New World Environmental Inc., d.b.a.
New World Technology *Bringing you the Technology of the New World*
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October 29, 2003

Ohio Department of Health, Bureau of Radiation Protection
Attention: Mr. Joe Crombie
35 E. Chestnut Street
Columbus, OH 43266

Ohio Environmental Protection Agency, Division of Emergency and Remedial Response
Attention: Ms. Eileen T. Mohr, Project Coordinator
2110 East Aurora Road
Twinsburg, OH 44087

United States Nuclear Regulatory Commission, Region III
Mr. Gene Bonano
801 Warrenville Road, Suite 255
Lisle, IL 60532

Ravenna Army Ammunition Plant
Mr. Irv Venger
8451 State Route 5
Ravenna, OH 44266-9297

Project No: ***USA 00-005***

Dear Ms. Mohr, Mr. Bonano, Mr. Crombie, and Mr. Venger,

New World Environmental, Inc. is pleased to submit the enclosed report titled: "Amended Final Status Survey Plan, Ravenna Army Ammunition Plant Former West Tank Farm Area, Monazite Sand Removal Project, Phase IV", Revision 1.

We are at your disposal to address any questions or concerns regarding this submittal. Please contact us at 419-690-4563.

Sincerely,

Daniel M. Spicuzza

Daniel M. Spicuzza
Project Manager
New World Environmental, Inc. *d.b.a. New World Technology*

AF.SSP.FWTFA.MSRP.P4RI 09.00F

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AMENDED FINAL STATUS SURVEY PLAN

RAVENNA ARMY AMMUNITION PLANT

FORMER WEST TANK FARM AREA

MONAZITE SAND REMOVAL PROJECT
Phase IV

Project No. USA 00-005

Revision 1
October 31, 2003

Prepared by:

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NEW WORLD TECHNOLOGY

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Approval

Written by:______________________________ Date:____________________
Dan Spicuzza
NWT Project Manager

Approved by:____________________________ Date:____________________
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Approved by:____________________________ Date:____________________
Regulatory Agency Representative

Approved by:____________________________ Date:____________________
Mike Styvaert
JMC Health Physicist

TABLE OF CONTENTS

Section **Page**

ACRONYMS

Ac-228	Actinium-228
AOC	Areas of concern
Bkg	background
Cal	calibration
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
DAC	Derived Air Concentration
$DCGL_W$	Derived Concentration Guideline Limit
$DCGL_{EMC}$	Derived Concentration Guideline Limit Elevated Measurement Comparison
dpm	disintegrations per minute
dpm/ $100cm^2$	disintegrations per minute per 100 square centimeters
Eff	Efficiency
FOP	Field Operating Procedures
G	Gram
Inst	Instrument
IAW	In Accordance with
IOC	U.S. Army Industrial Operations Command
JMC	U.S. Army Joint Munitions Command
LLD	Lower Level of Detection
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
mCi	Millicurie
mm	Millimeter
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Guide
NWT	New World Technology
ODH	Ohio Department of Health
OHEPA	Ohio EPA
OSC	U.S. Army Operations Support Command
pCi	picocurie
ppm	parts per million
RVAAP	Ravenna Army Ammunition Plant
RPO	Radiation Protection Officer
S/N	serial number
SOP	standing operating procedure
TCLP	Toxicity Characteristic Leaching Procedure
TEDE	Total Effective Dose Equivalent
Th-232	Thorium-232
Th nat	natural thorium
U-238	Uranium 238
USACOE	United States Army Corps of Engineers
µ/hr	microroentgen per hour
µCi	micro curies

1.0 INTRODUCTION

New World Technology (NWT) has been contracted by the U.S. Army, Joint Munitions Command (JMC) to perform Final Status Surveys at the West Tank Farm area of the Ravenna Army Ammunition Plant (RVAAP), in Ravenna Ohio. The sands had been stored as a part of the strategic stockpile plan under the General Services Administration (GSA), later the Defense Logistic Agency (DLA). The monazite sand had been removed in the mid 1970's and the license for possession issued by the Atomic Energy Commission was terminated at that time.

2.0 PROJECT SCOPE/PURPOSE

The purpose of the project is to release (radiological constituents only) the affected area of the former West Tank Farm area located at RVAAP for unrestricted use. This plan outlines the methods and procedures for the Final Status Survey activities. Analysis of the survey data will be done to determine if the areas meet the Derived Concentration Guideline Limit (DCGL) of 4.9 pCi/g-Th^{232} soil.

3.0 BACKGROUND INFORMATION

The Ravenna Army Ammunition Plant (RVAAP) is located in northeastern Ohio spanning areas of both Trumbull and Portage counties. The facility was a Department of Defense (DOD) facility for the loading, assembling, packing, and storage of ammunition and explosives. The plant began operations in 1940 and ended during the 1970s. Portions of the installation are being re-utilized by the Ohio National Guard.

Sections of the facility were utilized by the General Services Administration (GSA) for storage of strategic materials. Among the materials stored at the facility were quantities of monazite (thorium ore) totaling approximately 3 million pounds. The sand contains measurable quantities of natural thorium (Th-nat). Atomic Energy Commission license was terminated in the mid 1970s following transfer of the materials out of country.

The area is in a remote section of RVAAP, There are no physical barriers (i.e. fencing) protecting the area from potential access. The AOC presents no immediate hazard to facility personnel or the environment due to the fact that the areas of contamination are small in size and are low in activity levels.

The monazite AOC consists of an approximately 4,400 m^2 area between and along two former railroad lines in the West Tank Farm area of the RVAAP. The General Services Administration (GSA) owned Monazite ore and leased two tanks from RVAAP to store the ore from the late 1950's to 1974. The two storage tanks (tanks 1303 and 1305) were used to store approximately 3,023,553 pounds of monazite ore. The monazite ore contained less than 10-percent natural Thorium. The data on the license application indicates 170,000-pounds of Thorium or approximately 6-percent of the total weight.

The ore was removed and shipped to Holland under an AEC licensed action under export license STE-8179. The historical documentation of this export consist of the AEC license application and a few letters from GSA. It is unclear if the license number STE-8179 is an AEC number. GSA's policy of destroying records seven years after transactions has limited the available records.

Monazite ore was stored only at RVAAP. Monazite is a very insoluble and stable crystal structure and does not degrade in typical environmental conditions. Thorium is not very mobile in the environment and is normally only distributed by physical means.

GSA contracted with Health Physics Associates Ltd. To decontaminate the tanks and surrounding area in May 1975. The tanks were declared excess in January 1976 and demolished some time later. During the survey of the decontaminated tanks, contamination of the soil was found east of tank 1303. The top few inches of soil were to be removed, and drummed for disposal. A letter from GSA to the Commander of RVAAP, dated 7 January 1976, states that this was done and the drummed material shipped to a burial site in Kentucky.

