SUXO SUPERVISOR

The UXO personnel and supervisor will be responsible for UXO anomaly avoidance and oversight during project activities.

4.8 HEALTH PHYSICS AUDITS, INSPECTIONS, AND RECORD KEEPING PROGRAM

The project shall be subject to an audit as well as periodic inspections. Each are performed to determine if radiological operations are being conducted in accordance with regulations, license conditions, and written procedures.

An audit of the program shall be conducted at least once during the execution of the project. The audit shall be conducted by the CRSO or designee. The audit will consider the basic functional areas of the program; e.g., RWPs, Radiation Protection Procedures, radiological surveys and air monitoring, ALARA program, individual and area monitoring results, access controls, respiratory protection program, and training.

The audit shall be conducted in accordance with a specific audit plan developed by the auditor. A written report describing the results shall be generated upon completion of the audit. The report shall be distributed to site management. As necessary, a written corrective action plan shall be prepared to address non-compliance issues. All corrective actions shall be tracked

to completion. Once corrective actions have been completed, a written closure report shall be distributed to management documenting the completion of corrective actions. The Health and Safety staff shall conduct the periodic inspections. These inspections shall be routine reviews performed of operations and activities. The inspections shall normally be completed against a pre-established checklist. Checklists may be developed independently for differing periods; e.g., daily, weekly, monthly, etc. The checklist items shall usually be comprised of routine procedural requirements. Any findings discovered during the routine inspection shall be recorded on a tracking log. The log shall be maintained by the CRSO or designee. The log shall include a description of planned corrective action and date of completion of corrective action.

4.8.1 PERSONNEL RECORDS

A personnel file is maintained for each employee assigned work duties involving radioactive materials. The content of these files include at a minimum:

- A record of radiation exposure received by the individual during previous employment is maintained by requesting personal exposure information from previous employers where the individual worked with radioactive materials.
- A record of personnel dosimeter measurements is recorded in the personnel file to provide a permanent record of radiation exposure received during the course of work assignments.
- If a personal dosimeter is lost or damaged, an exposure investigation will be performed and an exposure will be assigned for the monitoring period. A report detailing the exposure estimate will be included in the personnel record.
- If the air concentration in the work area exceeds 10% of DAC values, air samples and bioassay samples will be used to estimate internal exposures received by the worker and included into their personal exposure file.
- If a worker finds contamination on their person above the limits specified in Section 8.7.1, a report of the incident will be placed in the personnel file to determine exposure from the incident.

The personnel records will be maintained indefinitely and personnel may review their file or request copies of information within their files. The licensee for which work is performed will be provided individual exposure information as required by their license or applicable regulations. Personnel records will be maintained electronically in a secured location, such as the AWS secure file transfer protocol (ftp) server located in Anchorage, AK. The CRSO or designee will ensure that individual records are protected from unauthorized review or distribution. Only the CRSO or designee, individual's supervisor, and individual will have access to an individual's personnel records. Personnel records will be maintained indefinitely and personnel may review their file or request copies of information within their files at any time during normal work hours.

4.8.2 RADIATION AND CONTAMINATION RECORDS

Radiation and contamination survey records collected during site surveys, remediation/decontamination activities, and other decommissioning activities shall be stored in project-specific files at the contractor office and electronically on the ftp site and contractor office computer. Duplicate copies of the records will also be supplied to the licensee where the work was performed.

4.8.3 RECORDS OF WASTE DISPOSAL

Radiation survey records, contamination survey records, shipping manifests, and certifications generated for a licensee's shipment of radioactive materials to a licensed disposal site shall be stored in specific shipment files in contractor office and electronically on the ftp site and contractor office computer. Duplicate copies of the records will be supplied to the licensee for the work performed.

5.0 RADIOLOGICAL CONTROL REQUIREMENTS

5.1 RADIATION WORK PERMIT

A Radiation Work Permit (RWP) shall be prepared and will specify the activities to be performed and all radiological safety requirements for the work. All personnel assigned to site work will be required to read and sign the RWP, acknowledging that they understand the requirements of the RWP, prior to beginning work.

The RWP will also be used as an information document for industrial safety. Hazards other than radiological may be included in the RWP so proper protective actions can be taken for all potential hazards. The RWP will clearly specify the need for a briefing on the radiological conditions present in the work environment.

The RWP shall list tasks and specific levels of protection for each worker covered by the RWP. The RWP shall also detail the dosimetry requirements, the protective clothing requirements, and the expected radiation and contamination levels to be encountered during the field survey activity.

Although the RWP is an AWS internal procedural document, a copy of the RWP will be provided to the appropriate Picatinny offices (Radiation Protection Office, ARDEC Risk Management Office, Garrison Safety Office, and Garrison Environmental Office) for approval.

5.2 PERSONNEL MONITORING AND DOSIMETRY

Even though the planned work consists of excavating soils, area surveys, and potential minor decontamination efforts, the likelihood that personnel will receive any external or internal exposure is considered minimal. Aleut World Solutions administrative policies require the use of external dosimetry on any field project that has the potential for exposure to radioactive material.

The Project Manager (or designee) is responsible for ensuring that all AWS personnel assigned to perform the work (employees, vendors, contractors, and visitors) are appropriately monitored for exposure to ionizing radiation. Each individual working at the site shall wear the dosimetry devices specified in the RWP. Personnel shall be issued a thermoluminescent dosimeter (TLD). The issuance of monitoring devices shall be documented on a Badge Issue Log and furnished to the vendor that processes the TLD's

5.3 PROPER LOCATION FOR WEARING DOSIMETRY DEVICES

Unless otherwise directed by the PM (or designee), personnel monitoring dosimetry shall be worn on the front of the body between the neck and the waist. When circumstances are such that other parts of the body could potentially receive a significantly greater dose, the PM may instruct

the individual to wear the dosimetry in a more representative location, or may specify additional dosimetric devices.

5.4 OFFICIAL EXPOSURE DETERMINATION AND PROJECT DOSE ESTIMATE

AWS will be responsible for distributing and collecting the dosimetric devices. The official and permanent record of accumulated external dose received by individuals is obtained from the processing of the personnel monitoring devices (TLDs) by an approved vendor. Once the processing of the personnel monitoring devices has been completed, personnel will be sent a hard copy record (NRC Form 5) of their exposure.

Due to the low exposure rates in the work areas, total crew Total Effective Dose Equivalent (TEDE) is expected to be < 10 mrem.

The NRC annual exposure limits for occupational exposure to radiation as found in 10 CFR Subpart C, Part 20.1201 are as follows:

5 Rem TEDE

50 Rem; Sum of Deep Dose Equivalent (DDE) and the Committed Dose Equivalent (CDE) to any individual organ or tissue other than the lens of the eye.

15 Rem; Lens Dose Equivalent (LDE) to the lens of the eye.

50 Rem; Shallow Dose Equivalent (SDE) to the skin of the whole body or to the skin of any extremity.

The AWS annual administrative exposure limits for occupational exposure to radiation are as follows:

500 millirem TEDE

5 Rem; Sum of Deep Dose Equivalent (DDE) and the Committed Dose Equivalent (CDE) to any individual organ or tissue other than the lens of the eye.

1,500 millirem; Lens Dose Equivalent (LDE) to the lens of the eye.

5 Rem; Shallow Dose Equivalent (SDE) to the skin of the whole body or to the skin of any extremity.

5.5 LOST OR DAMAGED DOSIMETRY DEVICES

Individuals shall immediately notify the PM (or designee) if they lose or damage their dosimeter. A thorough search shall be made for any dosimeter reported lost. Personnel whose exposures are being investigated shall be excluded from work in radiologically controlled areas until the investigation is completed and documented and dosimetry devices reissued. In the event of lost or damaged TLD devices, the PM shall investigate the exposure conditions and assign an external dose for the individual, with concurrence of AWS program management.

5.6 RESPIRATORY PROTECTION PROGRAM

It is AWS's policy to maintain personnel exposure to known or suspected airborne radioactive and/or hazardous material to ALARA with regulatory guidance. Respiratory protection shall be maintained by the application of practicable engineering controls such light wetting of the soils and the concurrent monitoring of airborne dusts.

The management of AWS does not consider protection of workers from airborne radioactive materials through the use of respirators to be a routine operation, and for this reason their use, except for emergencies, is not expected during the Gorge decommissioning activities. Emergency conditions are unplanned events characterized by the need for rapid and aggressive actions to prevent or mitigate the effects of rapidly deteriorating conditions. The use of respirators during such is often a reasonable substitute for engineering controls that must be assumed to be nonfunctional or ineffective. There exists an extremely low probability of the occurrence of an emergency event of this nature during Gorge decommissioning activities.

However, the respiratory protection program (program) provides guidance and instruction regarding protection of workers from occupational injury and illness due to exposure to airborne radioactive material. The program is implemented by written procedures. The program and implementing procedures are the primary means used to administratively establish safe respiratory protection practices and compliance with requirements of the NRC.

The program covers routine use of respiratory protection equipment. The functional areas of the program include medical evaluation; fit testing, selection, issue, inspection, use, cleaning, maintenance, storage, and training.

- Medical

Prior to the initial fit test, and at least every 12 months thereafter, an evaluation will be made of each worker required to wear respiratory protection equipment as part of the worker's duties as to whether or not the worker can wear the required respirator without physical risk. A worker will not be allowed to wear a particular type of respirator if, in the opinion of a physician, the worker might suffer physical harm due to wearing the respirator. A worker shall not be allowed to use a respirator without a current medical evaluation.

- Fit Test

All workers required to wear respiratory protection equipment shall be required to successfully complete a fit test prior to initial use of the equipment. The fit test shall be repeated at least annually. A worker shall not be allowed to wear a respirator without a current successful fit test.

- Selection

Respirators shall be selected from those approved by the National Institute for Occupational Safety and Health for the contaminant or situation to which the worker may be exposed. Health Physics shall select the respirator type. Selection shall be based on the physical, chemical, and physiological properties of the contaminant, the contaminant concentration likely to be encountered, and the likely physical conditions of the workplace environment in which the respirator will be used.

- Issue

Respirators, when it is determined to be necessary, shall only be assigned or issued to workers qualified, with respect to the program, to use respiratory protection equipment. The type of respirator selected shall be documented on the Radiation Work Permit.

- Inspection

All respirators shall be inspected with regard to operability before, and routinely after, each use, and after cleaning.

- Cleaning

Respiratory protection equipment that is used routinely shall be cleaned after each use. Respiratory protection equipment that is used by more than one worker shall be cleaned and disinfected after each use. The need for cleaning shall also be based on contamination surveys of the work area and of the respiratory protection equipment.

- Maintenance

Respiratory protection equipment shall be maintained to retain its original effectiveness. Replacement or repair shall be done only by experienced persons, with parts designed for the respirator. No attempt shall be made to replace components or to make adjustments or repairs beyond the manufacturer’s recommendations. Reducing valves or admission valves on regulators shall be returned to the manufacturer or equivalent for repair.

- Storage

Respirators shall be stored to protect against dust, sunlight, heat, extreme cold, excessive moisture, or damaging chemicals. Respirators shall be stored in dedicated carrying cases or cartons that protect from dirt and damage.

- Training

All workers required to use respiratory protection equipment shall be instructed in the content and applicability of the program and implementing procedures, and especially in the proper use of the equipment and its limitations. Refresher training shall be conducted annually.

A worker shall not be allowed to use a respirator without current successful completion of training.

5.7 INTERNAL EXPOSURE DETERMINATION

Internal exposure determination will be completed through analysis of breathing zone air samples in compliance with written procedure(s) and, as necessary, bioassay results. The assessment of a workers' Committed Effective Dose Equivalent (CEDE) will be limited to less than 10% of the allowable limit on intake (ALI) as specified in Table I, Columns 1 and 2, of Appendix B of 10 CFR Part 20, providing the total effective dose to the individual is maintained ALARA. The RSO will determine the validity of bioassay and air monitoring results prior to their inclusion in the internal dose assessment process.

5.8 EXTERNAL EXPOSURE DETERMINATION

External exposure potential will be routinely monitored through the use of microR or equivalent meters in order to assess the level of external exposures to ionizing radiation. All site personnel will be monitored by personnel dosimetry (themoluminescent dosimeters). The personnel dosimetry devices will indicate the amount of ionizing radiation to which the wearer was exposed. The personnel dosimeter will normally be worn on the upper front torso. Personnel are responsible for wearing dosimetry as directed by the PM. If a personnel dosimeter is lost, misplaced, or indicates an off-scale reading, the employee is required to notify his/her supervisor, health physics personnel, and/or the PM immediately.

All reasonable efforts will be made to keep ionizing radiation exposure to the unborn child to the lowest practical level, as prescribed in 10 CFR 20.1208. Once a female employee determines that she is pregnant, she is encouraged to notify in writing of her pregnancy. The contractor will then institute radiation control measures that will limit radiation exposure to the unborn fetus to less than 500 millirem (mrem) for the term of the pregnancy and below 50 mrem per month in any month after declaration.

5.9 SUMMATION OF INTERNAL AND EXTERNAL EXPOSURES

If the RSO makes a determination in accordance with 10 CFR 1201(a) that external dosimetry is not required (i.e., personnel are not likely to receive within one year, a dose in excess of 10 percent of the applicable limits from radiation sources external to the body), then the external dose need not be added to the internal dose.

If the RSO makes a determination in accordance with Appendix B, 10 CFR Part 20 that internal dosimetry is not required (i.e., personnel are not likely to receive within one year a dose in excess of 10 percent of the applicable ALI as specified in Table I, Columns 1 and 2, of Appendix B of 10 CFR Part 20), then the internal dose need not be added to the external dose.

5.10 CONTAMINATION CONTROL PROGRAM

Radioactive material will be controlled as specified in the project HASP and in such a manner that the surface contamination does not exceed the levels specified in NRC guidelines for the decontamination of facilities and equipment prior to release for unrestricted use as presented in the NRC's Policy and Guidance Directive FC 83-23 (NRC 1983).

Routine surveys will be performed throughout the decommissioning process, with each survey being planned in advance with regard to the specific radiation type, the predetermined radiation levels, the location where radiation is expected, and any special condition warranting a survey. The initial level of protection for the intrusive tasks of this decommissioning operation (i.e., where residual radioactivity may be encountered) will be Level D PPE, including hard hats, safety glasses with side shields, steel-toed boots, and gloves. Upgrading or downgrading the level of protection will be based on ambient conditions as work proceeds. The RSO will determine if it is necessary to upgrade to a higher level of protection.

To ensure that radioactive materials remain under the control of AWS, each worker involved in this decommissioning effort and working in a contaminated area will be frisked using calibrated, hand-held instruments prior to leaving the contaminated work area. Equipment and materials will be frisked and decontaminated, as necessary, prior to exiting the controlled area. Records of release surveys will be maintained on standardized forms and maps and will be placed in the decommissioning records. In the event that a sealed radioactive source is used at the site, the RSO will verify the conditions of the license, which regulates the use of the sealed source. This will include verifying the training of the operators and the frequency of wipe tests.

