ENCLOSURE 1

RADIOLOGICAL CHARACTERIZATION REPORT FOR THE HIGH LEVEL WASTE CANISTER INTERIM STORAGE AREA

for

TASK ORDER 9
WEST VALLEY DEMONSTRATION PROJECT ENVIRONMENTAL CHARACTERIZATION SERVICES
WEST VALLEY, NEW YORK

SEC-RCR
Rev. 1

April 2014

Prepared for:
U.S. Department of Energy
West Valley Demonstration Project (WVDP)
Environmental Characterization Services (ECS)
West Valley, New York

Prepared by:
Safety and Ecology Corporation (SEC)
2800 Solway Road
Knoxville, TN 37931

UNCONTROLLED DOCUMENT

RADIOLOGICAL CHARACTERIZATION REPORT FOR THE HIGH LEVEL WASTE CANISTER INTERIM STORAGE AREA

for

TASK ORDER 9
WEST VALLEY DEMONSTRATION PROJECT
ENVIRONMENTAL CHARACTERIZATION SERVICES
WEST VALLEY, NEW YORK

SEC-RCR
Rev. 1

April 2014

Prepared for:
U.S. Department of Energy
West Valley Demonstration Project (WVDP)
Environmental Characterization Services (ECS)
West Valley, New York

Prepared by:
Safety and Ecology Corporation (SEC)
2800 Solway Road
Knoxville, TN 37931

Radiological Characterization Report (RCR) for the High Level Waste Canister Interim Storage Area

Contract No.: DE-EM0001242

RCR APPROVALS

By their specific signature, the undersigned certify that they prepared, reviewed, or provided comments on this Radiological Characterization Report for the U.S. Department of Energy West Valley Demonstration Project, West Valley, New York.

PREPARED BY:

Steven Green

April 17, 2014
Date

Project Manager
Steven Green, CHP, PMP

April 17, 2014
Date

Independent Technical Reviewer
James Turner

APPROVED BY:

April 17, 2014
Date

Program Manager
Andrew Lombardo, CHP

Steven Green

April 17, 2014
Date

Project Manager
Steven Green, CHP, PMP

TBD by PM/RM
Effective Date

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

CG	Cleanup Goal
CHBWV	CH2M Hill B&W West Valley, LLC
CLP	Contract Laboratory Procedure
cm	centimeter
cpm	counts per minute
CSAP	Characterization Sampling and Analysis Plan
DOE	U.S. Department of Energy
ECS	Environmental Characterization Services
EDD	Electronic Data Deliverable
EPA	U.S. Environmental Protection Agency
FIDLER	Field Instrument for Detection of Low-Energy Radiation
FSP	Field Sampling Plan
FSSP	Final Status Survey Plan
ft	foot/feet
g	gram
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HLW	High Level Waste
LAGGSS	Large Area GPS Gamma Survey System
Lc	Lower Critical Level
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LLRW	Low-level Radioactive Waste
m	meter
m^2	square meter
m/s	meters per second
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	Minimum Detectable Activity
mR/hr	millirems per hour
NAD83	North American Datum of 1983
NaI	Sodium Iodide
NIST	National Institute of Standards and Technology
NYSERDA	New York State Energy Research and Development Authority
pCi	picocuries
PDOP	Position Dilution of Precision
PROI	Potential Radionuclide of Interest
PUREX	Plutonium Uranium Recovery Extraction
QA	Quality Assurance
QC	Quality Control
RE	Relative Error
ROI	Radionuclide of Interest
RPD	Relative Percent Difference
SEC	Safety and Ecology Corporation
SOP	Standard Operating Procedure
THOREX	Thorium Recovery Extraction
TPU	Total Propagated Uncertainty

TRU	Transuranic
UTL	Upper Tolerance Limit
WMA	Waste Management Area
WNYNSC	Western New York Nuclear Service Center
WVDP	West Valley Demonstration Project

EXECUTIVE SUMMARY

The High Level Waste (HLW) Canister Interim Storage Area was constructed beginning in September 2014. The construction area was excavated to allow the reinforced concrete pad to be built. A radiological survey was performed after excavation and before the concrete pad was poured. The purpose of the radiological survey was to characterize the condition of the soils that underlay the concrete pad and the soils that were excavated to allow construction of the pad. Characterization was performed in accordance with the Field Sampling Plan (FSP) for Task Order 9, West Valley Demonstration Project, Environmental Characterization Services (SEC 2013a).

The radiological characterization included collection of 41 soil samples and a gamma radiation survey of the surface of the excavated area. One soil sample was collected for each 100 square meters (m^2) of surface area in accordance with the specifications of the Characterization Sampling and Analysis Plan (CSAP) (DOE 2011). Sample locations were established for every 100 m^2 of surface area because radioactive contamination was detected while the soil was excavated; therefore, the area was considered a Multi-Agency Radiological Site Survey and Investigation Manual (MARSSIM) (EPA 2000) Class 1 Area, or *impacted* area.

Soil excavated from the pad construction area was deposited on a spoils pile. A gamma walkover survey (GWS) was performed as the spoils pile was built. The spoils pile was built in approximately 1- to 2-foot (ft) lifts and a gamma radiation survey was conducted on each lift.

The soil samples were analyzed for 18 Radionuclides of Interest (ROIs) and 12 Potential Radionuclides of Interest (PROIs) as described in the CSAP. The GWS was performed with a Field Instrument for Detecting Low Energy Radiation (FIDLER).

Radioactive contamination was found approximately 7 ft below the original ground surface in the HLW Canister Interim Storage Area during excavation. The contamination was removed as practical using gamma radiation measurements to guide excavation. Some of the contamination was spread to the spoils pile before it was detected during the GWS on the spoils pile. The contamination on the spoils pile was removed using the GWS data as a guide. Contamination detectable by surveying for gamma radiation was removed. No soil samples were collected. It is reasonable to suspect that some contamination above background remains.

1.0 INTRODUCTION

The West Valley Demonstration Project (WVDP) (established to implement the WVDP Act) is located on approximately 152 acres within the 3,345-acre Western New York Nuclear Service Center (WNYNSC), owned by the New York State Energy Research and Development Authority (NYSERDA) in rural Cattaraugus County, about 35 miles south of Buffalo, New York. The WVDP site is complex, involving a large number of potential radionuclides of concern and a variety of historical processes and events that are known to have or may have released contaminants into the environment. Known affected environmental media include surface soils, subsurface soils, groundwater, surface water, and sediments. The decommissioning of the WVDP site will involve a sequential set of activities that will vary significantly depending on the exact location and activity purpose.

The WVDP is a unique operation within the U.S. Department of Energy (DOE). The West Valley Demonstration Project Act of 1980 directed the Secretary of Energy to undertake five major activities, as follows:

- Solidify the liquid high level waste (HLW) stored at WNYNSC into a form suitable for transportation and disposal (completed);
- Develop containers for the solidified HLW suitable for permanent disposal of the HLW (completed);
- Transport the waste to a federal repository for disposal (pending);
- Dispose of low-level radioactive waste (LLRW) and transuranic (TRU) waste produced by the Project (in progress); and
- Decontaminate and decommission the HLW storage tanks (PUREX and THOREX HLW tanks deactivated, July 2003), the HLW solidification facilities (in progress), and any material and hardware used in connection with the Project (in progress).

Decommissioning of the site will occur in two phases. Phase 1 of the decommissioning will entail removal of the Main Plant Process Building, the Low-Level Waste Treatment Facility, and certain other facilities within the WVDP area, which is known as the project premises. These activities will clean up much of the project premises to standards that will not prejudice decisions on the approach for Phase 2, which will complete the decommissioning. The Phase 2 decision shall be made within 10 years of the Record of Decision and Findings Statement documenting the Phase 1 decisions. Phase 2 actions will complete the decommissioning or long-term management of those facilities remaining at WVDP and WNYNSC following the completion of Phase 1 decommissioning.

Part of the Phase 1 decommissioning is the construction of the new HLW Canister Interim Storage Area. This facility was under construction when this report was prepared. It is located on the south plateau near the rail spur. When complete, the facility will consist of a reinforced concrete pad of sufficient size and load capacity to store 57 vertical concrete storage casks containing vitrified HLW.

The radiological characterization of the location where the HLW Canister Interim Storage Area is being constructed is the subject of this report. Characterization was performed in accordance with the Field Sampling Plan (FSP) for Task Order 9, West Valley Demonstration Project Environmental Characterization Services (SEC 2013a).

1.1 Site Description

The HLW Canister Interim Storage Area is in the southwest corner of the WVDP premises. It consists of a reinforced concrete pad, an approach apron area south of the reinforced pad, and a crane alley on the west and east of the concrete pad. Soil was excavated to a depth of 1 to 2 meters (m) to construct the HLW pad, apron, and crane alleys. The excavated soil was fill material placed over the native Lavery Till. The Lavery Till is dense clay with geotechnical properties suitable to support the HLW Canister Interim Storage Area concrete structures. The excavated fill was placed on a spoils pile, west of the concrete pad and western crane alley. Figure 1-1 shows an aerial map of the study area.

A characterization study was performed previously in the summer of 2012 (SEC 2013a). Radioactivity was detected in soil samples collected from 0 – 15 centimeters (cm) and in 15 – 100 cm below ground surface in the study area at concentrations inconsistent with background. No samples were analyzed from the Lavery Till during this previous characterization effort.

1.2 Objectives

The primary objective of the characterization survey that is the subject of this report was to document the gamma radiation signal emanating from and the concentration of radioactivity in a 0 – 100 cm deep strata of Lavery Till that directly underlays the HLW Canister Interim Storage Area (concrete storage pad) and fill dirt at the approach apron and crane alleys. A second objective was to document the gamma radiation signal emanating from the six different lifts of soil placed in the spoils pile.

The characterization survey included a gamma walkover survey (GWS) and the collection of systematic and biased soil samples, all collected from 0 – 100 cm below the new surface formed after excavation in the HLW Canister Interim Storage Pad Area was completed. The concrete storage pad was typically 5 to 7 feet (ft) below the original ground surface and the approach apron was typically 3 ft below original ground surface. The systematic and biased soil samples were analyzed for the 18 radionuclides of interest (ROIs) and the 11 potential of 12 radionuclides of interest (PROIs) as described in the Characterization Sampling and Analysis Plan (CSAP) (DOE 2011) and listed in Table 1-1. Cadmium-113m is listed as a PROI in the CSAP; however, it cannot be detected by gamma spectroscopy and analysis by another means was not included in the subcontract with the analytical laboratory. However, this is not considered a significant issue as cesium-137 was the only fission product detected as discussed below. Thus, cadmium-113m is not likely to be present. An alternate method of detecting cadmium-113m will be explored with the laboratory for future work at WVDP. Also included in the table are the minimum volumes of soil collected and minimum required detection limits for each analysis and the analytical method used.

Safety and Ecology Corporation (SEC) planned and implemented the characterization activities consistent with the requirements in the FSP and (MARSSIM guidance (EPA 2000).

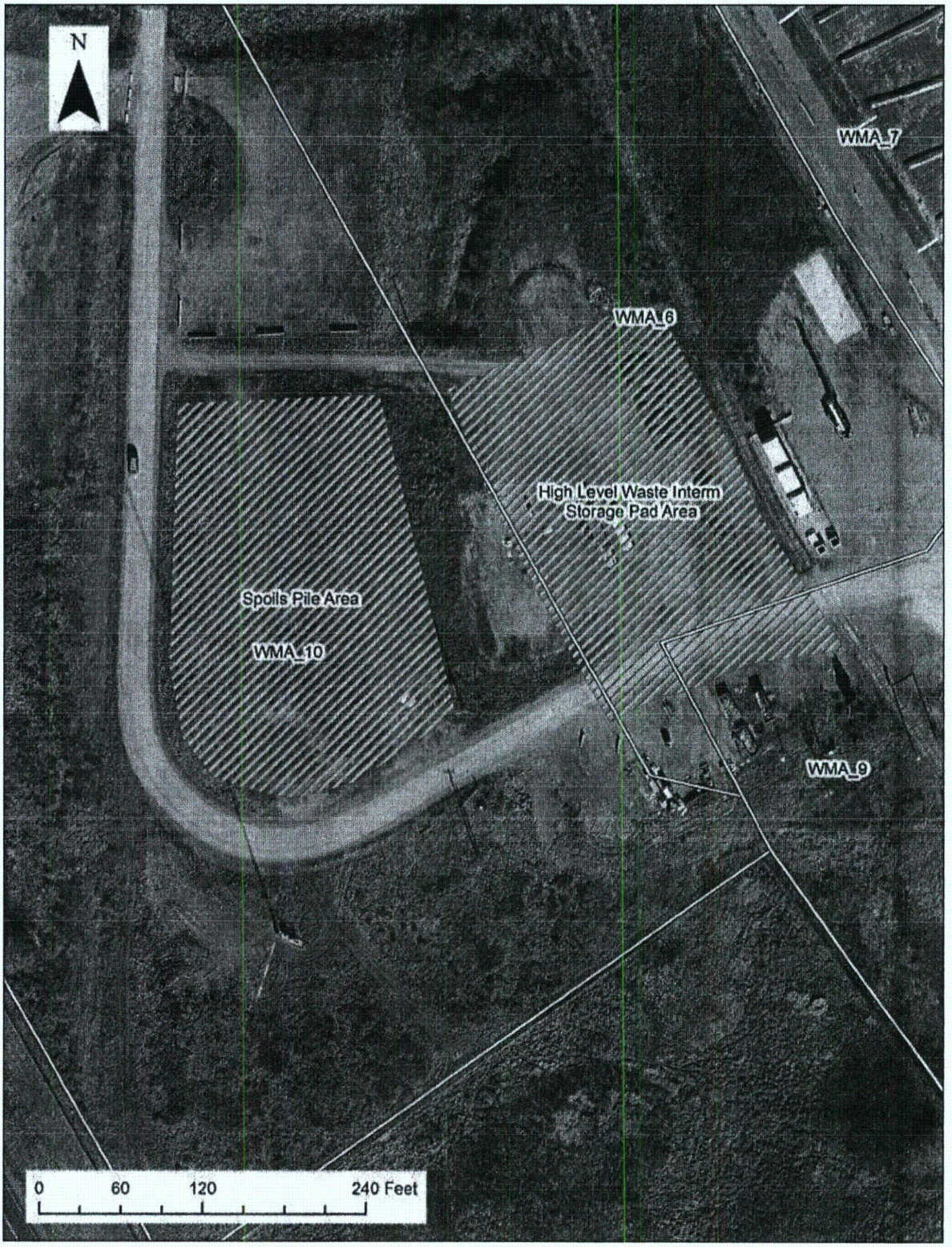


Figure 1-1. Study Area

Table 1-1. Radionuclides of Interest and Potential Radionuclides of Interest

Radionuclide	Minimum Volume	Analysis Method	Required Detection Limit (pCi/g)
Radionuclides of Interest			
Am-241	5 g	EML HASL 300 A-01-R (alpha spectroscopy)	1
C-14	100 g	EERF C-01-1 (liquid scintillation)	2
Cm-243	5 g	EML HASL 300 A-01-R	1
Cm-244	5 g	EML HASL 300 A-01-R	1
Cs-137	500 g	EML HASL 300 Ga-01-R (gamma spectroscopy)	0.1
I-129	500 g	EML HASL 300 Ga-01-R	1
Np-237	5 g	EML HASL 300 A-01-R	0.05
Pu-238	5 g	EML HASL 300 A-01-R	1
Pu-239	5 g	EML HASL 300 A-01-R	1
Pu-240	5 g	EML HASL 300 A-01-R	1
Pu-241	5 g	EML HASL 300 A-01-R	15
Sr-90	5 g	EML HASL 300 Sr-03-RC (extraction, gross beta)	0.9
Tc-99	100 g	EML HASL 300 TC-02-RC (extraction, gross beta)	3
U-232	5 g	EML HASL 300 A-01-R	0.5
U-233	5 g	EML HASL 300 A-01-R	0.2
U-234	5 g	EML HASL 300 A-01-R	0.2
U-235	5 g	EML HASL 300 A-01-R	0.1
U-238	5 g	EML HASL 300 A-01-R	0.2
Potential Radionuclides of Interest			
Ac-227	500 g	EML HASL 300 Ga-01-R	0.5
Co-60	500 g	EML HASL 300 Ga-01-R	0.5
Eu-154	500 g	EML HASL 300 Ga-01-R	1
H-3	100 g	EML HASL 300 H3-04-RC (liquid scintillation)	25
Pa-231	500 g	EML HASL 300 Ga-01-R	3
Ra-226	500 g	EML HASL 300 Ga-01-R	0.5
Ra-228	500 g	EML HASL 300 Ga-01-R	1
Sb-125	500 g	EML HASL 300 Ga-01-R	1
Sn-126	500 g	EML HASL 300 Ga-01-R	1
Th-229	500 g	EML HASL 300 Ga-01-R	1
Th-232	500 g	EML HASL 300 Ga-01-R	0.5

1.3 Survey Units

Two survey units were identified to attain the first two objectives for this characterization. The two units are the Lavery Till surface formed after the fill soil was excavated from the HLW Canister Interim Storage Area, and the spoils pile where the excavated fill was deposited. Survey unit 1 was sampled and surveyed via GWS. Survey unit 2 was only surveyed via GWS. The GWS for survey unit 2 consisted of six surveys as the spoils pile was built up in six lifts.