The Ohio Department of Health requested that, as part of the radiological survey of other areas of RVAAP, that the U.S. Army Corps of Engineers (USACOE) scan the former monazite storage area. This was done as part of a scoping survey in April 1998. During this survey it was determined that exposure levels in excess of 40 times background were present in several areas and the exposure rate across the area was greater than background for the RVAAP. The surface scan conducted by Health Physics Associates in 1975 identified elevated exposure readings in some of the same areas as found in this survey. The scoping survey performed by the USACOE (No. CESWT-SO-R2-05-98) formed the basis for the planned activities covered under NWT's original remediation effort.

Several decontamination and survey efforts were conducted from the mid 1970s to 2001, with the most recent being a remediation effort of elevated areas of activity in July of 2003.

NWT was contracted by the U.S. Army, Industrial Operations Munitions Command (presently Joint Munitions Command) to remove and dispose of soil contaminated with monazite sand in December of 1999.

The contract work plan required removal and disposal of approximately 245 cubic yards of materials followed by a final status survey to provide data for unrestricted (radiological constituents only) reuse of the area. During the removal effort it was discovered that a significant amount of monazite sand remained and that the site could not be released for unrestricted use until further remediation was performed.

New World Technology (NWT) was then contracted by the U.S. Army, Operations Support Command (OSC) to perform a characterization survey and sampling effort to determine the quantity of material that remained on site that required disposal. This survey was performed in May of 2000.
It was determined that an additional 1,150 cubic yards of contaminated soil required removal to a depth not to exceed one-foot.

NWT mobilized on site in late April of 2001 to remediate the additional 1,150 cubic yards of contaminated soil. During the loading of the 1,150 cubic yards of contaminated soil NWT discovered on or about 8 May 2001 that contamination was present in depths beyond one-foot below grade (down to approximately three-feet below grade) in various areas of the site not previously identified as having depth contamination. The majority of the drainage trench along the east side of the site previously identified as having surface contamination is excavated to a depth of approximately three-feet below grade. Some of the areas (excluding the drainage trench) excavated to that depth had the remains of the roots of vegetation (most likely trees ~ 6" or more in diameter) previously growing on the site that seemed to have drawn the monazite sand into the clay layer of the soil.

NWT discovered approximately 10 areas of the site having depth contamination to approximately three-feet below grade. Approximately one-foot diameter dark (grayish, black) circles were discovered in the clay layer of the soil. It is speculated that these circles were footprints of cardboard drums that may have been buried at the site but there was no indication of rust or metal that would be expected from a decayed metal drum. The soils around these areas were contaminated, with the most elevated radiation levels being the circles themselves. All of the areas discovered were remediated to below the DCGL and the soil was placed into the contaminated soil stockpile.

Although no confirmation samples were taken in these areas, scan surveys with a 2" by 2" NaI detector were performed in the excavated areas. The survey results indicated that the areas were remediated to below the DCGL of 4.9 pCi/g. In addition, soil samples were obtained from areas remediated and screened (qualitatively) on site in a lower background area with a 3" by 3" NaI detector coupled to a data logger. The results of the screenings indicate that the areas were below the DCGL and that no further remediation was required.

The contaminated soil stockpile was covered with plastic sheeting and had a silt screen installed to prevent erosion.

Based on the size of the contaminated soil stockpile the estimated remaining volume of contaminated soils was approximately 790 cubic yards.

NWT then removed the 790 cubic yards of contaminated soil (Phase 3-1) in September of 2001 and again performed a Final Status Survey.

Based upon soil sample results received after site demobilization, it was determined that there were thirteen small elevated areas of activity remaining on the site that would require further removal efforts.

NWT mobilized on site to perform removal of the elevated areas of activity in July of 2003.

45 cubic feet of contaminated soil was removed during that effort. Post remediation surveys and soil sampling was performed following the removal effort. The results of the post removal soil samples indicated all areas were remediated to below the $DCGL_W$ with the exception of one area (~ 1 m^2 in size) which was 9.3 pCi/g which is below the $DCGL_{EMC}$ of 49.2 pCi/g.

3.1 SITE INFORMATION

The West Tank Farm is located on the property of Ravenna Army Ammunition Plant located in Ravenna, Ohio. Figure 1 shows the location of the West Tank Farm.

3.2 SITE CONDITIONS

Approximately 2,100 cubic yards of soil have been removed by NWT to this point. Approximately one-foot of contaminated soil has been removed from the main area of the site between the abandoned railroad track bed along the eastern perimeter of the AOC and the former location of storage tanks along the western perimeter of the AOC. Approximately three feet of contaminated soil has been removed at various locations in the drainage ditch that is located along the eastern perimeter of the AOC. There will most likely be several areas of the site having free standing water.

4.0 RADIOLOGICAL SURVEY OVERVIEW

This section describes the overall approach to performing the Final Status Survey for this project, including radiation detection methods to be used, survey design, statistical considerations, and determining whether the site meets the remediation goal. Subsequent sections describe the detailed instrument performance characteristics and survey operations.

4.1 DETECTION METHODS

Two principle radiation detection methods will be used during the radiological surveys: gamma detector response rate measurements and soil sampling and analysis. Field survey methodology, techniques, and terminology are in accordance with the Federal guidance document MARSSIM (Revision 1, August 2000). Section 5 provides specific details as to how the surveys were and will be performed.

For soil sample data, non-parametric statistical methodologies (Wilcoxon Rank Sum test), described below, will be utilized to compare the post-remediation site conditions with the naturally occurring background thorium levels.

4.2 FINAL STATUS SURVEY

4.2.1 Survey Objectives

The final radiological survey will develop data to support a recommendation for unrestricted release (free from regulatory or institutional control) of the areas and document the final radiological status of the monazite sand site at RVAAP.

Specifically, thorium levels in the site's soil are required to meet a clean-up goal ($DCGL_W$) of 4.9 pCi/g. In meeting this limit, the survey is designed to limit Type I and Type II errors to 5%. That is, survey units exceeding the $DCGL_W$ will be missed with less than 5% probability, and survey units meeting the $DCGL_W$ will be rejected as too high with less than 5% probability.

By meeting the established $DCGL_W$, the site will meet the dose-based release criteria of 25-mrem/yr total effective dose equivalent (TEDE).

The DCGL was derived by the Ohio Department of Health using the resident farmer scenario and site-specific parameters provided by the U.S. Army Corp of Engineers, along with the appropriate dose and conversion factors. These scenarios, parameters, and factors were then inputted into the RESRAD modeling code which provided the site specific $DCGL_W$.

