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MARSAME Radiological Release Report for Weapons Facility Operations #5 Decontamination and Demolition Project

TA-15-0027, TA-15-0041, TA-15-0044, TA-15-0045, TA-15-0263

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1 Summary

Environmental Protection and Compliance, Environmental Stewardship (EPC-ES) has identified materials associated with Weapons Facility Operations (WFO) #5 that meet the criteria for unrestricted release to the public under Department of Energy (DOE) Order 458.1, *Radiation Protection for the Public and the Environment* (DOE, 2020) and materials in one building that did not meet the criteria for unrestricted release and are to be treated as low level waste (LLW). These conclusions are based on the known history of the area combined with radiation survey data data collected in 2022 and 2023. The findings are consistent with DOE Order 458.1 and Los Alamos National Laboratory (LANL) Functional Series Document EPC-ES-FSD-004, *Environmental Radiation Protection* (LANL, 2021). Sampling and data analysis, as described in this report, were sufficient to meet measurement quality objectives (MQOs) under the *Multi-Agency Radiation Survey and Assessment of Materials and Equipment* (MARSAME) manual (NUREG, 2009) and LANL procedures (LANL, 2020). Final approvals for waste disposition will come from LANL's Waste Management Program.

The scope of this final release report includes Technical Area (TA) 15 Buildings 27, 41, 44, 45, 263 (TA-15-0027/0041/0044/0045/0263). MARSAME provides guidance on statistical sampling for residual radionuclides in bulk materials; smaller, miscellaneous items can be released via the release procedures outlined in LANL Policy 121 *Radiation Protection* (LANL, 2023)

2 Introduction

TA-15-0027/0041/0044/0045/0263, collectively referred to as WFO #5 in this document, were characterized to support decontamination and demolition (D&D). Most of the buildings have no history of radiological work or radiological postings; however, all buildings are collocated with firing sites. Thus, buildings have a potential for radiological impact. Photos of the buildings and historical site assessment can be found in Attachment 1: Sample and Analysis Plan for Weapons Facility Operations (WFO#5) Decontamination and Demolition Project.

3 MARSAME Survey Description

WFO #5 required characterization to support future D&D of the buildings and supporting structures. Since the structures are still standing, the MARSSIM survey approach was utilized to perform the characterization surveys of these structures for residual radioactive contamination. Subsequently, the structures will be demolished, and the waste and any recyclable materials will be sent offsite for disposal. The MARSAME requirements are utilized to evaluate the resulting characterization data for waste debris and recyclable material disposal path decisions, as appropriate.

3.1 Survey Quality Objectives

The data quality and survey completeness of the characterization survey were compared to MARSSIM requirements for statistical coverage and representativeness. To ensure adequacy of survey coverage, EPC-ES used the statistical software Visual Sample Plan (VSP, 2023). This software generates a MARSSIM-compliant sampling plan that provides sufficient and representative data on which to base release decisions. Characterization surveys provide:

1) information on the nature and extent of contamination, if any,
2) data to support evaluation of remediation alternatives and technologies,
3) data for determining if the survey plan can be optimized for use in the final survey,
4) input for the final status survey design (NUREG, 2000).

Fundamental assumptions for this survey plan depended upon the disposition pathway and included the following:

- The data were not assumed to be normally distributed.
- For the Authorized Limit (AL) release pathway (material released to commercial landfill or for recycle):
    - The null hypothesis, Ho, is that the survey unit is contaminated above the AL. "Passing" the survey unit, and releasing the material, would result from rejecting the null hypothesis.
    - Type 1 error (incorrectly rejecting the null hypothesis) would mean concluding the material was below the AL, when in fact it was contaminated above the AL.
    - Type 2 error (incorrectly failing to reject the null hypothesis) would mean concluding the material was contaminated above the AL when it was uncontaminated.

Measurements collected during the characterization survey were used as input for calculating the relative shift and other statistical parameters used in the Sample and Analysis Plan (Attachment 1). Type I error was set at 5% and Type II error was set at 10%, resulting in approximately 26 samples per decision unit using VSP software (Appendix A). Biased and scan surveys were included in MARSAME-based plans for improved coverage and better specificity using process knowledge. The characterization survey coverage produced sufficient data to conclude that no additional sampling is required. This Final Release Report and Survey Plan are being submitted for independent review by the DOE in compliance with DOE Order 458.1 prior to release.

As detailed in the Sample and Analysis Plan (Attachment 1) smears for removeable alpha and beta/gamma radioactivity were taken according to LANL's Radiation Protection Program procedures. Direct 1-minute measurements of alpha and beta/gamma measurements were also taken per procedure and evaluated as total surface activity.

The number and placement of sampling locations were compared to MARSAME requirements for final release and were found to be adequate in number of measurements and spatial distribution to make valid, statistically based release decisions. Grid-like and bias (i.e., judgmental) sampling were performed in each room using direct counts and scan surveys. Table 1 presents a summary of the Characterization plan final status survey requirements and the corresponding survey that was performed.

Table 1 also provides the proposed disposition (i.e. indistinguishable from background (IFB), or LLW if above release criteria). The rooms or buildings that met the unrestricted release criteria for alpha and bata/gamma radioactivity were indistinguishable from natural background. The building materials that are not releasable for disposition in a commercial landfill or as recycling are recommended to be disposed of as LLW. TA-15-0027 was partially collapsed and entry was not possible. Unless entry into the building is made and surveys are performed, all materials should be disposed of as LLW. Final approvals for waste disposition will come from LANL's Waste Management Program.

Table 1: Final status survey requirements compared to completed surveys.

Acronyms provided at end of table.

