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Our ref: HEM-17-15
Date: February 27, 2017

Subject: Westinghouse Hematite Decommissioning Project - Request for NRC Review of Final Status Survey Final Report Volume 3, Chapter 8, Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02, Revision 1 (License No. SNM-00033, Docket No. 070-00036)

The purpose of this letter is to provide for the U.S. Nuclear Regulatory Commission (NRC) review of the FSS overview document Final Status Survey Final Report Volume 3, Chapter 8, Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02 (LSA 12-01 and LSA 12-02), Revision 1.

The NRC provided feedback during recurring weekly publicly noticed teleconferences in regards to the application of the WRS Test when applied to the Three Stratum approach. Westinghouse and the NRC discussed the path forward and resolution of the NRC comments. As such, Revision 3 to FSSFR Volume 3 Chapter 1 implemented the resolution of the comments {ML17046A005}. Revision 1 of FSSFR Volume 3, Chapter 8 implements Revision 3 to FSSFR Volume 3 Chapter 1 within the release record.

Attachment 1 contains Final Status Survey Final Report Volume 3, Chapter 8, Revision 1 with a CD containing the revised Appendices. Attachment 2 contains a Track Change version of Final Status Survey Final Report Volume 3, Chapter 8, Revision 1 for ease of review.

Please contact me at 314-810-3353, should you have questions or need additional information.

Sincerely,

Kenneth E. Pallagi
Licensing Manager,
Hematite Decommissioning Project

NMSS20

Attachment: 1) Final Status Survey Final Report Volume 3, Chapter 8, Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02, (LSA 12-01 and LSA 12-02) (HDP-RPT-FSS-210) with a CD containing Appendices

2) Final Status Survey Final Report Volume 3, Chapter 8, Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02, (LSA 12-01 and LSA 12-02) Track Change Version

cc: J. W. Smetanka, Westinghouse
M. R. Meyer, NRC/DUWP/MDB
J. A. Smith, NRC/DUWP/MDB

Attachment 1

Final Status Survey Final Report Volume 3, Chapter 8

Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02, Revision 1 with a CD containing Appendices

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Final Status Survey Report

Hematite Decommissioning Project

Final Status Survey Final Report Volume 3, Chapter 8

TITLE: **Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02 (LSA 12-01 and LSA 12-02)**

REVISION: **1**

EFFECTIVE DATE: FEB 2 7 2017

Approvals:

Author: Kenneth E. Pallagi — 02-27-2017 Date

Owner/Manager: W. Clark Evers — 2/27/17 Date

REVISION LOG	
Revision No. Effect. Date	**Revision**
0 12/26/2016	Revision 0 is the initial issuance of the Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02.
1 See Cover Page	The NRC provided feedback during recurring weekly publicly noticed teleconferences in regards to the application of the WRS Test when applied to the Three Stratum approach. Westinghouse and the NRC discussed the path forward and resolution of the NRC comments. Revision 3 to FSSFR Volume 3 Chapter 1 implemented the resolution of the comments. Revision 1 of this Survey Area Release Record implements Revision 3 to FSSFR Volume 3 Chapter 1 within this report. In addition, the title to Figure 2-3 was corrected.

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ALARA	As Low As Reasonably Achievable
bgs	below ground surface
CFR	Code of Federal Regulations
cm	centimeter(s)
cpm	count(s) per minute
CSM	Conceptual Site Model
DCGL	Derived Concentration Guideline Level
$DCGL_w$	DCGL for average concentrations over a survey unit, used with statistical tests. ("W" suffix denotes "Wilcoxon")
DGPS	Digital Global Positioning System
DP	Hematite Decommissioning Plan
DQO	Data Quality Observation
EMC	Elevated Measurement Comparison
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
FSS	Final Status Survey
FSSFR	Final Status Survey Final Report
gcpm	gross count(s) per minute
GIS	Graphical Information Software
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HDP	Hematite Decommissioning Project
HP	Health Physics
HRCR	Hematite Radiological Characterization Report
I & C	Isolation and Control
IAL	Investigation Action Level
LSA	Land Survey Area
m	meter(s)
m^2	square meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Concentration Limit
MDC	Minimum Detectable Concentration
mrem	milliroentgen equivalent man
NAD	North American Datum
NaI	Sodium Iodide
ncpm	net count(s) per minute
NCS	Nuclear Criticality Safety
NRC	U.S. Nuclear Regulatory Commission
pCi/g	picocurie(s) per gram
QC	Quality Control
Ra	Radium
RASS	Remedial Action Support Survey
RSO	Radiation Safety Officer
SOF	Sum of Fractions

SU	Survey Unit
Tc	Technetium
Th	Thorium
U	Uranium
WRS	Wilcoxon Rank Sum
yr	year

EXECUTIVE SUMMARY

This Survey Area Release Record (SARR) presents the results of the final status radiological surveys of the Hematite Decommissioning Project (HDP) Land Survey Area (LSA) 12, Survey Unit (SU) 01 (LSA 12-01) and SU 02 (LSA 12-02). As provided in Final Status Survey Final Report (FSSFR), Volume 1, Chapter 1, Section 7.0 {ML15257A307}, the final report summary, FSSFR Volume 7, *Final Status Survey Final Report*, will be submitted at the conclusion of the post-remediation groundwater monitoring period. FSSFR Volume 7 will be submitted to demonstrate that the site has met the requirements for unrestricted release consistent with the requirements of the Title 10 Code of Federal Regulations (CFR) 20 Subpart E, "Criteria for License Termination."

Both LSA 12-01 and LSA 12-02 were designated as Class 2 SUs as presented in Table 14-16 of the HDP Decommissioning Plan (DP) {ML092330123}. The Class 2 designation for both SUs remained in effect throughout remediation and Final Status Survey (FSS). For both SUs, evaluation of analytical results against the Derived Concentration Guideline Levels (DCGL) for the Uniform Stratum Conceptual Site Model (CSM) was the selected approach. The objective of the FSS for both SUs was to obtain and document measurement results, analytical data, and other supporting information in order to demonstrate that after completion of remediation the residual radioactivity levels in the LSA 12-01 and LSA 12-02 SUs are below the applicable Uniform Stratum DCGLs and therefore the land area of these SUs meet the criteria for unrestricted release.

The Uniform Stratum CSM assumes residual radioactivity is uniformly distributed over the entire depth profile of the SU from ground surface to 6.7 meter (m) below ground surface (bgs). As described in FSSFR Volume 3, Chapter 1, 6.2.1, *Systematic Soil Sampling*, systematic soil samples were obtained at depths dependent upon the systematic soil sample location.

This SARR was prepared as described in FSSFR Volume 3, Chapter 1, Section 7.0, *Survey Area Release Record Organization*, as implemented by FSS procedure HDP-PR-FSS-722.

1.0 REPORT BACKGROUND

As a result of the U. S. Nuclear Regulatory Commission (NRC) feedback regarding the submittal of the FSSFR, Westinghouse and the NRC agreed that Westinghouse would develop an outline presenting the format and content of FSS documents required for NRC review. Westinghouse provided the outline to the NRC for discussion during the August 19, 2015, publicly noticed teleconference and the format was agreed upon {ML15238B032}.

FSSFR Volume 3, Chapter 1, Revision 2, *Land Survey Areas (LSA) Overview* provides the information common to land survey areas. This report, FSSFR Volume 3, Chapter 8, builds upon the general information provided in FSSFR Volume 3, Chapter 1, Revision 2.

2.0 HDP SITE, LSA AND SURVEY UNIT DESCRIPTIONS

2.1 HDP Site Description

A general description of the HDP site is given in FSSFR Volume 1, Chapter 1.

2.2 LSA 12 Configuration

The DP Chapter 14 and DP Figure 14-14 provided the conceptual approach for the configuration of LSAs and the SUs within a LSA. Figure 2-1 indicates the LSA configurations for the HDP site.

The DP stated that it was expected that the conceptual boundaries of the SUs would be altered based on the actual configuration and condition of the SU at the time of survey design. As expected, it was necessary to modify the boundary of SUs within LSA 12 to facilitate the remediation process. Although the some of the SU boundaries within LSA 12 were modified the boundary of LSA 12 remained unchanged

LSA 12 encompasses the entire "East Reuse Soil Laydown Area" footprint within the Central Tract. LSA 12 consists of SUs LSA 12-01 through LSA 12-09.

2.2.1 LSA 12 SU Configuration Change

The expansion in the number of SUs within LSA 12 by the reduction in size of LSA 12-02 was due in part to the processing and storage of reuse soil. As site remediation operations generated more than the anticipated volume of reuse soil it became necessary to expand the Class 1 storage area portion of LSA 12.

The initial configuration change transferred a portion of LSA 12-02, a Class 2 SU, to create LSA 12-08, a Class 1 SU. Subsequently LSA 12-08 was divided into LSA 12-08 and LSA 12-09 to ensure compliance with the DP Class 1 SU size requirement.

To support the remediation plans described in the DP, although radiological characterization of the land indicated it was radiologically non-impacted, SUs were developed based upon future use (reuse soil laydown area). All SUs within LSA 12 that were initially classified as Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 1 (LSA 12-03 through LSA 12-07) remained classified as MARSSIM Class 1 SUs. SUs LSA 12-01 and 12-02 were initially classified as MARSSIM Class 2 and remained Class 2 SUS. The portion of LSA 12-02 that became LSA 12-08 and LSA 12-09 were classified as MARSSIM Class 1 SUs, thereby ensuring compliance with the DP.

2.3 LSA 12-01 and LSA 12-02 Survey Unit Description and Configuration

The land area that is LSA 12-01 and LSA 12-02, prior to and during site operations was woodlands (see Figure 2-2) and not associated with or impacted by any site operations other than ground water monitoring well sampling. There were no structures, piping, or spent limestone within the SUs. As a function of preparation for remediation operations, trees and vegetation were removed from portions of LSA 12-01 and LSA 12-02 and the area was graded to create the reuse soil laydown area for the reuse soil to be generated. Portions of LSA 12-01 and LSA 12-02 remained wooded (see Figure 2-3).

As all reuse soil that was placed in LSA 12-02 was subsequently removed and used as backfill in site excavations, remediation was not necessary in LSA 12-01 or LSA 12-02 to prepare it for FSS. As such, no excavations were performed to remove reuse or any native soil. The final surface of the SUs that was subject to FSS was the native soil. Ground water monitoring wells BR-04-JC and BR-04-RB were present in LSA 12-02 during site operations and remain undisturbed. These wells will continue to be monitored as part of the post-remediation ground water monitoring reported in Volume 6 of the FSSFR.

Figure 2-4 presents the Final Configuration of LSA 12 and the SUs. Figure 2-5 presents the Final Configuration of the HDP Land Survey Areas and SUs.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 12-01 presents 7,062 square meters (m^2) in planar (2-dimensional, un-excavated surface).

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 12-01 presents 3,254 square meters (m^2) in planar (2-dimensional, un-excavated surface).

Figure 2-1
HDP Land Survey Areas

Figure 2-2
Hematite Site Aerial Photograph – 04/02/1998
(Indicating General Location of LSA 12)

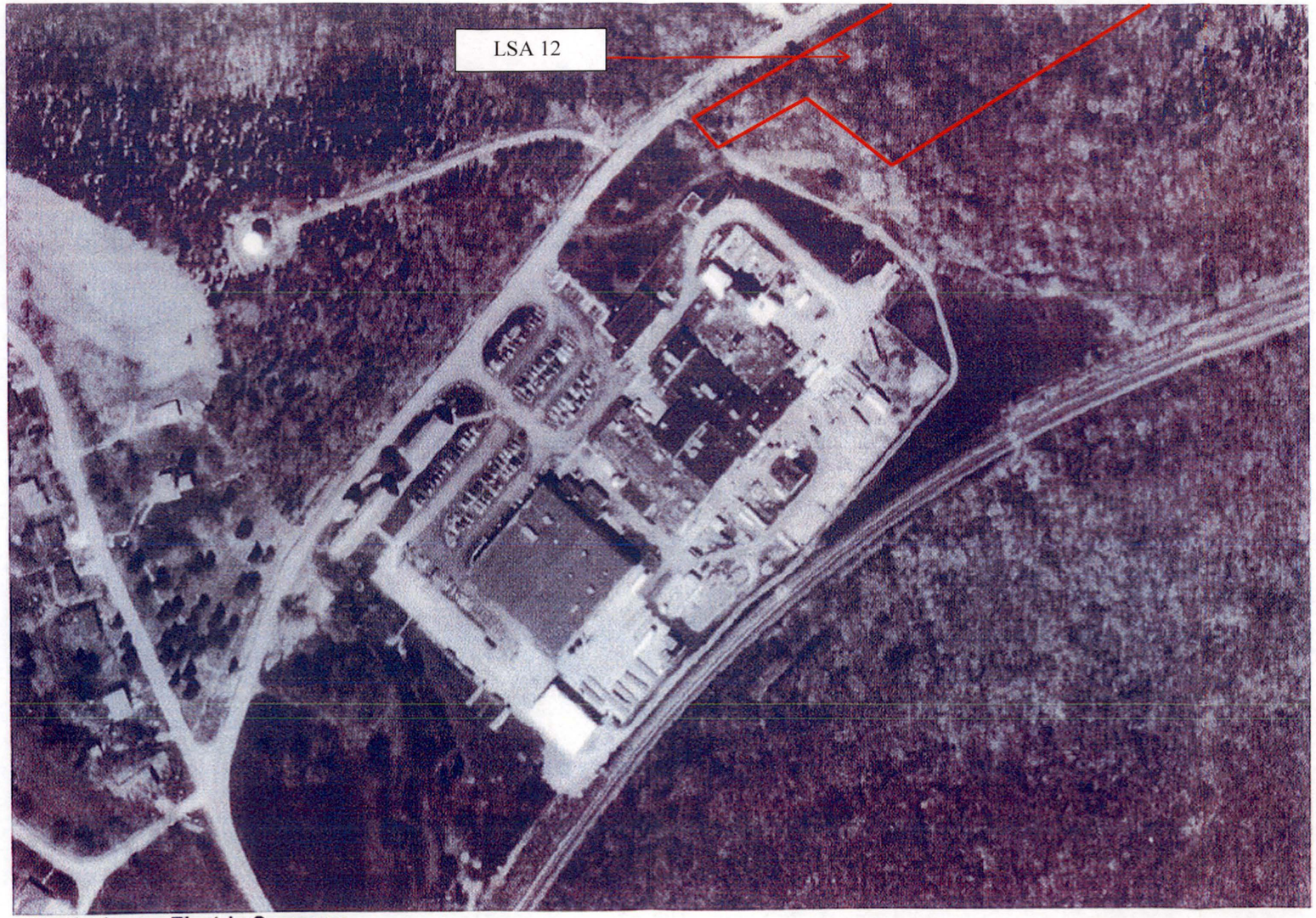


Figure 2-3
Hematite Site Aerial Photograph – Circa 2011

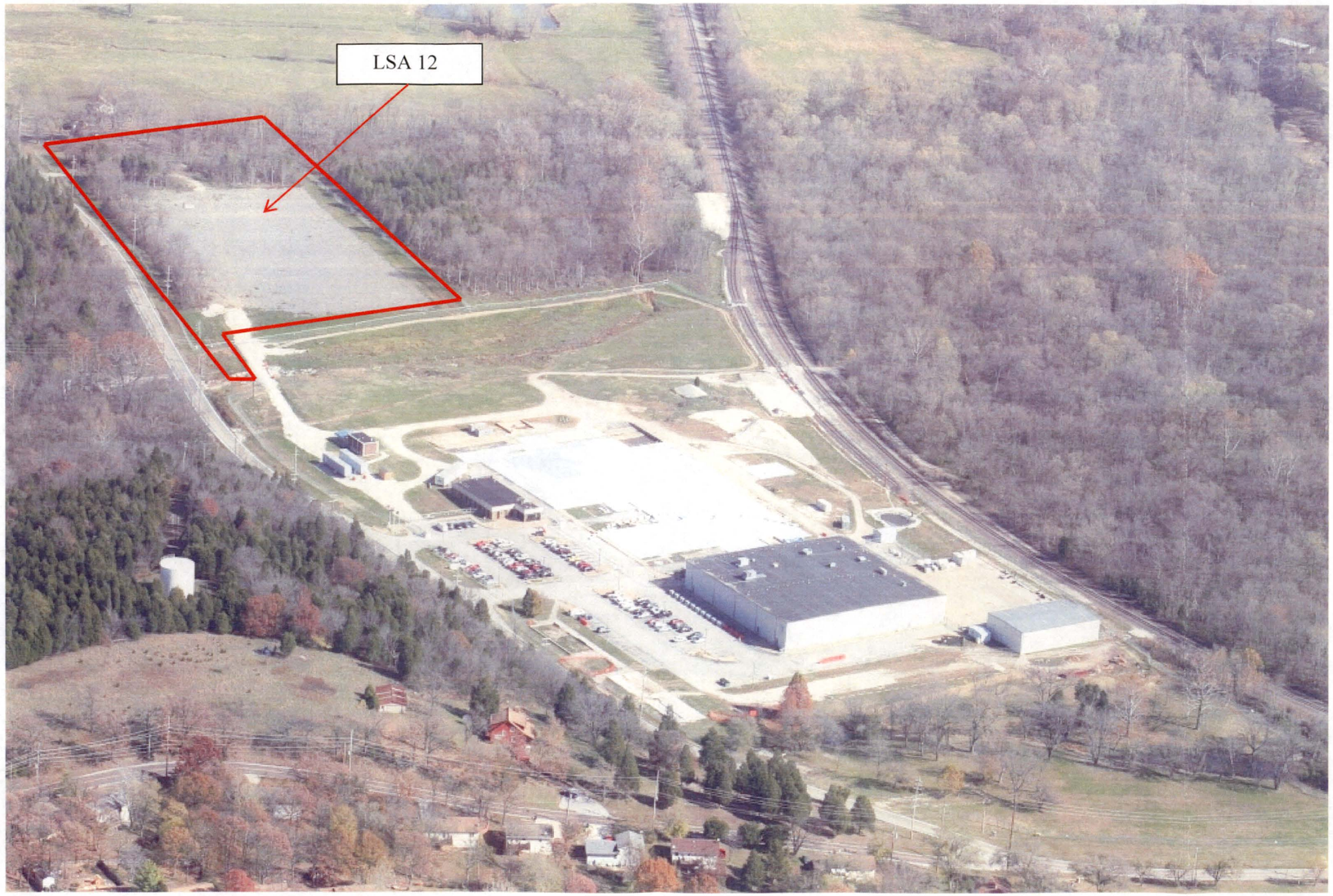
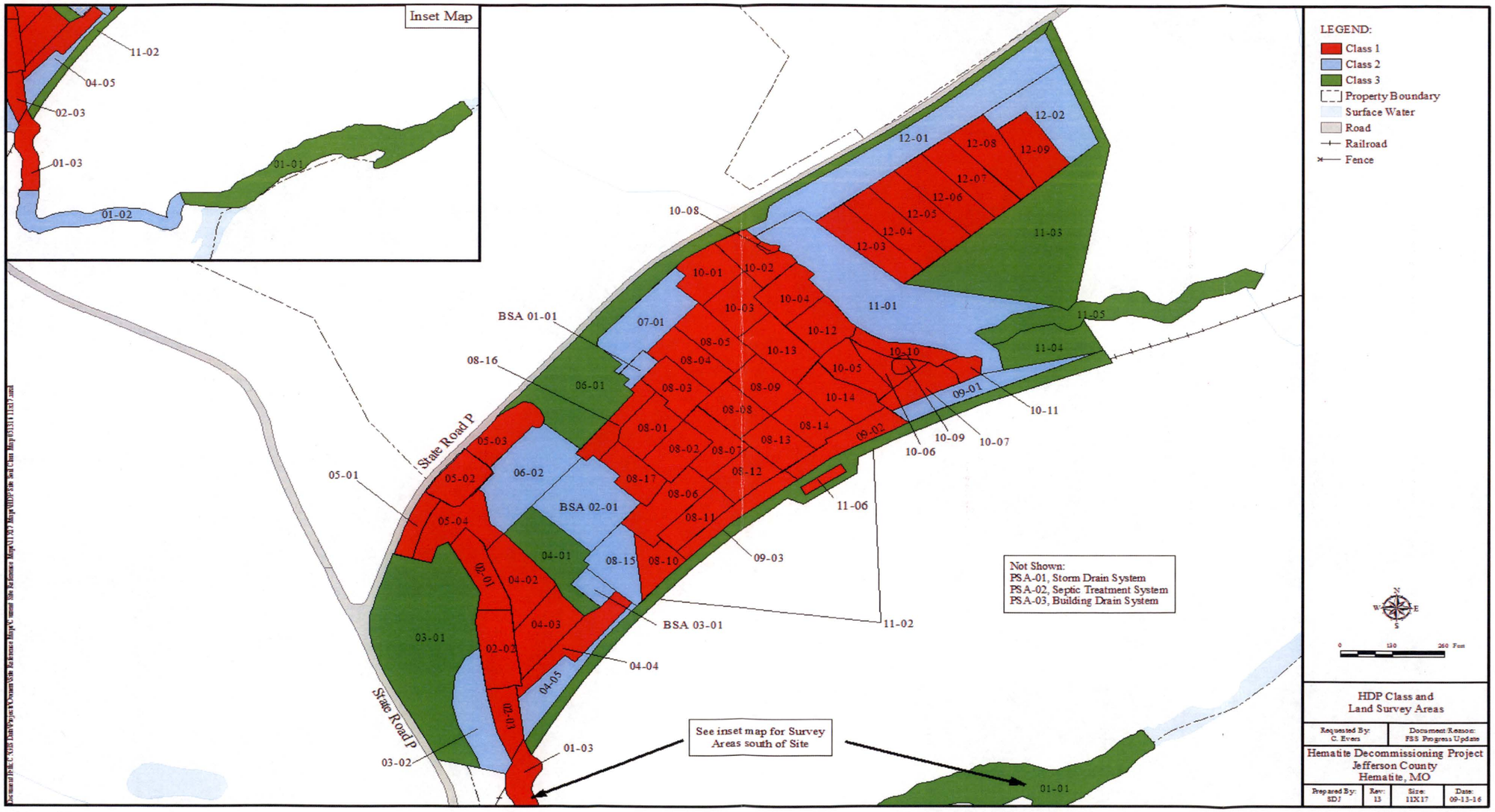


Figure 2-4
Final Configuration of Land Survey Area 12 and Survey Units

Figure 2-5
Final Configuration of Land Survey Areas and Survey Units



3.0 HISTORY OF OPERATIONS

A discussion of site historical operations prior to the decommissioning phase of the HDP is presented in the FSSFR Volume 1, Chapter 1, Section 3.0, *Site Historical Operations*.

A detailed discussion of the historical background information related to the general remediation process is presented in the FSSFR Volume 3, Chapter 1, Section 2.1.1, *Remediation and Excavation*.

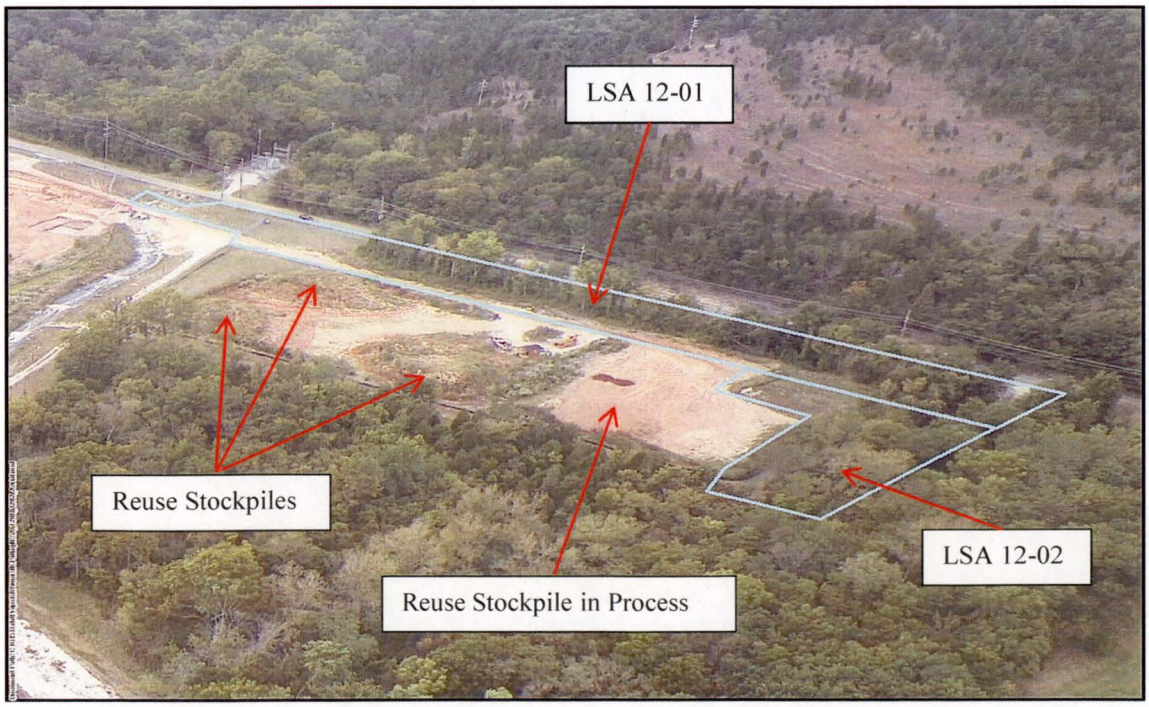
A detailed discussion of the historical background information related to reuse soils is presented in the FSSFR Volume 2, Chapter 1, Section 2.1, *History and Development of the Reuse Soil Stockpiles*.

3.1 Potential Radioactive Materials in LSA 12-01 and LSA 12-02

Potential radioactive materials within LSA 12-01 and LSA 12-02 resulted from placement of potential reuse soil into adjacent Class 1 LSA 12 SUs used for long term reuse soil storage (see Figure 3-1). During the time of reuse soil handling at HDP, reuse soils were transported through the Class 2 LSA's 12-01 and 12-02, in route to the neighboring Class 1 storage areas, and were also used for support activities such as the creation of haul roads, staging of dump trucks, and brush clearing to remove obstacles to site operations.

As no historical site operations ever occurred within this area and all reuse soil was removed from the area, no remedial actions were necessary within LSA 12,. The LSA 12 area only became potentially impacted as a result of the long term storage of reuse material.

Figure 3-1
Reuse Soil Stockpile Operations – 09/2013



3.2 Reuse Soil Disposition and Characterization

Prior to remediation and removal of contaminated soil and other waste materials within the Burial Pit Area and other areas designated to undergo remediation, overburden soils which exhibited characteristics suitable for potential reuse as onsite backfill material were removed, segregated, and subjected to reuse soil criteria requirements.

As LSA 12 was not designated for and did not require remediation there were no reuse soils generated by remediation excavation within the LSA 12 area. However it is noted that during movement of reuse stockpiles during the ISO-Pacific S3 Soil Sorting System sorting operations that a small quantity of the surface of the overburden from the LSA 12 land area was most likely removed and deposited into Reuse Stockpile 9 as a result of the creation of the stockpile. GPS measurements in LSA 12 did not indicate a discernable change in surface elevation.

A detailed discussion of reuse soils, including general description, segregation, surveys, ISO-Pacific S3 sorting technology and operations, and technical requirements may be found in the FSSFR Volume 2, Chapter 1, *Reuse Soil and Off-site Borrow Material Overview* {ML16152A752}.

3.3 Remedial Action Support Surveys (RASS) Phase of LSA 12-01 and LSA 12-02

The sections below provide a discussion of the various elements of the RASS phase of LSA 12-01 and LSA 12-02 necessary to prepare the SUs for FSS.

3.3.1 Remedial Actions

No remedial actions were required to be performed within the LSA 12 area. After all reuse soil was removed from the area, the area was prepared for Final RASS and FSS.

3.3.2 In Process Remedial Action Support Surveys

In process RASS was not required within LSA 12 since no remediation was performed.

3.3.3 Nuclear Criticality Safety (NCS) Borings

NCS Borings were not required within LSA 12 as the area was never subject to NCS controls.

3.3.4 Groundwater Monitoring Wells

A detailed discussion of history, purpose, use, issues, and results of the groundwater monitoring wells at HDP is presented in the FSSFR Volume 6, Chapter 1.

During the history of site operations and remediation there were no groundwater monitoring wells were located within the boundary limits of LSA 12-01. Groundwater monitoring wells BR-04-JC and BR-04-RB were located within LSA 12-02 prior to remediation and remain in place and operable as part of post-remediation groundwater monitoring.

3.3.5 Subterranean Piping

Preliminary remediation planning activities indicated that no subterranean process piping should be encountered in LSA 12-01 and LSA 12-02. During reuse stockpile operations within LSA 12-01 and LSA 12-02 no subterranean process piping was encountered.

As there is no buried piping under the footprint of LSA 12-01 and LSA 12-02 there is no dose contribution to the SUs from this pathway.

3.3.6 Characterization History

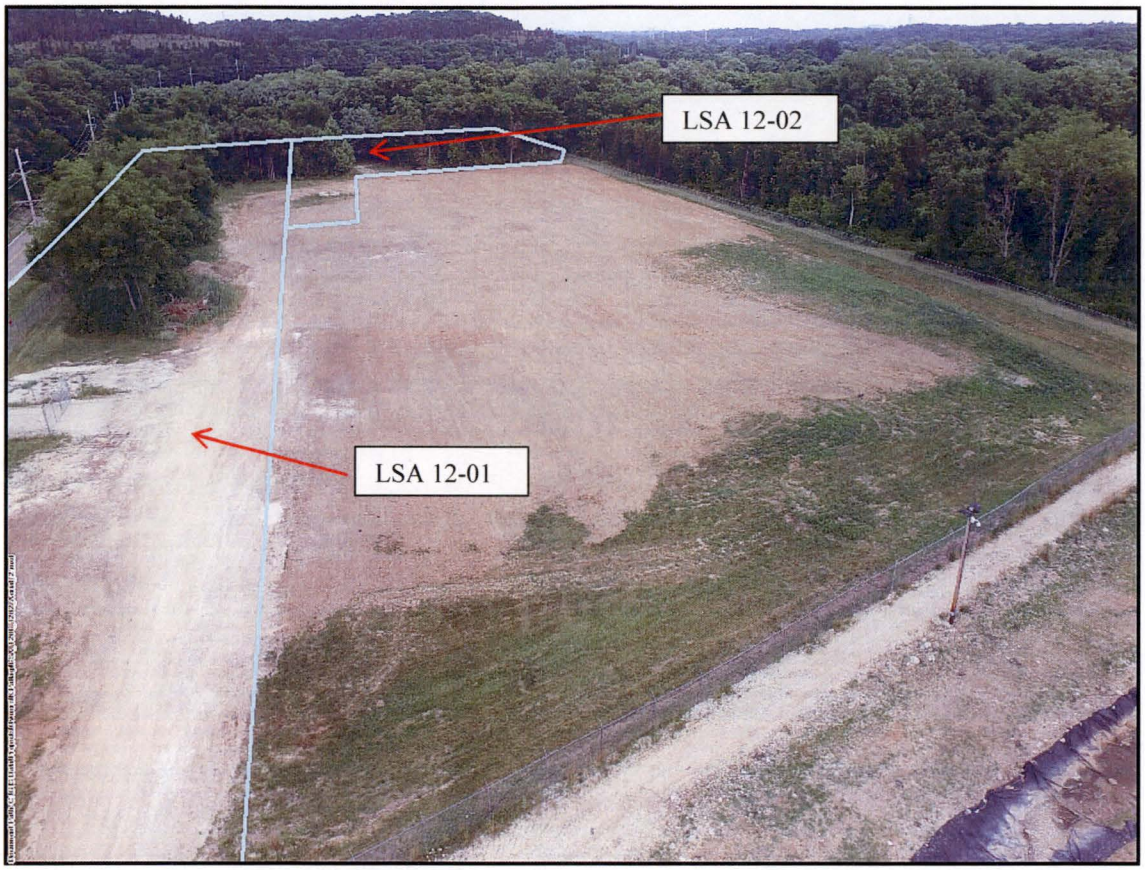
The LSA 12 area was not impacted by historic site operations, was previously covered by a heavily wooded area, and identified as a non-impacted area in the Historical Site Assessment. Brush clearing operations in 2011 removed a majority of the trees and brush from the landscape. During the remediation planning process, this area was identified as a potential reuse soil staging area. The LSA 12 area was considered a radiologically non-impacted area, however it was determined that the area would be potentially impacted by future site operations and therefore the LSA 12 area was identified for FSS purposes in the DP.

As a non-impacted area during site operations there were no characterization core bores performed within the LSA 12 area. FSS Planning was based on the information collected in the Final RASS.

3.3.7 Remedial Action Support Survey for FSS Design

The RASS was conducted within LSA 12, 1) to determine when a SU had been adequately prepared for FSS, and 2) to provide updated estimates of the parameters to be used for planning the FSS. Upon the removal of all reuse soil from the SUs and prior to implementation of FSS activities, a final RASS was performed to validate the status of the SU prior to implementing Isolation and Control (I & C) postings. The I & C posting for both LSA 12-01 and LSA 12-02 was completed on April of 2016. Figure 3-2 is a photograph which shows LSA 12-01 and LSA 12-02 ready for the final RASS.

