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1 Summary

Environmental Protection and Compliance, Environmental Stewardship (EPC-ES) has determined that only a portion of the soil associated with Replacement Water Lines from Technical Area (TA)-48 to TA-55 (Figure 1) meets 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). The remaining soil did not meet the criteria for unrestricted release and must be managed appropriately. These conclusions are based on the known history of the area combined with soil sample data collected in 2022; 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 excavated soil from the Replacement Water Lines from TA-48 and TA-55 (Figure 1).

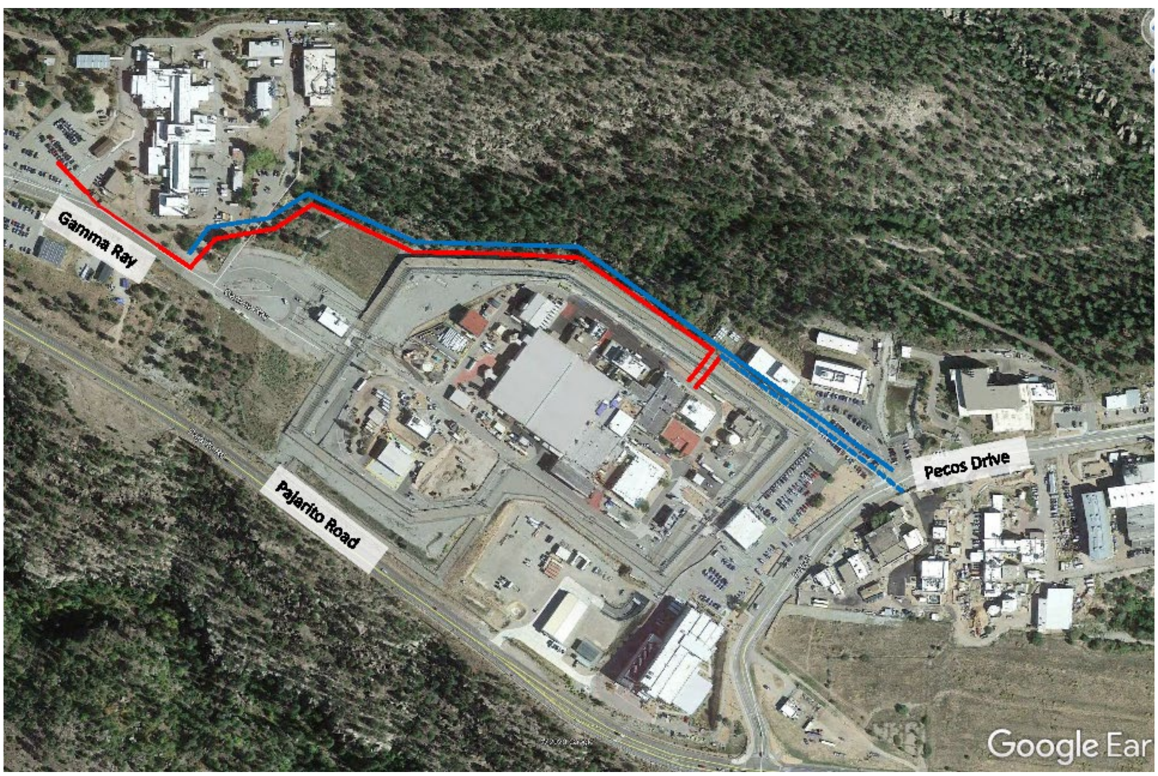

Figure 1. Aerial view of replacement water lines from TA-48 to TA-55.

2 Introduction

Two 12-inch water lines will be installed between TA-48 and TA-55, using both open-cut excavation and horizontal directional drilling (HDD) construction methods. HDD installation methods will be required in some areas of the project due to rough terrain, environmental constraints, or construction underneath existing security fencing. Each water line will tie into existing water distribution infrastructure in TA-48 and be routed along the north side of TA-55, ultimately tying into existing water distribution lines that reside in Pecos Drive. See Figure 1.

3 MARSAME Survey Description

Soil was characterized to support an off-site disposition decision. A MARSSIM survey approach was utilized to perform the soil sampling for residual radioactive contamination. Since the soil may be sent off-site for disposal, the MARSAME requirements are utilized to evaluate the resulting characterization data.

The primary objective of the MARSAME release report is to confirm, within the stated statistical confidence limits, that the mean levels of potential radioactive residual contamination in excavated soil are documented, in appropriate units, and are at or below background levels. Background levels are provided in Table 1.

Table 1. Background Levels

Radionuclide	Background [pCi/g] (Ryti 1998, Table 6.0-2)
Am-241	0.040
Cs-137	1.65
Pu-238	0.023
Pu-239	0.054
Sr-90	1.31
U-234	2.59
U-235	0.20
U-238	2.29

3.1 Survey Quality Objectives

The data quality and survey completeness of the characterization survey were compared to MARSAME requirements for statistical coverage and representativeness. To ensure adequacy of survey coverage, EPC-ES used the statistical software Visual Sample Plan (Matzke BD, 2010). This software generates a MARSAME-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, and 4) input for the final status survey design (NUREG, 2000).

Surface soil and sediment samples collected and reported in the Intellus[1] database were used as input for calculating the relative shift and other statistical parameters used in the Sample and Analysis Plan (Attachment A). Type I error was set at 5% and Type II error was set at 10%, resulting in approximately 24 samples per decision unit using VSP software (Attachment A). Based on characterization survey coverage, no additional sampling is required.

The number and placement of sampling locations were compared to MARSAME (Attachment A) requirements for final release and were found to be adequate in number of measurements and spatial distribution to make valid, statistically-based release decisions.