2.0 CHARACTERIZATION ACTIVITIES AND RESULTS

The site was characterized by performing GWSs, collecting soil samples with a geoprobe, and performing a civil survey to record the sampling locations. Systematic and biased locations were sampled. Gamma radiation was measured at each sampling location. The soil cores were scanned for gross gamma radiation. Results of the soil samples taken in Lavery Till were compared to sample results from a background reference area having Lavery Till. This background reference area is referred to as Background Reference Area 2 in the *Terrestrial Background Study* (SEC 2013b). The background reference area was surveyed using GWS and by collecting soil samples.

The work performed is specified in the FSP for Task Order 9 (SEC 2013a) and briefly summarized in this section. FSP data collection results are presented and interpreted in this characterization report.

Gross gamma measurements were made with the field instrument for detecting low energy radiation (FIDLER) for 30 seconds each, 15 cm above the ground surface at the location where each soil sample was collected. A gross gamma measurement was made before a soil sample was collected.

2.1 Gamma Walkover Survey

SEC performed a GWS of 100% of the accessible area of ground surface formed after excavation in the HLW Canister Interim Storage Area was completed with a FIDLER detector. The entire survey unit was 4,485 square meters (m^2) and 3,234 m^2 were surveyed. No survey of the side slopes of the excavation was possible because they were too steep to walk.

The spoils pile was built in 1- to 2-ft lifts of soils from the excavated area. A GWS with a FIDLER detector was performed after each of these lifts was completed. The area surveyed on each subsequent lift was less due to the slopes of the pile.

The detectors were coupled to a Large Area GPS Gamma Survey System (LAGGSS) consisting of a Trimble Global Positioning System (GPS) unit coupled to FIDLER detectors to survey the area and subsequently download and plot the results to provide a visual map and the relative gross gamma radiation. The SEC LAGGSS delivers multiple gross gamma radiation results and coordinates per square meter of surface area. The raw data was processed into graphic depictions of gamma ray count contours to aid in the selection of biased sample locations.

The walkovers were performed using the detector cart shown in Photograph 1 in Appendix A in the excavated areas of the site. Detectors on the cart were positioned no farther apart than 85 cm to assure the minimum data density of one measurement per square meter would not be exceeded. A technician walked with the detector on the spoils pile where cart access was not practical.

The LAGGSS recorded a survey measurement and a paired position every second. The GPS attained sub-meter accuracy (x, y data). Data were electronically logged and included coordinates in New York West State Plane coordinates (NAD83). Coordinates were measured with sub-meter accuracy with a density of approximately 11 points per square meter, exceeding the FSP requirement of attaining at least one measurement per square meter. The data contained

counts per minute (cpm), northing and easting (x, y), and position dilution of precision (PDOP), date, and time. The average walkover speed was approximately 0.5 meters per second (m/s) in accordance with the survey plan.

Figure 2-1 shows GWS results in the HLW Canister Interim Storage excavation area after all excavation was performed just prior to concrete being poured. GWS results for each lift during construction of the spoils pile are shown in Figures 2-2 – 2-7.

There were HLW vitrification vessels located along the southeastern boundary of the study area as shown in Photograph 2 in Appendix A. These vessels were in an area posted as a Radiation Area, meaning that the gamma exposure rate at 30 cm from the surfaces exceeded 5 millirems per hour (mR/hr). This Radiation Area caused a significant gamma radiation signal, referred to as shine, in the excavation area, but not on the spoils pile which was sufficiently far away. Some of the shine in the excavation area was reduced by shielding provided by excavation equipment parked in front of the vessels and additional shine reduction was afforded by the wall of the excavation.

The radiation shine is evident along the eastern portion of the excavation. All of the gamma count rate data greater than 40,918 cpm (shown in red on Figure 2-1) was determined to be shine except for the area near soil sample location B01. The contamination was at approximately 7 ft below original ground surface and extended into the floor of the excavation. This contamination was removed by CH2M Hill B&W West Valley, LLC (CHBWV) as practical with shovels. A gamma radiation survey was then performed and a soil sample was collected at B01 to document "as-left" conditions. The final "as-left" gamma survey results are as depicted on Figure 2-1.

Figure 2-2 shows the GWS for the first lift of the spoils pile. Radioactivity above background may have been detected at the gold-colored area on the southwest area of this lift, although this cannot be stated with certainty because the affected area was small and the count rate could still have been indicative of the upper bound of background for this location.

Figure 2-3 shows the GWS for the second lift of the spoils pile. The measurements were made as a light rain began to fall. The elevated readings shown across this lift were revealed when the gamma survey map was produced the following day. The elevated readings were believed to be radon-daughter atmospheric plate-out that commonly occurs during the first part of a rain storm, although this cannot be concluded with certainty. No above-background radioactivity was suspected by the survey technician at the time the measurements were made because discrete areas or spots of contamination did not occur.

Figure 2-4 shows the GWS for the third lift of the spoils pile. While the surveyor was collecting the data he did not notice the above-background radiation signal. Construction of the fourth lift began before the visual image of the GWS was available. It appears that there is a spot of elevated radiation near the center of the lift as depicted by the gold-colored area on the GWS map.

Figure 2-5 shows the GWS for the fourth lift of the spoils pile. The surveyor detected elevated radiation signal when performing the GWS after the lift was constructed. The construction contractor was notified and this resulted in a careful survey of additional soil as it was excavated so that it could be segregated and removed before placement on the spoils pile. The contaminated

material that had been placed on the spoils pile was remediated as was practicable using only the gamma radiation surveys to guide the removal. No soil sampling was performed to verify that the contaminated material was removed because laboratory results could not be obtained immediately and further excavation and deposition on the spoils pile could not cease due to work scheduling needs.

Figure 2-6 shows the GWS for the fifth lift. Spoil soil was only placed in the northern portion of this lift. It cannot be stated with certainty whether contamination was present along the eastern boundary of the lift. The several data points between 17,000 cpm and 19,000 cpm could represent contamination or could represent the upper range of background. Figure 2-8 is a frequency distribution of the count rate data. Perhaps there is a second data distribution indicating radioactivity above background, but this cannot be stated with certainty.

Figure 2-7 shows the GWS for the sixth and final lift. This survey was completed for the spoils pile in its final configuration. No radiation above background was detected from this final lift. Note that this survey was for the top of the spoils pile and did not include the side slopes. The side slopes were already surveyed for the other lifts as they were completed.