5.11 NUCLEAR CRITICALITY SAFETY

The licensed radioactive materials identified at the Gorge are not expected to meet the definition of Special Nuclear Material found in 10 CFR 70.4. The radioactive materials in the ratios that are currently known to exist at the Gorge will not trigger or sustain a critical reaction and therefore nuclear criticality safety measures will not be necessary.

6.0 SITE PREPARATION, EQUIPMENT

6.1 ACCESSIBILITY

Access to the active work areas will be controlled using barricades, and/or boundary rope/tape. The appropriate postings will be displayed. This will limit access to only those personnel performing work in the areas.

6.2 OFFICE SPACE AND RESTROOM FACILITIES

Temporary office space and restroom facilities will be utilized during the task. AWS will provide temporary restrooms and a temporary office trailer for the duration of the work activities. The location and placement of the temporary restrooms and temporary office trailer will be approved by the appropriate Picatinny personnel prior to starting work activities.

6.3 ELECTRICAL POWER

Portable generators will be used to provide electrical power in the work areas where it is needed.

6.4 AREA POSTING AND ACCESS CONTROL

In order to minimize unauthorized access to, and/or removal from the site of radioactive material(s), application of appropriate security protective measures will be exercised (i.e., temporary fencing with locked gates, boundary ropes with warning signs). Licensed radioactive sources and devices, as well as non-exempt quantities of radioactive materials in non-permitted sources, must be routinely inventoried and documented as such. Identification of locations where radioactive materials are present will be accomplished with the use of conspicuous postings compliant with Title 10 Code of Federal Regulations (CFR) Part 20.

Only pre-authorized areas approved by the ARDEC Radiation Protection Office will be used to store radioactive materials at the Picatinny Arsenal. These areas will be selected with concurrence of the appropriate Picatinny Arsenal Base personnel. Security measures for these areas will be coordinated with the appropriate Picatinny Arsenal Base Personnel.

Radioactive material handling activities must be performed in a manner to ensure:

- Access to areas is restricted where radioactive materials are known to be present
- Surveys of radioactive materials storage areas are completed at least weekly

6.5 TRAINING

Prior to the start of work, all site personnel, including subcontractors, will attend a briefing that will discuss radiological conditions and radiological controls that will be implemented at the site. AWS will provide this training and attendance will be documented on the appropriate form. A safety inbrief will also be conducted with Picatinny personnel prior to the work commencing.

7.0 OPEN DETONATION PIT AREA, HILLSIDE AREA SURVEY APPROACH SUMMARY

7.1 HILLSIDE AREA

The hillside area was covered with an impervious membrane and riprap in 2005 for storm water and erosion control purposes. A 100 % walkover gamma scan survey will be conducted in this area in accordance with Sections 8.8.2, 8.8.3, and 8.8.4 of this plan. For remediation and soil sampling purposes, the riprap will be removed and the membrane breached over the areas to be remediated/sampled. It is not anticipated that any remediation will be required in this area. The riprap will be replaced after remediation/sampling activities. The membrane underneath the riprap will be repaired so integrity of the membrane is maintained. The areas will be patched with a material that is the equivalent of the membrane material. The survey unit and systematic sampling locations will be laid out in accordance with Sections 8.5 and 8.6 of this plan. Soil samples will be collected in accordance with Section 8.8.6 of this plan.

7.2 OPEN DETONATION PIT AREA INTERIOR AREAS

The interior (within the bermed area) of open detonation pit area ($ODPA_{INT}$) be surveyed in a different manner than the open detonation pit exterior areas ($ODPA_{EXT}$) and hillside area since the probability of identifying the presence of subsurface (defined as below 6" of the existing grade surface) contamination, although unlikely, is highest in this area. Based on historical information gathered that UXO personnel typically dig 4' below grade surface (bgs) to bury explosives for detonation in the pit, it is currently planned that the surfaces in this area will be surveyed/sampled to a depth of 5' below the existing grade surface.

Due to potential levels of lead present in the area it is recommended that large scale movement of the soils out of the area not be done and a more localized approach of excavation be performed.

The area will be surveyed in ten foot by ten foot "cells". Each ten foot by ten foot cell will be excavated using a smooth bucket excavator in 1' lifts. Prior to each 1' lift being removed from the cell, the area will undergo a UXO sweep and a 100% walkover gamma scan survey. The walkover gamma scan survey will be conducted in accordance with Sections 8.8.2, 8.8.3, and 8.8.4 of this plan. The removed soils from the cell will be placed and spread onto the adjacent cell yet to be surveyed. After each bucket of soil is placed and spread in the adjacent cell another 100% walkover gamma scan survey will be performed. Areas found above the Action Level as defined in Section 8.8.4 of this plan will be investigated. Investigation may include:

- Remediation of the area (soil placed into B-25 box, or discrete item(s) placed into 55-gallon drum)
- Collection of a soil sample from the area

Once the soil has been excavated to a depth of 5' below the existing grade surface, the soils will be placed back into the cell. Excavation will then move onto the adjacent cell.

It is estimated that there will be a total of approximately 18 ten foot by ten foot cells inside the bermed area of the open detonation pit area (1,800 ft^2).

NOTE: An effort will be made to survey the cells from the inner cells working outward towards the berm areas to accommodate the ongoing mission at Picatinny.

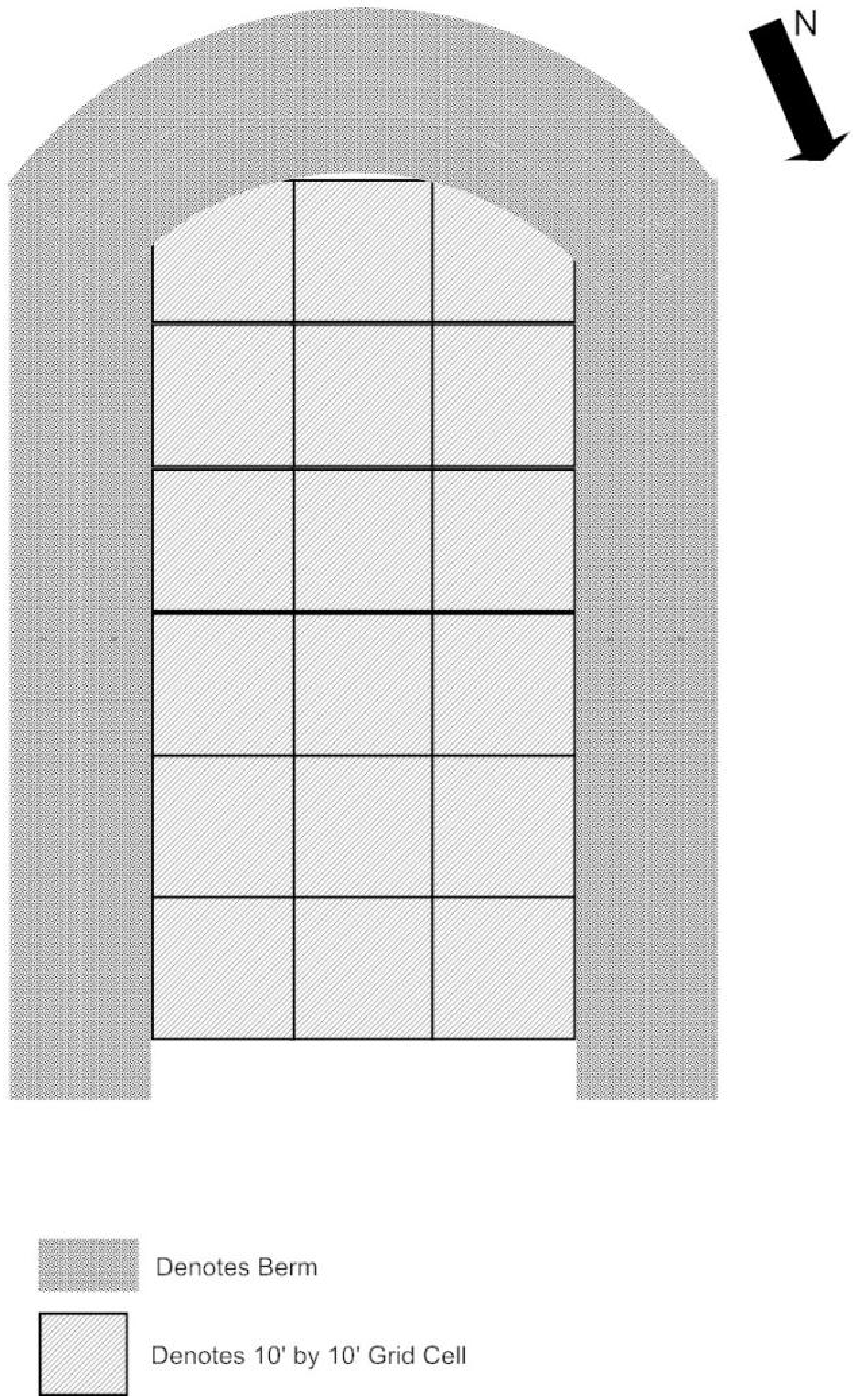
The survey unit(s) and systematic sampling locations will be laid out in accordance with Sections 8.5 and 8.6 of this plan. Soil samples will be collected in accordance with Section 8.8.6 of this plan.

NOTE: There will be 6 separate survey units in the open detonation pit interior area. Each survey unit will be 1 foot thick to a depth of 5' below the existing grade surface. A different random starting point for each survey unit will be calculated. A summary of the survey units is as follows:

- Survey Unit #1: From existing grade surface to 1' below existing grade surface.
- Survey Unit #2: From 1' below existing grade surface to 2' below existing grade surface.
- Survey Unit #3: From 2' below existing grade surface to 3' below existing grade surface.
- Survey Unit #4: From 3' below existing grade surface to 4' below existing grade surface.
- Survey Unit #5: From 4' below existing grade surface to 5' below existing grade surface.
- Survey Unit #6: At the excavation bottom at 5' below existing grade surface.

Figure 5 presents a diagram of the 10' by 10' cell layout of the open detonation pit interior area. The amount of cells and layout may be different than this diagram when actual field measurements are taken.

Figure 5 Interior Open Detonation Pit Area Cell Layout



7.3 OPEN DETONATION PIT AREA EXTERIOR AREAS

The open detonation pit exterior areas ($ODPA_{EXT}$) will have a 100% walkover surface gamma scan survey performed over the areas. Surface scans and surface soil samples will be collected in the exterior areas since the results of previous radiological investigations in these areas did not indicate subsurface contamination in these areas above the DCGL.

The survey unit(s) and systematic sampling locations will be laid out in accordance with Sections 8.5 and 8.6 of this plan. Soil samples will be collected in accordance with Section 8.8.6 of this plan.

7.4 STRUCTURE SURVEYS

There are numerous structures in and around the open detonation pit exterior area. These structures will be 100% alpha-beta/gamma scan surveyed in place. Gross alpha-beta/gamma direct measurements (static) will also be performed. The surveys will be conducted in accordance with Sections 8.1.3 and 8.1.4 of this plan. It is not anticipated that any of the structures will require any decontamination efforts.

Figure 6 presents a picture showing the structures to be surveyed.

Figure 6 Structure Picture

7.5 DUST SUPPRESSION

A water truck will be used to lightly wet the soils if dust levels increased during excavation activities.

7.6 AIR SAMPLING

Concentrations of radioactive material in air will be determined, as needed, by sampling the air. Air samples will be collected downwind during excavation activities in the immediate vicinity of the area being excavated. Air sampling will be conducted in accordance with the guidance provided in NRC Regulatory Guide 8.25, "Air Sampling in the Workplace", July 1992. The samples will be collected under known physical conditions (e.g. filter, sample time, flow rate). The flow meters of air samplers will be calibrated at least annually.

Air samples will be collected from general and localized areas when there was potential for generation of airborne radioactive material (during excavation activities) These samples will be used to verify that the confinement of radioactive material is effective, and provide warning of elevated concentrations for planning or response actions. In each case, the sampling point will be located in the airflow pathway near the known or suspected release point(s). If necessary, more than one air sample location will be used in order to provide a reasonable estimate of the general concentration of radioactive material in air.

The air sample filters will be analyzed onsite for gross alpha-beta/gamma activity with a Ludlum Model-2929 Dual Channel Scaler phoswich detector or equivalent.

The following equation will be used to calculate the initial and decayed count airborne activity:

$$A_F = \frac{(GrossCounts / CountTime) - BackgroundCountRate}{F * 2.22E+6 * V * \varepsilon_i * 2.83E+4}$$

Where,

A_F	Air Sample Activity in μCi/ml
F	Filter Efficiency Factor
V	Total Volume of Air Collected on Air Sample Filter in cubic feet
2.22E+6	Conversion Factor for dpm to μCi
ε_i	2 π Instrument Efficiency
2.83E+4	Conversion Factor for cubic feet to milliliter

The AWS Project Manager or his/her designee will apply professional judgment and experience to identify air sampling appropriate for the specific situation. Such judgment will be based on historical air sampling and characterization results, quantity of contamination of the material being handled, potential for release of contaminants based on physical form and activity, type of confinement or containment, and other factors specific to the activity.

An administrative action level will be established for breathing zone air samples of 10% of the derived air concentration (DAC); air sample results greater than this administrative action level shall be reported to the AWS Project Manager or his/her designee. Individual exposure greater than this action level will require the individual(s) to be restricted from work involving potential exposure to airborne radioactive material unless approved by the AWS RSO or his/her designee.

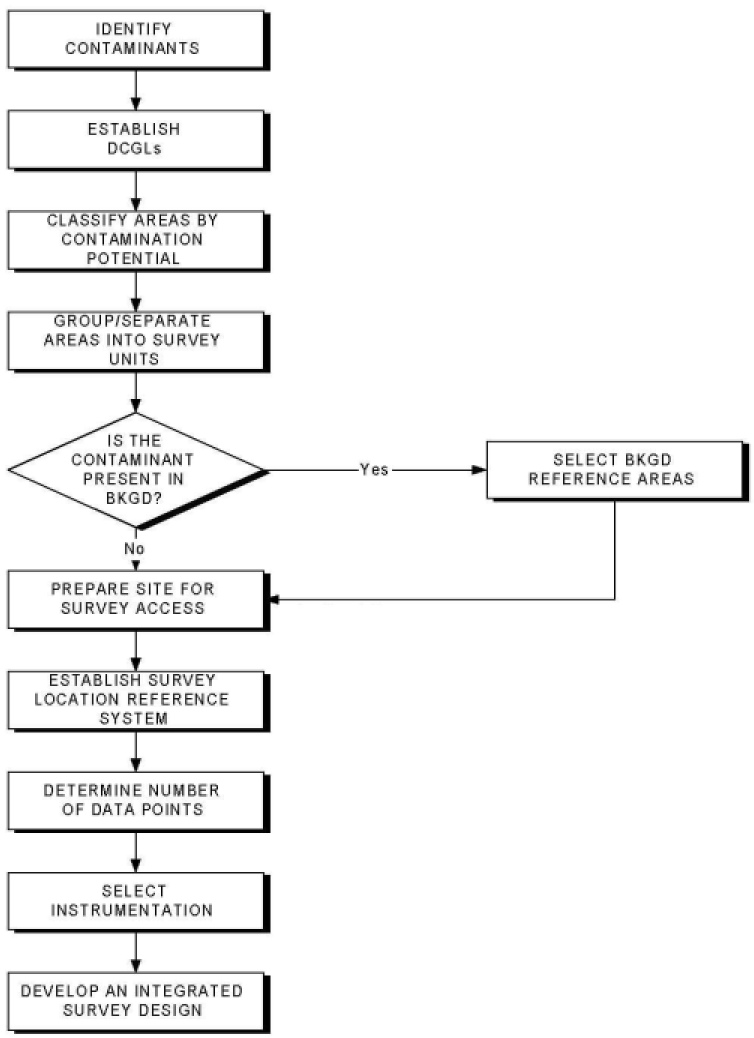
The 10% DAC value for Ra-226 is 3.0 E-11 μCi/ml which can be found in 10 CFR Part 20, Appendix B, Table 1, Column 3.