Due to accessibility issues within the sampling area some changes were made to the sampling points generated by Visual Sample Plan. Figure 1 shows the full project area and the sampling locations can be seen in Figure 2. The area to the southeast of the sample points in Figure 2 was not included in sampling due to rough terrain and further toward Pecos Drive the area is concrete and does not contain any Solid Waste Management Units/Areas of Concern (SWMUs/AOCs). Additionally, the sampling team was instructed to take samples as close as possible to the locations on the map, but to use discretion, as necessary. If sample locations were in concrete, behind the security fence or in difficult terrain, samplers were able to move the location. Sample locations 2220, 2222, and 2224 are behind or close to the security fence and were relocated to locations outside the fence.

3.2 Disposition Pathways

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

1. If results from radioactive contamination measurements of the soil are above the background values in Table 1, the soil is not a candidate for unrestricted off-site release.
2. If results from radioactive contamination measurements of the soil are below the background values in Table 1, the soil is a candidate for unrestricted off-site release.

Potential disposition pathways for this project included:

1. If results are above background values but below the Authorized Limits (ALs) for volumetric clearance found in EPC-ES-FSD-004 Table 10-2, soil can be released subject to acceptance criteria of receiver.
2. If results are below background values, soil may be disposed at commercial/municipal landfills using a release criterion of Indistinguishable from Background (IFB).
3. If results are above background and above the ALs, the soils must be disposed as Low Level Waste (LLW).

4 Data Analysis

Table 2 presents a summary of the soil concentration results. Most of the data met the unrestricted release criteria, with several samples exceeding the background levels. Given these results, a portion of the soil is recommended for unrestricted off-site release and the remainder of the soil must stay onsite or be treated as low level waste (LLW). Final approvals for waste disposition will be determined by LANL's Waste Management Program.

[1] https://www.intellusnm.com/gis/home_gis.cfm

Table 2. Soil concentrations of radionuclides (pCi/g)

	Am-241	Cs-137	Pu-238	Pu-239	Sr-90	U-234	U-235	U-238
N (# of data points)	24	24	24	24	24	24	24	24
Mean	0.0081	0.24	0.013	0.034	-0.027	0.95	0.050	1.04
Median	0.0033	0.071	0.0068	0.019	-0.054	0.93	0.046	0.89
Maximum	0.086	1.66	0.084	0.28	0.46	2.68	0.16	3.29
Minimum	-0.0079	-0.062	-0.011	0.0	-0.25	0.48	0.014	0.49
STD[a]	0.019	0.42	0.020	0.058	0.15	0.48	0.028	0.63
UCL (ProUCL 95%)[b]	0.025	0.62	0.031	0.086	0.028	1.12	0.061	1.26
Background[c]	0.04	1.65	0.023	0.054	1.31	2.59	0.20	2.29
Authorized Limit[d]	3	3	3	3	30	30	30	30

[a] Standard Deviation (STD)
[b] Upper Confidence Level (UCL).
[c] Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory; LA-UR-98-4847; R. T. Ryti, P. A. Longmire, D. E. Broxton, Steven L. Reneau, and E. V. Mcdonald.
[d] Authorized Limit, FSD-EPC-ES-004, Table 10-2.

4.1 Authorized Limit Release Pathway

Materials bearing volumetric 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 volumetric radioactivity were 1) Americium-241, Cesium-137, Plutonium-238, and Plutonium-239, which have pre-approved release limits of 3 pCi/g; and 2) Strontium-90, Uranium-324, Uranium 235, Uranium 238, which have pre-approved release limits of 30 pCi/g.

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 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 test is used, and if contamination is not present in background, use the Sign Test.

4.2 Indistinguishable From Background Pathway

Soil bearing volumetric radioactivity greater than the MDA were evaluated by comparison to the background values found in Table 1.

Decision Criteria for Indistinguishable from Background (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 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 soil sample results can be found in Table 2. Analysis of the IFB pathway for unrestricted release shows that the 95% UCL for both Pu-238 and Pu-239/240 are above the background values requiring further statistical analysis. The WRS test was performed for these data sets against the respective background. Pu-238 passes the WRS test. Pu-239/240 fails the WRS indicating that the data are not IFB. Sample locations are show in Figure 2 with the location information for each point found in Table 3. Samples 2219 and 2220 are the only two samples that are greater than background for Pu-239, with all other samples being below background. Based on these findings, the soil for this project should be separated into three areas: Area 1 to the west of sample location 2218 and Area 2 to the east of sample location 2218 and Area 3 to the southeast of Area 2, see Figure 3. Soil from Area 1 and Area 3 is IFB and candidate for unrestricted release. Soil from Area 2 is not IFB and must be treated as 1) LLW, 2) released using authorized limits, 3) left in place, or 4) relocated within LANL property with proper approvals.