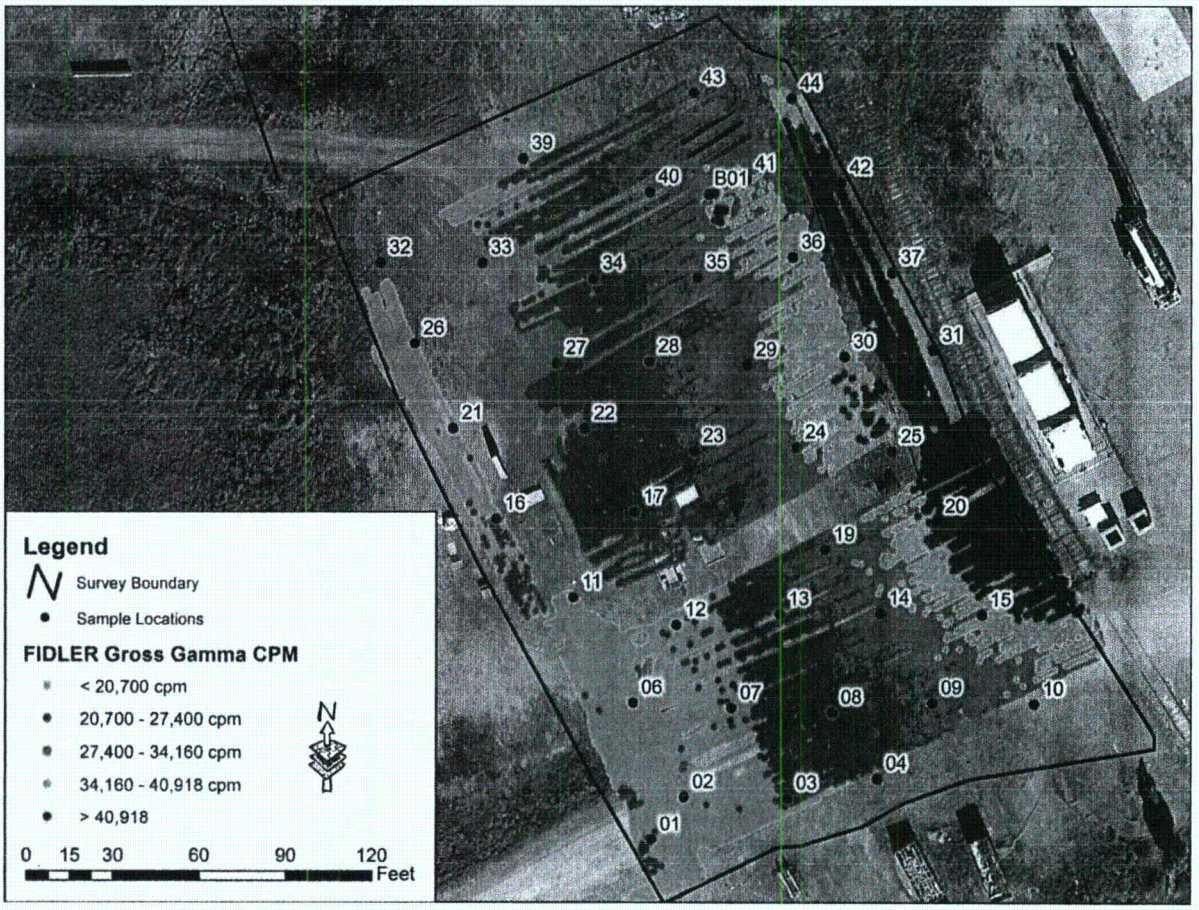


Figure 2-1. GWS Results HLW Canister Interim Storage Excavation Area

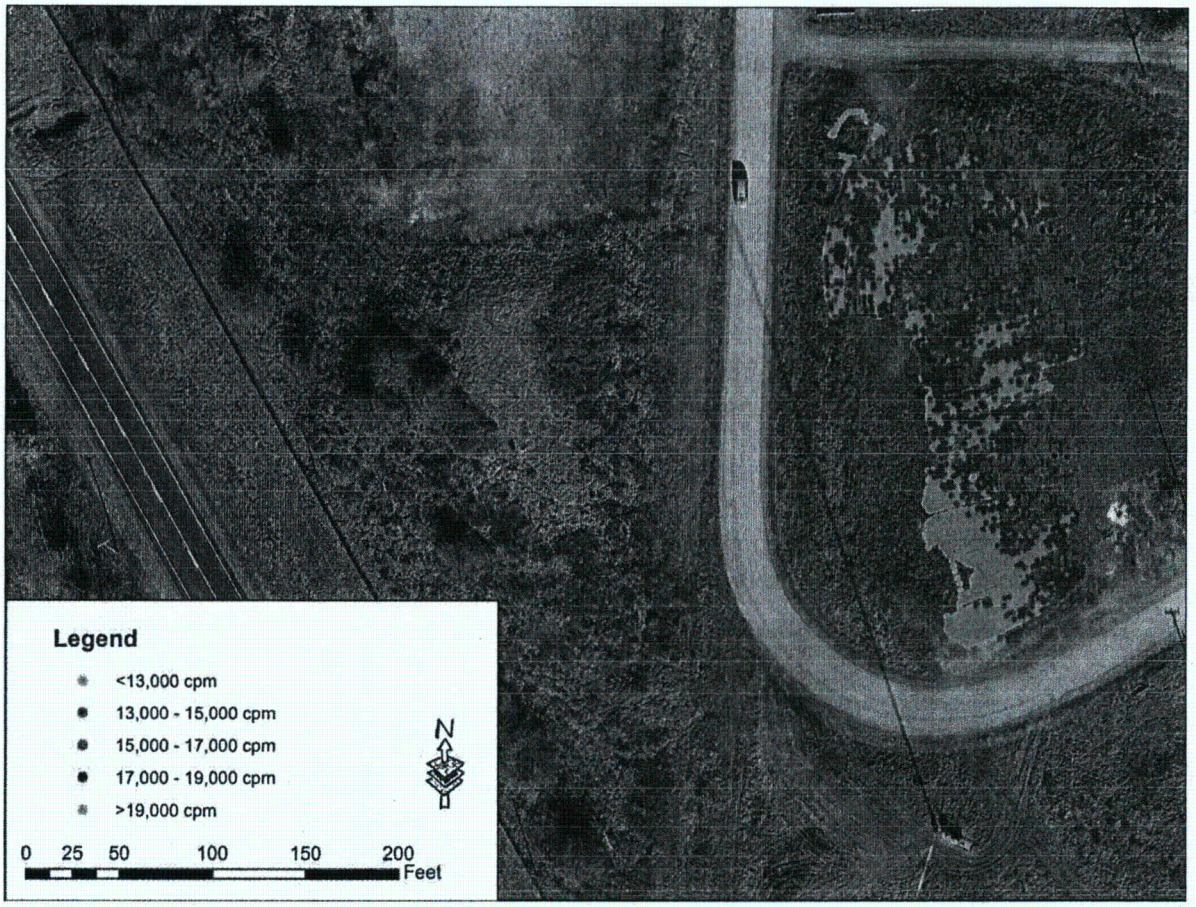


Figure 2-2. GWS for First Lift as Spoils Pile Was Constructed

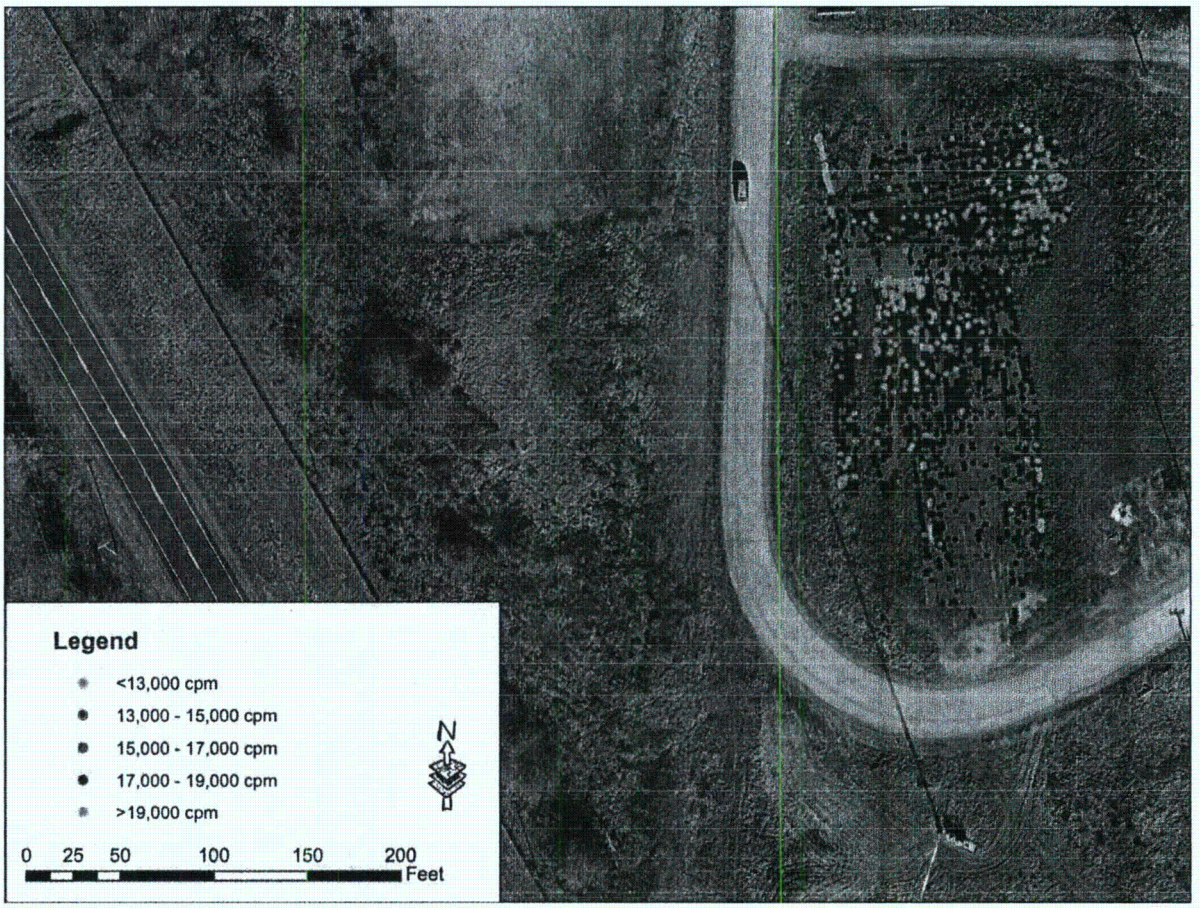


Figure 2-3. GWS for Second Lift as Spoils Pile Was Constructed

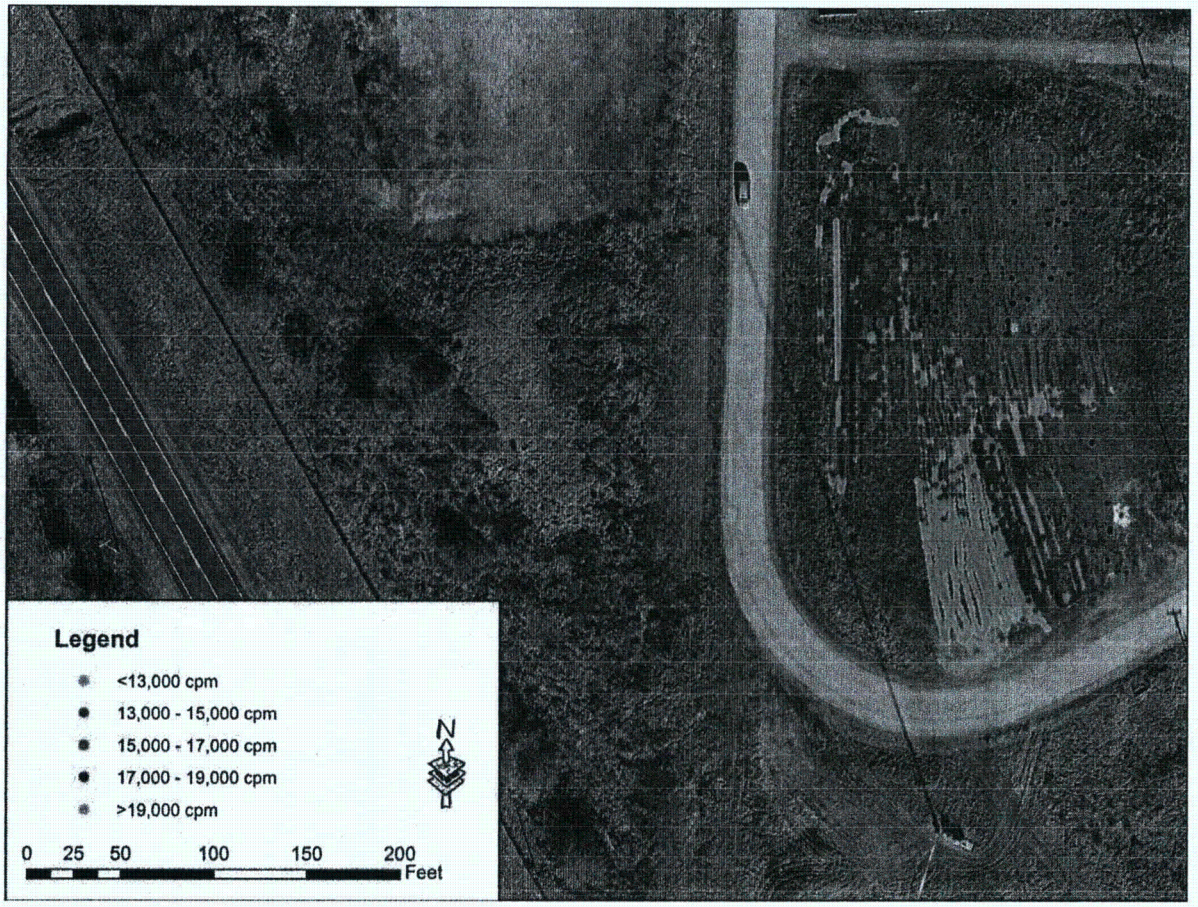


Figure 2-4. GWS for Third Lift as Spoils Pile Was Constructed

Figure 2-5. GWS for Fourth Lift as Spoils Pile Was Constructed

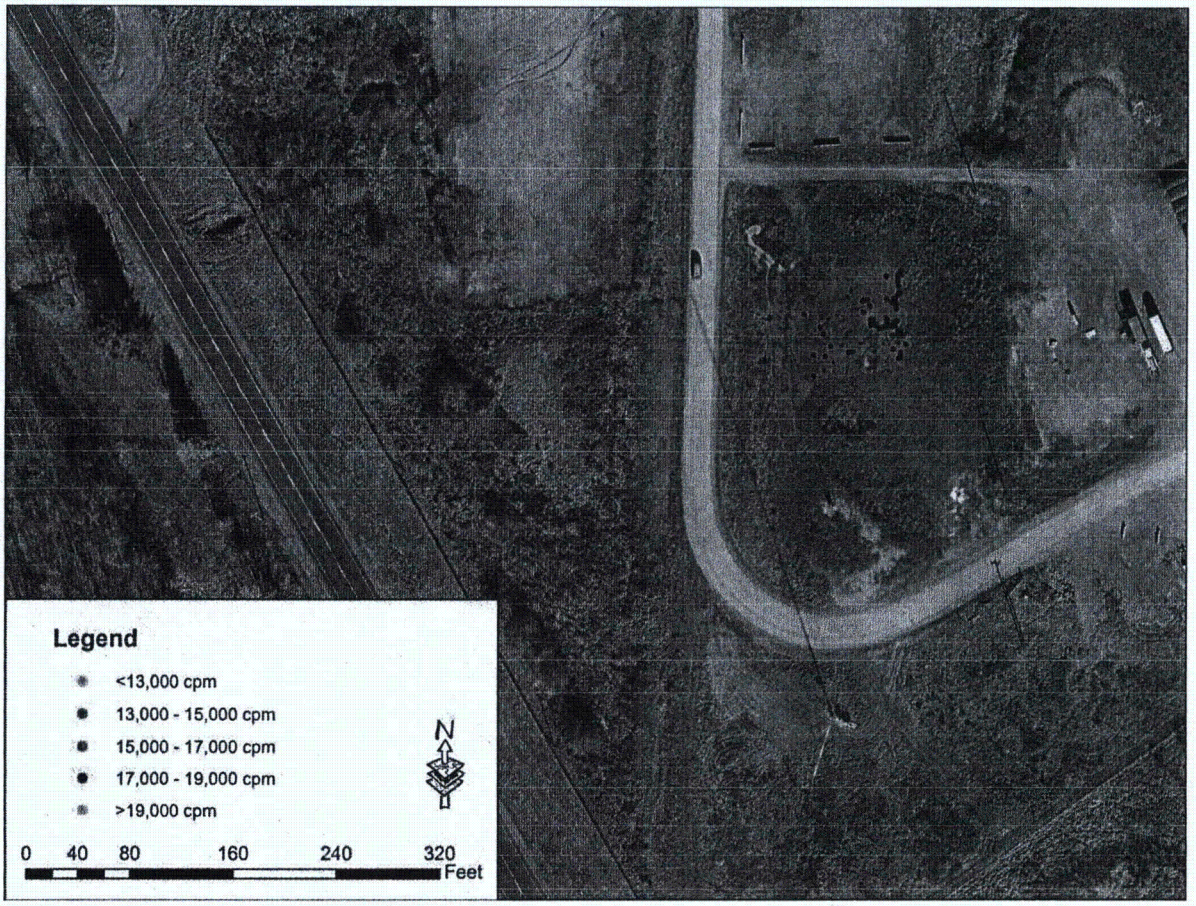


Figure 2-6. GWS for Fifth Lift as Spoils Pile Was Constructed

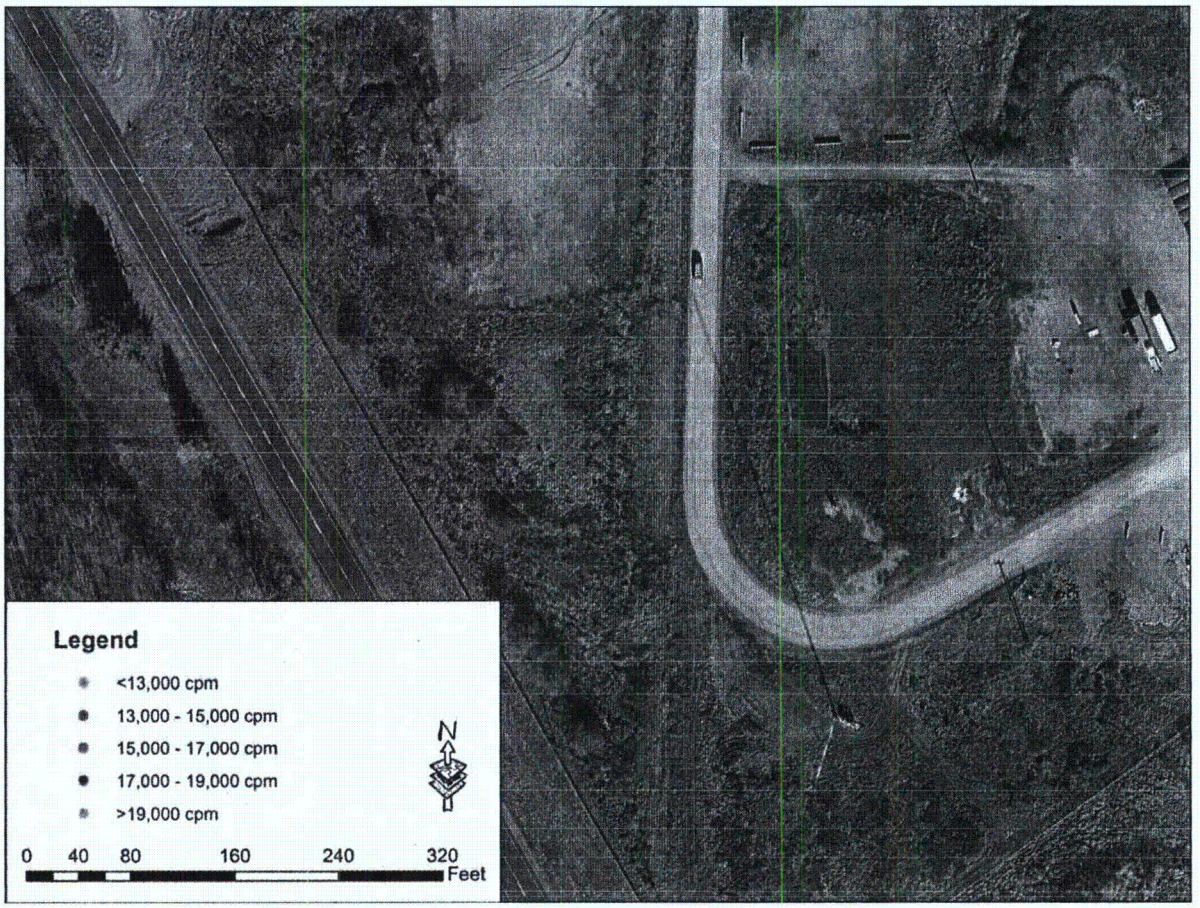


Figure 2-7. GWS for Sixth (and Final) Lift as Spoils Pile Was Constructed

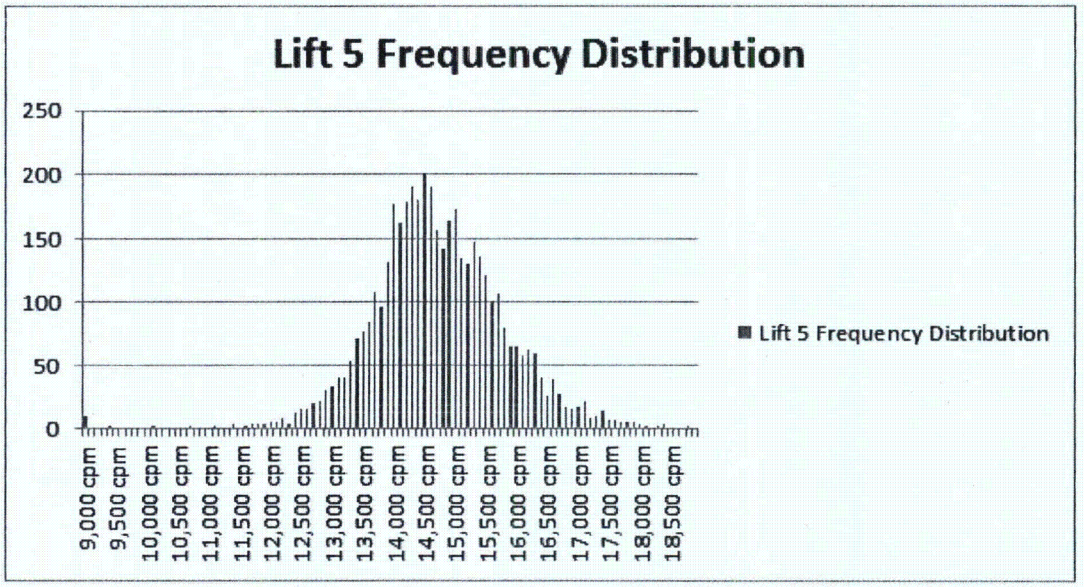


Figure 2-8. Count Rate Frequency Distribution

Table 2-1 provides a summary of the gamma walkover statistics for the FIDLER detectors used during the walkover of the floor of the excavated area. Provided are measurement minimum, maximum, standard deviation, average, median, and average walking velocity. These statistics are skewed by the contamination that was detected in the northeast part of the excavation and mostly by shine that affected the detectors along the eastern side of the survey area.

Table 2-1. Detector Statistics

Statistic	Result
Minimum	11,370 cpm
Maximum	121,580 cpm
Standard Deviation	9,368 cpm
Average	27,832 cpm
Median	25,393 cpm
Average Velocity	0.5 m/s
Number of Measurements	36,023

2.2 Soil Sampling

Forty-four systematic sample locations were established on a 100 m^2 triangular-spaced grid as shown on Figure 2-9. Radioactivity was detected while the fill material was being excavated. This resulted in the entire excavation being classified as an impacted, Class 1 survey unit which requires a sample grid spacing of 100 m^2.

Samples were collected from 41 of the 44 locations. Samples were not collected from locations 5 and 38 because they fell on the slope of the excavation and moving them into the excavation would have resulted in the locations falling too close to another location such that a sample collected there would be redundant. Location 18 was not sampled because it fell within a trench in the excavation and moving the location would have caused data to be redundant with another already-established location.

All samples were collected as specified in the CSAP from 0 – 100 cm below the ground surface formed by the excavation. All samples were collected using direct-push drilling methods (geoprobe), with one exception — a single biased sample was collected with a gasoline-powered auger as this sample was collected when the geoprobe was not available.

A sufficient volume of soil was collected allowing all 18 ROIs and 11 PROIs to be analyzed according to the methods shown in Table 1-1. Sufficient sample volume was approximately 900 grams (g).

A 30-second static FIDLER count was performed at a distance of 15 cm above the ground surface prior to acquiring samples at all but two locations. These readings were omitted in error. The location (coordinates) of the sample was recorded in NY State Plane West NAD83 with a quality of ± a hundredth of a foot (± 0.01 ft) for each sample. Table 2-2 includes the sample count rates that were converted to cpm (30 second measurement multiplied by two).