4.2.2 Survey Unit Classification

Class 1 areas are those areas that are known to contain, or are strongly suspected of containing, contamination due to historical activities. Areas that were previously decontaminated or remediated are Class 1 areas. All of the survey units at the West Tank Farm area have been classified as Class 1 survey units.

This site is divided into six Class 1 survey units. These are presented in Figure 2.

4.2.3 Systematic Sampling

It is important to randomly sample a site, so that each part of the site has an equal chance of being sampled. This type of sampling is called systematic.

Systematic sampling using a random start point will be employed at RVAAP. The gamma count rate surveys previously performed gave all areas of the site 100 % coverage.

4.3 STATISTICAL CONSIDERATIONS

4.3.1 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 1. 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 1. 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.

4.3.2 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.

4.3.3 Measurements Of Gamma Count Rate

Prior to conducting any soil sampling, ground surfaces were 100 % gamma scanned to identify the presence of elevated direct radiation that might indicate residual gross activity or hot spots. Gamma scans will again be performed at every soil sample location point and recorded on the appropriate forms. Scanning was/will be performed according to the following Field Operating Procedures (FOP's): NWT OP-001, Radiation and Contamination Survey Techniques, and HSP-010, Gamma Scanning of Site Grounds.

4.3.4 Instruments

Gamma count rate response was used to determine whether specific areas exhibit activity levels that are significantly above site-specific background. Gross gamma count rates were 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 Volt (keV). This energy range included gamma rays emitted by Thorium-232 and its decay products.

Although the gamma scanning method planned for use during the final status surveys is not specific to Th-232, it can be used, since Th-232 and decay daughters are the only nuclides present above background levels. Thus, any increase in gamma count rate can be attributed to them

4.3.5 Scanning Minimal 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 ~ 11,000 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' = index of sensitivity (a and ß error)

b_i = number of background counts in scan time interval

d' = 3.28

b_i = 11,000x(2/60)

b_i = 367

Therefore:

$S_i = 3.28\sqrt{367}$

$S_i = 63$

The MDCR is then calculated using the formula below:

$$\text{MDCR} = S_i x(60/i)$$

Where:

i = scan time interval

Therefore:

$\text{MDCR} = 63x(60/2)$

$\text{MDCR} = 1890 \text{ cpm}$

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

$$\text{MDCR}_{\text{surveyor}} = 1890/\sqrt{0.5}$$

$$\text{MDCR}_{\text{surveyor}} = 2673 \text{ cpm}$$

For example, the determined background count rate at the West Tank Farm Area is approximately 11,000 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 2,673 cpm (or 13,673 cpm-gross).

4.3.6 Scan MDC for Land Areas

In addition to the MDCR and detector characteristics, the scan MDC in pCi/g for land areas is based on the area of elevated activity, depth of contamination, and the radionuclide (*i.e.*, energy and yield of gamma emissions). If one assumes constant parameters for each of the above variables, with the exception of the specific radionuclide in question, the scan MDC may be reduced to a function of the radionuclide alone.

The corresponding minimum detectable exposure rate is determined for this detector and radionuclide. The manufacturer of this particular 2" by 2". NaI(Tl) scintillation detector quotes a count rate to exposure rate ratio for Th-232 and it's daughters in equilibrium of 830 cpm per µR/h. The minimum detectable exposure rate is calculated by dividing the count rate (2673 cpm) by the count rate to exposure rate ratio for the radionuclide of interest (830 cpm per µR/h). The minimum detectable exposure rate for this example is 3.2 µR/h.

Modeling using Microshield ™ Version 5.05 was used to determine the net exposure rate produced by 4.0 pCi/g of Th-232 and it's daughters of contaminated soil.

The factors considered in the modeling included:

The dose point of 2 inches above the soil was used.

The density of 1.6 g/cm^3 was used for soil.

The depth of the area of elevated activity was 15 cm.

The areal dimension of the cylindrical area of elevated activity was .25 m^2.

The corresponding minimum detectable exposure rate was then determined for a 2" by 2" NaI(Tl). The modeling code performed the appropriate calculations and determined an exposure rate of 5.5 µR/hr for Th-232 which also accounts for buildup.

A count rate due to the presence of Th-232 in soil at a concentration of 4.0 pCi/g can then be calculated by the following:

$$\frac{830\ \text{cpm}}{\mu\text{R/hr}}\ x\ 5.5\ \mu\text{R/hr} = 4565\ \text{cpm}$$

The concentration of Th-232 (scan MDC) necessary to yield the minimum detectable exposure rate (3.2 µR/hr) may be calculated using the following formula.

$$\text{ScanMDC} = \frac{4.0\ \text{pCi/g}\ (3.2\ \mu\text{R/hr})}{5.5\ \mu\text{R/hr}} = 2.3\ \text{pCi/g}$$

This technique was adequate to determine compliance with the numerical goal of 4.9 pCi/g.

4.3.7 Calculation of Number of Samples Obtained From Survey Units

An important factor in performing Wilcoxon Rank Sum Test is the number of samples taken. A minimum number must be taken. The minimum is calculated based on confidence limits, the general distribution of the contaminant at the site, the $DCGL_w$ and other factors.

The number of soil samples, to be obtained for the Wilcoxon Rank Sum Test is calculated using the following formula:

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2} \text{ x } 1.2$$

where,

N	=	number of samples;
$Z_{1-\alpha}$	=	percentile represented by selected value of $\alpha = 0.05$;
$Z_{1-\beta}$	=	percentile represented by selected value of $\beta = 0.05$; and
P_r	=	the probability that a random measurement from the survey unit exceeds a random measurement from the background reference area by less than the $DCGL_w$ when the survey unit median is equal to the LBGR above background
1.2	=	correction factor for additional 20% samples

The lower bound of the gray region (LBGR) value was selected as one half the DCGL (2.45) for Th-232, the radionuclide of concern.

The standard deviation was calculated from the results of soil samples obtained during the last Final Status Survey effort performed by NWT, and soil samples obtained following removal of elevated areas of activity by NWT. The calculated average standard deviation from all of the survey units was used.

The calculated standard deviation is 1.5.

Attachment 1 of this plan presents a worksheet that shows the calculation of the standard deviation.

The initial step in determining the number of data points is to calculate the relative shift, $\Delta/\sigma = (DCGL\text{-}LBGR)/\sigma$, from the DCGL value, the lower bound of the gray region (LBGR), and the standard deviation of the contaminant in the survey unit, σ.

The calculated value of the relative shift is 1.63.

The P_r is used to calculate the minimum number of data points necessary for the survey to meet the DQOs. The value of the relative shift calculated above is used to obtain the corresponding value of P_r from Table 5.1 in Chapter 5 of MARSSIM.

The value of P_r is 0.871014

The percentiles, $Z_{1-\alpha}$ and $Z_{1-\beta}$, represented by the selected decision error levels, α and β, respectively are calculated from Table 5.2 in Chapter 5 of MARSSIM.