Figure 2. Sample locations

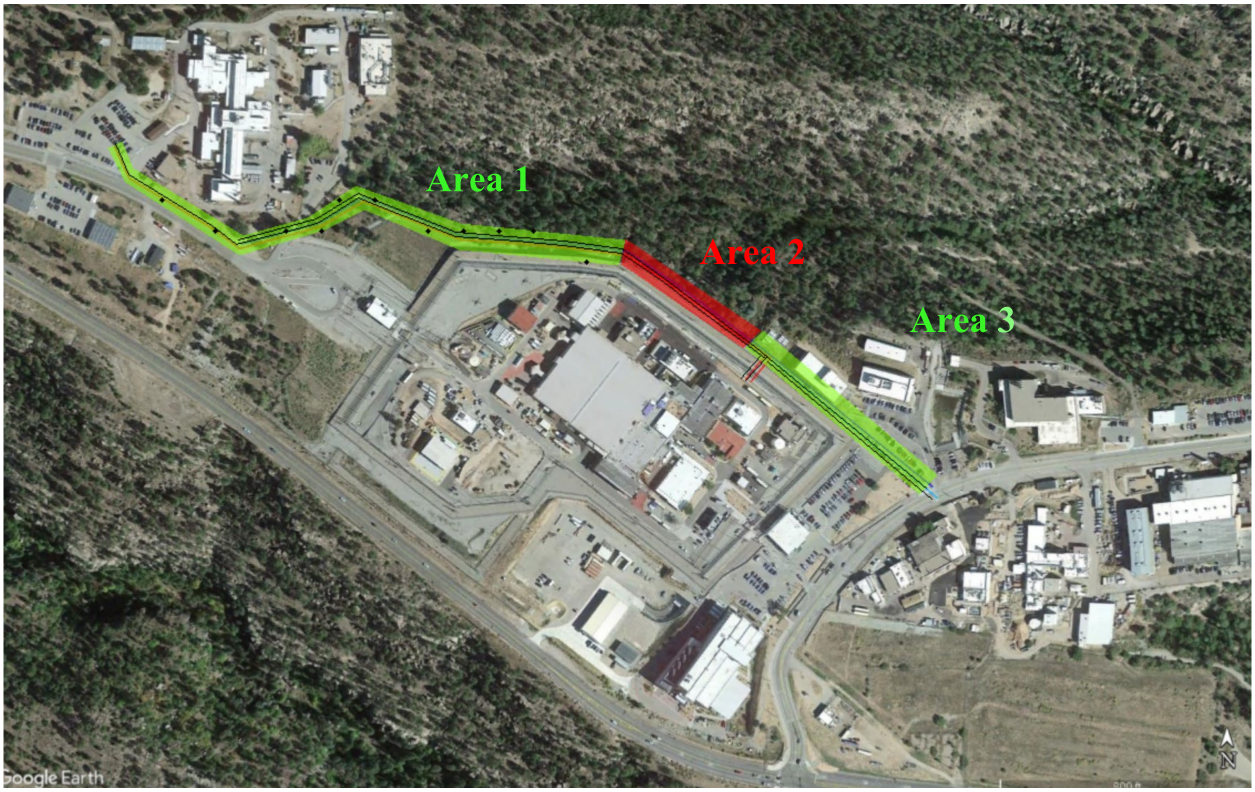

Figure 3. Project Map with Areas 1, 2 and 3

Table 3. Sample Location Information

Location ID	Latitude (Decimal)	Longitude (Decimal)	Easting	Northing
2201	35.8654467	-106.3073446	1623426.347	1770292.271
2202	35.8653177	-106.3071401	1623486.933	1770245.265
2203	35.8652123	-106.3070129	1623524.575	1770206.884
2204	35.8651199	-106.306864	1623568.694	1770173.219
2205	35.8650021	-106.3065855	1623651.163	1770130.323
2206	35.864781	-106.3061654	1623775.599	1770049.775
2207	35.8648823	-106.3060399	1623812.792	1770086.599
2208	35.8650563	-106.3056799	1623919.491	1770149.873
2209	35.8650593	-106.3054379	1623991.193	1770150.925
2210	35.8652313	-106.3053199	1624026.19	1770213.512
2211	35.8652333	-106.3050779	1624097.891	1770214.199
2212	35.8651761	-106.3048907	1624153.368	1770193.372
2213	35.8650673	-106.3047119	1624206.297	1770153.715
2214	35.8650693	-106.3044709	1624277.703	1770154.403
2215	35.8649003	-106.3043469	1624314.408	1770092.868
2216	35.8649033	-106.3041049	1624386.11	1770093.92
2217	35.8649063	-106.3038629	1624457.812	1770094.973
2218	35.8649083	-106.3036209	1624529.513	1770095.661
2219	35.8649113	-106.3033799	1624600.919	1770096.714
2220	35.8649133	-106.3031379	1624672.62	1770097.403
2221	35.8649163	-106.3028959	1624744.322	1770098.456
2222	35.8648128	-106.3027634	1624783.567	1770060.772

2223	35.8649193	-106.3026539	1624816.024	1770099.51
2224	35.8648365	-106.3025465	1624847.833	1770069.352

Conclusions

Given the process knowledge and sample data presented in this report package, EPC-ES concludes that the soil associated with Replacement Water Lines from TA-48 to TA-55 must be divided into three areas, Area 1, Area 2 and Area 3, see Figure 3. Soil coming from Area 1 and Area 3 is a candidate for unrestricted release under DOE Order 458.1. Soil from Area 2 must be must be treated as 1) LLW, 2) released using authorized limits, 3) left in place, or 4) relocated within LANL property with proper approvals. 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
DOE	(U.S.) Department of Energy
EPA	(U.S.) Environmental Protection Agency
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
MQO	measurement quality objective

Acronym	Definition
SAP	Sample and Analysis Plan
TA	Technical Area
VSP	Visual Sample Plan

7 Attachments

Attachment A: Sample and Analysis Plan for Replacement Water Lines From TA-48 to TA-55

Attachment A: Sample and Analysis Plan for Replacement Water Lines from TA-48 to TA-55

March 2022

Sample and Analysis Plan for Replacement Water Lines from TA-48 to TA-55

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1 Sample and Analysis Plan Overview

1.1 Purpose and Scope of the Sample and Analysis Plan

Water line routes between Technical Area (TA)-48 and TA-55 at Los Alamos National Laboratory (LANL) run through several solid waste management units (SWMUs)/areas of concern (AOCs) and potential environmental radioactivity areas; therefore, the potential exists for radiological contamination in soil and/or sediment from excavations from the project. The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NUREG, 2000) survey approach will be used to perform the characterization surveys of soil and/or sediment for residual radioactive contamination. Because materials from the project will be sent offsite for disposal, 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 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 soils are documented to determine that they are at background levels and are candidates for release for offiste disposal. The nominal release criteria for this project are background values in Table 1 (Ryti, 1998).

