APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area

Survey Unit: 13 **Description:** Northern SU in "Area 2"

1. Verify Survey Unit Isolation & Control

Survey Unit properly isolated and/or controlled (indicated by outlining the area with green rope and posting the appropriate signage) as required by HDP-PR-HP-602, *Data Package Development and Isolation and Control Measures to Support Final Status Survey*? Yes☒ No☐
(If "No", discontinue survey design until area turnover requirements have been met.)

2. Evaluate Final Remedial Action Support Survey (RASS) Data

a. Number of RASS Samples = 8
b. Record analytical results and summary statistics for each RASS sample.

	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Tc-99 (pCi/g)	Th-232 (pCi/g)	Ra-226 (pCi/g)
Minimum	0.967	0.049	0.637	0.000	0.080	0 (<BKG)
Maximum	14.398	0.795	2.500	0.651	0.280	0.040
Mean	3.958	0.216	1.062	0.212	0.191	0.005
Median	2.425	0.131	0.834	0.095	0.215	0.000
Standard Deviation	4.406	0.245	0.617	0.274	0.076	0.014
# of Samples	8	8	8	8	8	8

c. Are all RASS results less, or equal to the appropriate $DCGL_w$ from Appendix A of HDP-PR-FSS-701? Yes☒ No☐

d. If "No", have remaining locations of elevated concentration been evaluated? N/A☒ Yes☐ No☐
(If "No", discontinue survey design until investigation is complete.)

e. Have elevated areas identified by gamma walkover surveys been investigated? Yes☒ No☐
(If "No", then terminate survey design and perform additional investigation and repeat the planning process.)

f. Are the Initial Characterization and RASS data sufficient to support FSS Design? Yes☒ No☐
(If "No", terminate survey design, perform additional characterization or remediation and repeat the planning process.)

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

3. Define the Survey Unit Classification

Write a short description of the survey unit based on historical use and remedial activities:

The LSA 10-13 survey unit (SU) is classified as MARSSIM Class 1. LSA 10-13 is located in the central Burial Pits Open Land Area. This SU along with LSA 10-14 is collectively referred to as "Area 2" for the purposes of remediation planning and work sequencing. Area 2 contained various types of waste materials, including drums, bags of trash, fuel pellets, construction debris, spent limestone, and contaminated soils.

Although this SU is in the Burial Pits Open Land Area, during remediation, the excavation encroached into the Tc-99 SEA, therefore, Tc-99 SEA DCGLs were used to calculate a Scan MDC where the inferred Tc-99 DCGL for U-235 is 1.2 pCi/g. The surrogate DCGL for U-235 was used for the calculation of Scan MDC only. Laboratory analysis for Tc-99 will be performed on all final status survey samples and as such, the adjusted U-235 DCGL values will not be used to demonstrate compliance with the final status survey dose criteria.

The area that comprises the footprint of LSA 10-13 was used to bury radioactive and chemical wastes during the operational period of the Hematite Fuel Fabrication Facility. Documented burial pits, under the governance of the Atomic Energy Commission's regulations, were generated between 1965 and 1970. Also, undocumented waste burials occurred prior to 1965.

Classification: 1 Survey Unit Area (m^2): 2,101.2 (gamma walkover survey total surface area)

Survey Unit Area (m^2): 1,895.4 (planar area on which systematic grid is based)

a. Has the Classification changed from the Initial Classification as indicated in DP Ch. 14 Table 14-16 and Figures 14-14 through 14-17? Yes☐ No☒
(If "Yes", then include a copy of Appendix P-5, *Survey Unit Classification Change Form.*)

b. Is the Survey Unit area less than the maximum size for the Classification? Yes☒ No☐
(If "No", then terminate survey design and evaluate dividing the survey unit into multiple survey units.)

4. Define the Surrogate Evaluation Area (SEA)

Select the appropriate SEA as input to calculating scan sensitivity and variability in the RASS SOF.
Plant Soils SEA ☐ Tc-99 SEA ☒ Burial Pit SEA ☐

5. Define Final Survey Unit Conditions

☐ No Excavations, Paved/Partially Paved or Excavated but not Backfilled

☒ Excavated and to be Backfilled

☐ Excavated and Backfilled

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

Note: If a portion of a Survey Unit is paved, then Surface Soil Stratum begins at the bottom of the paved surface and extends 15 cm from that point below grade. The lower depth of the Root Stratum remains at 1.5 m below grade. The pavement is then treated as a separate structural Survey Unit within the Survey Area.

6. Define the Type of FSS Samples and Measurements

Select the appropriate types of samples and measurements for FSS of this Survey Unit that corresponds to the final condition and survey classification of the Survey Unit.

Not Excavated, Paved/Partially Paved or Excavated but not Backfilled:

- ☐ Surface Soil (<15cm) Samples.
- ☐ Root Stratum Soil Samples composited from 15cm to 1.5m.

Note: If the SOF of the Root Stratum sample exceeds 0.5, a composite sample is collected from 1.5 meters to an appropriate depth (Deep Stratum).

Excavated and to be Backfilled:

- ☐ Surface Soil Samples taken from any remaining surface soil Stratum and Root Stratum Soil Samples taken at the same locations as Surface Samples, composited over the entire root stratum.
- ☒ Root Stratum Soil Samples composited from exposed grade to 1.5m and Deep Stratum Soil Samples taken at the same locations as Root Samples of the top 15cm of the Deep Stratum.
- ☒ Deep Stratum Soil Samples of the top 15 cm of the exposed Deep Stratum.

Excavated and Backfilled:

- ☐ Core through backfill layer to the lowest point where remediation occurred and composite a sample from a coring that extends one meter deeper than the lowest point where remediation occurred.

Scan Measurements:

- ☒ 100% Scan Coverage of Exposed Soil.
- ☐ _____% Scan Coverage of Exposed Soil.
- ☐ Other _____

7. Define Derived Concentration Guideline Levels (DCGL)

a. Select the appropriate DCGL for each Radionuclide of Concern (ROC) based on the corresponding SEA and the Uniform Conceptual Site Model (CSM).
   - If Tc-99 was measured during the characterization/RASS survey, then the "Measure Tc-99" DCGLs will be used from Appendix A of HDP-PR-FSS-701.
   - If Tc-99 was not measured in the characterization/RASS survey, then the modified U-235 DCGL ("Infer Tc-99") will be used from Appendix A HDP-PR-FSS-701.