The value of the percentiles, $Z_{1-\alpha}$ and $Z_{1-\beta}$ is 1.645.

Therefore:

$$32 = \frac{(1.645 + 1.645)^2}{3(0.871014 - 0.5)^2} \text{ x } 1.2$$

The calculated number of samples required to demonstrate compliance using the Wilcoxon Rank Sum Test is 16.

4.3.8 Confidence Levels

The survey is designed to limit Type I and Type II errors to 5%. It is important to minimize the chances that area grids exceeding the DCGL will be missed (Type I) and area grids meeting the DCGL will be rejected as too high (Type II). The probability of either of these occurring is set at a maximum of 5%. The Critical Value for the Wilcoxon Rank Sum Test is calculated from these probability values and from the number of samples/measurements taken.

4.3.9 Statistical Wilcoxon Rank Sum Test

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 4.3.8).

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

The *m* adjusted reference sample measurements, Z_i, from the reference area and the *n* sample measurements, Y_i, 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=32.

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, W_r.

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, W_s, and compute $W_r = N(N+1)/2 - W_s$.

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

For the case of *n >20* and *m >20* the critical value is calculated using the following equation

$$m(n+m+1)/2 + z\sqrt{nm(n+m+1)/12}$$

For this case *n*=16 *m*=16 and α=0.05.

The calculated value of the Critical Value for this case is: 308.

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

5.0 RADIOLOGICAL RELEASE SURVEY AND SAMPLING

The surveys to be conducted in support of the remediation and final release of the site will be performed according to this survey plan and NWT Field Operating Procedures (FOP). Specific survey techniques are detailed in FOPs. Any deviations from this plan or from the FOPs will be documented in the survey report.

5.1 MEASUREMENTS OF SOIL CONTAMINATION

Samples of soil and/or sand will be collected and analyzed by a qualified laboratory. The number of soil samples to be taken from each of the survey units, 6 Class 1 areas, has been determined to be 24 and is detailed in Section 4.3.7 of this plan.

5.1.1 Soil Sampling

5.1.1.1 Surface Soil Samples

In each survey unit 16 soil samples will be taken from the systematic locations. Surface (0-15 cm below ground surface) samples will be collected from each sampling location. A total of 16 soil samples will be obtained from each survey unit. The calculations that were used to obtain the number of required samples are presented in Section 4.3.7 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 300 to 500 grams 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 NWT's FOP's.

5.1.2 Minimum Detectable Activity

The samples will be sent to Paragon Analytic's laboratory in Fort Collins, CO for gamma spectral analysis.

Paragon will analyze the samples for Ac-228, Pb-212, Bi-212, Tl-208, Pb-214, and Bi-214 as these are the decay daughters of Th-232, the primary radionuclide found in the monazite sand. Any other identified peaks found will also be reported.

The laboratory will utilize the gamma emissions from the daughter product Ac-228 to determine the total activity of Th-232.

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 to1 pCi/gram. This level of activity represents 20% of the specified DCGL of 4.9 pCi/g.

5.2 SURVEY UNITS

Because the entire West Tank Farm area has been contaminated with thorium, this area will be divided into 6 Class 1 survey units. Each survey unit will be less than 2,000 m^2 in area, the survey unit area limit proscribed in MARSSIM. The survey unit layout is presented in Figure 2.

The Class 1 survey units were previously surveyed for gamma count rate over 100% of their area.

5.3 REFERENCE GRIDS

A reference coordinate system will be laid out for each of the survey units. A square grid system will be used for the Final Status Surveys. The length, L, of a side of the square grid was determined by the total number of samples or measurements to be taken. The length of the square determined the distance between direct measurement/soil sample location points (NUREG-1505). The length or spacing of the grids was calculated for each of the survey units using the following equation:

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

Where,

L = length of squares grids (m);
A = surface area of the survey unit (m^2); and
N = statistically calculated number of samples.

The length of the measurement/sampling intervals for each of the survey units is presented in Table 2 below.

Table 2. Survey Unit Interval Table

Survey Unit #	Survey Unit Size in Square Meters	Sampling Interval in Meters
Railroad Tracks	1860	19.0
Survey Unit # 1	1440	9.5
Survey Unit # 2	2000	11.0
Survey Unit # 3	2000	11.0
Survey Unit # 4	1550	9.5
Survey Unit # 5	1155	8.5

Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, and Figure 8 present diagrams of the sampling pattern layout for each of the survey units.

5.4 BACKGROUND REFERENCE AREA-SOIL

An area approximately 1.1 miles east of the intersection of Route 80 and North Line Road along and to the north of North Line Road will used as the background reference area. This area was chosen for the background reference area because it has similar physical, chemical, geological, radiological, and biological characteristics as the West Tank Farm area and is non-impacted by former operations.

A total of 16 background samples will obtained from the surface (within 6 inches) at randomly selected locations within the background reference area described above.

The samples will be sent to Paragon Analytic's laboratory in Fort Collins, CO for gamma spectral analysis as described above.

5.5 BACKGROUND REFERENCE AREA-RAILROAD TRACKS

An area approximately 1.1 miles east of the intersection of Route 80 and North Line Road along, and to the south of North Line Road will be used as the background reference area for the railroad track ballast. This area was chosen for the background reference area because it has similar physical, chemical, geological, radiological, and biological characteristics as the railroad tracks at the West Tank Farm area and is non-impacted by former operations.

A total of 5 background samples will obtained from the surface underneath the railroad ballast (within 6 inches) at randomly selected locations within the background reference area described above.

The samples will be sent to Paragon Analytic's laboratory in Fort Collins, CO for gamma spectral analysis as described above.

6.0 QUALITY CONTROL AND QUALITY ASSURANCE

The goal of quality assurance and quality control (QA/QC) is to identify and implement sampling and analytical methodologies that limit the introduction of error into analytical data. For the purposes of this plan, a system is required to ensure that radiological survey data are of the type and quality to support their intended use. Both the project and the corporate QA/QC programs are constructed to ensure that all quality and regulatory requirements are satisfied. Quality assurance issues related to data verification and reliability will be handled according to approved and controlled FOPs and the Work Plan (WP).

6.1 TRAINING AND CERTIFICATION OF STAFF

The majority of the training requirements for staff conducting activities under this plan are detailed in the Health and Safety Plan (HASP) and NWT procedures. All personnel performing activities that may expose them to hazards as defined in the HASP must comply with applicable training requirements.

6.2 EQUIPMENT MAINTENANCE AND CALIBRATION

Measuring equipment will be maintained, calibrated and tested to assure the validity of the survey data. The requirements for calibration frequency, performance checks, and equipment maintenance are detailed in NWT HP-AP-001, Revision 0, Quality Control for Health Physics Counting Equipment and Systems.