Table 1. Background Levels

Radionuclide	Background [pCi/g] (Ryti 1998, Table 6.0-2)
Am-241	0.040
Cs-137	1.65
Tritium (H-3)	0.08
Pu-238	0.023
Pu-239	0.054
Sr-90	1.31
U-234	2.59
U-235	0.20
U-238	2.29

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) have already been completed, and the results are detailed in this document. The purpose of this plan is to satisfy the third and fourth principal steps (scoping and characterization) to assess for radiological impact and, if impacted, to characterize the potential contamination. Although the purpose of 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 1.5. The water line route runs through several SWMUs and potential environmental radioactivity areas, and the potential exists for radiological contamination in excavated materials. 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 from excavations are candidates for unrestricted release 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 of the water lines from TA-48 to TA-55 project, a Class 1 and/or Class 2 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 below.

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 Replacement Water Lines from TA-48 to TA-55 Project Overview and Site Identification

Two 12-inch water lines will be installed between TA-48 and TA-55, using both open-cut excavation and horizontal directional drilling (HDD) construction methods. HDD installation methods will be required in some areas of the project due to rough terrain, environmental constraints, or construction underneath existing security fencing. Each water line will tie into existing water distribution infrastructure in TA-48 and be routed along the north side of TA-55, ultimately tying into existing water distribution lines that reside in Pecos Drive. See Figure 1.

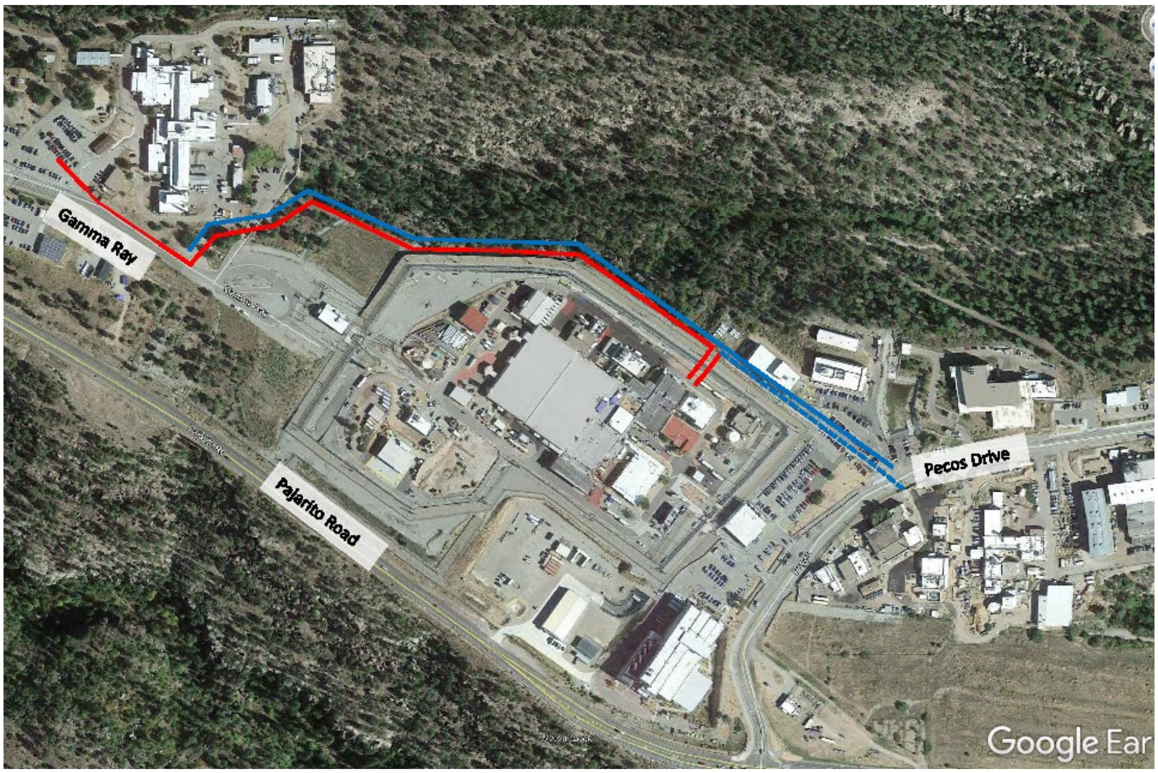

Figure 1. Aerial view of replacement water lines from TA-48 to TA-55.

1.5 Historical Site Assessment[1]

The route of the water lines runs through several SWMUs/AOCs, which are detailed below.

AOC 48-001 consists of historical operational releases from stacks associated with the air-exhaust system at the main radiochemistry laboratory in TA-48-0001. Surface soil around TA-48-0001 was potentially impacted by deposition from the operational stack emissions. The radiochemistry laboratory in TA-48-0001 was constructed in 1957 to analyze samples collected from nuclear weapons tests, and additional radiochemical analyses are conducted in support a variety of weapons programs. Emissions from the chemical hoods are not filtered because the chemicals used in the hoods (e.g., hydrochloric, hydrofluoric, nitric, and perchloric acids) will degrade the filters; however, these hoods are equipped with wet scrubbers. The glovebox stack (stack FE54) is permitted and monitored under the National Emissions Standards for Hazardous Air Pollutants Program of the Clean Air Act. According to the Resource

[1] All information in this section comes from the LANL Potential Release Site Website, prs.lanl.gov.

Conservation and Recovery Act Facility Investigation work plan, monitoring data are available for stack FE54 beginning in 1967 for plutonium and beginning in 1974 for uranium and fission products. These data indicate releases of plutonium, uranium, and fission products, principally cesium-137, cerium-144, and strontium-90.