Figure 3-2
LSA 12-01 and LSA 12-02 Prepared for RASS FSS Design



The RASS included a GWS, systematic surface sample collection based on an eight (8)-point triangular grid, and biased surface sampling. Since LSA 12-01 and LSA 12-02 were immediately adjacent to each other, and were similar, a Final RASS performed over both SU's concurrently. The Final RASS results were used to develop the FSS Plan for each SU. The Final RASS systematic sample results used to develop the FSS sampling grid are summarized in Table 3-1 below:

Table 3-1
Summary of Final RASS Results for LSA 12-01 and LSA 12-02

LSA	Ra-226 (net)		Tc-99		Th-232 (net)		U-234		U-235		U-238	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
12-01 and 12-02	0.00	0.00	0.15	0.34	0.04	0.19	2.27	4.22	0.12	0.23	0.97	1.52
DCGL[3]	1.9		25.1		2.0		195.4		51.6		168.8	

Notes:
1. All units are in picocuries per gram (pCi/g)
2. Results reflect net concentrations after subtraction of background (Ra-226 bkg = 0.9 pCi/g; Th-232 bkg = 1.0 pCi/g).
3. Uniform Stratum DCGLs (From Table 4-1)

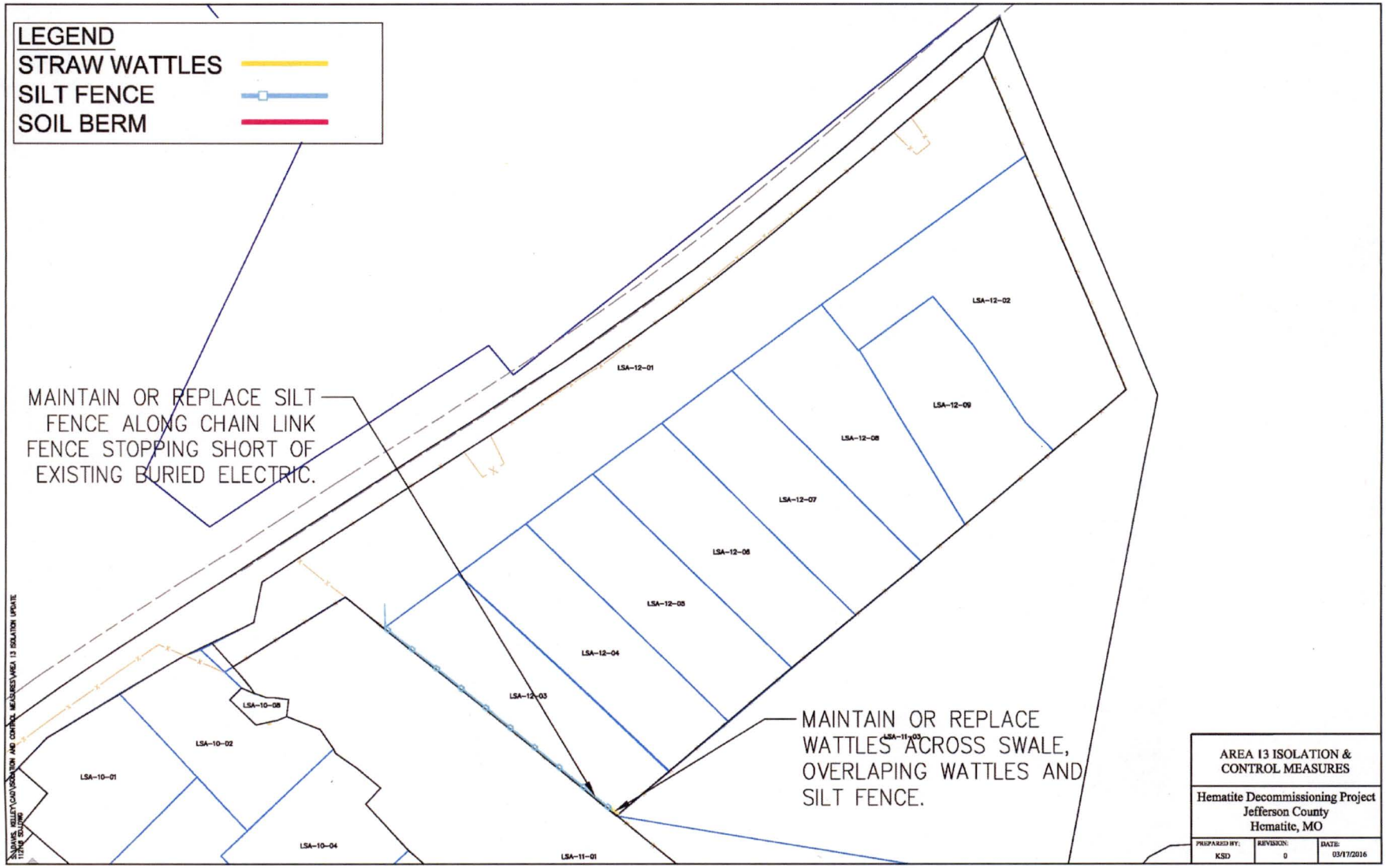
All Final RASS systematic sample and biased sample results were less than the appropriate $DCGL_w$ (Uniform Stratum) and the Final RASS data set was considered sufficient to support FSS design.

3.3.8 Isolation and Control

As directed by HDP-PR-HP-602, *Data Package Development and Isolation and Control Measures to Support Final Status Survey,* in April of 2016, LSA 12-01 and LSA 12-02 were isolated and controlled in accordance with Work Package HDP-WP-ENG-803, *Isolation and Control Measures,* (See Figure 3-3) Isolation and control measures included silt fence and straw wattles between these SUs and the adjacent area to ensure that cross-contamination of these LSAs undergoing FSS did not occur.

The administrative control of multiple postings labeled "Contact Health Physics Prior to Entry" was installed around the entire perimeter of the SUs prior to FSS field activities to prevent inadvertent entry by site personnel. LSA 12-01 and LSA 12-02 are located within the fenced security perimeter of the HDP which therefore prevents access by the general public.

Figure 3-3
Isolation and Control of Area Containing LSA 12-01 and LSA 12-02



3.3.9 Surveillance Following FSS

Following the completion of a FSS, the DP requires continued surveillance to minimize the potential to re-contaminate a SU (e.g., surface water transport of potentially contaminated sediment or a soil pile that was not present during FSS). The surveillance included the routine visual inspection of the integrity of the I & C measures implemented for LSA 12-01 and LSA 12-02. If a SU is suspected of having been re-contaminated then an investigation survey will be performed to reconfirm the FSS survey validity.

During the timeframe since the completion of FSS field activities to the date of completion of all physical work at HDP and project demobilization, LSA 12-01 and LSA 12-02 did not evidence an event that would cause them to be suspect and thus require investigation.

3.3.10 Backfill of Survey Units

No backfill was required for LSA 12-01 and LSA 12-02.

3.3.11 Groundwater Monitoring

In response to NRC RAI Chapter 3-4, during the review and approval process for the DP, Westinghouse documented in letter HEM-11-96 {ML111880290} the revised text of DP Section 14.5.1 to be as follows:

> "*Post-remediation monitoring wells will be sampled quarterly after the completion of remediation until license termination. The data collected will be used to confirm that the sum of the annual dose from groundwater for all the radionuclides does not exceed the EPA Maximum Contaminant Level (MCL) of 4 millirem/year. Separately, the sum of the dose from all residual sources remaining after remediation, including soil and groundwater pathways, will be confirmed to result in an annual dose that does not exceed 25 millirem/year.*"

As stated in the Executive Summary section, the exposure results of this report will be combined with the dose attributed to groundwater to demonstrate that the site has met the requirements for unrestricted release consistent with the requirements of the Title 10 CFR 20 Subpart E, "Criteria for License Termination." As such, for the purpose of this report, groundwater will be assigned a conservative SOF of 0.16 which equates to 4 mrem/yr until such time that the post-remediation groundwater sampling has been completed and reported as part of FSSFR Volume 6, Chapter 7, *Post-remediation Groundwater Monitoring Summary*. The final dose for LSA 12-01 and LSA 12-02 will be reported in FSSFR Volume 7, reflecting the updated results of the post-remediation groundwater monitoring.

4.0 LSA RELEASE CRITERIA

As the release criteria for all LSA SUs is common, FSSFR Volume 3, Chapter 1, Section 3.0, *Release Criteria*, provides a detailed discussion on the release criteria that is applicable to LSA 12-01 and LSA 12-02. Table 4-1 provides the applicable DCGLs.

Table 4-1
Adjusted Soil $DCGL_w$'s by CSM[a]

Radionuclide	Three Layer Approach $DCGL_w$ Values (pCi/g)[b]			Uniform Stratum (pCi/g)
	Surface Stratum	Root Stratum	Excavation Scenario	
Radium-226+C[d]	5.0	2.1	5.4	**1.9**
Technetium-99	151.0	30.1	74.0	**25.1**
Thorium-232+C[d]	4.7	2.0	5.2	**2.0**
Uranium-234	508.5	235.6	872.4	**195.4**
Uranium-235+D[c]	102.3	64.1	208.1	**51.6**
Uranium-238+D[c]	297.6	183.3	551.1	**168.8**

[a] Table as presented in FSSFR Volume 3, Chapter 1.
[b] The reported DCGLw's are the activities for the parent radionuclide 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.

5.0 FINAL STATUS SURVEY DESIGN LSA 12-01

This section of the report describes the method for determining the number of samples required for the FSS of LSA 12-01 as well as summarizing the applicable requirements of the FSS Plan. These include the $DCGL_w$, scan survey coverage, and Investigation Action Levels (IAL). The radiological instrumentation used in the FSS of LSA 12-01 and the detection sensitivities are also discussed.

5.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 12-01 were driven by the type (Open Land) and Class (Class 2) of the survey unit and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

5.1.1 Surrogate Evaluation Areas

A discussion of Surrogate Evaluation Areas is given in the FSSFR Volume 3, Chapter 1, Section 5.0, *Final Status Survey Design.*

5.1.2 $DCGL_w$

During the FSS design process a review was performed of the RASS data for LSA 12-01. The RASS data was used as confirmation that no known areas of residual radioactivity remained within the SU that exceeded the Uniform Stratum $DCGL_w$. Therefore the Uniform Stratum $DCGL_w$ was selected for use in demonstrating compliance with the release criteria.

5.1.3 GWS Coverage

As a Class 2 SU, LSA 12-01 was required to undergo a minimum of a 50% GWS.

5.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 12-01 was the Ludlum 44-10 2" x 2" sodium iodide (NaI) detectors, coupled to a Ludlum 2221 scaler-ratemeter.

5.1.5 Scan Minimum Detectable Concentration (MDC)

Scan MDCs for LSA 12-01 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. As background levels were approximately 9,000 counts per minute (cpm) within LSA 12-01, the scan minimal detection concentration (MDC) calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3471\,pCi/g}\right)+\left(\frac{f_{U-235}}{2.2pCi/g}\right)+\left(\frac{f_{U-238}}{29.0pCi/g}\right)\right)}$$

Equation 5-1

To determine isotopic Uranium fractions HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* assumes that the average LSA enrichment is 4% or less. Based on the systematically collected RASS samples in LSA 12-01, the average enrichment for the SU was 2.0%. All other Scan MDC parameters agreed upon between Westinghouse and the NRC were applied (e.g. use of a 2 in air gap, scan rate of 1 ft/sec, 0.75 surveyor efficiency), therefore no subsequent changes to the calculated Scan MDCs were required to be made.

Prospectively calculated scan MDCs for 2" x 2" NaI detectors that were used in LSA 12-01 are shown below:

Table 5-1
Scan MDCs for 2" x 2" NaI detector, 9,000 cpm background: LSA 12-01

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 12-01	38.8	50.9	1.14	2.8	0.82	3.0

*$DCGL_w$ includes background concentrations of 0.9 pCi/g for Ra-226 (no ingrowth) and 1.0 pCi/g for Th-232. DCGLw values are based on the Uniform Stratum release criteria.

The values in Table 5-1 reflect those presented in the FSS Plans prepared for the SU prior to FSS.

5.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum $DCGL_w$ 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 20 I 5. The IAL used during the GWS of LSA 12-01 was established at 1,624 net counts per minute (ncpm). This value is equivalent to the $DCGL_w$ for Uniform soil assuming a 4% Uranium enrichment, and using the inferred values for Tc-99 (Inferred Tc-99 values used for prospective scan calculations only).

5.1.7 LSA 12-01 FSS Design Summary

The FSS Plans for LSA 12-01 can be found in Appendix C. Table 5-2 presents an overall FSS design and implementation summary for LSA 12-01.

Table 5-2
FSS Design Summary for LSA 12-01

Gamma Walkover Survey (GWS):		
Scan Coverage	50% exposed soil and rock	
Scan MDC	38.8 pCi/g total Uranium (based on a 9,000 cpm background); 0.82 pCi/g Th-232; 1.14 pCi/g Ra-226*	
Investigation Action Level (IAL)	1,624 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	8	These samples will be taken on a random-start systematic grid.
15 cm – 1.5 m (Root)	8	
> 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 RSO or Radiological Engineering.		
Sidewall Sampling Locations:		
A minimum of one (1) discretionary sidewall sample will be collected based on the following definition of "sidewall": sidewall candidates for sampling must be vertical or near vertical (> 45° angle) and at least 12" in height.		
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).* The Scan MDC for total Uranium reflects a conservative assumption of 4% enrichment. The actual RASS enrichment (2.0%) would result in Scan MDC values slightly less than those calculated for FSS planning purposes.		
**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.		

6.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 12-01

FSS was performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment.*

6.1 Gamma Walkover Survey

6.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 12-01 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS (Digital Global Positioning System) and handheld data logger.

Prior to the first field use of the GWS instrumentation, initial set-ups were performed. Also, daily pre- and post-use source checks were performed for each day that GWS was performed within the SU. Initial set-ups, daily source checks, and control charting were performed according to the requirements of HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey.*

6.1.2 GWS Performance

All GWS measurements on the exposed SU surface collected with the NaI detector(s) were connected to a Trimble DGPS and with a hand-held data logger. The logging frequency in the survey unit was 1 GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

The GWS requirements involved moving the NaI detector in a side-to-side fashion no faster than 1 foot per second while holding the probe as close as possible to the excavation surface (nominally 1", but not to exceed 3"). At the same time, the technician was required to slowly advance, causing the detector to trace out a serpentine path over the excavation surface.

FSS Technicians performing GWS in LSA 12-01 used the 1,624 ncpm IAL as a field guide to know when to slow or pause the GWS for more deliberate investigation. If during the GWS, audible count rates noticeably increase above the general area average (i.e., > minimum detectable count rate), FSS Technicians were required to pause momentarily and observe count rates. If sustained count rates approached the IAL, further focused investigation was conducted within the locally elevated area.

To use the IAL effectively, FSS Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to excavation geometry and relative distance from contaminated materials in nearby remedial excavations, the average background rate (measured at waist level) within the LSA ranged between 9,000 and 10,000 gross counts per minute (gcpm). Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 10,624 to 11,624 gcpm, FSS Technicians slowed or paused the GWS for more careful investigation of the small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

Hard to reach areas, and non-typical areas were surveyed manually as necessary in order to assess the potential for an area of elevated residual activity over 50% of the exposed ground surface.

After the GWS survey was complete, the GPS/GWS data was reviewed by Radiological Engineering and the Health Physics (HP) Technician performing the survey to determine if possible areas of elevated residual activity remained within the SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

6.2 Soil Sampling

6.2.1 Systematic Soil Sampling Summary

Table 6-1 provides a summary of systematic sampling by stratum for LSA 12-01.

Table 6-1
Systematic Sampling Summary by Stratum for LSA 12-01

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
12-01	7,062	8	8	8*	2

*Excavation samples were collected and archived, analysis only required if a overlying Root sample exceeds a 0.5 SOF

6.2.1.1 Systematic Sampling LSA 12-01

Within LSA 12-01, there were 8 systematic locations in which the surface stratum [0 – 15 centimeters (cm)] was sampled in the SU. The underlying root stratum was sampled at all 8 locations. Excavation stratum samples were collected and archived, but were not required to be analyzed since no root stratum sample exceeded a 0.5 Uniform SOF.

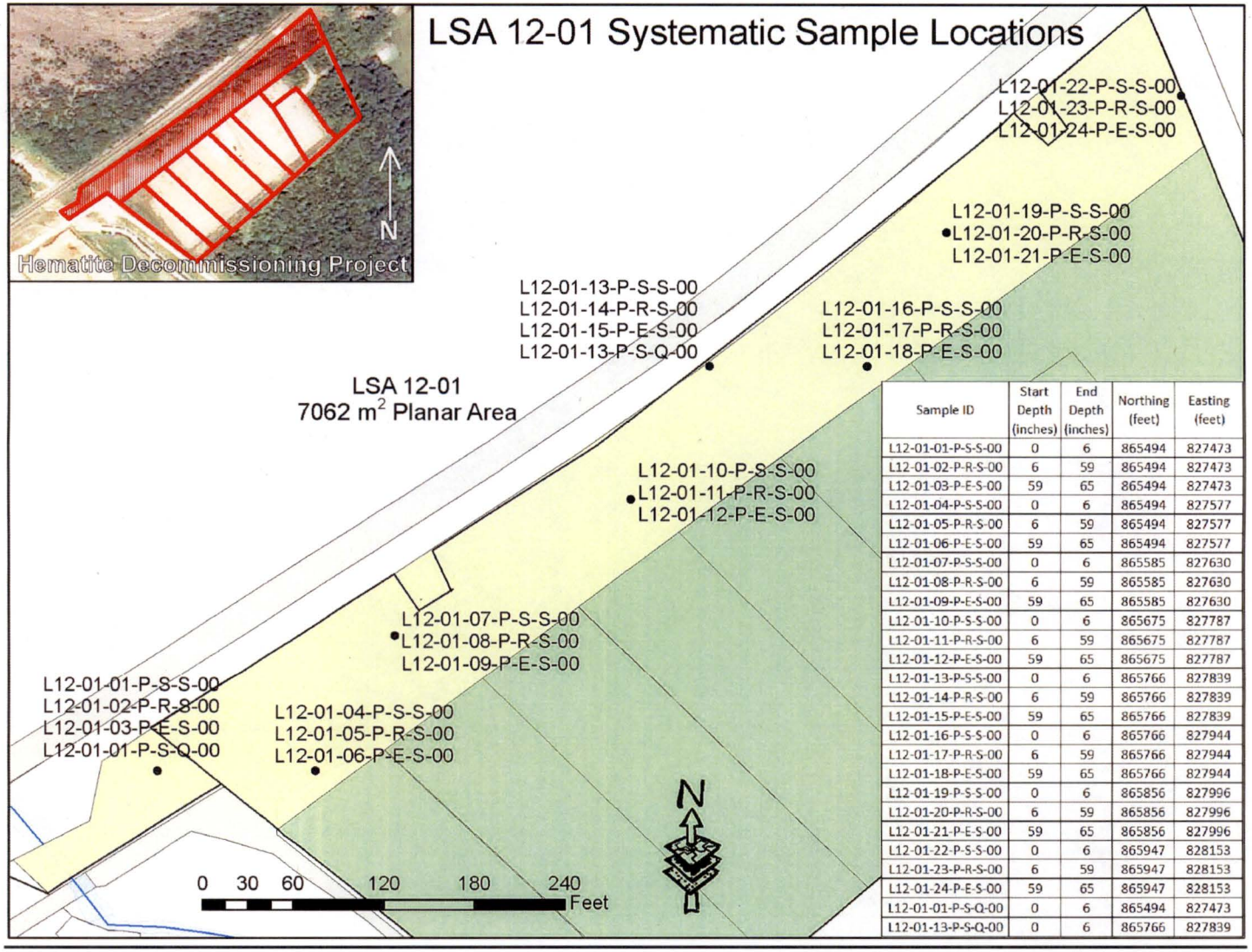
Given a planar area of 7,062 m^2 for LSA 12-01 and an eight - point systematic triangular grid, the point-to-point distance within each row was 27.6 m with spacing of 31.9 m between each of the parallel grid rows within the SU.

While there were eight (8) systematic locations on the LSA 12-01 sampling grid, a total of eighteen (18) samples were collected and analyzed at these locations, including:

- Eight (8) samples collected and analyzed within the surface stratum
- Eight (8) samples collected and analyzed within the root stratum
- Zero (0) samples analyzed within the excavation, or "deep"
- Two (2) Quality Control (QC) field replicate

Figure 6-1 presents the map of the eight systematic sample locations which were sampled within LSA 12-01. The inset table notes the location coordinates (Missouri East, North American Datum (NAD) 1983) and collection intervals for each systematic location.

Figure 6-1
LSA 12-01 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L12-01-01-P-S-S-00	0	6	865494	827473
L12-01-02-P-R-S-00	6	59	865494	827473
L12-01-03-P-E-S-00	59	65	865494	827473
L12-01-04-P-S-S-00	0	6	865494	827577
L12-01-05-P-R-S-00	6	59	865494	827577
L12-01-06-P-E-S-00	59	65	865494	827577
L12-01-07-P-S-S-00	0	6	865585	827630
L12-01-08-P-R-S-00	6	59	865585	827630
L12-01-09-P-E-S-00	59	65	865585	827630
L12-01-10-P-S-S-00	0	6	865675	827787
L12-01-11-P-R-S-00	6	59	865675	827787
L12-01-12-P-E-S-00	59	65	865675	827787
L12-01-13-P-S-S-00	0	6	865766	827839
L12-01-14-P-R-S-00	6	59	865766	827839
L12-01-15-P-E-S-00	59	65	865766	827839
L12-01-16-P-S-S-00	0	6	865766	827944
L12-01-17-P-R-S-00	6	59	865766	827944
L12-01-18-P-E-S-00	59	65	865766	827944
L12-01-19-P-S-S-00	0	6	865856	827996
L12-01-20-P-R-S-00	6	59	865856	827996
L12-01-21-P-E-S-00	59	65	865856	827996
L12-01-22-P-S-S-00	0	6	865947	828153
L12-01-23-P-R-S-00	6	59	865947	828153
L12-01-24-P-E-S-00	59	65	865947	828153
L12-01-01-P-S-Q-00	0	6	865494	827473
L12-01-13-P-S-Q-00	0	6	865766	827839

Figure 6-2 below presents a tabular listing of all FSS samples collected within LSA 12-01 with associated IDs, sample types, collection intervals, coordinates, and notes.

Figure 6-2
FSS Sample Locations and Coordinates for LSA 12-01

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
		Revision: 10	Appendix P-4, Page 1 of 1

APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA

Survey Unit: 01 **Description:** Class 2 Laydown Land Area in "Area 13"

Survey Type: FSS **Classification:** Class 2

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L12-01-01-P-S-S-00	Uniform	S	428.0	427.5	865494	827473	Surface 6-inch grab
L12-01-02-P-R-S-00	Uniform	S	427.5	423.1	865494	827473	Root 59-inch composite
L12-01-04-P-S-S-00	Uniform	S	429.9	429.4	865494	827577	Surface 6-inch grab
L12-01-05-P-R-S-00	Uniform	S	429.4	424.9	865494	827577	Root 59-inch composite
L12-01-07-P-S-S-00	Uniform	S	434.4	433.9	865585	827630	Surface 6-inch grab
L12-01-08-P-R-S-00	Uniform	S	433.9	429.5	865585	827630	Root 59-inch composite
L12-01-10-P-S-S-00	Uniform	S	433.6	433.1	865675	827787	Surface 6-inch grab
L12-01-11-P-R-S-00	Uniform	S	433.1	428.7	865675	827787	Root 59-inch composite
L12-01-13-P-S-S-00	Uniform	S	434.6	434.2	865766	827839	Surface 6-inch grab
L12-01-14-P-R-S-00	Uniform	S	434.2	429.7	865766	827839	Root 59-inch composite
L12-01-16-P-S-S-00	Uniform	S	431.9	431.4	865766	827944	Surface 6-inch grab
L12-01-17-P-R-S-00	Uniform	S	431.4	427.0	865766	827944	Root 59-inch composite
L12-01-19-P-S-S-00	Uniform	S	432.9	432.4	865856	827996	Surface 6-inch grab
L12-01-20-P-R-S-00	Uniform	S	432.4	428.0	865856	827996	Root 59-inch composite
L12-01-22-P-S-S-00	Uniform	S	431.2	430.7	865947	828153	Surface 6-inch grab
L12-01-23-P-R-S-00	Uniform	S	430.7	426.3	865947	828153	Root 59-inch composite
L12-01-01-P-S-Q-00	Uniform	Q	428.0	427.5	865494	827473	Surface 6-inch grab
L12-01-13-P-S-Q-00	Uniform	Q	434.6	434.2	865766	827839	Surface 6-inch grab
L12-01-25-P-S-B-00	Uniform	B	435.0	434.5	865960.1	828106.4	Biased 6-inch grab

Green shaded samples are the samples at each sample location, for use in WRS Test.

*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) or Uniform DCGLs used

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

Quality Record

6.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 12-01 one (1) biased sample location was selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. This biased location represented the maximum GWS measurement encountered within the SU. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

6.4 Judgmental/Sidewall Sampling for Tc-99

As an un-excavated Class 2 SU, no Tc-99 sidewall sampling was necessary for LSA 12-01.

6.5 Quality Control Soil Sampling

Two QC field duplicate sample point were randomly selected and collected at systematic locations L12-01-01 and L12-01-13 for LSA 12-01.

7.0 FINAL STATUS SURVEY RESULTS LSA 12-01

7.1 Gamma Walkover Survey

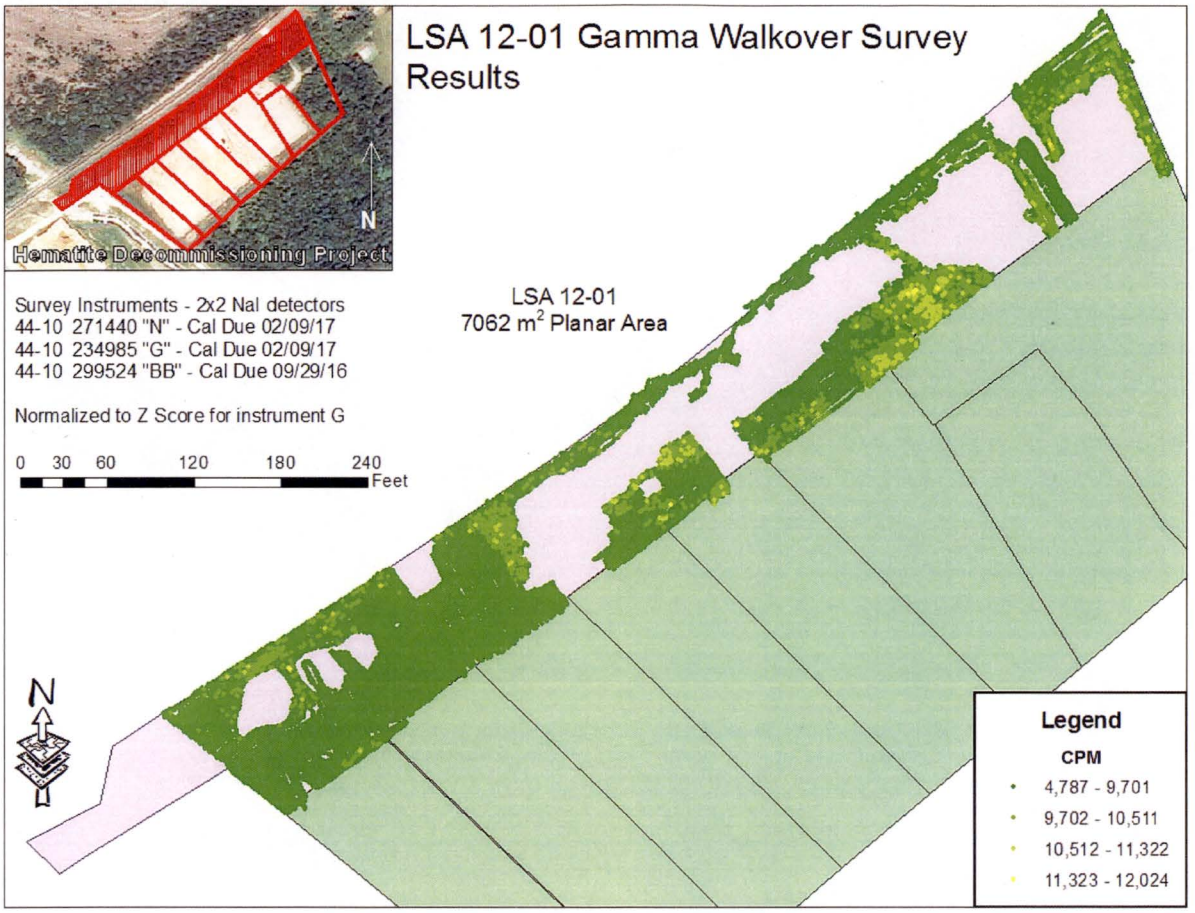
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are plotted "on top" (e.g. if any slopped areas featured more elevated readings than the floor directly below, the sloped area radiological measurements would overlie the lower floor readings).

GWS measurements were collected in LSA 12-01 between May 3, 2016, and May 4, 2016.

7.1.1 GWS Results for LSA 12-01

For LSA 12-01, GWS count rates ranged between 4,787 gcpm and 12,024 gcpm, with a mean count rate of 8,891gcpm. The median count rate was 8,405 gcpm and the standard deviation was 810 cpm. Figure 7-1 below presents a map of the complete GWS data set.

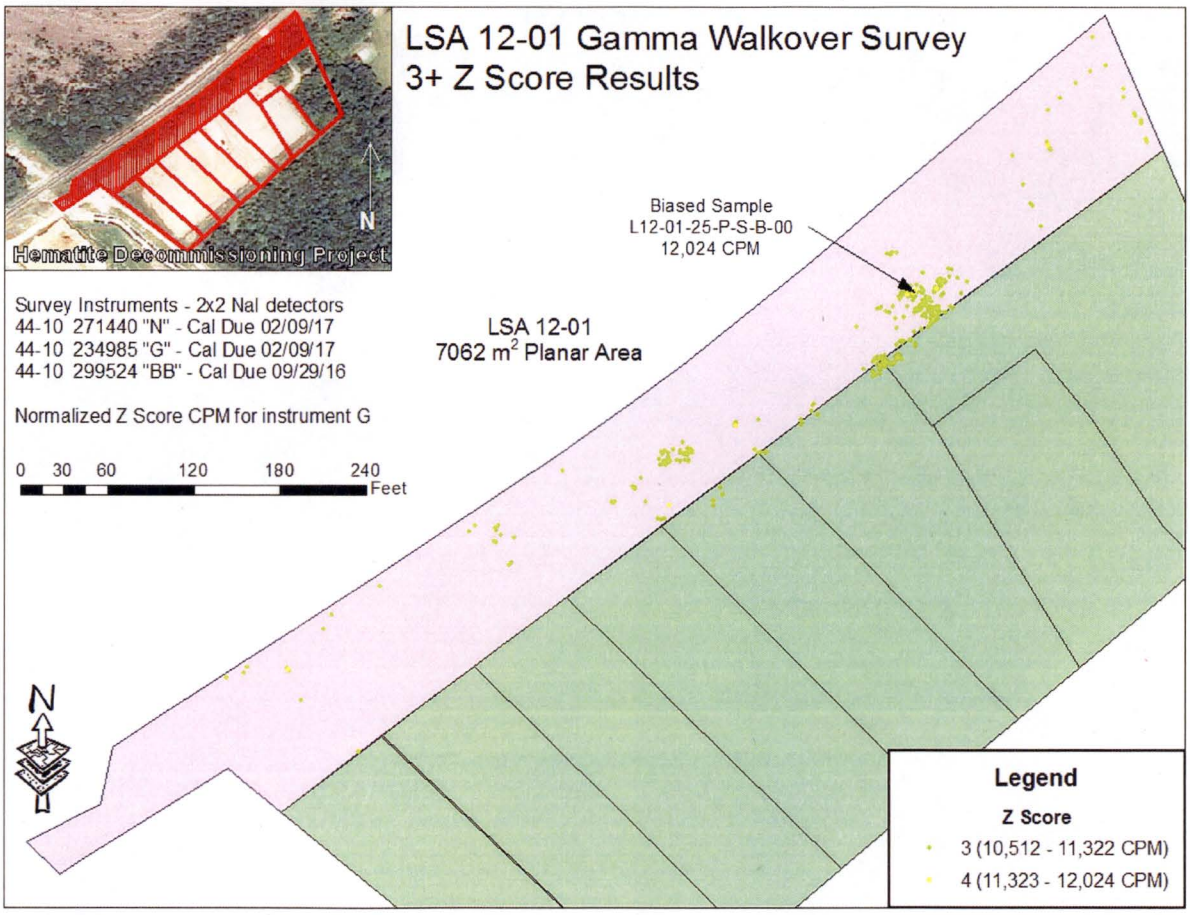
Figure 7-1
Colorimetric GWS Plot for LSA 12-01



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location, L12-01-25, was selected for biased sample collection. This biased location represented the maximum GWS measurement encountered within the SU.

Figure 7-2 below presents a map of the +3 Z-score GWS measurements within LSA 12-01, including the selected biased sampling location (ID: L12-01-25-P-S-B-00).

Figure 7-2
Colorimetric GWS Plot for LSA 12-01 (Measurements > Z-score of 3)



All GWS data collected in LSA 12-01 was datalogged and post-processed in Graphical Information Software (GIS).

7.1.2 GWS Coverage Results LSA 12-01

As a Class 2 SU, LSA 12-01 was required to be subject to a minimum of a 50% GWS in accordance with the FSS plans. The actual FSS GWS achieved 53.7% GWS coverage exceeding the minimum requirement.

7.2 Soil Sample Results LSA 12-01

Appendix A presents the analytical results and associated statistics for all FSS samples collected within LSA 12-01.

7.2.1 Surface Soil Sample Results LSA 12-01

There were eight systematic samples collected within the surface stratum (0 – 15 cm) of LSA 12-01. Additionally there were two QC samples, and one biased sample collected in the surface layer of soil. The maximum Uniform SOF result for the "topmost" samples was 0.04.

7.2.2 Subsurface Soil Sample Results LSA 12-01

There were eight systematic locations within LSA 12-01 where root stratum composite sampling was necessary. The root stratum zone is between 0.15 and 1.50 m below final grade surface. At each of the eight root stratum composite sampling locations, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected and archived, however these excavation samples were not required to be analyzed as no overlying root stratum sample exceeded a 0.5 SOF. The maximum SOF result of the subsurface samples collected in LSA 12-01 was 0.19.

7.2.3 WRS Evaluation

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was not required for LSA 12-01 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was less than one using the Uniform Stratum criteria. However, for illustrative purposes, the WRS evaluation was still performed for LSA 12-01. All systematically collected samples regardless of depth are used to perform the WRS Test, however biased and QC sample results are not utilized in the WRS Test. The 16 systematically collected samples in LSA 12-01 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (1040) was greater than the critical value (860) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix A.

7.2.4 Graphical Data Review LSA 12-01

Table 7-1 below presents summary results for the all systematically collected samples (includes surface, root, and excavation stratum samples (none analyzed in this SU), but not biased or QC samples) collected within LSA 12-01, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.04.

Table 7-1
LSA 12-01 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Uniform DCGL)
Average	0.009	0.115	0.033	1.327	0.023	0.913	**0.04**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.067	-0.133	0.421	0.01
Maximum	0.080	0.664	0.270	3.716	0.204	1.390	0.19

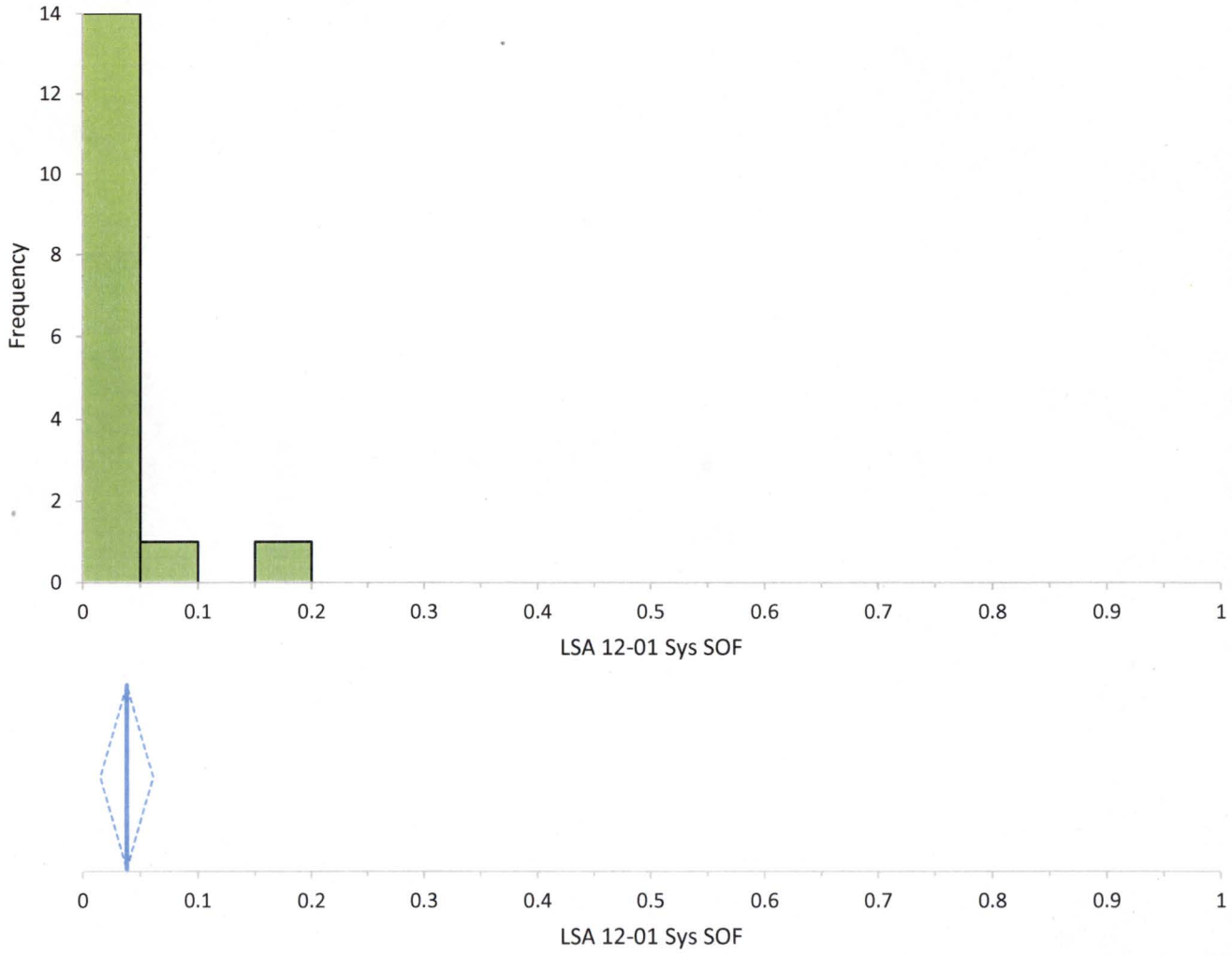
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide concentrations.
3. U-234 values are inferred from the U-235/U-238 ratio.

Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within a certain range of values. The frequency plot will reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution for the survey unit. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 7-3 presents the overall statistical metrics for the SOF parameter for the 16 systematically collected samples from LSA 12-01. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 12-01. The middle graph presents the mean SOF (0.04 as indicated by the blue vertical line) of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.02 to 0.06. The 97.9% confidence interval based on the median (0.03) of the sample results is 0.01 to 0.04. The bottom two charts present the various statistical metrics of the LSA 12-01 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 7-3 exhibits no unusual symmetry or bimodality concerns for the LSA 12-01 data associated with the systematically collected measurement locations.

Figure 7-3
Graphic Statistical Summary for LSA 12-01 (SOF parameter)



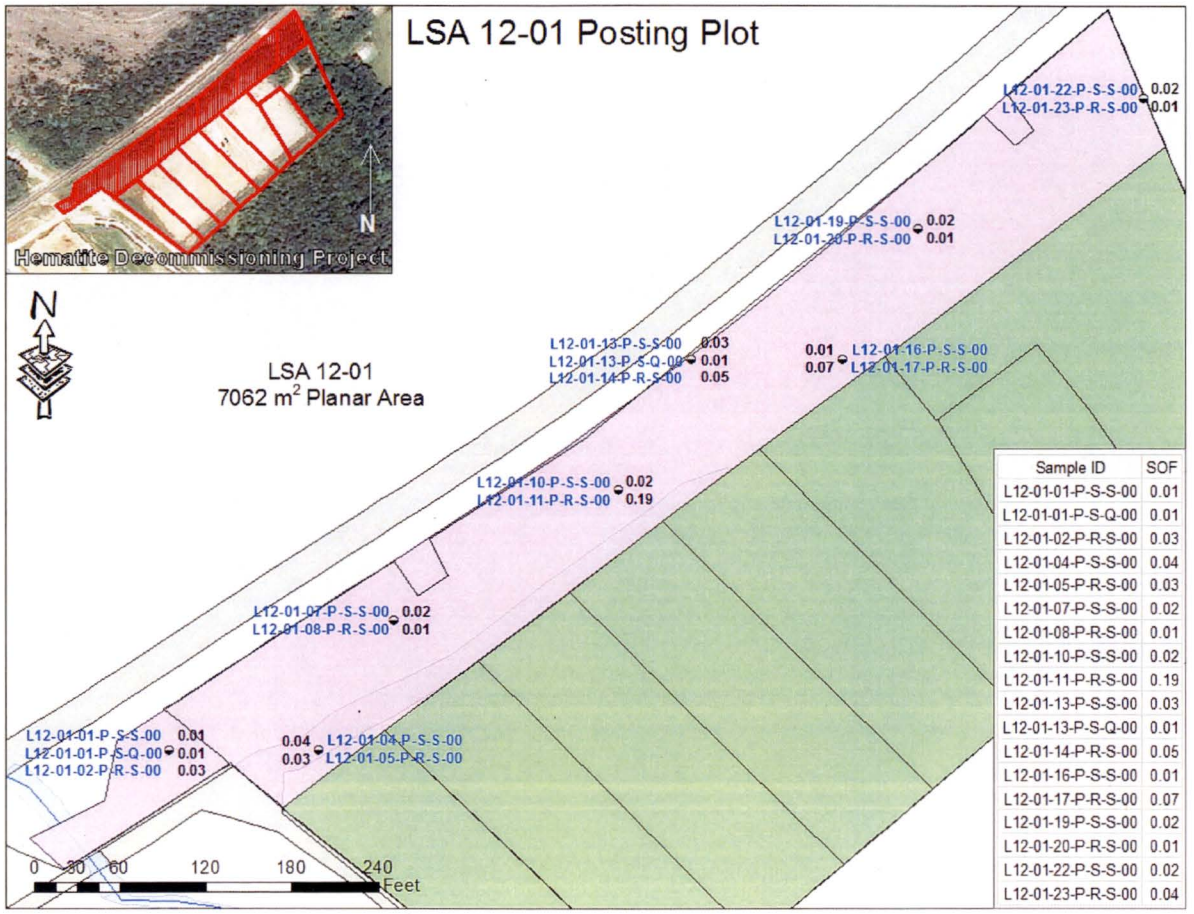
	N
	16

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 12-01 Sys SOF	0.04	0.02	to 0.06	0.011	0.04	0.00	3.1	10.52

	Minimum	1st quartile	Median	97.87% CI		3rd quartile	Maximum	IQR
LSA 12-01 Sys SOF	0.01	0.01	0.03	0.01	to 0.04	0.04	0.2	0.03

A posting plot is simply a map of the survey unit with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 12-01 is presented below in Figure 7-4. Figure 7-4 shows no unusual patterns in the data.

Figure 7-4
Posting Plot for LSA 12-01 Systematic Measurement Locations



Appendix A to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 7-1, Figure 7-3, and Figure 7-4 above. A summary of the analytical data is presented in Table 7-2 below. Appendix E to this report presents the TestAmerica Analytical Laboratory soil sample reports.

Table 7-2
Final Status Survey Analytical Data: LSA 12-01

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			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 (%)	SOF
L12-01-01-P-S-S-00	0.50	S	0.777	0.112	0.0472	N/A	-0.293	0.000	0.156	0.156	0.096	0.227	U	0.72	0.116	0.093	N/A	-0.280	0.000	0.067	NA	NA	NA	0.0015	0.003	0.459	U	0.856	0.391	0.594	N/A	0.1	0.01
L12-01-02-P-R-S-00	4.85	S	0.904	0.129	0.0504	N/A	-0.166	0.000	0.664	0.664	0.084	0.256	N/A	0.85	0.133	0.091	N/A	-0.150	0.000	0.719	NA	NA	NA	-8E-04	0.0048	0.345	U	0.719	0.449	0.706	N/A	0.7	0.03
L12-01-04-P-S-S-00	0.50	S	0.905	0.14	0.0657	N/A	-0.165	0.000	0.278	0.278	0.123	0.228	N/A	0.851	0.149	0.138	N/A	-0.149	0.000	3.054	NA	NA	NA	0.167	0.14	0.185	U	1.01	0.541	0.838	N/A	2.6	0.04
L12-01-05-P-R-S-00	4.85	S	0.993	0.145	0.0709	N/A	-0.077	0.000	0.0074	0.007	0.055	0.246	U	1.03	0.16	0.0969	N/A	0.030	0.030	1.752	NA	NA	NA	0.0942	0.283	0.47	U	0.771	0.277	0.756	N/A	1.9	0.03
L12-01-07-P-S-S-00	0.50	S	0.627	0.118	0.0678	N/A	-0.443	0.000	0.141	0.141	0.041	0.234	U	0.773	0.159	0.0745	N/A	-0.227	0.000	1.110	NA	NA	NA	-0.099	0.146	0.505	U	1.11	0.59	0.742	N/A	0.7	0.02
L12-01-08-P-R-S-00	4.85	S	0.867	0.124	0.0548	N/A	-0.203	0.000	0.0211	0.021	0.079	0.234	U	0.953	0.14	0.103	N/A	-0.047	0.000	1.109	NA	NA	NA	0.055	0.123	0.469	U	0.991	0.49	0.758	N/A	0.9	0.01
L12-01-10-P-S-S-00	0.50	S	0.799	0.133	0.0879	N/A	-0.271	0.000	0.239	0.239	0.066	0.249	U	0.747	0.174	0.109	N/A	-0.253	0.000	0.404	NA	NA	NA	0.0087	0.0134	0.683	U	1.39	0.582	0.865	N/A	0.1	0.02
L12-01-11-P-R-S-00	4.85	S	1.15	0.16	0.0688	N/A	0.080	0.080	0.0255	0.026	0.076	0.231	U	1.27	0.193	0.0902	N/A	0.270	0.270	0.850	NA	NA	NA	-0.044	0.105	0.541	U	0.85	0.346	0.83	N/A	0.7	0.19
L12-01-13-P-S-S-00	0.50	S	0.881	0.144	0.0697	N/A	-0.189	0.000	0.0448	0.045	0.113	0.263	U	0.9	0.169	0.114	N/A	-0.100	0.000	3.716	NA	NA	NA	0.204	0.148	0.202	N/A	1.1	0.741	0.931	N/A	2.9	0.03
L12-01-14-P-R-S-00	4.85	S	1.03	0.153	0.0698	N/A	-0.040	0.000	-0.0303	0.000	0.097	0.276	U	1.07	0.174	0.122	N/A	0.070	0.070	1.495	NA	NA	NA	0.0778	0.225	0.387	U	0.963	0.485	0.741	N/A	1.3	0.05
L12-01-16-P-S-S-00	0.50	S	0.647	0.121	0.0778	N/A	-0.423	0.000	0.215	0.215	0.082	0.259	U	0.762	0.142	0.102	N/A	-0.238	0.000	0.421	NA	NA	NA	-0.133	0.183	0.594	U	0.421	0.236	1.51	U	0.7	0.01
L12-01-17-P-R-S-00	4.85	S	1.13	0.153	0.0641	N/A	0.060	0.060	-0.0352	0.000	0.07	0.251	U	1.07	0.163	0.0721	N/A	0.070	0.070	0.748	NA	NA	NA	-0.113	0.319	0.528	U	0.748	0.292	0.748	N/A	0.7	0.07
L12-01-19-P-S-S-00	0.50	S	0.962	0.171	0.0964	N/A	-0.108	0.000	0.0245	0.025	0.026	0.272	U	0.985	0.189	0.126	N/A	-0.015	0.000	1.751	NA	NA	NA	0.0954	0.326	0.541	U	0.616	0.302	0.867	U	2.4	0.02
L12-01-20-P-R-S-00	4.85	S	0.947	0.132	0.0516	N/A	-0.123	0.000	0.0179	0.018	0.064	0.256	U	0.956	0.162	0.0955	N/A	-0.044	0.000	1.028	NA	NA	NA	0.05	0.148	0.489	U	1.02	0.554	0.738	N/A	0.8	0.01
L12-01-22-P-S-S-00	0.50	S	0.873	0.133	0.0593	N/A	-0.197	0.000	-0.0321	0.000	0.071	0.247	U	1.03	0.184	0.115	N/A	0.030	0.030	0.891	NA	NA	NA	-0.103	0.234	0.409	U	0.891	0.287	0.744	N/A	0.7	0.02
L12-01-23-P-R-S-00	4.85	S	0.944	0.152	0.0885	N/A	-0.126	0.000	-0.0249	0.000	0.043	0.249	U	1.05	0.182	0.104	N/A	0.050	0.050	2.122	NA	NA	NA	0.112	0.214	0.531	U	1.15	0.573	0.882	N/A	1.5	0.04
L12-01-01-P-S-Q-00	0.50	Q	0.789	0.127	0.0567	N/A	-0.281	0.000	0.241	0.241	0.064	0.241	N/A	0.695	0.145	0.111	N/A	-0.305	0.000	0.420	NA	NA	NA	-0.007	0.0092	0.494	U	0.42	0.256	0.713	U	0.7	0.01
L12-01-13-P-S-Q-00	0.50	Q	0.926	0.125	0.0484	N/A	-0.144	0.000	-0.0027	0.000	0.019	0.268	U	0.789	0.131	0.0868	N/A	-0.211	0.000	0.844	NA	NA	NA	-0.008	0.0158	0.489	U	0.844	0.275	0.7	N/A	0.7	0.01
L12-01-25-P-S-B-00	0.50	B	0.97	0.145	0.075	N/A	-0.100	0.000	0.172	0.172	0.066	0.21	U	0.782	0.145	0.135	N/A	-0.218	0.000	1.065	NA	NA	NA	0.0518	0.0633	0.627	U	1.04	0.342	0.856	N/A	0.8	0.02
Systematic Minimum			0.000						0.000					0.000						0.067				-0.133				0.421				1.1	0.01
Systematic Maximum			0.080						0.664					0.270						3.716				0.204				1.390				Average Enrichment (%)	0.19
Systematic Mean			0.009						0.115					0.033						1.327				0.023				0.913					0.04
Systematic Median			0.000						0.025					0.000						1.069				0.029				0.927					0.03
Systematic Standard Deviation			0.024						0.175					0.068						0.976				0.102				0.232					0.04
			With ingrowth, use Ra226 bkg =				1.07							Th232 bkg =	1.0																		

NOTES:

Gross results in units of pCi/g.

* Background with ingrowth (1.07 pCi/g) subtracted from gross result.

**Background (1.0 pCi/g) subtracted from gross result.

U Qualifier: Result is less than the sample detection limit.

All uncertainty values are reported at the 2-sigma confidence level.

7.2.5 Biased Soil Sample Result LSA 12-01

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 12-01 one (1) biased sample location was selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. This biased location represented the maximum GWS measurement encountered within the SU. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

7.2.6 Quality Control Soil Sample Result LSA 12-01

Two QC field duplicate sample points were randomly selected for LSA 12-01 which were collected at systematic locations L12-01 -01 and L12-01-13.

For the 17 samples (i.e., 16 systematic + 1 biased) collected within LSA 12-01, two field duplicate samples were collected. This frequency equates to 11.8%, (i.e. 2/17). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated warning limits (see Figure 7-5 below).

Figure 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 12-01 (1 of 2)

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FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.:	LSA 12-01				Survey Unit Description:		Class 2 Laydown Land Area in "Area 13"					
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
			Activity (x_i)	MDC	Activity (x_i)	MDC						
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	Ra-226	0.777	0.0472	0.789	0.0567	0.783	1.9	0.012	0.269	0.403	N
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	Tc-99	0.156	0.227	0.241	0.241	0.199	25.1	NA	3.552	5.321	NA
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	Th-232	0.72	0.093	0.695	0.111	0.708	2.0	0.025	0.283	0.424	N
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	U-234[1]	0.067	N/A	0.420	N/A	0.244	195.4	0.353	27.649	41.425	N
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	U-235	0.00145	0.459	-0.00666	0.494	-0.003	51.6	NA	7.301	10.939	NA
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	U-238	0.856	0.594	0.42	0.713	0.638	168.8	NA	23.885	35.786	NA

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy / [signature]

Reviewed by: W. Van Evers / [signature]

Date: 11-23-16

Date: 11/23/16

Quality Record

Figure 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 12-01 (2 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control	Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.: LSA 12-01 — Survey Unit Description: Class 2 Laydown Land Area in "Area 13"

Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	Ra-226	0.881	0.0697	0.926	0.0484	0.904	1.9	0.045	0.269	0.403	N
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	Tc-99	0.0448	0.263	-0.00268	0.268	0.021	25.1	NA	3.552	5.321	NA
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	Th-232	0.9	0.114	0.789	0.0868	0.845	2.0	0.111	0.283	0.424	N
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	U-234[1]	3.716	N/A	0.844	N/A	2.280	195.4	2.872	27.649	41.425	N
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	U-235	0.204	0.202	-0.00837	0.489	0.098	51.6	NA	7.301	10.939	NA
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	U-238	1.1	0.931	0.844	0.7	0.972	168.8	0.256	23.885	35.786	N

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy / [illegible] Date: 11-23-16

Reviewed by: W. Clark Eves / W. Clark Eves Date: 11/23/16

Quality Record

7.3 Tc-99 Hot Spot Assessment LSA 12-01

A review of the available data shows that as a Class 2 LSA SU there is no history of a Tc-99 sample result ever exceeding the Tc-99 Uniform $DCGL_w$. The highest Tc-99 sample result collected from both Final RASS and FSS was 0.66 pCi/g.

8.0 ALARA EVALUATION LSA 12-01

All samples collected within LSA 12-01 were evaluated against the Uniform Stratum $DCGL_w$. For LSA 12-01 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.04 for LSA 12-01. The average SOF equates to residual activity contributions from the survey unit area of 1.0 mrem/yr for LSA 12-01. Groundwater Monitoring Well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528} and Chapter 4 {ML16342B552}, indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/yr based upon the U.S. Environmental Protection Agency (EPA) MCLs will be added to the total estimated dose for LSA 12-01. Adding these dose contributions together, the total estimated dose for LSA 12-01 is 5 mrem/yr.

Since the estimated Total Effective Dose Equivalent is well below the regulatory release criterion of 25 mrem/yr, the conclusion of the ALARA evaluation is that the FSS of LSA 12-01 was successful and that there would be no discernable benefit to the health and safety of the public in attempting to further reduce the results of FSS by performing remediation of LSA 12-01.

9.0 FSS PLAN DEVIATIONS LSA 12-01

9.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 12-01.

9.2 Adjustments to Scan MDC Calculations

As previously stated in Section 5.1.5, Scan MDCs for LSA 12-01 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD-FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. The assumed LSA background count rate of 9,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 8,891 cpm. Therefore the calculated Scan MDCs are conservative, and no adjustments need to be made.

10.0 DATA QUALITY ASSESSMENT

The Data Quality Objective (DQO) process is thoroughly integrated within the DP and Hematite FSS procedures. The steps of the DQO process are presented in Volume 3, Chapter 1, Section 4.0 of the FSSFR and correspond to the DQO steps described in Chapter 14, Section 4.2.1 of the DP. The HDP DQO process reflects the recommendations given in MARSSIM, Chapter 2, Figure 2-2.

10.1 Data Quality Assessment for LSA 12-01

The Data Quality Assessment of the survey methodology, sampling and sample analysis results, and the Quality Control sampling and analysis results to ascertain the validity of the conclusion for LSA 12-01 (see Figure 10-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment.*
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody.*
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control.*
- LSA 12-01 survey and sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721 *Final Status Survey Data Validation.*
- The WRS Test is not necessary when the difference between the maximum survey unit data set measurement SOF and the minimum background area measurement SOF is less than or equal to one. For LSA 12-01, no individual gross SOF result in the FSS data set exceeded the SOF of the minimum background reference area measurement by more than one using the Uniform Stratum criteria. Therefore, the WRS Test was not required for LSA 12-01. However, the WRS Test was still performed for illustrative purposes. Since the test statistic, WR (1040) exceeded the critical value (860), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix A.

- A biased soil sample was collected from the location of the highest gamma count rate within the SU, and the result was a 0.02 Uniform SOF.
- The maximum SOF result for all surface samples within LSA 12-01 was 0.04. The maximum SOF result for all subsurface samples within LSA 12-01 was 0.19. The average SOF result for all systematically collected samples within LSA 12-01 was 0.04, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.06.
- No FSS sample result in LSA 12-01 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an elevated measurement comparisons (EMC) or supplemental investigations was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (8) of systematic samples actually collected within LSA 12-01. The successful result of the retrospective power evaluation presented in Table 10-1 for LSA 12-01 indicates that the minimum number of samples required (8) for the WRS Test were equal to the number of sampling locations actually collected within LSA 12-01. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight topmost excavation surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.
- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures were performed periodically, and confirmed that there were no instances of potential cross contamination from weather events until the FSS of all remaining areas at HDP were completed.

Table 10-1
Retrospective Sample Size Verification for LSA 12-01

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.04
$DCGL_{SOF}$	1
LBGR (Mean)	0.04
Shift	0.96
Relative Shift (Δ/σ)	22.33
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS 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

Figure 10-1
Data Evaluation Checklists prepared for LSA 12-01 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
		Revision: 10	Appendix G-1, Page 1 of 2

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA
Survey Unit: 01 **Description:** Class 2 Laydown Land Area in "Area 13"

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FSS been individually reviewed and validated in accordance with Section 8.1 of this procedure?	Yes ☒	No ☐	
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
3.	Have all scans surveys been performed of the areas specified as required in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
4.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FSSP & the FSS Sample Instructions?	Yes ☒	No ☐	NA ☐
5.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☒	No ☐	NA ☐
6.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the appropriate investigation level?	Yes ☒	No ☐	
7.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use and were those calibrations performed using a NIST traceable source?	Yes ☒	No ☐	
8.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☒	No ☐	
9.	Do the samples match those identified on the chain of custody?	Yes ☒	No ☐	NA ☐
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒	No ☐	
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	

If "No" was the response to any of the questions above, then document the discrepancy as well as any corrective actions that were taken to resolve the discrepancy.

Comments: N/A

Quality Record

Figure 10-1
Data Evaluation Checklists prepared for LSA 12-01 (page 2 of 2)

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA
Survey Unit: 01 **Description:** Class 2 Laydown Land Area in "Area 13"

Discrepancy: N/A

Corrective Actions Taken: N/A

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐ NA ☒
    a. If "No", then forward this form to the RSO.
12. The following questions will be answered by the RSO.
    a. If the answer to question 11 was "No", then is the affected data still valid? Yes ☐ No ☐ NA ☒
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ NA ☒
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

Prepared by (HP Staff):	Thomas Yardley (Print Name)	(Signature)	11-23-16 (Date)
Approved by (RSO):	W. Mark Ensey (Print Name)	W. Ensey (Signature)	11/23/16 (Date)

Quality Record

11.0 CONCLUSION LSA 12-01

An adequate quantity and quality of radiological surveys and samples, as well as the corresponding laboratory analysis has been performed, evaluated and documented to demonstrate that the dose associated with all sources within SU LSA 12-01 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402.

Table 11-1
LSA 12-01 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.04	N/A	0.16	N/A	N/A	**0.20**
DOSE	1.0 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**5.0 mrem/year**

12.0 FINAL STATUS SURVEY DESIGN LSA 12-02

This section describes the method for determining the number of samples required for the FSS of LSA 12-02 as well as summarizing the applicable requirements of the FSS Plan. These include the $DCGL_w$, scan survey coverage, and IAL. The radiological instrumentation used in the FSS of LSA 12-02 and their detection sensitivities are also discussed.

12.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 12-02 were driven by the type (Open Land) and Class (Class 2) of the survey unit and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

12.1.1 Surrogate Evaluation Areas

A discussion of Surrogate Evaluation Areas is given in the FSSFR Volume 3, Chapter 1, Section 5.0, *Final Status Survey Design.*

12.1.2 $DCGL_w$

During the FSS design process a review was performed of the RASS data for LSA 12-02. The RASS data was used as confirmation that no known areas of residual radioactivity remained within the survey areas that exceeded the Uniform Stratum $DCGL_w$. Therefore the Uniform Stratum $DCGL_w$ was selected for use in demonstrating compliance with the release criteria.

12.1.3 GWS Coverage

As a Class 2 SU, LSA 12-02 was required to undergo a minimum of a 50% GWS.

12.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 12-02 was the Ludlum 44-10 2" x 2" sodium iodide (NaI) detectors, coupled to a Ludlum 2221 scaler-ratemeter.

12.1.5 Scan Minimum Detectable Concentration

Scan MDCs for LSA 12-01 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS).* As background levels were approximately 9,000 counts per minute (cpm) within LSA 12-02, the scan minimal detection concentration (MDC) calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3471\,pCi/g}\right)+\left(\frac{f_{U-235}}{2.2pCi/g}\right)+\left(\frac{f_{U-238}}{29.0pCi/g}\right)\right)}$$

Equation 12-1

To determine isotopic Uranium fractions HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* assumes that the average LSA enrichment is 4% or less. Based on the systematically collected RASS samples in LSA 12-02, the average enrichment for the SU was 1.5%. All other Scan MDC parameters agreed upon between Westinghouse and the NRC were applied (e.g. use of a 2 in air gap, scan rate of 1 ft/sec, 0.75 surveyor efficiency), therefore no subsequent changes to the calculated Scan MDCs need to be made.

Prospectively calculated scan MDCs for 2" x 2" NaI detectors that were used in LSA 12-02 are shown below:

Table 12-1
Scan MDCs for 2" x 2" NaI detector, 9,000 cpm background: LSA 12-02

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 12-02	38.8	50.9	0.82	2.8	1.14	3.0

*$DCGL_w$ includes background concentrations of 0.9 pCi/g for Ra-226 (no ingrowth) and 1.0 pCi/g for Th-232. DCGLw values are based on the Uniform Stratum release criteria.

The values in Table 12-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

12.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum $DCGL_w$ 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 20 I 5. The IAL used during the GWS of LSA 12-01 was established at 1,624 net counts per minute (ncpm). This value is equivalent to the $DCGL_w$ for Uniform soil assuming a 4% Uranium enrichment, and using the inferred values for Tc-99 (Inferred Tc-99 values used for prospective scan calculations only).

12.1.7 LSA 12-02 FSS Design Summary

The FSS Plan for LSA 12-02 can be found in Appendix D. Table 12-2 presents an overall FSS design and implementation summary for LSA 12-02.

Table 12-2
FSS Design Summary for LSA 12-02

Gamma Walkover Survey (GWS):		
Scan Coverage	50% exposed soil and rock	
Scan MDC	38.8 pCi/g total Uranium (based on a 9,000 cpm background); 0.82 pCi/g Th-232; 1.14 pCi/g Ra-226*	
Investigation Action Level (IAL)	1,624 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	8	These samples will be taken on a random-start systematic grid.
15 cm – 1.5 m (Root)	8	
> 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 RSO or Radiological Engineering.		
Sidewall Sampling Locations:		
A minimum of one (1) discretionary sidewall sample will be collected based on the following definition of "sidewall": sidewall candidates for sampling must be vertical or near vertical (> 45° angle) and at least 12" in height.		
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).* The Scan MDC for total Uranium reflects a conservative assumption of 4% enrichment. The actual RASS enrichment (2.0%) would result in Scan MDC values slightly less than those calculated for FSS planning purposes.		
**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.		

13.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 12-02

FSS was performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment.*

13.1 Gamma Walkover Survey

13.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 12-02 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS (Digital Global Positioning System) and handheld data logger.

Prior to the first field use of the GWS instrumentation, initial set-ups were performed. Also, daily pre- and post-use source checks were performed for each day that GWS was performed within the SU. Initial set-ups, daily source checks, and control charting were performed according to the requirements of HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey*.

13.1.2 GWS Performance

All GWS measurements on the exposed SU surface collected with the NaI detector(s) were connected to a Trimble DGPS and with a hand-held data logger. The logging frequency in the SU was one (1) GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

The GWS requirements involved moving the NaI detector in a side-to-side fashion no faster than 1 foot per second while holding the probe as close as possible to the excavation surface (nominally 1", but not to exceed 3"). At the same time, the technician was required to slowly advance, causing the detector to trace out a serpentine path over the excavation surface.

FSS Technicians performing GWS in LSA 12-02 used the 1,624 ncpm IAL as a field guide to know when to slow or pause the GWS for more deliberate investigation. If during the GWS, audible count rates noticeably increase above the general area average (i.e., > minimum detectable count rate), FSS Technicians were required to pause momentarily and observe count rates. If sustained count rates approached the IAL, further focused investigation was conducted within the locally elevated area.

To use the IAL effectively, FSS Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to excavation geometry and relative distance from contaminated materials in nearby remedial excavations, the average background rate (measured at waist level) within the LSA ranged between 9,000 and 10,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 10,624 to 11,624 gcpm, FSS Technicians slowed or paused the GWS for more careful investigation of the small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

Hard to reach areas, and non-typical areas were surveyed manually as necessary in order to assess the potential for an area of elevated residual activity over 50% of the exposed excavation surface.

After the GWS survey was complete, the GPS/GWS data was reviewed by Radiological Engineering and the HP Technician performing the survey to determine if possible areas of elevated residual activity remained within the survey unit that required biased sample

investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

13.2 Soil Sampling

13.2.1 Systematic Soil Sampling Summary

Table 13-1 provides a summary of systematic sampling by stratum for LSA 12-02.

Table 13-1
Systematic Sampling Summary by Stratum for LSA 12-02

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
12-02	3,254	8	8	8*	2

*Excavation samples were collected and archived, analysis only required if a overlying Root sample exceeds a 0.5 SOF

13.2.2 Systematic Sampling LSA 12-02

Within LSA 12-02, there were 8 systematic locations in which the surface stratum [0 – 15 centimeters (cm)] was sampled in the SU. The underlying root stratum was sampled at all 8 locations. Excavation stratum samples were collected and archived, but were not required to be analyzed since no root stratum sample exceeded a 0.5 Uniform SOF.

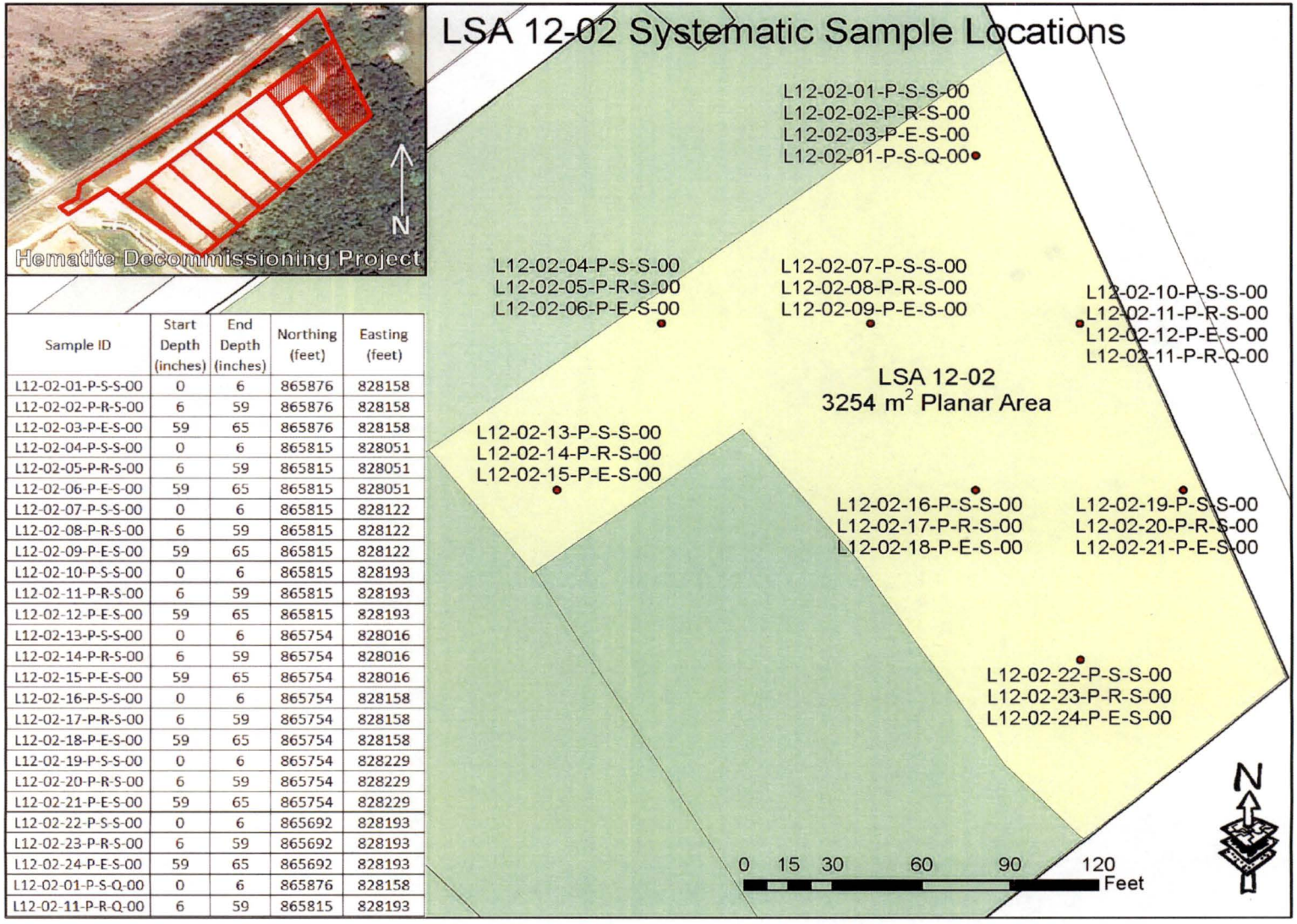
Given a planar area of 7.062 m^2 for LSA 12-02 and an eight - point systematic triangular grid, the point-to-point distance within each row was 27.6 m with spacing of 31.9 m between each of the parallel grid rows within the SU.

While there were eight (8) systematic locations on the LSA 12-02 sampling grid, a total of eighteen (18) samples were collected and analyzed at these locations, including:

- Eight (8) samples collected and analyzed within the surface stratum
- Eight (8) samples collected and analyzed within the root stratum
- Zero (0) samples analyzed within the excavation, or "deep"
- Two (2) Quality Control (QC) field replicate

Figure 13-1 presents the map of the eight systematic sample locations which were sampled within LSA 12-02. The inset table notes the location coordinates (Missouri East, North American Datum (NAD) 1983) and collection intervals for each systematic location.

Figure 13-1
LSA 12-02 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L12-02-01-P-S-S-00	0	6	865876	828158
L12-02-02-P-R-S-00	6	59	865876	828158
L12-02-03-P-E-S-00	59	65	865876	828158
L12-02-04-P-S-S-00	0	6	865815	828051
L12-02-05-P-R-S-00	6	59	865815	828051
L12-02-06-P-E-S-00	59	65	865815	828051
L12-02-07-P-S-S-00	0	6	865815	828122
L12-02-08-P-R-S-00	6	59	865815	828122
L12-02-09-P-E-S-00	59	65	865815	828122
L12-02-10-P-S-S-00	0	6	865815	828193
L12-02-11-P-R-S-00	6	59	865815	828193
L12-02-12-P-E-S-00	59	65	865815	828193
L12-02-13-P-S-S-00	0	6	865754	828016
L12-02-14-P-R-S-00	6	59	865754	828016
L12-02-15-P-E-S-00	59	65	865754	828016
L12-02-16-P-S-S-00	0	6	865754	828158
L12-02-17-P-R-S-00	6	59	865754	828158
L12-02-18-P-E-S-00	59	65	865754	828158
L12-02-19-P-S-S-00	0	6	865754	828229
L12-02-20-P-R-S-00	6	59	865754	828229
L12-02-21-P-E-S-00	59	65	865754	828229
L12-02-22-P-S-S-00	0	6	865692	828193
L12-02-23-P-R-S-00	6	59	865692	828193
L12-02-24-P-E-S-00	59	65	865692	828193
L12-02-01-P-S-Q-00	0	6	865876	828158
L12-02-11-P-R-Q-00	6	59	865815	828193

Figure 13-2 below presents a tabular listing of all FSS samples collected within LSA 12-02 with associated IDs, sample types, collection intervals, coordinates, and notes.