6.3 DATA MANAGEMENT

Documentation of all surveys and associated data will be documented according to the NWT Work Plan, and FOPs. Presentation of data will be in accordance with applicable requirements.

8.0 FINAL REPORT

After all laboratory results are complete, the data will be analyzed and a report will be prepared. The report will include all measurements, laboratory reports 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.

REFERENCES

1. ISO-7503-1. 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. ISO-7503-1 (first edition), ISO, Geneva, Switzerland

2. 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

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4. NUREG-1575. Nuclear Regulatory Commission (NRC). 2000. Multi-Agency Radiation Survey and Site Investigation Manual. NUGEG-1575, Rev 1

5. NUREG/CR-5512, Vol. 2. Nuclear Regulatory Commission (NRC) and Sandia National Laboratory. Apr 2001. Residual Radioactivity Contamination from Decommissioning: User's Manual DandD Version 2.1. NUREG/CR-5512, Vol. 2 / SAND2001-0822P

6. New World Technology. 2000. "Draft Final Report, Characterization Survey/Sampling Effort, Ravenna Army Ammunition Plant, Monazite Sand Removal Project, Phase II," USA 00-005, Revision 0. May 30.

7. New World Technology. 2001. "Draft Final Report, Ravenna Army Ammunition Plant Monazite Sand Removal Project, Phase I & III," USA-00-005, Revision 0. 12-7-2001.

8. New World Technology. 2003. "Draft Interim Report, Ravenna Army Ammunition Plant Monazite Sand Removal Project, Remediation of Elevated Areas of Activity, Phase IV", USA-00-005, Revision 0. 9-17-2003.

9. United States Army Corps of Engineers, Radiation Survey Report, *CESWT-SO-R2-05-98, Monazite AOC, Ravenna Army Ammunition Plant, 18-20 May 1998*

10. U.S. Code of Federal Regulations, 10 CFR 20

11. "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)."

12. New World Technology, *Field Operations Procedures*

Figure 1. West Tank Farm Location Map

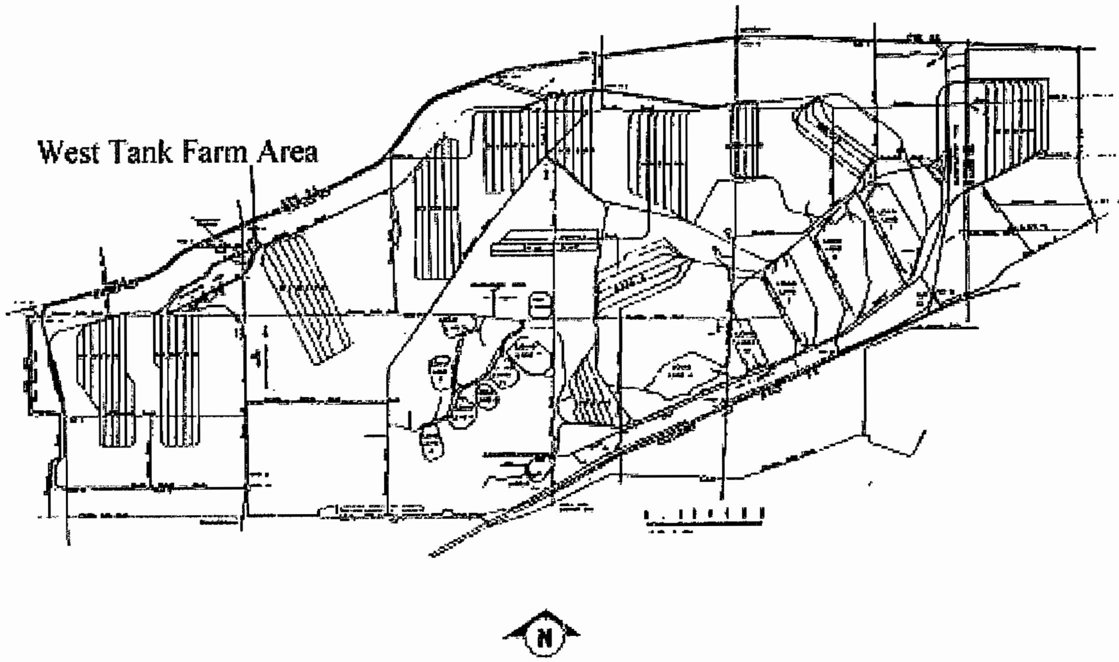
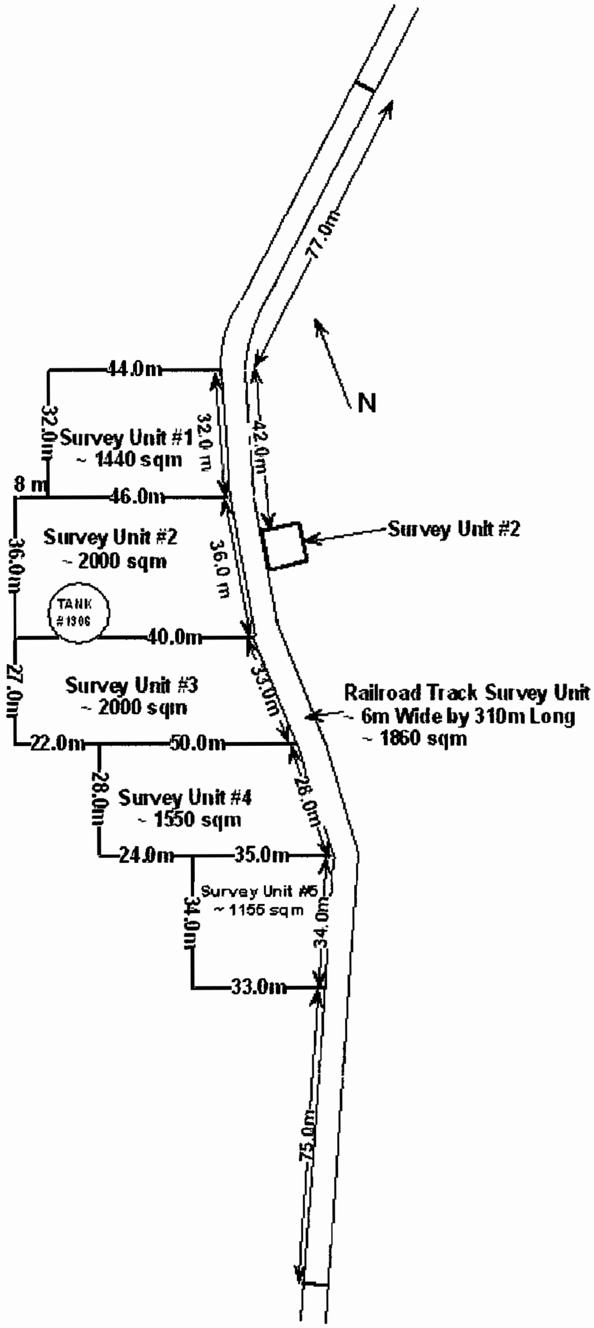
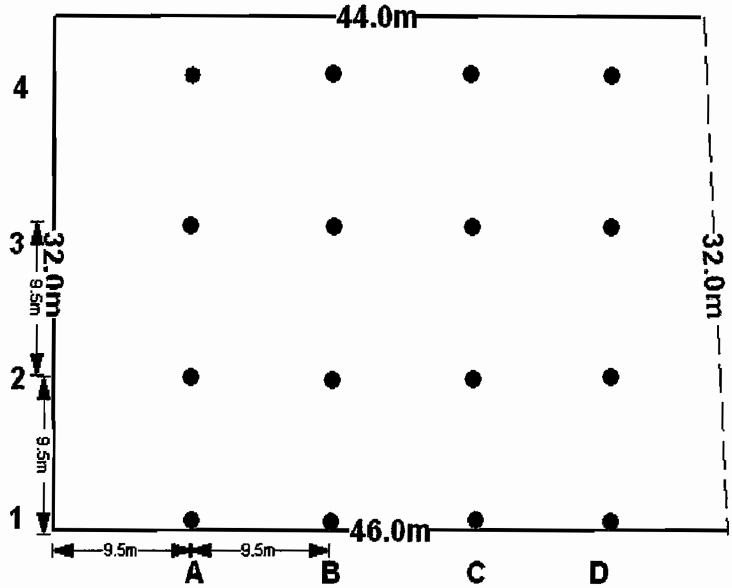