The 10% DAC value for U-238 is 2.0 E-12 μCi/ml which can be found in 10 CFR Part 20, Appendix B, Table 1, Column 3.

8.0 PLANNING PHASE OF RADIOLOGICAL SURVEYS

The MARSSIM roadmap was used as a guideline in developing the final status survey design. The flow diagram for the design of the final status survey is provided in Figure 7 below.

Figure 7 Flow Diagram for Designing a Final Status Survey



8.1 RADIONUCLIDE (S) OF CONCERN

Based upon historical information from previous investigations and soil sample analysis conducted at the open detonation pit area and adjacent hillside area, the radionuclides of concern are radium-226 (^{226}Ra), and depleted uranium (DU). Table 1 lists the radionuclide of concern with the half-life and principle types of radiation (alpha, beta, or gamma).

Depleted uranium consists of three naturally occurring, long lived uranium isotopes, uranium-234, uranium-235, and uranium-238. Compared to naturally occurring uranium, depleted uranium contained less uranium-234 and uranium-235. The fractions in terms of activity concentrations of the three long lived uranium isotopes in depleted uranium are:

- U-234 0.152
- U-235 0.011
- U-238 0.837

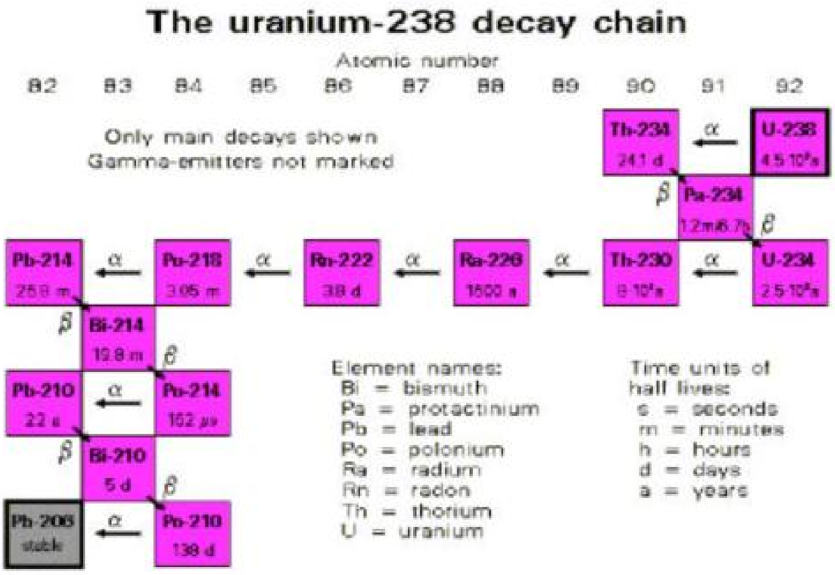
The radionuclides of concern are the radionuclides at a particular site that could contribute significantly to the dose received by the public.

Figure 8 presents an illustration of the uranium-238 decay series.

Table 1 Radionuclides of Concern

Radionuclide	Half-life	Radiations
Radium-226	1,600 years	Alpha (α)/gamma (γ)
Uranium-234	2.44×10^5 years	Alpha (α)/gamma (γ)
Uranium-235	7.04×10^8 years	Alpha (α)/gamma (γ)
Uranium-238	4.47×10^9 years	Alpha (α)/gamma (γ)

Figure 8 U-238 Decay Series



Uranium-238 Decay Series		
Nuclide	**Half-Life**	**Radiation ***
U-238	$4.468 \cdot 10^9$ years	alpha
Th-234	24.1 days	beta
Pa-234m	1.17 minutes	beta
U-234	244,500 years	alpha
Th-230	77,000 years	alpha
Ra-226	1,600 years	alpha
Rn-222	3.8235 days	alpha
Po-218	3.05 minutes	alpha
Pb-214	26.8 minutes	beta
Bi-214	19.9 minutes	beta
Po-214	63.7 microseconds	alpha
Pb-210	22.26 years	beta
Bi-210	5.013 days	beta
Po-210	138.378 days	alpha
Pb-206	Stable	-

only major decays shown
* in addition, all decays emit gamma radiation

8.2 DATA QUALITY OBJECTIVES (DQO'S)

A multi-agency committee representing the Department of Defense (DOD), Department of Energy (DOE), the Environmental Protection Agency (EPA), and the Nuclear Regulatory Commission (NRC) has addressed this need by producing a guidance document known as the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

Published in December 1997, MARSSIM provides detailed guidance for planning, implementing and evaluating environmental and facility radiological surveys to demonstrate compliance with a dose- or risk-based regulation. MARSSIM focuses on the demonstration of compliance during the final status survey once scoping, characterization and any necessary remedial actions are completed.

MARSSIM provides a single, nationally consistent guide for verifying that radioactively contaminated sites have been cleaned up to standards. Combining this information into one manual has increased efficiency, and has eliminated the confusion that can result from contractors working from multiple manuals.

The surveys of the open detonation pit and hill areas will require sufficient detail to determine if the release criteria are met. The data from the Final Status Surveys that will be performed as defined in MARSSIM will meet the data quality objectives stated below.

The final status survey design process for the excavation bottom and overburden soil begins with development of data quality objectives (DQOs) in accordance with the guidelines outlined in Appendix D of MARSSIM and EPA QA/G4 "Guidance for the Data Quality Objectives Process" (EPA, 2000). The DQOs are then used in conjunction with the radiological conditions at the site to calculate the number and locations of measurement and sampling points to demonstrate compliance with the release criterion as discussed in Section 6.3. Survey techniques and analytical methodologies were selected to generate the required analytical data. Once the data is received from the surveys and laboratory and is validated, it will be evaluated using statistical techniques to test against the hypothesis stated in Section 7.9.2. Sampling, as discussed in this and subsequent sections, refers to the collection of measurement data. “Sampling” includes soil samples for off-site analysis, alpha/beta direct measurements, and swipe samples.

8.3 STATEMENT OF THE PROBLEM

For the Final Status Surveys of the open detonation pit and hillside areas it must be determined if the allowable release limits have been met or if investigation/remediation is warranted. Therefore, the decision to be made can be stated: “Do the Final Status Survey Units meet the allowable soil concentration release limits presented in Table 2. The null hypothesis (H_o) as required by MARSSIM is stated and tested in the negative form: “The median concentration in the survey unit exceeds the soil concentration release limit.”

Final Status Surveys are surveys, measurements, and sampling, once performed that describe the radiological conditions of a site, following completion of decontamination/remediation activities (if any) in preparation for unrestricted release.

It is anticipated that successful completion of activities described in this Final Status Survey (FSS) Plan will provide sufficient data for the unrestricted release of the areas undergoing survey. Resources available to provide the necessary data include the following:

Activities outlined in this FSS Plan.

Guidance provided in the Multi Agency Radiation Survey & Site Investigation Manual (MARSSIM) for performing Final Status Surveys (FSS).

Process knowledge, inspections, and various radiological survey reports previously conducted in the areas.

Data obtained during previous surveys discussed in Section 2.3.

Statistical analysis of survey data collected during survey activities outlined in this FSS Plan.

8.4 IDENTIFICATION OF DECISIONS

The need to provide data for unrestricted release of the open detonation pit and hillside areas requires the performance of radiological surveys as specified in this FSS Plan.

The primary uses of the data expected to result from completion of this FSS Plan is to provide information and data to support the unrestricted release of the open detonation pit and hillside areas.

8.5 INPUTS TO THE DECISION

Radiological surveys and sampling required to support the unrestricted release of the areas will include:

Locate and survey background reference area(s) where meaningful background radiation levels can be determined;

100 % gamma scan surveys of the open detonation pit and hillside areas with Ludlum Model 2350-1 Data Loggers coupled to Ludlum Model 44-10 2-inch by 2-inch NaI detectors will be performed;

Systematic soil samples in the survey units;

Laboratory data validation and statistical analysis of collected data.

8.6 DEFINITION OF STUDY BOUNDARIES

The spatial boundary for this survey effort is the open detonation pit area which is ~ 23,000 ft^2 (2,136 m^2) in size (which includes interior and exterior areas), and hillside areas. The hillside area is ~ 17,222 ft^2 (1,600 m^2) in size. The open detonation pit interior area is ~ 1,800 ft^2 (167 m^2) size and from current grade surface to 5’ below grade surface (bgs). The exterior area of the

open detonation area is ~ 21,200 ft^2 (1,970 m^2) in size. Each survey unit will be 100 % gamma scan surveyed. Systematic soil samples will also be collected from each survey unit.

8.7 DEVELOPMENT OF A DECISION RULE

The Derived Concentration Guideline Level (DCGL) is defined in MARSSIM as the radionuclide specific concentration within a survey unit corresponding to the release criterion. As specified in the current regulations and regulatory guidance, the release criteria is dose based, and the Total Effective Dose Equivalent (TEDE) to an individual will not exceed 15 mrem/yr plus ALARA as a result of any residual contamination distinguishable from background.

The DCGL is dependent upon several factors including the radionuclides of interest, applicable dose pathways, area occupancy and the future use of the facility. Contained within the current regulations, specific average guidelines ($DCGL_{WS}$) have been documented for a variety of radionuclides following typical default parameters for either residential or building occupancy scenarios. These guidelines are documented as concentration limits (pCi/g) which correspond to a TEDE of 15 mrem/yr.

For most radionuclides, the documented release criteria are easily achieved; however, issues are encountered when dealing with the naturally occurring radionuclides and alpha emitters such as uranium and radium at the Picatinny Arsenal due to the Redding Prong which is part of the Taconic Range and the larger Appalachian chain of eastern North America which runs across the Hudson southwestward, and terminates in Redding, Pennsylvania. The guideline levels using the default dose modeling codes have resulted in unachievable low DCGLs for radionuclides such as depleted uranium.

8.7.1 DCGLS FOR THE FREE RELEASE OF TOOLS AND EQUIPMENT

As defined in: "Guidelines for Decontamination of Facilities and equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials (NRC 1987), Office of Nuclear Material Safety and Safeguards (NMSS)." The DCGL's for free release of tools and equipment from the site are:

a) 5,000 dpm/100 cm^2 beta-gamma, averaged over 1 m^2.
b) 15,000 dpm/100 cm^2 beta-gamma, maximum.
c) 1,000 dpm/100 cm^2 beta-gamma, removable.
d) 100 dpm/100 cm^2 alpha, averaged over 1 m^2.
e) 300 dpm/100 cm^2 alpha, maximum.
f) 20 dpm/100 cm^2 alpha, removable.

8.7.2 DCGLS FOR THE REMAINING STRUCTURES ON SITE

The largest structure that is to remain on site is a blast shield which has a total surface area of 38 square meters and is constructed of steel. Based upon the number of calculated samples of 14, the calculated spacing of the triangular grid sampling pattern is 1.5 meters and the area in between sampling points is approximately 2 square meters.

The DCGL's and area factors for structure surfaces were calculated using the DandD Version 2.1 modeling code. All default input parameters were used with the exception of the "Area of Contamination" and the "Resuspension Factor". The Resuspension Factor of 10-6 m^{-1} in accordance with NUREG-1720 recommendations was used in all of the calculations.

A value of 300 dpm/100cm^2 for Ra-226 was used as the input distribution value for the calculations. The resulting calculated dose of 5.1 mrem/yr is in compliance with the NJDEP dose based release criteria of 15 mrem/yr established at N.J.A.C 7:28-12.8

Table 2 presents a summary of the calculations for Ra-226. The DandD Version 2.1 input/output files are presented in Attachment 1 of this plan.

A value of 600 dpm/100cm^2 for depleted uranium was used as the input distribution value for the calculations. Three separate input values for U-234, U-235, and U-238 using different values for isotopic abundance by activity for depleted uranium were used. They were:

International Atomic Energy Agency (IAEA) values for isotopic abundance by activity for depleted uranium of 15.2 % for U-234, 1.1% for U-235, and 83.7% for U-238 the individual activity input levels were:

- U-234: 91dpm/100cm^2
- U-235: 6 dpm/100cm^2
- U-238: 502 dpm/100cm^2

International Atomic Energy Agency (IAEA) values for isotopic abundance by activity for natural uranium of 48.8 % for U-234, 2.4% for U-235, and 48.8% for U-238 the individual activity input levels were:

- U-234: 293dpm/100cm^2
- U-235: 14 dpm/100cm^2
- U-238: 293 dpm/100cm^2

Values used in the decommissioning of Building 611B at the Picatinny Arsenal of 30.5 % for U-234, 1.3% for U-235, and 68.2% for U-238 the individual activity input levels were:

- U-234: 183 dpm/100cm2
- U-235: 8 dpm/100cm2
- U-238: 409 dpm/100cm2

The resulting calculated dose of 11.3 mrem/yr that was calculated using the conservative IAEA input values for natural uranium is in compliance with the NJDEP dose based release criteria of 15 mrem/yr established at N.J.A.C 7:28-12.8

Tables 3, 4, and 5 present a summary of the calculations for depleted uranium. The DandD Version 2.1 input/output files are presented in Attachment 1 of this plan.

Table 2 Ra-226 DandD Run Summary Table

Activity Concentration in dpm/100cm^2	Contaminated Area in Square Meters	Dose in millirem/yr	Area Factor
300	38	5.1	
300	10	5.1	1
300	2	0.8	6.3

Table 3 DandD Run Summary Table Using IAEA Values for Depleted Uranium

Activity Concentration in dpm/100cm^2	Contaminated Area in Square Meters	Dose in millirem/yr	Area Factor
600	38	11	
600	10	11	1
600	2	2.2	5.0

Table 4 DandD Run Summary Table Using IAEA Values for Natural Uranium

Activity Concentration in dpm/100cm^2	Contaminated Area in Square Meters	Dose in millirem/yr	Area Factor
600	38	11.3	
600	10	11.3	1
600	2	2.3	4.9

Table 5 DandD Run Summary Table Using Building 611B Values

Activity Concentration in dpm/100cm^2	Contaminated Area in Square Meters	Dose in millirem/yr	Area Factor
600	38	11.1	
600	10	11.1	1
600	2	2.2	5

8.7.3 SOIL

8.7.3.1 RA-226

The RESRAD Version 6.5 Modeling Code was used to develop the DCGL's for Ra-226 in soils. The calculated DCGL's are to comply with the NJDEP's unrestricted release criteria of 15 mrem/year TEDE.