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

	Surface Stratum DCGL (pCi/g)	Root Stratum DCGL (pCi/g)	Deep Stratum DCGL [1] (pCi/g)	Uniform DCGL (pCi/g)
U-234	N/A	N/A	N/A	195.4
U-235	N/A	N/A	N/A	51.6
U-238	N/A	N/A	N/A	168.8
Tc-99	N/A	N/A	N/A	25.1
Th-232 + C	N/A	N/A	N/A	2.0
Ra-226 + C	N/A	N/A	N/A	1.9

1. The Deep Stratum DCGLs correspond to the Excavation Scenario DCGL from Appendix A of HDP-PR-FSS-701.

8. Determine the Number of Samples in the Statistical Survey Population

Note: The statistical survey population is routinely derived based on the Uniform DCGL.

- Alternatively, if the Survey Unit excavation extends into multiple CSMs (e.g. surface, root & deep), then the DCGL(s) from the most limiting strata can be used with the equations below; OR
- If the excavation significantly extends into the Deep Stratum, then the alternate approach presented in Section 8.2.5 of HDP-PR-FSS-701 may be used for determining the mean SOF and weighted standard deviation that accounts for the reduced dose from the deeper surface, i.e., by weighting the Root Stratum and Excavation $DCGL_w$ values.
- The values used in the following equations (SOF_{mean} and σ_{SOF}) can be found in the tables from Step 2b and Step 7a.

a. Determine a mean SOF for the characterization/RASS survey data set using the equation from Section 8.2.5a of HDP-PR-FSS-701.

Lower Bound of the Grey Region (LBGR) = SOF_{Mean} = 0.14

b. Determine the weighted standard deviation in the SOF for the characterization/RASS survey data set using the equation from Section 8.2.5b of HDP-PR-FSS-701.

Note: For the determination of SOF_{Mean} and σ_{SOF}, include the concentration for Tc-99 if it was measured. If Tc-99 was not measured, include the modified U-235 DCGL and omit Tc-99 concentration term.

✓ Larger of the two used in worksheet survey design

Survey Unit σ_{SOF} =	0.05	☐
Background σ_{SOF}=	0.13	☒

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

c. Define the Decision Errors.

Type I Error = 0.05 Type II Error = 0.10

Note: The Type II Error is set at 0.10 initially but it may be adjusted with RSO concurrence.

d. Determine the Relative Shift using the equation in Section 8.2.5d of HDP-PR-FSS-701.

Relative Shift = 6.86* *spreadsheet value may differ slightly from hand-calculated results due to rounding

e. Is the Relative Shift between 1 and 3? Yes☐ No☒

- If "Yes", then continue to Step 8f.
- If "No", then adjust the LBGR as necessary to achieve a relative shift between 1 and 3. In order to accomplish this, the LBGR may be set as low as the MDC for the analytical technique.

Adjusted LBGR = 0.62

Adjusted Relative Shift = 3.00

f. Determine the Number of Samples (N/2) required corresponding to the Type I error, Type II Error and the Relative Shift from Appendix F of HDP-PR-FSS-701 or calculate using equation 5-1 from MARSSIM.

No. of Samples (N/2) = 8

9. Determine the Scan MDC for Total Uranium

- When U-235 is reported as negative or zero and U-238 is reported as positive, set the sample enrichment to 0.71% (natural uranium).
- When U-235 is reported as positive and U-238 is reported as negative or zero, set the sample enrichment to 100% (highly enriched).
- When both U-235 and U-238 data are reported as positive, determine the U-238/U-235 ratio for each sample and use Appendix G of HDP-PR-FSS-701, to determine the uranium enrichment that corresponds to the mean U-238:U-235 ratio.

a. Record the average Uranium enrichment for the survey unit using the enrichment determined for each individual sample.

Average Enrichment (%) = 2.8

Note: The Activity Fractions (f) for each radionuclide corresponding to the mean enrichment used in the following calculations is obtained from Appendix G of HDP-PR-FSS-701.

If the Uniform DCGL is not used, and the excavation extends into multiple CSMs (e.g. surface, root & deep), then the most conservative DCGLs should be used in the following calculation.

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

b. Determine a $DCGL_w$ for Total Uranium using the equation from Section 8.2.6b of HDP-PR-FSS-701.

$DCGL_{wTotU}$ for Total Uranium = 25.7 pCi/g

c. Identify the Radiological Instrument that will be used for scanning.

☒ 2"x 2" NaI Detector ☐ FIDLER NaI Detector ☐ Other_____

d. Determine the Scan MDC for the selected instrument using the equation in Section 8.2.6d of HDP-PR-FSS-701 or the calculations presented in the Open Land Area Gamma Scan MDCs section in Chapter 14 of the DP.

MDC_{scan} for Total Uranium = 40.4 pCi/g

10. Determine the Scan MDC for Th-232 and Ra-226

a. Select the appropriate $DCGL_w$ for Th-232 and Ra-226 corresponding to the soil strata that will be exposed at the time of FSS and the SEA where the survey unit is located.

Th-232 $DCGL_w$ = 2.0 pCi/g Ra-226 $DCGL_w$ = 1.9 pCi/g

Note: If the Uniform DCGL is not used, and the excavation extends into multiple CSMs (e.g. surface, root & deep), then the most conservative DCGL for the strata should be used. With RSO concurrence, the alternate approach as presented in DP Ch. 14, Section 14.4.3.1.10 may be used in lieu of using the most conservative.

b. Determine the Scan MDC for the selected instrument

Note: Appendix C of HDP-TBD-FSS-002 documents the calculated MDC_{scan} of 0.85 pCi/g for Th-232 and 1.19 pCi/g for Ra-226 when using a 2" x 2" NaI detector.

Note: If the selected instrument is not a 2"x 2" NaI detector, then the MDC_{scan} can be determined in accordance with the Open Land Area Gamma Scan MDCs section in DP Ch. 14.

MDC_{scan} for Th-232 = 0.85 pCi/g MDC_{scan} for Ra-226 = 1.19 pCi/g

Note: If a value is not applicable, mark as N/A.

11. Adjust the Statistical Sample Population Size (N/2) for Scan MDC

a. If the survey unit is either Class 2 or 3, then proceed to Step 12. If the survey unit is Class 1, then proceed to the next step.

b. Divide the total area of the survey unit by the Number of Samples (N/2) determined in Step 8f to determine the area bounded by the statistical sample population.

Area Bounded by the Statistical Sample Population (A_{SU}) = 236.9 m^2

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

URANIUM

c. Is the Scan MDC for the selected instrument less than the $DCGL_w$ that was determined for Total Uranium? (compare values from Step 9b and 9d) Yes☐ No☒

(If "Yes", then proceed to Step 12, if "No", then proceed to the next step).

d. Using the Area Factors in Appendix H of HDP-PR-FSS-701 and using the equation from Section 8.2.8d of HDP-PR-FSS-701, determine a Total Uranium AF for each listed area using the Activity Fractions (*f*) for each radionuclide that corresponds to the mean enrichment from Appendix G of HDP-PR-FSS-701.