Figure 13-2
FSS Sample Locations and Coordinates for LSA 12-02

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
		Revision: 10	Appendix P-4, Page 1 of 1

APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA

Survey Unit: 02 **Description:** Class 2 Laydown Land Area in "Area 13"

Survey Type: FSS **Classification:** Class 2

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L12-02-01-P-S-S-00	Uniform	S	431.7	431.2	865876	828158	Surface 6-inch grab
L12-02-02-P-R-S-00	Uniform	S	431.2	426.8	865876	828158	Root 59-inch composite
L12-02-04-P-S-S-00	Uniform	S	430.8	430.4	865815	828051	Surface 6-inch grab
L12-02-05-P-R-S-00	Uniform	S	430.4	425.9	865815	828051	Root 59-inch composite
L12-02-07-P-S-S-00	Uniform	S	431.7	431.2	865815	828122	Surface 6-inch grab
L12-02-08-P-R-S-00	Uniform	S	431.2	426.7	865815	828122	Root 59-inch composite
L12-02-10-P-S-S-00	Uniform	S	431.0	430.5	865815	828193	Surface 6-inch grab
L12-02-11-P-R-S-00	Uniform	S	430.5	426.1	865815	828193	Root 59-inch composite
L12-02-13-P-S-S-00	Uniform	S	430.7	430.2	865754	828016	Surface 6-inch grab
L12-02-14-P-R-S-00	Uniform	S	430.2	425.7	865754	828016	Root 59-inch composite
L12-02-16-P-S-S-00	Uniform	S	430.4	429.9	865754	828158	Surface 6-inch grab
L12-02-17-P-R-S-00	Uniform	S	429.9	425.5	865754	828158	Root 59-inch composite
L12-02-19-P-S-S-00	Uniform	S	430.6	430.1	865754	828229	Surface 6-inch grab
L12-02-20-P-R-S-00	Uniform	S	430.1	425.6	865754	828229	Root 59-inch composite
L12-02-22-P-S-S-00	Uniform	S	430.7	430.2	865692	828193	Surface 6-inch grab
L12-02-23-P-R-S-00	Uniform	S	430.2	425.8	865692	828193	Root 59-inch composite
L12-02-01-P-S-Q-00	Uniform	Q	431.7	431.2	865876	828158	Surface 6-inch grab
L12-02-11-P-R-Q-00	Uniform	Q	430.5	426.1	865815	828193	Surface 6-inch grab
L12-02-25-P-S-B-00	Uniform	B	430.7	430.2	865664.5	828226.7	Biased 6-inch grab

Green shaded samples are the samples at each sample location, for use in WRS Test.

*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) or Uniform DCGLs used

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

Quality Record

13.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 12-02 one (1) biased sample location was selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. This biased location represented the maximum GWS measurement encountered within the SU. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

13.4 Judgmental/Sidewall Sampling for Tc-99

As an un-excavated Class 2 SU, no Tc-99 sidewall sampling was necessary for LSA 12-02.

13.5 Quality Control Soil Sampling

Two QC field duplicate sample point were randomly selected and collected at systematic location L12-02-01 and L12-02-11 for LSA 12-02.

14.0 FINAL STATUS SURVEY RESULTS LSA 12-02

14.1 Gamma Walkover Survey

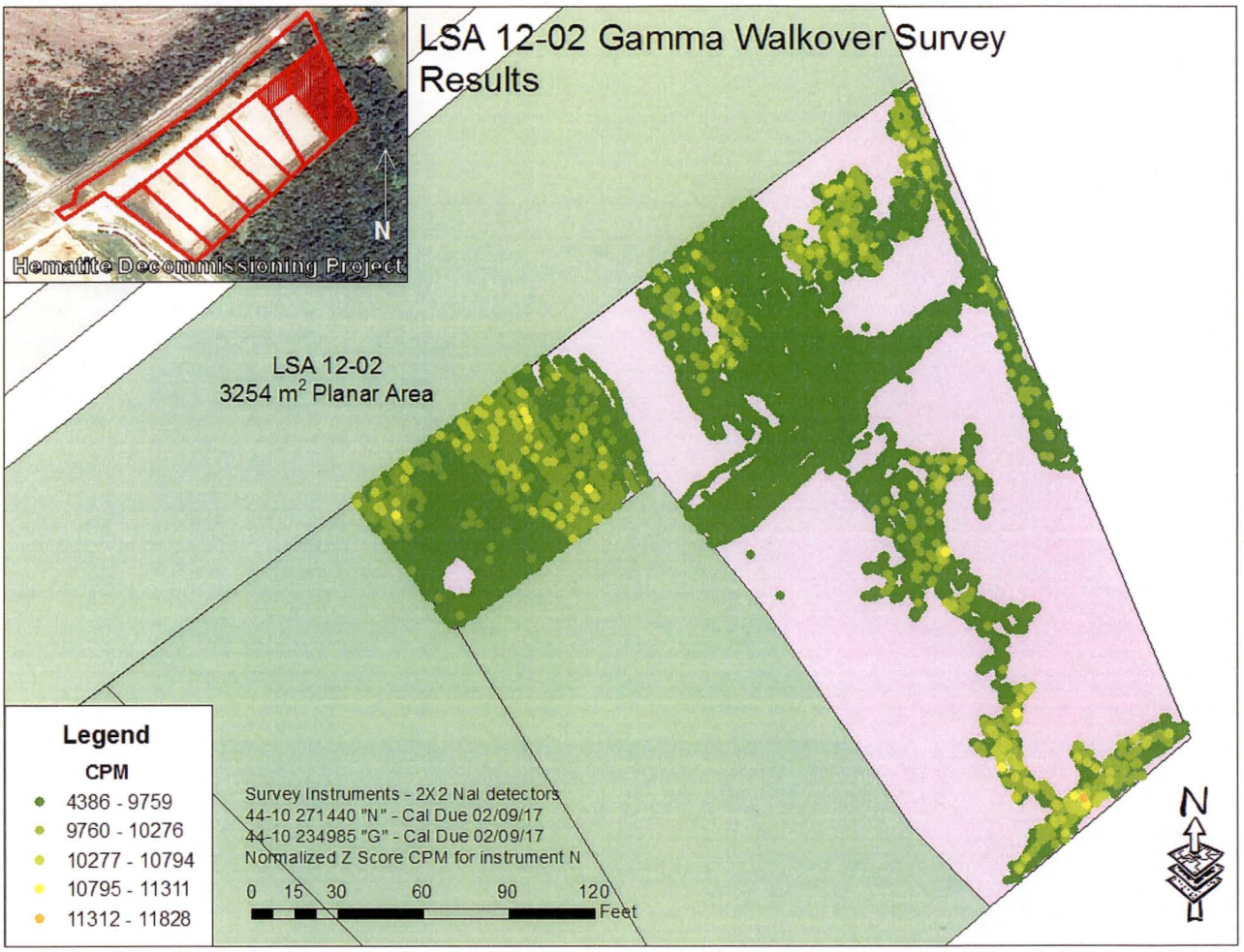
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are plotted "on top"(e.g. if any sloped areas featured more elevated readings than the floor directly below, the sloped area radiological measurements would overlie the lower floor readings).

GWS measurements were collected in LSA 12-02 on March 23, 2015.

14.1.1 GWS Results for LSA 12-02

For LSA 12-02, GWS count rates ranged between 4,386 gcpm and 11,828 gcpm, with a mean count rate of 9,470 gcpm. The median count rate was 8,107 gcpm with a standard deviation of 695 cpm. Figure 14-1 below presents a map of the complete GWS data set.

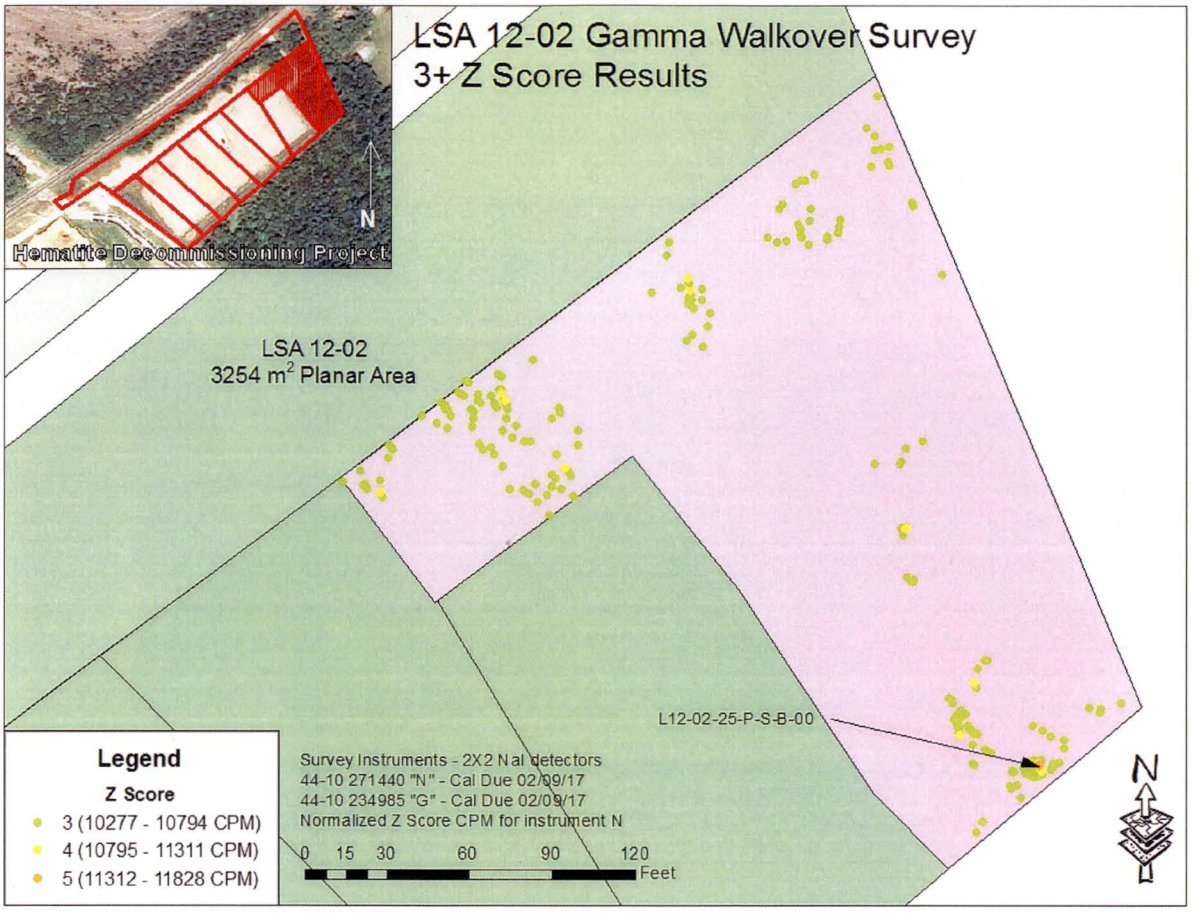
Figure 14-1
Colorimetric GWS Plot for LSA 12-02



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded both the IAL (> 4000 ncpm) and three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location (L12-02-25) was selected for biased sample collection. The sample collected at location L12-02-25 represented the maximum GWS measurement (11,828 gcpm) within the SU.

Figure 14-2 presents a map of the +3 Z-score GWS measurements within LSA 12-02, including the selected biased sampling location.

Figure 14-2
Colorimetric GWS Plot for LSA 12-02 (Measurements > Z-score of 3)



All GWS data collected in LSA 12-02 was datalogged and post-processed in GIS software.

14.1.2 GWS Coverage Results LSA 12-02

As a Class 2 SU, LSA 12-02 was required to be subject to a minimum of a 50% GWS in accordance with the FSS plans. The actual FSS GWS achieved 50.21% GWS coverage exceeding the minimum requirement.

14.2 Soil Sample Results LSA 12-02

Appendix B presents the analytical results and associated statistics for all FSS samples collected within LSA 12-02.

14.2.1 Surface Soil Sample Results LSA 12-02

There were eight systematic samples collected within the surface stratum (0 – 15 cm) of LSA 12-02. Additionally there were two QC samples, and one biased sample collected from the topmost layer of soil. The maximum Uniform SOF result for the "topmost" samples was 0.15.

14.2.2 Subsurface Soil Sample Results LSA 12-02

There were eight systematic locations within LSA 12-02 where root stratum composite sampling was necessary. The root stratum zone is between 0.15 and 1.50 m below final grade surface. At each of the eight root stratum composite sampling locations, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected and archived, however these excavation samples were not required to be analyzed as no overlying root stratum sample exceeded a 0.5 SOF. The maximum SOF result of the subsurface samples collected in LSA 12-02 was 0.30.

14.2.3 WRS Evaluation

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was not required for LSA 12-02 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was less than one using the Uniform Stratum criteria. However, for illustrative purposes, the WRS evaluation was still performed for LSA 12-02. All systematically collected samples regardless of depth are used to perform the WRS Test, however biased and QC sample results are not utilized in the WRS Test. The 16 systematically collected samples in LSA 12-02 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (1040) was greater than the critical value (860) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix B.

14.2.4 Graphical Data Review LSA 12-02

Table 14-1 below presents summary results for the all systematically collected samples (includes surface, root, and excavation stratum samples, but not biased or QC samples) collected within LSA 12-02, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.09.

Table 14-1
LSA 12-02 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Uniform DCGL)
Average	0.025	0.091	0.104	2.319	0.070	1.079	**0.09**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.397	0.00 (NEG)	0.584	0.02
Maximum	0.190	0.355	0.340	7.278	0.402	1.380	0.30

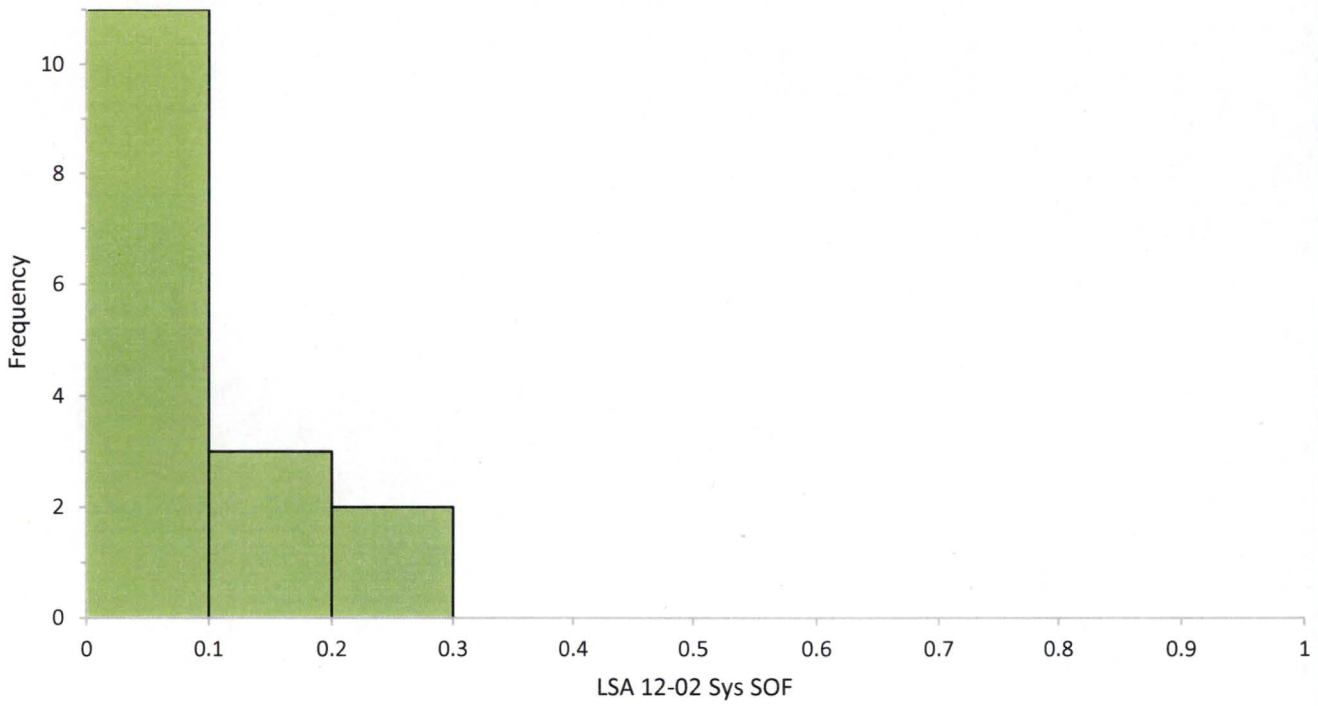
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide concentrations.
3. U-234 values are inferred from the U-235/U-238 ratio.

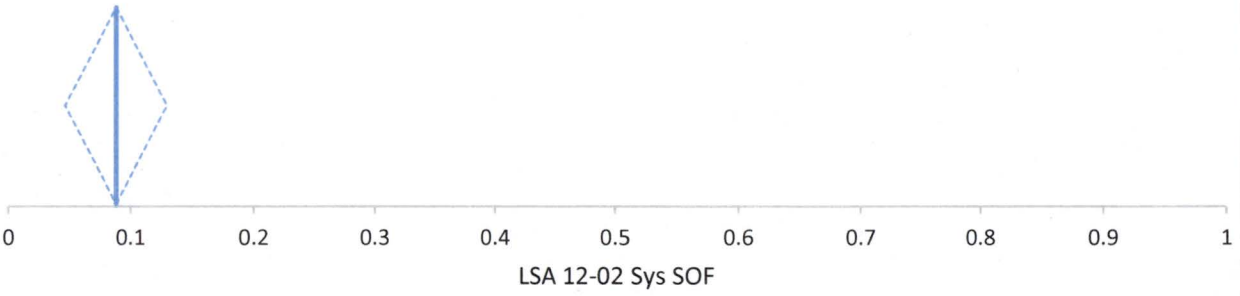
Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within a certain range of values. The frequency plot will reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution for the survey unit. The presence of two peaks in the survey unit frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 14-3 presents the overall statistical metrics for the SOF parameter for the 16 systematically collected samples from LSA 12-02. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 12-02. The middle graph presents the mean SOF (0.09) as indicated by the blue vertical line of the sample population, and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.05 to 0.13. The 97.87% confidence interval based on the median (0.06) of the sample results is 0.03 to 0.13. The bottom two charts present the various statistical metrics of the LSA 12-02 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 14-3 exhibits no unusual symmetry or bimodality concerns for the LSA 12-02 data associated with the systematically collected measurement locations.

Figure 14-3
Graphic Statistical Summary for LSA 12-02 (SOF parameter)





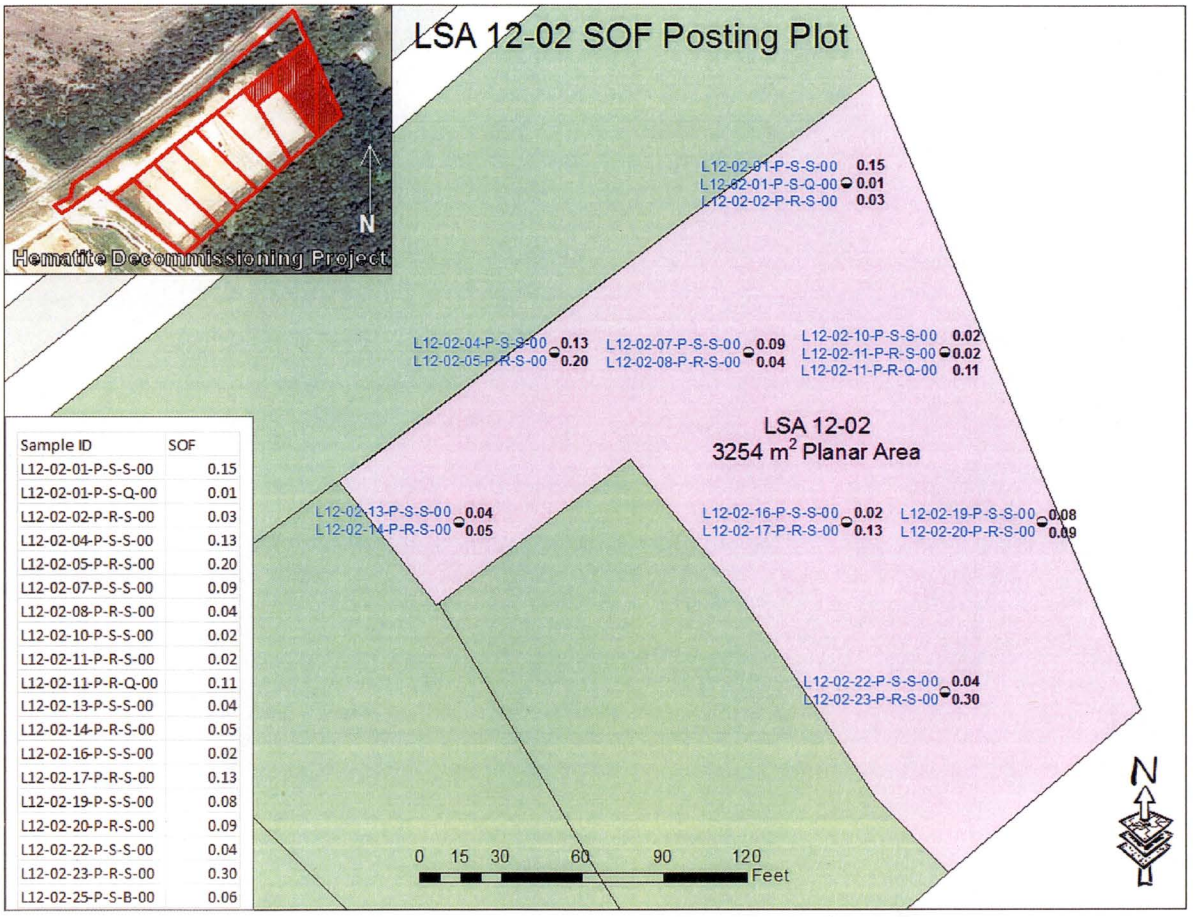
N	16

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 12-02 Sys SOF	0.09	0.05	to 0.13	0.020	0.08	0.01	1.5	2.24

	Minimum	1st quartile	Median	97.87% CI		3rd quartile	Maximum	IQR
LSA 12-02 Sys SOF	0.02	0.03	0.06	0.03	to 0.13	0.13	0.3	0.10

A posting plot is simply a map of the survey unit with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 12-02 is presented below in Figure 14-4. Figure 14-4 shows no unusual patterns in the data.

Figure 14-4
Posting Plot for LSA 12-02 Systematic Measurement Locations



Sample ID	SOF
L12-02-01-P-S-S-00	0.15
L12-02-01-P-S-Q-00	0.01
L12-02-02-P-R-S-00	0.03
L12-02-04-P-S-S-00	0.13
L12-02-05-P-R-S-00	0.20
L12-02-07-P-S-S-00	0.09
L12-02-08-P-R-S-00	0.04
L12-02-10-P-S-S-00	0.02
L12-02-11-P-R-S-00	0.02
L12-02-11-P-R-Q-00	0.11
L12-02-13-P-S-S-00	0.04
L12-02-14-P-R-S-00	0.05
L12-02-16-P-S-S-00	0.02
L12-02-17-P-R-S-00	0.13
L12-02-19-P-S-S-00	0.08
L12-02-20-P-R-S-00	0.09
L12-02-22-P-S-S-00	0.04
L12-02-23-P-R-S-00	0.30
L12-02-25-P-S-B-00	0.06

Appendix B to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 14-1, Figure 14-3, and Figure 14-4 above. A summary of the analytical data is presented in Table 14-2 below. Appendix F to this report presents the Test America Analytical Laboratory soil sample reports.

Table 14-2
Final Status Survey Analytical Data: LSA 12-02

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			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 (%)	SOF
L12-02-01-P-S-S-00	0.00	S	1.1	0.165	0.0801	N/A	0.030	0.030	0.171	0.171	0.079	0.245	U	1.18	0.181	0.155	N/A	0.180	0.180	4.440	NA	NA	NA	0.244	0.157	0.219	N/A	1.23	0.571	0.869	N/A	3.0	0.15
L12-02-02-P-R-S-00	0.50	S	0.856	0.138	0.077	N/A	-0.214	0.000	-0.0381	0.000	0.044	0.254	U	1.05	0.174	0.104	N/A	0.050	0.050	0.397	NA	NA	NA	0.0149	0.229	0.384	U	1.1	0.522	0.794	N/A	0.3	0.03
L12-02-04-P-S-S-00	0.00	S	0.928	0.136	0.0655	N/A	-0.142	0.000	0.355	0.355	0.055	0.232	N/A	1.13	0.173	0.0983	N/A	0.130	0.130	7.278	NA	NA	NA	0.402	0.143	0.22	N/A	1.38	0.563	0.846	N/A	4.4	0.13
L12-02-05-P-R-S-00	0.50	S	1.25	0.187	0.0819	N/A	0.180	0.180	0.0936	0.094	0.079	0.246	U	1.2	0.197	0.0837	N/A	0.200	0.200	0.798	NA	NA	NA	-0.136	0.274	0.681	U	0.798	0.351	0.893	U	0.7	0.20
L12-02-07-P-S-S-00	0.00	S	0.97	0.157	0.0701	N/A	-0.100	0.000	0.0578	0.058	0.061	0.231	U	1.15	0.195	0.131	N/A	0.150	0.150	1.100	NA	NA	NA	-0.13	0.196	0.669	U	1.1	0.553	0.845	N/A	0.7	0.09
L12-02-08-P-R-S-00	0.50	S	1.04	0.143	0.055	N/A	-0.030	0.000	0.0276	0.028	0.095	0.251	U	1.05	0.164	0.121	N/A	0.050	0.050	1.050	NA	NA	NA	-0.101	0.311	0.516	U	1.05	0.511	0.786	N/A	0.7	0.04
L12-02-10-P-S-S-00	0.00	S	0.918	0.141	0.0774	N/A	-0.152	0.000	0.161	0.161	0.14	0.236	U	0.969	0.176	0.108	N/A	-0.031	0.000	1.090	NA	NA	NA	-0.019	0.0379	0.369	U	1.09	0.558	0.856	N/A	0.7	0.02
L12-02-11-P-R-S-00	0.50	S	0.882	0.141	0.0899	N/A	-0.188	0.000	-0.0174	0.000	0.055	0.249	U	0.913	0.157	0.13	N/A	-0.087	0.000	2.724	NA	NA	NA	0.147	0.285	0.605	U	1.18	0.597	0.918	N/A	2.0	0.02
L12-02-13-P-S-S-00	0.00	S	1.06	0.164	0.0875	N/A	-0.010	0.000	0.0692	0.069	0.055	0.238	U	0.976	0.164	0.109	N/A	-0.024	0.000	4.236	NA	NA	NA	0.233	0.148	0.207	N/A	1.14	0.569	0.879	N/A	3.1	0.04
L12-02-14-P-R-S-00	0.50	S	0.958	0.144	0.0716	N/A	-0.112	0.000	0.0152	0.015	0.024	0.253	U	1.07	0.163	0.105	N/A	0.070	0.070	1.323	NA	NA	NA	0.0656	0.182	0.349	U	1.14	0.636	0.825	N/A	0.9	0.05
L12-02-16-P-S-S-00	0.00	S	0.861	0.148	0.0795	N/A	-0.209	0.000	0.231	0.231	0.039	0.251	U	0.932	0.173	0.151	N/A	-0.068	0.000	0.584	NA	NA	NA	-0.01	0.362	0.607	U	0.584	0.302	1.65	U	0.7	0.02
L12-02-17-P-R-S-00	0.50	S	0.902	0.131	0.0633	N/A	-0.168	0.000	0.0246	0.025	0.086	0.246	U	1.24	0.171	0.096	N/A	0.240	0.240	1.190	NA	NA	NA	-0.126	0.588	0.538	U	1.19	0.475	0.707	N/A	0.7	0.13
L12-02-19-P-S-S-00	0.00	S	0.896	0.128	0.0693	N/A	-0.174	0.000	0.138	0.138	0.059	0.255	U	1.1	0.192	0.134	N/A	0.100	0.100	2.240	NA	NA	NA	0.12	0.147	0.193	U	1.06	0.477	0.717	N/A	1.8	0.08
L12-02-20-P-R-S-00	0.50	S	0.897	0.132	0.0588	N/A	-0.173	0.000	0.0299	0.030	0.061	0.25	U	1.15	0.184	0.0991	N/A	0.150	0.150	0.838	NA	NA	NA	-0.012	0.0197	0.34	U	0.838	0.294	0.727	N/A	0.7	0.09
L12-02-22-P-S-S-00	0.00	S	0.88	0.157	0.0935	N/A	-0.190	0.000	0.0743	0.074	0.13	0.248	U	0.945	0.184	0.149	N/A	-0.055	0.000	4.500	NA	NA	NA	0.248	0.167	0.202	N/A	1.12	0.362	0.953	N/A	3.4	0.04
L12-02-23-P-R-S-00	0.50	S	1.26	0.17	0.0751	N/A	0.190	0.190	-0.0336	0.000	0.027	0.24	U	1.34	0.198	0.142	N/A	0.340	0.340	3.317	NA	NA	NA	0.18	0.164	0.203	U	1.27	0.584	0.896	N/A	2.2	0.30
L12-02-01-P-S-Q-00	0.00	Q	0.956	0.15	0.0723	N/A	-0.114	0.000	-0.0073	0.000	0.059	0.244	U	0.916	0.165	0.142	N/A	-0.084	0.000	1.280	NA	NA	NA	-0.144	0.216	0.676	U	1.28	0.599	0.911	N/A	0.7	0.01
L12-02-11-P-R-Q-00	0.00	Q	1.06	0.144	0.0572	N/A	-0.010	0.000	-0.017	0.000	0.081	0.243	U	1.2	0.191	0.131	N/A	0.200	0.200	0.729	NA	NA	NA	-0.113	0.178	0.51	U	0.729	0.296	0.793	U	0.7	0.11
L12-02-25-P-S-B-00	0.00	B	0.909	0.132	0.064	N/A	-0.161	0.000	0.252	0.252	0.071	0.236	N/A	1.050	0.162	0.095	N/A	0.050	0.050	2.968	NA	NA	NA	0.159	0.139	0.175	U	1.410	0.490	0.706	N/A	1.8	0.06
Systematic Minimum			0.000						0.000					0.000						0.397				-0.136				0.584				1.5	0.02
Systematic Maximum			0.190						0.355					0.340						7.278				0.402				1.380				Average Enrichment (%)	0.30
Systematic Mean			0.025						0.091					0.104						2.319				0.070				1.079					0.09
Systematic Median			0.000						0.064					0.085						1.256				0.040				1.110					0.06
Systematic Standard Deviation			0.063						0.099					0.102						1.945				0.162				0.194					0.08
			With ingrowth, use Ra226 bkg = 1.07											Th232 bkg = 1.0																			

NOTES:

Gross results in units of pCi/g.

* Background with ingrowth (1.07 pCi/g) subtracted from gross result.

**Background (1.0 pCi/g) subtracted from gross result.

U Qualifier: Result is less than the sample detection limit.

All uncertainty values are reported at the 2-sigma confidence level.

14.2.5 Biased Soil Sample Result LSA 12-02

One (1) biased sample was collected from LSA 12-02. The sample collected at location L12-02-25 represented the maximum GWS measurement (11,828 gcpm) within the SU, and had a result of 0.06 Uniform SOF.

14.2.6 Quality Control Soil Sample Result LSA 12-02

Two QC field duplicate sample points were randomly selected for LSA 12-02 which were collected at systematic locations L12-02-01 and L12-012-11.

For the 17 samples (i.e., 16 systematic + 1 biased) collected within LSA 12-02, two field duplicate samples were collected. This frequency equates to 11.8%, (i.e. 2/17). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated warning limits (see Figure 7-5 below).

The statistical assessment of the Laboratory QC sample results indicated that one field duplicate sample exceeded the calculated Warning Limit, but was less than the calculated Control Limit. The one sample result that exceeded the Warning Limit was sample L12-02-11-P-R-S-00 for Th-232. In accordance with procedure HDP-PR-FSS-703, when an exceedance occurs an investigation is performed to determine if corrective actions were necessary. The investigation determined that for Th-232, the calculated statistic (0.287) only slightly exceeded the calculated Warning Limit (0.283). Also, considering the low activity and the errors associated with the sample results, the Th-232 activity of both samples were relatively close. Based upon the investigation of the exceedance and the results of previous Quality Assurance audits of the overall performance of the laboratory, no corrective actions were determined to be necessary.

Figure 14-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 12-02 (1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control		
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FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.:	LSA 12-02				Survey Unit Description:		Class 2 Laydown Land Area in "Area 13"					
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	Ra-226	1.1	0.0801	0.956	0.0723	1.028	1.9	0.144	0.269	0.403	N
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	Tc-99	0.171	0.245	-0.00733	0.244	0.082	25.1	NA	3.552	5.321	NA
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	Th-232	1.18	0.155	0.916	0.142	1.048	2.0	0.264	0.283	0.424	N
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	U-234[1]	4.440	N/A	1.280	N/A	2.860	195.4	3.160	27.649	41.425	N
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	U-235	0.244	0.219	-0.144	0.676	0.050	51.6	NA	7.301	10.939	NA
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	U-238	1.23	0.869	1.28	0.911	1.255	168.8	0.050	23.885	35.786	N

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy / [signature]

Date: 11-23-16

Reviewed by: W. Clark Evers / W. Clark Evers

Date: 11/23/16

Quality Record

Figure 14-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 12-02 (1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control		
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FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.:	LSA 12-02				Survey Unit Description:		Class 2 Laydown Land Area in "Area 13"						
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	Ra-226	0.882	0.0899	1.06	0.0572	0.971	1.9	0.178	0.269	0.403	N
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	Tc-99	-0.0174	0.249	-0.017	0.243	-0.017	25.1	NA	3.552	5.321	NA
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	Th-232	0.913	0.13	1.2	0.131	1.057	2.0	0.287	0.283	0.424	Y
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	U-234[1]	2.724	N/A	0.729	N/A	1.727	195.4	1.995	27.649	41.425	N
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	U-235	0.147	0.605	-0.113	0.51	0.017	51.6	NA	7.301	10.939	NA
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	U-238	1.18	0.918	0.729	0.793	0.955	168.8	NA	23.885	35.786	NA

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy / [signature]

Date: 11-23-16

Reviewed by: W. Van Every / [signature]

Date: 11/23/16

Quality Record

14.3 Tc-99 Hot Spot Assessment LSA 12-02

A review of the available data shows that as a Class 2 LSA SU there is no history of a Tc-99 sample result ever exceeding the Tc-99 Uniform $DCGL_w$. The highest Tc-99 sample result collected from both Final RASS and FSS was 0.355 pCi/g.

15.0 ALARA EVALUATION LSA 12-02

All samples collected within LSA 12-02 were evaluated against the Uniform Stratum $DCGL_w$. For LSA 12-02 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.09 for LSA 12-02. The average SOF equates to residual activity contributions from the survey unit area of 2.25 mrem/yr for LSA 12-02. Groundwater Monitoring Well data provided in FSSFR Volume 6, Chapters 2 and 3, indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/yr based upon the EPA MCLs will be added to the total estimated dose for LSA 12-02. Adding these dose contributions together, the total estimated dose for LSA 12-02 is 6.25 mrem/yr.

Since the estimated Total Effective Dose Equivalent is well below the regulatory release criterion of 25 mrem/yr, the conclusion of the ALARA evaluation is that the FSS of LSA 12-02 was successful and that there would be no discernable benefit to the health and safety of the public in attempting to further reduce the results of FSS by performing remediation of LSA 12-02.

16.0 FSS PLAN DEVIATIONS LSA 12-02

16.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 12-02.