The NJDEP unrestricted release criteria is 2 pCi/g for Ra-226.

8.7.3.2 DEPLETED URANIUM (U-238)

The RESRAD Version 6.5 Modeling Code was used to develop the DCGL's each individual uranium isotope in depleted uranium for soils. The calculated DCGL's are to comply with the New Jersey Department of Environmental Protection (NJDEP) unrestricted release criteria of 15 mrem/year TEDE.

The NJDEP unrestricted release criteria is 17 pCi/g for U-234, 12 pCi/g for U-235, and 17 pCi/g for U-238.

The default "Residential Farmer" scenario parameters were used with the exception of the following site specific conditions:

"Contaminated Zone" was changed from the default parameter of 10,000 m2 to the site-specific value of 2,200 m2 (size of open detonation pit interior and exterior area (2,136 m2) conservatively rounded up).

"Thickness of Contaminated Zone" was changed from the default value of 2 meters to a site-specific value of 1.5 meters.

The pathway selection was set as follows:

- External Gamma Active
- Inhalation (w/o radon) Active
- Plant Ingestion Active
- Meat Ingestion Active
- Milk Ingestion Active
- Aquatic Foods Active
- Drinking Water Active
- Soil Ingestion Active
- Radon Suppressed
- Find peak pathway doses Active

The first step used to determine the appropriate DCGL was to evaluate each isotope for a TEDE of 15 mrem/yr using the RESRAD Code. Although the NRC requirement is 25 mrem/yr, the more conservative 15 mrem/yr was selected to meet NJDEP requirements for unrestricted release. The resulting DCGLs for each isotope, with the exception of U-235, were very close to

the NJ unrestricted release criteria for each isotope. For U-235, the evaluation revealed a DCGL of around 4 pCi/g

Based on the above evaluation, and to comply with NJDEP release standards, the following concentrations were input into RESRAD:

- U-234 17 pCi/g
- U-235 4 pCi/g
- U-238 17 pCi/g
- Ra-226 1 pCi/g

The resulting calculated maximum TEDE's were as follows:

- U-234 12.9 millirem @ 1,000 years
- U-235 13.3 millirem @ 1,000 years
- U-238 12.4 millirem @ 1,000 years
- Ra-226 13.5 millirem @ 42.8 years

Following collection of samples, and using guidance in Section 2.7 of NUREG-1757, Vol. 2, Rev. 1, the sum of the fraction rule will be applied using International Atomic Energy Agency (IAEA) values for isotopic abundance by activity for depleted uranium of 15.2 % for U-234, 1.1% for U-235, and 83.7% for U-238. The following is the calculation:

$$\frac{U_{234}\text{ Sample Concentration}}{DCGL_{U234}} + \frac{U_{235}\text{ Sample Concentration}}{DCGL_{U235}} + \frac{U_{238}\text{ Sample Concentration}}{DCGL_{U238}} + \frac{Ra_{226}\text{ Sample Concentration}}{DCGL_{Ra226}} = \leq 1$$

If the result of the calculation is ≤ 1, then the site is compliance with 15 mrem/yr TEDE limit for unrestricted release.

Copies of the RESRAD input and output files are provided in this plan in Attachment #1.

In accordance with ALARA, a remedial action level, based on the Minimum Detectable Activity (MDA) of the proposed scanning instrumentation will be established. The gamma scan action level (Section 8.8.4) will be used as the remedial action level. Any surface anomalies soils identified during scanning which exceed this action level will be investigated and possibly remediated and/or biased samples will be collected. For the purposes of this survey effort, it is estimated that a maximum volume of 180 cubic feet (two B-25 boxes and one 30-gallon drum) of material will require remediation. The purpose of the remedial actions is to ensure that activity concentrations of samples collected during the Final Status Survey will not exceed the DCGL, thus eliminating the need for elevated measurement criteria.

The DCGL's are summarized in Table 6 below. Project personnel will compare the survey results with these values to assess the areas surveyed. This will determine the extent of any remediation, if required.

Table 6 Derived Concentration Guideline Levels

Radionuclide	Release Limit in pCi/g [1]
Radium-226	1
Uranium-234	17
Uranium-235	4
Uranium-238	17

[1] Above Established Background Levels

RESRAD Version 6.5 was used to develop the area factors for soil for Ra-226, U-234, U-235, and U-238. All RESRAD Version 6.5 default parameters were used with the exception of the “Area of the Contaminated Zone” and the “Length Parallel to Aquifer Flow”. Tables 7, 8, 9, and 10 below present summaries of the RESRAD Version 6.5 runs and the calculated area factors. The RESRAD version 6.5 input and output reports are presented in Attachment 2 of this plan.

Table 7 Ra-226 RESRAD Run Summary Table

Size in Square Meters	Length Parallel to Aquifer Flow in Meters	Dose in millirem/yr	Area Factor
2200	71	1.351 E+01	
1250	50	1.341 E+01	1
10	5	2.471 E+00	**5.5**

Table 8 U234 RESRAD Run Summary Table

Size in Square Meters	Length Parallel to Aquifer Flow in Meters	Dose in millirem/yr	Area Factor
2200	71	1.322 E+01	
1250	50	1.320 E+01	1
10	5	7.926 E-01	**16.7**

Table 9 U235 RESRAD Run Summary Table

Size in Square Meters	Length Parallel to Aquifer Flow in Meters	Dose in millirem/yr	Area Factor
2200	71	1.334 E+01	
1250	50	1.332 E+01	1
10	5	7.215 E-01	**18.5**

Table 10 U238 RESRAD Run Summary Table

Size in Square Meters	Length Parallel to Aquifer Flow in Meters	Dose in millirem/yr	Area Factor
2200	71	1.242 E01	
1250	50	1.240 E01	1
10	5	8.340 E-01	**14.9**

NOTE: Following completion of the final status surveys and the collection of soil sample data, dose calculations will be performed using the RESRAD Version 6.5 Modeling Code using actual soil concentrations from the soil samples collected during the final status survey effort.

8.8 LIMITS ON DECISION ERRORS

There are two types of decision error applied to analytical results: Type I (α) and Type II (β) errors. A Type I error, or false positive, is the probability that a survey result/measurement is above the release criteria when in fact it is not, while a Type II error, or false negative, is the probability of determining that a result/measurement is below the release criteria when it is not. The probability of making decision errors can be controlled by adopting an approach called hypothesis testing. The null hypothesis (H_0) is treated like a baseline condition and is defined by MARSSIM as:

H_0 = residual radioactivity in the survey exceeds the release criterion.

This means that the site or survey area is assumed contaminated until proven otherwise. For the purpose of this survey, both Type I and Type II, α and β, will be set at 0.05 or 5 percent.

8.9 OPTIMIZING DATA COLLECTION

8.9.1 REVIEW OUTPUTS AND EXISTING DATA FOR CONSISTENCY

Radioactive source readings will be used to check instruments for consistency prior to use in each daily shift. The instrument will only be used after readings are compared and agree within +/- 20 %. The Project Manager will review the information each day to verify equipment is operating satisfactorily.

The Project Manager will review the survey data on a daily basis. This will ensure an ongoing independent review for consistency of all survey data collected.

8.9.2 DETERMINATION OF SCAN PERCENTAGE

100% of the interior (inside bermed area) of the open detonation pit, exterior area of the open detonation pit, and hillside areas will be gamma scan surveyed. This is necessary to determine the extent, if any, of residual contamination that might be present.

8.9.3 DATA COLLECTION DECISION ALTERNATIVES

The data collection design alternatives may change slightly based on conditions found in the field being different than the information furnished based on prior surveys and available information.

In the event that a survey unit classification is revised as a result of detecting unexpected contamination, the Army will be notified and changes to this survey plan will be required prior to resumption of survey activity.

8.9.4 SELECT MOST RESOURCE EFFECTIVE SURVEY DESIGN

As indicated above, the survey design specified for use in this survey plan was developed in accordance with best management practices and MARSSIM guidelines and will provide the necessary data for a radiological final status survey. Coupled with the use of experienced personnel and proper instrumentation, this design is the most efficient and resource effective.

8.9.5 DOCUMENT OPERATIONAL DETAILS AND THEORETICAL ASSUMPTIONS

Operational details for the radiological survey process have been developed for and are included as part of this survey plan. The theoretical assumptions are based on guidelines contained in MARSSIM (MARSSIM, 2000). Specific assumptions regarding types of radiation measurements, instrument detection capabilities, quantities and locations of data to be collected, and action levels are contained in this survey plan.

8.9.6 SAMPLING PROCESS DESIGN

The sampling process design includes the following elements:

The *types of samples and sampling matrices* for the Final Status Survey of the areas are gamma scans, and soil samples.

The *sampling frequency* at the areas is set at a minimum of 14 soil samples for each of the survey units.

8.10 RELATIVE SHIFT

The relative shift is defined as Δ/σ where Δ is the DCGL - LBGR (Lower Bound of the Gray Region) and σ is the standard deviation of the contaminant distribution. In order to calculate the relative shift, the DCGL must be determined and two assumptions made to estimate the LBGR and the standard deviation of the measurement distribution. MARSSIM suggests that the LBGR be set at 50%, of the DCGL but can be adjusted later to provide a value for the relative shift between the range of 1 to 3. The standard deviation may be calculated from preliminary survey data, prior surveys of similar areas and materials or the standard deviation of a reference background area. It should be noted that σ represents the standard deviation prior to release after all area decontamination is thought to be complete. If no reference data is available to make a reasonable estimate, MARSSIM suggests using 30% of the mean survey unit background.

Table 11 below summarizes the soil sample results for thirty-eight samples analyzed for depleted uranium (U-238) from the open detonation pit area previously surveyed by NWT in November of 2001. The calculated standard deviation is 1.6. It should be noted that the maximum sample result (60 pCi/g) was excluded from the standard deviation calculation as this sample was a biased sample.

Table 7 Open Detonation Pit Area Soil Sample Summary Table

	U-238 Results in pCi/g	
1	1.2	
2	-0.4	
3	2.4	
4	8.1	
5	1.3	
6	0.5	
7	1.3	
8	0.5	
9	1.7	
10	1.3	
11	0.5	
12	0.9	
13	2.3	
14	0.7	
15	60.0	
16	0.8	
17	1.6	
18	0.9	
19	0.3	
20	3.1	
21	0.5	
22	1.5	
23	1.2	
24	0.9	
25	0.4	
26	1.4	
27	1.5	
28	0.8	
29	0.6	
30	-0.6	
31	-3.0	
32	1.8	
33	0.5	
34	4.1	
35	2.2	
36	1.4	
37	2.2	
38	1.2	
	3.2	Average
	60	Maximum
	0.3	Minimum
	1.6	Standard Deviation

Using a DCGL of 17 pCi/g for U-238 and a calculated standard deviation of 1.6 the LBGR must be adjusted in order to provide a relative shift in between 1 and 3. In this instance the LBGR is adjusted to a value of 14 to provide a value for the relative shift of 1.9. The following equation is used to calculate the relative shift using a DCGL value of 17 pCi/g, a standard deviation value of 1.6 and a LBGR value of 14:

$$\Delta/\sigma = \text{Relative Shift} = \frac{17-14}{1.6} = 1.9$$

8.11 NUMBER OF SAMPLES/MEASUREMENTS

Once the relative shift, Δ/σ, is determined the calculated value can be used to obtain the minimum number of measurements or samples necessary to reject the null hypothesis based upon the initial assumptions and justify that the survey unit meets the requirements for free release. Table 12 below contains the number of samples or measurements necessary for the given decision errors, α and β, and the calculated relative shift, Δ/σ, when dealing with non-radionuclide specific measurements or when the radionuclide is present in the background. The value N/2 from Table 12 represents the number of samples or measurements to be collected in the survey unit and the background reference.

Based upon a relative shift of 1.9 and a Type I decision rate of 5 %, and a Type II decision rate of 5 %, the calculated number of samples for each survey unit and background reference area is 13. As a conservative measure, 14 samples will be collected from each survey unit and the background reference area.

8.12 DETERMINING DATA POINTS FOR SMALL AREAS OF ELEVATED ACTIVITY

The statistical test described above evaluates whether or not the residual radioactivity in an area exceeds the $DCGL_W$ for contamination conditions that are approximately uniform across the survey unit. In order to obtain reasonable assurance that any small areas of elevated residual radioactivity are not missed during the final status survey the total number of samples might have to be increased.

For example, the scan MDC for ^{238}U has been determined to be 56 pCi/g. The area in between the 14 sampling points calculated above for the open detonation pit area is 11.5 m^2. Interpolating into Table 5.6 of MARSSIM gives an area factor for 11.5 m^2 of 10.7 for ^{238}U. This results in a $DCGL_{EMC}$ = ($DCGL_W$) = 17(10.7) = 182 pCi/g. The scan MDC of 56 pCi/g is less than the $DCGL_{EMC}$ so no additional samples will be needed in order to find elevated areas of activity.

For example, the scan MDC for ^{226}Ra has been determined to be 2.8 pCi/g. The area in between the 14 sampling points calculated above for the open detonation pit area is 11.5 m^2. Interpolating into Table 5.6 of MARSSIM gives an area factor for 11.5 m^2 of 5.3 for ^{226}Ra. This results in a $DCGL_{EMC}$ = $(DCGL_W)$ = 1(5.3) = 5.3 pCi/g. The scan MDC of 2.8 pCi/g is less than the $DCGL_{EMC}$ so no additional samples will be needed in order to find elevated areas of activity.