Characterization Plan Designation			Final Status Survey Requirements			Completed			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
TA-15-0027*									
Interior	3	walls, ceiling, floor	~30 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	-	-	-	LLW
Exterior	3	walls, roof	~25 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	-	-	-	LLW
TA-15-0041									
Room 1	3	walls, floor, ceiling	~30 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	5/18/2022	30 Grid 5 Biased 2 QA	10%	IFB
Room 2	3	walls, floor, ceiling	~30 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	5/18/2022	30 Grid 5 Biased 3 QA	10%	IFB
Room 3	3	walls, floor	~30 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	3/9/2023	10 Grid 3 Biased 3 QA	5%	IFB
Exterior	3	walls, roof	~25 Grid ~3 Biased ~3 QA	<5%	Alpha Beta	5/18/2022	12 Grid 3 Biased 3 QA	10%	IFB
TA-15-0044									
Interior/ Exterior	3	floors, ceiling, walls, roof	~55 Grid ~8 Biased ~4 QA	<5%	Alpha Beta	4/20/2023	33 Grid 3 Biased 3 QA	10%	IFB
TA-15-0045									

Characterization Plan Designation			Final Status Survey Requirements			Completed			
Survey Unit	**Class**	**Description**	**Directs & Smears**	**Scanning**	**Other**	**Date(s)**	**Sampling (direct and smear)**	**Scan %**	**Proposed disposition criteria**
Interior	3	floors, walls, ceiling	~30 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	5/18/2022	30 Grid 5 Biased 5 QA	10%	IFB
Exterior	3	walls, roof	~25 Grid ~3 Biased ~3 QA	<5%	Alpha Beta	5/18/2022	25 Grid 3 Biased 2 QA	10%	IFB
TA-15-0263									
Room 1 North	3	floors, walls, ceiling	~30 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	2/1/2023	25 Grid 5 Biased 5 QA	10%	IFB
Room 2 North	3	floors, walls, ceiling	~30 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	2/1/2023	25 Grid 5 Biased 5 QA	10%	IFB
Room 3 South	3	floors, walls, ceiling	~30 Grid ~5 Biased ~3 QA	<5%	Alpha Beta	2/1/2023	25 Grid 5 Biased 5 QA	10%	IFB
Exterior	3	walls, roof	~25 Grid ~3 Biased ~3 QA	<5%	Alpha Beta	2/1/2023	20 Grid 5 Biased 5 QA	10%	IFB

* TA-15-0027 was inaccessible. It must be treated as LLW unless surveyed.

Acronyms:

IFB – Indistinguishable from Background

LLW – Low Level Waste

QA – Quality Assurance Measurement

3.2 Measurement Quality Objectives

1. Rooms were classified as non-impacted (no reasonable potential for containing radioactivity in excess of natural background), Class 1 (likely contaminated), Class 2 (potential for contamination and possibly near surface contamination limits), and/or Class 3 (minimal potential for contamination) consistent with MARSAME methodology. Sampling and analysis protocol for all items was consistent with LANL policy and procedures. Direct measurements were made using a Ludlum 43-93 Alpha/Beta probe coupled with a Thermo RadEye instrument. This instrument is appropriate for alpha/beta surface contamination measurements. The minimum detectable activity (MDAs) for the direct surveys were below the release limits in Table 10-2 in EPC-ES-FSD-004, as required. Smears were used to collect removable samples and were counted on a Berthold Model LB770 Alpha/Beta Counter with MDAs that were approximately 6 dpm alpha and 11 dpm beta.
2. This assessment confirms that the measurement quality objectives were met for the disposition of the materials, specifically:
   a. Appropriate instrumentation and techniques were used for the measurements and the expected radionuclides (uranium was identified as the dominant radionuclide for surface contamination);
   b. Scanning surveys (< 5% coverage for non-impacted, at least 10% for Class 3 and Class 2, and 100% for Class 1) were used to search for hot spots, as documented in the characterization surveys;
   c. Instruments were calibrated, response checked, and background measurements were within expected ranges; and
   d. Minimum detectable concentrations of the measurements were calculated to be below the surface radioactivity values in Table 10-2 of EPC-ES-FSD-004.

3.3 Statistical Objectives for Disposition Pathways

Depending on the disposition pathway, the objectives of the measurements were to confirm, within the stated statistical confidence limits, that:

1. Measurements of total and removable surface radioactivity are below Table 10-2 values in EPC-ES-FSD-004; and/or
2. Potential residual radioactive contamination is within background levels (i.e. sample measurement distribution is statistically indistinguishable from background distribution).

Potential disposition pathways for this project included:

1. Release of metal for recycle using the Authorized Limits for surface radioactivity found in EPC-ES-FSD-004 Table 10-2 and as low as reasonably achievable (ALARA) considerations.
2. Release of concrete for recycle using a release criterion of IFB.
3. Release of construction and demolition debris (all other material) for disposal at commercial/municipal landfills using a release criterion of IFB.
4. Low Level Waste disposal for any material that does not meet release requirements for any of the above (items 1-3) disposition pathways.

4 Data Analysis

4.1 Authorized Limit Release Pathway

Materials bearing surface radioactivity greater than the Minimum Detectable Activity (MDA) were evaluated by comparison to the preapproved ALs found in Table 10-2 of EPC-ES-FSD-004. The radionuclides of concern for surface radioactivity were gross alpha and beta/gamma which have a preapproved release limit of 20 dpm/100cm^2 and 1,000 dpm/100cm^2 removeable activity respectively.

Decision Criteria for AL pathway:

- If all measurements are ≤ AL, then no further action is required, and the items are candidates for unrestricted release.
- If all measurements or the 95% upper confidence limit (UCL) are > the AL, then the item is not a candidate for unrestricted release through the AL release pathway.
- If the UCL for a set of measurements is below the AL, but some individual measurements are above the AL, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum (WRS) test is used, and if contamination is not present in background, the Sign Test is used.

4.2 Indistinguishable From Background Pathway

Materials bearing surface radioactivity greater than the MDA were evaluated by comparison to the reference background values for common construction materials with naturally occurring radioactive material (NORM) found in Bullock et al. (2019), see Appendix B. Without pre-approved volumetric limits, the IFB release criterial were applied for these releases.

Decision Criteria for IFB pathway:

- If all measurements are: 1) ≤ detectable levels, or 2) < reference background values such as the 95% UCL, then no further action is required, and the items are candidates for unrestricted release.
- If all measurements are > 95% UCL of background, then the item is not a candidate for unrestricted release through the IFB pathway and the item can be considered for decontamination or decay in storage followed by resampling before it can be released.
- If the mean for a set of measurements is below the 95% UCL background level, but some individual measurements are above the 95% UCL level, then statistical analysis is needed. Generally, non-parametric statistical approaches are used to evaluate the null hypothesis. If contamination is present in background, the Wilcoxon Rank Sum (WRS) test is suggested, and if contamination is not present in background, use the Sign Test.

4.3 Sampling Results

The sample summary results can be found in Table 2 where they are grouped by building and rooms, then compared to the AL and IFB criteria. These surface radioactivity results show that most measurements were below the limits in EPC-ES-FSD-004 Table 10-2 and met indistinguishable from background criteria. For measurements that did not meet indistinguishable from background criteria, gamma spectroscopy was performed.