Area (m^2)	153375	10000	3000	1000	300	100	30	10	3	1
AF_{TotalU}	1.0	1.1	1.1	1.1	2.0	2.7	3.6	5.2	10.6	22.6

Note: The AFs for the Uniform Stratum will generally be used. The RSO may approve use of AFs from the Surface, Root or Deep CSMs, or the Excavation Scenario.

e. Find the Area Factor (AF_{TotalU}) determined in the previous step that corresponds to the area bounded by the statistical sample population (A_{SU}).

AF_{TotU} for the Bounded Area (A_{SU}) = 2.0

f. Multiply the $DCGL_w$ determined for Total Uranium by the Area Factor (AF_{TotU}) to derive a $DCGL_{EMC}$ for Total Uranium.

$DCGL_{EMC}$ for Total Uranium = 51.9 pCi/g

g. Is the MDC_{scan} for the selected instrument less than the $DCGL_{EMC}$ that was determined for Total Uranium? NA☐ Yes☒ No☐

(If "Yes", then proceed to Step 12, if "No", then proceed to the next step.)

h. Determine a new AF (AF_{EMC}) corresponding to the MDC_{scan} for the selected instrument by dividing the MDC_{scan} by the DCGLw.

AF_{EMC} for U_{total} = NA

i. Find the Area (A') that corresponds to the Area Factor (AF_{EMC}).

A' for U_{total} = NA

j. Determine an Adjusted Number of Samples (N_{EMC}) for the statistical sample population size that corresponds to the bounded A_{EMC} using the equation from Section 8.2.8j of HDP-PR-FSS-701.

N_{EMC} corresponding to A' for U_{total} = NA

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

12. Determine the Grid Spacing

a. Larger of N/2 from Step 8f and the maximum value of N_{EMC} from 11j.

(N_{EMC}[max] or N/2) = 8

b. Is the Survey Unit a Class 3 Survey Unit? Yes☐ No☒
(If "Yes", then continue to Step 13, if "No", then proceed to the next step).

c. Determine Grid Spacing (L) using the equation from Section 8.2.9 of HDP-PR-FSS-701.

Grid Spacing (L) for Survey Unit = 16.5 m

13. Generate a Survey Map

a. Assign a unique identification number to each sample in the statistical sample population using the guidance and direction provided in Appendix M of HDP-PR-FSS-701.

b. Generate a graphic representation of the Survey Unit with dimensions and boundaries corresponding to the established reference coordinate system in accordance with Section 8.2.10 of HDP-PR-FSS-701.

c. Using the reference coordinate system, ascertain coordinates for each sample location.

d. Designate sample locations, and location coordinates on Appendix P-4, *FSS Sample & Measurement Locations & Coordinates* and attach a copy of that form to the FSSP.

e. Attach a copy of the developed Survey Map with sample locations to the FSSP.

14. QC & Biased Samples

a. Randomly choose 5% of the statistical sample population as QC samples in accordance with HDP-PR-FSS-703, *Final Status Survey Quality Control*.

b. Designate QC sample locations, and location coordinates on attached Appendix P-4, *FSS Sample & Measurement Locations & Coordinates*.

c. Designate if any biased samples will be taken at the discretion of the HP Staff designing the survey and the basis for taking them. Necessary biased samples will be explained on Appendix P-3, *FSS Sampling Plan.*

d. Using the reference coordinate system, determine coordinates for each biased sample location.

e. Designate biased sample locations, and location coordinates on attached Appendix P-4, *FSS Sample & Measurement Locations & Coordinates*.

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

15. Scan Coverage

a. The Survey Unit is: ☒ Class 1 ☐ Class 2 ☐ Class 3

b. Based on the Survey Unit Classification, the scan coverage in this Survey Unit is;

☒ 100% Scan Coverage of exposed soil ☐ _____% Scan Coverage of exposed soil

c. Designate any specific scan locations as determined necessary, on Appendix P-3, *FSS Sampling Plan.*

16. Investigation Levels

a. The Survey Unit is: ☐ Class 3

1) Scan Investigation Levels are set at: NA cpm

Sample Investigation Levels are set at 50% of the $DCGL_w$ when expressed as the SOF.

b. The Survey Unit is: ☐ Class 2

2) Scan Investigation Levels are set at: NA cpm

Sample Investigation Levels are set at the $DCGL_w$ when expressed as the SOF.

c. The Survey Unit is: ☒ Class 1

3) Scan Investigation Levels are set at: 4,000 net cpm

Sample Investigation Levels are set at the $DCGL_w$ when expressed as the SOF.

17. Attachments

Attach a copy of completed forms as appropriate:

☒ Appendix P-3, *FSS Survey Sampling Plan,*

☒ Appendix P-4, *FSS Sample & Measurement Locations & Coordinates*

☐ Appendix P-5, *FSS Unit Classification Change Form*

☒ Appendix P-6, *FSS Field Log*

☒ Survey Unit Figure

☐ Other:

APPENDIX P-1
FINAL STATUS SURVEY SAMPLING PLAN DEVELOPMENT CHECKLIST FOR SOIL SURVEY UNITS

18. FSSP Development Checklist Approval

Prepared by:	Ellen C. Jakub (Print Name)	(Signature)	3/30/15 (Date)
Peer Reviewed by:	Brian A. Miller (Print Name)	(Signature)	3/30/15 (Date)
Approved by (RSO):	W. Clark Evers (Print Name)	(Signature)	3/30/15 (Date)

HDP-PR-FSS-701, Final Status Survey Plan Development (Revision 5)
APPENDIX P-3
FSS PLAN

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: 13 **Description:** Northern SU in "Area 2"

Overview: The Survey Unit (SU) identified as LSA 10-13 has been prepared for Final Status Survey (FSS) by the Hematite Decommissioning Project (HDP). This appendix provides an overview of the proposed FSS implementation as well as general and specific instructions for the technicians responsible for performing the FSS.

- **Data Quality Objectives**

1. Personnel performing FSS duties meet the qualifications listed in HDP-PR-HP-102 *Health Physics Technician Training* and have received training and instruction commensurate with their duties. The RSO has approved all FSS personnel to perform work associated with their individual roles and responsibilities. Training records are documented in accordance with HDP-PR-GM-020 *Training Material Development and Documentation of Training*.
2. All HDP FSS procedures ("700 series") have been reviewed, revised, and validated in order to ensure performance of actual FSS work activities reflect the requirements detailed in the individual FSS Procedures and the HDP Decommissioning Plan.
3. All FSS instrumentation has undergone a receipt inspection by HDP QA personnel, is within current calibration, and is determined to be functioning within acceptable ranges based on initial set-up and daily source checks in accordance with HDP-PR-HP-411 *Radiological Instrumentation*. Prior to field use, HP technicians will confirm than environmental conditions (e.g. operating temperature range, no standing water) are acceptable for use of FSS instrumentation.