Samples obtained by direct push methods were collected in acetate liners. Once removed from the steel collection tube, the acetate liners were cut open and the sample was extracted and

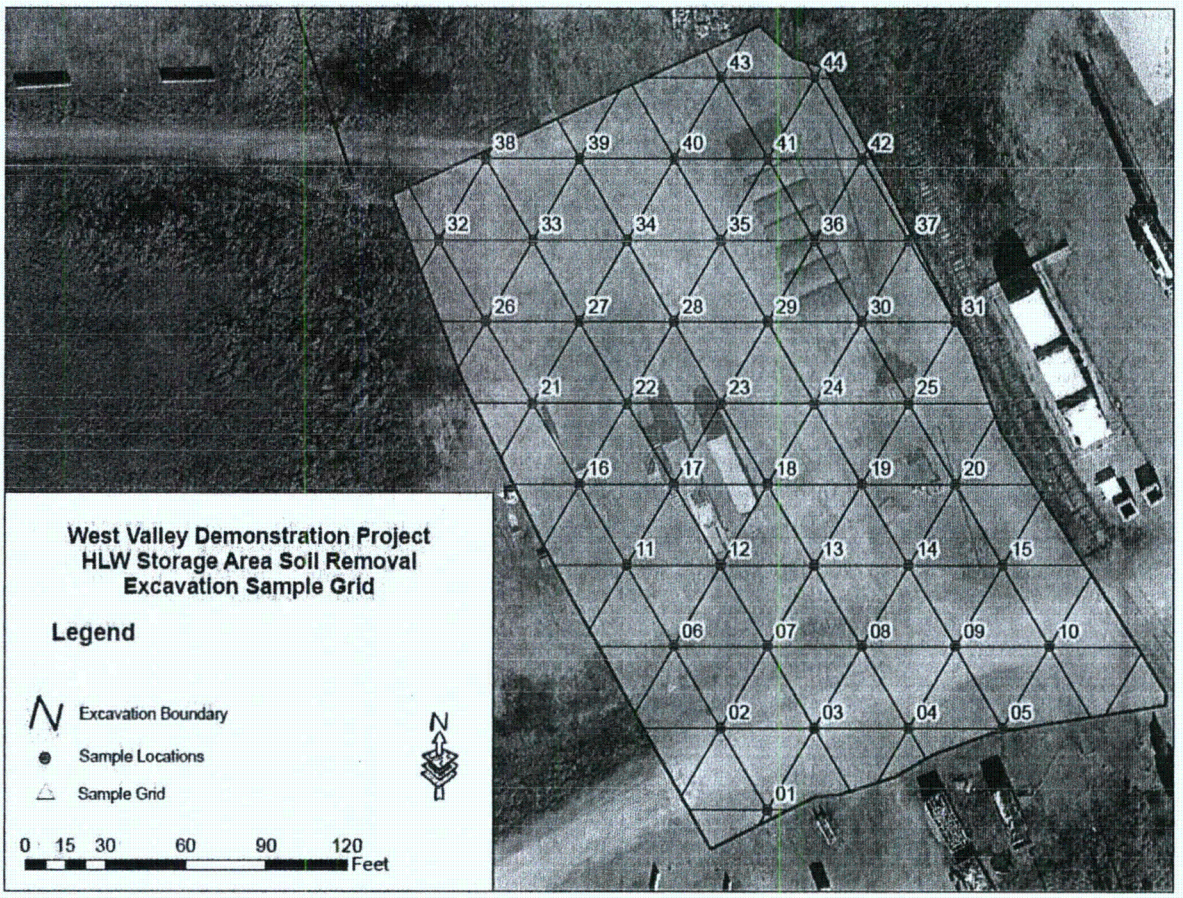


Figure 2-9. Soil Sampling Grid in Excavation Area

Table 2-2. Sample Static Measurements and Locations

Location	FIDLER (cpm)	Northing	Easting	Elevation
01	19,408	891171.25	1129638.88	1388.20
02	18,578	891186.13	1129650.29	1388.87
03	20,936	891185.74	1129686.38	1391.13
04	24,046	891192.48	1129717.54	1391.18
06	19,040	891218.67	1129632.43	1388.25
07	20,814	891216.77	1129666.76	1389.73
08	24,462	891215.27	1129701.93	1391.01
09	27,406	891218.59	1129736.68	1391.09
10	29,954	891218.22	1129772.07	1391.27
11	#	891255.07	1129611.74	#
12	19,048	891245.49	1129647.50	1389.29
13	24,238	891249.27	1129683.54	1390.77
14	30,926	891249.57	1129718.49	1391.23
15	38,446	891248.97	1129753.78	1391.37
16	18,994	891282.68	1129584.68	1392.25
17	23,466	891285.13	1129633.03	1383.61
19	29,456	891271.89	1129699.36	1390.76
20	44,822	891281.75	1129737.98	1391.13
21	19,530	891314.47	1129569.62	1392.06
22	21,956	891314.36	1129615.77	1382.32
23	26,836	891306.51	1129653.78	1386.03
24	29,676	891307.90	1129689.39	1388.56
25	39,216	891306.35	1129722.56	1385.94
26	16,492	891343.76	1129556.22	1392.12
27	20,972	891336.87	1129606.02	1384.71
28	26,178	891337.49	1129638.16	1386.10
29	28,980	891336.30	1129672.18	1388.09
30	37,022	891339.05	1129706.05	1389.28
31	43,770	891341.34	1129736.82	1392.48
32	16,346	891371.73	1129544.31	1392.26
33	#	891371.58	1129579.83	1382.93
34	23,628	891366.15	1129618.70	1386.35
35	29,294	891366.66	1129654.90	1387.12
36	35,112	891373.57	1129688.03	1389.88
37	57,032	891368.35	1129722.50	1392.69
39	23,440	891407.75	1129594.11	#
40	27,096	891396.35	1129638.16	1385.65
41	32,730	891400.80	1129671.87	1388.39
42	47,370	891399.49	1129704.82	1392.76
43	20,840	891430.98	1129653.42	1387.01
44	29,954	891428.97	1129687.53	1392.86
B01	39,972	891395.58	1129658.81	#

Data not obtained.

placed into a mixing bowl for homogenization and packaging. Sample collection was performed on a table that was covered with plastic sheeting. The typical sample collection approach is shown in Photograph 3 in Appendix A.

Sample tools and drilling equipment was wiped clean with masslin and 409 cleaning solution as necessary to remove visible dirt. Tools were scanned for alpha and beta-gamma radiation and a swipe for radioactive contamination was collected. The swipe was counted in a low background counter in the sampling van. No gross alpha radiation exceeding the instrument lower critical level (Lc) of 1 cpm was ever detected on the sampling equipment. No gross beta-gamma contamination exceeding the Lc of 19 cpm was ever detected on the sampling equipment. The swipe counter is shown in Photograph 4 in Appendix A.

Samples were scanned for gamma radiation before they were homogenized. This was done to help determine if there are discrete horizons of radioactive contamination in the soil cores. None were found.

Laboratory analytical results are provided in Sections 2.2.1 through 2.2.3. There were no field changes or other deviations from the FSP.

2.2.1 Evaluation of Results

Sample results were reviewed in light of background concentrations taking into account the error associated with sample results and minimum detectable activity (MDA). A discussion of background concentrations is provided in reference SEC 2013b (*Terrestrial Background Study*).

Background comparisons are based on results from the reference area surface soil sampling analyses. The 95 percent upper tolerance limit (UTL) was estimated for each radionuclide that could be expected to be present in measurable quantities in background soils (i.e., naturally occurring radionuclides and those anthropogenic radionuclides present in background surface soils due to historical fallout) based on the 0 – 15 cm deep sample results and the 15 – 100 cm deep sample results for the Background Reference Areas 1 and 2. Sample locations 1–15 were from the approach apron and had characteristics of sand and gravel, represented by Background Reference Area 1. Sample locations 16–44 were taken in Lavery Till, represented by Background Reference Area 2. The raw sample results were used to perform the UTL calculations regardless of whether sample results were considered detections or not. The naturally occurring radionuclides evaluated in this manner were carbon-14, tritium, uranium-234, uranium-235, uranium-238, actinium-227, protactinium-231, radium-226, and radium-228. Note that the thorium-232 results were inferred from the gamma spectroscopy results for Ra-228 and, therefore, the results for these two radionuclides are the same. Review of the overall data set including the background sampling results revealed that cesium-137 was the only anthropogenic radionuclide found in fallout with enough results in excess of the MDA to compute a meaningful 95 percent UTL; and this was only possible for the samples collected from 0 – 15 cm. Sample results for these radionuclides were considered inconsistent with background if the activity concentration of one or more radionuclides exceeded its respective 95 percent UTL. All other ROIs and PROIs were considered inconsistent with background when a soil sample result was greater than three times its reported uncertainty (DOE 2011).

2.2.2 Systematic Sample Results from Survey Unit 1 – HLW Canister Interim Storage Area Excavation

Forty-four systematic sample locations were required in the approximately 4,400 m^2 excavated area. Samples were collected at 41 of the locations as discussed above.

The tables in Appendix B contain the analytical results for the ROIs and PROIs. These tables include the sample results, total propagated uncertainty (TPU), and the MDA. The TPU is the analytical error at two standard deviations taking into account all potential error sources, including sample counting error, background counting error, error in tracer yield, etc. The soil sample analytical data is evaluated in light of background sampling in Background Reference Areas 1 and 2, and the MDA.

The results are summarized in Tables 2-3 and 2-4 for the ROI and PROI, respectively. The tables show the analytical result along with notations whether the result exceeded the MDA and was considered inconsistent with background according to the criteria specified in Section 2.2.1. Values shown in bold font were determined to exceed the analytical MDA. Underlined values reflect whether the sample was determined inconsistent with background.

2.2.3 Biased Sample Results from Excavated Area

Gamma radiation exceeding background was found in the northeast corner of the HLW Canister Interim Storage Area excavation. The contamination seemed to be in a lens of soil material mixed with pieces of asphalt. The lens ran in a north-south direction near the excavation floor and appeared to extend to the north outside of the excavation area.

One biased sample was collected by SEC as shown on Figure 2-1. Table 2-5 shows the results of the biased samples for the ROI. Table 2-6 has the results of the biased samples for the PROI.

Table 2-3. Systematic Sample ROI Results

Loc. No.	Depth (cm)	Am-241 Result	C-14 Result	Cm-243/ Cm-244 Result	Cs-137 Result	I-129 Result	Np-237 Result	Pu-238 Result	Pu-239/ Pu-240 Result	Pu-241 Result	Sr-90 Result	Tc-99 Result	U-232 Result	U-233/ U-234 Result	U-235 Result	U-238 Result
01	0-100	0.086	-0.129	0.065	-0.029	-0.320	0.015	0.070	0.160	-0.457	0.091	-0.472	-0.003	**0.941**	0.044	**1.03**
02	0-100	0.089	0.232	-0.056	0.025	-0.159	-0.003	-0.038	0.063	-0.975	-0.280	-0.093	0.002	**0.948**	**0.111**	**0.980**
03	0-100	0.000	-0.980	-0.054	0.001	0.038	-0.003	0.121	0.046	1.48	0.205	0.022	0.036	**0.850**	0.006	**1.01**
04	0-100	0.256	0.038	-0.091	-0.043	-0.011	-0.004	0.065	0.099	1.64	-0.398	0.504	-0.037	**0.707**	**0.063**	**0.739**
06	0-100	0.040	-0.339	-0.018	-0.017	-0.307	-0.001	0.144	0.144	1.81	-0.138	0.309	0.024	**0.898**	**0.054**	**0.886**
07	0-100	0.099	-0.573	-0.045	-0.025	-0.193	-0.002	-0.044	0.100	2.96	-0.098	0.550	-0.015	**0.856**	0.032	**0.974**
08	0-100	-0.075	-0.312	-0.025	0.000	-0.273	0.002	-0.045	0.157	-1.50	0.115	0.341	-0.009	**0.868**	**0.098**	**1.13**
09	0-100	0.004	0.033	-0.026	0.029	-0.243	-0.004	0.041	-0.039	1.39	0.270	0.204	-0.001	**0.957**	0.045	**0.970**
10	0-100	0.000	0.126	-0.045	0.001	0.474	0.000	0.068	-0.062	-0.340	0.092	-0.107	-0.009	**0.804**	0.047	**0.909**
11	0-100	0.058	0.306	-0.016	**1.13**	-0.558	-0.001	0.034	0.017	-1.53	0.124	0.142	0.044	**0.989**	**0.105**	**0.714**
12	0-100	-0.052	-0.185	0.126	0.004	0.180	-0.003	0.000	-0.113	0.752	0.377	-0.077	-0.006	**0.504**	0.033	**0.593**
13	0-100	-0.022	-0.658	-0.066	-0.003	0.166	-0.009	-0.029	0.331	2.73	-0.472	0.832	0.021	**0.811**	0.038	**0.982**
14	0-100	0.083	-0.103	-0.026	-0.022	-0.058	-0.001	-0.016	-0.109	1.50	0.642	0.478	0.008	**1.11**	0.042	**0.965**
15	0-100	0.000	-0.476	-0.025	-0.040	-0.128	-0.002	-0.023	-0.035	1.81	0.462	0.050	-0.019	**0.759**	**0.078**	**0.995**
16	0-100	0.032	-0.284	0.032	**0.708**	0.028	-0.004	0.014	0.033	-3.39	0.150	-0.898	0.031	**0.950**	0.047	**1.15**
17	0-100	0.025	0.216	-0.009	-0.016	0.050	0.003	0.041	0.006	-1.18	-0.305	-0.815	0.036	**1.25**	**0.159**	**1.38**
19	0-100	0.106	-0.733	-0.076	-0.021	0.258	-0.003	-0.019	-0.019	4.40	0.185	0.512	-0.008	**1.05**	**0.072**	**1.10**
20	0-100	-0.054	0.022	-0.081	-0.047	-0.318	-0.006	0.000	0.000	3.35	0.252	0.017	0.014	**0.934**	**0.053**	**1.13**
21	0-100	0.038	-0.469	0.000	**0.770**	0.080	0.000	0.039	0.0009	-2.00	**0.520**	-0.233	0.008	**0.767**	**0.075**	**0.765**
22	0-100	0.000	-0.861	0.000	-0.043	-0.006	-0.002	-0.009	0.015	**7.20**	0.173	0.365	0.048	**0.762**	0.113	**0.768**
23	0-100	0.007	0.099	0.036	-0.021	0.065	-0.001	-0.004	0.019	-4.72	-0.005	0.366	-0.002	**1.02**	**0.064**	**1.02**
24	0-100	0.024	0.510	-0.016	0.036	-0.126	0.000	-0.011	0.042	-3.46	-0.184	1.00	-0.003	**1.01**	**0.086**	**0.943**
25	0-100	-0.007	0.216	-0.003	-0.012	-0.117	-0.002	0.022	0.019	-7.54	-0.021	0.571	0.013	**0.904**	0.004	**0.985**
26	0-100	0.018	-0.164	0.007	**1.25**	**0.313**	-0.005	-0.020	0.057	-1.53	0.023	-0.041	0.030	**0.946**	**0.086**	**0.826**
27	0-100	0.004	0.212	0.007	0.017	0.041	0.004	-0.022	0.027	-8.88	-0.187	-0.123	0.023	**1.08**	**0.052**	**0.872**
28	0-100	0.033	0.263	0.007	0.017	-0.210	0.002	0.028	0.001	-7.20	-0.253	0.557	-0.014	**1.02**	**0.101**	**1.16**
29	0-100	0.015	0.425	-0.017	0.007	-0.086	0.004	-0.006	0.004	-1.85	-0.118	-0.273	0.006	**0.820**	**0.054**	**1.03**
30	0-100	0.026	0.458	-0.009	-0.044	0.284	-0.003	-0.010	-0.003	-1.39	0.088	0.438	-0.000	**1.01**	**0.049**	**1.16**
31	0-100	0.042	0.073	0.041	**3.23**	**0.429**	0.001	0.033	0.038	-0.293	-0.216	0.202	0.001	**3.08**	**0.14**	**3.08**
32	0-100	-0.005	-0.309	0.032	**0.260**	0.347	-0.001	0.039	0.014	0.801	0.0935	-0.395	-0.021	**0.721**	0.055	**0.690**

Loc. No.	Depth (cm)	Am-241 Result	C-14 Result	Cm-243/ Cm-244 Result	Cs-137 Result	I-129 Result	Np-237 Result	Pu-238 Result	Pu-239/ Pu-240 Result	Pu-241 Result	Sr-90 Result	Tc-99 Result	U-232 Result	U-233/ U-234 Result	U-235 Result	U-238 Result
33	0-100	-0.009	-0.168	-0.018	0.008	**0.224**	-0.001	0.005	0.009	-4.55	-0.112	-0.363	0.205	**0.918**	0.080	1.12
34	0-100	0.012	0.084	-0.003	0.026	0.100	0.002	0.000	0.000	-7.11	-0.347	0.016	-0.013	**0.903**	**0.053**	1.28
35	0-100	-0.012	-0.025	-0.020	0.020	0.019	0.002	-0.015	0.009	-1.40	0.004	-0.180	0.014	1.10	**0.051**	1.09
36	0-100	0.007	-0.282	0.006	0.009	0.195	0.010	-0.010	0.004	-2.50	-0.165	0.033	-0.010	1.02	**0.054**	1.17
37	0-100	0.087	0.339	0.021	0.565	0.044	-0.000	0.227	0.059	-0.117	-0.258	-0.070	-0.019	1.50	0.096	1.45
39	0-100	-0.011	0.150	-0.008	-0.015	-0.131	0.001	0.007	-0.005	-0.227	-0.163	-0.419	-0.007	**0.922**	**0.021**	1.10
40	0-100	0.027	0.516	-0.010	-0.035	-0.008	-0.004	0.010	0.009	-6.17	0.145	0.210	0.011	**0.843**	0.031	1.21
41	0-100	0.037	-0.098	-0.003	-0.041	0.325	0.004	0.037	-0.004	1.91	-0.087	-0.221	-0.019	**0.954**	**0.100**	1.05
42	0-100	0.189	0.056	0.017	1.13	0.121	0.001	0.426	**0.139**	3.70	-0.177	-0.286	-0.002	1.74	**0.119**	1.77
43	0-100	-0.003	0.281	0.007	0.011	-0.010	0.000	-0.003	0.015	-1.66	-0.004	0.382	-0.009	**0.882**	0.025	0.984
44	0-100	0.103	0.240	0.011	2.84	0.190	-0.002	0.006	0.037	2.16	-0.172	-0.097	0.057	1.56	0.181	1.77

1. Results are gross pCi/g.
2. **Bold** results represent analytical results greater than the respective MDA.
3. Underlined results represent analytical results inconsistent with background as discussed in Section 2.2.1.