Decision-level data for AOC 48-001 consists of results from 101 samples collected at 101 locations during investigation activities in 1993, 1997, and 2009. The samples include those collected for AOC 48-001 and surface samples collected at SWMUs and AOCs around TA-48-0001. The 2015 supplemental investigation report concluded that the nature and extent of contamination have been defined, and no further sampling for extent is warranted. This site does not pose a potential unacceptable risk or dose under the industrial, construction worker, or residential scenarios and poses no potential ecological risk.

AOC 55-011(a) consists of an active storm-drainage system, including a storm drain (TA-55-0079), drain line, and outfall. This storm-drainage system is located northwest of the Plutonium Facility (TA-55-0004) and receives stormwater runoff from paved areas and roof drains. AOC 55-011(a) discharges to the north of TA-55-0004 at the rim of Mortandad Canyon. AOC 55-011(a) was reviewed for ecological risk in the Documentation of Ecological Risk Assessment completed in 1999, and no further action (NFA) approval was granted by DOE on July 19, 1999.

AOC 55-011(b) consists of an active storm-drainage system, including a storm drain (TA-55-0082), drain line, and outfall. This storm-drainage system is located northeast of TA-55-0004 and receives stormwater runoff from paved areas and roof drains. AOC 55-011(b) discharges to the northeast of TA-55-0004 at the rim of Mortandad Canyon. This outfall also serves AOC 55-011(e). AOC 55-011(b) was reviewed for ecological risk in the Documentation of Ecological Risk Assessment completed in 1999, and NFA approval was granted by DOE on July 19, 1999.

AOC 55-011(e) consists of an active storm-drainage system, including a storm drain (TA-55-0081), drain line, and outfall. This storm-drainage system is located northeast of TA-55-0004 and receives stormwater runoff from paved areas and roof drains. AOC 55-011(e) discharges to the northeast of TA-55-0004 at the rim of Mortandad Canyon. This outfall also serves AOC 55-011(b). AOC 55-011(e) was reviewed for ecological risk in the Documentation of Ecological Risk Assessment completed in 1999, and NFA approval was granted by DOE on July 19, 1999.

SWMU 55-009 is a former sanitary sewer–monitoring station (TA-55-0263) located in the LANL high-security, high access–controlled TA-55 plutonium complex. The monitoring equipment and surrounding concrete structure were installed in approximately 1975, when the TA-55 complex was originally constructed. The monitoring equipment was installed at this portion of the sanitary waste line solely as a security measure; however, the monitoring equipment never functioned as originally intended. It failed because of moisture condensation in the concrete structure in which it was housed. After several attempts to make the detection equipment perform properly, in May 1983, DOE and TA-55 personnel agreed to discontinue further attempts to monitor the waste line. The monitoring equipment was removed later that year, but the concrete-lined pit was left in place. In September 2001, nine radiological swipe samples were collected within the concrete enclosure. No activity above background was detected in any of the nine samples, demonstrating that the monitoring station never received contaminants or released contaminants to the environment. After a site visit by the New Mexico Environment Department (NMED) in 2001 and review of the radiological screening data collected at this site, this SWMU was recommended for NFA. Hazardous wastes were not generated, treated, stored, or disposed at the site, and radioactivity was never detected in the waste stream. In 2002, NMED concurred with the NFA determination.

AOC 55-011 consists of an active storm-drainage system, including a storm drain (TA-55-0083), drain line, and outfall. This storm-drainage system is located northeast of TA-55-0004 and receives stormwater runoff from paved areas and roof drains. AOC 55-011 discharges to the northeast of TA-55-0004 at the rim of Mortandad Canyon. AOC 55-011 was reviewed for ecological risk in the Documentation of Ecological Risk Assessment completed in 1999, and NFA approval was granted by DOE on July 19, 1999.

1.6 Results from Historical Surveys for Residual Contamination

For the purpose of developing a MARSSIM-based sample plan, previous data were used to determine an expected standard deviation for sample plan development. Surface soil and sediment samples collected and reported in the Intellus[2] database were used; see Table 2. The data in Table 2 are compared with the background values in Table 1. Most radionuclides are below background, with Pu-239 being slightly above background.

Table 2. Summary Data and Statistics for Previous Soil/Sediment Measurements from Intellus

Soil Concentrations by Radionuclide (pCi/g)								
	Am-241	Cs-137	Pu-238	Pu-239/240	Sr-90	U-234	U-235/236	U-238
n*	12	14	9	12	14	12	15	12
average	0.12	0.356	0.0028	0.34	-0.032	0.88	0.086	0.9
max	0.056	2.02	0.13	0.089	0.14	2.48	0.248	3.21
median	0.0050	0.14	0.001	0.013	0.013	0.70	0.069	0.65
STD	0.017	0.55	0.0053	0.036	0.19	0.60	0.070	0.80
UCL	0.034	0.62	0.0060	0.082	0.19	1.32	0.14	1.46

n = number of data points
max = maximum
STD = standard deviation
UCL = upper confidence limit (ProUCL 5.1)

2 Data Quality Objectives for the SAP

This SAP was prepared in accordance with EPC-ES-FSD-004, *Environmental Radiation Protection* (LANL, 2021) 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, 2020). The data quality objectives (DQOs) are described in the following sections.

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 the soil radioactive contamination measurements are at or above background (collectively), the materials *are not* candidate for release to commercial landfill.
- If results from the soil radioactive contamination measurements are below background (collectively), the materials *are* candidate for release to commercial landfill.