- **Location**

LSA 10-13 is designated **Class 1** and is located in the southern half of the Burial Pits Open Land Area. Although this SU is in the Burial Pits Open Land Area, during remediation, the excavation encroached into the Tc-99 Surrogate Evaluation Area (SEA), therefore, Tc-99 SEA DCGLs were used only for Scan MDC calculations where the inferred Tc-99 DCGL for U-235 is 1.2 pCi/g. The two-dimensional areal extent of LSA 10-13 is 1,895.4 m^2 upon which the systematic sampling grid is based. The interior surface area (three-dimensional) of Survey Unit LSA 10-13 is 2,101.2 m^2.

- **Background**

Remedial actions began in LSA 10-13 in April 2012 and continued through March 2015. This SU along with LSA 10-14 are collectively known as "Area 2" for the purposes of Construction planning and work sequencing. Area 2 contained various types of waste materials, including drums, bags of trash, fuel pellets, construction debris, spent limestone, and contaminated soils.

HDP Satellite Site View: "Area 2" in Red Outline; LSA 10-13 in Red Crosshatching

The average depth of excavation in this SU relative to the final backfill grade is 8.6 feet bgs which corresponds to an approximate quantity of removed materials of 6,500 cubic yards. Portions of this SU were excavated to a depth beyond 8.6 feet bgs to ensure all areas identified during site characterization and remedial

action survey efforts were adequately remediated.

LSA 10-13 was subject to final Remedial Action Support Surveys (RASS) during the month prior to Isolation and Control posting finalization on March 11, 2015. RASS included 100% gamma walkover survey (GWS), systematic (8-point grid), and biased sampling. Prior to completion of RASS, borings were performed to ensure there was no waste material indicative of a burial pit present. These borings were conducted for the purpose of downgrading from nuclear criticality safety (NCS) controls and to provide additional radiological information to determine if the area was ready for Final Status Survey. These borings were performed to a minimum depth of 3 feet below the excavation surface on a grid with maximum spacing of 20 feet between boreholes.

Radiological surveys were performed on the soil spoils, and within the borehole when conditions permitted (i.e., were not filled with water). The radiological surveys were performed by Health Physics Technicians and consisted of dual independent scans of both the soil spoils and within the borehole. The highest readings obtained within Area 2 which contains LSA 10-13 were 9,000 net counts per minute (ncpm) on the spoils material and 16,000 ncpm within the borehole. No material indicative of a burial pit was encountered.

- **Criteria**

Soil samples will be collected from each remaining soil stratum at all systematic locations in LSA 10-13 in accordance with Step 8.2.3.b of HDP-PR-FSS-701. However, all FSS analytical results for samples collected within LSA 10-13 will be conservatively evaluated against the ***Uniform Stratum*** DCGLs.

Radionuclide	*Three - Layer* $DCGL_w$ Values (pCi/g)[b]			**Uniform Stratum (pCi/g)**
	Surface Stratum	Root Stratum	Excavation Stratum	
Radium-226+C[d]	NA	NA	NA	**195.4**
Technetium-99	NA	NA	NA	**51.6**
Thorium-232+C[d]	NA	NA	NA	**168.8**
Uranium-234	NA	NA	NA	**25.1**
Uranium-235+D[c]	NA	NA	NA	**2.0**
Uranium-238+D[c]	NA	NA	NA	**1.9**

[a] Table adapted from HDP FSS Procedure HDP-PR-FSS-701 *Final Status Survey Plan Development*, Revision 5, February 2015.
[b] The reported $DCGL_w$s are the activities for the parent radionuclide as specified and were calculated to account for the dose contribution from insignificant radionuclides.
[c] +D indicates the $DCGL_w$ includes short-lived (half-life ≤ 6 mo.) decay products.
[d] +C indicates the $DCGL_w$ includes all radionuclides in the associated decay chain.

- **Implementation**

As a Class 1 SU, LSA 10-13 will undergo a 100% gamma walkover survey (GWS) using a collimated 2" x 2" sodium iodide (NaI) detector. If there are any remaining interior sidewalls, they will be scanned by holding the probe perpendicular as closely as possible to the sidewall moving the probe up and down the sidewall face while advancing.

Based on a statistical evaluation of the RASS dataset, an eight (8) point systematic grid was developed for LSA 10-13. No surface stratum remains in the SU; at four (4) of the eight systematic locations, composite root strata samples will be collected prior to collection of the "top-six inch" excavation sample.

Biased samples may be collected after a statistical review (e.g. greater than 3σ above mean) of the entire GWS dataset based upon the professional judgment of the FSS Supervisor.

HDP-PR-FSS-701, Final Status Survey Plan Development (Revision 5)
APPENDIX P-3
FSS PLAN

A minimum of one QC duplicate per SU (or 5% of the total number of samples) will be collected.

FSS IMPLEMENTATION SUMMARY TABLE

Gamma Walkover Survey (GWS):	
Scan Coverage	100% accessible excavation floors and walls
Scan MDC	40.4 pCi/g total Uranium (based on a 13,000 cpm background); 0.85 pCi/g Th-232; 1.19 pCi/g Ra-226*
Investigation Action Level (IAL)	4,000 net cpm **

Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	0	These samples will be taken on a systematic grid.
15 cm – 1.5 m (Root)	4	
> 1.5m (Excavation)	8	

Biased Survey/Sampling Locations:
Biased samples may be collected during GWS at the discretion of the HP Technician, after statistical analysis of the survey data, or at the direction of the FSS Supervisor.

Instrumentation	
Ludlum 2221 with 44-10 (2x2 NaI) detector; with collimation for investigations	Used for GWS and to obtain static count rates at biased measurement locations.

*Values based on information provided in HDP-TBD-FSS-002, "*Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS).*

**IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum DCGLw derived from the technical bases presented in HEM-MEMO-15-021 and HDP-TBD-FSS-003 "*Modeling and Calculation of Investigative Action Levels for Final Status Soil Survey Units*", Westinghouse, March 2015.