Table 2-4. Systematic Sample PROI Results

Loc. No.	Depth (cm)	Ac-227 Result	Co-60 Result	Eu-154 Result	H-3 Result	Pa-231 Result	Ra-226 Result	Ra-228 Result	Sb-125 Result	Sn-126 Result	Th-229 Result	Th-232 Result
01	0-100	-0.047	0.057	-0.193	1.78	-0.638	1.24	1.53	-0.026	0.000	0.166	1.53
02	0-100	-0.035	-0.025	-0.064	0.938	-0.988	1.15	1.40	0.044	0.130	-0.082	1.40
03	0-100	0.111	0.014	-0.009	-0.912	1.15	1.13	1.37	0.076	0.000	0.109	1.37
04	0-100	0.138	0.031	0.051	-1.43	1.32	0.99	1.29	-0.021	0.000	0.078	1.29
06	0-100	-0.066	-0.029	-0.092	1.35	0.687	1.2	1.17	0.042	0.117	0.032	1.17
07	0-100	-0.025	-0.000	0.065	1.33	0.280	0.775	0.868	-0.054	0.062	-0.009	0.868
08	0-100	-0.062	0.020	0.046	-0.163	-0.773	1.24	1.43	-0.030	0.095	0.002	1.43
09	0-100	-0.096	0.015	-0.049	1.66	-0.511	0.972	1.10	0.081	0.000	0.068	1.10
10	0-100	0.038	-0.014	-0.154	5.44	-1.50	1.29	0.877	0.025	0.000	-0.043	0.877
11	0-100	0.201	-0.017	0.025	-5.50	0.841	1.09	1.32	0.066	0.064	0.032	1.32
12	0-100	-0.026	0.003	-0.014	-0.120	0.288	0.823	1.14	0.046	0.079	-0.081	1.14
13	0-100	0.077	0.036	0.192	8.34	0.118	1.20	1.42	0.005	0.000	0.108	1.42
14	0-100	0.128	0.019	0.099	-4.82	-0.001	1.23	1.14	0.084	0.105	-0.019	1.14
15	0-100	0.061	-0.054	-0.067	-4.66	-0.193	1.18	1.08	0.030	0.000	0.205	1.08
16	0-100	0.058	0.005	-0.078	-4.45	0.109	0.977	1.38	-0.026	0.000	0.161	1.38
17	0-100	-0.202	0.041	0.066	-6.29	0.512	1.14	1.35	0.042	0.000	0.083	1.35
19	0-100	-0.206	0.003	-0.043	-0.716	0.506	1.12	1.09	-0.002	0.000	0.120	1.09
20	0-100	-0.141	-0.011	-0.123	-4.91	0.917	1.03	1.04	0.002	0.000	0.069	1.04
21	0-100	0.028	-0.014	-0.034	-3.14	0.334	0.906	1.06	-0.010	0.000	0.155	1.06
22	0-100	0.189	0.002	-0.043	-4.67	-0.236	0.998	1.52	-0.062	0.000	-0.037	1.52
23	0-100	-0.198	-0.033	0.098	7.76	0.834	1.15	1.53	0.005	0.000	0.058	1.53
24	0-100	-0.012	0.035	0.090	10.2	0.471	1.22	1.10	-0.026	0.000	-0.274	1.10
25	0-100	-0.268	0.022	-0.030	7.10	-0.919	0.798	1.15	-0.016	0.000	0.123	1.15
26	0-100	-0.045	0.004	0.089	-10.7	-1.10	0.938	1.04	-0.052	0.000	0.046	1.04
27	0-100	-0.144	-0.009	0.011	-1.86	-0.724	0.970	1.10	0.031	0.000	0.215	1.10
28	0-100	-0.187	0.022	-0.166	8.75	-0.977	1.18	1.41	0.078	0.000	-0.017	1.41
29	0-100	0.082	-0.016	-0.186	8.04	1.07	1.12	1.39	0.017	0.000	0.090	1.39
30	0-100	0.069	-0.004	0.029	8.11	-0.118	1.26	1.26	0.043	0.000	0.056	1.26
31	0-100	0.211	0.008	-0.094	-1.08	3.01	1.76	1.62	0.031	0.000	0.208	1.62
32	0-100	-0.007	-0.025	-0.024	-3.56	0.090	0.854	1.06	0.011	0.077	-0.097	1.06
33	0-100	-0.088	0.011	0.057	3.62	0.144	0.948	1.17	0.058	0.000	0.117	1.17
34	0-100	-0.071	-0.003	0.095	11.5	-0.631	0.885	1.33	-0.050	0.000	0.100	1.33
35	0-100	0.124	0.020	0.152	8.81	-0.439	0.986	1.26	0.028	0.000	0.108	1.26
36	0-100	0.014	0.017	-0.179	7.73	-0.054	1.15	1.35	-0.009	0.000	-0.054	1.35
37	0-100	0.256	0.006	0.034	-8.46	-1.12	2.67	1.63	-0.082	0.120	0.392	1.63
39	0-100	-0.189	-0.032	0.065	4.62	-1.50	0.799	1.25	0.066	0.143	0.097	1.25
40	0-100	-0.230	-0.023	0.067	9.31	-0.357	1.06	1.18	0.050	0.000	-0.016	1.18
41	0-100	0.018	0.016	-0.031	11.5	-0.177	1.16	1.23	0.003	0.000	-0.049	1.23
42	0-100	-0.012	0.015	0.004	0.934	-0.386	1.16	1.44	-0.064	0.000	0.029	1.44

Loc. No.	Depth (cm)	Ac-227 Result	Co-60 Result	Eu-154 Result	H-3 Result	Pa-231 Result	Ra-226 Result	Ra-228 Result	Sb-125 Result	Sn-126 Result	Th-229 Result	Th-232 Result
43	0-100	-0.015	0.030	-0.039	8.69	-1.21	**1.06**	**1.06**	-0.085	0.000	0.035	**1.06**
44	0-100	-0.194	0.012	0.069	2.37	-0.087	**1.15**	**1.30**	0.020	0.000	0.042	**1.30**

1. Results are gross pCi/g.
2. **Bold** results represent analytical results greater than the respective MDA.
3. Underlined results represent analytical results inconsistent with background as discussed in Section 2.2.1.

Table 2-5. Biased Sample ROI Results

Loc. No.	Depth (cm)	Am-241 Result	C-14 Result	Cm-243/ Cm-244 Result	Cs-137 Result	I-129 Result	Np-237 Result	Pu-238 Result	Pu-239/ Pu-240 Result	Pu-241 Result	Sr-90 Result	Tc-99 Result	U-232 Result	U-233/ U-234 Result	U-235 Result	U-238 Result
B01	0-100	0.031	-0.384	0.017	**0.126**	-0.355	-0.002	-0.013	0.000	0.150	**0.500**	-0.227	0.036	**3.91**	**0.193**	**4.21**

1. Results are gross pCi/g.
2. **Bold** results represent analytical results greater than the respective MDA.
3. Underlined results represent analytical results inconsistent with background as discussed in Section 2.2.1.

Table 2-6. Biased Sample PROI Results

Loc. No.	Depth (cm)	Ac-227 Result	Co-60 Result	Eu-154 Result	H-3 Result	Pa-231 Result	Ra-226 Result	Ra-228 Result	Sb-125 Result	Sn-126 Result	Th-229 Result	Th-232 Result
B01	0-100	0.305	-0.033	-0.145	-4.44	-0.709	**3.81**	**1.25**	-0.007	0.114	-0.024	**1.25**

1. Results are gross pCi/g.
2. **Bold** results represent analytical results greater than the respective MDA.
3. Underlined results represent analytical results inconsistent with background as discussed in Section 2.2.1.

3.0 QUALITY ASSURANCE

Quality assurance (QA) information was collected for soil data and for the GWS data. Soil QA data is presented in Section 3.1 and GWS QA data is presented in Section 3.2.

The soil analytical data was validated and verified by an independent third party. Ten percent of the data was validated and 100 percent was verified. The data validation is discussed in Section 3.3. Verification of the data was performed to assure that the electronic data deliverable (EDD) matched the hard copy laboratory reports with 100 percent accuracy.

3.1 Soil Sample Quality Assurance

The characteristics of precision, accuracy, representativeness, completeness, and comparability are discussed in Sections 3.1.1 through 3.1.5, respectively.

3.1.1 Precision

Precision is a measure of the degree to which two or more measurements are in agreement. Precision in the laboratory results was assessed through the calculation of relative percent differences (RPDs) field duplicate sample analyses.

According to the CSAP, precision reflects measurement variability as observed in repeated measurements of the same subsample; for radio-analytical methods, the required precision is reflected by required method detection limits (DOE 2011). In other words, specifying the required detection limits is equivalent to specifying the required method precision; therefore, specific tolerance limits for precision were not set in the FSP. The results of precision evaluations are simply reported.

Field duplicates tend to be less precise because they introduce all sample uncertainty from field sample collection through laboratory analysis. Field duplicates are collected as sample splits from the same sample mass. Two samples were extracted after homogenization with hand tools. These two samples were sent separately for laboratory analysis and the results were compared to establish a measure of precision.

The RPD calculation allows for the comparison of two analysis values in terms of precision with no estimate of accuracy. RPD is calculated as:

$$RPD = \left(\frac{m - M}{\overline{M}} \right) \times 100$$

Where:
m = First measurement value,
M = Second measurement value, and
$\overline{M}$ = Mean value of M and m.

Precision for the field duplicates was calculated for cases when both samples analyzed for the same analyte had results greater than the MDA. Precision for field duplications was determined for cesium-137, uranium-233/234, uranium-235, radium-226, and radium-228. Precision is shown as the RPD in Table 3-1. Precision for the field duplicates is considered good given that the values of the all sample results were all low; many were less than 1.0.

Table 3-1. Precision for Field Duplicates

Sample Number	Radionuclide					
	Cs-137	U-233/234	U-235	U-238	Ra-226	Ra-228
CPSE -SS04-092513-SS-0-100		0.707		0.739	0.99	1.29
CPSE -SS04-092513-SSD-0-100		0.86		0.852	1.06	1.01
RPD		**19.5**		**14.2**	**6.8**	**24.3**
CPSE -SS10-110413-SS-0-100		0.804		0.909	1.29	0.877
CPSE -SS10-110413-SSD-0-100		0.933		1.17	1.1	1.04
RPD		**14.9**		**25.1**	**15.9**	**17.0**
CPSE -SS30-091913-SS0-100		1.01	0.0494	1.16	1.26	1.26
CPSE -SS30-091913-SSD-0-100		1.04	0.0956	1.02	1.04	1.41
RPD		**2.9**	**63.7**	**12.8**	**19.1**	**11.2**
CPSE -SS36-091913-SS0-100		1.02	0.0538	1.17	1.15	1.35
CPSE -SS36-091913-SSD-0-100		0.926	0.0474	0.977	1.09	1.12
RPD		**9.7**	**12.6**	**18.0**	**5.4**	**18.6**
CPSE -SS44-092513-SS0-100	2.84	1.56	0.181	1.77	0.141	1.3
CPSE -SS44-092513-SSD-0-100	2.03	1.55	0.224	1.9	0.158	1.1
RPD	**33.3**	**0.6**	**21.2**	**7.1**	**11.4**	**16.7**

3.1.2 Accuracy

Accuracy addresses the potential for bias and lack of precision in laboratory analytical results and is typically monitored through the use of standards, spikes, blanks, and control charts, as appropriate, depending on the method. The accuracy requirement for off-site laboratory analyses set in the CSAP is a relative standard error of 10 percent, as measured at the CGw value, after correcting for precision.

Analytical accuracy is expressed as the percent recovery of an analyte that has been added to the control samples at a known concentration prior to analysis or duplicate analysis of a gamma spectroscopy standard with a known amount of radioactivity.

The accuracy of data was summarized in terms of relative error (RE). This calculation reflects the degree to which the measured value agrees with the actual value, in terms of percent of the actual value. RE is calculated as:

$$\%RE = 1 - \frac{|Measured\ Value - Actual\ Value|}{Average\ Value}$$

Table 3-2 shows the results of accuracy determinations for Laboratory Control Sample (LCS) and Laboratory Control Sample Duplicate (LCSD) samples.

Table 3-2. Accuracy Data

Method	Nuclide	Minimum Accuracy	Maximum Accuracy	Average Accuracy	Standard Deviation	Number of Measurements
Alpha Spectroscopy	Am-241	79.6	109	99.9	13.0	6
Liquid Scintillation	C-14	98.1	103	99.5	1.83	6
Gamma Spectroscopy	Co-60	91.9	93.6	93.0	0.954	3
Gamma Spectroscopy	Cs-137	96.8	98.7	97.8	0.961	3
Liquid Scintillation	H-3	86.2	112	96.3	9.80	6
Liquid Scintillation	I-129	75.9	101	94.3	14.6	5
Alpha Spectroscopy	Np-237	94	102	98.5	4.08	3
Alpha Spectroscopy	Pu-239/240	85.1	122	102.7	18.5	3
Gamma Spectroscopy	Sr-90	91.8	112	101.6	10.1	3
Liquid Scintillation	Tc-99	77.5	98.6	90.5	11.4	3
Alpha Spectroscopy	U-238	100	100	100	0	3

3.1.3 Representativeness

Representativeness is guaranteed by appropriate sampling and analytical protocols and by collecting sufficient samples or obtaining sufficient measurements such that uncertainties introduced by the heterogeneity of contaminated media are sufficiently controlled for decision making purposes. There is no formal quantitative requirement for representativeness; representativeness is monitored by ensuring that sampling and analytical protocols are, in fact, carried out during field and laboratory work and that the quantity of data collected are sufficient to allow decision-making with the necessary level of confidence.

The data were collected in accordance with the FSP and the standard operating procedures (SOPs) contained in the FSP and the supporting plans and procedures. The data are considered representative of the field conditions and locations where they were collected.

3.1.4 Completeness

Completeness is a measure of the degree to which the amount of sample data collected meets the scope and a measure of the relative number of analytical data points that meet the acceptance criteria, including accuracy, precision, and any other criteria required by the specific analytical method used. Completeness is defined as a comparison of the actual numbers of valid data points and expected numbers of points expressed as a percentage. The data completeness goal for the CSAP is 80 percent, consistent with the Phase 1 Final Status Survey Plan (FSSP).

Completeness is calculated after the quality control (QC) data have been evaluated, and the results applied to the measurement data. In addition to results identified as being outside of the QC limits established for the method, broken or spilled samples, or samples that could not be

analyzed for any other reason, are included in the assessment of completeness. The percent of valid results is reported as completeness. The completeness will be calculated as follows:

$$Completeness\ (\%) = \frac{T-(I+NC)}{T} \times 100$$

Where:
T = Total number of expected measurements for a method and matrix,
I = Number of invalidated results for a method and matrix, and
NC = Number of results not collected (e.g., bottles broken, etc.) for a method and a matrix.

The percentage completeness is shown in Table 3-3. The completeness criterion of 80 percent was met for all analytes except tin-126. Some tin-126 data was rejected during validation due to interference from other nearby gamma photo-peaks. No results were reported for cadmium-113m because this radionuclide does not emit gamma radiation and thus cannot be detected by gamma spectroscopy.

Table 3-3. Completeness

ROI	
Nuclide	Percent Valid
Am-241	100
C-14	100
Cm-243/244	96
Cs-137	100
I-129	100
Np-237	100
Pu-238	100
Pu-239/240	100
Pu-241	100
Sr-90	100
Tc99	100
U-232	100
U-233/234	100
U-235	100
U-238	100

PROI	
Nuclide	Percent Valid
Ac-227	100
Co-60	100
Cd-113m	0
Eu-154	100
H-3	100
Pa-231	100
Ra-226	100
Ra-228	100
Sb-125	100
Sn-126	75
Th-229	100
Th-232	100

3.1.5 Comparability

Comparability refers to how well data sets generated by CSAP work pertain to the decisions that need to be made. Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. The comparability of the data, a relative measure, is influenced by sampling and analytical procedures. The data was collected with the specific protocols in the FSP. The collection methods were in accordance with the CSAP; therefore, this

data set and future data sets should be comparable regardless of who obtains the sample or performs the analysis.