Table 8 Values of N/2 for Use with the Wilcoxon Rank Sum Test

	α=0.01					α=0.025					α=0.05					α=0.10					α=0.25				
	β					β					β					β					β				
Δ/σ	0.01	0.025	0.05	0.10	0.25	0.01	0.025	0.05	0.10	0.25	0.01	0.025	0.05	0.10	0.25	0.01	0.025	0.05	0.10	0.25	0.01	0.025	0.05	0.10	0.25
0.1	5452	4627	3972	3278	2268	4627	3870	3273	2646	1748	3972	3273	2726	2157	1355	3278	2646	2157	1655	964	2268	1748	1355	964	459
0.2	1370	1163	998	824	570	1163	973	823	665	440	998	823	685	542	341	824	665	542	416	243	570	440	341	243	116
0.3	614	521	448	370	256	521	436	369	298	197	448	369	307	243	153	370	298	243	187	109	256	197	153	109	52
0.4	350	297	255	211	146	297	248	210	170	112	255	210	175	139	87	211	170	139	106	62	146	112	87	62	30
0.5	227	193	166	137	95	193	162	137	111	73	166	137	114	90	57	137	111	90	69	41	95	73	57	41	20
0.6	161	137	117	97	67	137	114	97	78	52	117	97	81	64	40	97	78	64	49	29	67	52	40	29	14
0.7	121	103	88	73	51	103	86	73	59	39	88	73	61	48	30	73	59	48	37	22	51	39	30	22	11
0.8	95	81	69	57	40	81	68	57	46	31	69	57	48	38	24	57	46	38	29	17	40	31	24	17	8
0.9	77	66	56	47	32	66	55	46	38	25	56	46	39	31	20	47	38	31	24	14	32	25	20	14	7
1.0	64	55	47	39	27	55	46	39	32	21	47	39	32	26	16	39	32	26	20	12	27	21	16	12	6
1.1	55	47	40	33	23	47	39	33	27	18	40	33	28	22	14	33	27	22	17	10	23	18	14	10	5
1.2	48	41	35	29	20	41	34	29	24	16	35	29	24	19	12	29	24	19	15	9	20	16	12	9	4
1.3	43	36	31	26	18	36	30	26	21	14	31	26	22	17	11	26	21	17	13	8	18	14	11	8	4
1.4	38	32	28	23	16	32	27	23	19	13	28	23	19	15	10	23	19	15	12	7	16	13	10	7	4
1.5	35	30	25	21	15	30	25	21	17	11	25	21	18	14	9	21	17	14	11	7	15	11	9	7	3
1.6	32	27	23	19	14	27	23	19	16	11	23	19	16	13	8	19	16	13	10	6	14	11	8	6	3
1.7	30	25	22	18	13	25	21	18	15	10	22	18	15	12	8	18	15	12	9	6	13	10	8	6	3
1.8	28	24	20	17	12	24	20	17	14	9	20	17	14	11	7	17	14	11	9	5	12	9	7	5	3
1.9	26	22	19	16	11	22	19	16	13	9	19	16	13	11	7	16	13	11	8	5	11	9	7	5	3
2.0	25	21	18	15	11	21	18	15	12	8	18	15	13	10	7	15	12	10	8	5	11	8	7	5	3
2.25	22	19	16	14	10	19	16	14	11	8	16	14	11	9	6	14	11	9	7	4	10	8	6	4	2
2.5	21	18	15	13	9	18	15	13	10	7	15	13	11	9	6	13	10	9	7	4	9	7	6	4	2
2.75	20	17	15	12	9	17	14	12	10	7	15	12	10	8	5	12	10	8	6	4	9	7	5	4	2
3.0	19	16	14	12	8	16	14	12	10	6	14	12	10	8	5	12	10	8	6	4	8	6	5	4	2
3.5	18	16	13	11	8	16	13	11	9	6	13	11	9	8	5	11	9	8	6	4	8	6	5	4	2
4.0	18	15	13	11	8	15	13	11	9	6	13	11	9	7	5	11	9	7	6	4	8	6	5	4	2

9.0 SURVEY DESIGN AND IMPLEMENTATION

The objective of this survey is to demonstrate that residual radioactivity levels meet the release criterion. In demonstrating the objective is met, the null hypothesis (H_o) that residual contamination exceeds the release criterion is tested with the survey data using the Wilcoxon Rank Sum Test (WRS).

- Survey instrumentation will be set up and source checked to ensure proper operation.
- The Project Manager/Supervisor will perform preliminary inspections of the areas to identify additional specific survey requirements in accordance with the UXO anomaly avoidance protocol that will be agreed upon at the pre job briefing that will be held prior to the project starting.
- Survey personnel will grid the survey areas as specified by the agreed upon UXO anomaly avoidance protocol and the following survey protocols and mark or map the survey locations as applicable.
- Survey personnel will take survey measurements using appropriate calibrated instruments and perform daily source and background checks before each day's work.
- The Project Manager will review all survey data to ensure that all required surveys have been performed.
- The Project Manager will review the survey results to identify any areas exceeding the specified release criteria.

9.1 FACILITY RADIATION SURVEYS

9.1.1 RELEASE CRITERIA

The radiological release criteria are discussed in Section 8.7.

9.1.2 CHARACTERIZATION SURVEYS

Characterization surveys of the Gorge area were performed in 2001 and 2002 by New World Technology, Inc.

9.1.3 IN-PROCESS SURVEYS

Radiological support surveys will be performed during decommissioning activities to assist and guide excavation activities. In addition, surveys of waste materials if found will be conducted.

9.1.4 FINAL STATUS SURVEY DESIGN

The Final Status Survey (FSS) was designed in accordance with MARSSIM guidance and applicable Federal and New Jersey regulations and guidance and is being performed to support the release of the Gorge area for unrestricted use. A background reference area will be established in a non-impacted area. The design for the FSS and establishment of radiological release criteria are presented in Sections 8 and 9 of this plan.

9.1.5 FINAL STATUS SURVEY REPORT

The Final Status Survey Report will be prepared following decommissioning and FSS activities.

9.2 INSTRUMENT SELECTION

Instruments will be selected that are suitable for the physical and environmental conditions at the site. The instruments and measurement methods selected are able to detect the radionuclide of concern from the uranium-238 series and the radium-226 series or radiation types of interest i.e. alpha, beta, and/or gamma and are, in relation to the survey or analytical technique, capable of measuring levels that are equal to or less than the DCGL.

Several radiation detection methods will be used during the radiological surveys: gamma detector response rate (scan) measurements, and soil sampling and analysis.

9.2.1 GAMMA SCANS OF SOIL

Gamma count rate responses will be used to determine whether specific areas exhibit activity levels that are significantly above site-specific background. Gross gamma count rates will be measured using a 2" by 2" sodium iodide (NaI) gamma scintillation detector system (Ludlum Instruments Model 2350-1 Data Logger coupled to a Ludlum Instruments Model 44-10 NaI or the equivalent). This radiation detection system measures energies in the range of about 80 to 3,000 kilo electron volts (keV). This energy range includes gamma rays emitted by Radium-226, depleted uranium, and their decay products.

Static gamma measurements require positioning the detector assembly 4 inches (10 centimeters [cm]) above the designated surveillance surface and recording a stationary 60-second integrated count. NaI scintillation detectors are very sensitive to photon gamma radiation and are ideal for locating elevated radiation levels above background when performing gamma scans and static measurements.

Scan measurements will be obtained by traversing a path at a maximum speed (scan rate) of approximately 0.5 meters per second (m/s) and slowly sweeping the detector assembly in a serpentine (snakelike, S-shaped) pattern, while maintaining the detector between 2.5 to 4 inches (6 to 10 cm) above the area to be surveyed.

Field survey methodology, techniques, and terminology will be in accordance with the Federal guidance document MARSSIM (Rev. 1, August 2000). Chapters 5.3 and 5.5 provide specific details as to how the surveys will be performed.

9.2.2 INSTRUMENT FOR THE SCAN SURVEYS FOR BETA SURFACE ACTIVITY (STRUCTURES, MATERIAL, EQUIPMENT AND TOOLS)

Surface scan surveys for beta radiation will be conducted with Ludlum Model 44-9 thin windowed pancake GM detectors or equivalent, coupled to Ludlum Model 3 Survey Meters. The detector will be moved over the surface being surveyed at a rate of 1.0 cm per second. The detector will be held within ½-inch of the surface being surveyed. Audible indicators will be used during the surveys.

9.2.3 INSTRUMENT FOR THE SCAN SURVEYS FOR ALPHA AND BETA SURFACE ACTIVITY (STRUCTURES, MATERIAL, EQUIPMENT AND TOOLS)

Surface scan surveys for alpha and beta radiation will be conducted with Ludlum Model 43-89 large area scintillation probes coupled to Ludlum Model 2360 Data Loggers. The probes have 1.2 mg/cm^2 thick Mylar windows. The detector will be moved over the surface being surveyed at a rate of 0.5 to 1.0 cm per second. The detector will be held within ¼-inch of the surface being surveyed. Audible indicators will be used during the surveys.

9.2.4 INSTRUMENT FOR THE DIRECT MEASUREMENTS FOR ALPHA AND BETA SURFACE ACTIVITY (STRUCTURES, MATERIAL, EQUIPMENT AND TOOLS)

Direct surface static contamination surveys for alpha and beta radiation will be conducted with Ludlum Model 43-89 large area scintillation probes coupled to Ludlum Model 2360 Data Loggers. The probes have 1.2 mg/cm2 thick Mylar windows. Direct measurements will conducted with the detector within ¼" of the surface for a period of 1-2 minutes.

9.2.5 GROSS BETA-GAMMA-ALPHA LOOSE SURFACE CONTAMINATION SURVEYS

Loose surface contamination surveys of alpha and beta/gamma emitters will be performed using cloth smears.

The swipe survey will be performed by wiping a cloth smear over an area of 100 cm^2 (approximately 4 inch by 4 inch) using moderate pressure.

The smears will be analyzed with a Ludlum Model-2929 Dual Channel Scaler and a Ludlum Model 3030 Dual Channel Scaler with phoswich detectors.

9.2.6 INSTRUMENT FOR EXPOSURE RATE SURVEYS

Exposure rate measurements will be performed using a Ludlum Model 19 microR/meter. The Ludlum Model 19 is a high sensitivity gamma microR/meter employing an internally housed 1-inch diameter by 1-inch thick NaI crystal. The maximum exposure rate that can be measured with the microR/meter is 5,000 microR/hr.

9.3 INSTRUMENT CALIBRATION

The data loggers, associated detectors and all other portable instrumentation will calibrated on an annual basis using National Institute of Standards and Technology (NIST) traceable sources and calibration equipment. Calibration typically involves the ratemeter and the detector:

The ratemeter calibration includes:

- High Voltage calibration,
- Discriminator/threshold calibration,
- Window calibration,
- Alarm operation verification, and

The detector calibration includes:

- Operating voltage determination,
- Calibration constant determination, and
- Dead time correction determination

Calibration labels showing the instrument identification number, calibration date and calibration due date are attached to all portable field instruments.

9.4 RESPONSE CHECK SOURCES

All sources used for calibration or efficiency determinations for the survey will be representative of the instrument's response to the identified radionuclides and are traceable to NIST. The sources that will be used during the surveys are ^{232}Th, ^{99}Tc, and ^{137}Cs exempt quantity check sources which will be stored in a designated location agreed upon by Picatinny Arsenal personnel.

An ARP application IAW Paragraph 2-4 of DA PAM 385-24 will be submitted to Garrison Commander at Picatinny at least 30 days before the requested start date of the permit for all radioactive check sources brought on site.

9.5 SURVEY UNIT CLASSIFICATION

For the purposes of establishing the sampling and measurement frequency and pattern, the various site areas will be divided into impacted areas.

The impacted areas may be further subdivided into one of the three following classifications:

- *Class 1 Area*s: Areas that have, or had prior to remediation, a potential for radioactive contamination (based on site operational history) or known contamination (based on previous radiation surveys) above the DCGL. Examples of Class 1 areas include:

1) site areas previously subjected to remedial actions
2) locations where leaks or spills are known (or suspected) to have occurred
3) former burial or disposal sites

- *Class 2 Areas:* Areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination but are not expected to exceed the DCGL. To justify changing the classification from Class 1 to Class 2, there should be measurement data that provides a high degree of confidence that no individual measurement would exceed the DCGL. Other justifications for reclassifying an area, as Class 2 may be appropriate, based on site-specific considerations. Examples of areas that might be classified as Class 2 include:

1) locations where radioactive materials were present in an unsealed form
2) potentially contaminated transport routes
3) areas downwind from the main areas of concern (AOC)
4) areas handling radioactive materials
5) areas on the perimeter of former contamination control areas

- *Class 3 Areas:* Any impacted areas that are not expected to contain any residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the DCGL, based on site operating history and previous radiation surveys.

Examples of areas that might be classified as Class 3 include buffer zones around Class 1 or Class 2 areas and areas with very low potential for residual contamination but insufficient information to justify a non-impacted classification.

For the purpose of this survey both the area on the hill adjacent to the open detonation pit and the open detonation pit interior and exterior areas will be classified as Class 1 areas.

9.6 SURVEY UNITS

The areas to be surveyed are approximately 1,800 ft^2, 21,200 ft^2 and 17,222 ft^2 in size.

If the areas when measured are larger than 21,527 ft^2 in size, additional Class 1 survey units will be established.

Survey units are limited in size based on classification, exposure pathway modeling assumptions, and site-specific conditions. MARSSIM recommends areas for survey units according to the following:

Classification	**Suggested Area**
Class 1 Open Land Areas	up to 2000 m^2 (21,527 ft^2)
Class 2 Open Land Areas	2000 to 10,000 m^2 (21,527 to 107,639 ft^2)
Class 3 Open Land Areas	no limit

9.7 REFERENCE COORDINATE SYSTEM

NOTE: The information below is for informational purposes only. The actual length of the measurement/sampling intervals for each of the survey units will be determined on site once the areas are measured and the survey unit sizes determined.

A reference coordinate system will be laid out for each of the survey units. A triangular shaped reference coordinate system will be used for the Final Status Surveys. The length, L, of a side of the grid was determined by the total number of samples or measurements to be taken. The length of the figure will determine the distance between direct measurement/soil sample location points. A random number generator will be used to generate the starting point for the sampling pattern for each 5’ lift inside of the detonation pit area. The length or spacing of the sampling points will be calculated for each of the survey units using the following equation:

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

Where,

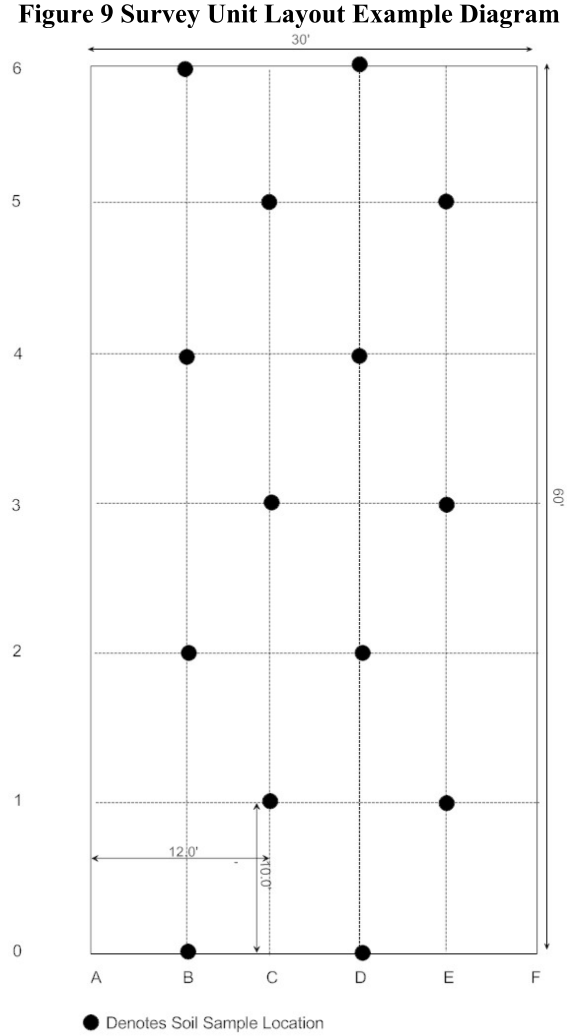
L = spacing between sampling points (ft);
A = surface area of the survey unit (ft^2); and
N = statistically calculated number of samples.

Figure 9 below is an illustrative example of how a survey unit would be laid out for an area that is 30 ft by 60 ft (the interior of the detonation pit area).

Note: A different random starting point will be selected for each separate survey (1 foot depth) unit using a random number generator. Samples will be collected prior to the excavation of the one foot lifts.

$$L = \sqrt{\frac{1800}{0.866 * 14}} = 12$$

Figure 9 Survey Unit Layout Example Diagram



9.8 BACKGROUND REFERENCE AREA

A background reference area non-impacted by former operations and that has similar physical, chemical, geological, natural radiological, and biological characteristics as the areas to be surveyed will be chosen.