HDP-PR-FSS-701, Final Status Survey Plan Development (Revision 5)
APPENDIX P-3
FSS PLAN

General Instructions:

1. Summarize daily work activities on the log sheets provided in Appendix P-6 (*FSS Field Log*). Provide a description of site conditions (including the condition of isolation controls), samples collected and the status of gamma walkover surveys for every shift that involves work in this survey unit. Document the surveyor name and instrumentation used for each GWS event (i.e., data file) in Appendix P-6 for reporting traceability. In the event that a situation arises where the survey instructions cannot be followed as written, stop work and contact the FSS Supervisor for resolution. All changes to the survey instructions shall be approved by the RSO before continuing work and be documented in the *FSS Field Log*.
2. In accordance with HDP-PR-FSS-701, *Final Status Survey Plan Development (Sec. 8.4.2),* documentation of activities performed, equipment used, and potential safety hazards that may be encountered during the performance of characterization activities (along with associated controls) will be documented using the FSS Daily Task Briefing log sheet.
3. In accordance with HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey*, confirm that FSS instrumentation is within the current calibration period, has been pre-use source checked, and environmental conditions are acceptable for use as per the manufacturer's recommended operating parameters. After field use, FSS instrumentation will be response checked before end-of-shift.
4. Verify that isolation controls established in accordance with HDP-PR-HP-416 are in placed prior to the start of FSS. Ensure isolation controls included, as necessary, the use of "wattles", berms, or trenching to minimize the potential for contaminated soils and water from adjacent areas to cross the boundary into LSA 10-013.
5. A gamma walkover survey (GWS) will be performed using a 2"x2" NaI (Tl) detector. Move the survey probe in a serpentine pattern approximately 6-inches off-set from centerline to the body (e.g., "shoulder-to-shoulder") with the probe as close to the surface as possible; maintaining the detector as close as possible to the surface (nominally 1", but not to exceed 3-in. distance from the surface). The meter will be moved at a speed of approximately 0.3 meter (or 1.0 feet) per second or less. The gamma walkover survey will cover the percentage of the accessible surface areas within the area of interest as indicated in the table above. Notify the FSS Supervisor of any areas, conditions or constraints where surveying (or subsequent sampling) may not be possible. Document the conditions and any resolutions in the FSS Field Log.
6. A GPS system and data logger should be interfaced with the meter. The downloaded information will then be used to prepare maps illustrating relative count rates and to perform statistical analysis of the data. If a GPS data logging system is not available, contact the FSS Supervisor to determine specific instructions for performing and documenting gamma walkover surveys.
7. LSA 10-13 is a Class 1 Survey Unit. Each sample location will be selected systematically and have associated GPS coordinates specified. In the case of inaccessible sampling locations, additional sample coordinates may be generated with the FSS Supervisor's and RSO's approval in order to identify an acceptable sampling location.
8. A map of the survey unit showing predetermined sample locations with associated GPS coordinates will be generated. A copy of the sample map and survey locations will be attached to the survey instruction.
9. At each systematic soil sampling location a composite soil sample will be collected from each location and depth as determined after the completion of excavation (and will be provided in Appendix P-4). The systematic sample locations will include zero (0) samples taken at a depth of 0 – 15 cm (surface), four (4) samples collected at a depth of 15 cm – 1.5 m (root), and 8 (eight) samples collected at a depth of 1.5 m to 1.65 m (excavation).

HDP-PR-FSS-701, Final Status Survey Plan Development (Revision 5)
APPENDIX P-3
FSS PLAN

10. Biased soil sampling locations may be determined at the discretion of the HP Technician during the performance of the GWS. Biased soil sampling locations may also be determined at the discretion of the FSS Supervisor based on statistical analysis of the survey/sampling data or process/historical knowledge of the area. Biased soil samples will be collected from the top six inches of the excavation surface. Radiological Engineer and/or the HP Technician will log the reason for collection of biased samples on the *FSS Field Log* and record the location of biased samples on Appendix P-4 of this survey instruction.

    NOTE: If trash, waste, or other non-native materials are observed during sample collection, stop sampling activities and notify HP Supervision (or Radiological Engineering) before collecting samples at any sample location in the unit.

11. All samples collected as part of this survey will be analyzed at an off-site laboratory by gamma spectroscopy for radium, thorium, and uranium, and ICP-MS for Tc-99.

Specific Instructions:

NOTE: Unless otherwise indicated, the performance of these specific instructions is the responsibility of the HP Technician.

Before Beginning Work

1. **Rad. Engineer/HP Technician:** Verify, each shift, that isolation controls, established in accordance with HDP-PR-HP-602, are in place prior to the start of field work using the FSS Daily Task Briefing log sheet.
2. **Rad. Engineering/HP Technician:** Prior to gamma walkover survey in the area to be surveyed, walk the area looking specifically for any debris material (e.g. asphalt, plastic, concrete, etc.) that may indicate further remediation efforts are necessary.
3. **Rad. Engineer/HP Technician:** Perform a daily task-specific briefing; documenting the attendants, planned work activities, anticipated hazards, and controls on the FSS Daily Task Briefing log sheet.

    NOTE: If soil sampling to a depth greater than one foot is required, ensure HDP Safety & Health is aware of the activity, an Excavation Permit (Form HDP-PR-EHS-021-1) has been performed for the work area, and underground utilities have been identified and marked.

Gamma Walkover Surveys (GWS)

1. Establish a general area background, in accordance with HDP-PR-FSS-711. Use this background level in conjunction with the Investigation Action Level (IAL) of 4,000 net counts per minute as a field guide to pause and, if necessary, flag locations for possible biased sampling (see following Steps 2 and 3 below for details).
2. Perform a gamma walkover of the survey unit holding the probe as close to the surface as possible (nominally 1", but not to exceed 3"), in accordance with HDP-PR-FSS-711.
    a. Look and/or listen for elevated count rates and then pause to determine locations that exhibit anomalous readings (e.g., count rates that exceed the IAL for this unit).
    b. Mark the location(s) exhibiting anomalous readings to facilitate possible future investigations (for example, use a flag, stake, or other marking resistant to anticipated environmental conditions).
3. At each location where anomalous readings occur, perform a more detailed point survey of the area. Pause and place the survey probe as close as possible to the surface to define and record the total count rate associated with the area of interest on the *FSS Field Log*.

HDP-PR-FSS-701, Final Status Survey Plan Development (Revision 5)
APPENDIX P-3
FSS PLAN

NOTE: If field conditions limit the ability to perform contact readings, collect readings as close as practical. Contact the FSS Supervisor (or Radiological Engineering) regarding the issue for each location. The FSS Technician, FSS Supervisor, and/or Radiological Engineer will log the issue (and resolution) for each location in the *FSS Field Log* and on applicable HDP survey forms.

4. **GPS (and associated data logger) is the preferred method for performing GWS.**
   When a GPS and data logger is used, down load and provide the survey data to a GIS Specialist.

   a. **GIS Specialist**: Provide colorimetric maps indicating survey coverage and measurements exceeding the IAL and send the survey data to the FSS Supervisor.

   b. **FSS Supervisor**: Provide statistical analysis to determine population characteristics of the survey data set and identify any areas requiring additional surveys or sampling. Contact FSS Technician to mark additional locations requiring survey or sampling.