4.3.1 Gamma Spectroscopy Measurements

Though all measurement of surface radioactivity were below the release limits in radiation protection policy P121, measurements in two of the buildings showed counts above the 95% UCL of background. These buildings had no history of radiological work or contamination. EPC-ES health physics staff performed gamma spectroscopy measurements in TA-15-0041 and TA-15-0044 to determine the cause of the elevated direct count results. Measurements of approximately five minutes were taken at locations where the elevated direct counts were measured. For comparison to background, one 14-hour background gamma spectral measurement was also taken away from the building.

Analysis of the spectra taken inside the building and the background spectrum reveals peaks identified as Tl-208, Bi-214, and Ac-228, which are decay isotopes of naturally occurring U-238 and Th-232. K-40 is naturally occurring in background and was present in the spectra. Peaks identified as Pb-212 (239 keV) and Ac-228 (338 keV) can also be seen on the spectra inside the building. These two peaks are also in the background spectrum but are much smaller and much more difficult to decipher against background. The isotopes found are consistent with naturally occurring thorium. The conclusion from these measurements is that some of the building materials contain higher than usual concentrations of natural thorium. This explains the IFB failure for all measurements made in the TA-15-0041 and TA-15-0044. No LANL-derived isotopes were found.

Table 2: Summary statistics for gross alpha and beta surface radioactivity levels in sampling and release decisions.

* Units are dpm/100 cm^2. Acronyms provided at end of table.

Room			**n**	**mean**	**STD**	**Max**	**95% UCL**	**Release AL**	**Decision**
TA-15-0027, survey unable to be completed due to building degradation, materials should be disposed of as LLW unless surveys can be completed									
TA-15-0041									
Room 1 Interior	removable	alpha	35	0.4	0.8	2.7	0.7	20	< AL, IFB
		beta	35	1.1	1.7	4.8	1.6	1000	< AL, IFB
	total	alpha	37	25	10	67	28	100	< AL, IFB
		beta	37	1053	121	1472	1086	5000	< AL, IFB
Room1 Exterior	removable	alpha	15	0.7	0.9	2.4	1.1	20	< AL, IFB
		beta	15	1.3	1.6	5.7	2	1000	< AL, IFB
	total	alpha	19	42	19	84	51	100	< AL, IFB
		beta	19	1198	176	1552	1269	5000	< AL, IFB
Room 2 Interior	removable	alpha	35	0.5	0.9	3.7	0.8	20	< AL, IFB
		beta	35	0.9	1.3	5.6	1.3	1000	< AL, IFB
	total	alpha	38	24	9	55	26	100	< AL, IFB
		beta	38	1146	224	1997	1207	5000	< AL, IFB

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
Room 3 Interior	removable	alpha	13	0.8	1.1	3.5	1.4	20	< AL, IFB
		beta	13	1.2	1.7	5	2	1000	< AL, IFB
	total	alpha	16	26	34	142	40	100	< AL, IFB
		beta	16	1200	550	3232	1441	5000	< AL, IFB
TA-15-0044									
Interior/Exterior	removable	alpha	30	0.6	0.8	2.1	0.9	20	<AL, IFB
		beta	30	2	2.2	7	2.6	1000	< AL, IFB
	total	alpha	33	46	21	91	52	100	<AL, IFB
		beta	33	1023	372	2821	1132	5000	< AL, IFB
TA-15-0045									
Interior	removable	alpha	35	0.3	0.6	2.4	0.5	20	< AL, IFB
		beta	35	1	1.8	6.9	1.5	1000	< AL, IFB
	total	alpha	38	15	4	20	16	100	< AL, IFB
		beta	38	1080	153	1680	1122	5000	< AL, IFB
Exterior	removable	alpha	18	0.4	0.7	2.4	0.7	20	< AL, IFB
		beta	18	0.9	1.9	7.2	1.7	1000	< AL, IFB
	total	alpha	20	14	2	19	15	100	< AL, IFB
		beta	20	1130	145	1680	1186	5000	< AL, IFB
TA-15-0263									
Room 1 North	removable	alpha	30	0.2	0.5	2.4	0.3	20	< AL, IFB
		beta	30	1.4	1.8	5.5	2	1000	< AL, IFB
	total	alpha	35	28	12	48	31	100	< AL, IFB
		beta	35	993	309	1647	1081	5000	< AL, IFB
Room 2 North	removable	alpha	30	0.3	0.5	1.2	0.5	20	< AL, IFB
		beta	30	0.7	1.3	5.6	1.1	1000	< AL, IFB
	total	alpha	35	32	22	116	39	100	< AL, IFB
		beta	35	863	255	1461	936	5000	< AL, IFB
Room 3 South	removable	alpha	30	0.2	0.4	1.2	0.4	20	< AL, IFB

Room			n	mean	STD	Max	95% UCL	Release AL	Decision
		beta	30	2	2.3	7.7	2.7	1000	< AL, IFB
	total	alpha	35	32	19	83	38	100	< AL, IFB
		beta	35	867	241	1394	928	5000	<AL, IFB
Exterior	removable	alpha	25	0.8	1.2	5	1.2	20	< AL, IFB
		beta	25	1.8	2.2	7.6	2.6	1000	< AL, IFB
	total	alpha	30	65	28	144	73	100	< AL, IFB
		beta	30	837	54	940	854	5000	< AL, IFB

Acronyms:
AL – Authorized Limit
LLW – Low Level Waste
Max – Maximum
n – Number of samples
STD – Standard Deviation
UCL – Upper Confidence Level (taken as the 95% upper-bound estimate of the mean)

Conclusions

Given the process knowledge and sample data presented in this report package, EPC-ES concludes that the materials from TA15-0041/0044/0045/0263 are candidates for unrestricted release under DOE Order 458.1 (DOE, 2020). Materials from 15-0027 are not candidates for unrestricted release and are recommended for LLW unless surveys can be completed. Final waste disposition decisions for radiological and non-radiological constituents require appropriate approvals from the waste management coordinator.