Figure 2. Survey Unit Layout Diagram



Drawing to Scale +/- 1 Meter

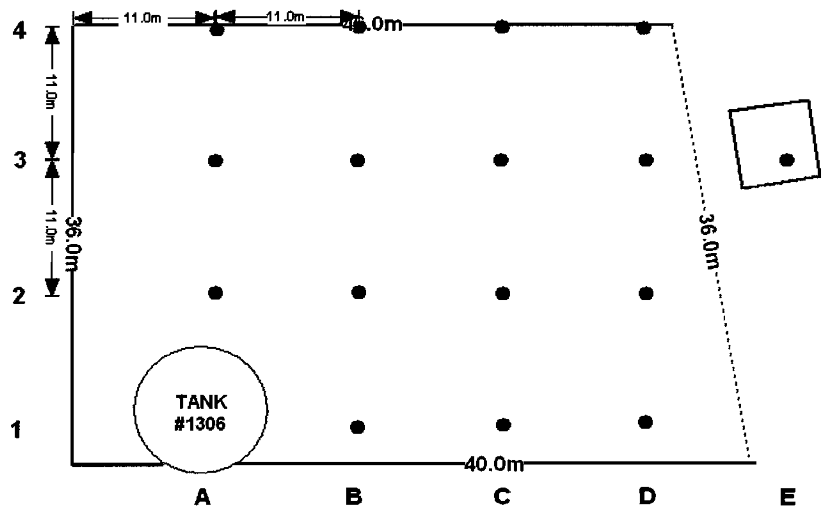
Figure 3. Survey Unit #1 Sampling Pattern Diagram