[2] https://www.intellusnm.com/gis/home_gis.cfm

2.2 Study Boundaries

The study is limited to the area between TA-48 and TA-55, running along Gamma Ray Drive, northeast toward Mortandad Canyon, and along the TA-55 fence (~2.5 acres). Figure 2 shows the sampling area (decision area) in yellow and the sample locations. The decision area was chosen based on the HSA and previous data from Intellus. The list of radionuclides in the analysis includes Am-241, Cs-137, Pu-239, Sr-90, U-234, U-235, and U-238.

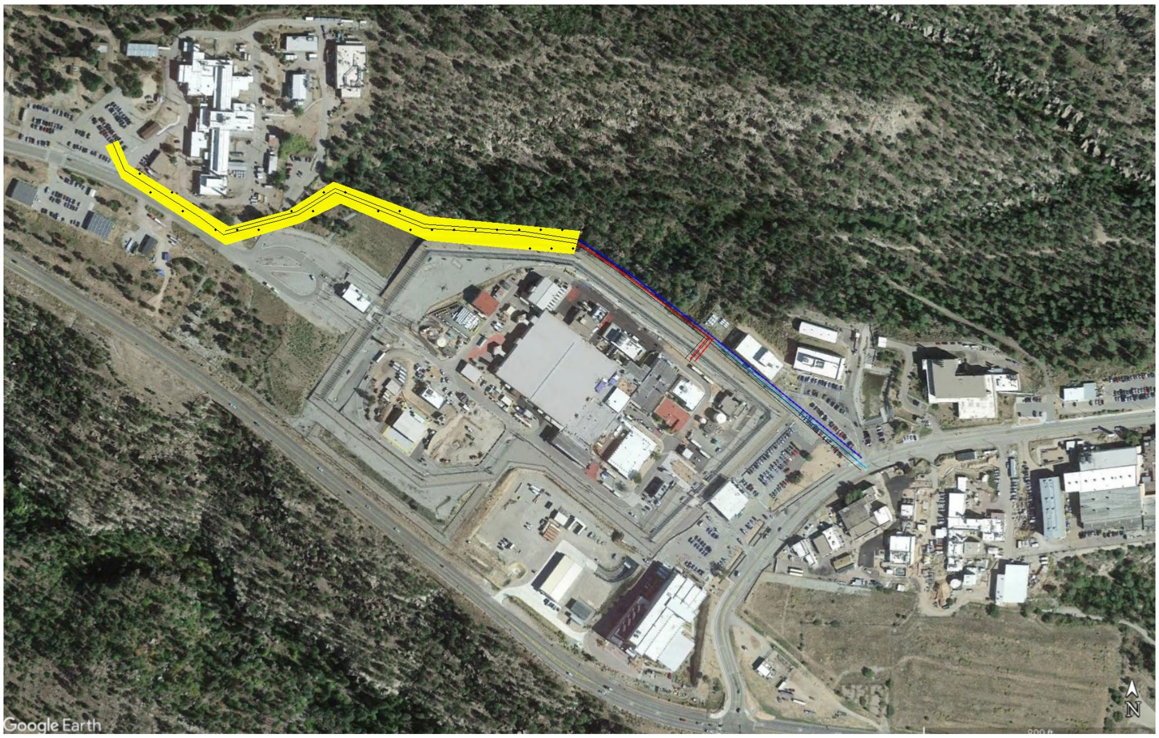

Figure 2. Decision Area and Sampling Locations.

2.3 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 level in soil and/or sediment is below background and releasable.

2.4 Limits on Decision Errors

The acceptable statistical errors for this analysis are that Type I error (i.e., conclude contamination levels at the site are < background when in fact they are > background) has a probability of $p < 0.05$; and the Type II error (i.e., conclude soil contamination levels are > background when in fact they are < background) has a probability of $p < 0.1$. The distribution for the preliminary data is not assumed to be normal.

2.5 Statistically Based Evaluation for Number of Samples Required Using MARSSIM

The specific details of the analysis (specific statistical parameter values, analysis, results, and approximate coordinates for the randomly selected sampling locations using MARSSIM) are provided in Appendix A: of this report. Results showed that 24 systematic samples are needed within the decision area. The approximate locations are indicated in Figure 2, and coordinates are provided in Appendix A:. Google Earth was used to plan sampling, and a geo-referenced image file with an associated polygon (.shp) for the water lines was incorporated into Visual Sample Plan (VSP) software (Matzke BD, 2010). The sampling area was defined inside the initial polygon Figure 2. The MARSSIM application within VSP was then used to determine the statistically based sampling plan.

2.6 Instrumentation and Measurement Quality Objectives

The main objectives are to determine appropriate analysis techniques for each radionuclide and 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.

2.6.1 *MQOs*

- Detection Capability: Minimum detection concentration 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.

2.6.2 *Procedures Used to Meet the MQOs*

1. Collection of valid soil sample appropriate for the dose assessment:

   (a) Soil sampling will follow the procedure EPC-ES-TP-003, *Soil and Vegetation Sampling for the Environmental Surveillance Program* (LANL, 2022b). These are surface soil samples appropriate for the deposition pathway and the exposure scenario. Subsurface soil samples are not required because depositions would be to surfaces with little migration to deeper soil expected.

   (b) Additional quality assurance for the collection of the samples is provided through procedure EPC-ES-QAPP-0001, *Implementation of the Soil, Foodstuffs, and Biota Program* (LANL, 2022a).

2. Soil sample analysis will use U.S. Environmental Protection Agency (EPA)-approved analytical procedures for each radionuclide. The following will be used by the independent laboratory:

(a) Environmental Measurements Laboratory (EML) 1997. *The Procedures Manual of the Environmental Measurements Laboratory*. Radionuclide-specific procedures for Am-241, Pu-239, and U-238.