16.2 Adjustments to Scan MDC Calculations

As previously stated in Section 5.1.5, Scan MDCs for LSA 12-01 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD-FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. The assumed LSA background count rate of 9,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 9,470 cpm. Therefore the calculated Scan MDCs are appropriate, and no adjustments need to be made.

17.0 DATA QUALITY ASSESSMENT

The DQO process is thoroughly integrated within the DP and Hematite FSS procedures. The steps of the DQO process are presented in Volume 3, Chapter 1, Section 4.0 of the FSSFR and correspond to the DQO steps described in Chapter 14, Section 4.2.1 of the DP. The HDP DQO process reflects the recommendations given in MARSSIM, Chapter 2, Figure 2-2.

17.1 Data Quality Assessment for LSA 12-02

The Data Quality Assessment of the survey methodology, sampling and sample analysis results, and the Quality Control sampling and analysis results to ascertain the validity of the conclusion for LSA 12-02 (see Figure 17-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 12-02 survey and sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721 *Final Status Survey Data Validation*.
- The WRS Test is not necessary when the difference between the maximum SU data set measurement SOF and the minimum background area measurement SOF is less than or equal to one. For LSA 12-02, no individual gross SOF result in the FSS data set exceeded the SOF of the minimum background reference area measurement by more than one using the Uniform Stratum criteria. Therefore, the WRS Test was not required for LSA 12-02. However, the WRS Test was performed for illustrative purposes. Since the test statistic, WR (1040) exceeded the critical value (860), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix B.
- The maximum systematic SOF result for all surface samples within LSA 12-02 was 0.15. The maximum systematic SOF result for all subsurface samples within LSA 12-02 was 0.30. The average SOF result for all systematically collected

samples within LSA 12-02 was 0.09, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.13.

- No FSS sample result in LSA 12-02 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an EMC or supplemental investigations was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number of systematic samples actually collected within LSA 12-02. The successful result of the retrospective power evaluation presented in Table 17-1 for LSA 12-02 indicates that the minimum number of samples required (8) for the WRS Test was equal to the number of sampling locations actually collected within LSA 12-02. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight topmost excavation surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.
- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures were performed periodically, and confirmed that there were no instances of potential cross contamination from weather events until the FSS of all remaining areas at HDP were completed.

Table 17-1
Retrospective Sample Size Verification for LSA 12-02

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.08
$DCGL_{SOF}$	1
LBGR (Mean)	0.09
Shift	0.91
Relative Shift (Δ/σ)	11.65
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS 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

Figure 17-1
Data Evaluation Checklists prepared for LSA 12-02 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
		Revision: 10	Appendix G-1, Page 1 of 2

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA
Survey Unit: 02 **Description:** Class 2 Laydown Land Area in "Area 13"

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FSS been individually reviewed and validated in accordance with Section 8.1 of this procedure?	Yes ☒	No ☐	
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
3.	Have all scans surveys been performed of the areas specified as required in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
4.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FSSP & the FSS Sample Instructions?	Yes ☒	No ☐	NA ☐
5.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☒	No ☐	NA ☐
6.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the appropriate investigation level?	Yes ☒	No ☐	
7.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use and were those calibrations performed using a NIST traceable source?	Yes ☒	No ☐	
8.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☒	No ☐	
9.	Do the samples match those identified on the chain of custody?	Yes ☒	No ☐	NA ☐
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒*	No ☐	
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	

If "No" was the response to any of the questions above, then document the discrepancy as well as any corrective actions that were taken to resolve the discrepancy.

Comments: *One QC duplicate sample L12-02-11-P-R-Q-00 exceeded Warning Limit for Th-232, but did not exceed Control Limit, results acceptable.

Quality Record

Figure 17-1
Data Evaluation Checklists prepared for LSA 12-02 (page 2 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation	Revision: 10	Appendix G-1, Page 2 of 2

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA
Survey Unit: 02 **Description:** Class 2 Laydown Land Area in "Area 13"

Discrepancy: N/A

Corrective Actions Taken: N/A

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐ NA ☒
    a. If "No", then forward this form to the RSO.
12. The following questions will be answered by the RSO.
    a. If the answer to question 11 was "No", then is the affected data still valid? Yes ☐ No ☐ NA ☒
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ NA ☒
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

	(Print Name)	(Signature)	(Date)
Prepared by (HP Staff):	Thomas Yardy		11-23-16
Approved by (RSO):	W. Clark Evans		11/23/16

Quality Record

18.0 CONCLUSION LSA 12-02

An adequate quantity and quality of radiological surveys and samples, as well as the corresponding laboratory analysis has been performed, evaluated and documented to demonstrate that the dose associated with all sources within SU LSA 12-02 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402.

Table 18-1
LSA 12-02 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.09	N/A	0.16	N/A	N/A	**0.25**
DOSE	2.25 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**6.25 mrem/year**

19.0 REFERENCES

19.1 DO-08-004, Hematite Decommissioning Plan {ML092330123}.

19.2 DO-08-003, Radiological Characterization Report, July 2009 {ML092870496}

19.3 Westinghouse letter HEM-11-96, dated July 5, 2011, *Final Supplemental Response to NRC Request for Additional Information on the Hematite Decommissioning Plan and Related Revision to a Pending License Amendment Request* {ML111880290}

19.4 HDP-TBD-FSS-002, "*Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*

20.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A: Analytical Data Evaluation Spreadsheets for LSA 12-01

APPENDIX B: Analytical Data Evaluation Spreadsheets for LSA 12-02

APPENDIX C: FSS Plan Development for LSA 12-01

APPENDIX D: FSS Plan Development for LSA 12-02

APPENDIX E: TestAmerica Laboratory Analytical Data Reports for LSA 12-01

APPENDIX F: TestAmerica Laboratory Analytical Data Reports for LSA 12-02

Attachment 2

Final Status Survey Final Report Volume 3, Chapter 8

Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02, Revision 1 Track Change Version

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Final Status Survey Report

Hematite Decommissioning Project

Final Status Survey Final Report Volume 3, Chapter 8

TITLE: **Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02 (LSA 12-01 and LSA 12-02)**

REVISION: **1**

EFFECTIVE DATE: FEB 2 7 2017

Track Change Version

Approvals:

Author: Kenneth E. Pallagi — Date: 02.27.2017

Owner/Manager: W. Clark Evers — Date: 2/27/17

REVISION LOG	
Revision No. Effect. Date	**Revision**
0 12/26/2016	Revision 0 is the initial issuance of the Survey Area Release Record for Land Survey Area 12, Survey Units 01 and 02.
1 See Cover Page	The NRC provided feedback during recurring weekly publicly noticed teleconferences in regards to the application of the WRS Test when applied to the Three Stratum approach. Westinghouse and the NRC discussed the path forward and resolution of the NRC comments. Revision 3 to FSSFR Volume 3 Chapter 1 implemented the resolution of the comments. Revision 1 of this Survey Area Release Record implements Revision 3 to FSSFR Volume 3 Chapter 1 within this report. In addition, the title to Figure 2-3 was corrected.

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LIST OF ACRONYMS AND SYMBOLS

ALARA	As Low As Reasonably Achievable
bgs	below ground surface
CFR	Code of Federal Regulations
cm	centimeter(s)
cpm	count(s) per minute
CSM	Conceptual Site Model
DCGL	Derived Concentration Guideline Level
$DCGL_w$	DCGL for average concentrations over a survey unit, used with statistical tests. ("W" suffix denotes "Wilcoxon")
DGPS	Digital Global Positioning System
DP	Hematite Decommissioning Plan
DQO	Data Quality Observation
EMC	Elevated Measurement Comparison
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
FSS	Final Status Survey
FSSFR	Final Status Survey Final Report
gcpm	gross count(s) per minute
GIS	Graphical Information Software
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HDP	Hematite Decommissioning Project
HP	Health Physics
HRCR	Hematite Radiological Characterization Report
I & C	Isolation and Control
IAL	Investigation Action Level
LSA	Land Survey Area
m	meter(s)
m^2	square meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Concentration Limit
MDC	Minimum Detectable Concentration
mrem	milliroentgen equivalent man
NAD	North American Datum
NaI	Sodium Iodide
ncpm	net count(s) per minute
NCS	Nuclear Criticality Safety
NRC	U.S. Nuclear Regulatory Commission
pCi/g	picocurie(s) per gram
QC	Quality Control
Ra	Radium
RASS	Remedial Action Support Survey
RSO	Radiation Safety Officer
SOF	Sum of Fractions

SU	Survey Unit
Tc	Technetium
Th	Thorium
U	Uranium
WRS	Wilcoxon Rank Sum
yr	year

EXECUTIVE SUMMARY

This Survey Area Release Record (SARR) presents the results of the final status radiological surveys of the Hematite Decommissioning Project (HDP) Land Survey Area (LSA) 12, Survey Unit (SU) 01 (LSA 12-01) and SU 02 (LSA 12-02). As provided in Final Status Survey Final Report (FSSFR), Volume 1, Chapter 1, Section 7.0 {ML15257A307}, the final report summary, FSSFR Volume 7, *Final Status Survey Final Report*, will be submitted at the conclusion of the post-remediation groundwater monitoring period. FSSFR Volume 7 will be submitted to demonstrate that the site has met the requirements for unrestricted release consistent with the requirements of the Title 10 Code of Federal Regulations (CFR) 20 Subpart E, "Criteria for License Termination."

Both LSA 12-01 and LSA 12-02 were designated as Class 2 SUs as presented in Table 14-16 of the HDP Decommissioning Plan (DP) {ML092330123}. The Class 2 designation for both SUs remained in effect throughout remediation and Final Status Survey (FSS). For both SUs, evaluation of analytical results against the Derived Concentration Guideline Levels (DCGL) for the Uniform Stratum Conceptual Site Model (CSM) was the selected approach. The objective of the FSS for both SUs was to obtain and document measurement results, analytical data, and other supporting information in order to demonstrate that after completion of remediation the residual radioactivity levels in the LSA 12-01 and LSA 12-02 SUs are below the applicable Uniform Stratum DCGLs and therefore the land area of these SUs meet the criteria for unrestricted release.

The Uniform Stratum CSM assumes residual radioactivity is uniformly distributed over the entire depth profile of the SU from ground surface to 6.7 meter (m) below ground surface (bgs). As described in FSSFR Volume 3, Chapter 1, 6.2.1, *Systematic Soil Sampling*, systematic soil samples were obtained at depths dependent upon the systematic soil sample location.

This SARR was prepared as described in FSSFR Volume 3, Chapter 1, Section 7.0, *Survey Area Release Record Organization*, as implemented by FSS procedure HDP-PR-FSS-722.

1.0 REPORT BACKGROUND

As a result of the U. S. Nuclear Regulatory Commission (NRC) feedback regarding the submittal of the FSSFR, Westinghouse and the NRC agreed that Westinghouse would develop an outline presenting the format and content of FSS documents required for NRC review. Westinghouse provided the outline to the NRC for discussion during the August 19, 2015, publicly noticed teleconference and the format was agreed upon {ML15238B032}.

FSSFR Volume 3, Chapter 1, Revision 2, *Land Survey Areas (LSA) Overview* provides the information common to land survey areas. This report, FSSFR Volume 3, Chapter 8, builds upon the general information provided in FSSFR Volume 3, Chapter 1, Revision 2.

2.0 HDP SITE, LSA AND SURVEY UNIT DESCRIPTIONS

2.1 HDP Site Description

A general description of the HDP site is given in FSSFR Volume 1, Chapter 1.

2.2 LSA 12 Configuration

The DP Chapter 14 and DP Figure 14-14 provided the conceptual approach for the configuration of LSAs and the SUs within a LSA. Figure 2-1 indicates the LSA configurations for the HDP site.

The DP stated that it was expected that the conceptual boundaries of the SUs would be altered based on the actual configuration and condition of the SU at the time of survey design. As expected, it was necessary to modify the boundary of SUs within LSA 12 to facilitate the remediation process. Although the some of the SU boundaries within LSA 12 were modified the boundary of LSA 12 remained unchanged

LSA 12 encompasses the entire "East Reuse Soil Laydown Area" footprint within the Central Tract. LSA 12 consists of SUs LSA 12-01 through LSA 12-09.

2.2.1 LSA 12 SU Configuration Change

The expansion in the number of SUs within LSA 12 by the reduction in size of LSA 12-02 was due in part to the processing and storage of reuse soil. As site remediation operations generated more than the anticipated volume of reuse soil it became necessary to expand the Class 1 storage area portion of LSA 12.

The initial configuration change transferred a portion of LSA 12-02, a Class 2 SU, to create LSA 12-08, a Class 1 SU. Subsequently LSA 12-08 was divided into LSA 12-08 and LSA 12-09 to ensure compliance with the DP Class 1 SU size requirement.

To support the remediation plans described in the DP, although radiological characterization of the land indicated it was radiologically non-impacted, SUs were developed based upon future use (reuse soil laydown area). All SUs within LSA 12 that were initially classified as Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 1 (LSA 12-03 through LSA 12-07) remained classified as MARSSIM Class 1 SUs. SUs LSA 12-01 and 12-02 were initially classified as MARSSIM Class 2 and remained Class 2 SUS. The portion of LSA 12-02 that became LSA 12-08 and LSA 12-09 were classified as MARSSIM Class 1 SUs, thereby ensuring compliance with the DP.

2.3 LSA 12-01 and LSA 12-02 Survey Unit Description and Configuration

The land area that is LSA 12-01 and LSA 12-02, prior to and during site operations was woodlands (see Figure 2-2) and not associated with or impacted by any site operations other than ground water monitoring well sampling. There were no structures, piping, or spent limestone within the SUs. As a function of preparation for remediation operations, trees and vegetation were removed from portions of LSA 12-01 and LSA 12-02 and the area was graded to create the reuse soil laydown area for the reuse soil to be generated. Portions of LSA 12-01 and LSA 12-02 remained wooded (see Figure 2-3).

As all reuse soil that was placed in LSA 12-02 was subsequently removed and used as backfill in site excavations, remediation was not necessary in LSA 12-01 or LSA 12-02 to prepare it for FSS. As such, no excavations were performed to remove reuse or any native soil. The final surface of the SUs that was subject to FSS was the native soil. Ground water monitoring wells BR-04-JC and BR-04-RB were present in LSA 12-02 during site operations and remain undisturbed. These wells will continue to be monitored as part of the post-remediation ground water monitoring reported in Volume 6 of the FSSFR.

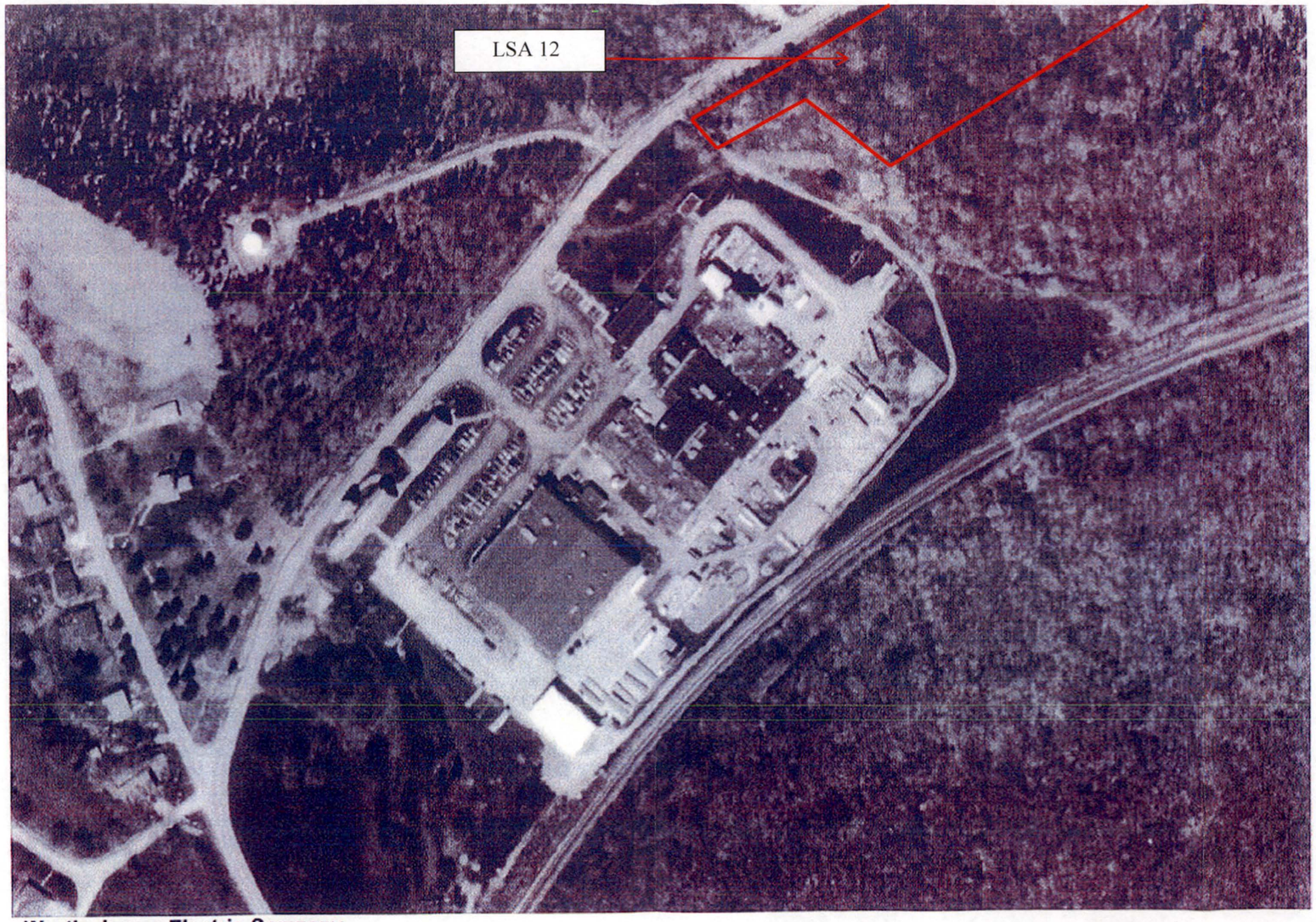
Figure 2-4 presents the Final Configuration of LSA 12 and the SUs. Figure 2-5 presents the Final Configuration of the HDP Land Survey Areas and SUs.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 12-01 presents 7,062 square meters (m^2) in planar (2-dimensional, un-excavated surface).

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 12-01 presents 3,254 square meters (m^2) in planar (2-dimensional, un-excavated surface).

Figure 2-1
HDP Land Survey Areas

Figure 2-2
Hematite Site Aerial Photograph – 04/02/1998
(Indicating General Location of LSA 12)



Westinghouse Electric Company
Hematite Plant - Festus, MO
4/2/1998
Photo Source: Surdex Corp.

N W E S

100 0 100 Feet

AERO-DATA CORP
ENVIRONMENTAL
REMOTE SENSING CONSULTING SERVICES
AERIAL PHOTO ACQUISITION
INTERPRETATION and MAPPING

Figure 2-3
Hematite Site Aerial Photograph – Circa 2011

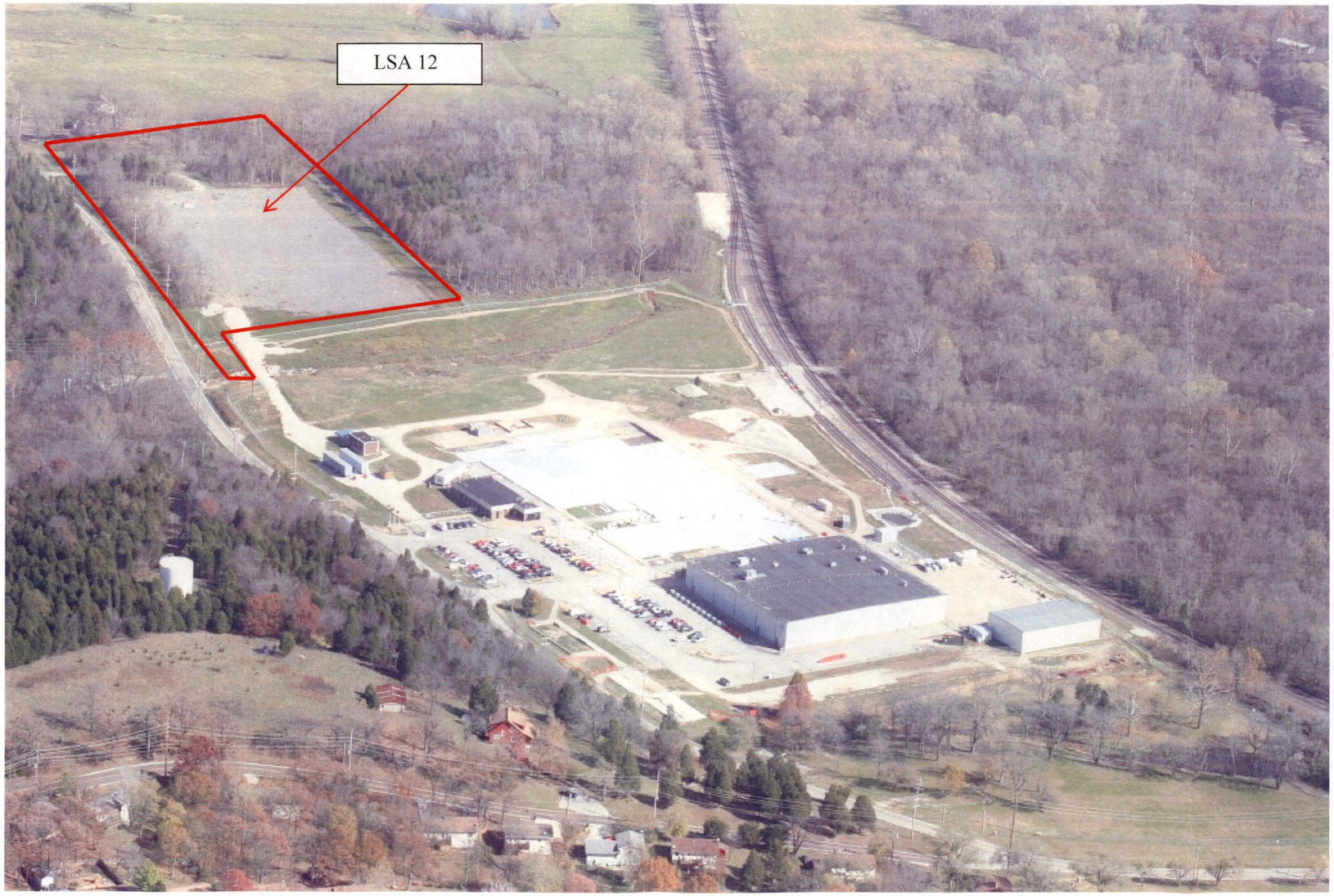
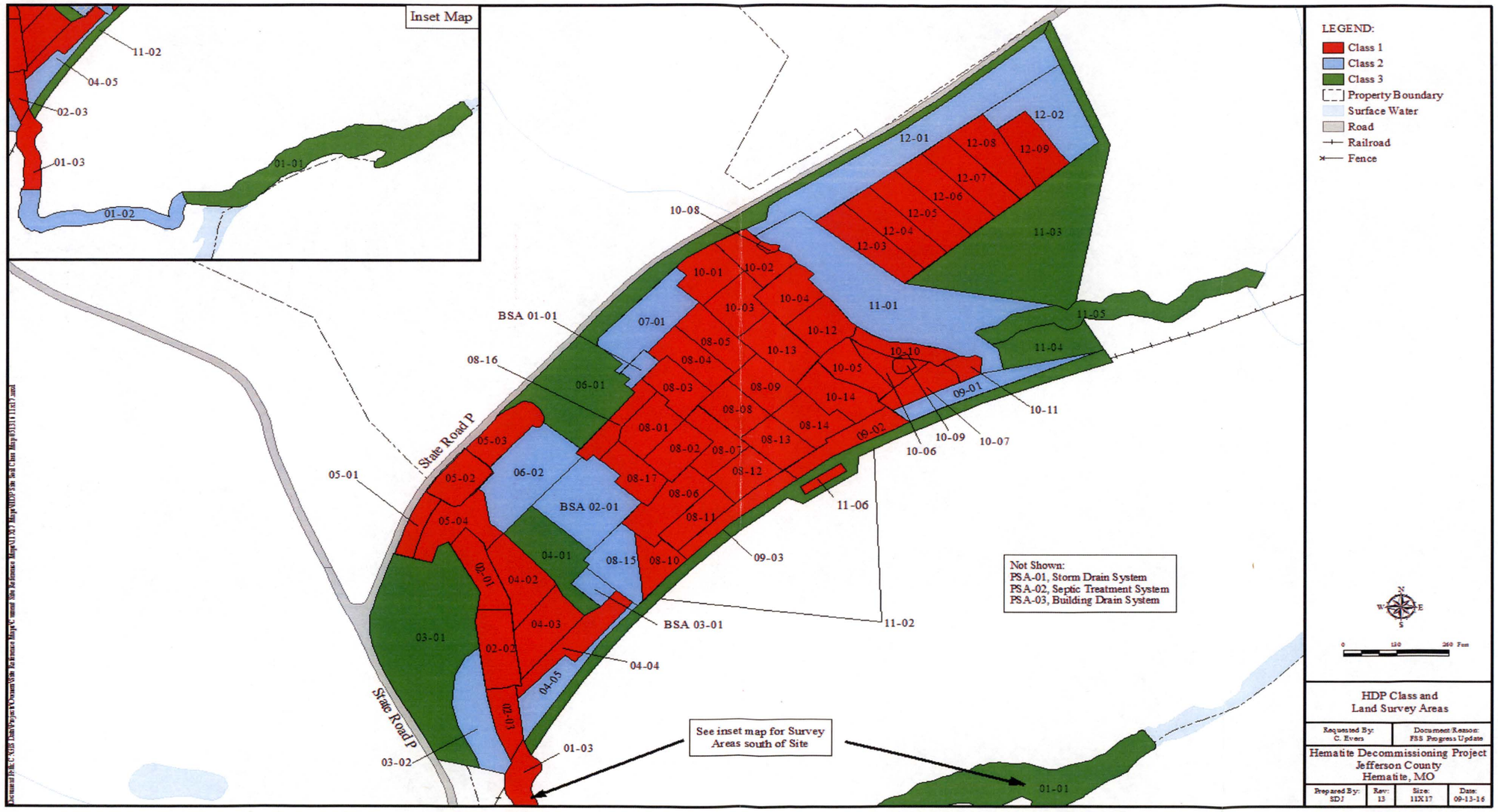


Figure 2-4
Final Configuration of Land Survey Area 12 and Survey Units

Figure 2-5
Final Configuration of Land Survey Areas and Survey Units



3.0 HISTORY OF OPERATIONS

A discussion of site historical operations prior to the decommissioning phase of the HDP is presented in the FSSFR Volume 1, Chapter 1, Section 3.0, *Site Historical Operations*.

A detailed discussion of the historical background information related to the general remediation process is presented in the FSSFR Volume 3, Chapter 1, Section 2.1.1, *Remediation and Excavation*.

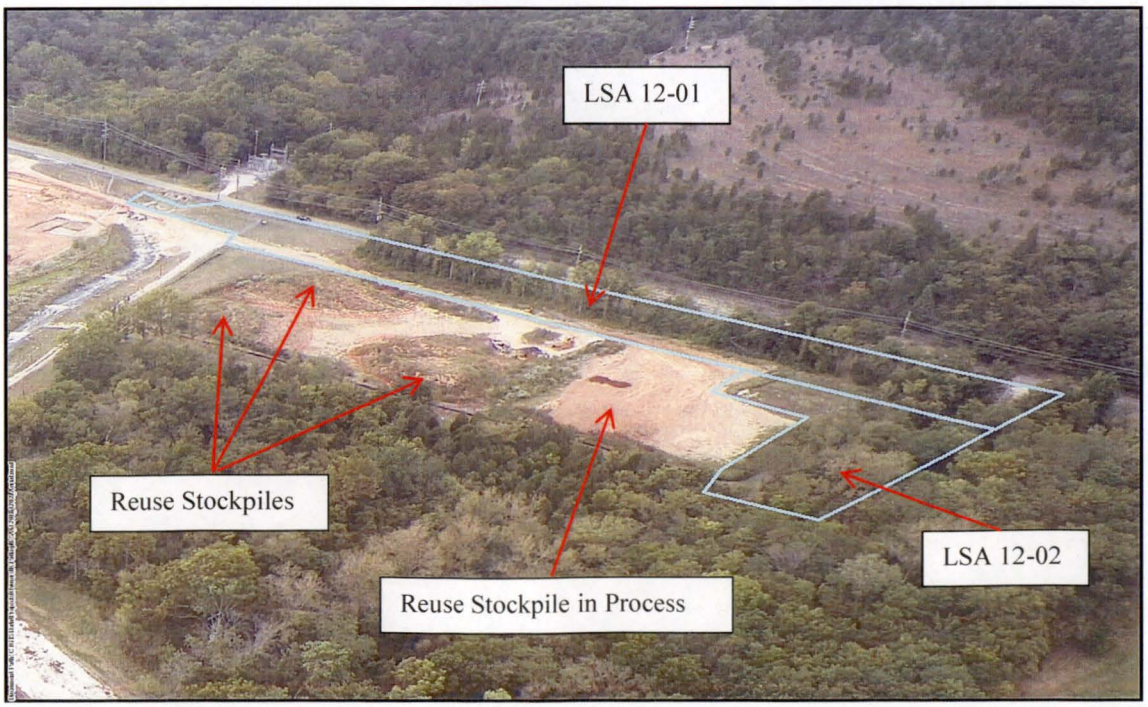
A detailed discussion of the historical background information related to reuse soils is presented in the FSSFR Volume 2, Chapter 1, Section 2.1, *History and Development of the Reuse Soil Stockpiles*.

3.1 Potential Radioactive Materials in LSA 12-01 and LSA 12-02

Potential radioactive materials within LSA 12-01 and LSA 12-02 resulted from placement of potential reuse soil into adjacent Class 1 LSA 12 SUs used for long term reuse soil storage (see Figure 3-1). During the time of reuse soil handling at HDP, reuse soils were transported through the Class 2 LSA's 12-01 and 12-02, in route to the neighboring Class 1 storage areas, and were also used for support activities such as the creation of haul roads, staging of dump trucks, and brush clearing to remove obstacles to site operations.

As no historical site operations ever occurred within this area and all reuse soil was removed from the area, no remedial actions were necessary within LSA 12,. The LSA 12 area only became potentially impacted as a result of the long term storage of reuse material.

Figure 3-1
Reuse Soil Stockpile Operations – 09/2013



3.2 Reuse Soil Disposition and Characterization

Prior to remediation and removal of contaminated soil and other waste materials within the Burial Pit Area and other areas designated to undergo remediation, overburden soils which exhibited characteristics suitable for potential reuse as onsite backfill material were removed, segregated, and subjected to reuse soil criteria requirements.

As LSA 12 was not designated for and did not require remediation there were no reuse soils generated by remediation excavation within the LSA 12 area. However it is noted that during movement of reuse stockpiles during the ISO-Pacific S3 Soil Sorting System sorting operations that a small quantity of the surface of the overburden from the LSA 12 land area was most likely removed and deposited into Reuse Stockpile 9 as a result of the creation of the stockpile. GPS measurements in LSA 12 did not indicate a discernable change in surface elevation.

A detailed discussion of reuse soils, including general description, segregation, surveys, ISO-Pacific S3 sorting technology and operations, and technical requirements may be found in the FSSFR Volume 2, Chapter 1, *Reuse Soil and Off-site Borrow Material Overview* {ML16152A752}.

3.3 Remedial Action Support Surveys (RASS) Phase of LSA 12-01 and LSA 12-02

The sections below provide a discussion of the various elements of the RASS phase of LSA 12-01 and LSA 12-02 necessary to prepare the SUs for FSS.

3.3.1 Remedial Actions

No remedial actions were required to be performed within the LSA 12 area. After all reuse soil was removed from the area, the area was prepared for Final RASS and FSS.

3.3.2 In Process Remedial Action Support Surveys

In process RASS was not required within LSA 12 since no remediation was performed.

3.3.3 Nuclear Criticality Safety (NCS) Borings

NCS Borings were not required within LSA 12 as the area was never subject to NCS controls.

3.3.4 Groundwater Monitoring Wells

A detailed discussion of history, purpose, use, issues, and results of the groundwater monitoring wells at HDP is presented in the FSSFR Volume 6, Chapter 1.

During the history of site operations and remediation there were no groundwater monitoring wells were located within the boundary limits of LSA 12-01. Groundwater monitoring wells BR-04-JC and BR-04-RB were located within LSA 12-02 prior to remediation and remain in place and operable as part of post-remediation groundwater monitoring.

3.3.5 Subterranean Piping

Preliminary remediation planning activities indicated that no subterranean process piping should be encountered in LSA 12-01 and LSA 12-02. During reuse stockpile operations within LSA 12-01 and LSA 12-02 no subterranean process piping was encountered.

As there is no buried piping under the footprint of LSA 12-01 and LSA 12-02 there is no dose contribution to the SUs from this pathway.

3.3.6 Characterization History

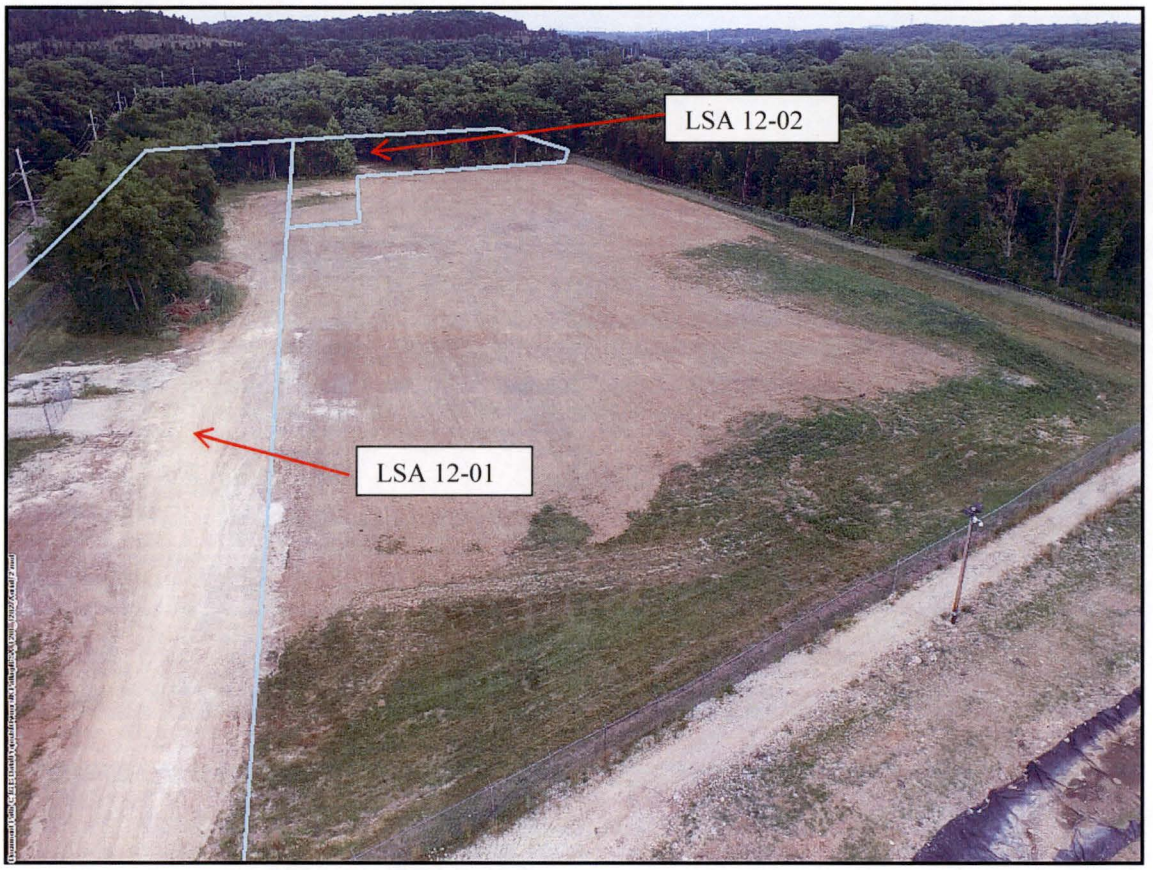
The LSA 12 area was not impacted by historic site operations, was previously covered by a heavily wooded area, and identified as a non-impacted area in the Historical Site Assessment. Brush clearing operations in 2011 removed a majority of the trees and brush from the landscape. During the remediation planning process, this area was identified as a potential reuse soil staging area. The LSA 12 area was considered a radiologically non-impacted area, however it was determined that the area would be potentially impacted by future site operations and therefore the LSA 12 area was identified for FSS purposes in the DP.