● - **Denotes Sample Location Point**

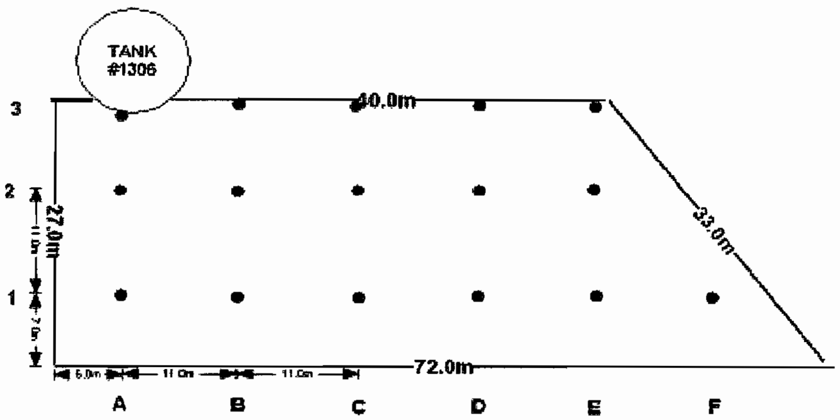
● - **Denotes Random Start Point**

Figure 4. Survey Unit #2 Sampling Pattern Diagram



● - Denotes Sample Location Point
● - Denotes Random Start Point

Figure 5. Survey Unit #3 Sampling Pattern Diagram



● - Denotes Sample Location Point
● - Denotes Random Start Point

Figure 6. Survey Unit #4 Sampling Pattern Diagram

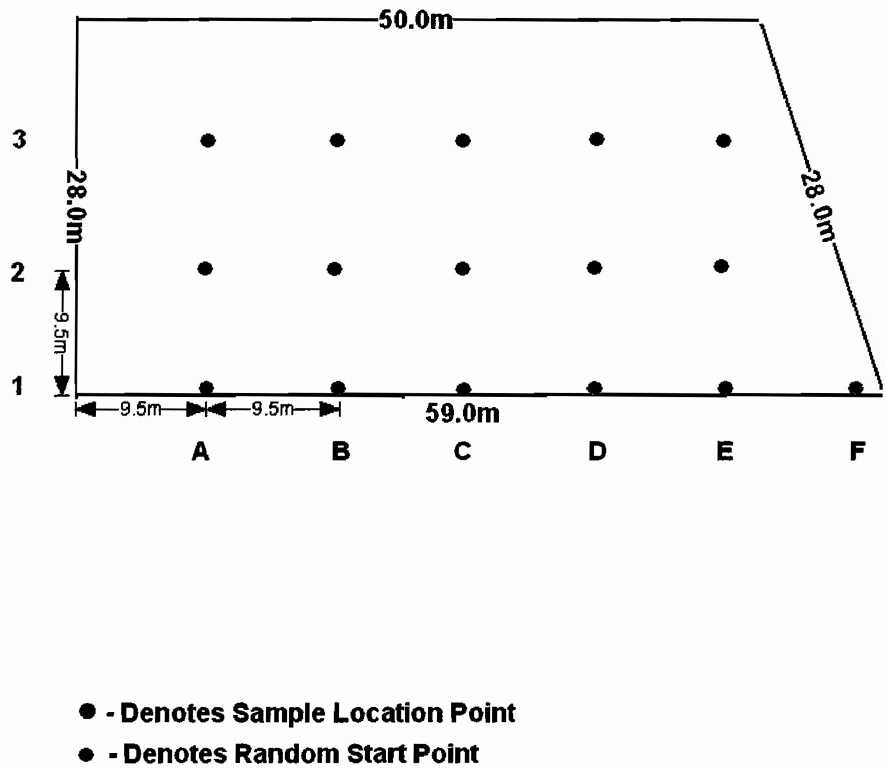


Figure 7. Survey Unit #5 Sampling Pattern Diagram

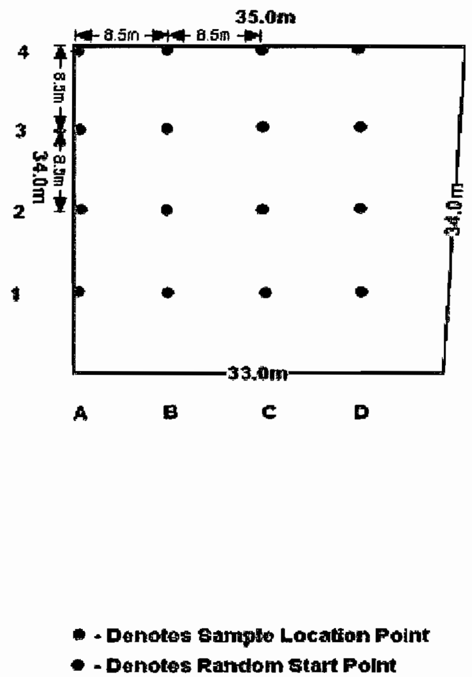
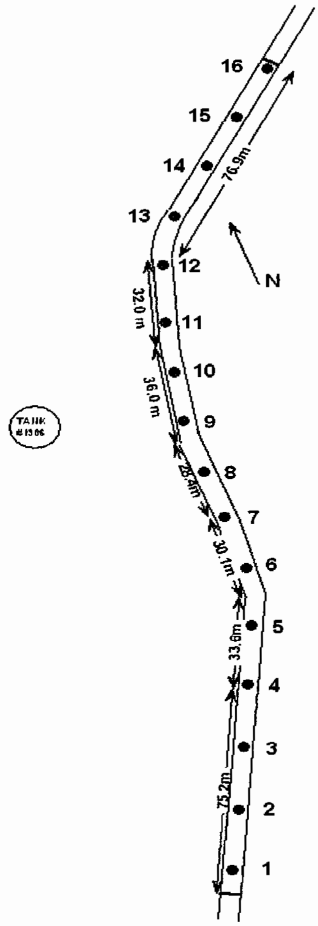


Figure 8. Railroad Track Survey Unit Sampling Pattern Diagram



Drawing to Scale +/- 1 Meter

Spacing Between Sample Locations is 19 Meters

- **Denotes Sample Location**
- **Denotes Random Start Point**

ATTACHMENT 1

SOIL SAMPLE SUMMARY TABLES/STANDARD DEVIATION CALCULATION WORK SHEET

Sample Calculation Worksheet

Sample ID Class 2 Survey Unit	Ac-228 Results in pCi/g	Bi-212 Results in pCi/g	Bi-214 Results in pCi/g	Cs-137 Results in pCi/g	K-40 Results in pCi/g	Pb-212 Results in pCi/g	Pb-214 Results in pCi/g	Th-234 Results in pCi/g	Tl-208 Results in pCi/g	Sample Gross Weight in Grams	Notes
Z-18	2.31	3.40	1.12	0.11	6.10	2.75	1.45	2.60	0.88	315.80	
B-11	0.31	0.11	0.27	0.12	5.40	0.28	0.38	0.25	0.16	439.00	
Z-14	1.42	1.04	0.98	0.54	6.30	1.96	1.02	1.00	0.57	371.10	
E-24	3.84	4.40	1.58	0.15	7.60	4.63	1.61	4.10	1.40	314.30	
F-21	9.30	7.30	1.45	0.18	10.40	10.30	1.56	7.90	2.90	285.70	
F-17	1.25	1.01	0.71	-0.02	13.10	1.62	0.63	0.56	0.41	363.40	
I-10	2.08	4.00	2.10	0.96	8.60	2.63	2.14	3.00	0.86	299.30	
H-7	3.35	4.20	0.76	0.44	5.60	3.77	0.77	2.90	1.33	344.30	
C-9	1.94	3.10	1.14	0.34	5.80	3.00	1.29	2.10	0.93	338.30	
B-21	0.44	1.29	0.47	0.03	5.80	0.51	0.46	0.68	0.21	429.50	
G-14	0.37	0.34	0.09	0.04	4.70	0.47	0.21	0.38	0.08	424.80	
Average:	**2.42**	**2.74**	**0.97**	**0.26**	**7.22**	**2.90**	**1.05**	**2.32**	**0.88**		
Standard Deviation:	**2.56**	**2.20**	**0.60**	**0.29**	**2.55**	**2.82**	**0.61**	**2.25**	**0.81**		

Sample ID Survey Unit #1	Ac-228 Results in pCi/g	Bi-212 Results in pCi/g	Bi-214 Results in pCi/g	Cs-137 Results in pCi/g	K-40 Results in pCi/g	Pb-212 Results in pCi/g	Pb-214 Results in pCi/g	Th-234 Results in pCi/g	Tl-208 Results in pCi/g	Sample Gross Weight in Grams	Notes
E-28	3.44	3.51	1.46	0.22	9.50	3.35	1.73	1.98	0.98	275.30	
C-21	0.74	1.01	0.65	0.39	10.30	0.94	0.80	0.75	0.38	371.00	
E-21	1.07	1.05	0.63	-0.01	12.90	1.24	0.81	0.90	0.32	416.70	
D-20	0.58	0.63	0.29	0.03	6.10	0.74	0.35	0.72	0.21	408.10	
D-19	1.22	1.40	0.89	0.21	5.90	1.80	1.04	1.73	0.52	387.70	
C-19	2.47	2.40	0.54	0.54	4.60	2.42	0.60	1.60	0.82	361.80	
D-18	0.23	0.26	0.18	0.01	6.30	0.41	0.23	0.07	0.11	510.30	
F-18	3.45	3.67	1.39	0.09	12.10	3.31	1.53	2.30	1.06	397.90	
E-23	1.62	2.10	0.77	0.02	11.90	1.56	0.96	1.00	0.79	283.90	
E-19	0.88	0.90	0.61	0.01	12.60	1.09	0.89	1.20	0.04	363.40	
B-18	0.52	0.30	0.49	-0.02	5.30	0.49	0.31	0.27	0.22	396.80	
Average:	**1.47**	**1.57**	**0.72**	**0.13**	**8.86**	**1.58**	**0.84**	**1.14**	**0.50**		
Standard Deviation:	**1.15**	**1.20**	**0.40**	**0.19**	**3.26**	**1.04**	**0.48**	**0.70**	**0.38**		