5 References

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6 Acronyms and Abbreviations

Acronym	Definition
AL	Authorized Limits
DOE	(U.S.) Department of Energy
D&D	Decontamination and Demolition
EPA	(U.S.) Environmental Protection Agency
EPC-ES	Environmental Programs and Compliance- Environemtal Stewardship Group
IFB	Indistinguishable From Background
LANL	Los Alamos National Laboratory
LLW	Low Level Waste
MARSAME	Multi-Agency Radioactive Survey and Assessment of Material and Equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MQO	measurement quality objective
SAP	Sample and Analysis Plan
TA	Technical Area
VSP	Visual Sample Plan
WFO	Weapons Facility Operations

Appendix A: Visual Sample Plan Analysis Output

Random sampling locations for comparing a median with a fixed threshold (nonparametric - MARSSIM)

Summary
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. The type of medium to sample (i.e., soil, groundwater, etc.) and how to analyze the samples (in-situ, fixed laboratory, etc.) are addressed in other sections of the sampling plan.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Compare a site mean or median to a fixed threshold
Type of Sampling Design	Nonparametric
Sample Placement (Location) in the Field	Simple random sampling
Working (Null) Hypothesis	The median(mean) value at the site exceeds the threshold
Formula for calculating number of sampling locations	Sign Test - MARSSIM version
Calculated number of samples	21
Number of samples adjusted for EMC	21
Number of samples with MARSSIM Overage	26
Number of samples on map [a]	0
Number of selected sample areas [b]	0
Specified sampling area [c]	5000.00 ft^2

[a] This number may differ from the calculated number because of 1) grid edge effects, 2) adding judgment samples, or 3) selecting or unselecting sample areas.
[b] The number of selected sample areas is the number of colored areas on the map of the site. These sample areas contain the locations where samples are collected.
[c] The sampling area is the total surface area of the selected colored sample areas on the map of the site.

Primary Sampling Objective
The primary purpose of sampling at this site is to compare a site median or mean value with a fixed threshold. The working hypothesis (or 'null' hypothesis) is that the median(mean) value at the site is equal to or exceeds the threshold. The alternative hypothesis is that the median(mean) value is less than the threshold. VSP calculates the number of samples required to reject the null hypothesis in favor of the alternative one, given a selected sampling approach and inputs to the associated equation.

Selected Sampling Approach
A nonparametric random sampling approach was used to determine the number of samples and to specify sampling locations. A nonparametric formula was chosen because the conceptual model and historical information (e.g., historical data from this site or a very similar site) indicate that typical parametric assumptions may not be true.

Both parametric and non-parametric equations rely on assumptions about the population. Typically, however, non-parametric equations require fewer assumptions and allow for more uncertainty about the statistical distribution of values at the site. The trade-off is that if the parametric assumptions are valid, the required number of samples is usually less than if a non-parametric equation was used.

VSP offers many options to determine the locations at which measurements are made or samples are collected and subsequently measured. For this design, simple random point sampling was chosen. Locating the sample points randomly provides data that are separated by varying distances, providing good information about the spatial structure of the potential contamination. Knowledge of the spatial structure is useful for geostatistical analysis. However, it may not ensure that all portions of the site are equally represented.

Nuclides

The following table summarizes the analyzed nuclides.

Nuclide	**$DCGL_W$** *dpm/100cm²*	**$DCGL_W$ = UBGR**	**LBGR** (*dpm/100cm²*)	**Standard Deviation** (*dpm/100cm²*)
Removable Alpha	20	AL-Removable α	Zero	MDA HPALα (6)
Removable Beta	1000	AL- Removable β	Zero	MDA HPALβ (11)
Total Alpha	100	AL-Total α	Median Ref. α (31)	Mean STD of Ref. α (74)
Total Beta	5000	AL-Total β	Median Ref. β (1454)	Mean STD of Ref. β (237)
IFB Alpha	210	Mean+2 STD Ref α	Median Ref. α (31)	Mean STD of Ref. α (74)
IFB Beta	2048	Mean+2 STD Ref β	Median Ref. β (1454)	Mean STD of Ref. β (237)

Number of Total Samples: Calculation Equation and Inputs

The equation used to calculate the number of samples is based on a Sign test (see PNNL 13450 for discussion). For this site, the null hypothesis is rejected in favor of the alternative one if the median(mean) is sufficiently smaller than the threshold. The number of samples to collect is calculated so that if the inputs to the equation are true, the calculated number of samples will cause the null hypothesis to be rejected.

The formula used to calculate the number of samples is:

$$n = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)^2}{4(SignP - 0.5)^2}$$

where

$$SignP = \Phi\left(\frac{\Delta}{S_{total}}\right)$$

$\Phi(z)$ is the cumulative standard normal distribution on $(-\infty,z)$ (see PNNL-13450 for details),

n is the number of samples,

S_{total} is the estimated standard deviation of the measured values including analytical error,

Δ is the width of the gray region,

α is the acceptable probability of incorrectly concluding the site median(mean) is less than the threshold,

β is the acceptable probability of incorrectly concluding the site median(mean) exceeds the threshold,

$Z_{1-\alpha}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\alpha}$ is $1-\alpha$,

$Z_{1-\beta}$ is the value of the standard normal distribution such that the proportion of the distribution less than $Z_{1-\beta}$ is $1-\beta$.

Note: MARSSIM suggests that the number of samples should be increased by at least 20% to account for missing or unusable data and uncertainty in the calculated value of n. VSP allows a user-supplied percent overage as discussed in MARSSIM (EPA 2000, p. 5-33).

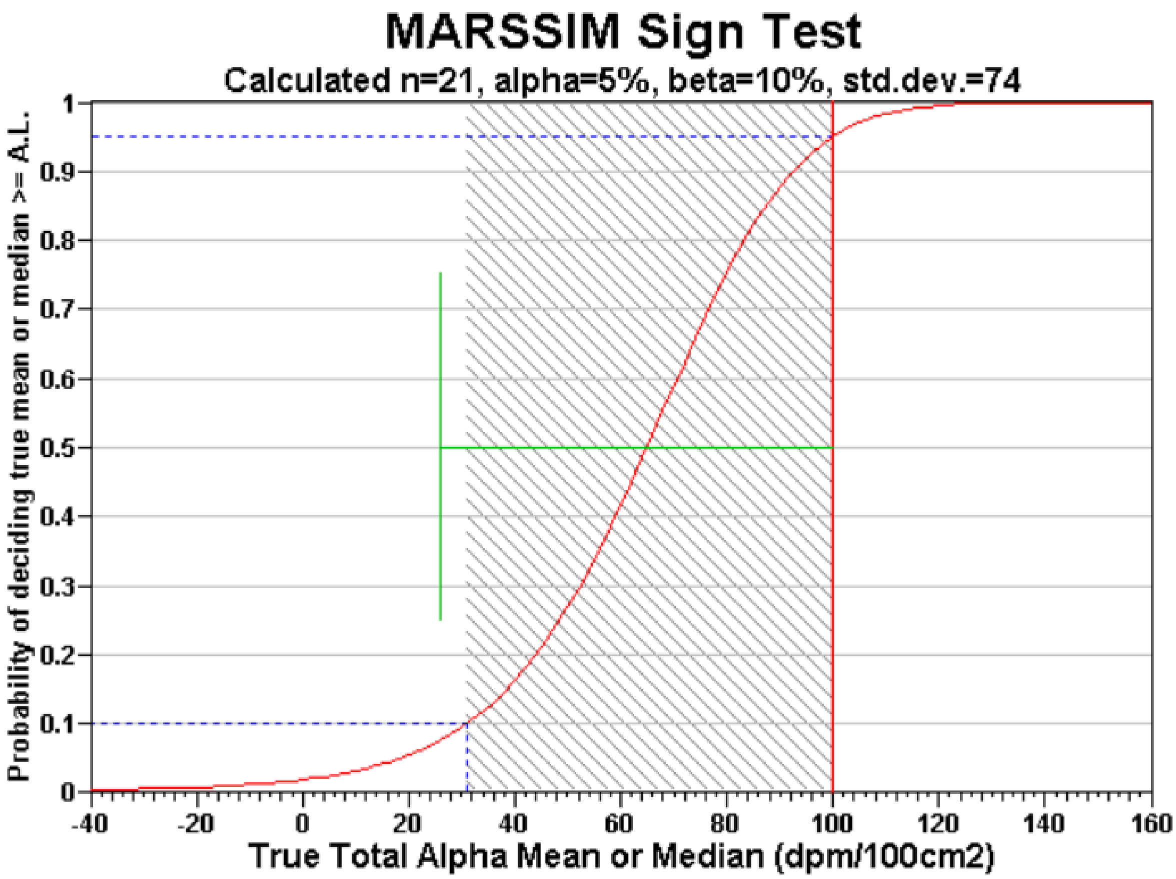
For each nuclide in the table, the values of these inputs that result in the calculated number of sampling locations are:

Nuclide	n[a]	n[b]	n[c]	Parameter					
				S_{total}	Δ	α	β	$Z_{1-\alpha}$ [d]	$Z_{1-\beta}$ [e]
Removable Alpha	9	9	11	6	20	0.05	0.1	1.64485	1.28155
Removable Beta	9	9	11	11	1000	0.05	0.1	1.64485	1.28155
Total Alpha	21	21	26	74	69	0.05	0.1	1.64485	1.28155
Total Beta	9	9	11	237	3546	0.05	0.1	1.64485	1.28155
IFB Alpha	9	9	11	74	179	0.05	0.1	1.64485	1.28155
IFB Beta	9	9	11	237	594	0.05	0.1	1.64485	1.28155

[a] The number of samples calculated by the formula.
[b] The number of samples increased by EMC calculations.
[c] The final number of samples increased by the MARSSIM Overage of 20%.
[d] This value is automatically calculated by VSP based upon the user defined value of α.
[e] This value is automatically calculated by VSP based upon the user defined value of β.

Performance
The following figure is a performance goal diagram, described in EPA's QA/G-4 guidance (EPA, 2000). It shows the probability of concluding the sample area is dirty on the vertical axis versus a range of possible true median(mean) values for the site on the horizontal axis. This graph contains all of the inputs to the number of samples equation and pictorially represents the calculation.

The red vertical line is shown at the threshold (action limit) on the horizontal axis. The width of the gray shaded area is equal to Δ; the upper horizontal dashed blue line is positioned at 1-α on the vertical axis; the lower horizontal dashed blue line is positioned at β on the vertical axis. The vertical green line is positioned at one standard deviation below the threshold. The shape of the red curve corresponds to the estimates of variability. The calculated number of samples results in the curve that passes through the lower bound of Δ at β and the upper bound of Δ at 1-α. If any of the inputs change, the number of samples that result in the correct curve changes.



Statistical Assumptions
The assumptions associated with the formulas for computing the number of samples are:
1. the computed sign test statistic is normally distributed,
2. the variance estimate, S^2, is reasonable and representative of the population being sampled,
3. the population values are not spatially or temporally correlated, and
4. the sampling locations will be selected randomly.

The first three assumptions will be assessed in a post data collection analysis. The last assumption is valid because the sample locations were selected using a random process.

Sensitivity Analysis
The sensitivity of the calculation of number of samples was explored by varying the standard deviation, lower bound of gray region (% of action level), beta (%), probability of mistakenly concluding that μ > action level and alpha (%), probability of mistakenly concluding that μ < action level. The following table shows the results of this analysis.

Number of Samples							
AL=5000		**α=5**		**α=10**		**α=15**	
		s=148	**s=74**	**s=148**	**s=74**	**s=148**	**s=74**
LBGR=90	**β=5**	4476	1125	3543	891	2974	748
	β=10	3543	891	2717	683	2223	558
	β=15	2974	748	2223	558	1778	447
LBGR=80	**β=5**	1125	287	891	227	748	191

	β=10	891	227	683	174	558	143
	β=15	748	191	558	143	447	114
LBGR=70	**β=5**	504	132	399	105	335	88
	β=10	399	105	306	81	251	66
	β=15	335	88	251	66	201	53

s = Standard Deviation
LBGR = Lower Bound of Gray Region (% of Action Level)
β = Beta (%), Probability of mistakenly concluding that μ > action level
α = Alpha (%), Probability of mistakenly concluding that μ < action level
AL = Action Level (Threshold)

Note: Values in table are not adjusted for EMC.

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Appendix B: Background Material Values for RadEye SX with Ludlum 43-9

Summary statistics for measured total surface activities in various common construction materials. Units of measurement are GROSS dpm/100 cm2. Data from Bullock et al. (2019).

Construction Material	Mean	Maximum	Standard Deviation	95% upper confidence level for mean
Wood (n=10)				
Alpha	29	93	29	47
Beta	906	1170	147	992
Painted Metal Interior (n=27)				
Alpha	54	592	134	167
Beta	1049	1413	148	1098
Painted Metal Exterior (n=25)				
Alpha	45	73	14	50
Beta	827	1269	185	891
Beta/Alpha Ratio	18			
Rusted Metal (n=11)				
Alpha	326	569	161	415
Beta	1355	1607	211	1471
Galvanized Metal (n=8)				
Alpha	65	93	19	78
Beta	790	869	66	834
Bare Metal (n=25)				
Alpha	12	29	7	15
Beta	1237	1632	252	1324
Painted Concrete Poured Interior (n=30)				
Alpha	20	47	12	24
Beta	1547	2427	291	1638
Painted Concrete Poured Exterior (n=20)				
Alpha	26	63	13	31
Beta	1363	1688	204	1688
Bare Concrete Poured Interior (n=25)				
Alpha	27	107	32	56
Beta	1538	1948	360	1853
Bare Concrete Poured Exterior (n=20)				