A total of 14 surface background samples will be obtained from the surface (within 6 inches) at randomly selected locations within the background reference area described above.

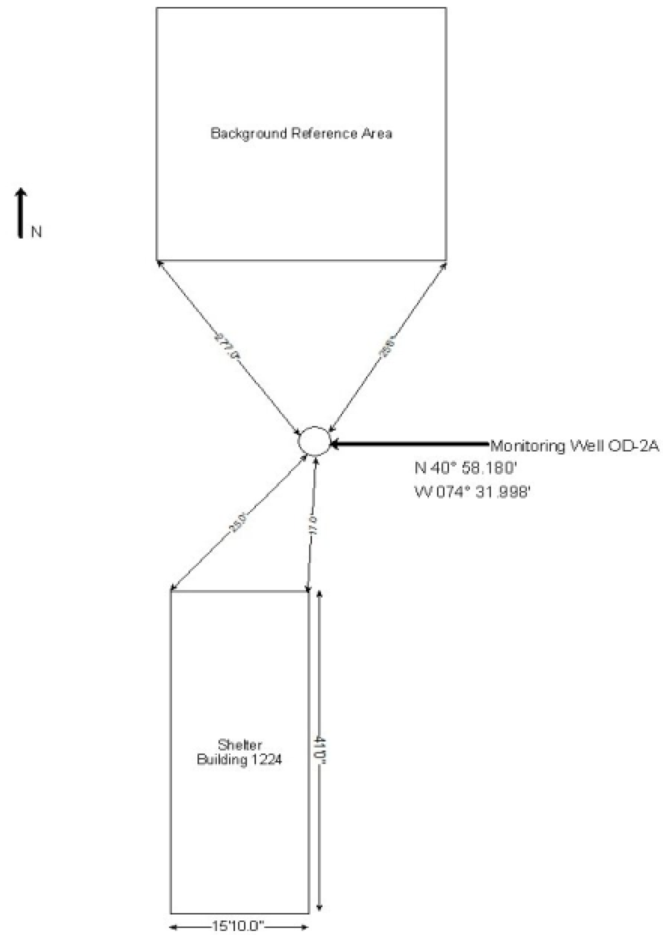
The samples will be sent to Test America's Inc. laboratory in Earth City, MO for gamma spectroscopy and isotopic uranium by alpha spectroscopy analysis as described under the heading of Measurements of Soil Contamination in Section 8.8.6 of this plan.

The site background count rate levels will be established for the final status surveys by obtaining sixteen, 1-minute static readings (with each instrument to be used), taken at 4" from the surface of soil and concrete surfaces for gamma surveys from areas unlikely to be affected by the residual radioactive materials that could be present at the different survey areas. The average value for these readings will be used as the area background radiation levels.

The UXO report and attachments will be provided to the on post Explosive Ordnance and Technology Division for action and also be included in the Final Report.

Figure 10 presents a map of the background reference area location previously used in Area 1222 during previous radiological investigations.

Figure 10 Background Reference Area Location Map



9.9 RADIOLOGICAL SURVEY METHODS (OPEN DETONATION PIT AND HILL AREA)

9.9.1 SUMMARY

The open detonation pit areas and hillside will be 100 % gamma scan surveyed. Systematic surface soil samples will also be collected in these areas.

9.9.2 GAMMA SCANS OF LAND AREAS

Gamma count rate response will be used to determine whether specific areas exhibit activity levels that are significantly above site-specific background. Gross gamma count rates will be

measured using a 2" by 2" sodium iodide (NaI) gamma scintillation detector system (Ludlum Instruments Model 2350-1 Data Logger coupled to a Ludlum Instruments Model 44-10 NaI or the equivalent). This radiation detection system measures energies in the range of about 80 to 3,000 kilo electron volts (keV).

Scanning speeds will be no greater than 0.5 m per second for gamma instruments. The detector will be held within proximity of four inches or less from the surface being surveyed. The detector will be moved back and forth in a serpentine pattern to ensure 100% coverage of the surface being surveyed. Audible indicators will be used to identify locations having elevated levels of direct radiation.

9.9.3 SCANNING MINIMUM DETECTABLE COUNT RATE (MDCR)

The minimum detectable number of net source counts in the interval is given by S_i. Therefore, for an ideal observer, the number of source counts required for a specified level of performance can be arrived at by multiplying the square root of the number of background counts (determined to be ~ 12,000 cpm) by the detectability value associated with the desired performance (as reflected in d') as shown in the equation below:

$$S_i = d' \sqrt{b_i}$$

Where:

$$d' = \textit{index of sensitivity } (\alpha \textit{ and } \beta \textit{ error}) \textit{ Table } 6.5 \textit{ of MARSSIM}$$
$$b_i = \textit{number of background counts in scan time interval}$$

$$d' = 3.28$$

$$b_i = 12,000\ (2/60)$$

$$b_i = 400$$

Therefore:

$$S_i = 3.28\sqrt{400}$$

$$S_i = 66$$

The MDCR is then calculated using the formula below:

$$MDCR = S_i \ x(60/i)$$

Where:
$i = scan\ time\ interval$

Therefore:

$$MDCR = 66\ x(60/2)$$
$$MDCR = 1980\ cpm$$

The $MDCR_{surveyor}$ may then be calculated assuming a surveyor efficiency (p) of 0.5 as follows:

$$MDCR_{SURVEYOR} = 1980/\sqrt{0.5}$$

$$MDCR_{SURVEYOR} = 2800\ cpm$$

For example, the determined background count rate at Area 1222 is approximately 12,000 cpm. The instrumentation uses a two second scan interval. Using an index of sensitivity of 3.28 (95% true positive rate and 5% false positive rate); the $MDCR_{surveyor}$ is 2,800 cpm (or 14,800 cpm-gross).

9.9.4 GAMMA SCAN ACTION LEVEL

The gamma scan Action Level will be set at the $MDCR_{SURVEYOR}$ (Section 8.8.3). Any areas exceeding the action level during the surveys will be further investigated. Soil samples may be collected in these areas and sent to the Test America Inc. laboratory for gamma spectroscopy analysis, and isotopic uranium by alpha spectroscopy analysis.

9.9.5 GAMMA SCAN MINIMUM DETECTABLE CONCENTRATIONS (MDCS)

The estimated scan MDC's obtained from Table 6.7 in MARSSIM for NaI 2" by 2" NaI detectors is:

2.8 pCi/g for Ra-226

56 pCi/g for U-238

9.9.6 MEASUREMENTS OF SOIL CONTAMINATION

Samples of soil and/or sand will be collected and sent to Test America Inc. for gamma spectroscopy and isotopic uranium by alpha spectroscopy analysis. The number of soil samples

to be taken from each of the survey units of the Reference Coordinate System on the impacted Class 1 area of the hillside, and the impacted Class 1 areas of the open detonation pit, and the non impacted background area has been determined to be 14 for each as described under the heading of Number of Samples/ Measurements in Section 8.11 of this plan.

9.9.6.1 SURFACE SOIL SAMPLES

A minimum of 14 surface soil samples will be taken from the systematic locations in each survey unit (does not include biased samples). Surface samples (defined as 0-6.0-in. below ground surface) will be collected from each sampling location. A minimum of 14 soil samples will be obtained from each survey unit. The calculations that were used to obtain the number of required surface samples are presented under the heading “Number of Samples/Measurements” in Section 8.11 of this plan.

Sampling equipment and tools will be wiped down and surveyed after each sample to ensure no cross contamination occurs during the sampling process. If contamination is found above the minimum detectable count rate of the survey instrument, the equipment will be decontaminated.

Approximately 500 to 700 grams or 1.10 to 1.54 pounds of soil will be collected from each location. Samples will be prepared by removing vegetation, rocks, and foreign objects exceeding ¼ inch in diameter. The samples, once prepared, will be placed into an appropriate container. Collection methodology, chain of custody, and analysis requirements are detailed in AWS's Standard Operating Procedures (SOP’s).

9.9.6.2 MINIMUM DETECTABLE ACTIVITY

The samples will be sent to a State of New Jersey certified laboratory, Test America Inc’s laboratory in Earth City, MO for gamma spectroscopy and isotopic uranium by alpha spectroscopy analysis.

The samples will be counted at the laboratory for the period of time, determined a priori, to achieve a Minimum Detectable Activity (MDA) of less than or equal to ~ 0.5 pCi/gram for Ra-226 and ~ 0.05 pCi/g for U-234, U-235, and U-238.

Test America Inc’s information is as follows:

Test America Laboratories, Inc.

13715 Rider Trail North

Earth City, MO 63045

DOD ELAP Cert # ADE-1430

State of New Jersey Laboratory Certification ID# MO002

9.9.7 STATISTICAL CONSIDERATIONS

9.9.7.1 DEMONSTRATION OF COMPLIANCE

When determining compliance with remediation goals, the entire site consisting of the survey units is examined. One measurement does not determine compliance. Rather, the site data are examined statistically. The three compliance tests are summarized in Table 13. They include the following:

- Compare the largest site measurement to the smallest background measurement.
- Compare the average site measurement to the average background measurement.
- Use the Wilcoxon rank sum test (MARSSIM, Revision 1, August 2000) to determine if the site data (less background) exceed the DCGL.

Table 9 Statistical Comparisons With The DCGL

SURVEY RESULT	CONCLUSION
Difference between the largest survey measurement and the smallest background measurement is less than the DCGL.	Site meets release criterion.
Difference between the average survey measurement and the average background measurement is greater than the DCGL.	Site does not meet release criterion.
Difference between the average survey measurement and the average background measurement is less than the DCGL, but the difference between any site measurement and any background measurement exceeds the DCGL.	Site meets release criterion if Wilcoxon rank sum test is negative.

9.9.7.2 NULL HYPOTHESIS

Using the MARSSIM methodology, the null hypothesis is stated as "the residual activity in the survey unit exceeds the release criteria" (Revision 1, August 2000). Thus, in order to pass the survey unit (that is, release the area), the null hypothesis must be rejected. If necessary, the Wilcoxon Rank-Sum test will be used on the soil data to test the null hypothesis.

9.9.7.3 STATISTICAL WILCOXON RANK SUM TEST

The Wilcoxon Rank Sum test will be performed as described in MARSSIM, using $\alpha = 0.05$ and $\beta = 0.05$. Each Survey Unit meeting the third condition in Table 5 will be tested using this

test. The test will determine if the survey area's median Ra-226 and depleted uranium concentration exceeds the background plus the DCGL.

The Wilcoxon Rank Sum test is used to compare two groups of data, to determine if there is a significant difference in the groups. Significance is measured by confidence levels (see Section 7.8).

For this case, the DCGLw is added to each of background soil sample results that were obtained in the background reference area to obtain the adjusted reference area measurement Zi.

The m adjusted reference sample measurements, Zi , from the reference area and the n sample measurements, Yi , from the survey unit are pooled and ranked in order of increasing size from 1 to N, where N = m+n. For this case N=28.

If several measurements are tied (i.e., have the same value), they are all assigned the average rank of that group of tied measurements.

If there are t "less than" values, they are all given the average of the ranks from 1 to t. Therefore, they are all assigned the rank t(t+1)/(2t) = (t+1)/2, which is the average of the first t integers. If there is more than one detection limit, all observations below the largest detection limit should be treated as "less than" values.

The ranks of the adjusted measurements from the background reference area are then summed, Wr .

Since the sum of the first N integers is N(N+1)/2, one can equivalently sum the ranks of the measurements from the survey unit, Ws , and compute Wr = N(N+1)/2 - Ws .

Compare Wr with the critical value given in Table I.4 found in Appendix I of MARSSIM for the appropriate values of n, m, and □. If Wr is greater than the critical value, the hypothesis that the survey unit exceeds the release criterion is rejected.

For this case n=14 m=14 and □=0.05.

The Critical Value from Table I.4 for this case is 668.

If the test shows that the first group is larger than the second, then the DCGLW is not met.

9.10 RADIOLOGICAL SURVEY METHODS (REMAINING BUILDING STRUCTURES)

9.10.1 SUMMARY

The remaining building structures will be 100 % gross alpha/beta scan surveyed. Systematic gross alpha/beta direct measurements will also be collected on these structures.

9.10.2 GROSS ALPHA/BETA SCANS OF BUILDING STRUCTURES

Surface scan surveys for alpha and beta radiation will be conducted with Ludlum Model 43-89 large area scintillation probes or equivalent, and/or Ludlum Model 43-37 large area gas proportional probes, coupled to Ludlum Model 2360 Data Loggers. The probes have 0.8 mg/cm^2 or 1.2 mg/cm^2 thick Mylar windows. The detector will be moved over the surface being surveyed at a rate of 0.5 to 1.0 cm per second. The detector will be held within ¼" of the surface being surveyed. Audible indicators will be used during the surveys.

9.10.3 GROSS ALPHA/BETA DIRECT MEASUREMENTS OF BUILDING STRUCTURES

Direct surface contamination surveys for alpha and beta radiation will be conducted with Ludlum Model 43-89 large area scintillation probes and/or Ludlum Model 43-37 large area gas proportional probes coupled to Ludlum Model 2360 Data Loggers or equivalent. The probes have 0.8 mg/cm^2 or 1.2 mg/cm^2 thick Mylar windows. Direct measurements will be conducted with the detector on contact with the surface for a period of 1 to 2 minutes.

9.11 DETECTION SENSITIVITY—STATIC AND SCAN MINIMUM DETECTABLE CONCENTRATION (MDC), GROSS ALPHA-GROSS BETA SURVEYS

9.11.1 DETERMINATION OF INSTRUMENT EFFICIENCY (εI) FOR ALPHA AND BETA SURFACE ACTIVITY MEASUREMENTS

The instrument efficiency (ε_I) will be determined during calibration and is defined as the ratio between the net count rate (in counts per minute (cpm)) of the instrument and the surface emission rate of the calibration source for a specified geometry. The surface emission rate is the 2π particle fluence that is affected by both the attenuation and backscatter of the radiation emitted from the calibration source. Equation 1 will be used to calculate the instrument efficiency in counts per particle, although efficiency is typically reported as having no units or unitless.

Equation 1

$$\varepsilon_i = \frac{R_{S+B} - R_B}{q_{2\Pi}\left(W_A / S_A \right)}$$

Where,

R_{S+B} = the gross count rate of the calibration measurement (cpm)

R_B = the background count rate in cpm

$q_{2\pi}$ = surface emission rate of the calibration source (NIST traceable)

W_A = Active Area of the detector window (cm^2)

S_A = Area of the source (cm^2)

Note: This equation assumes that the dimensions of the calibration source are sufficient to cover the window of the instrument detector. If the dimensions of the calibration source are smaller than the detector's window, set W_A equal to the dimensions of the calibration source, i.e., set the quotient of W_A and S_A equal to 1.