As a non-impacted area during site operations there were no characterization core bores performed within the LSA 12 area. FSS Planning was based on the information collected in the Final RASS.

3.3.7 Remedial Action Support Survey for FSS Design

The RASS was conducted within LSA 12, 1) to determine when a SU had been adequately prepared for FSS, and 2) to provide updated estimates of the parameters to be used for planning the FSS. Upon the removal of all reuse soil from the SUs and prior to implementation of FSS activities, a final RASS was performed to validate the status of the SU prior to implementing Isolation and Control (I & C) postings. The I & C posting for both LSA 12-01 and LSA 12-02 was completed on April of 2016. Figure 3-2 is a photograph which shows LSA 12-01 and LSA 12-02 ready for the final RASS.

Figure 3-2
LSA 12-01 and LSA 12-02 Prepared for RASS FSS Design



The RASS included a GWS, systematic surface sample collection based on an eight (8)-point triangular grid, and biased surface sampling. Since LSA 12-01 and LSA 12-02 were immediately adjacent to each other, and were similar, a Final RASS performed over both SU's concurrently. The Final RASS results were used to develop the FSS Plan for each SU. The Final RASS systematic sample results used to develop the FSS sampling grid are summarized in Table 3-1 below:

Table 3-1
Summary of Final RASS Results for LSA 12-01 and LSA 12-02

LSA	Ra-226 (net)		Tc-99		Th-232 (net)		U-234		U-235		U-238	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
12-01 and 12-02	0.00	0.00	0.15	0.34	0.04	0.19	2.27	4.22	0.12	0.23	0.97	1.52
DCGL[3]	1.9		25.1		2.0		195.4		51.6		168.8	

Notes:
1. All units are in picocuries per gram (pCi/g)
2. Results reflect net concentrations after subtraction of background (Ra-226 bkg = 0.9 pCi/g; Th-232 bkg = 1.0 pCi/g).
3. Uniform Stratum DCGLs (From Table 4-1)

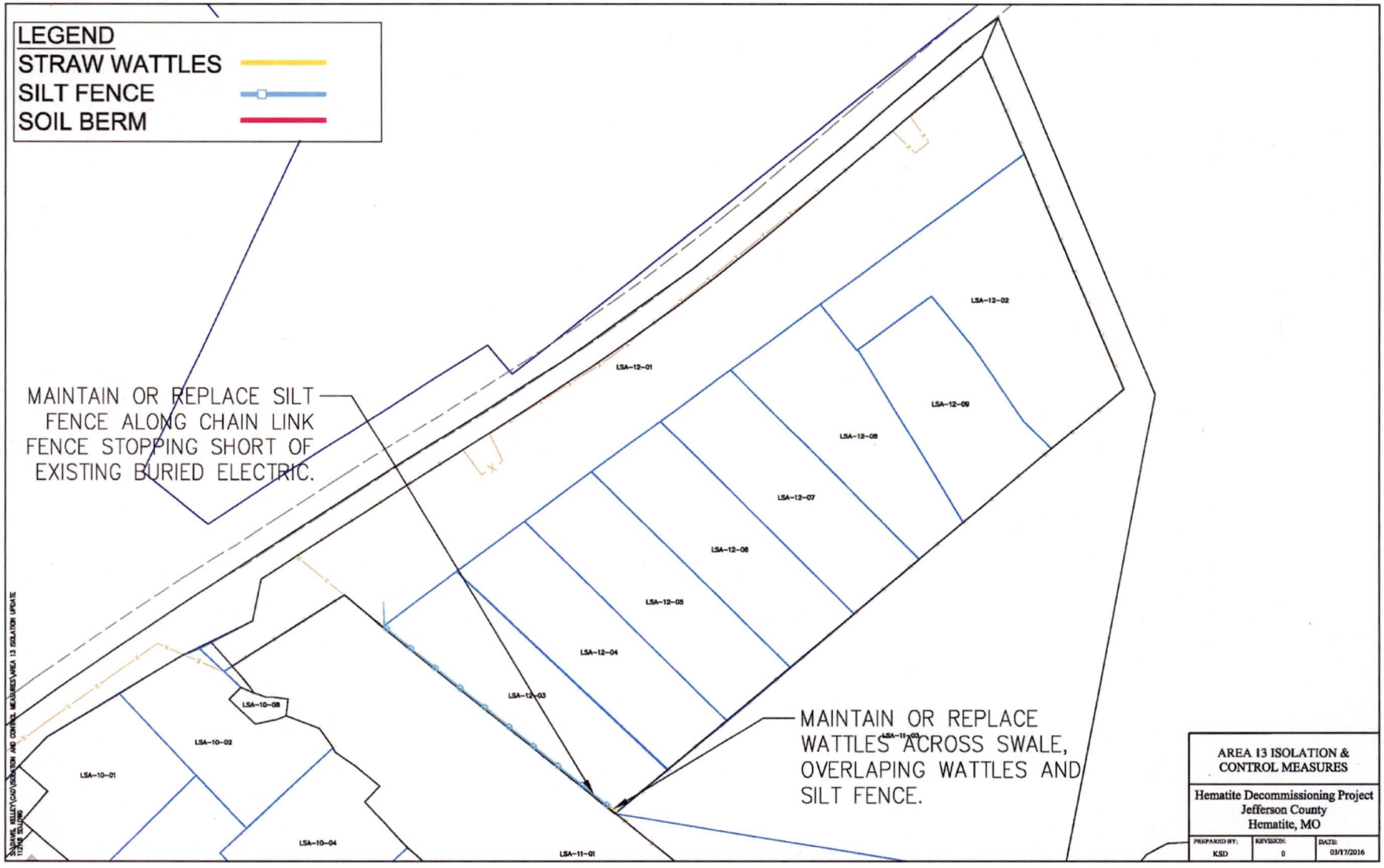
All Final RASS systematic sample and biased sample results were less than the appropriate $DCGL_w$ (Uniform Stratum) and the Final RASS data set was considered sufficient to support FSS design.

3.3.8 Isolation and Control

As directed by HDP-PR-HP-602, *Data Package Development and Isolation and Control Measures to Support Final Status Survey,* in April of 2016, LSA 12-01 and LSA 12-02 were isolated and controlled in accordance with Work Package HDP-WP-ENG-803, *Isolation and Control Measures,* (See Figure 3-3) Isolation and control measures included silt fence and straw wattles between these SUs and the adjacent area to ensure that cross-contamination of these LSAs undergoing FSS did not occur.

The administrative control of multiple postings labeled "Contact Health Physics Prior to Entry" was installed around the entire perimeter of the SUs prior to FSS field activities to prevent inadvertent entry by site personnel. LSA 12-01 and LSA 12-02 are located within the fenced security perimeter of the HDP which therefore prevents access by the general public.

Figure 3-3
Isolation and Control of Area Containing LSA 12-01 and LSA 12-02



3.3.9 Surveillance Following FSS

Following the completion of a FSS, the DP requires continued surveillance to minimize the potential to re-contaminate a SU (e.g., surface water transport of potentially contaminated sediment or a soil pile that was not present during FSS). The surveillance included the routine visual inspection of the integrity of the I & C measures implemented for LSA 12-01 and LSA 12-02. If a SU is suspected of having been re-contaminated then an investigation survey will be performed to reconfirm the FSS survey validity.

During the timeframe since the completion of FSS field activities to the date of completion of all physical work at HDP and project demobilization, LSA 12-01 and LSA 12-02 did not evidence an event that would cause them to be suspect and thus require investigation.

3.3.10 Backfill of Survey Units

No backfill was required for LSA 12-01 and LSA 12-02.

3.3.11 Groundwater Monitoring

In response to NRC RAI Chapter 3-4, during the review and approval process for the DP, Westinghouse documented in letter HEM-11-96 {ML111880290} the revised text of DP Section 14.5.1 to be as follows:

> "*Post-remediation monitoring wells will be sampled quarterly after the completion of remediation until license termination. The data collected will be used to confirm that the sum of the annual dose from groundwater for all the radionuclides does not exceed the EPA Maximum Contaminant Level (MCL) of 4 millirem/year. Separately, the sum of the dose from all residual sources remaining after remediation, including soil and groundwater pathways, will be confirmed to result in an annual dose that does not exceed 25 millirem/year.*"

As stated in the Executive Summary section, the exposure results of this report will be combined with the dose attributed to groundwater to demonstrate that the site has met the requirements for unrestricted release consistent with the requirements of the Title 10 CFR 20 Subpart E, "Criteria for License Termination." As such, for the purpose of this report, groundwater will be assigned a conservative SOF of 0.16 which equates to 4 mrem/yr until such time that the post-remediation groundwater sampling has been completed and reported as part of FSSFR Volume 6, Chapter 7, *Post-remediation Groundwater Monitoring Summary*. The final dose for LSA 12-01 and LSA 12-02 will be reported in FSSFR Volume 7, reflecting the updated results of the post-remediation groundwater monitoring.

4.0 LSA RELEASE CRITERIA

As the release criteria for all LSA SUs is common, FSSFR Volume 3, Chapter 1, Section 3.0, *Release Criteria*, provides a detailed discussion on the release criteria that is applicable to LSA 12-01 and LSA 12-02. Table 4-1 provides the applicable DCGLs.

Table 4-1
Adjusted Soil $DCGL_w$'s by CSM[a]

Radionuclide	Three Layer Approach $DCGL_w$ Values (pCi/g)[b]			Uniform Stratum (pCi/g)
	Surface Stratum	Root Stratum	Excavation Scenario	
Radium-226+C[d]	5.0	2.1	5.4	**1.9**
Technetium-99	151.0	30.1	74.0	**25.1**
Thorium-232+C[d]	4.7	2.0	5.2	**2.0**
Uranium-234	508.5	235.6	872.4	**195.4**
Uranium-235+D[c]	102.3	64.1	208.1	**51.6**
Uranium-238+D[c]	297.6	183.3	551.1	**168.8**

[a] Table as presented in FSSFR Volume 3, Chapter 1.
[b] The reported DCGLw's are the activities for the parent radionuclide 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.

5.0 FINAL STATUS SURVEY DESIGN LSA 12-01

This section of the report describes the method for determining the number of samples required for the FSS of LSA 12-01 as well as summarizing the applicable requirements of the FSS Plan. These include the $DCGL_w$, scan survey coverage, and Investigation Action Levels (IAL). The radiological instrumentation used in the FSS of LSA 12-01 and the detection sensitivities are also discussed.

5.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 12-01 were driven by the type (Open Land) and Class (Class 2) of the survey unit and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

5.1.1 Surrogate Evaluation Areas

A discussion of Surrogate Evaluation Areas is given in the FSSFR Volume 3, Chapter 1, Section 5.0, *Final Status Survey Design.*

5.1.2 $DCGL_w$

During the FSS design process a review was performed of the RASS data for LSA 12-01. The RASS data was used as confirmation that no known areas of residual radioactivity remained within the SU that exceeded the Uniform Stratum $DCGL_w$. Therefore the Uniform Stratum $DCGL_w$ was selected for use in demonstrating compliance with the release criteria.

5.1.3 GWS Coverage

As a Class 2 SU, LSA 12-01 was required to undergo a minimum of a 50% GWS.

5.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 12-01 was the Ludlum 44-10 2" x 2" sodium iodide (NaI) detectors, coupled to a Ludlum 2221 scaler-ratemeter.

5.1.5 Scan Minimum Detectable Concentration (MDC)

Scan MDCs for LSA 12-01 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. As background levels were approximately 9,000 counts per minute (cpm) within LSA 12-01, the scan minimal detection concentration (MDC) calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3471\,pCi/g}\right)+\left(\frac{f_{U-235}}{2.2pCi/g}\right)+\left(\frac{f_{U-238}}{29.0pCi/g}\right)\right)}$$

Equation 5-1

To determine isotopic Uranium fractions HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* assumes that the average LSA enrichment is 4% or less. Based on the systematically collected RASS samples in LSA 12-01, the average enrichment for the SU was 2.0%. All other Scan MDC parameters agreed upon between Westinghouse and the NRC were applied (e.g. use of a 2 in air gap, scan rate of 1 ft/sec, 0.75 surveyor efficiency), therefore no subsequent changes to the calculated Scan MDCs were required to be made.

Prospectively calculated scan MDCs for 2" x 2" NaI detectors that were used in LSA 12-01 are shown below:

Table 5-1
Scan MDCs for 2" x 2" NaI detector, 9,000 cpm background: LSA 12-01

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 12-01	38.8	50.9	1.14	2.8	0.82	3.0

*$DCGL_w$ includes background concentrations of 0.9 pCi/g for Ra-226 (no ingrowth) and 1.0 pCi/g for Th-232. DCGLw values are based on the Uniform Stratum release criteria.

The values in Table 5-1 reflect those presented in the FSS Plans prepared for the SU prior to FSS.

5.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum $DCGL_w$ 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 20 I 5. The IAL used during the GWS of LSA 12-01 was established at 1,624 net counts per minute (ncpm). This value is equivalent to the $DCGL_w$ for Uniform soil assuming a 4% Uranium enrichment, and using the inferred values for Tc-99 (Inferred Tc-99 values used for prospective scan calculations only).

5.1.7 LSA 12-01 FSS Design Summary

The FSS Plans for LSA 12-01 can be found in Appendix C. Table 5-2 presents an overall FSS design and implementation summary for LSA 12-01.

Table 5-2
FSS Design Summary for LSA 12-01

Gamma Walkover Survey (GWS):		
Scan Coverage	50% exposed soil and rock	
Scan MDC	38.8 pCi/g total Uranium (based on a 9,000 cpm background); 0.82 pCi/g Th-232; 1.14 pCi/g Ra-226*	
Investigation Action Level (IAL)	1,624 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	8	These samples will be taken on a random-start systematic grid.
15 cm – 1.5 m (Root)	8	
> 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 RSO or Radiological Engineering.		
Sidewall Sampling Locations:		
A minimum of one (1) discretionary sidewall sample will be collected based on the following definition of "sidewall": sidewall candidates for sampling must be vertical or near vertical (> 45° angle) and at least 12" in height.		
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).* The Scan MDC for total Uranium reflects a conservative assumption of 4% enrichment. The actual RASS enrichment (2.0%) would result in Scan MDC values slightly less than those calculated for FSS planning purposes.		
**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.		

6.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 12-01

FSS was performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment.*

6.1 Gamma Walkover Survey

6.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 12-01 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS (Digital Global Positioning System) and handheld data logger.

Prior to the first field use of the GWS instrumentation, initial set-ups were performed. Also, daily pre- and post-use source checks were performed for each day that GWS was performed within the SU. Initial set-ups, daily source checks, and control charting were performed according to the requirements of HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey.*

6.1.2 GWS Performance

All GWS measurements on the exposed SU surface collected with the NaI detector(s) were connected to a Trimble DGPS and with a hand-held data logger. The logging frequency in the survey unit was 1 GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

The GWS requirements involved moving the NaI detector in a side-to-side fashion no faster than 1 foot per second while holding the probe as close as possible to the excavation surface (nominally 1", but not to exceed 3"). At the same time, the technician was required to slowly advance, causing the detector to trace out a serpentine path over the excavation surface.

FSS Technicians performing GWS in LSA 12-01 used the 1,624 ncpm IAL as a field guide to know when to slow or pause the GWS for more deliberate investigation. If during the GWS, audible count rates noticeably increase above the general area average (i.e., > minimum detectable count rate), FSS Technicians were required to pause momentarily and observe count rates. If sustained count rates approached the IAL, further focused investigation was conducted within the locally elevated area.

To use the IAL effectively, FSS Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to excavation geometry and relative distance from contaminated materials in nearby remedial excavations, the average background rate (measured at waist level) within the LSA ranged between 9,000 and 10,000 gross counts per minute (gcpm). Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 10,624 to 11,624 gcpm, FSS Technicians slowed or paused the GWS for more careful investigation of the small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

Hard to reach areas, and non-typical areas were surveyed manually as necessary in order to assess the potential for an area of elevated residual activity over 50% of the exposed ground surface.

After the GWS survey was complete, the GPS/GWS data was reviewed by Radiological Engineering and the Health Physics (HP) Technician performing the survey to determine if possible areas of elevated residual activity remained within the SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

6.2 Soil Sampling

6.2.1 Systematic Soil Sampling Summary

Table 6-1 provides a summary of systematic sampling by stratum for LSA 12-01.

Table 6-1
Systematic Sampling Summary by Stratum for LSA 12-01

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
12-01	7,062	8	8	8*	2

*Excavation samples were collected and archived, analysis only required if a overlying Root sample exceeds a 0.5 SOF

6.2.1.1 Systematic Sampling LSA 12-01

Within LSA 12-01, there were 8 systematic locations in which the surface stratum [0 – 15 centimeters (cm)] was sampled in the SU. The underlying root stratum was sampled at all 8 locations. Excavation stratum samples were collected and archived, but were not required to be analyzed since no root stratum sample exceeded a 0.5 Uniform SOF.

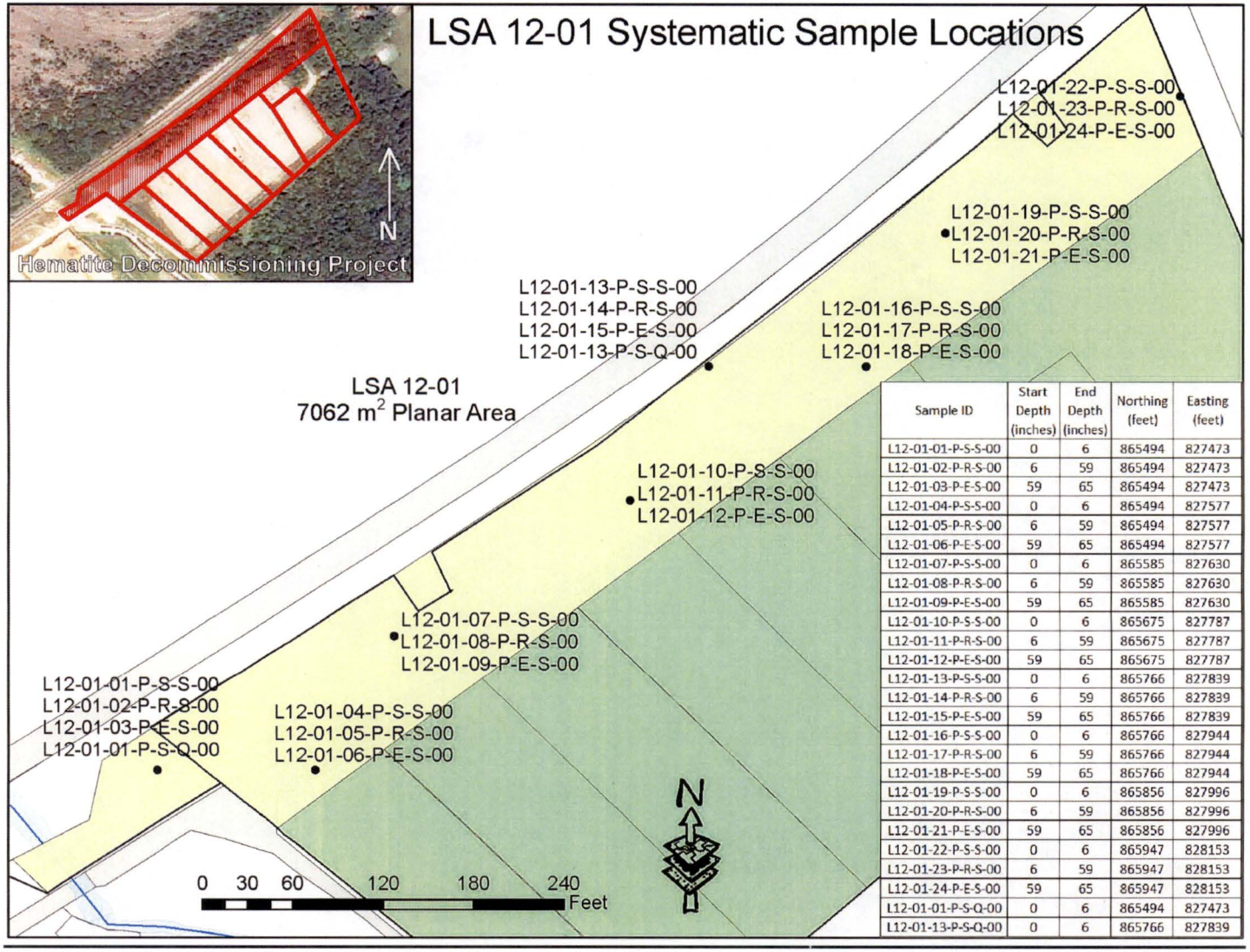
Given a planar area of 7,062 m^2 for LSA 12-01 and an eight - point systematic triangular grid, the point-to-point distance within each row was 27.6 m with spacing of 31.9 m between each of the parallel grid rows within the SU.

While there were eight (8) systematic locations on the LSA 12-01 sampling grid, a total of eighteen (18) samples were collected and analyzed at these locations, including:

- Eight (8) samples collected and analyzed within the surface stratum
- Eight (8) samples collected and analyzed within the root stratum
- Zero (0) samples analyzed within the excavation, or "deep"
- Two (2) Quality Control (QC) field replicate

Figure 6-1 presents the map of the eight systematic sample locations which were sampled within LSA 12-01. The inset table notes the location coordinates (Missouri East, North American Datum (NAD) 1983) and collection intervals for each systematic location.

Figure 6-1
LSA 12-01 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L12-01-01-P-S-S-00	0	6	865494	827473
L12-01-02-P-R-S-00	6	59	865494	827473
L12-01-03-P-E-S-00	59	65	865494	827473
L12-01-04-P-S-S-00	0	6	865494	827577
L12-01-05-P-R-S-00	6	59	865494	827577
L12-01-06-P-E-S-00	59	65	865494	827577
L12-01-07-P-S-S-00	0	6	865585	827630
L12-01-08-P-R-S-00	6	59	865585	827630
L12-01-09-P-E-S-00	59	65	865585	827630
L12-01-10-P-S-S-00	0	6	865675	827787
L12-01-11-P-R-S-00	6	59	865675	827787
L12-01-12-P-E-S-00	59	65	865675	827787
L12-01-13-P-S-S-00	0	6	865766	827839
L12-01-14-P-R-S-00	6	59	865766	827839
L12-01-15-P-E-S-00	59	65	865766	827839
L12-01-16-P-S-S-00	0	6	865766	827944
L12-01-17-P-R-S-00	6	59	865766	827944
L12-01-18-P-E-S-00	59	65	865766	827944
L12-01-19-P-S-S-00	0	6	865856	827996
L12-01-20-P-R-S-00	6	59	865856	827996
L12-01-21-P-E-S-00	59	65	865856	827996
L12-01-22-P-S-S-00	0	6	865947	828153
L12-01-23-P-R-S-00	6	59	865947	828153
L12-01-24-P-E-S-00	59	65	865947	828153
L12-01-01-P-S-Q-00	0	6	865494	827473
L12-01-13-P-S-Q-00	0	6	865766	827839

Figure 6-2 below presents a tabular listing of all FSS samples collected within LSA 12-01 with associated IDs, sample types, collection intervals, coordinates, and notes.

Figure 6-2
FSS Sample Locations and Coordinates for LSA 12-01

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
		Revision: 10	Appendix P-4, Page 1 of 1

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA

Survey Unit: 01 **Description:** Class 2 Laydown Land Area in "Area 13"

Survey Type: FSS **Classification:** Class 2

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L12-01-01-P-S-S-00	Uniform	S	428.0	427.5	865494	827473	Surface 6-inch grab
L12-01-02-P-R-S-00	Uniform	S	427.5	423.1	865494	827473	Root 59-inch composite
L12-01-04-P-S-S-00	Uniform	S	429.9	429.4	865494	827577	Surface 6-inch grab
L12-01-05-P-R-S-00	Uniform	S	429.4	424.9	865494	827577	Root 59-inch composite
L12-01-07-P-S-S-00	Uniform	S	434.4	433.9	865585	827630	Surface 6-inch grab
L12-01-08-P-R-S-00	Uniform	S	433.9	429.5	865585	827630	Root 59-inch composite
L12-01-10-P-S-S-00	Uniform	S	433.6	433.1	865675	827787	Surface 6-inch grab
L12-01-11-P-R-S-00	Uniform	S	433.1	428.7	865675	827787	Root 59-inch composite
L12-01-13-P-S-S-00	Uniform	S	434.6	434.2	865766	827839	Surface 6-inch grab
L12-01-14-P-R-S-00	Uniform	S	434.2	429.7	865766	827839	Root 59-inch composite
L12-01-16-P-S-S-00	Uniform	S	431.9	431.4	865766	827944	Surface 6-inch grab
L12-01-17-P-R-S-00	Uniform	S	431.4	427.0	865766	827944	Root 59-inch composite
L12-01-19-P-S-S-00	Uniform	S	432.9	432.4	865856	827996	Surface 6-inch grab
L12-01-20-P-R-S-00	Uniform	S	432.4	428.0	865856	827996	Root 59-inch composite
L12-01-22-P-S-S-00	Uniform	S	431.2	430.7	865947	828153	Surface 6-inch grab
L12-01-23-P-R-S-00	Uniform	S	430.7	426.3	865947	828153	Root 59-inch composite
L12-01-01-P-S-Q-00	Uniform	Q	428.0	427.5	865494	827473	Surface 6-inch grab
L12-01-13-P-S-Q-00	Uniform	Q	434.6	434.2	865766	827839	Surface 6-inch grab
L12-01-25-P-S-B-00	Uniform	B	435.0	434.5	865960.1	828106.4	Biased 6-inch grab

Green shaded samples are the ~~topmost~~ samples at each sample location, for use in WRS Test.

*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) or Uniform DCGLs used

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

Quality Record

6.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 12-01 one (1) biased sample location was selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. This biased location represented the maximum GWS measurement encountered within the SU. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

6.4 Judgmental/Sidewall Sampling for Tc-99

As an un-excavated Class 2 SU, no Tc-99 sidewall sampling was necessary for LSA 12-01.

6.5 Quality Control Soil Sampling

Two QC field duplicate sample point were randomly selected and collected at systematic locations L12-01-01 and L12-01-13 for LSA 12-01.

7.0 FINAL STATUS SURVEY RESULTS LSA 12-01

7.1 Gamma Walkover Survey

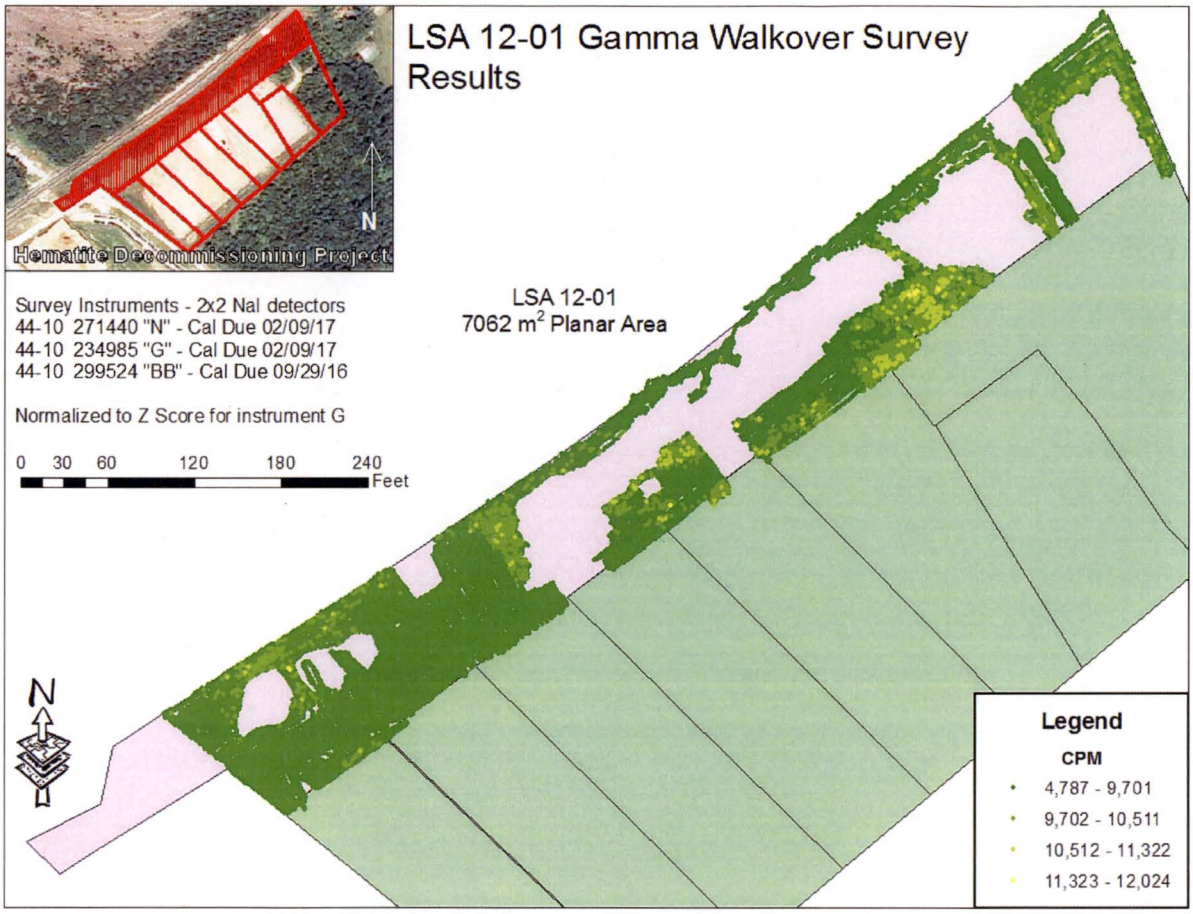
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are plotted "on top" (e.g. if any slopped areas featured more elevated readings than the floor directly below, the sloped area radiological measurements would overlie the lower floor readings).

GWS measurements were collected in LSA 12-01 between May 3, 2016, and May 4, 2016.

7.1.1 GWS Results for LSA 12-01

For LSA 12-01, GWS count rates ranged between 4,787 gcpm and 12,024 gcpm, with a mean count rate of 8,891gcpm. The median count rate was 8,405 gcpm and the standard deviation was 810 cpm. Figure 7-1 below presents a map of the complete GWS data set.

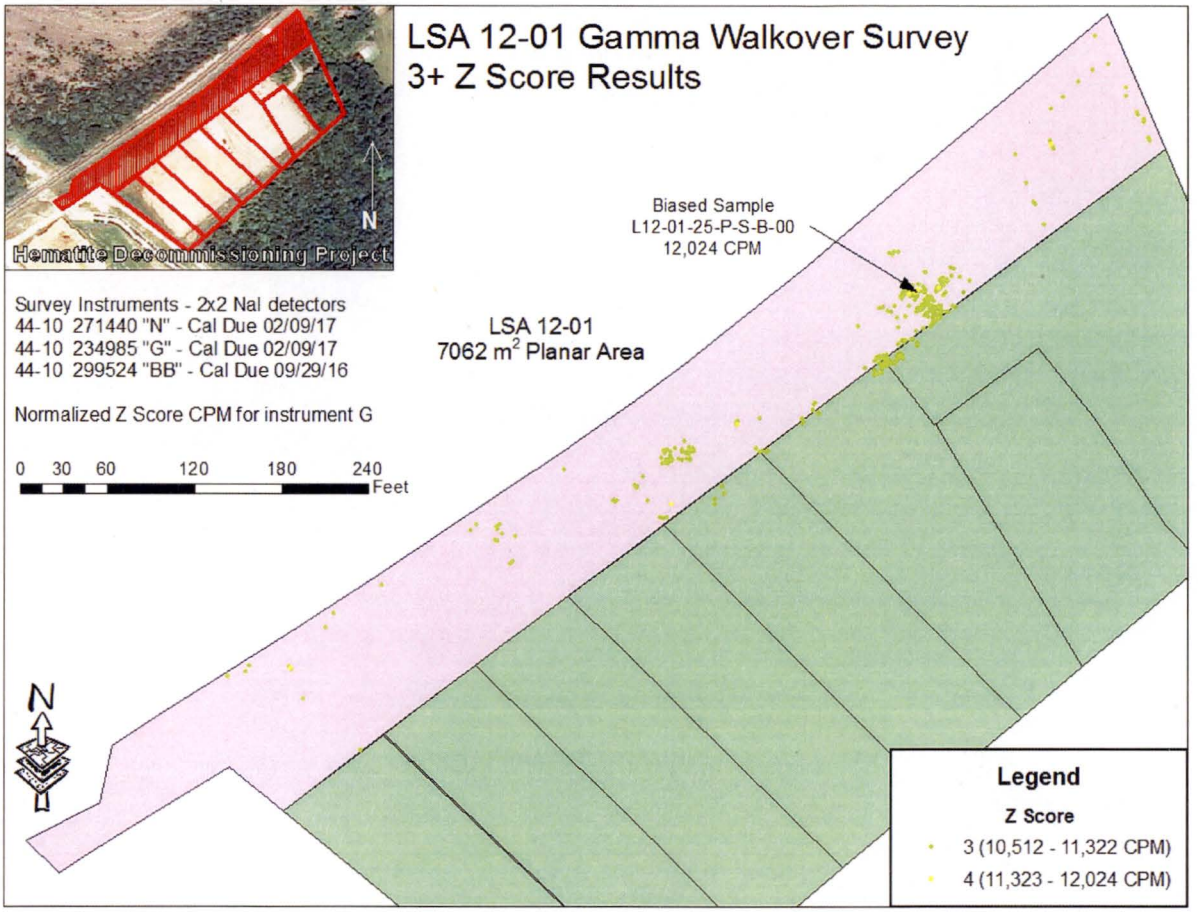
Figure 7-1
Colorimetric GWS Plot for LSA 12-01



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location, L12-01-25, was selected for biased sample collection. This biased location represented the maximum GWS measurement encountered within the SU.

Figure 7-2 below presents a map of the +3 Z-score GWS measurements within LSA 12-01, including the selected biased sampling location (ID: L12-01-25-P-S-B-00).

Figure 7-2
Colorimetric GWS Plot for LSA 12-01 (Measurements > Z-score of 3)



All GWS data collected in LSA 12-01 was datalogged and post-processed in Graphical Information Software (GIS).

7.1.2 GWS Coverage Results LSA 12-01

As a Class 2 SU, LSA 12-01 was required to be subject to a minimum of a 50% GWS in accordance with the FSS plans. The actual FSS GWS achieved 53.7% GWS coverage exceeding the minimum requirement.