Alpha	83	155	44	100
Beta	1757	2247	238	2235
Painted Cinderblock (n=25)				
Alpha	27	68	17	33
Beta	1938	2248	276	2033
Bare Cinderblock Exterior (n=20)				
Alpha	66	128	31	78
Beta	1774	2695	477	1986
Brick (n=25)				
Alpha	95	179	47	111
Beta	2153	2660	458	2311

Attachment 1: Sample and Analysis Plan for Weapons Facility Operations (WFO#5) Decontamination and Demolition Project

April 2022

Sample and Analysis Plan for Weapons Facility Operations #5 Decontamination and Demolition Project

TA-15-0027, TA-15-0041, TA-15-0044, TA-15-0045, TA-15-0263

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1 Sample and Analysis Plan Overview

1.1 Purpose and Scope of the Sample and Analysis Plan

Technical Area (TA) 15 Building 27 (TA-15-0027), TA-15 Building 41 (TA-15-0041), TA-15 Building 44 (TA-15-0044), TA-15 Building 45 (TA-15-0045), and TA-15 Building 263 (TA-15-0263), collectively referred to as WFO #5 structures in this document, need to be characterized to support future decontamination and demolition. The buildings have no history of radiological work nor are there any radiological postings; however, these buildings are colocated with firing sites. Thus, the buildings have a potential for radiological impact. The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NUREG, 2000) survey approach will be used to perform the characterization surveys of the standing structures for residual radioactive surface contamination. The structures will eventually be demolished, and the waste and any recyclable materials will be sent offsite for disposal. At this point, the Multi-Agency Radiation Survey and Assessment of Materials and Equipment (MARSAME) (NUREG, 2009) requirements will be used to evaluate the resulting characterization data for waste debris and recyclable material disposal path decisions, as appropriate.

1.2 Objective of the Sample and Analysis Plan

The objective of this sample and analysis plan (SAP) is to confirm, within the stated statistical confidence limits, that the mean levels of potential radioactive residual contamination in the construction and demolition debris are documented to determine that they are at background levels and are candidates for release for offiste disposal.

1.3 MARSSIM Guidance

According to MARSSIM Section 2.4, the six principal steps in the MARSSIM Radiation Survey and Site Investigation Process are as follows:

- Site Identification
- Historical Site Assessment (HSA)
- Scoping Survey
- Characterization Survey
- Remedial Action Support Survey
- Final Status Survey

The first two principal steps (site identification and HSA) are completed, and the results are detailed in this document. The purpose of this Plan is to satisfy the third and forth principal steps (scoping and characterization) to assess for radiological impact and, if impacted, to characterize the potential contamination. Although the purpose this plan is to provide scoping data, the rigor of the sampling is designed to meet the quality objectives of a characterization survey.

The MARSSIM HSA information for these structures is contained in Section 1.4. The MARSSIM surveys will be used to assess the radioactive contamination. The survey results will be evaluated against against MARSAME release requirements, and if release requirements are met, the materials are candidates for unrestricted release to the public under U.S. Department of Energy (DOE) Order 458.1 (DOE, 2020).

If surveys measure radioactive contamination, in accordance with MARSSIM Chapter 2, Section 2.4.4., "If an area could be classified as Class 1 or Class 2 for the final status survey, based on the HSA and scoping survey results, a characterization survey is warranted. This type of survey is a detailed radiological environmental characterization of the area." Based on the HSA, a Class 3 final status survey unit is possible. Although the less rigorous elements of a scoping survey may be sufficient, a characterization survey structure was used as described in the Sections 2, 3, and 5.

According to MARSSIM Chapter 2, Section 2.4.4., the primary objectives of a characterization survey are as follows:

- Determine the nature and extent of the contamination.
- Collect data to support evaluation of remedial alternatives and technologies.
- Evaluate whether the survey plan can be optimized for use in the final status survey.
- Provide input to the final status survey design.

From MARSSIM Chapter 2, Section 2.4.4., "The characterization survey is the most comprehensive of all the survey types and generates the most data. This includes preparing a reference grid, systematic as well as judgment measurements, and surveys of different media (e.g., surface soils, interior and exterior surfaces of buildings). The decision as to which media will be surveyed is a site-specific decision addressed throughout the Radiation Survey and Site Investigation Process."

Once the scoping survey has been completed according to this Plan, the data will be analyzed using the MARSAME statistical methods, and these results will be used to plan for the remedial action support surveys and/or final status surveys, as appropriate.

Notes and Assumptions

The results of this survey are to be used for waste disposal planning purposes. According to MARSSIM Section 2.4.6, ". . . data from other surveys conducted during the Radiation Survey and Site Investigation Process – such as scoping, characterization, and remedial action support surveys – can provide valuable information for planning a final status survey provided they are of sufficient quality." Release of materials is contingent upon material surveys passing a final status survey, as appropriate.

Further restrictions may be imposed by the waste management coordinator.

1.4 Historical Site Assessment[1]

TA-15, R Site, is located on top of Three-Mile Mesa between Cañon de Valle and Three-Mile Canyon. During World War II, the flash photography method was used at TA-15 to study the implosion of cylinders. Manhattan Project facilities at TA-15 included control and observation buildings, as well as firing pits and other firing structures. Many of these early implosion-testing structures have been removed. During TA-15's history, about 12 different firing areas have been used.

[1] *DX Division's Facility Strategic Plan: Consolidation and Revitalization at Technical Areas 6, 8, 9, 14, 15, 22, 36, 39, 40, 60, and 69.*

TA-15-0027 is a one-story building, rectangular-in-plan, with an exterior measurement of 40 ft by 14 ft, that occupies approximately 560 gross ft^2. The original plan was divided into three main rooms and a restroom that contains approximately 384 net usable ft^2. The building was constructed with a reinforced concrete foundation and floor slab, 1-ft-thick reinforced concrete walls, and a 1-ft-thick flat concrete roof under earthen fill.

The south wall contains a single, reinforced, metal door that serves as the main and only entrance to the building. The building's north, east, and west walls and roof are covered with compacted earth. Wooden posts support wooden, triangularly shaped wing walls that extend out from the face or entrance to the building. These wing walls extend approximately 16 ft at a 45-degree angle and serve as a retaining system for the surrounding compacted earth. The wing walls are sheathed with asbestos containing–material shingles. The compacted earth serves as a blast suppressor in the event that an explosion occurred during one of the controlled experiments north of the building. Directly east of the entrance and wing wall is a set of concrete steps with a metal railing; the steps lead to a level area where earlier experiments were probably conducted. This control room originally housed equipment used to monitor experiments in this vicinity.