The instrument efficiency is determined during calibration by obtaining static counts with the detector over a calibration source that has a National Institute of Standards and Technology (NIST) traceable surface emission rate. The 2π particle fluence rate is corrected for decay, attenuation and scatter, then; the surface emission rate of the source must be corrected for the area subtended by the probe. Factors that can also affect the instruments efficiency are discussed below:

<u>Calibration Sources:</u> The calibration sources selected emit alpha or beta radiation with energies similar to those expected from the contaminant in the field, i.e., similar to the expected radionuclide(s) of concern.

<u>Source Geometry Factors:</u> The instrument efficiency is determined with a calibration source equal to or greater than the area of the probe.

<u>Source-to-Detector Distance:</u> The detector is calibrated at a source-to-detector distance that is the same as the detector-to-surface distance used in the field.

<u>Window Density Thickness:</u> The detector is calibrated with a probe window density thickness that is the same as the probe window density thickness used in the field.

<u>Detector-Related Factors - Ambient Conditions:</u> The variation between ambient conditions such as the temperature, pressure, and humidity between calibration and field use, corrections to the detector's response were considered. None were noted.

NOTE: The 2π instrument efficiencies calculated during instrument calibration were used for the instruments.

9.11.2 STATIC MDC FOR GROSS ALPHA-BETA SURVEYS

The static MDC is the level of radioactivity, on a surface, that is practically achievable by the overall measurement process. The conventional equation, Equation 2 below, will be used to calculate instrument MDCs in dpm per 100 cm^2 when the background and sample are counted for the same time intervals.

Equation 2

$$MDC = \frac{3 + 4.65\sqrt{C_B * \mathrm{T_B}}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} \mathrm{T_B}}$$

where;

C_B = background count rate (cpm)

T_B = background counting time (min)

ε_i = instrument efficiency (count per particle)

ε_s = contaminated surface efficiency (particle per disintegration)

W_A= area of the detector window (cm^2)

If the background and sample are counted for different time intervals, Equation 3 below will be used to calculate the MDC in dpm per 100 cm^2.

Equation 3

$$MDC = \frac{3 + 3.29\sqrt{R_B T_{S+B}\left(1 + \frac{T_{S+B}}{T_B}\right)}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2} T_{S+B}}$$

Where;

R_B = background count rate (cpm)

T_B = background counting time (min)

T_{S+B} = sample counting time (min)

ε_i = the instrument efficiency (count per particle)

ε_s = the contaminated surface efficiency (particle per disintegration)

W_A = the area of the detector window (cm^2)

9.11.3 SURFACE EFFICIENCY (εS) FOR SURFACE ACTIVITY MEASUREMENTS

The surface efficiency term in Equation 2 is used to determine the 4π total efficiency for a particular surface and condition. Suitable values are based on the radiation and radiation energy, and are primarily impacted by the backscatter and self-absorption characteristics of the surface on which the contamination exists in the field. Backscatter is most affected by the energy of the radiation and the density of the surface material. Self-absorption characteristics or attenuation are also a function of the radiation's energy and surface condition. Surfaces typically encountered in the field include concrete, wood, dry wall, plaster, carpet, and metal. Surface conditions include both physical effects, such as scabbled concrete, and the effect of surface coatings, i.e., dust, paint, rust, water, and oil.

In the absence of experimentally determined surface efficiencies, ISO-7503-1 and NUREG 1507, provide conservative recommendations for surface efficiencies. ISO-7503-1, recommends a surface efficiency of 0.5 for maximum beta energies exceeding 0.5 MeV, and to use a surface efficiency of 0.25 for beta energies between 0.15 and 0.4 MeV and for alpha emitters (ISO, 1998), (NRC, 1997). NUREG-1507 provides surface efficiencies based on studies performed primarily at ORISE. In general, NUREG-1507 indicates that the ISO rule-of-thumb for surface efficiencies is conservative, particularly for beta-emitting radionuclides with end-point energies between 0.25 MeV and 0.4 MeV.

The surface condition on the structures are metal and concrete surfaces that are slightly covered with dust and rust. The surface efficiency for alpha emitters used in accordance with ISO-7503-1 under these conditions is 0.25 and for beta emitters is 0.25.

9.11.4 PROBE AREA CORRECTION FACTOR FOR SURFACE ACTIVITY MEASUREMENTS

In Equation 2, W_A is the size of the "active" area of the detector window. If the area of the detector window (cm^2) does not equal 100 cm^2, it is necessary to convert the detector response to units of dpm per 100 cm^2.

9.11.5 SCANNING MINIMUM DETECTABLE COUNT RATE, (MDCR)

The minimum detectable number of net source counts in the scan interval, for an ideal observer, is arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in *d'*) as shown in Equation 4 below.

Equation 4

$$MDCR = d'\sqrt{b_i} \times 60/i$$

where,

d' = index of sensitivity (α and β error) – MARSSIM Table 6.5

b_i = number of background counts in scan time interval (count)

i = scan or observation interval (s) (time that a typical source remains under the probe during the scan)

9.11.6 SCAN MDC FOR GROSS BETA SURVEYS

The scan MDC will be determined from the minimum detectable count rate (MDCR) by applying conversion factors that account for detector and surface characteristics and surveyor efficiency. As discussed above, the MDCR accounts for the background level, performance criteria (d'), and observation interval. The observation interval during scanning is the actual time that the detector can respond to the contamination source. This interval depends on the scan speed, detector size in the direction of the scan, and area of elevated activity.

The scan MDC for structure surveys will calculated using Equation 5 below.

Equation 5

$$Scan\ MDC = \frac{MDCR}{\sqrt{p}\ \varepsilon_i \varepsilon_s \frac{W_A}{100\ cm^2}}$$

Where;

MDCR = discussed in Section 8.10.5

p = surveyor efficiency factor

ε_i = instrument efficiency (count per particle)

ε_s = contaminated surface efficiency (particles per disintegration)

W_A = area of the detector window (cm^2)

9.11.7 SCAN MDC FOR GROSS ALPHA SURVEYS

Using the following equation (Abelquist, 2001), one can calculate the activity of a 100 cm^2 "hot spot" with a 90 % probability of detection using Equation 6 below.

Equation 6

$$\alpha\ scanMDC = \frac{[-\ln(1-P(n \geq 1))]60}{t\varepsilon_s\varepsilon_i}$$

Where

t	=	dwell time over source (seconds)
ε_i	=	Instrument efficiency (counts per particle)
ε_s	=	contaminated surface efficiency (particles per disintegration)

Based upon an Instrument Efficiency (ε_i) of 30% and a Surface Efficiency Factor (ε_s) of 0.25. The estimated scan MDC for the gross alpha surveys is ~ 310 dpm/100cm^2.

9.10.8 ALPHA SCAN/DIRECT MEASUREMENT ACTION LEVEL

For building surfaces, the action level will be calculated as 90% of the allowable gross alpha release limits for direct measurement (static) readings.

If a survey measurement exceeds the Action Level, the survey area will be further characterized to identify the extent of contamination. The size of the elevated area of activity will be determined first by the performance of scan surveys and direct measurements, at 1-foot increments, in areas immediately adjacent to the elevated area. The determination if the elevated area is due to fixed or removable contamination will be accomplished by obtaining and analyzing swipe samples in the elevated area.

10.0 QUALITY ASSURANCE PROGRAM

All survey tasks which are essential to survey data quality will be controlled by AWS's SOP's, this work plan, and the applicable Contractor's Safety Permit and Radiation Work Permit.

10.1 ORGANIZATION

Only qualified and trained personnel will operate the equipment and instrumentation used in the field activities specified in this decommissioning plan. Personnel will be trained in the technical, quality control, and health and safety aspects of the project, as well as in the calibration, maintenance, and SOPs for their assigned equipment.

Daily tailgate safety meetings will provide supplemental training and ensure that personnel are given clear direction and the proper tools for performing their respective tasks. These meetings will also provide a forum for the field personnel to relate any potential safety or quality concerns that may require attention from the PM. Tailgate meeting notes and attendance sheets will be maintained onsite and included in the project file.

Persons responsible for ensuring that the QA Program has been established and for verifying that activities affecting quality are being correctly performed will have sufficient authority, access to work areas, and organizational freedom to accomplish the following:

- Identify quality concerns.

- Ensure that further decommissioning activities are controlled until proper resolution of a non-conformance or deficiency has occurred.

- Initiate, recommend, or provide solutions to quality problems through designated channels.

- Verify implementation of solutions.

The CRSO will serve as QA Officer for the project and will have direct access to responsible management at a level at which appropriate corrective actions can be implemented, as necessary. Therefore, the onsite quality control representative will report to the PM, or designee, in order to ensure that the required authority and organizational freedom are provided. The quality control representative may authorize others to implement specific elements of the QA Program.

10.2 QUALITY ASSURANCE PROGRAM

Activities associated with this work plan shall be performed in accordance with written procedures in order to ensure consistent, repeatable results. Topics covered in project procedures may include proper use of instrumentation, quality control requirements, equipment limitation,

etc. Implementation of quality assurance measures for this work plan is described in the following sections.

10.3 DOCUMENT CONTROL

Data will be recorded electronically and documented in accordance with the Contractor's data management system. The radiation survey maps will designate the location being surveyed, as well as the name of the surveyor. Site-specific references will be used to locate a sample. Project management personnel will ensure that chain-of-custody (CoC) procedures are followed for samples related to the FSS. Procedures to properly handle, ship, and store samples after they are collected will follow established protocols.

Both direct radiation measurements and analytical results will be documented. The results for each survey measurement and/or each sample will be listed in tabular form along with the corresponding grid block location or coordinate. Radiation survey data will be recorded in a verifiable manner and reviewed for accuracy and consistency. Each of the major phases of the decommissioning process will be documented in a manner that is suitable for audits or assessments.

Substantive changes to the Work Plan will be submitted to the Army, NRC, and NJDEP for review and approval before they are implemented. The records discussed in the preceding paragraphs will be maintained until the license termination.

10.4 CONTROL OF MEASURING AND TEST EQUIPMENT

The CRSO, or designee, is responsible for determining the instrumentation required to complete the requirements of this work plan. Only instrumentation approved by the PM will be used to collect radiological data. The PM is responsible for ensuring individuals are appropriately trained to use project instrumentation and other equipment, and that instrumentation meets the required detection sensitivities. Instrumentation shall be operated in accordance with either a written procedure or manufacturers' manual, as determined by the PM. The procedure and/or manual will provide guidance to field personnel on the proper use and limitations of the instrument.

AWS has selected instruments proven to reliably detect the radionuclides in the Uranium-238 and Radium-226 series possibly present in the open detonation pit area and adjacent hillside area. Instruments will be calibrated by qualified vendors under approved procedures using calibration sources traceable to the National Institute of Standards and Technology (NIST).

Instruments used during the decommissioning activities will have current calibration and maintenance records kept on the Site for review and inspection. The records will include, at a minimum, the following:

- Name of the equipment

- Equipment identification (model and serial number)
- Manufacturer
- Date of calibration
- Calibration due date

Instrumentation shall be maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments are maintained. Instruments will be under current calibration, from a facility possessing appropriate NRC and/or Agreement State licenses for performing calibrations using National Institute of Standards and Technology (NIST) traceable sources.

Prior to daily use, project instrumentation will be QC checked by comparing instrument response to a benchmark response. Prior to the commencement of field operations, site reference locations shall be selected for performance of these checks; subsequent QC checks will be performed at these locations. QC source checks will consist of a one-minute integrated count, or other count time designated by the PM, or designee, with the designated source positioned in a reproducible geometry, performed at the reference location. Prior to the start of initial surveys, this procedure will be repeated at least ten times to establish average instrument response. Equipment should also be inspected for physical damage, current calibration and erroneous readings in accordance with applicable procedures and/or protocols. Instrumentation that does not meet the specified requirements of calibration, inspection, or response check will be removed from operation. The instruments and systems used for the work effort will be calibrated on an annual frequency using the manufacturer's calibration protocol to National Institute of Standards and Technology (NIST) traceable sources.

The survey instruments will be source checked each day prior to the start of the survey activities to verify proper operation of detectors and detection systems.

Procedures for calibration, maintenance, accountability, operation and quality control of radiation detection instruments implement the guidelines established in American National Standard Institute (ANSI) standard ANSI N323-1978 and ANSI N42.17A-1989.

10.5 CORRECTIVE ACTION

The QA Officer has overall responsibility for reporting all procedural and contract violations found. The PM will determine if the deficiency requires work to be stopped or if notification is required to the Army, NRC, or NJDEP.

A deficiency or nonconforming condition is documented on a Corrective Action Request (CAR) Form. The form is completed by the individual who reported the nonconformance and submitted to the QA Officer, who will review the CAR for completeness. The completed form will provide a detailed description of the nonconforming condition and reference the affected documents that apply.

The QA Officer will review the response and verify that the actions address the original concern and provide effective preventive actions. If satisfactory, the QA Officer will accept the response and close the CAR. The person writing the CAR will sign the document. The QA Officer will review the form and maintain a log of all CARs, indicating the current status of the CAR. After corrective action has been completed and verified by the QA Officer, the closed CAR (original) will be filed. If needed, a new CAR will be issued to address additional required corrective action.

10.6 QUALITY ASSURANCE RECORDS

QA records will be monitored by the contractor. Data reduction, QC review, and reporting will be the responsibility of the analytical laboratory. Data reduction includes all automated and manual processes for reducing or organizing raw data generated by the laboratory. The laboratory will provide a data package for each set of analyses that will include a copy of the raw data in electronic format, and any other information needed to check and recalculate the analytical results. Once a data package is received from the laboratory, the analytical results and pertinent QC data will be entered into a computer database. The data packages will serve as basic reference sheets for data validation, as well as for project data use.

The generation, handling, computations, evaluation, and reporting of final radiological survey data will be as specified in written procedures. Included in these procedures will be a system for data review and validation to ensure consistency, thoroughness, and acceptability of the data.

Some data points will be chosen for evaluation and will be examined in order to establish compliance with QA requirements and other factors that determine the quality of the data. Any rejected sample data or data omissions identified during the data validation will be evaluated to determine their impact on the project. Other corrective action may include re-sampling and reanalyzing, evaluating and amending sampling and analytical procedures, and accepting data acknowledging the level of uncertainty.

One of the most important aspects of sample management is to ensure that the integrity of the sample is maintained, that is, that there is an accurate record of sample collection, transport, analysis, and disposal. This ensures that samples are neither lost nor tampered with, and that the sample analyzed in the laboratory is actually and verifiably the sample taken from a specific location in the field. The individual(s) responsible for sample collection will initiate a CoC record using a standard form provided by the contractor. A copy of this form will accompany the samples throughout transportation and analyses; and any breach in custody or evidence of tampering will be documented.

10.7 AUDITS AND SURVEILLANCE

Periodic audits will be performed to verify that decommissioning activities comply with the Work Plan, established decommissioning procedures, and to evaluate the overall effectiveness of the QA Program. The PM and QA Officer will verify that qualified personnel are employed to

conduct audits to ensure that the applicable procedures are being properly implemented. The audits will be conducted at least once for the duration of decommissioning activities. External program audits may also be used at the discretion of the contractor.

Audit results will be reported to the Army in writing, and actions to resolve identified deficiencies will be tracked and appropriately documented. The audit information will become part of the decommissioning record for the site.