(b) EPA 1980. Method 901.1 – Gamma Emitting Radionuclides in Drinking Water: Prescribed Procedures for Measurement of Radioactivity in Drinking Water.

(c) EPA 1980. Method 905.0 – Radioactive Strontium in Drinking Water: Prescribed Procedures for Measurement of Radioactivity in Drinking Water.

After the measurements are completed, the laboratory results in units equivalent to background values will be evaluated with respect to the MQOs, as stated above.

3 References

DOE (U.S. Department of Energy). (2020). *Radiation Protection of the Public and the Environment.* DOE O 458.1, Chg 4.

LANL (Los Alamos National Laboratory). (2020). EPC-ES-TPP-001. *Data Quality Objectives for Measurement of Radioactivity in or on Items for Transfer Into the Public Domain*. New Mexico.

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Matzke BD, W. J. (2010). *Visual Sample Plan Version 6.0 User's Guide*. PNNL-19915, Pacific Northwest National Laboratory.

NUREG. (2000). *The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).* NUREG-1575, Rev 1; EPA 402-R-97-016, Rev. 1; DOE/EH-0624, Rev. 1.

NUREG. (2009). *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME).* NUREG-1575, Supp. 1; EPA 402-R-09-001; DOE/HS-0004.

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4 Acronyms and Abbreviations

Acronym	Definition
AOC	area of concern
DOE	(U.S.) Department of Energy
DQO	data quality objective
EPA	(U.S.) Environmental Protection Agency
HDD	horizontal directional drilling
HAS	historical site assessment
LANL	Los Alamos National Laboratory

Acronym	Definition
LBGR	lower bound of the gray region
MARSAME	Multi-Agency Radioactive Survey and Assessment of Material and Equipment
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MQO	measurement quality objective
NFA	no further action
NMED	New Mexico Environment Department
SAP	Sample and Analysis Plan
SWMU	solid waste management unit
TA	Technical Area
VSP	Visual Sample Plan

Appendix A: Visual Sample Plan Summary Report

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

Summary

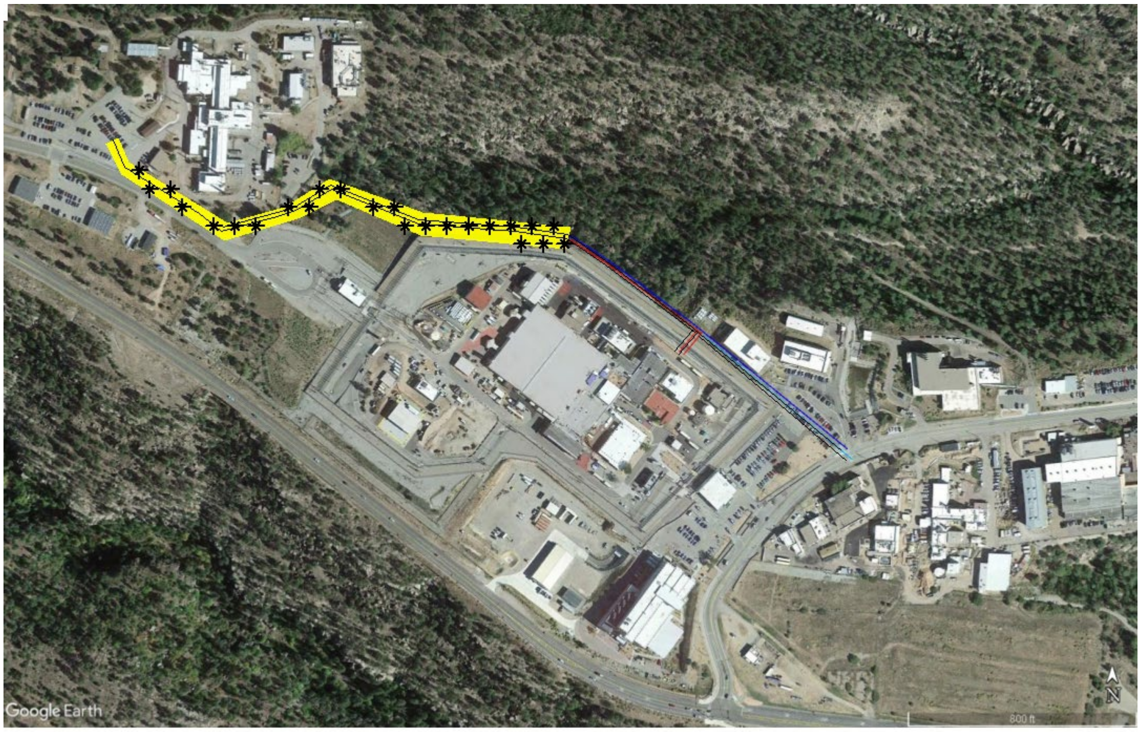
This report summarizes the sampling design used, associated statistical assumptions, as well as general guidelines for conducting post-sampling data analysis. Sampling plan components presented here include how many sampling locations to choose and where within the sampling area to collect those samples. 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. A figure that shows sampling locations in the field and a table that lists sampling location coordinates are also provided below.

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	Systematic with a random start location
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	16
Number of samples adjusted for EMC	16
Number of samples with MARSSIM Overage	20
Number of samples on map [a]	24
Number of selected sample areas [b]	1
Specified sampling area [c]	10199.69 m^2
Size of grid / Area of grid cell [d]	71.654 feet / 4446.43 ft^2
Grid pattern	Triangular

[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.
[d] Size of grid / Area of grid gives the linear and square dimensions of the grid used to systematically place samples. If there was more than one sample area, this represents the largest dimensions used.