This building functioned as the control building for TA-15's firing sites E and F, which are located to the north and east of this building. The building is not being used and is in a state of deterioration.

Figure 1. TA-15-0027 view from southwest side

TA-15-0041 is a one-story, rectangular building that measures 9 ft 10 in. by 32 ft and contains a total of 232 ft^2 of usable interior floor space. The building has a reinforced concrete foundation and floor slab, concrete walls, and a low-pitched concrete/tar/gravel roof with galvanized metal fascia. A concrete apron spans the front of the building.

The interior of the building is divided into three individual rooms (Room 1, Room 2, and Room 3), each with its own exterior access. Each door is a two-panel metal door equipped with an overhead wall-mounted light fixture. Both Rooms 2 and 3 had windows that consisted of two glass-block panels located on the north side. The roof contains two vent stacks and lightning rods.

This building has continuously functioned as a storage facility since its construction.

Figure 2. TA-15-0041 view from the south side

TA-15-0044 is a one-story, rectangular-in-plan building with an exterior measurement of 29 ft 4 in. by 18 ft. The single interior room contains 422 ft^2 of useable floor space. The building was constructed with a vibration-proof foundation system that consists of 2 ft of crushed rock, a 1-ft-thick concrete slab foundation covered with 1 ft of compacted sawdust, and an 8-in.-thick reinforced concrete floor slab. The building has 1-ft-thick reinforced concrete walls with an exterior 2-ft layer of crushed rock. The flat concrete roof is covered with a combination of crushed rock and compacted dirt. The two rear corners of the building, hidden below grade, are constructed at a 45-degree angle to accommodate five 3.5-in.-diameter sleeves and five 5-in.-diameter sleeves. The sleeves penetrate the concrete walls and support the numerous cables that connect the control room with the instrument shelter located more than 30 ft away.

The south headwall is exposed, and compacted earth covers the remaining three walls and roof. A wall constructed of concrete-filled burlap bags is located on top of the roof. Over time, the concrete cured, and the bags disintegrated, leaving a "bag-formed," miniature blast wall in their place. Triangle-shaped wing walls extend out from the face of the building at a 45-degree angle and serve as a retaining system for the surrounding compacted earth. The compacted earth serves as a blast suppressor in the event that an explosion occurs within the building. Metal pipe railings are located along the entire length of the wing walls and on the front edge of the roof. A concrete apron fills the space between the wing walls and in front of the door.

A single, reinforced metal door set within the face of the headwall provides the only access into the control room. The building has a wall-mounted light fixture, loudspeakers, a fire extinguisher, explosion-proof outlet and switches, informational signage, and lightning rods. The building also has air-handling equipment, conduit, and junction boxes.

This building was constructed as a control building for firing site activities located to the north.

Figure 3. TA-15-0044 view from south side

TA-15-0045 is virtually identical to TA-15-0044; however, TA-15-0045 has more air-handling equipment and has a cable tray located approximately 8 ft above grade on the front of the building. Two vent stacks protrude from the flat roof as well. Concrete stairs are located to the east of the building and provide access to the roof area.

This building was constructed as a control building for firing-site activities located to the north.

Figure 4. TA-15-0045 view from south side

TA-15-0263 is a former laboratory building located in close proximity to TA-15-0045 firing site. It appears to have been used as a shop rather than a laboratory. A shed attached to the structure housed cooling equipment.

Figure 5. TA-15-0263 view from overhead

2 Data Quality Objectives for the SAP

This SAP was prepared in accordance with EPC-ES-FSD-004, *Environmental Radiation Protection*, (LANL, 2021b) and was developed using EPC-ES-TPP-001, *Data Quality Objectives for Measurement of Radioactivity in or on Items for Transfer into the Public Domain* (LANL, 2020a).

2.1 Decision Identification

The principal study question is: Does the residual radioactive contamination exceed background levels? The decision alternatives are as follows:

- If results from measurements show detectable surface or volumetric contamination above reference background levels, then the item *is not a candidate* for release unless decontamination or radioactive decay in storage is successful in removing all measurable contamination.
- If results from measurements do not show detectable surface or volumetric contamination above background, then the item *is a candidate* for release to the public without controls.

2.2 Decision Rule

The decision rule is based on the null hypothesis that the mean residual contamination level in soil and/or sediment is above background and not releasable. The alternative hypothesis is that the mean residual contamination levels in soil and/or sediment is below background and releasable.

2.3 Limits on Decision Errors

The decision rule is based on an L_c (critical limit) using a 5% false alarm rate and an upper confidence limit (UCL) of 95%.

2.4 Procedures used to meet the Data Quality Objectives

Characterization data obtained from this survey may be used to supplement the MARSSIM final status survey if the characterization data meet final status survey data quality objectives (DQOs). MARSSIM Sections 2.3, 2.4.6, 2.6, 5.1, 5.2.4, and 5.3.3.1 discuss the use of characterization surveys (and other MARSSIM surveys) to supplement and augment the final status survey requirements.

Table 1. Nominal release criteria for surface contamination

Values from EPC-ES-FSD-004 Section 1021 Table 10-2	
Radionuclide	dpm/100cm^2
U-natural, U-235, U-238 and associated decay products (Removable)	1,000
U-natural, U-235, U-238 and associated decay products (Total)	5,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129 (Removable)	20
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227,I-125, I-129 (Total)	100
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 (Removable)	200
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133 (Total)	1,000
β/γ emitters (Removable)	1,000
β/γ emitters (Total)	5,000
Tritium and Special Tritium Compounds	10,000

Sampling and data analysis for volumetric contamination are not required based on the history and potential for activation of building materials.

3 Instrumentation and Measurement Quality Objectives

The main objectives are to determine appropriate analysis techniques for each radionuclide and to ensure that measurement quality objectives (MQOs) are satisfied. One should be confident that the measurement results are valid and appropriate for the decisions being made.

3.1 Measurement Quality Objectives

- Detection Capability: Minimum detection concentration (MDC) should be below the MARSSIM defined lower-bound of the gray region (LBGR).
- The degree of measurement uncertainty (combined precision and bias) should be reported, and the level should be reasonable relative to the needed accuracy of the decision and accounted for in the statistical analysis.
- Range of the instrument and measurement technique should be appropriate for the concentrations expected.
- The instrument and measurement technique should be specific for the radionuclide(s) being measured. Specificity is the ability of the measurement method to measure the radionuclide of concern in the presence of interferences.
- For field instruments, the instrument should be rugged enough to consistently provide reliable measurements; however, in this case, all samples will be analyzed in the laboratory.