   If a GPS and data logger cannot be used to perform GWS in any portion of this survey unit, the FSS Technician will contact the FSS Supervisor and RSO to determine compensatory survey methods. The FSS Supervisor will log the compensatory methods in the *FSS Field Log*.

   Download the survey data at the end of each shift. To minimize data loss, periodically back up GWS data files.

Soil Sampling

1. Collect soil samples in accordance with HDP-PR-FSS-711 at locations identified in Appendix P-4. Note that additional biased sampling locations may also be listed as determined by the GWS or as determined by the FSS Supervisor.
2. Collect a minimum of one duplicate sample for every 20 samples (i.e., 5% frequency). A minimum of one duplicate sample is required for each survey unit.
3. Care should be exercised to ensure the entire sample is included from within the depths specified for sampling. When collecting the composite samples, vegetation and native debris/rocks with a diameter greater than 1 inch should be discarded.

   NOTE: If a discrete source of radiation (e.g., a fuel pellet) is discovered during the performance of sampling activities, contact the FSS Supervisor who will then notify the RSO. Pause any additional characterization work in the immediate area and use a plastic bag to contain the material. Label the plastic bag per HDP-PR-HP-201, Section 8.2 "Labeling Radioactive Material" and transfer the material from the survey unit for controlled storage in the Building 230 Sample Cage via physical turnover to the shift Sample Custodian.
4. Monitor the count rates observed at all accessible surfaces within close proximity (e.g., 2 meter diameter) of each biased sampling location, as practical. Note any accessibility issues and discuss compensatory measures with supervision.

   a. Inform the FSS Supervisor of the results obtained from monitoring the locations of biased sampling to receive instructions for further investigation or the need for additional excavation.
5. Collect bias samples from the surface to a depth of 6 inches.
6. Monitor the count rates within the depression created by the collection of biased soil samples.

HDP-PR-FSS-701, Final Status Survey Plan Development (Revision 5)
APPENDIX P-3
FSS PLAN

7. Obtain and record the count rate on contact with features other than soil within the excavation. (e.g., native rock). Record the nature and extent of features other than soil found within the excavation in the *FSS Field Log* and contact the FSS Supervisor to determine additional characterization methods, if necessary.
8. Submit samples for analysis to TestAmerica following sample chain of custody requirements contained in HDP-PR-QA-006.

Prepared by:	Brian A. Miller (Print Name)	Brian A. Miller (Signature)	3/30/15 (Date)
Peer Reviewed by:	Ellen Jakub (Print Name)	Ellen Jakub (Signature)	3/30/15 (Date)
Approved by (RSO):	W. Clark Evers (Print Name)	W. Clark Evers (Signature)	3/30/15 (Date)

APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area

Survey Unit: 13 **Description:** Northern Survey Unit in "Area 2"

Survey Type: FSS **Classification:** Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L10-13-01-B-E-S-00	Uniform	S	426.4	426.0	865152.8	827426.0	Excavation 6-inch grab
L10-13-02-B-R-S-00	Uniform	S	431.2	430.2	865105.9	827398.9	Root 12-inch composite
L10-13-03-B-E-S-00	Uniform	S	430.2	429.7	865105.9	827398.9	Excavation 6-inch grab
L10-13-04-B-E-S-00	Uniform	S	421.5	421.1	865105.9	827453.1	Excavation 6-inch grab
L10-13-05-B-R-S-00	Uniform	S	429.1	428.5	865105.9	827507.2	Root 7-inch composite
L10-13-06-B-E-S-00	Uniform	S	428.5	428.0	865105.9	827507.2	Excavation 6-inch grab
L10-13-07-B-R-S-00	Uniform	S	431.5	431.1	865059.0	827426.0	Root 5-inch composite
L10-13-08-B-E-S-00	Uniform	S	431.1	430.6	865059.0	827426.0	Excavation 6-inch grab
L10-13-09-B-E-S-00	Uniform	S	415.3	414.8	865059.0	827480.1	Excavation 6-inch grab
L10-13-10-B-R-S-00	Uniform	S	429.7	428.9	865059.0	827534.3	Root 10-inch composite
L10-13-11-B-E-S-00	Uniform	S	428.9	428.4	865059.0	827534.3	Excavation 6-inch grab
L10-13-12-B-E-S-00	Uniform	S	419.1	418.6	865012.1	827507.2	Excavation 6-inch grab
L10-13-07-B-R-Q-00	Uniform	Q	431.5	431.1	865059.0	827426.0	Excavation 6-inch grab
L10-13-13-B-E-B-00	Uniform	B	TBD	TBD	TBD	TBD	Bias sample may be taken after evaluation of GWS data (e.g., data > 3σ over the mean of the walkover data).

* Elevations are in feet above mean sea level

** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983]

Surface: Floor = F; Wall = W; Ceiling = C; Roof = R

CSM: Three-Layer (Surface-Root-Excavation) with conservative use of Uniform DCGLs

Type: Systematic = S, Biased = B; QC =Q; Investigation = I

LSA 10-13 Systematic Sample Locations

LSA 10-03

LSA 10-04

LSA 10-12

LSA 10-14

L10-13-01-B-E-S-00

L10-13-02-B-R-S-00
L10-13-03-B-E-S-00

L10-13-04-B-E-S-00

L10-13-05-B-R-S-00
L10-13-06-B-E-S-00

LSA 10-13
1895 m^2 Planar Area

L10-13-07-B-R-S-00
L10-13-08-B-E-S-00
L10-13-07-B-R-Q-00

L10-13-09-B-E-S-00

L10-13-10-B-R-S-00
L10-13-11-B-E-S-00

L10-13-12-B-E-S-00

N

0 10 20 40 60 80 Feet

Sample ID	Start Depth (inches)	End Depth (inches)	Northing	Easting
L10-13-01-B-E-S-00	0	6	865152.8	827426.0
L10-13-02-B-R-S-00	0	12	865105.9	827398.9
L10-13-03-B-E-S-00	12	18	865105.9	827398.9
L10-13-04-B-E-S-00	0	6	865105.9	827453.1
L10-13-05-B-R-S-00	0	7	865105.9	827507.2
L10-13-06-B-E-S-00	7	13	865105.9	827507.2
L10-13-07-B-R-S-00	0	5	865059.0	827426.0
L10-13-08-B-E-S-00	5	11	865059.0	827426.0
L10-13-09-B-E-S-00	5	11	865059.0	827480.1
L10-13-10-B-R-S-00	0	10	865059.0	827534.3
L10-13-11-B-E-S-00	10	16	865059.0	827534.3
L10-13-12-B-E-S-00	0	6	865012.1	827507.2
L10-13-07-B-R-Q-00	0	5	865059.0	827426.0

FSS TRIANGULAR GRID SPACING CALC

INPUTS

Survey Unit Area	1895.4	m^2	
Minimum # Required Locations	8	includes +20%	

Survey Unit Absolute Compass Limits

Ymax (Northing)	865434	ft	Enter from GIS.
Ymin (Northing)	865260	ft	
Xmax (Easting)	827503	ft	
Xmin (Easting)	827296	ft	

RANDOMIZER MODULE

Click this button to generate a new set of random coordinates

Randomization occurs at GIS.