3.2 Gamma Walkover Quality Assurance

GWS QA included the following:

- Each detector was calibrated in accordance with the manufacturer's specifications and SEC's Instrumentation Quality Assurance Plan, using National Institute of Standards and Technology (NIST)-traceable standards.
- Instruments were set up and checked according to procedure SEC-RP-52, *Set-up and Operability Tests for Portable Field Instruments*. This establishes reference readings and a ±20 percent acceptance range.
- Instruments were checked with a source of known radioactivity and for background according to procedure SEC-RP-53, *Operability Tests – Field Instruments*. Instruments all passed the specification that source and background checks fall within ±20 percent of their original set-up readings. The purpose of these measurements is to assure the instruments are functioning properly at the beginning of each day.
- A 30-second measurement was made each day before use and at the end of the day at a reference location as specified in the FSP.

In addition to the measures listed above, each different detector was used to survey two 100-m^2 areas established in Background Reference Area 1. One of the areas had been covered by a tarp since November of 2012 and the other was an uncovered area next to the area covered by the tarp. The purpose was to allow measurements made by different detectors of the same type [FIDLER or Sodium Iodide (NaI)] to be normalized, if needed. The tarp was placed over the area to attain (over time) and maintain stable soil moisture content. Soil moisture may have an impact on the detector response. It is expected that the moisture content will equilibrate over the course of several weather seasons.

Detector statistics for data set pairs are shown in Table 3-4. A t-test showed that with 99 percent confidence the results for the covered area are different than for the uncovered area. Detector response is affected by moisture content. No corrections were made to the detector responses obtained during the survey work, however. The data was evaluated qualitatively by plotting the count rate data and looking for areas with elevated readings in order to place biased sampling locations. Correcting readings to dry soil conditions was not necessary to achieve this purpose.

3.3 Data Verification and Validation

Data verification was performed on 100% of the laboratory analytical data. Verification was performed to assure that samples sent for analysis were analyzed with results returned in hard copy and as an EDD. Verification of completeness for chain of custody records was performed. Verification that hard copy records from the laboratory matched the EDD was also completed. Errors found during verification were corrected.

Data deliverables meet U.S. Environmental Protection Agency (EPA) Level IV quality. Contract Laboratory Procedure (CLP)-like data packages were provided by the analytical laboratory to support independent third party validation. Ten percent of analyses were validated by an

Table 3-4. Detector Statistics (readings in cpm)

Instrument	Minimum	Maximum	Average	Median	Standard Deviation	Number of Points	Status	Date
2221 – 132836	7,755	12,321	9,778	9,765	705	838	Uncovered	9/30/13
2221 – 132836	7,795	16,293	10,990	10,755	1,447	1,283	Covered	8/22/13
2221 – 184009	7,364	10,185	8,788	8,791	425	795	Uncovered	9/30/13
2221 – 184009	7,657	22,816	12,116	12,349	1,967	1,153	Covered	8/22/13
2221 – 149961	7,969	18,524	10,228	10,148	983	1,223	Uncovered	9/30/13
2221 – 149961	6,927	12,094	9,603	9,606	776	856	Covered	10/30/13
2221 – 172045	3,836	11,178	9,857	9,878	566	780	Uncovered	9/30/13
2221 – 172045	7,237	12,437	9,621	9,633	784	589	Covered	10/30/13

independent third party. The independent third party performed validation according to the *U.S. Department of Energy NNSA Service Center Model Data Validation Procedure* (AQA 2010) and the applicable methods.

All data were used in computations (e.g., means of data sets) unless they were rejected by the validator. The data that were rejected are shown in Appendix B. Twenty-five percent of the tin-126 data were rejected due to interference from nearby gamma-ray photo-peaks.

4.0 REFERENCES

1. AQA 2010. *Model Data Validation Procedure*, Analytical Quality Associates, February.

2. DOE 2011. *Phase 1 Characterization Sampling and Analysis Plan for the West Valley Demonstration Project*, Rev. 1, ANL/EVS/R-11/6, June.

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

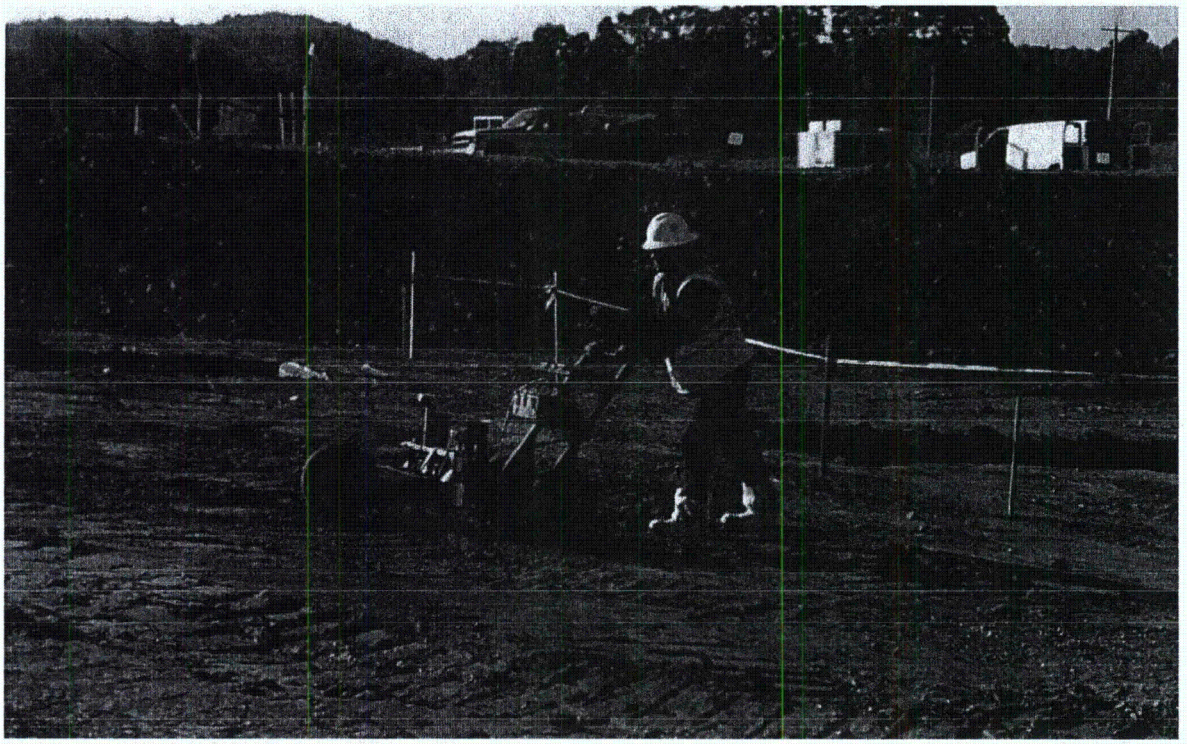
4. SEC 2013a. *Field Sampling Plan (FSP) for Task Order 9, West Valley Demonstration Project Environmental Characterization Services*, September.

5. SEC 2013b. *West Valley Demonstration Project Terrestrial Background Study*, February.

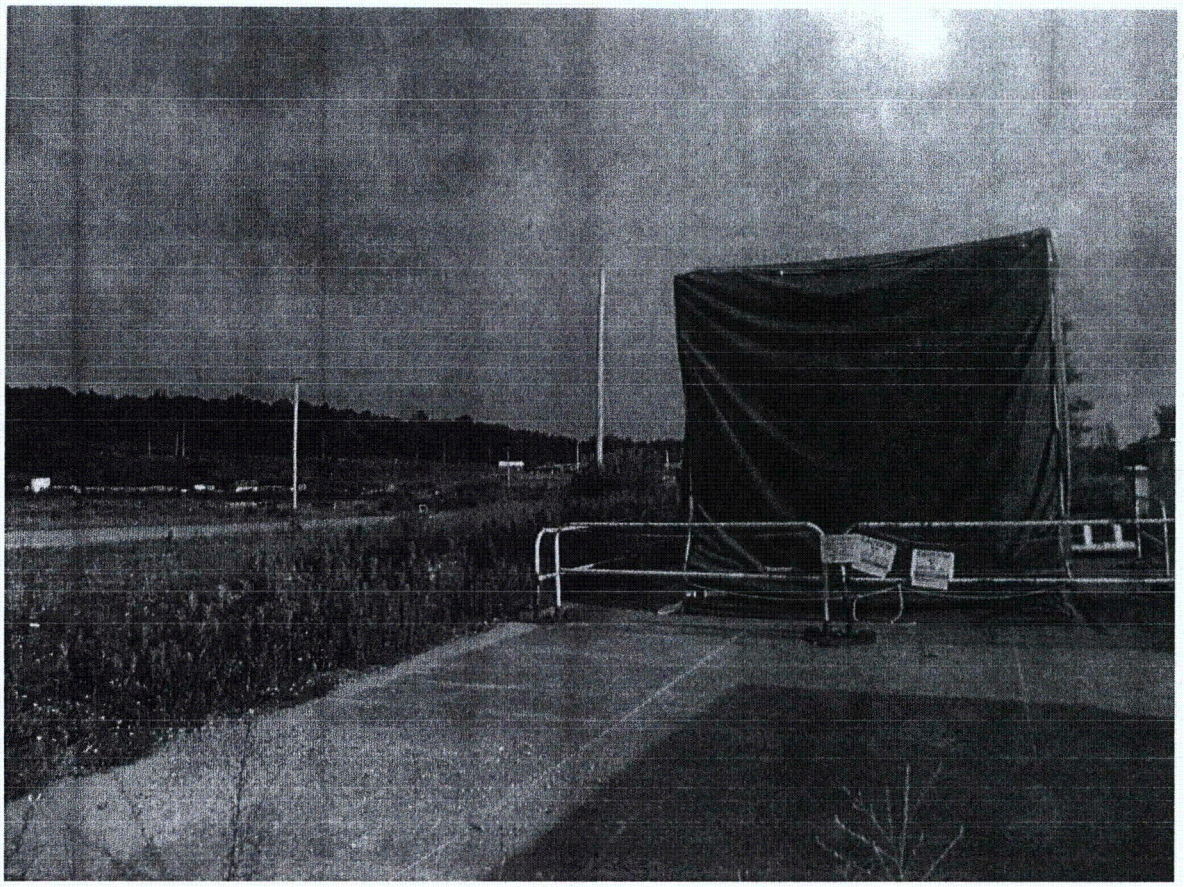
APPENDIX A

Photographs

Photograph 1. Detector Cart in HLW Excavation

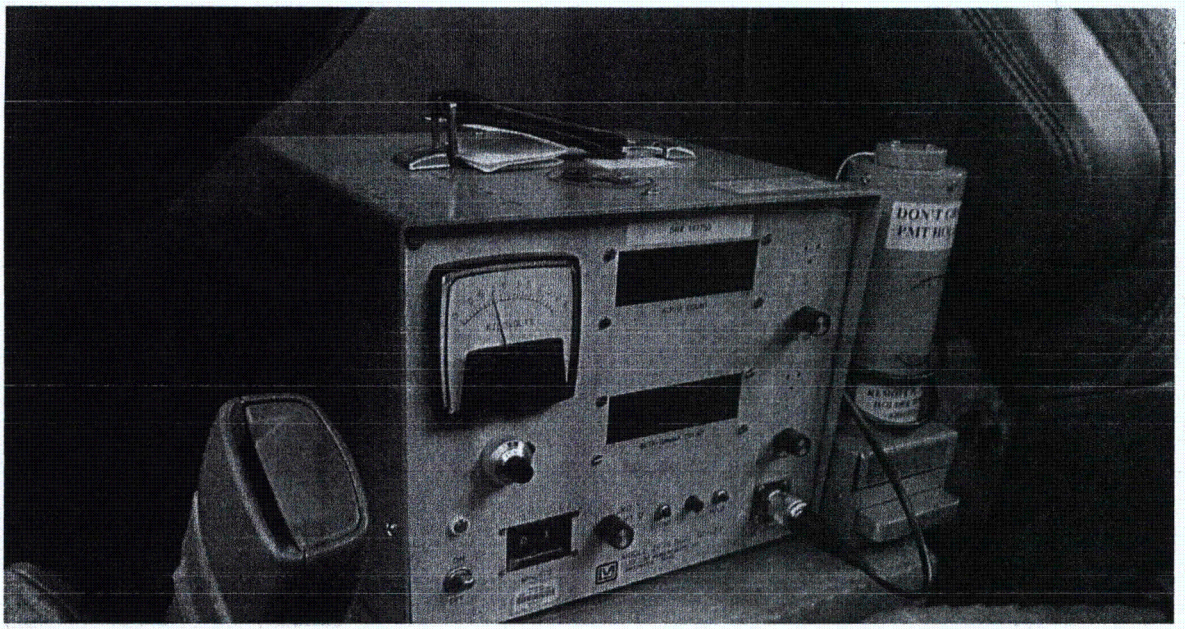


Photograph 2. Vitrification Vessels



Photograph 3. Typical Soil Sampling

Photograph 4. Swipe Counter



APPENDIX B

Sample Analytical Results

Table B-1. Systematic Sample ROIs Data

Location	Am241 Result	Am241 Error	Am241 MDA	C14 Result	C14 Error	C14 MDA	Cm243 244 Result	Cm243 244 Error	Cm243/244 MDA
01	0.086	0.243	0.259	-0.129	0.766	1.33	0.065	0.243	0.409
02	0.089	0.334	0.563	0.232	0.790	1.35	-0.056	0.246	0.641
03	0.000	0.230	0.342	-0.980	0.749	1.34	-0.054	0.239	0.623
04	0.256	0.438	0.384	0.038	0.750	1.29	-0.091	0.274	0.771
06	0.040	0.221	0.424	-0.339	0.755	1.32	-0.018	0.156	0.362
07	0.099	0.339	0.629	-0.573	0.782	1.38	-0.045	0.200	0.521
08	-0.075	0.226	0.635	-0.312	0.746	1.3	-0.025	0.212	0.492
09	0.004	0.323	0.719	0.033	0.761	1.31	-0.026	0.223	0.516
10	0.000	0.193	0.287	0.126	0.781	1.34	-0.045	0.200	0.523
11	0.058	0.158	0.114	0.306	1.62	0.948	-0.016	0.181	0.069
12	-0.052	0.158	0.444	-0.185	0.762	1.32	0.126	0.248	0.344
13	-0.022	0.191	0.443	-0.658	0.761	1.34	-0.066	0.198	0.557
14	0.083	0.313	0.526	-0.103	0.762	1.32	-0.026	0.224	0.519
15	0.000	0.209	0.311	-0.476	0.768	1.35	-0.025	0.211	0.490
16	0.032	0.010	0.091	-0.284	1.64	0.945	0.032	0.100	0.090
17	0.025	0.121	0.070	0.216	1.62	0.947	-0.009	0.145	0.060
19	0.106	0.299	0.319	-0.733	0.736	1.31	-0.076	0.228	0.641
20	-0.054	0.241	0.628	0.022	0.750	1.29	-0.081	0.243	0.683
21	0.038	0.105	0.076	-0.469	1.59	0.912	0.000	0.065	0.043
22	0.000	0.111	0.074	-0.861	1.63	0.926	0.000	0.109	0.073
23	0.007	0.038	0.074	0.099	0.883	1.52	0.036	0.052	0.063
24	0.024	0.047	0.065	0.510	0.887	1.50	-0.016	0.031	0.094
25	-0.007	0.030	0.078	0.216	0.882	1.51	-0.003	0.029	0.067
26	0.018	0.114	0.068	-0.164	1.61	0.931	0.008	0.143	0.069
27	0.004	0.038	0.079	0.212	0.870	1.49	0.007	0.037	0.071
28	0.033	0.052	0.073	0.263	0.866	1.48	0.007	0.037	0.072
29	0.015	0.042	0.072	0.425	0.884	1.50	-0.017	0.063	0.144
30	0.026	0.0507	0.070	0.458	0.894	1.52	-0.009	0.055	0.130
31	0.042	0.063	0.072	0.073	1.63	0.949	0.041	0.062	0.071
32	-0.005	0.275	0.122	-0.309	1.60	0.919	0.032	0.097	0.091
33	-0.009	0.180	0.078	-0.168	1.57	0.905	-0.018	0.205	0.079
34	0.012	0.035	0.037	0.084	0.860	1.48	-0.003	0.025	0.059
35	-0.012	0.039	0.101	-0.025	0.858	1.48	-0.020	0.048	0.123
36	0.007	0.036	0.069	-0.282	0.845	1.47	0.006	0.036	0.068
37	0.087	0.155	0.107	0.339	1.65	0.966	0.021	0.16	0.083
39	-0.011	0.024	0.072	0.150	0.879	1.51	-0.008	0.023	0.066
40	0.027	0.046	0.041	0.516	0.862	1.46	-0.010	0.029	0.082
41	0.037	0.059	0.081	-0.098	0.853	1.47	-0.003	0.044	0.102
42	0.189	0.113	0.119	0.056	1.67	0.973	0.017	0.104	0.056
43	-0.003	0.029	0.066	0.281	0.876	1.50	0.007	0.040	0.076
44	0.103	0.104	0.105	0.240	1.61	0.940	0.011	0.119	0.062