7.2 Soil Sample Results LSA 12-01

Appendix A presents the analytical results and associated statistics for all FSS samples collected within LSA 12-01.

7.2.1 Surface Soil Sample Results LSA 12-01

There were eight systematic samples collected within the surface stratum (0 – 15 cm) of LSA 12-01. ~~Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was not required for LSA 12-01 since the difference between~~

~~the maximum survey unit gross SOF and the minimum background area adjusted SOF was less than one. However, for illustrative purposes, the WRS evaluation was performed and is included in Appendix A. Biased and QC sample results are not utilized in the WRS Test. The eight systematic samples collected in the "topmost" excavation surface layer were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (784) was greater than the critical value (705) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_w$ was rejected.~~ Additionally there were two QC samples, and one biased sample collected in the surface layer of soil. The maximum Uniform SOF result for the "topmost" samples was 0.04.

~~Appendix A presents the analytical results and associated statistics for all FSS samples collected within LSA 12-01.~~

7.2.2 Subsurface Soil Sample Results LSA 12-01

There were eight systematic locations within LSA 12-01 where root stratum composite sampling was necessary. The root stratum zone is between 0.15 and 1.50 m below final grade surface. At each of the eight root stratum composite sampling locations, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected and archived, however these excavation samples were not required to be analyzed as no overlying root stratum sample exceeded a 0.5 SOF. The maximum SOF result of the subsurface samples collected in LSA 12-01 was 0.19.

~~These subsurface samples are presented in Appendix A.~~

7.2.3 WRS Evaluation

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was not required for LSA 12-01 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was less than one using the Uniform Stratum criteria. However, for illustrative purposes, the WRS evaluation was still performed for LSA 12-01. All systematically collected samples regardless of depth are used to perform the WRS Test, however biased and QC sample results are not utilized in the WRS Test. The 16 systematically collected samples in LSA 12-01 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (1040) was greater than the critical value (860) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix A.

7.2.4 Graphical Data Review LSA 12-01

Table 7-1 below presents summary results for the all systematically collected samples (includes surface, root, and excavation stratum samples (none analyzed in this SU), but not biased or QC samples) collected within LSA 12-01, and the associated SOF when compared to the Uniform Stratum $DCGL_w$s. The arithmetic average concentration resulted in a SOF of 0.04.

Table 7-1
LSA 12-01 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Uniform DCGL)
Average	0.009	0.115	0.033	1.327	0.023	0.913	**0.04**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.067	-0.133	0.421	0.01
Maximum	0.080	0.664	0.270	3.716	0.204	1.390	0.19

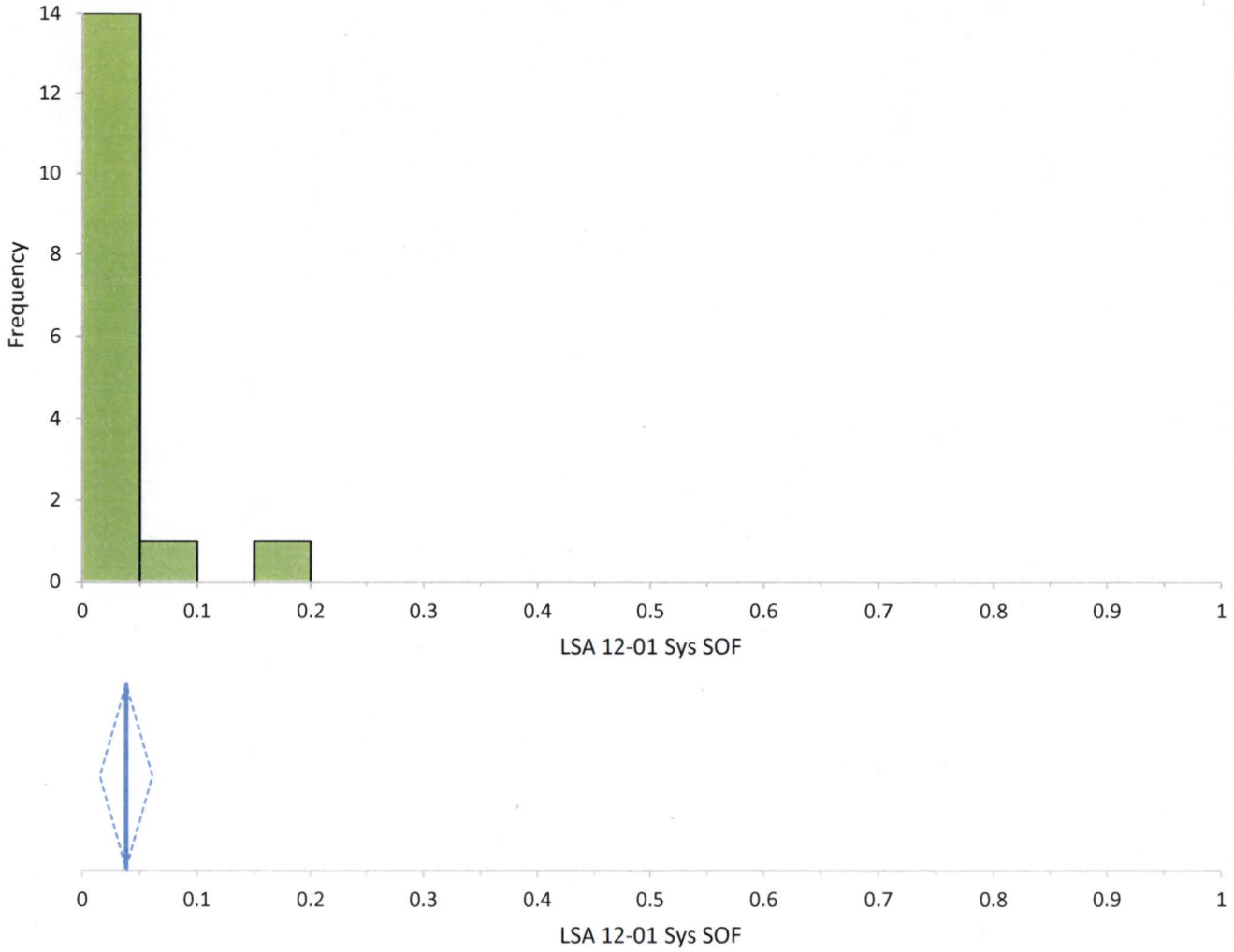
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide concentrations.
3. U-234 values are inferred from the U-235/U-238 ratio.

Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within a certain range of values. The frequency plot will reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution for the survey unit. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 7-3 presents the overall statistical metrics for the SOF parameter for the 16 systematically collected samples from LSA 12-01. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 12-01. The middle graph presents the mean SOF (0.04 as indicated by the blue vertical line) of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.02 to 0.06. The 97.9% confidence interval based on the median (0.03) of the sample results is 0.01 to 0.04. The bottom two charts present the various statistical metrics of the LSA 12-01 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 7-3 exhibits no unusual symmetry or bimodality concerns for the LSA 12-01 data associated with the systematically collected measurement locations.

Figure 7-3
Graphic Statistical Summary for LSA 12-01 (SOF parameter)



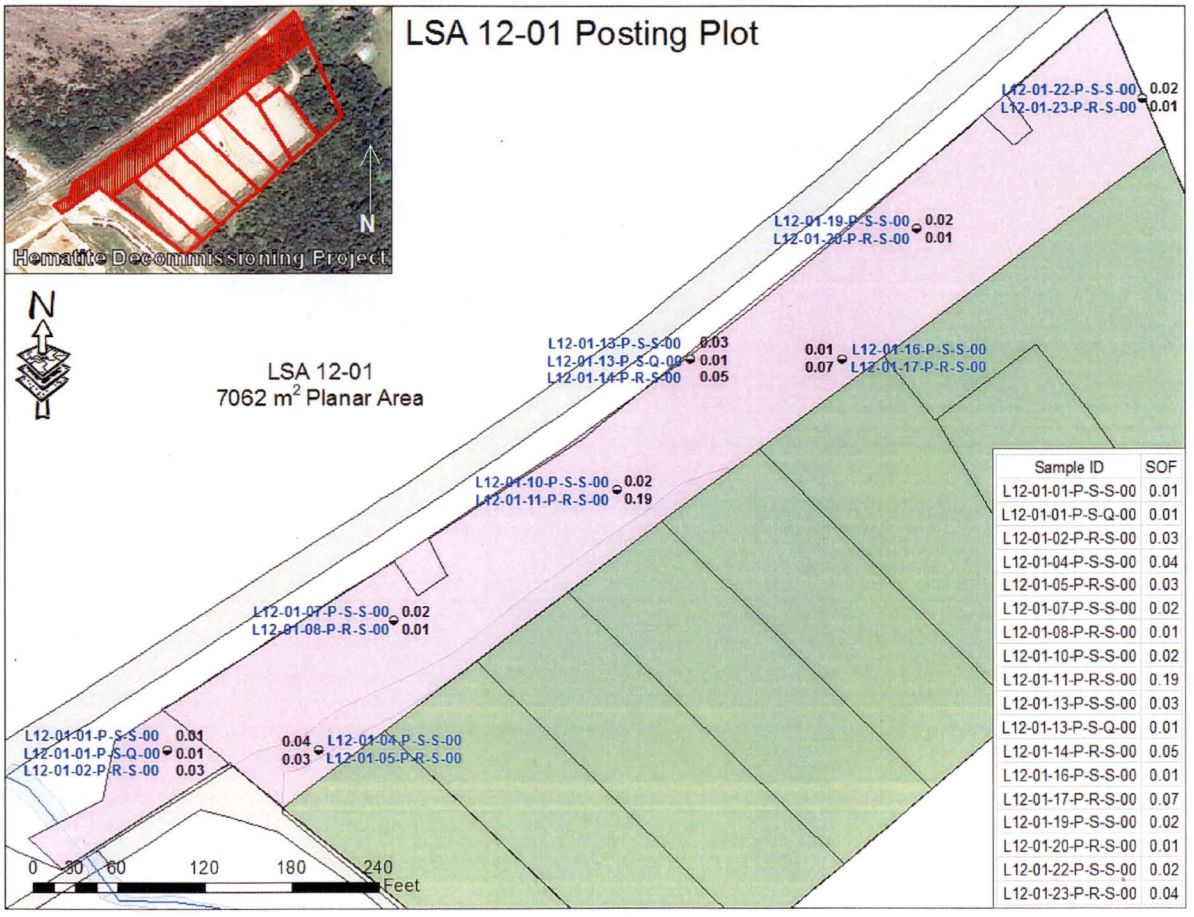
	N
	16

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 12-01 Sys SOF	0.04	0.02	to 0.06	0.011	0.04	0.00	3.1	10.52

	Minimum	1st quartile	Median	97.87% CI		3rd quartile	Maximum	IQR
LSA 12-01 Sys SOF	0.01	0.01	0.03	0.01	to 0.04	0.04	0.2	0.03

A posting plot is simply a map of the survey unit with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 12-01 is presented below in Figure 7-4. Figure 7-4 shows no unusual patterns in the data.

Figure 7-4
Posting Plot for LSA 12-01 Systematic Measurement Locations



Sample ID	SOF
L12-01-01-P-S-S-00	0.01
L12-01-01-P-S-Q-00	0.01
L12-01-02-P-R-S-00	0.03
L12-01-04-P-S-S-00	0.04
L12-01-05-P-R-S-00	0.03
L12-01-07-P-S-S-00	0.02
L12-01-08-P-R-S-00	0.01
L12-01-10-P-S-S-00	0.02
L12-01-11-P-R-S-00	0.19
L12-01-13-P-S-S-00	0.03
L12-01-13-P-S-Q-00	0.01
L12-01-14-P-R-S-00	0.05
L12-01-16-P-S-S-00	0.01
L12-01-17-P-R-S-00	0.07
L12-01-19-P-S-S-00	0.02
L12-01-20-P-R-S-00	0.01
L12-01-22-P-S-S-00	0.02
L12-01-23-P-R-S-00	0.04

Appendix A to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 7-1, Figure 7-3, and Figure 7-4 above. A summary of the analytical data is presented in Table 7-2 below. Appendix E to this report presents the TestAmerica Analytical Laboratory soil sample reports.

Table 7-2
Final Status Survey Analytical Data: LSA 12-01

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			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 (%)	SOF
L12-01-01-P-S-S-00	0.50	S	0.777	0.112	0.0472	N/A	-0.293	0.000	0.156	0.156	0.096	0.227	U	0.72	0.116	0.093	N/A	-0.280	0.000	0.067	NA	NA	NA	0.0015	0.003	0.459	U	0.856	0.391	0.594	N/A	0.1	0.01
L12-01-02-P-R-S-00	4.85	S	0.904	0.129	0.0504	N/A	-0.166	0.000	0.664	0.664	0.084	0.256	N/A	0.85	0.133	0.091	N/A	-0.150	0.000	0.719	NA	NA	NA	-8E-04	0.0048	0.345	U	0.719	0.449	0.706	N/A	0.7	0.03
L12-01-04-P-S-S-00	0.50	S	0.905	0.14	0.0657	N/A	-0.165	0.000	0.278	0.278	0.123	0.228	N/A	0.851	0.149	0.138	N/A	-0.149	0.000	3.054	NA	NA	NA	0.167	0.14	0.185	U	1.01	0.541	0.838	N/A	2.6	0.04
L12-01-05-P-R-S-00	4.85	S	0.993	0.145	0.0709	N/A	-0.077	0.000	0.0074	0.007	0.055	0.246	U	1.03	0.16	0.0969	N/A	0.030	0.030	1.752	NA	NA	NA	0.0942	0.283	0.47	U	0.771	0.277	0.756	N/A	1.9	0.03
L12-01-07-P-S-S-00	0.50	S	0.627	0.118	0.0678	N/A	-0.443	0.000	0.141	0.141	0.041	0.234	U	0.773	0.159	0.0745	N/A	-0.227	0.000	1.110	NA	NA	NA	-0.099	0.146	0.505	U	1.11	0.59	0.742	N/A	0.7	0.02
L12-01-08-P-R-S-00	4.85	S	0.867	0.124	0.0548	N/A	-0.203	0.000	0.0211	0.021	0.079	0.234	U	0.953	0.14	0.103	N/A	-0.047	0.000	1.109	NA	NA	NA	0.055	0.123	0.469	U	0.991	0.49	0.758	N/A	0.9	0.01
L12-01-10-P-S-S-00	0.50	S	0.799	0.133	0.0879	N/A	-0.271	0.000	0.239	0.239	0.066	0.249	U	0.747	0.174	0.109	N/A	-0.253	0.000	0.404	NA	NA	NA	0.0087	0.0134	0.683	U	1.39	0.582	0.865	N/A	0.1	0.02
L12-01-11-P-R-S-00	4.85	S	1.15	0.16	0.0688	N/A	0.080	0.080	0.0255	0.026	0.076	0.231	U	1.27	0.193	0.0902	N/A	0.270	0.270	0.850	NA	NA	NA	-0.044	0.105	0.541	U	0.85	0.346	0.83	N/A	0.7	0.19
L12-01-13-P-S-S-00	0.50	S	0.881	0.144	0.0697	N/A	-0.189	0.000	0.0448	0.045	0.113	0.263	U	0.9	0.169	0.114	N/A	-0.100	0.000	3.716	NA	NA	NA	0.204	0.148	0.202	N/A	1.1	0.741	0.931	N/A	2.9	0.03
L12-01-14-P-R-S-00	4.85	S	1.03	0.153	0.0698	N/A	-0.040	0.000	-0.0303	0.000	0.097	0.276	U	1.07	0.174	0.122	N/A	0.070	0.070	1.495	NA	NA	NA	0.0778	0.225	0.387	U	0.963	0.485	0.741	N/A	1.3	0.05
L12-01-16-P-S-S-00	0.50	S	0.647	0.121	0.0778	N/A	-0.423	0.000	0.215	0.215	0.082	0.259	U	0.762	0.142	0.102	N/A	-0.238	0.000	0.421	NA	NA	NA	-0.133	0.183	0.594	U	0.421	0.236	1.51	U	0.7	0.01
L12-01-17-P-R-S-00	4.85	S	1.13	0.153	0.0641	N/A	0.060	0.060	-0.0352	0.000	0.07	0.251	U	1.07	0.163	0.0721	N/A	0.070	0.070	0.748	NA	NA	NA	-0.113	0.319	0.528	U	0.748	0.292	0.748	N/A	0.7	0.07
L12-01-19-P-S-S-00	0.50	S	0.962	0.171	0.0964	N/A	-0.108	0.000	0.0245	0.025	0.026	0.272	U	0.985	0.189	0.126	N/A	-0.015	0.000	1.751	NA	NA	NA	0.0954	0.326	0.541	U	0.616	0.302	0.867	U	2.4	0.02
L12-01-20-P-R-S-00	4.85	S	0.947	0.132	0.0516	N/A	-0.123	0.000	0.0179	0.018	0.064	0.256	U	0.956	0.162	0.0955	N/A	-0.044	0.000	1.028	NA	NA	NA	0.05	0.148	0.489	U	1.02	0.554	0.738	N/A	0.8	0.01
L12-01-22-P-S-S-00	0.50	S	0.873	0.133	0.0593	N/A	-0.197	0.000	-0.0321	0.000	0.071	0.247	U	1.03	0.184	0.115	N/A	0.030	0.030	0.891	NA	NA	NA	-0.103	0.234	0.409	U	0.891	0.287	0.744	N/A	0.7	0.02
L12-01-23-P-R-S-00	4.85	S	0.944	0.152	0.0885	N/A	-0.126	0.000	-0.0249	0.000	0.043	0.249	U	1.05	0.182	0.104	N/A	0.050	0.050	2.122	NA	NA	NA	0.112	0.214	0.531	U	1.15	0.573	0.882	N/A	1.5	0.04
L12-01-01-P-S-Q-00	0.50	Q	0.789	0.127	0.0567	N/A	-0.281	0.000	0.241	0.241	0.064	0.241	N/A	0.695	0.145	0.111	N/A	-0.305	0.000	0.420	NA	NA	NA	-0.007	0.0092	0.494	U	0.42	0.256	0.713	U	0.7	0.01
L12-01-13-P-S-Q-00	0.50	Q	0.926	0.125	0.0484	N/A	-0.144	0.000	-0.0027	0.000	0.019	0.268	U	0.789	0.131	0.0868	N/A	-0.211	0.000	0.844	NA	NA	NA	-0.008	0.0158	0.489	U	0.844	0.275	0.7	N/A	0.7	0.01
L12-01-25-P-S-B-00	0.50	B	0.97	0.145	0.075	N/A	-0.100	0.000	0.172	0.172	0.066	0.21	U	0.782	0.145	0.135	N/A	-0.218	0.000	1.065	NA	NA	NA	0.0518	0.0633	0.627	U	1.04	0.342	0.856	N/A	0.8	0.02
Systematic Minimum			0.000						0.000					0.000						0.067				-0.133				0.421				1.1	0.01
Systematic Maximum			0.080						0.664					0.270						3.716				0.204				1.390				Average Enrichment (%)	0.19
Systematic Mean			0.009						0.115					0.033						1.327				0.023				0.913					0.04
Systematic Median			0.000						0.025					0.000						1.069				0.029				0.927					0.03
Systematic Standard Deviation			0.024						0.175					0.068						0.976				0.102				0.232					0.04
			With ingrowth, use Ra226 bkg =					1.07						Th232 bkg =		1.0																		

NOTES:

Gross results in units of pCi/g.

* Background with ingrowth (1.07 pCi/g) subtracted from gross result.

**Background (1.0 pCi/g) subtracted from gross result.

U Qualifier: Result is less than the sample detection limit.

All uncertainty values are reported at the 2-sigma confidence level.

7.2.5 Biased Soil Sample Result LSA 12-01

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 12-01 one (1) biased sample location was selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. This biased location represented the maximum GWS measurement encountered within the SU. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

7.2.6 Quality Control Soil Sample Result LSA 12-01

Two QC field duplicate sample points were randomly selected for LSA 12-01 which were collected at systematic locations L12-01 -01 and L12-01-13.

For the 17 samples (i.e., 16 systematic + 1 biased) collected within LSA 12-01, two field duplicate samples were collected. This frequency equates to 11.8%, (i.e. 2/17). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated warning limits (see Figure 7-5 below).

Figure 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 12-01 (1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control		
		Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.:	LSA 12-01				Survey Unit Description:		Class 2 Laydown Land Area in "Area 13"					
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
			Activity (x_i)	MDC	Activity (x_i)	MDC						
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	Ra-226	0.777	0.0472	0.789	0.0567	0.783	1.9	0.012	0.269	0.403	N
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	Tc-99	0.156	0.227	0.241	0.241	0.199	25.1	NA	3.552	5.321	NA
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	Th-232	0.72	0.093	0.695	0.111	0.708	2.0	0.025	0.283	0.424	N
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	U-234[1]	0.067	N/A	0.420	N/A	0.244	195.4	0.353	27.649	41.425	N
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	U-235	0.00145	0.459	-0.00666	0.494	-0.003	51.6	NA	7.301	10.939	NA
L12-01-01-P-S-S-00	L12-01-01-P-S-Q-00	U-238	0.856	0.594	0.42	0.713	0.638	168.8	NA	23.885	35.786	NA

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy / [signature]

Date: 11-23-16

Reviewed by: W. Clark Evers / [signature]

Date: 11/23/16

Quality Record

Figure 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 12-01 (2 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control	Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.:	LSA 12-01				Survey Unit Description:		Class 2 Laydown Land Area in "Area 13"					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$)	Nuclide DCGL				Statistic Exceeds Limit?
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	(pCi/g)	(pCi/g)	Statistic[2]	Warning Limit	Control Limit	(Y/N)
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	Ra-226	0.881	0.0697	0.926	0.0484	0.904	1.9	0.045	0.269	0.403	N
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	Tc-99	0.0448	0.263	-0.00268	0.268	0.021	25.1	NA	3.552	5.321	NA
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	Th-232	0.9	0.114	0.789	0.0868	0.845	2.0	0.111	0.283	0.424	N
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	U-234[1]	3.716	N/A	0.844	N/A	2.280	195.4	2.872	27.649	41.425	N
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	U-235	0.204	0.202	-0.00837	0.489	0.098	51.6	NA	7.301	10.939	NA
L12-01-13-P-S-S-00	L12-01-13-P-S-Q-00	U-238	1.1	0.931	0.844	0.7	0.972	168.8	0.256	23.885	35.786	N

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy / [signature] Reviewed by: W. Clark Eves / W. Clark Eves

Date: 11-23-16 Date: 11/23/16

Quality Record

7.3 Tc-99 Hot Spot Assessment LSA 12-01

A review of the available data shows that as a Class 2 LSA SU there is no history of a Tc-99 sample result ever exceeding the Tc-99 Uniform $DCGL_W$. The highest Tc-99 sample result collected from both Final RASS and FSS was 0.66 pCi/g.

8.0 ALARA EVALUATION LSA 12-01

All samples collected within LSA 12-01 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 12-01 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.04 for LSA 12-01. The average SOF equates to residual activity contributions from the survey unit area of 1.0 mrem/yr for LSA 12-01. Groundwater Monitoring Well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528} and Chapter 4 {ML16342B552}, indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/yr based upon the U.S. Environmental Protection Agency (EPA) MCLs will be added to the total estimated dose for LSA 12-01. Adding these dose contributions together, the total estimated dose for LSA 12-01 is 5 mrem/yr.

Since the estimated Total Effective Dose Equivalent is well below the regulatory release criterion of 25 mrem/yr, the conclusion of the ALARA evaluation is that the FSS of LSA 12-01 was successful and that there would be no discernable benefit to the health and safety of the public in attempting to further reduce the results of FSS by performing remediation of LSA 12-01.

9.0 FSS PLAN DEVIATIONS LSA 12-01

9.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 12-01.

9.2 Adjustments to Scan MDC Calculations

As previously stated in Section 5.1.5, Scan MDCs for LSA 12-01 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD-FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. The assumed LSA background count rate of 9,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 8,891 cpm. Therefore the calculated Scan MDCs are conservative, and no adjustments need to be made.

10.0 DATA QUALITY ASSESSMENT

The Data Quality Objective (DQO) process is thoroughly integrated within the DP and Hematite FSS procedures. The steps of the DQO process are presented in Volume 3, Chapter 1, Section 4.0 of the FSSFR and correspond to the DQO steps described in Chapter 14, Section 4.2.1 of the DP. The HDP DQO process reflects the recommendations given in MARSSIM, Chapter 2, Figure 2-2.

10.1 Data Quality Assessment for LSA 12-01

The Data Quality Assessment of the survey methodology, sampling and sample analysis results, and the Quality Control sampling and analysis results to ascertain the validity of the conclusion for LSA 12-01 (see Figure 10-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 12-01 survey and sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721 *Final Status Survey Data Validation*.
- The WRS Test is not necessary when the difference between the maximum survey unit data set measurement SOF and the minimum background area measurement SOF is less than or equal to one. For LSA 12-01, no individual gross SOF result in the FSS data set exceeded the SOF of the minimum background reference area measurement by more than one using the Uniform Stratum criteria. Therefore, the WRS Test was not required for LSA 12-01. However, the WRS Test was still performed for illustrative purposes. Since the test statistic, WR (1040) exceeded the critical value (860), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix A.

- ~~Eight systematic samples were collected at the excavation surface layer. For LSA 12-01, no individual gross SOF results in the FSS data set exceeded the $DCGL_W$ (SOF of 1.0) by more than the adjusted SOF of the minimum background reference area result using the Uniform Stratum criteria. Therefore, the WRS Test was not required for LSA 12-01. The WRS Test worksheet is presented in Appendix A.~~
- A biased soil sample was collected from the location of the highest gamma count rate within the SU, and the result was a 0.02 Uniform SOF.
- The maximum SOF result for all surface samples within LSA 12-01 was 0.04. The maximum SOF result for all subsurface samples within LSA 12-01 was 0.19. The average SOF result for all systematically collected samples within LSA 12-01 was 0.04, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.06.
- No FSS sample result in LSA 12-01 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an elevated measurement comparisons (EMC) or supplemental investigations was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (8) of systematic samples actually collected within LSA 12-01. The successful result of the retrospective power evaluation presented in Table 10-1 for LSA 12-01 indicates that the minimum number of samples required (8) for the WRS Test were equal to the number of sampling locations actually collected within LSA 12-01. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight topmost excavation surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.
- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures were performed periodically, and confirmed that there were no instances of potential cross contamination from weather events until the FSS of all remaining areas at HDP were completed.

Table 10-1
Retrospective Sample Size Verification for LSA 12-01

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.04
$DCGL_{SOF}$	1
LBGR (Mean)	0.04
Shift	0.96
Relative Shift (Δ/σ)	22.33
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS 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

Figure 10-1
Data Evaluation Checklists prepared for LSA 12-01 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
		Revision: 10	Appendix G-1, Page 1 of 2

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA
Survey Unit: 01 **Description:** Class 2 Laydown Land Area in "Area 13"

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FSS been individually reviewed and validated in accordance with Section 8.1 of this procedure?	Yes ☒	No ☐	
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
3.	Have all scans surveys been performed of the areas specified as required in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
4.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FSSP & the FSS Sample Instructions?	Yes ☒	No ☐	NA ☐
5.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☒	No ☐	NA ☐
6.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the appropriate investigation level?	Yes ☒	No ☐	
7.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use and were those calibrations performed using a NIST traceable source?	Yes ☒	No ☐	
8.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☒	No ☐	
9.	Do the samples match those identified on the chain of custody?	Yes ☒	No ☐	NA ☐
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒	No ☐	
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	

If "No" was the response to any of the questions above, then document the discrepancy as well as any corrective actions that were taken to resolve the discrepancy.

Comments: N/A

Quality Record

Figure 10-1
Data Evaluation Checklists prepared for LSA 12-01 (page 2 of 2)

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA
Survey Unit: 01 **Description:** Class 2 Laydown Land Area in "Area 13"

Discrepancy: N/A

Corrective Actions Taken: N/A

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐ NA ☒
    a. If "No", then forward this form to the RSO.
12. The following questions will be answered by the RSO.
    a. If the answer to question 11 was "No", then is the affected data still valid? Yes ☐ No ☐ NA ☒
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ NA ☒
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

	(Print Name)	(Signature)	(Date)
Prepared by (HP Staff):	Thomas Yardley		11-23-16
Approved by (RSO):	W. Mark Enoch		11/23/16

Quality Record

11.0 CONCLUSION LSA 12-01

An adequate quantity and quality of radiological surveys and samples, as well as the corresponding laboratory analysis has been performed, evaluated and documented to demonstrate that the dose associated with all sources within SU LSA 12-01 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402.

Table 11-1
LSA 12-01 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.04	N/A	0.16	N/A	N/A	**0.20**
DOSE	1.0 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**5.0 mrem/year**

12.0 FINAL STATUS SURVEY DESIGN LSA 12-02

This section describes the method for determining the number of samples required for the FSS of LSA 12-02 as well as summarizing the applicable requirements of the FSS Plan. These include the $DCGL_W$, scan survey coverage, and IAL. The radiological instrumentation used in the FSS of LSA 12-02 and their detection sensitivities are also discussed.

12.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 12-02 were driven by the type (Open Land) and Class (Class 2) of the survey unit and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

12.1.1 Surrogate Evaluation Areas

A discussion of Surrogate Evaluation Areas is given in the FSSFR Volume 3, Chapter 1, Section 5.0, *Final Status Survey Design.*

12.1.2 $DCGL_W$

During the FSS design process a review was performed of the RASS data for LSA 12-02. The RASS data was used as confirmation that no known areas of residual radioactivity remained within the survey areas that exceeded the Uniform Stratum $DCGL_W$. Therefore the Uniform Stratum $DCGL_W$ was selected for use in demonstrating compliance with the release criteria.

12.1.3 GWS Coverage

As a Class 2 SU, LSA 12-02 was required to undergo a minimum of a 50% GWS.

12.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 12-02 was the Ludlum 44-10 2" x 2" sodium iodide (NaI) detectors, coupled to a Ludlum 2221 scaler-ratemeter.

12.1.5 Scan Minimum Detectable Concentration

Scan MDCs for LSA 12-01 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD- FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS).* As background levels were approximately 9,000 counts per minute (cpm) within LSA 12-02, the scan minimal detection concentration (MDC) calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3471\,pCi/g}\right)+\left(\frac{f_{U-235}}{2.2pCi/g}\right)+\left(\frac{f_{U-238}}{29.0pCi/g}\right)\right)}$$

Equation 12-1

To determine isotopic Uranium fractions HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* assumes that the average LSA enrichment is 4% or less. Based on the systematically collected RASS samples in LSA 12-02, the average enrichment for the SU was 1.5%. All other Scan MDC parameters agreed upon between Westinghouse and the NRC were applied (e.g. use of a 2 in air gap, scan rate of 1 ft/sec, 0.75 surveyor efficiency), therefore no subsequent changes to the calculated Scan MDCs need to be made.

Prospectively calculated scan MDCs for 2" x 2" NaI detectors that were used in LSA 12-02 are shown below:

Table 12-1
Scan MDCs for 2" x 2" NaI detector, 9,000 cpm background: LSA 12-02

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 12-02	38.8	50.9	0.82	2.8	1.14	3.0

*$DCGL_w$ includes background concentrations of 0.9 pCi/g for Ra-226 (no ingrowth) and 1.0 pCi/g for Th-232. DCGLw values are based on the Uniform Stratum release criteria.

The values in Table 12-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

12.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum $DCGL_w$ 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 20 I 5. The IAL used during the GWS of LSA 12-01 was established at 1,624 net counts per minute (ncpm). This value is equivalent to the $DCGL_w$ for Uniform soil assuming a 4% Uranium enrichment, and using the inferred values for Tc-99 (Inferred Tc-99 values used for prospective scan calculations only).

12.1.7 LSA 12-02 FSS Design Summary

The FSS Plan for LSA 12-02 can be found in Appendix D. Table 12-2 presents an overall FSS design and implementation summary for LSA 12-02.

Table 12-2
FSS Design Summary for LSA 12-02

Gamma Walkover Survey (GWS):		
Scan Coverage	50% exposed soil and rock	
Scan MDC	38.8 pCi/g total Uranium (based on a 9,000 cpm background); 0.82 pCi/g Th-232; 1.14 pCi/g Ra-226*	
Investigation Action Level (IAL)	1,624 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	8	These samples will be taken on a random-start systematic grid.
15 cm – 1.5 m (Root)	8	
> 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 RSO or Radiological Engineering.		
Sidewall Sampling Locations:		
A minimum of one (1) discretionary sidewall sample will be collected based on the following definition of "sidewall": sidewall candidates for sampling must be vertical or near vertical (> 45° angle) and at least 12" in height.		
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).* The Scan MDC for total Uranium reflects a conservative assumption of 4% enrichment. The actual RASS enrichment (2.0%) would result in Scan MDC values slightly less than those calculated for FSS planning purposes.		
**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.		

13.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 12-02

FSS was performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment.*

13.1 Gamma Walkover Survey

13.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 12-02 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS (Digital Global Positioning System) and handheld data logger.

Prior to the first field use of the GWS instrumentation, initial set-ups were performed. Also, daily pre- and post-use source checks were performed for each day that GWS was performed within the SU. Initial set-ups, daily source checks, and control charting were performed according to the requirements of HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey*.

13.1.2 GWS Performance

All GWS measurements on the exposed SU surface collected with the NaI detector(s) were connected to a Trimble DGPS and with a hand-held data logger. The logging frequency in the SU was one (1) GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

The GWS requirements involved moving the NaI detector in a side-to-side fashion no faster than 1 foot per second while holding the probe as close as possible to the excavation surface (nominally 1", but not to exceed 3"). At the same time, the technician was required to slowly advance, causing the detector to trace out a serpentine path over the excavation surface.

FSS Technicians performing GWS in LSA 12-02 used the 1,624 ncpm IAL as a field guide to know when to slow or pause the GWS for more deliberate investigation. If during the GWS, audible count rates noticeably increase above the general area average (i.e., > minimum detectable count rate), FSS Technicians were required to pause momentarily and observe count rates. If sustained count rates approached the IAL, further focused investigation was conducted within the locally elevated area.

To use the IAL effectively, FSS Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to excavation geometry and relative distance from contaminated materials in nearby remedial excavations, the average background rate (measured at waist level) within the LSA ranged between 9,000 and 10,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 10,624 to 11,624 gcpm, FSS Technicians slowed or paused the GWS for more careful investigation of the small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

Hard to reach areas, and non-typical areas were surveyed manually as necessary in order to assess the potential for an area of elevated residual activity over 50% of the exposed excavation surface.

After the GWS survey was complete, the GPS/GWS data was reviewed by Radiological Engineering and the HP Technician performing the survey to determine if possible areas of elevated residual activity remained within the survey unit that required biased sample

investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

13.2 Soil Sampling

13.2.1 Systematic Soil Sampling Summary

Table 13-1 provides a summary of systematic sampling by stratum for LSA 12-02.

Table 13-1
Systematic Sampling Summary by Stratum for LSA 12-02

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
12-02	3,254	8	8	8*	2

*Excavation samples were collected and archived, analysis only required if a overlying Root sample exceeds a 0.5 SOF

13.2.2 Systematic Sampling LSA 12-02

Within LSA 12-02, there were 8 systematic locations in which the surface stratum [0 – 15 centimeters (cm)] was sampled in the SU. The underlying root stratum was sampled at all 8 locations. Excavation stratum samples were collected and archived, but were not required to be analyzed since no root stratum sample exceeded a 0.5 Uniform SOF.

Given a planar area of 7.062 m^2 for LSA 12-02 and an eight - point systematic triangular grid, the point-to-point distance within each row was 27.6 m with spacing of 31.9 m between each of the parallel grid rows within the SU.