865267.0	Northing (ft)
827341.0	Easting (ft)

Enter Selected Random Start Point (Origin)

865338	Northing (ft)	Enter from GIS.
827399	Easting (ft)	

GRID SPACING MODULE

(Appendix P-1 Step 12.c, in meters)

L_{POINT}	16.5 m	54.1 ft	Distance between points.
L_{ROW}	14.3 m	46.9 ft	Distance between rows.

Sample ID	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.
		Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238				
		Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)
0862-SS-150202-05-01	S	1.24	0.18	0.0818		-0.230	0.000	0.623	0.623	0.189	0.225		1.23	0.186	0.132		0.230	0.230	1.620	NA	NA	NA	0.086	0.165	0.265	U	0.839	0.313	0.874	U	1.6
0862-SS-150202-05-02	S	1.36	0.212	0.107		-0.110	0.000	0.651	0.651	0.188	0.23		1.2	0.215	0.157		0.200	0.200	14.398	NA	NA	NA	0.795	0.217	0.277		2.5	0.788	1.140		4.8
0862-SS-150202-05-03	S	1.44	0.213	0.102		-0.030	0.000	0.0008	0.001	0.0516	0.264	U	1.28	0.191	0.069		0.280	0.280	2.650	NA	NA	NA	0.143	0.175	0.289	U	1.09	0.364	0.986		2.0
0862-SS-150202-05-04	S	1.24	0.192	0.132		-0.230	0.000	-0.0417	0.000	0.0678	0.238	U	1.25	0.235	0.143		0.250	0.250	2.576	NA	NA	NA	0.142	0.195	0.319	U	0.637	0.354	1.310	U	3.4
0862-SS-150202-05-05	S	1.32	0.178	0.0706		-0.150	0.000	0.0983	0.098	0.122	0.249	U	1.24	0.196	0.086		0.240	0.240	2.274	NA	NA	NA	0.12	0.157	0.254	U	1.23	0.524	0.803		1.5
0862-SS-150202-05-06	S	1.51	0.238	0.112		0.040	0.040	-0.0453	0.000	0.0884	0.256	U	1.08	0.236	0.190		0.080	0.080	1.890	NA	NA	NA	0.103	0.188	0.333	U	0.663	0.491	1.380	U	2.4
0862-SS-150202-05-07	S	1.09	0.166	0.0841		-0.380	0.000	0.092	0.092	0.148	0.296	U	1.08	0.167	0.080		0.080	0.080	5.289	NA	NA	NA	0.291	0.146	0.179		0.711	0.280	0.779	U	6.0
0862-SS-150202-05-08	S	1.2	0.193	0.104		-0.270	0.000	0.232	0.232	0.0828	0.233	U	1.17	0.199	0.135		0.170	0.170	0.967	NA	NA	NA	0.0487	0.138	0.313	U	0.828	0.445	1.260	U	1.0
Minimum		-0.380						-0.045					0.080						0.967				0.049				0.637				
Maximum		0.040						0.651					0.280						14.398				0.795				2.500				
Mean		0.005						0.212					0.191						3.958				0.216				1.062				**2.8**
Median		0.000						0.095					0.215						2.425				0.131				0.834				Average Enrichment
Standard Deviation		0.014						0.274					0.076						4.406				0.245				0.617				
		Ingrowth, use Ra226 bkg (pCi/g) = 1.47											Th232 bkg (pCi/g) = 1.0																		

NOTES:

Gross results in units of pCi/g
* Background with ingrowth (1.47 pCi/g) subtracted from gross result
**Background (1.0 pCi/g) subtracted from gross result
U qualifier: A normal, non-detected result (result less than MDC).
All uncertainty values are reported at the 2-sigma confidence level.

(Average Enrichment = Appendix P-1 Step 9.a)

(Appendix P-1 Step 2.a) 8

(Appendix P-1 Step 2.b) List Min, Max, Mean, Median, Standard Deviation as above.

Appendix P-1 Step 2. Evaluate final RASS Data

Sample ID	Type (Systematic, Bias, QC)	SOF (Uniform DCGL)
		SOF (Uniform DCGL)
0862-SS-150202-05-01	S	0.15
0862-SS-150202-05-02	S	0.23
0862-SS-150202-05-03	S	0.16
0862-SS-150202-05-04	S	0.14
0862-SS-150202-05-05	S	0.15
0862-SS-150202-05-06	S	0.08
0862-SS-150202-05-07	S	0.08
0862-SS-150202-05-08	S	0.11
Minimum		0.08
Maximum		0.23
Mean		**0.14**
Median		0.14
Standard Deviation		0.05
		0.05
		0.13
		0.13

SOF_{MEAN} (Appendix P-1 Step 8.a)

σ_{SOF} (Appendix P-1 Step 8.b)

σ_{SOF} Background Reference Area

σ_{SOF} Greater of RASS SoF or BKG SoF (Appendix P-1 Step 8.b)

$DCGL_W$, Uniform, Measure Tc-99

U-234	195.4
U-235	51.6
U-238	168.8
Tc-99	25.1
Th-232	2.0
Ra-226	1.9

(Appendix P-1 Step 7)

Infer U234			
U-238/U235 Ratio	U-234/U235 Ratio	U-234	% Enrichment
9.755814	18.83901	1.620155	1.6
3.144654	18.11084	14.39811	4.8
7.622378	18.53245	2.650141	2.0
4.485915	18.14414	2.576468	3.4
10.25	18.94644	2.273573	1.5
6.436893	18.34906	1.889953	2.4
2.443299	18.17647	5.289353	6.0
17.00205	19.85309	0.966845	1.0

average enrichment **2.8** (Appendix P-1 Step 9.a)

Appendix P-1 Step 8. Calculate the Number of Samples in the Statistical Population