Location	Cs137 Result	Cs137 Error	Cs137 MDA	I129 Result	I129 Error	I129 MDA	Np237 Result	Np237 Error	Np237 MDA
01	-0.029	0.045	0.076	-0.320	0.509	0.918	0.015	0.030	0.053
02	0.025	0.040	0.075	-0.159	0.683	1.290	-0.003	0.008	0.023
03	0.010	0.046	0.062	0.038	0.538	1.13	-0.003	0.008	0.023
04	-0.043	0.043	0.069	-0.011	0.255	0.634	-0.004	0.008	0.026
06	-0.017	0.035	0.060	-0.307	0.425	0.370	-0.001	0.011	0.027
07	-0.025	0.024	0.041	-0.193	0.636	1.30	-0.002	0.008	0.020
08	0.000	0.043	0.055	-0.273	0.350	0.667	0.002	0.015	0.030
09	0.029	0.022	0.049	-0.243	0.525	0.906	-0.004	0.011	0.030
10	0.001	0.055	0.097	0.474	0.627	1.44	0.000	0.008	0.011
11	1.13	0.070	0.105	-0.558	0.828	0.500	-0.001	0.012	0.004
12	0.004	0.026	0.049	0.180	0.513	1.17	-0.003	0.008	0.023
13	-0.003	0.040	0.073	0.166	0.546	1.19	-0.009	0.009	0.031
14	-0.022	0.043	0.063	-0.058	0.551	1.21	-0.001	0.008	0.018
15	-0.040	0.037	0.060	-0.128	0.750	1.40	-0.002	0.008	0.020
16	0.708	0.049	0.073	0.029	0.685	0.350	-0.004	0.018	0.005
17	-0.016	0.073	0.043	0.051	0.593	0.293	0.003	0.016	0.009
19	-0.021	0.037	0.061	0.258	0.379	1.29	-0.003	0.008	0.023
20	-0.047	0.044	0.071	-0.318	0.358	0.650	-0.006	0.008	0.027
21	0.770	0.057	0.076	0.080	0.455	0.210	0.000	0.012	0.005
22	-0.043	0.059	0.037	-0.006	0.677	0.307	-0.002	0.018	0.007
23	-0.021	0.045	0.078	0.066	0.232	0.629	-0.001	0.006	0.015
24	0.036	0.044	0.087	-0.126	0.235	0.391	0.000	0.008	0.018
25	-0.012	0.040	0.068	-0.117	0.251	0.471	-0.002	0.006	0.016
26	1.25	0.058	0.101	0.313	0.474	0.204	-0.005	0.020	0.007
27	0.017	0.034	0.059	0.042	0.168	0.439	0.004	0.010	0.015
28	0.017	0.036	0.060	-0.210	0.394	0.690	0.002	0.008	0.013
29	0.007	0.050	0.089	-0.086	0.178	0.309	0.004	0.010	0.015
30	-0.044	0.039	0.068	0.284	0.243	0.524	-0.003	0.007	0.020
31	3.23	0.078	0.146	0.429	0.995	0.339	0.001	0.013	0.006
32	0.260	0.046	0.045	0.347	1.06	0.550	-0.001	0.017	0.007
33	0.007	0.059	0.033	0.224	0.674	0.220	-0.001	0.014	0.005
34	0.026	0.0442	0.083	0.100	0.220	0.482	0.002	0.009	0.014
35	0.020	0.043	0.079	0.020	0.201	0.379	0.002	0.008	0.014
36	0.009	0.030	0.055	0.195	0.086	0.392	0.010	0.017	0.028
37	0.565	0.061	0.064	0.044	0.569	0.278	0.000	0.011	0.005
39	-0.015	0.035	0.063	-0.131	0.203	0.336	0.001	0.008	0.018
40	-0.035	0.041	0.069	-0.008	0.175	0.335	-0.004	0.007	0.022
41	-0.041	0.041	0.069	0.325	0.281	0.585	0.004	0.015	0.028
42	1.13	0.081	0.140	0.121	0.678	0.335	0.001	0.015	0.007
43	0.011	0.034	0.066	-0.010	0.151	0.293	0.000	0.010	0.022
44	2.84	0.065	0.142	0.190	0.537	0.379	-0.002	0.014	0.005

Location	Pu238 Result	Pu238 Error	Pu238 MDA	Pu239/240 Result	Pu239/240 Error	Pu239/240 MDA	Pu241 Result	Pu241 Error	Pu241 MDA
01	0.070	0.197	0.210	0.160	0.283	0.428	-0.457	5.89	10.3
02	-0.038	0.167	0.435	0.063	0.282	0.551	-0.975	5.69	10.0
03	0.121	0.207	0.182	0.046	0.173	0.290	1.48	5.83	10.1
04	0.065	0.183	0.195	0.099	0.227	0.360	1.64	6.71	11.6
06	0.144	0.287	0.466	0.144	0.287	0.466	1.81	5.61	9.67
07	-0.044	0.198	0.499	0.100	0.265	0.476	2.96	5.76	9.84
08	-0.045	0.135	0.380	0.157	0.249	0.344	-1.50	5.68	10.0
09	0.041	0.155	0.260	-0.039	0.118	0.331	1.39	5.19	8.96
10	0.068	0.231	0.428	-0.062	0.144	0.428	-0.340	5.22	9.15
11	0.034	0.050	0.058	0.017	0.050	0.047	-1.53	8.17	4.64
12	0.000	0.139	0.206	-0.113	0.221	0.615	0.752	5.65	9.81
13	-0.029	0.126	0.330	0.331	0.338	0.441	2.73	7.27	12.5
14	-0.016	0.134	0.311	-0.109	0.153	0.502	1.50	6.15	10.6
15	-0.023	0.103	0.270	-0.035	0.106	0.297	1.81	5.68	9.78
16	0.014	0.090	0.053	0.033	0.090	0.065	-3.39	9.18	5.15
17	0.041	0.185	0.102	0.006	0.135	0.065	-1.18	9.72	5.54
19	-0.019	0.161	0.372	-0.019	0.161	0.372	4.40	5.54	9.35
20	0.000	0.102	0.152	0.000	0.102	0.152	3.35	5.65	9.62
21	0.039	0.058	0.067	0.001	0.128	0.058	-2.00	11.4	6.46
22	-0.009	0.106	0.041	0.015	0.092	0.055	7.20	9.75	5.88
23	-0.004	0.030	0.070	0.019	0.051	0.089	-4.72	6.33	11.3
24	-0.011	0.0334	0.094	0.042	0.061	0.074	-3.46	6.29	11.2
25	0.022	0.043	0.060	0.019	0.043	0.069	-7.54	5.36	9.83
26	-0.020	0.135	0.046	0.057	0.098	0.081	-1.53	9.77	5.56
27	-0.022	0.036	0.115	0.027	0.054	0.075	-8.88	6.98	12.8
28	0.028	0.048	0.042	0.001	0.041	0.092	-7.20	6.18	11.2
29	-0.006	0.043	0.104	0.004	0.041	0.086	-1.85	6.46	11.4
30	-0.010	0.032	0.088	-0.003	0.030	0.069	-1.39	6.52	11.4
31	0.033	0.091	0.065	0.038	0.057	0.065	-0.293	8.40	4.82
32	0.039	0.130	0.077	0.014	0.140	0.070	0.801	8.95	5.17
33	0.005	0.105	0.050	0.009	0.095	0.050	-4.55	11.4	6.40
34	0.000	0.027	0.040	0.000	0.027	0.040	-7.11	6.22	11.3
35	-0.015	0.028	0.085	0.009	0.035	0.058	-1.40	5.88	10.3
36	-0.010	0.042	0.105	0.004	0.040	0.082	-2.50	6.08	10.7
37	0.227	0.093	0.128	0.059	0.093	0.075	-0.117	9.66	5.55
39	0.007	0.036	0.068	-0.005	0.037	0.091	-0.227	5.97	10.4
40	0.010	0.051	0.103	0.009	0.035	0.059	-6.17	5.92	10.7
41	0.037	0.059	0.082	-0.004	0.031	0.071	1.91	6.78	11.7
42	0.426	0.096	0.174	0.139	0.114	0.109	3.70	8.53	5.04
43	-0.003	0.042	0.099	0.015	0.050	0.093	-1.66	5.52	9.71
44	0.006	0.128	0.061	0.037	0.100	0.073	2.16	9.11	5.32

Location	Sr90 Result	Sr90 Error	Sr90 MDA	Tc99 Result	Tc99 Error	Tc99 MDA	U232 Result	U232 Error	U232 MDA
01	0.091	0.346	0.638	-0.472	1.19	2.07	-0.003	0.030	0.066
02	-0.280	0.301	0.664	-0.093	1.03	1.77	0.002	0.024	0.048
03	0.205	0.344	0.606	0.022	0.932	1.60	0.036	0.062	0.107
04	-0.398	0.391	0.833	0.504	1.21	2.06	-0.037	0.048	0.109
06	-0.138	0.286	0.621	0.309	1.05	1.79	0.024	0.034	0.053
07	-0.098	0.289	0.600	0.550	1.18	2.00	-0.015	0.033	0.078
08	0.115	0.303	0.554	0.341	1.04	1.78	-0.009	0.040	0.086
09	0.270	0.371	0.634	0.204	0.887	1.52	-0.001	0.045	0.089
10	0.092	0.330	0.617	-0.107	1.25	2.15	-0.009	0.047	0.103
11	0.124	0.638	0.352	0.142	1.55	0.871	0.044	0.171	0100
12	0.377	0.377	0.619	-0.077	0.965	1.67	-0.006	0.046	0.104
13	-0.472	0.312	0.739	0.832	0.918	1.54	0.021	0.034	0.058
14	0.642	0.537	0.877	0.478	0.874	1.48	0.008	0.049	0.093
15	0.462	0.458	0.758	0.050	1.36	2.34	-0.019	0.030	0.079
16	0.150	0.553	0.309	-0.898	2.02	1.05	0.031	0.118	0.068
17	-0.305	0.573	0.239	-0.815	1.86	0.971	0.036	0.385	0.201
19	0.185	0.379	0.669	0.512	1.05	1.79	-0.008	0.027	0.063
20	0.252	0.474	0.828	0.017	1.31	2.26	0.014	0.039	0.071
21	0.520	0.617	0.394	-0.233	1.82	0.992	0.008	0.047	0.026
22	0.173	0.582	0.327	0.365	1.70	0.970	0.048	0.155	0.096
23	-0.005	0.305	0.596	0.366	1.15	1.98	-0.002	0.019	0.042
24	-0.184	0.231	0.515	1.00	1.01	1.70	-0.003	0.030	0.064
25	-0.020	0.264	0.517	0.571	1.10	1.88	0.013	0.045	0.084
26	0.023	0.512	0.264	-0.041	1.50	0.83	0.030	0.137	0.075
27	-0.187	0.298	0.602	-0.123	1.12	1.95	0.023	0.028	0.036
28	-0.253	0.226	0.530	0.557	0.953	1.62	-0.014	0.030	0.069
29	-0.118	0.294	0.594	-0.273	1.11	1.94	0.006	0.027	0.051
30	0.088	0.260	0.477	0.438	1.01	1.73	-0.000	0.036	0.072
31	-0.216	0.618	0.288	0.202	1.42	0.802	0.001	0.104	0.047
32	0.094	0.551	0.298	-0.395	1.75	0.939	-0.021	0.122	0.040
33	-0.112	0.422	0.198	-0.363	1.57	0.843	0.205	0.300	0.227
34	-0.347	0.279	0.630	0.016	0.949	1.65	-0.013	0.028	0.064
35	0.004	0.263	0.511	-0.18	0.888	1.56	0.014	0.033	0.061
36	-0.165	0.175	0.412	0.033	0.833	1.45	-0.010	0.028	0.063
37	-0.258	0.703	0.333	-0.070	1.84	1.01	-0.019	0.134	0.050
39	-0.163	0.355	0.700	-0.419	0.970	1.71	-0.007	0.030	0.067
40	0.145	0.358	0.638	0.210	1.03	1.77	0.011	0.022	0.033
41	-0.087	0.249	0.519	-0.221	1.08	1.90	-0.019	0.027	0.066
42	-0.177	0.737	0.373	-0.286	1.87	1.01	-0.002	0.103	0.046
43	-0.004	0.236	0.467	0.382	1.01	1.73	-0.009	0.027	0.063
44	-0.172	0.535	0.237	-0.097	1.89	1.04	0.057	0.168	0.101

Location	U233/234 Result	U233/234 Error	U233/234 MDA	U235 Result	U235 Error	U235 MDA	U238 Result	U238 Error	U238 MDA
01	0.941	0.167	0.074	0.044	0.043	0.052	1.03	0.172	0.052
02	0.948	0.223	0.104	0.111	0.083	0.077	0.980	0.226	0.092
03	0.850	0.211	0.092	0.006	0.068	0.139	1.01	0.233	0.123
04	0.707	0.147	0.046	0.063	0.050	0.055	0.739	0.152	0.062
06	0.898	0.173	0.078	0.054	0.048	0.049	0.886	0.171	0.072
07	0.856	0.147	0.056	0.032	0.035	0.045	0.974	0.156	0.038
08	0.868	0.161	0.053	0.098	0.059	0.054	1.13	0.182	0.044
09	0.957	0.184	0.053	0.045	0.050	0.064	0.970	0.186	0.064
10	0.804	0.153	0.068	0.047	0.045	0.058	0.909	0.160	0.022
11	0.989	0.084	0.260	0.105	0.052	0.091	0.714	0.052	0.221
12	0.504	0.154	0.116	0.033	0.049	0.071	0.593	0.160	0.071
13	0.811	0.148	0.060	0.038	0.040	0.055	0.982	0.161	0.021
14	1.11	0.181	0.045	0.042	0.041	0.045	0.965	0.170	0.054
15	0.759	0.147	0.071	0.078	0.048	0.021	0.995	0.165	0.041
16	0.950	0.038	0.215	0.047	0.060	0.056	1.15	0.076	0.238
17	1.25	0.175	0.290	0.159	0.048	0.108	1.38	0.048	0.293
19	1.05	0.227	0.064	0.072	0.066	0.064	1.10	0.232	0.064
20	0.934	0.162	0.062	0.053	0.043	0.042	1.13	0.176	0.050
21	0.767	0.053	0.182	0.075	0.053	0.062	0.765	0.061	0.182
22	0.762	0.138	0.277	0.113	0.139	0.122	0.768	0.120	0.277
23	1.02	0.122	0.029	0.064	0.035	0.036	1.02	0.121	0.029
24	1.01	0.146	0.050	0.086	0.044	0.016	0.943	0.141	0.036
25	0.904	0.152	0.071	0.004	0.026	0.052	0.985	0.156	0.042
26	0.946	0.104	0.237	0.086	0.071	0.078	0.826	0.071	0.220
27	1.08	0.158	0.065	0.052	0.037	0.017	0.872	0.142	0.054
28	1.02	0.153	0.081	0.101	0.048	0.017	1.16	0.159	0.046
29	0.820	0.137	0.018	0.054	0.038	0.018	1.03	0.155	0.049
30	1.01	0.151	0.047	0.049	0.040	0.047	1.16	0.162	0.038
31	3.08	0.105	0.436	0.140	0.076	0.099	3.08	0.0762	0.435
32	0.721	0.105	0.199	0.055	0.089	0.067	0.690	0.089	0.193
33	0.918	0.306	0.308	0.080	0.060	0.096	1.12	0.221	0.313
34	0.903	0.164	0.062	0.053	0.043	0.023	1.28	0.193	0.023
35	1.10	0.155	0.046	0.0506	0.036	0.017	1.09	0.155	0.052
36	1.02	0.152	0.047	0.054	0.039	0.039	1.17	0.163	0.054
37	1.50	0.156	0.347	0.096	0.097	0.098	1.45	0.133	0.340
39	0.922	0.138	0.036	0.021	0.025	0.016	1.10	0.153	0.060
40	0.843	0.139	0.039	0.031	0.033	0.039	1.21	0.166	0.039
41	0.954	0.151	0.041	0.100	0.053	0.041	1.05	0.159	0.041
42	1.74	0.037	0.161	0.119	0.037	0.046	1.77	0.012	0.161
43	0.882	0.139	0.061	0.025	0.031	0.045	0.984	0.144	0.036
44	1.56	0.103	0.309	0.181	0.116	0.116	1.77	0.087	0.328