3.2 Procedures used to meet the Measurement Quality Objectives

1. Follow P121, *Radiation Protection* (LANL, 2020b); RP-PROG-TP-200, *Radiation Protection Manual* (LANL, 2021a); and other applicable characterization and sampling procedures. Document all survey results on the appropriate survey form(s) and survey map(s). All direct and removable measurement results are to be reported as dpm/100 cm^2. Do not use no detectable activity (NDA).

2. The number of direct and removable measurements is specified in the following survey unit and survey requirement tables for each survey unit. Survey point locations (both direct counts and smears) will be a combination of “uniformly distributed” and “biased” locations determined by the surveyors. Uniformly distributed points shall be spread across all survey unit surfaces in a uniform, even, systematic pattern (similar to a grid pattern). Survey point locations may be changed based on accessibility issues via consultation with the project manager and the Environmental Stewardship staff responsible for compliance with DOE Order 458.1.

3. Collect and record direct measurement instrument background readings periodically during surveys (approximately five background measurements per survey unit). Identify and document background measurements on the survey form and maps using the survey unit number. Collect background measurements on direct reading probes by pointing the probe into the air and away from any nearby surfaces.

4. Required Characterization Surveys include the following:

   - Surface scan surveys using an SHP380AB (α/β) detector, listening for increased count rate areas
   - 60-second scalar direct surveys using an SHP380AB (α/β) detector
   - Smears (counted for α and β/γ)

5. Scan percentages are specified in the survey unit and survey requirement tables for each survey unit (Section 5). For any areas of noticeably elevated count rate, a biased measurement (direct and smear) shall be collected and documented. When biased surveying is required, scan surveys should be used to decide locations of biased survey points, or the biased locations can be selected based on process knowledge. Denote biased surveys sequentially after the last systematic survey location. Biased measurement locations may include high-traffic areas such as room entrances; heating/ventilation/air conditioning intakes and exhaust ducts; storage areas; areas of frequent personnel contact such as doors and door frames; horizontal surfaces such as lab counter tops and shelves; sinks; the openings to sink and floor drains; and the tops of lights, beams, crane rails, structural beams, etc.

6. On the survey forms, denote surface material (“concrete,” “metal,” etc.) and locations of biased surveys.

7. Use provided survey maps, or create scaled maps, as necessary, to document the survey locations and results.

8. Smear survey results are to be reported in the form consistent with the results from Health Physics Analysis Laboratory (HPAL). HPAL should be requested to report results as dpm/100 cm^2 (not NDA). In consultation with HPAL, isotopic analysis can be performed on smears with high gross alpha/beta results if the radioisotope (or mixture) is unknown. Save all smears for possible future HPAL analysis.

9. Collect and maintain all characterization paperwork. Number each page of the survey unit packages using the format “XX of XX”. Survey unit packages should include survey forms, maps, HPAL smear results, and HPAL isotopic analysis (if required). Provide all completed paperwork to the project manager and the Environmental Stewardship staff.

10. Surface Labeling Requirements

    - Denote survey unit location numbers on structure surfaces where measurements are obtained. Mark locations using the survey unit designation plus the next sequential survey point location number. For example, for survey unit 08-0032, room 102, location survey point number 5, mark the structure surface with the number 08-0032-102-5.
    - The direct reading probe outline shall be drawn on the surface with a marker and a template to identify the exact surveyed location in the event that a re-survey is necessary.
    - Denote on the survey map where the direct and smear surveys were performed. Scan area may be approximated by a highlighted/circled area in survey units that require less than 100% scanning. Record the general scan findings on the survey forms and/or maps.

4 Special Support and Safety Requirements

- Upper walls and ceilings/roofs require access via ladders, scaffolding, manlifts, etc.
- Survey technicians shall be trained for elevated work.
- Pest control may be required in and around all structures.

5 Sampling and Analysis Plans for Characterization Surveys

The following table outlines the requirements for the characterization surveys in the WFO #5 structures. Include 10% side-by-side measurements for quality assurance (QA). Gamma and neutron measurements are not required.

Table 2. Characterization Survey Requirements

Building	Smear surveys	Direct (α, β)	Scan (α, β)
15-0027 (interior)	Quasi-systematic grid per room: • 5 each wall • 5 on ceiling • 5 on floor • 5 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations
15-0027 (exterior)	Quasi-systematic grid per room: • 5 each wall • 5 on roof (not soil) • 3 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations
15-0041 (interior)	Quasi-systematic grid per room: • 5 each wall • 5 on ceiling • 5 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations

Building	Smear surveys	Direct (α, β)	Scan (α, β)
15-0041 (exterior)	Quasi-systematic grid per room: • 5 each wall • 5 on roof (not soil) • 3 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations
15-0044 (interior)	Quasi-systematic grid per room: • 5 each wall • 5 on ceiling • 5 on floor • 5 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations
15-0044 (exterior)	Quasi-systematic grid per room: • 5 each wall • 5 on roof (not soil) • 3 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations
15-0045 (interior)	Quasi-systematic grid per room: • 5 each wall • 5 on ceiling • 5 on floor • 5 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations
15-0045 (exterior)	Quasi-systematic grid per room: • 5 each wall • 5 on roof (not soil) • 3 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations
15-0263 (interior)	Quasi-systematic grid per room: • 5 each wall • 5 on ceiling • 5 on floor • 5 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations
15-0263 (exterior)	Quasi-systematic grid per room: • 5 each wall • 5 on roof (not soil) • 3 bias locations	Perform direct surveys next to each location smears were taken. Take side-by-side QA measurements at 2–3 locations	<5% surface area, biased locations

6 References

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7 Acronyms and Abbreviations

Acronym	Definition
DQO	data quality objective
LBGR	lower bound of the grey region
MDC	minimum detection concentration
MQO	measurement quality objective
DOE	(U.S.) Department of Energy
EPA	(U.S.) Environmental Protection Agency
EPC-ES	Environmental Protection and Compliance-Environmental Stewardship
HPAL	Health Physics Analysis Laboratory
HSA	historical site assessment
LANL	Los Alamos National Laboratory
MARSAME	Multi-Agency Radioactive Survey and Assessment of Material and Equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NDA	no detectable activity
QA	quality assurance
SAP	sample and analysis plan
TA	Technical Area
UCL	upper confidence limit
WFO	Weapons Facility Operations