Sample ID Survey Unit #2	Ac-228 Results in pCi/g	Bi-212 Results in pCi/g	Bi-214 Results in pCi/g	Cs-137 Results in pCi/g	K-40 Results in pCi/g	Pb-212 Results in pCi/g	Pb-214 Results in pCi/g	Th-234 Results in pCi/g	Tl-208 Results in pCi/g	Sample Gross Weight in Grams	Notes
C-17	3.20	2.50	0.84	0.01	11.10	3.13	0.98	3.50	0.94	472.70	
E-16	0.75	1.51	0.43	-0.01	8.40	0.89	0.48	0.89	0.39	446.80	
C-16	0.88	0.91	0.45	0.03	1.24	1.24	0.73	-0.19	0.33	326.00	
F-15	4.40	4.30	0.92	0.19	7.50	5.07	1.07	5.90	1.31	292.40	
C-15	1.26	0.79	0.70	0.03	12.30	1.42	0.70	1.06	0.40	404.40	
D-14	1.10	1.30	0.76	-0.01	12.10	1.17	1.00	1.60	0.35	354.70	
F-14	2.22	2.45	0.48	0.08	4.50	2.34	0.56	2.40	0.80	430.90	
D-15	1.10	1.10	0.75	0.02	14.80	1.02	0.73	1.49	0.33	393.00	
A-14	0.86	0.60	0.66	0.00	12.70	0.99	0.65	0.46	0.36	357.70	
C-14	1.57	1.78	0.48	0.10	6.60	2.05	0.57	1.50	0.63	407.80	
D-16	1.79	1.90	0.56	0.01	11.10	2.03	0.77	1.58	0.56	345.40	
Average:	**1.74**	**1.74**	**0.64**	**0.04**	**9.30**	**1.94**	**0.75**	**1.84**	**0.58**		
Standard Deviation:	**1.14**	**1.06**	**0.17**	**0.06**	**4.06**	**1.25**	**0.19**	**1.66**	**0.32**		

Sample ID Survey Unit #3	Ac-228 Results in pCi/g	Bi-212 Results in pCi/g	Bi-214 Results in pCi/g	Cs-137 Results in pCi/g	K-40 Results in pCi/g	Pb-212 Results in pCi/g	Pb-214 Results in pCi/g	Th-234 Results in pCi/g	Tl-208 Results in pCi/g	Sample Gross Weight in Grams	Notes
F-13	3.10	3.30	0.95	-0.01	5.30	3.01	1.04	1.30	0.98	365.20	
C-12	0.69	1.28	0.52	0.04	5.10	0.70	0.41	0.63	0.20	355.30	
E-13	2.90	3.10	1.87	0.03	5.30	3.49	2.21	2.90	0.95	367.40	
G-11	0.41	0.54	0.29	0.06	3.90	0.44	0.32	0.68	0.11	410.60	
E-12	0.85	0.96	0.36	0.03	5.90	0.82	0.45	1.10	0.20	357.90	
D-12	1.14	1.20	1.02	0.01	5.60	1.04	0.73	1.04	0.44	365.70	
A-13	0.31	0.52	0.36	0.03	5.30	0.28	0.34	-0.02	0.13	397.80	
D-11	3.31	4.10	19.20	0.00	1.90	3.57	19.20	12.10	1.13	514.80	
E-11	0.57	0.96	0.61	0.06	8.20	0.69	0.61	1.07	0.26	361.40	
F-12	0.83	1.45	0.40	0.03	5.10	0.95	0.40	1.03	0.23	454.20	
C-13	2.56	2.80	0.74	-0.03	5.10	3.59	0.58	2.70	1.03	362.70	
Average:	**1.51**	**1.84**	**2.39**	**0.02**	**5.15**	**1.69**	**2.39**	**2.23**	**0.51**		
Standard Deviation:	**1.19**	**1.25**	**5.59**	**0.03**	**1.49**	**1.39**	**5.60**	**3.38**	**0.41**		

Sample ID Survey Unit #4	Ac-228 Results in pCi/g	Bi-212 Results in pCi/g	Bi-214 Results in pCi/g	Cs-137 Results in pCi/g	K-40 Results in pCi/g	Pb-212 Results in pCi/g	Pb-214 Results in pCi/g	Th-234 Results in pCi/g	Tl-208 Results in pCi/g	Sample Gross Weight in Grams	Notes
G-10	2.06	2.90	0.82	0.25	5.90	2.76	0.90	1.80	0.92	361.80	
F-7	0.27	0.44	0.28	0.27	5.30	0.40	0.37	0.72	0.10	458.90	
E-8	0.68	1.12	0.39	0.06	4.80	0.62	0.52	0.36	0.16	381.50	
G-8	0.20	0.40	0.29	0.03	4.50	0.28	0.20	0.23	0.12	426.70	
H-9	0.77	1.60	0.59	0.00	12.20	1.08	0.68	0.80	0.35	345.40	
F-9	3.30	3.40	1.33	0.73	5.60	1.49	1.49	3.60	1.25	310.30	
E-10	0.68	0.97	0.73	0.22	6.60	0.90	4.19	1.41	0.26	401.90	
D-10	3.10	3.50	2.98	0.18	5.00	3.50	3.31	5.70	1.02	406.00	
F-10	3.85	4.60	2.50	0.83	4.40	4.83	2.43	4.00	1.37	320.50	
D-9	3.26	4.70	2.11	0.07	3.80	4.07	2.74	1.50	1.17	333.40	
H-8	2.96	3.16	1.05	0.39	7.70	2.92	1.11	2.63	0.88	351.00	
Average:	**1.92**	**2.44**	**1.19**	**0.27**	**5.98**	**2.08**	**1.63**	**2.07**	**0.69**		
Standard Deviation:	**1.41**	**1.59**	**0.94**	**0.28**	**2.33**	**1.60**	**1.34**	**1.74**	**0.49**		

Totals	Ac-228	Bi-212	Bi-214	Cs-137	K-40	Pb-212	Pb-214	Th-234	Tl-208
Average:	**1.81**	**2.08**	**1.18**	**0.15**	**7.30**	**2.04**	**1.33**	**1.92**	**0.63**
Standard Deviation:	**1.49**	**1.46**	**1.54**	**0.17**	**2.74**	**1.62**	**1.64**	**1.95**	**0.48**

LBGR=	**2.45**	**1/2 of the DCGL of 4.9**
Standard Deviation =	**1.5**	
Relative Shift =	**1.63**	
Calculated Number of Samples=	**16**	**In Reference Area and Each Survey Unit**

Note: Samples in red are re-samples of areas remediated.