Uniform DCGL Criteria Evaluation		
N/2 Value Verification		
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**	
St. Dev.	0.13	
$DCGL_{SOF}$	1	
LBGR (Mean)	0.14	
Shift	0.86	
Relative Shift (Δ/σ)	6.86	(Appendix P-1 Step 8.d)
MARSSIM Table 5.1 (P_r)	1.000000	
N	12	
N + 20%	14.4	
N/2	8	(Appendix P-1 Step 8.f)
RASS N/2	8	
Verification Check	**SUFFICIENT MEASUREMENTS**	
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test		

Hard input of Rel. Shift = 3 for Rel. Shift >3 above

Uniform DCGL Criteria Evaluation		
N/2 Value Verification		
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**	
St. Dev.	0.13	
$DCGL_{SOF}$	1	
LBGR (Adjusted)	0.62	(Appendix P-1 Step 8.e)
Shift	0.38	
Adjusted Relative Shift (Δ/σ)	3.00	
MARSSIM Table 5.1 (P_r)	0.974067	
N	13	
N + 20%	15.6	
N/2	8	
RASS N/2	8	
Verification Check	**SUFFICIENT MEASUREMENTS**	
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test		

MARSSIM Table 5.1

Δ/σ	P_r
0.1	0.528182
0.2	0.556223
0.3	0.583985
0.4	0.611335
0.5	0.638143
0.6	0.664290
0.7	0.689665
0.8	0.714167
0.9	0.737710
1.0	0.760217
1.1	0.781627
1.2	0.801892
1.3	0.820978
1.4	0.838864
1.5	0.855541
1.6	0.871014
1.7	0.885299
1.8	0.898420
1.9	0.910413
2.0	0.921319
2.25	0.944167
2.5	0.961428
2.75	0.974067
3.0	0.983039
3.5	0.993329
4.0	0.997658
4.01	1.000000

MARSSIM Table 5.2, α = 0.05, β = 0.10

α (or β)	$Z_{1-\alpha}$ (or $Z_{1-\beta}$)
0.005	2.576
0.01	2.326
0.015	2.241
0.025	1.960
0.05	1.645
0.10	1.282
0.15	1.036
0.2	0.842
0.25	0.674
0.30	0.524

α
β

Scan MDC Calculations (2" x 2" NaI)			
Appendix P-1 (Step 9.a)	Average Enrichment:	2.8	
Appendix P-1 (Step 9.b)	f_{U-234}	0.74027	
	f_{U-235}	0.04059	
	f_{U-238}	0.21913	
		1.0000	
	$DCGL_{wTotU}$	25.7	pCi/g
Appendix P-1 (Step 9.c)	Select Instrument	2" x 2" NaI	
	SU Background =	13,000	cpm
Appendix P-1 (Step 9.d)	Scan MDC (Tot U)*	40.4	pCi/g
Appendix P-1 (Step 10)	Scan MDC (Th-232)**	0.85	pCi/g
	Scan MDC (Ra-226)**	1.19	pCi/g

DCGL U-235 (inferred Tc-99)
Tc-99 SEA

SEA		
Burial Pit	Plant Area	Tc-99
pCi/g	pCi/g	pCi/g
5.8	2.5	1.2

HDP-TBD-FSS-002, Appendix C
Scan MDCs at Various Background Levels (pCi/g)

BKG (CPM)	Ra-226	Th-232	U-234	U-235	U-238	Tot U (4% Enrich)
4000	0.66	0.47	2004	1.27	16.8	22.4
5000	0.74	0.53	2241	1.42	18.7	25.1
6000	0.81	0.58	2455	1.56	20.5	27.5
7000	0.87	0.63	2651	1.68	22.2	29.7
8000	0.93	0.67	2834	1.80	23.7	31.7
9000	0.99	0.71	3006	1.91	25.2	33.6
10000	1.04	0.75	3169	2.01	26.5	35.5
11000	1.09	0.79	3324	2.11	27.8	37.2
12000	1.14	0.82	3471	2.20	29.0	38.8
13000	1.19	0.85	3613	2.29	30.2	40.4
14000	1.23	0.89	3750	2.38	31.4	42.0
15000	1.28	0.92	3881	2.46	32.5	43.4

Assumes surveyor efficiency of 1, observation interval = 1.64 sec, and air gap of 2".

Appendix P-1 Step 11. Adjust the Statistical Sample Population Size (N/2) for Scan MDC

Survey Unit ID	LSA 10-13		
Enter SU Area	1895.4 m^2	(Appendix P-1 Step 3)	
# Samples Required	8		
Appendix P-1 Step 11.a	If SU is Class 2 or Class 3, proceed no further.		
Appendix P-1 Step 11.b	Sample Bounding Area (A_{su})	236.9 m^2	

URANIUM

Appendix P-1 Step 11.c	Is Scan MDC less than the $DCGL_{wTotU?}$	NO	If yes, go to Step 12 If no, go to Step 11.d
Appendix P-1 Step 11.d	Calculate a Tot_U AF for Key Area Factors		

Area (m^2)	1	3	10	30	100	300	1000	3000	10,000	153,375
roundup	1	1.1	3.1	10.1	30.1	100.1	300.1	1000.1	3000.1	10,000.1
AF_{totU}	22.6	10.6	5.2	3.6	2.7	2.0	1.1	1.1	1.1	1.0

Appendix P-1 Step 11.e	Determine closest AF_{totU} match for A_{su} value in E6.	2.0	
Appendix P-1 Step 11.f	Derive the $DCGL_{emc}$ for $_{tot}U$	51.9	pCi/g
Appendix P-1 Step 11.g	Compare calculated Scan MDC for $_{tot}U$ to the $DCGL_{EMC}$	YES	If yes, go to Step 12 If no, go to Step 11.h as necessary

Area Factors, Uniform Soil;

	Elevated Measurement Area (m^2)									
Radionuclide	**153,375**	**10,000**	**3,000**	**1,000**	**300**	**100**	**30**	**10**	**3**	**1**
U-234	1.0	1.2	1.3	1.3	4.0	9.3	19.6	34.3	70.5	132.8
U-235	1.0	1.1	1.1	1.1	1.9	2.5	3.3	4.7	9.6	20.5
U-238	1.0	1.1	1.3	1.3	2.5	3.6	5.0	7.2	14.9	31.6
Tc-99	1.0	1.0	1.0	1.0	3.4	10.3	34.3	102.9	342.7	1,027
Th-232	1.0	1.0	1.0	1.0	2.1	3	4.2	6.1	12.9	28.9
Ra-226	1.0	1.1	1.1	1.1	2.5	4.1	6.1	9.1	19.3	43.4

$DCGL_W$, Uniform, Tc-99 Area, Inferred Tc-99

U-234	195.4
U-235	1.2
U-238	168.8
Tc-99	
Th-232	2.0
Ra-226	1.9