10.8 REVIEW OF SURVEY RESULTS

The survey package and survey data from each area will be reviewed by two separate people to verify all documentation is complete and accurate. This will include the surveyor and either the PM or designee.

10.9 DATA ANALYSIS

The PM will review data at the end of each survey to determine the validity of the results and adequate coverage of the survey area.

Basic statistical quantities will be calculated for the data in order to identify patterns, relationships and any type anomaly.

11.0 HEALTH AND SAFETY CONSIDERATIONS

The surveys, sampling, and removal of radiologically impacted soils at the open detonation pit area and adjacent hillside area will be conducted in accordance with the applicable sections of the AWS Health and Safety Plan. Excavation health and safety considerations will be described in this plan. All on site personnel shall read and understand the contents of the plan prior to beginning work on the project. All on-site workers shall sign a statement that they have read and understand the requirements of the HASP.

11.1 HAZARD ANALYSIS

The job hazard Analysis identifies potential safety, health and environmental hazards and provides for the protection of personnel, the community, and the environment.

11.1.1 RADIOLOGICAL EXPOSURE

Residual amounts of low-level radioactive material may be present in the soil in the open detonation pit area and adjacent hillside area. Personnel performing the surveys and soil removal shall wear dosimetry and modified Level D PPE as described in Section 11.3.1 of this plan.

11.2 HAZARD CONTROLS

The following control measures will be implemented during the survey activities. The control measures are intended to supplement the HASP.

11.3 RADIATION WORK PERMIT

A Radiation Work Permit (RWP) shall be prepared and will specify the activities to be performed and all radiological control requirements and safety requirements for the work. All personnel assigned to site work will be required to read and sign the RWP acknowledging that they understand the requirements prior to beginning work.

The RWP will also be used as an information document for industrial safety. Hazards other than radiological may be included in the RWP so proper protection can be taken for all possible hazards from one controlling document. Implicit in any RWP is the need for a briefing on the radiological conditions present in the work environment.

The RWP shall list tasks and specific levels of protection for each worker covered by the RWP. The RWP shall also detail the dosimetry requirements, the protective clothing requirements, and the expected radiation and contamination levels to be encountered during the job.

11.3.1 PERSONNEL PROTECTIVE EQUIPMENT (PPE)

Personnel performing the work in the open detonation pit area and adjacent hillside area will wear modified Level D PPE in accordance with the PPE selection matrix in the HASP.

The modified Level D PPE will consist of:

- Steel-toed shoes;
- Hard hat;
- Safety glasses;
- Rubber boots (when working in areas with lead contamination);
- Safety vests;
- Latex or equivalent gloves (when collecting soil samples).

11.3.2 SAFETY EQUIPMENT

In addition to other equipment specified in this work plan, the following safety equipment will be staged at the work site:

- First aid kit
- Eye wash kit

11.4 TRAINING

Personnel performing activities associated with the open detonation pit area and adjacent hillside work activities will receive training covering this work plan.

All on-site project personnel shall have completed at least 40 hours of hazardous waste operations-related training, as required by the Occupational Safety and Health administration (OSHA) Regulation 29 CFR Part 1910.120. Those personnel who have completed the 40-hour training more than 12 months prior to start of field activities shall have completed an 8-hour refresher course within the past twelve months.

The Project Manager shall have completed an additional 8 hours of relevant supervisory health and safety training.

Personnel operating the survey detection equipment will be qualified ANSI 3.1 Senior Health Physics Technicians based on training and experience outlined in Section 4.4.6 and 4.5.3.2 of ANSI standard ANSI/ANS-3.1-1993 (ANSI/ANS, 1993).

A formal review and documentation of the key personnel qualifications to perform the required work will be made by management and verified during the pre job briefing that will be conducted prior to start of work.

The personnel will be familiar with the handling and storage of radioactive materials, contamination controls, and the use of radiation survey equipment. In addition, any discrete radioactive devices found will be stored in 30-gallon drums and placed into a secured area of the site.

11.5 HAZARD COMMUNICATIONS

The Project Manager or designee shall ensure that crewmembers understand their obligation to safety and ensure that members are familiar with the elements of the Health and Safety Plan. A copy of this plan will be maintained in the on-site project office.

Daily tailgate safety meetings shall be conducted and documented as specified in the Health and Safety Plan. Material Safety Data Sheets (MSDSs) for all hazardous substances and materials that will be used on site will be maintained in the on-site project office.

11.6 ENVIRONMENTAL MONITORING AND CONTROL PROGRAM

11.6.1 ENVIRONMENTAL ALARA EVALUATION PROGRAM

ARDEC and AWS management and personnel are committed to maintaining exposure of ionizing radiation to workers, the public, and to the environment at ALARA levels and will strive to conduct decommissioning activities in a manner that supports this commitment. The contractor will ensure the minimization of the impact of ionizing radiation to human health and the environment through the use of approved SOPs. Environmental monitoring and control activities performed during decommissioning activities will comply with 10 CFR Part 20 regulatory requirements.

11.6.2 EFFLUENT MONITORING PROGRAM

Concentrations of radionuclides in site effluents are not expected to change as a result of decommissioning activities. The primary routes of contaminant transport during the on-site decommissioning activities are anticipated to be airborne dust from the excavation of the site, handling of the waste, covering operations, and from the movement of vehicles and equipment. Area air samples will be collected in locations that present the possibility of airborne effluent releases. In addition, samplers will be positioned downwind of work locations to ensure that the samples collected within the immediate work area are representative of actual releases. The positions of the air samplers will be evaluated frequently by the PM/RSO to take into account any shifts in prevailing wind direction and any movement in the locations of dust-generating operations. Breathing zone and general area air monitoring will be performed daily, following SOPs, and air samples will be analyzed in order to estimate inhalation dose to the public and workers by airborne radioactive material. Consideration will be given to more frequent filter

change-outs during high dust conditions, as determined using best professional judgment. Air samples will be analyzed onsite for gross alpha and gross beta emitters. Releases will be maintained ALARA and below the limits in Table 2 of Appendix B to 10 CFR Part 20.

Background samples will also be collected prior to the commencement of site activities in order to establish baseline background radionuclide concentrations.

Significant amounts of liquid effluents are not expected to be encountered or generated during decommissioning activities. During the period of excavation, it is not anticipated that groundwater will be encountered.

11.6.3 EFFLUENT CONTROL PROGRAM

Based on the results of the previous characterization surveys, decommissioning activities are not expected to generate significant levels of airborne particulate contamination. If significant dust is generated during decommissioning activities, controls will be implemented to moisten excavation areas as necessary in order to reduce the potential for generating airborne contamination. Any soil or similar material that is staged in piles, containers, or vehicles will be covered as practical in order to prevent dispersion by wind and precipitation.

If radiological air monitoring results indicate the presence of airborne contaminants exceeding project action levels, then work will be stopped, proper personnel including the PM/RSO will be informed, corrective measures will be implemented, and dose evaluations performed, as necessary.

If potentially contaminated liquid effluents are encountered, runoff will be controlled through the use of berms, silt fencing, absorbent materials, solidifying agents, or by other means as necessary. Any captured liquids will be collected and stored for disposition in accordance with applicable regulations.

12.0 WASTE MANAGEMENT

12.1 WASTE MATERIAL VOLUME ESTIMATE

Based upon past surveys and sampling conducted in the open detonation pit and adjacent hillside, it is estimated that there will be ~ 180 cubic feet of contaminated soil and one 30-gallon drum of discrete items of radioactive material.

12.2 PACKAGING OF WASTE MATERIALS

It is currently planned that soil will be packaged into two B-25 boxes. The container(s) shall meet all applicable Department of Transportation (DOT) requirements.

Discrete items found will be placed into a 30-gallon drum.

- B-25 boxes can contain ~ 90 cubic feet.

Once loaded, a radiological survey of the container's exterior surface will be performed and documented to ensure compliance with the applicable DOT regulations. The surveys will consist of exposure rate surveys and loose surface contamination surveys.

12.3 WASTE PROFILE SAMPLES

Representative composite waste profile soil samples will collected from the B-25 boxes and be sent to Test America, Inc. for Toxicity Characteristic Leaching Procedure (TCLP) analysis. In accordance with 40 CFR Part 261.21 through 40 CFR Part 261.24 the samples will be analyzed for:

- Volatiles
- Metals
- Semi-Volatiles
- PCB's
- Herbicides
- Pesticides
- Reactive Sulfide
- Reactive Cyanide
- pH

- Ignitability
- Gamma Spectroscopy
- Isotopic Uranium by Alpha Spectroscopy

The information for Test America is as follows:

Test America Laboratories, Inc.
13715 Rider Trail North
Earth City, MO 63045
DOD ELAP Cert # ADE-1430
State of New Jersey Laboratory Certification ID# MO002

Based upon review of the sample analysis, it will be determined if RCRA hazardous waste is present along with radioactive material.

12.4 SHIPMENT AND DISPOSAL OF THE WASTE MATERIALS

It is currently planned that the waste materials will be shipped shortly after receiving waste profile sample results to the Energy Solutions Inc. disposal facility in Clive, UT, the U.S. Ecology disposal facility located in Grandview, ID, or the Waste Control Specialist's disposal facility located in Andrews, TX. These are the possible disposal sites depending on the classification for this waste. Transportation is expected to be via truck.

AWS will transport the waste containers to Building 312 for storage prior to shipping. Prior to transport to Building 312, AWS will ensure that all exterior surfaces of the container(s) are free of removable contamination. AWS will also perform exposure rate surveys of the containers exterior surfaces prior to movement to Building 312.

The waste will be classified, and all shipping manifests, appropriate DOT labeling and shipping documentation will be completed by a JMC approved broker employed by AWS prior to the containers leaving the Picatinny Arsenal property.

Once the material is received by the disposal facility, manifests, and appropriate documents will be completed and then sent to AWS by the disposal facility. Copies of these documents will be summarized and included in the Final Report for the project.

It is currently anticipated that it will take anywhere from 45-60 days once the boxes and drum is loaded, for them to make their arrival at the disposal facility.

12.5 LIQUID RADIOACTIVE WASTE

It is anticipated that no liquid radioactive waste will be generated.

12.6 MIXED WASTE

It is anticipated that no mixed waste will be generated.

13.0 FINANCIAL ASSURANCE

13.1 COST ESTIMATE

The U.S. Army JMC has issued a fully funded delivery order to AWS to include the performance of D & D activities and Final Status Surveys in the Gorge area at the Picatinny Arsenal. The purpose of the delivery order is to release the area for unrestricted use. A long-term control (LTC) license or an NRC legal agreement and restrictive covenant (LA/RC) is not expected to be requested or proposed. If it is determined the Gorge area requires additional remediation, outside of the scope of the delivery order, the Gorge will continue to be included in ARDEC's Decommissioning Funding Plan (DFP), Certification of Financial Assurance, and Statement of Intent. As required by 10 CFR 30.35(e)(2), ARDEC reevaluates the DFP at intervals not exceeding three years. ARDEC DFP covers NRC licenses 29-00047-02, 29-00047-06 and SUB-348.

14.0 RESTRICTED USE/ALTERNATE CRITERIA

Since this decommissioning plan's goal is the unrestricted release of the site, there is no current restricted use/alternate criteria planned at this time.

15.0 MODIFICATIONS TO DECOMMISSIONING PROGRAMS AND PROCEDURES

Based upon past survey findings, no significant radioactive material or contamination is anticipated to be found during this decommissioning effort. Therefore the risk level will not be reduced as we reduce contamination. It is not planned that the decommissioning program and procedures will be required to be revised to address the reduced threat.

16.0 FINAL REPORT

After all measurements have been made and laboratory results are complete, the data will be analyzed and a report will be prepared within 30 days following completion of the project. The report will include this work plan, permits, all measurements, laboratory reports (including quality control results), SUXO report, and analysis of the data. A narrative of the work and conclusions drawn from the results will be presented. Any deviations from this work plan will be noted and explained.

Data and findings from previous radiological investigations in the area will also be referenced in the final report.

It is the objective that the narrative in the final report will conclude and state that the results of the MARSSIM final status survey of the open detonation pit and adjacent hillside area demonstrates that each of the survey units meet the release criterion and rejects the initial assumption that they are contaminated.

17.0 REFERENCES

American National Standards Institute/American Nuclear Society (ANSI/ANS), 1993. *Selection, Qualification, and Training of Personnel for Nuclear Power Plants*, ANSI/ANS, 1993.

EW Abelquist, (Abelquist), 2002. *Decommissioning Health Physics A Handbook for MARSSIM Users,* Institute of Physics Publishing, 2001

International Organization for Standardization, (ISO), 1988. *Evaluation of Surface Contamination -Part 1 :Beta-emitters (Maximum Beta Energy Greater Than 0,15 MeV) and Alpha-emitters, 1st Edition*, 1 August 1988

Multi-Agency Radiation Survey & Site Investigation Manual (MARSSIM), 2000. *U.S. Nuclear Regulatory Commission (NRC), 2000, Multi-Agency Radiation Survey and Site Investigation Manual, MARSSIM, NUREG-1575, EPA 402-R-97-016*.

New World Technology (NWT), 2006a. *Final Report, Radiological Surveys and Sampling, Area 1222, ARDEC Picatinny Arsenal NJ, Revision 1,* January 30, 2006

New World Technology (NWT), 2006b. *Final Report, Picatinny Arsenal, Radiological Remediation/Release Surveys and Sampling Project, Revision 4,* September 27, 2006.

Picatinny Arsenal (PA), 2001. *Integrated Natural Resources management Plan,* Department of the Army, U.S. Army Tank-Automotive and Armaments Command Armament Research, Development and Engineering Center(TACOM-ARDEC), May 2001.

Picatinny Arsenal (PA), 2015. *http://www.pica.army.mil*.

U.S. Army Environmental Hygiene Agency (USAEHA), 1993. *Industrial Radiation Study No. 27-43-EQ86-93,U.S.Army Armament Research, Development, and Engineering Center, Picatinny Arsenal, NJ,* May 16-21, 1993.

U.S. Atomic Energy Commission (AEC), 1974. *Termination of Operating Licenses for Nuclear Reactors, Regulatory Guide 1.86*, June, 1974.

U.S. Environmental Protection Agency (EPA), 2000. *Guidance for the Data Quality Objectives Process, EPA QA/G-4*, U.S. Environmental Protection Agency, Office of Research and Development, August, 2000.

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

U.S. Nuclear Regulatory Commission (NRC), 2002. *Re-evaluation of the Indoor Resuspension Factor for the Screening Analysis of the Building Occupancy Scenario for NRC's License Termination Rule, NUREG-1720*, April, 2002.

U.S. Nuclear Regulatory Commission (NRC), 2003. *Consolidated NMSS Decommissioning Guidance, Decommissioning Process for Materials Licensees,* NUREG-1757, Volumes 1, 2, 3, September, 2003.

U.S. Census Bureau (USCB), 2015. *http:www.census.gov*.

ATTACHMENT 1
DandD Version 2.1 Input/Output Files

ATTACHMENT 2
RESRAD Version 6.5 Code Run
(Residential Farmer Scenario, Area 1222 Open Detonation Pit Site Specific Values)