Appendix A: Visual Sample Plan Summary Report



Area: Sampling Area		
X Coord	Y Coord	Type
382358.1411	3969731.2586	Systematic
382379.9812	3969731.2586	Systematic
382401.8214	3969731.2586	Systematic
382041.4589	3969750.1728	Systematic
382063.2991	3969750.1728	Systematic
382085.1392	3969750.1728	Systematic
382238.0203	3969750.1728	Systematic
382259.8604	3969750.1728	Systematic
382281.7006	3969750.1728	Systematic
382303.5407	3969750.1728	Systematic
382325.3809	3969750.1728	Systematic
382347.2210	3969750.1728	Systematic
382369.0611	3969750.1728	Systematic
382390.9013	3969750.1728	Systematic
382008.6987	3969769.0869	Systematic
382117.8994	3969769.0869	Systematic
382139.7396	3969769.0869	Systematic
382205.2600	3969769.0869	Systematic
382227.1002	3969769.0869	Systematic
381975.9385	3969788.0010	Systematic
381997.7786	3969788.0010	Systematic
382150.6597	3969788.0010	Systematic
382172.4998	3969788.0010	Systematic
381965.0184	3969806.9151	Systematic

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 systematic sampling approach with a random start 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, systematic grid point sampling was chosen. Locating the sample points systematically provides data that are all equidistant apart. This approach does not provide as much information about the spatial structure of the potential contamination as simple random sampling does. Knowledge of the spatial structure is useful for geostatistical analysis. However, it ensures that all portions of the site are equally represented. Statistical analyses of systematically collected data are valid if a random start to the grid is used.

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:

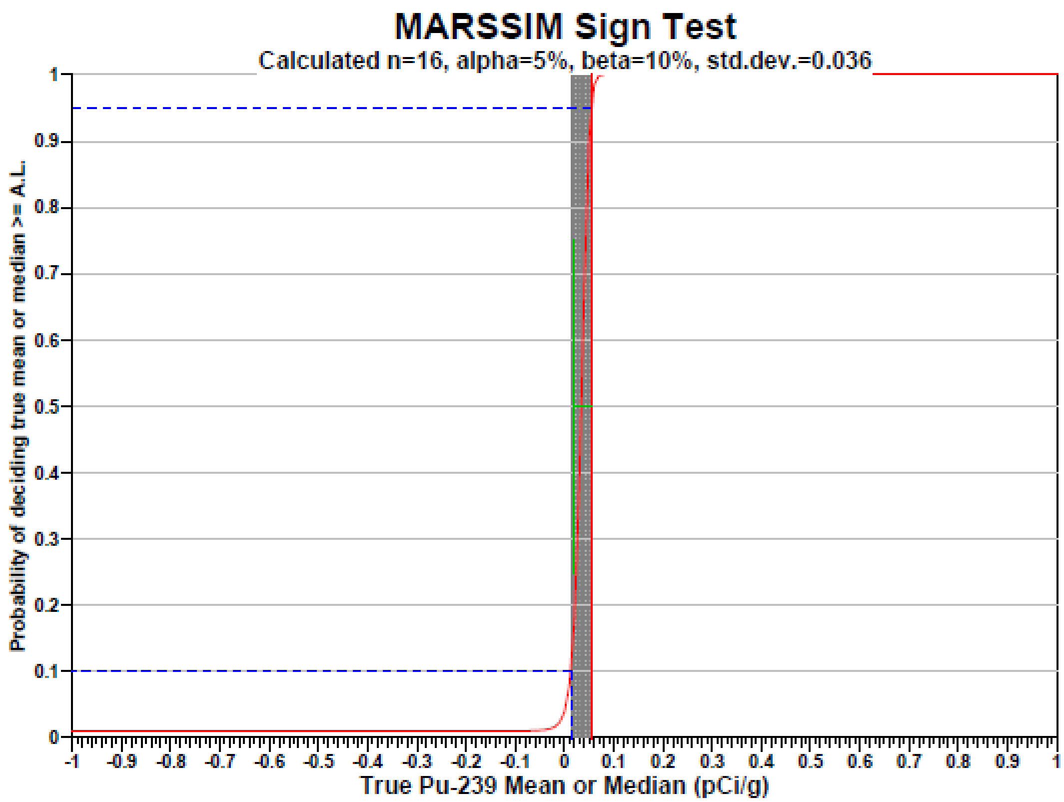
Nuclide	n[a]	n[b]	n[c]	Parameter					
				S_{total}	Δ	α	β	$Z_{1-\alpha}$ [d]	$Z_{1-\beta}$ [e]
Am-241	10	10	12	0.017	0.035	0.05	0.1	1.64485	1.28155
Cs-137	9	9	11	0.55	1.515	0.05	0.1	1.64485	1.28155
Pu-238	9	9	11	0.0053	0.022	0.05	0.1	1.64485	1.28155
Pu-239	16	16	20	0.036	0.041	0.05	0.1	1.64485	1.28155
Sr-90	9	9	11	0.19	1.297	0.05	0.1	1.64485	1.28155
U-234	9	9	11	0.6	1.89	0.05	0.1	1.64485	1.28155
U-235	10	10	12	0.07	0.13	0.05	0.1	1.64485	1.28155
U-238	10	10	12	0.8	1.64	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 probabilistically.

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

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=2.29		α=5		α=10		α=15	
		s=0.072	s=0.036	s=0.072	s=0.036	s=0.072	s=0.036
LBGR=90	β=5	3634	915	2876	724	2415	608
	β=10	2876	724	2206	556	1805	454
	β=15	2415	608	1805	454	1444	364
LBGR=80	β=5	915	234	724	185	608	156
	β=10	724	185	556	143	454	117
	β=15	608	156	454	117	364	94
LBGR=70	β=5	411	108	326	87	273	72
	β=10	326	87	250	66	204	54
	β=15	273	72	204	54	164	44

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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