Table B-2. Systematic Sample PROI Data

Location	Ac227 Result	Ac227 Error	Ac227 MDA	Co60 Result	Co60 Error	Co60 MDA	Eu154 Result	Eu154 Error	Eu154 MDA
01	-0.047	0.290	0.499	0.057	0.064	0.091	-0.193	0.152	0.236
02	-0.035	0.288	0.489	-0.025	0.046	0.077	-0.064	0.141	0.240
03	0.111	0.235	0.431	0.014	0.036	0.072	-0.009	0.150	0.236
04	0.138	0.299	0.509	0.031	0.039	0.079	0.051	0.127	0.214
06	-0.066	0.261	0.433	-0.029	0.041	0.057	-0.092	0.130	0.206
07	-0.025	0.164	0.306	-0.000	0.025	0.048	0.065	0.057	0.133
08	-0.062	0.248	0.437	0.020	0.039	0.075	0.046	0.106	0.204
09	-0.096	0.180	0.326	0.015	0.027	0.050	-0.049	0.085	0.141
10	0.038	0.289	0.500	-0.014	0.052	0.097	-0.154	0.164	0.255
11	0.201	0.501	0.279	-0.017	0.066	0.038	0.025	0.246	0.134
12	-0.026	0.180	0.339	0.003	0.029	0.054	-0.014	0.083	0.152
13	0.077	0.238	0.443	0.036	0.044	0.0868	0.192	0.185	0.242
14	0.128	0.241	0.432	0.019	0.0405	0.070	0.099	0.128	0.226
15	0.061	0.216	0.380	-0.054	0.050	0.065	-0.068	0.126	0.221
16	0.058	0.356	0.197	0.005	0.055	0.030	-0.078	0.164	0.119
17	-0.202	0.501	0.298	0.041	0.099	0.050	0.066	0.295	0.158
19	-0.206	0.215	0.366	0.003	0.035	0.067	-0.043	0.115	0.207
20	-0.141	0.281	0.475	-0.011	0.049	0.075	-0.123	0.141	0.23
21	0.028	0.397	0.216	-0.014	0.047	0.027	-0.034	0.152	0.102
22	0.189	0.406	0.216	0.002	0.075	0.040	-0.043	0.215	0.120
23	-0.198	0.309	0.502	-0.033	0.052	0.087	0.098	0.147	0.296
24	-0.012	0.214	0.396	0.035	0.053	0.107	0.090	0.164	0.330
25	-0.268	0.268	0.422	0.022	0.044	0.087	-0.030	0.132	0.230
26	-0.045	0.392	0.224	0.005	0.056	0.034	0.089	0.170	0.089
27	-0.144	0.226	0.401	-0.009	0.036	0.063	0.011	0.108	0.197
28	-0.187	0.234	0.387	0.022	0.036	0.072	-0.166	0.121	0.196
29	0.082	0.282	0.496	-0.016	0.046	0.084	-0.186	0.176	0.273
30	0.069	0.252	0.457	-0.004	0.037	0.069	0.029	0.130	0.215
31	0.211	0.534	0.289	0.008	0.078	0.044	-0.094	0.222	0.132
32	-0.007	0.328	0.180	-0.025	0.042	0.030	-0.024	0.141	0.078
33	-0.088	0.394	0.225	0.011	0.062	0.039	0.057	0.191	0.119
34	-0.071	0.265	0.465	-0.003	0.042	0.077	0.095	0.173	0.252
35	0.124	0.250	0.467	0.020	0.047	0.089	0.152	0.162	0.281
36	0.014	0.211	0.372	0.017	0.033	0.0624	-0.179	0.111	0.168
37	0.256	0.468	0.298	0.006	0.070	0.039	0.034	0.213	0.125
39	-0.189	0.229	0.403	-0.032	0.035	0.059	0.065	0.124	0.247
40	-0.230	0.247	0.422	-0.023	0.036	0.063	0.067	0.132	0.250
41	0.018	0.261	0.465	0.016	0.040	0.076	-0.031	0.114	0.202
42	-0.012	0.512	0.287	0.015	0.106	0.059	0.004	0.330	0.180
43	-0.015	0.223	0.391	0.030	0.041	0.066	-0.039	0.104	0.184
44	-0.194	0.420	0.238	0.012	0.064	0.033	0.069	0.200	0.077

Location	H3 Result	H3 Error	H3 MDA	Pa231 Result	Pa231 Error	Pa231 MDA	Ra226 Result	Ra226 Error	Ra226 MDA
01	1.78	11.3	20.0	-0.638	1.69	2.76	1.24	0.179	0.147
02	0.938	11.1	19.8	-0.988	1.62	2.63	1.15	0.187	0.147
03	-0.912	10.9	19.5	1.15	1.37	2.56	1.13	0.166	0.14
04	-1.43	10.0	18.0	1.32	1.77	2.94	0.99	0.156	0.151
06	1.35	11.8	20.9	0.687	1.45	2.50	1.20	0.134	0.106
07	1.33	11.2	19.8	0.280	0.997	1.68	0.775	0.124	0.088
08	-0.163	12.1	21.6	-0.773	1.41	2.43	1.24	0.166	0.125
09	1.66	11.4	20.2	-0.511	1.09	1.85	0.972	0.116	0.103
10	5.44	12.2	21.2	-1.50	1.79	2.72	1.29	0.189	0.172
11	-5.50	20.1	11.0	0.841	2.92	1.88	1.09	0.128	0.159
12	-0.120	11.3	20.3	0.288	1.01	1.94	0.823	0.122	0.087
13	8.34	10.7	18.2	0.118	1.32	2.43	1.20	0.156	0.132
14	-4.82	11.0	20.2	-0.001	1.48	2.38	1.23	0.137	0.127
15	-4.66	11.1	20.3	-0.193	1.36	2.15	1.18	0.143	0.122
16	-4.45	19.3	10.6	0.109	1.90	1.15	0.977	0.093	0.122
17	-6.29	16.9	9.17	0.512	2.73	1.74	1.14	0.147	0.180
19	-0.716	11.8	21.1	0.506	1.29	2.20	1.12	0.143	0.115
20	-4.91	11.2	20.7	0.917	1.52	2.70	1.03	0.132	0.142
21	-3.14	19.9	11.1	0.334	2.24	1.22	0.906	0.096	0.146
22	-4.67	20.3	11.2	-0.236	2.24	1.27	0.998	0.115	0.151
23	7.76	11.0	18.8	0.834	2.03	3.01	1.15	0.192	0.151
24	10.2	10.2	17.0	0.471	1.31	2.46	1.22	0.176	0.134
25	7.10	10.1	17.1	-0.919	1.29	2.25	0.798	0.178	0.130
26	-10.7	19.4	10.3	-1.1	2.05	1.23	0.938	0.119	0.126
27	-1.86	10.2	18.5	-0.724	1.27	2.25	0.970	0.144	0.106
28	8.75	9.40	15.7	-0.977	1.38	2.28	1.18	0.161	0.111
29	8.04	10.5	17.8	1.07	1.72	2.81	1.12	0.193	0.147
30	8.11	9.40	15.8	-0.118	1.40	2.48	1.26	0.160	0.125
31	-1.08	18.2	10.2	3.01	3.13	1.79	1.76	0.134	0.206
32	-3.56	17.3	9.54	0.090	1.84	1.04	0.854	0.095	0.129
33	3.62	19.0	10.9	0.144	2.41	1.36	0.948	0.115	0.143
34	11.5	11.2	18.6	-0.631	1.49	2.58	0.885	0.174	0.137
35	8.81	10.6	17.8	-0.439	1.46	2.60	0.986	0.170	0.122
36	7.73	8.96	15.1	-0.054	1.40	2.12	1.15	0.154	0.107
37	-8.46	20.1	10.8	-1.12	2.42	1.69	2.67	0.122	0.197
39	4.62	9.20	15.9	-1.50	1.34	2.29	0.799	0.174	0.122
40	9.31	8.81	14.6	-0.357	1.44	2.55	1.06	0.160	0.132
41	11.5	10.5	17.5	-0.177	1.39	2.45	1.16	0.156	0.117
42	0.934	20.3	11.5	-0.386	2.76	1.57	1.16	0.168	0.204
43	8.69	9.64	16.2	-1.21	1.38	2.21	1.06	0.156	0.110
44	2.37	16.5	9.45	-0.087	2.37	1.35	1.15	0.109	0.141

Location	Ra228 Result	Ra228 Error	Ra228 MDA	Sb125 Result	Sb125 Error	Sb125 MDA	Sn126 Result	Sn126 Error	Sn126 MDA
01	1.53	0.337	0.272	-0.026	0.101	0.180	0.000	0.111	0.132
02	1.40	0.357	0.277	0.044	0.104	0.193	0.130	0.180	0.167
03	1.37	0.246	0.232	0.076	0.098	0.181	0.000	0.086	0.103
04	1.29	0.277	0.249	-0.021	0.107	0.188	0.000	0.103	0.127
06	1.17	0.239	0.244	0.042	0.090	0.164	0.117	0.140	0.133
07	0.868	0.194	0.160	-0.054	0.059	0.101	0.062	0.074	0.096
08	1.43	0.270	0.236	-0.030	0.088	0.151	0.095	0.106	0.130
09	1.10	0.189	0.169	0.081	0.069	0.130	0.000	0.087	0.104
10	0.877	0.447	0.310	0.025	0.116	0.212	0.000	0.079	0.094
11	1.32	0.275	0.286	0.066	0.187	0.101	0.064	0.147	0.104
12	1.14	0.227	0.178	0.046	0.062	0.122	0.079	0.112	0.100
13	1.42	0.304	0.279	0.005	0.096	0.171	0.000	0.077	0.085
14	1.14	0.284	0.256	0.084	0.104	0.169	0.105	0.089	0.122
15	1.08	0.258	0.217	0.030	0.078	0.145	0.000	0.056	0.080
16	1.38	0.187	0.262	-0.026	0.127	0.072	0.000	0.103	0.078
17	1.35	0.308	0.281	0.042	0.182	0.103	0.000	0.163	0.101
19	1.09	0.316	0.233	-0.002	0.077	0.142	0.000	0.1	0.094
20	1.04	0.265	0.256	0.002	0.100	0.170	0.000	0.106	0.121
21	1.06	0.190	0.252	-0.010	0.139	0.075	0.000	0.101	0.090
22	1.52	0.246	0.274	-0.062	0.154	0.102	0.000	0.093	0.100
23	1.53	0.341	0.342	0.005	0.115	0.205	0.000	0.100	0.131
24	1.10	0.319	0.309	-0.026	0.113	0.172	0.000	0.068	0.067
25	1.15	0.281	0.240	-0.016	0.089	0.158	0.000	0.107	0.120
26	1.04	0.202	0.207	-0.052	0.144	0.087	0.000	0.093	0.084
27	1.10	0.283	0.237	0.031	0.096	0.155	0.000	0.179	0.148
28	1.41	0.279	0.226	0.078	0.083	0.147	0.000	0.109	0.117
29	1.39	0.365	0.315	0.017	0.107	0.196	0.000	0.078	0.090
30	1.26	0.293	0.269	0.043	0.086	0.157	0.000	0.097	0.116
31	1.62	0.277	0.280	0.031	0.211	0.120	0.000	0.103	0.094
32	1.06	0.170	0.233	0.011	0.121	0.067	0.077	0.105	0.081
33	1.17	0.201	0.236	0.058	0.153	0.085	0.000	0.120	0.099
34	1.33	0.311	0.286	-0.050	0.096	0.171	0.000	0.124	0.162
35	1.26	0.279	0.291	0.028	0.101	0.181	0.000	0.110	0.119
36	1.35	0.226	0.199	-0.009	0.074	0.131	0.000	0.096	0.105
37	1.63	0.224	0.237	-0.082	0.154	0.095	0.120	0.136	0.122
39	1.25	0.310	0.253	0.066	0.100	0.170	0.143	0.112	0.160
40	1.18	0.309	0.290	0.050	0.096	0.177	0.000	0.100	0.154
41	1.23	0.258	0.276	0.003	0.079	0.146	0.000	0.114	0.120
42	1.44	0.404	0.371	-0.064	0.209	0.145	0.000	0.087	0.076
43	1.06	0.251	0.209	-0.085	0.080	0.127	0.000	0.084	0.096
44	1.30	0.215	0.267	0.020	0.171	0.095	0.000	0.106	0.097

Location	Th229 Result	Th229 Error	Th229 MDA	Th232 Result	Th232 Error	Th232 MDA
01	0.166	0.269	0.417	1.53	0.337	0.272
02	-0.082	0.186	0.507	1.40	0.357	0.277
03	0.109	0.193	0.293	1.37	0.246	0.232
04	0.078	0.178	0.283	1.29	0.277	0.249
06	0.032	0.141	0.276	1.17	0.239	0.244
07	-0.009	0.140	0.327	0.868	0.194	0.160
08	0.002	0.175	0.389	1.43	0.270	0.236
09	0.068	0.187	0.325	1.10	0.189	0.169
10	-0.043	0.129	0.364	0.877	0.447	0.310
11	0.032	0.338	0.177	1.32	0.275	0.286
12	-0.081	0.153	0.473	1.14	0.227	0.178
13	0.108	0.215	0.349	1.42	0.304	0.279
14	-0.019	0.086	0.224	1.14	0.284	0.256
15	0.205	0.390	0.685	1.08	0.258	0.217
16	0.161	0.280	0.232	1.38	0.187	0.262
17	0.083	0.397	0.229	1.35	0.308	0.281
19	0.120	0.177	0.259	1.09	0.316	0.233
20	0.069	0.217	0.406	1.04	0.265	0.256
21	0.155	0.289	0.212	1.06	0.190	0.252
22	-0.037	0.418	0.166	1.52	0.246	0.274
23	0.058	0.219	0.368	1.53	0.341	0.342
24	-0.274	0.320	0.904	1.10	0.319	0.309
25	0.123	0.241	0.334	1.15	0.281	0.240
26	0.046	0.699	0.341	1.04	0.202	0.207
27	0.215	0.309	0.373	1.10	0.283	0.237
28	-0.017	0.145	0.335	1.41	0.279	0.226
29	0.090	0.248	0.430	1.39	0.365	0.315
30	0.056	0.159	0.169	1.26	0.293	0.269
31	0.208	0.255	0.224	1.62	0.277	0.280
32	-0.097	0.447	0.137	1.06	0.170	0.233
33	0.117	0.378	0.233	1.17	0.201	0.236
34	0.100	0.231	0.366	1.33	0.311	0.286
35	0.108	0.298	0.517	1.26	0.279	0.291
36	-0.054	0.164	0.461	1.35	0.226	0.199
37	0.392	0.448	0.352	1.63	0.224	0.237
39	0.097	0.224	0.355	1.25	0.310	0.253
40	-0.016	0.141	0.326	1.18	0.309	0.290
41	-0.049	0.147	0.412	1.23	0.258	0.276
42	0.029	0.305	0.159	1.44	0.404	0.371
43	0.035	0.225	0.461	1.06	0.251	0.209
44	0.042	0.263	0.156	1.30	0.215	0.267

Table B-3. Biased Sample ROI Data

Location	Am241 Result	Am241 Error	Am241 MDA	C14 Result	C14 Error	C14 MDA	Cm243 244 Result	Cm243 244 Error	Cm243/244 MDA
B01	0.031	0.083	0.060	-0.384	1.59	0.911	0.017	0.051	0.048

Location	Cs137 Result	Cs137 Error	Cs137 MDA	I129 Result	I129 Error	I129 MDA	Np237 Result	Np237 Error	Np237 MDA
B01	0.126	0.074	0.063	-0.355	0.847	0.493	-0.002	0.015	0.006

Location	Pu238 Result	Pu238 Error	Pu238 MDA	Pu239/240 Result	Pu239/240 Error	Pu239/240 MDA	Pu241 Result	Pu241 Error	Pu241 MDA
B01	-0.013	0.112	0.040	0.000	0.055	0.037	0.150	8.88	5.11

Location	Sr90 Result	Sr90 Error	Sr90 MDA	Tc99 Result	Tc99 Error	Tc99 MDA	U232 Result	U232 Error	U232 MDA
B01	0.500	0.740	0.453	-0.227	1.88	1.03	0.036	0.138	0.079

Location	U233/234 Result	U233/234 Error	U233/234 MDA	U235 Result	U235 Error	U235 MDA	U238 Result	U238 Error	U238 MDA
B01	3.91	0.089	0.492	0.193	0.048	0.114	4.21	0.048	0.509

Table B-4. Biased Sample PROI Data

Location	Ac227 Result	Ac227 Error	Ac227 MDA	Co60 Result	Co60 Error	Co60 MDA	Eu154 Result	Eu154 Error	Eu154 MDA
B01	0.305	0.517	0.319	-0.033	0.074	0.0437	-0.145	0.220	0.145

Location	H3 Result	H3 Error	H3 MDA	Pa231 Result	Pa231 Error	Pa231 MDA	Ra226 Result	Ra226 Error	Ra226 MDA
B01	-4.44	18.8	10.3	-0.709	2.74	1.60	3.81	0.129	0.231

Location	Ra228 Result	Ra228 Error	Ra228 MDA	Sb125 Result	Sb125 Error	Sb125 MDA	Sn126 Result	Sn126 Error	Sn126 MDA
B01	1.25	0.290	0.270	-0.007	0.181	0.105	0.114	0.150	0.134

Location	Th229 Result	Th229 Error	Th229 MDA	Th232 Result	Th232 Error	Th232 MDA
B01	-0.024	0.410	0.168	1.25	0.290	0.270