While there were eight (8) systematic locations on the LSA 12-02 sampling grid, a total of eighteen (18) samples were collected and analyzed at these locations, including:

- Eight (8) samples collected and analyzed within the surface stratum
- Eight (8) samples collected and analyzed within the root stratum
- Zero (0) samples analyzed within the excavation, or "deep"
- Two (2) Quality Control (QC) field replicate

Figure 13-1 presents the map of the eight systematic sample locations which were sampled within LSA 12-02. The inset table notes the location coordinates (Missouri East, North American Datum (NAD) 1983) and collection intervals for each systematic location.

Figure 13-1
LSA 12-02 Systematic Soil Sample Locations

Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L12-02-01-P-S-S-00	0	6	865876	828158
L12-02-02-P-R-S-00	6	59	865876	828158
L12-02-03-P-E-S-00	59	65	865876	828158
L12-02-04-P-S-S-00	0	6	865815	828051
L12-02-05-P-R-S-00	6	59	865815	828051
L12-02-06-P-E-S-00	59	65	865815	828051
L12-02-07-P-S-S-00	0	6	865815	828122
L12-02-08-P-R-S-00	6	59	865815	828122
L12-02-09-P-E-S-00	59	65	865815	828122
L12-02-10-P-S-S-00	0	6	865815	828193
L12-02-11-P-R-S-00	6	59	865815	828193
L12-02-12-P-E-S-00	59	65	865815	828193
L12-02-13-P-S-S-00	0	6	865754	828016
L12-02-14-P-R-S-00	6	59	865754	828016
L12-02-15-P-E-S-00	59	65	865754	828016
L12-02-16-P-S-S-00	0	6	865754	828158
L12-02-17-P-R-S-00	6	59	865754	828158
L12-02-18-P-E-S-00	59	65	865754	828158
L12-02-19-P-S-S-00	0	6	865754	828229
L12-02-20-P-R-S-00	6	59	865754	828229
L12-02-21-P-E-S-00	59	65	865754	828229
L12-02-22-P-S-S-00	0	6	865692	828193
L12-02-23-P-R-S-00	6	59	865692	828193
L12-02-24-P-E-S-00	59	65	865692	828193
L12-02-01-P-S-Q-00	0	6	865876	828158
L12-02-11-P-R-Q-00	6	59	865815	828193

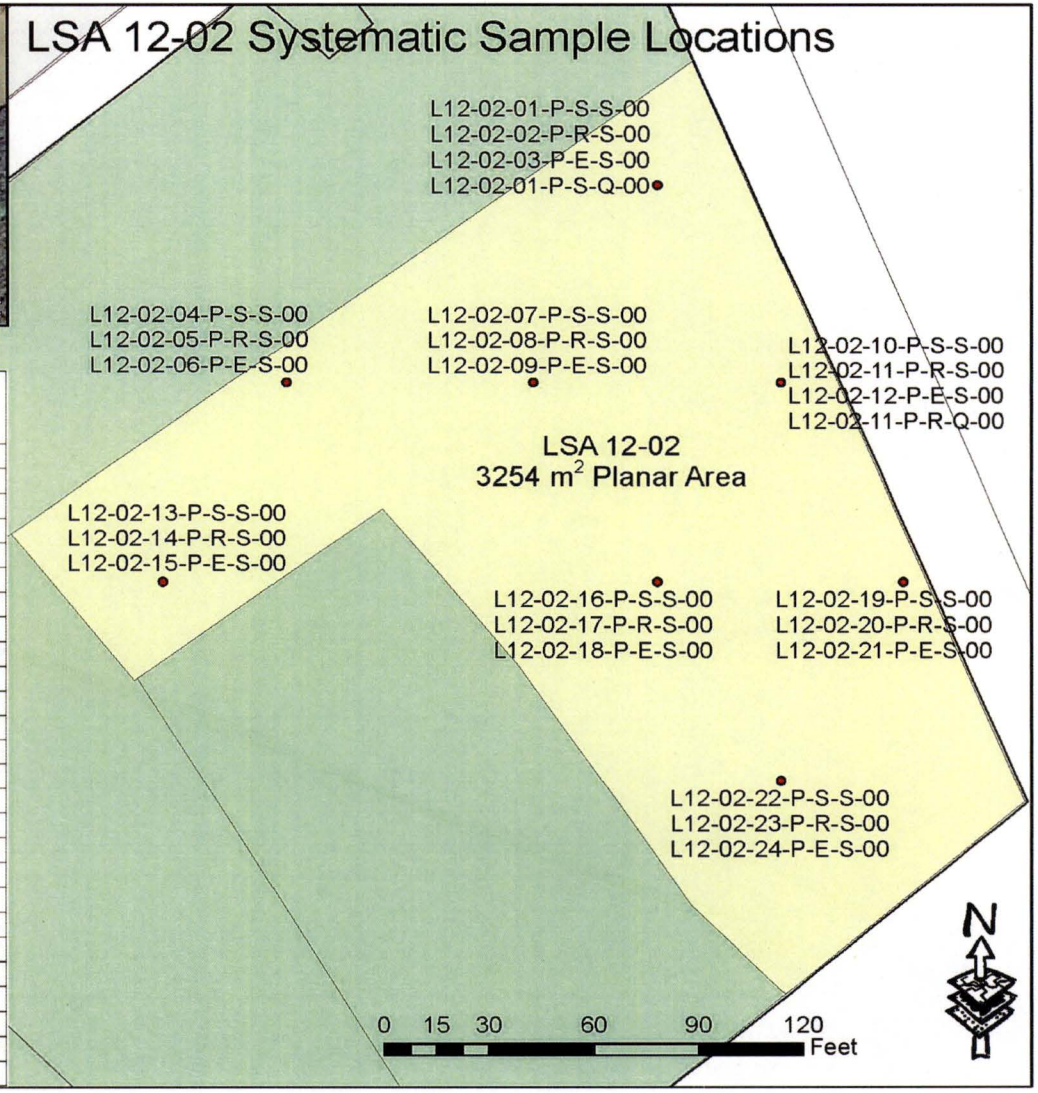


Figure 13-2 below presents a tabular listing of all FSS samples collected within LSA 12-02 with associated IDs, sample types, collection intervals, coordinates, and notes.

Figure 13-2
FSS Sample Locations and Coordinates for LSA 12-02

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
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APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA

Survey Unit: 02 **Description:** Class 2 Laydown Land Area in "Area 13"

Survey Type: FSS **Classification:** Class 2

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L12-02-01-P-S-S-00	Uniform	S	431.7	431.2	865876	828158	Surface 6-inch grab
L12-02-02-P-R-S-00	Uniform	S	431.2	426.8	865876	828158	Root 59-inch composite
L12-02-04-P-S-S-00	Uniform	S	430.8	430.4	865815	828051	Surface 6-inch grab
L12-02-05-P-R-S-00	Uniform	S	430.4	425.9	865815	828051	Root 59-inch composite
L12-02-07-P-S-S-00	Uniform	S	431.7	431.2	865815	828122	Surface 6-inch grab
L12-02-08-P-R-S-00	Uniform	S	431.2	426.7	865815	828122	Root 59-inch composite
L12-02-10-P-S-S-00	Uniform	S	431.0	430.5	865815	828193	Surface 6-inch grab
L12-02-11-P-R-S-00	Uniform	S	430.5	426.1	865815	828193	Root 59-inch composite
L12-02-13-P-S-S-00	Uniform	S	430.7	430.2	865754	828016	Surface 6-inch grab
L12-02-14-P-R-S-00	Uniform	S	430.2	425.7	865754	828016	Root 59-inch composite
L12-02-16-P-S-S-00	Uniform	S	430.4	429.9	865754	828158	Surface 6-inch grab
L12-02-17-P-R-S-00	Uniform	S	429.9	425.5	865754	828158	Root 59-inch composite
L12-02-19-P-S-S-00	Uniform	S	430.6	430.1	865754	828229	Surface 6-inch grab
L12-02-20-P-R-S-00	Uniform	S	430.1	425.6	865754	828229	Root 59-inch composite
L12-02-22-P-S-S-00	Uniform	S	430.7	430.2	865692	828193	Surface 6-inch grab
L12-02-23-P-R-S-00	Uniform	S	430.2	425.8	865692	828193	Root 59-inch composite
L12-02-01-P-S-Q-00	Uniform	Q	431.7	431.2	865876	828158	Surface 6-inch grab
L12-02-11-P-R-Q-00	Uniform	Q	430.5	426.1	865815	828193	Surface 6-inch grab
L12-02-25-P-S-B-00	Uniform	B	430.7	430.2	865664.5	828226.7	Biased 6-inch grab

Green shaded samples are the ~~topmost~~ samples at each sample location, for use in WRS Test.

*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) or Uniform DCGLs used

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

Quality Record

13.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 12-02 one (1) biased sample location was selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. This biased location represented the maximum GWS measurement encountered within the SU. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

13.4 Judgmental/Sidewall Sampling for Tc-99

As an un-excavated Class 2 SU, no Tc-99 sidewall sampling was necessary for LSA 12-02.

13.5 Quality Control Soil Sampling

Two QC field duplicate sample point were randomly selected and collected at systematic location L12-02-01 and L12-02-11 for LSA 12-02.

14.0 FINAL STATUS SURVEY RESULTS LSA 12-02

14.1 Gamma Walkover Survey

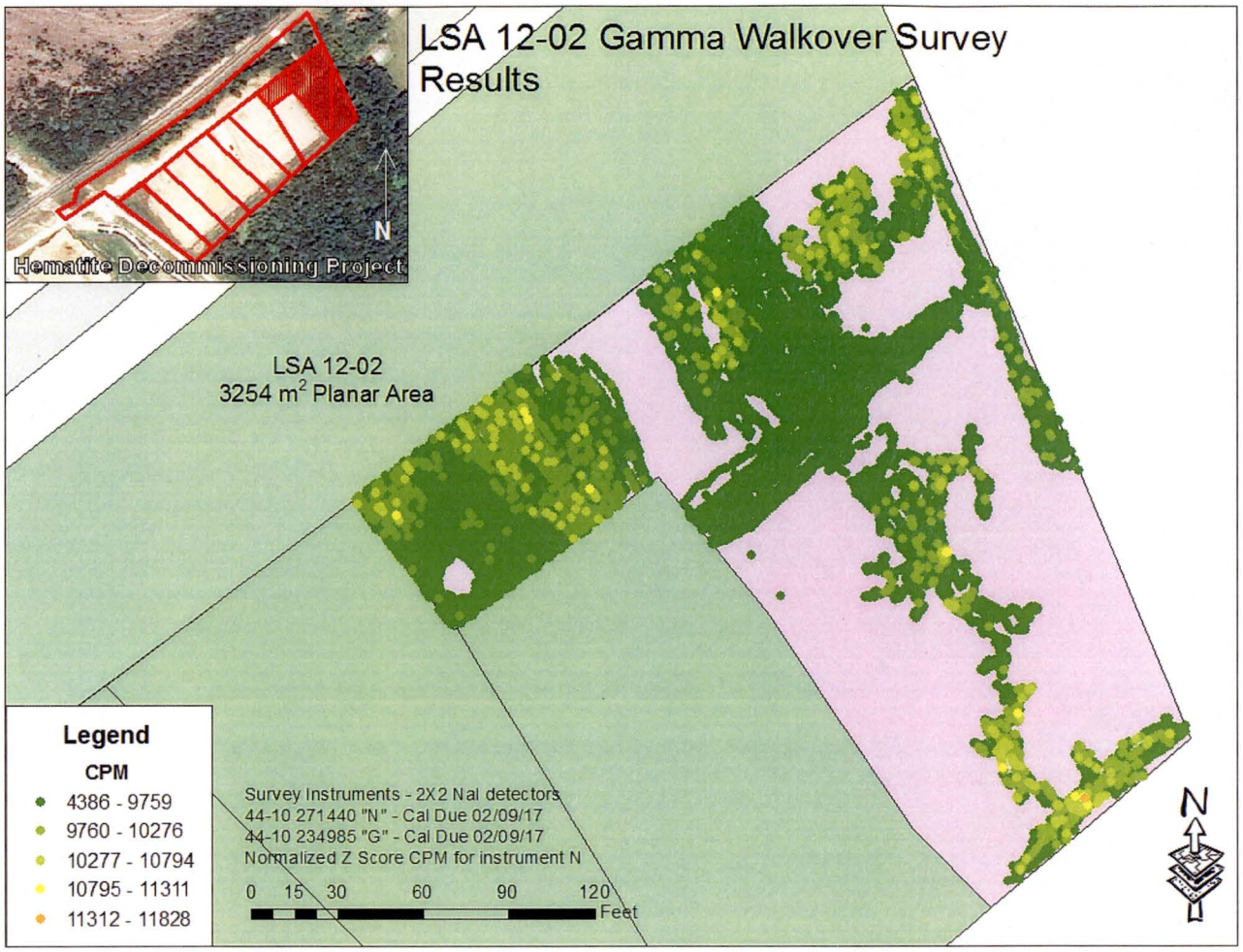
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are plotted "on top"(e.g. if any sloped areas featured more elevated readings than the floor directly below, the sloped area radiological measurements would overlie the lower floor readings).

GWS measurements were collected in LSA 12-02 on March 23, 2015.

14.1.1 GWS Results for LSA 12-02

For LSA 12-02, GWS count rates ranged between 4,386 gcpm and 11,828 gcpm, with a mean count rate of 9,470 gcpm. The median count rate was 8,107 gcpm with a standard deviation of 695 cpm. Figure 14-1 below presents a map of the complete GWS data set.

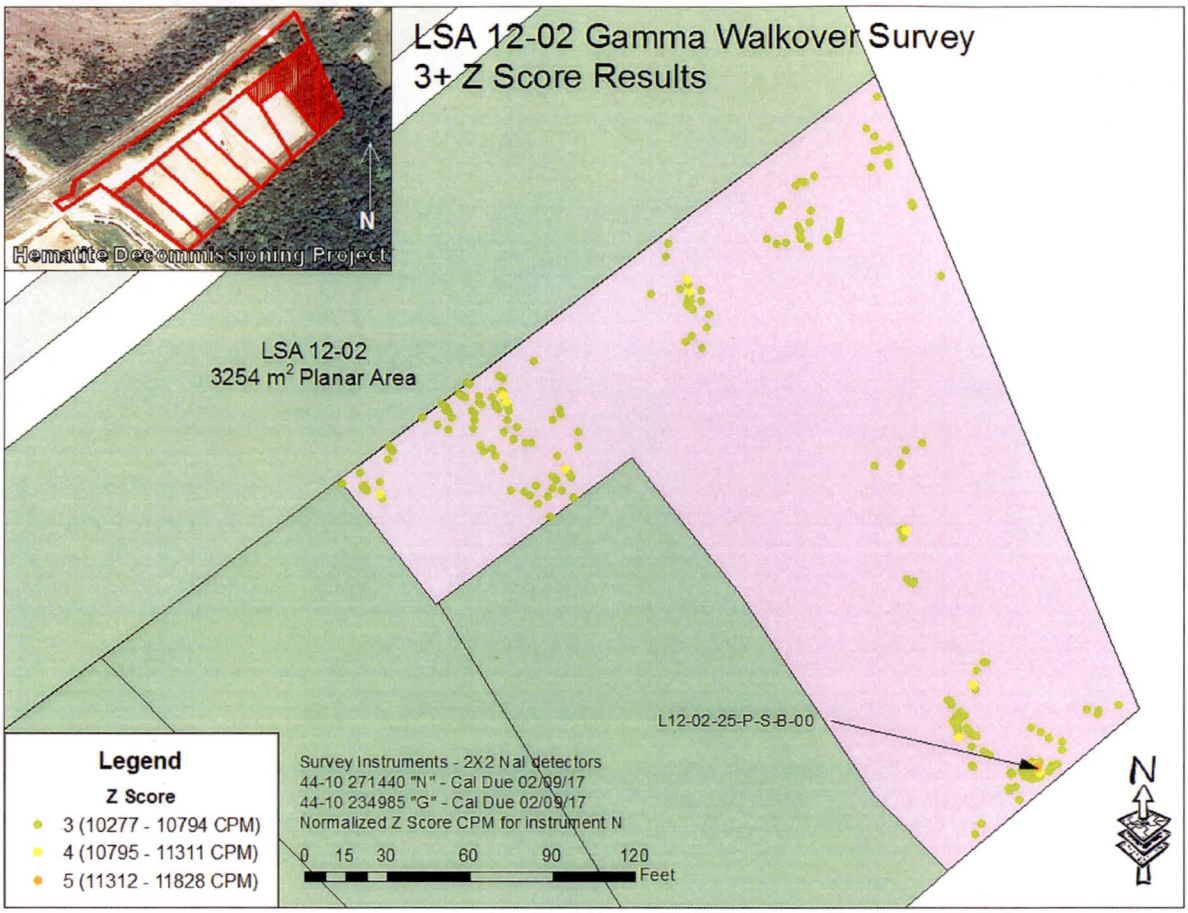
Figure 14-1
Colorimetric GWS Plot for LSA 12-02



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded both the IAL (> 4000 ncpm) and three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location (L12-02-25) was selected for biased sample collection. The sample collected at location L12-02-25 represented the maximum GWS measurement (11,828 gcpm) within the SU.

Figure 14-2 presents a map of the +3 Z-score GWS measurements within LSA 12-02, including the selected biased sampling location.

Figure 14-2
Colorimetric GWS Plot for LSA 12-02 (Measurements > Z-score of 3)



All GWS data collected in LSA 12-02 was datalogged and post-processed in GIS software.

14.1.2 GWS Coverage Results LSA 12-02

As a Class 2 SU, LSA 12-02 was required to be subject to a minimum of a 50% GWS in accordance with the FSS plans. The actual FSS GWS achieved 50.21% GWS coverage exceeding the minimum requirement.

14.2 Soil Sample Results LSA 12-02

Appendix B presents the analytical results and associated statistics for all FSS samples collected within LSA 12-02.

14.2.1 Surface Soil Sample Results LSA 12-02

There were eight systematic samples collected within the surface stratum (0 – 15 cm) of LSA 12-02. ~~Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was not required for LSA 12-02 since the difference between the maximum survey unit gross SOF and the minimum background area adjusted SOF was less~~

~~than one. However, for illustrative purposes, the WRS evaluation was performed and is included in Appendix A. Biased and QC sample results are not utilized in the WRS Test. The eight systematic samples collected in the "topmost" excavation surface layer were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The survey unit passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (784) was greater than the critical value (705) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_w$ was rejected.~~ Additionally there were two QC samples, and one biased sample collected from the topmost layer of soil. The maximum Uniform SOF result for the "topmost" samples was 0.15.

~~Appendix B presents the analytical results and associated statistics for all FSS surface samples collected within LSA 12-02.~~

14.2.2 Subsurface Soil Sample Results LSA 12-02

There were eight systematic locations within LSA 12-02 where root stratum composite sampling was necessary. The root stratum zone is between 0.15 and 1.50 m below final grade surface. At each of the eight root stratum composite sampling locations, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected and archived, however these excavation samples were not required to be analyzed as no overlying root stratum sample exceeded a 0.5 SOF. The maximum SOF result of the subsurface samples collected in LSA 12-02 was 0.30.

~~The results of the three subsurface samples collected in LSA 12-02 are also presented in Appendix B.~~

14.2.3 WRS Evaluation

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was not required for LSA 12-02 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was less than one using the Uniform Stratum criteria. However, for illustrative purposes, the WRS evaluation was still performed for LSA 12-02. All systematically collected samples regardless of depth are used to perform the WRS Test, however biased and QC sample results are not utilized in the WRS Test. The 16 systematically collected samples in LSA 12-02 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic W_R, (1040) was greater than the critical value (860) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix B.

14.2.4 Graphical Data Review LSA 12-02

Table 14-1 below presents summary results for the all systematically collected samples (includes surface, root, and excavation stratum samples, but not biased or QC samples) collected within LSA 12-02, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.09.

Table 14-1
LSA 12-02 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Uniform DCGL)
Average	0.025	0.091	0.104	2.319	0.070	1.079	**0.09**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.397	0.00 (NEG)	0.584	0.02
Maximum	0.190	0.355	0.340	7.278	0.402	1.380	0.30

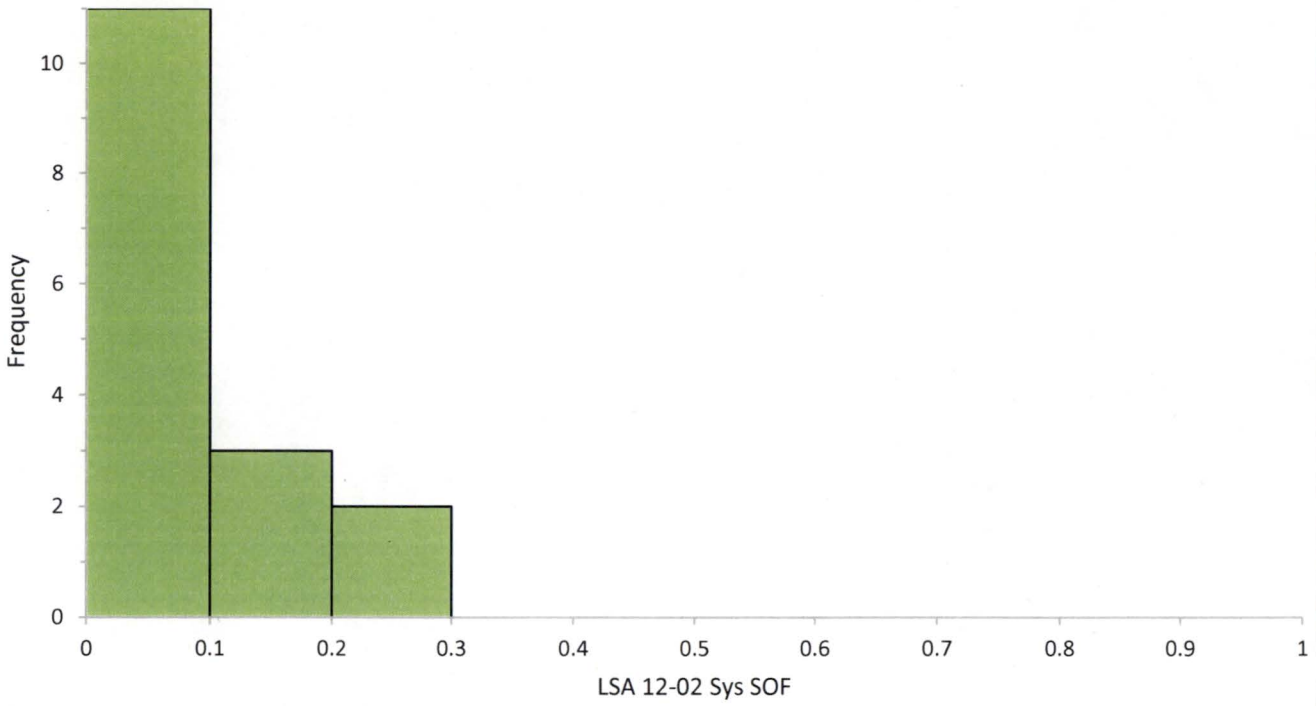
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide concentrations.
3. U-234 values are inferred from the U-235/U-238 ratio.

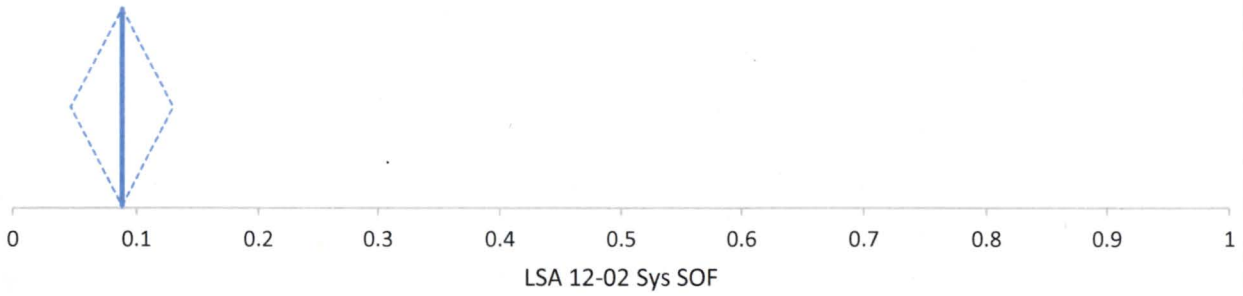
Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within a certain range of values. The frequency plot will reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution for the survey unit. The presence of two peaks in the survey unit frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 14-3 presents the overall statistical metrics for the SOF parameter for the 16 systematically collected samples from LSA 12-02. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 12-02. The middle graph presents the mean SOF (0.09) as indicated by the blue vertical line of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.05 to 0.13. The 97.87% confidence interval based on the median (0.06) of the sample results is 0.03 to 0.13. The bottom two charts present the various statistical metrics of the LSA 12-02 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 14-3 exhibits no unusual symmetry or bimodality concerns for the LSA 12-02 data associated with the systematically collected measurement locations.

Figure 14-3
Graphic Statistical Summary for LSA 12-02 (SOF parameter)





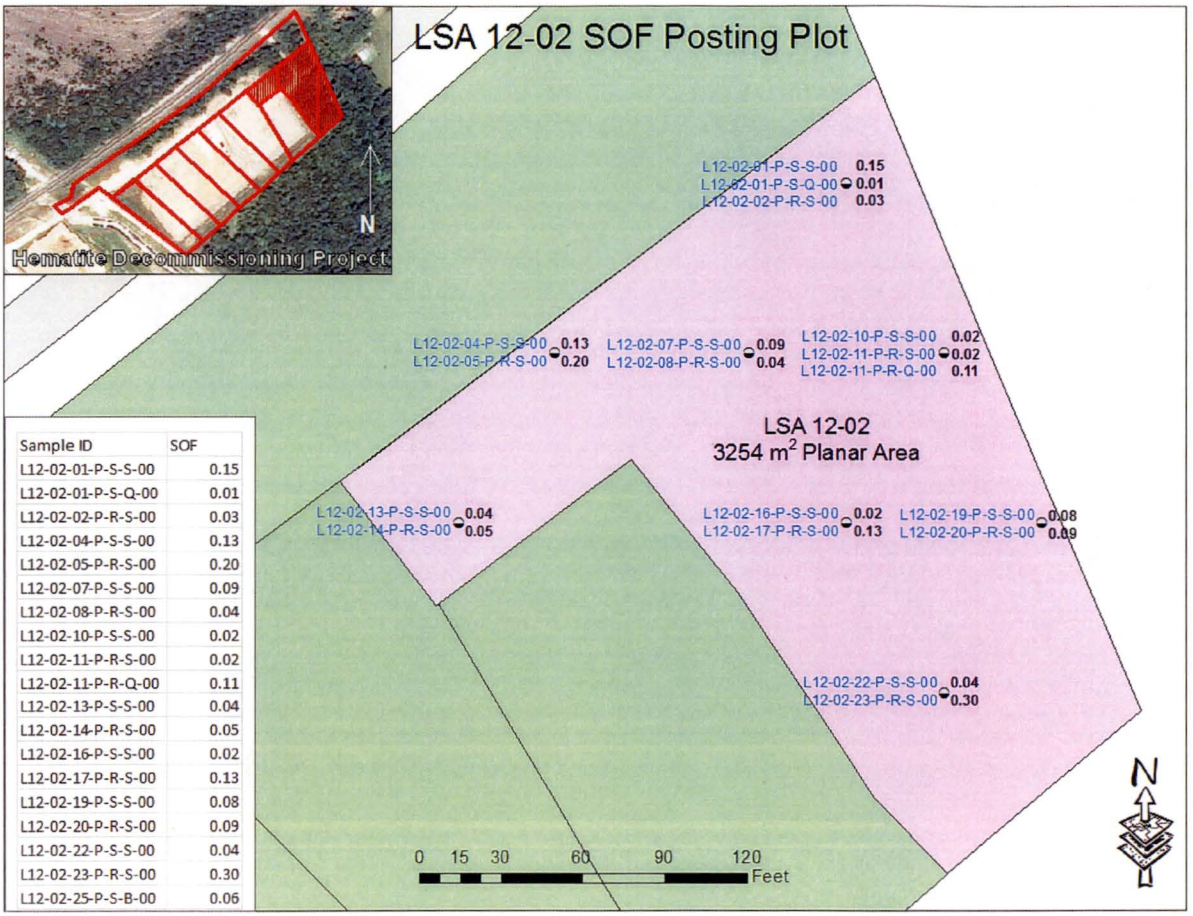
N	16

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 12-02 Sys SOF	0.09	0.05	to 0.13	0.020	0.08	0.01	1.5	2.24

	Minimum	1st quartile	Median	97.87% CI		3rd quartile	Maximum	IQR
LSA 12-02 Sys SOF	0.02	0.03	0.06	0.03	to 0.13	0.13	0.3	0.10

A posting plot is simply a map of the survey unit with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 12-02 is presented below in Figure 14-4. Figure 14-4 shows no unusual patterns in the data.

Figure 14-4
Posting Plot for LSA 12-02 Systematic Measurement Locations



Sample ID	SOF
L12-02-01-P-S-S-00	0.15
L12-02-01-P-S-Q-00	0.01
L12-02-02-P-R-S-00	0.03
L12-02-04-P-S-S-00	0.13
L12-02-05-P-R-S-00	0.20
L12-02-07-P-S-S-00	0.09
L12-02-08-P-R-S-00	0.04
L12-02-10-P-S-S-00	0.02
L12-02-11-P-R-S-00	0.02
L12-02-11-P-R-Q-00	0.11
L12-02-13-P-S-S-00	0.04
L12-02-14-P-R-S-00	0.05
L12-02-16-P-S-S-00	0.02
L12-02-17-P-R-S-00	0.13
L12-02-19-P-S-S-00	0.08
L12-02-20-P-R-S-00	0.09
L12-02-22-P-S-S-00	0.04
L12-02-23-P-R-S-00	0.30
L12-02-25-P-S-B-00	0.06

Appendix B to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 14-1, Figure 14-3, and Figure 14-4 above. A summary of the analytical data is presented in Table 14-2 below. Appendix F to this report presents the Test America Analytical Laboratory soil sample reports.

Table 14-2
Final Status Survey Analytical Data: LSA 12-02

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			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 (%)	SOF
L12-02-01-P-S-S-00	0.00	S	1.1	0.165	0.0801	N/A	0.030	0.030	0.171	0.171	0.079	0.245	U	1.18	0.181	0.155	N/A	0.180	0.180	4.440	NA	NA	NA	0.244	0.157	0.219	N/A	1.23	0.571	0.869	N/A	3.0	0.15
L12-02-02-P-R-S-00	0.50	S	0.856	0.138	0.077	N/A	-0.214	0.000	-0.0381	0.000	0.044	0.254	U	1.05	0.174	0.104	N/A	0.050	0.050	0.397	NA	NA	NA	0.0149	0.229	0.384	U	1.1	0.522	0.794	N/A	0.3	0.03
L12-02-04-P-S-S-00	0.00	S	0.928	0.136	0.0655	N/A	-0.142	0.000	0.355	0.355	0.055	0.232	N/A	1.13	0.173	0.0983	N/A	0.130	0.130	7.278	NA	NA	NA	0.402	0.143	0.22	N/A	1.38	0.563	0.846	N/A	4.4	0.13
L12-02-05-P-R-S-00	0.50	S	1.25	0.187	0.0819	N/A	0.180	0.180	0.0936	0.094	0.079	0.246	U	1.2	0.197	0.0837	N/A	0.200	0.200	0.798	NA	NA	NA	-0.136	0.274	0.681	U	0.798	0.351	0.893	U	0.7	0.20
L12-02-07-P-S-S-00	0.00	S	0.97	0.157	0.0701	N/A	-0.100	0.000	0.0578	0.058	0.061	0.231	U	1.15	0.195	0.131	N/A	0.150	0.150	1.100	NA	NA	NA	-0.13	0.196	0.669	U	1.1	0.553	0.845	N/A	0.7	0.09
L12-02-08-P-R-S-00	0.50	S	1.04	0.143	0.055	N/A	-0.030	0.000	0.0276	0.028	0.095	0.251	U	1.05	0.164	0.121	N/A	0.050	0.050	1.050	NA	NA	NA	-0.101	0.311	0.516	U	1.05	0.511	0.786	N/A	0.7	0.04
L12-02-10-P-S-S-00	0.00	S	0.918	0.141	0.0774	N/A	-0.152	0.000	0.161	0.161	0.14	0.236	U	0.969	0.176	0.108	N/A	-0.031	0.000	1.090	NA	NA	NA	-0.019	0.0379	0.369	U	1.09	0.558	0.856	N/A	0.7	0.02
L12-02-11-P-R-S-00	0.50	S	0.882	0.141	0.0899	N/A	-0.188	0.000	-0.0174	0.000	0.055	0.249	U	0.913	0.157	0.13	N/A	-0.087	0.000	2.724	NA	NA	NA	0.147	0.285	0.605	U	1.18	0.597	0.918	N/A	2.0	0.02
L12-02-13-P-S-S-00	0.00	S	1.06	0.164	0.0875	N/A	-0.010	0.000	0.0692	0.069	0.055	0.238	U	0.976	0.164	0.109	N/A	-0.024	0.000	4.236	NA	NA	NA	0.233	0.148	0.207	N/A	1.14	0.569	0.879	N/A	3.1	0.04
L12-02-14-P-R-S-00	0.50	S	0.958	0.144	0.0716	N/A	-0.112	0.000	0.0152	0.015	0.024	0.253	U	1.07	0.163	0.105	N/A	0.070	0.070	1.323	NA	NA	NA	0.0656	0.182	0.349	U	1.14	0.636	0.825	N/A	0.9	0.05
L12-02-16-P-S-S-00	0.00	S	0.861	0.148	0.0795	N/A	-0.209	0.000	0.231	0.231	0.039	0.251	U	0.932	0.173	0.151	N/A	-0.068	0.000	0.584	NA	NA	NA	-0.01	0.362	0.607	U	0.584	0.302	1.65	U	0.7	0.02
L12-02-17-P-R-S-00	0.50	S	0.902	0.131	0.0633	N/A	-0.168	0.000	0.0246	0.025	0.086	0.246	U	1.24	0.171	0.096	N/A	0.240	0.240	1.190	NA	NA	NA	-0.126	0.588	0.538	U	1.19	0.475	0.707	N/A	0.7	0.13
L12-02-19-P-S-S-00	0.00	S	0.896	0.128	0.0693	N/A	-0.174	0.000	0.138	0.138	0.059	0.255	U	1.1	0.192	0.134	N/A	0.100	0.100	2.240	NA	NA	NA	0.12	0.147	0.193	U	1.06	0.477	0.717	N/A	1.8	0.08
L12-02-20-P-R-S-00	0.50	S	0.897	0.132	0.0588	N/A	-0.173	0.000	0.0299	0.030	0.061	0.25	U	1.15	0.184	0.0991	N/A	0.150	0.150	0.838	NA	NA	NA	-0.012	0.0197	0.34	U	0.838	0.294	0.727	N/A	0.7	0.09
L12-02-22-P-S-S-00	0.00	S	0.88	0.157	0.0935	N/A	-0.190	0.000	0.0743	0.074	0.13	0.248	U	0.945	0.184	0.149	N/A	-0.055	0.000	4.500	NA	NA	NA	0.248	0.167	0.202	N/A	1.12	0.362	0.953	N/A	3.4	0.04
L12-02-23-P-R-S-00	0.50	S	1.26	0.17	0.0751	N/A	0.190	0.190	-0.0336	0.000	0.027	0.24	U	1.34	0.198	0.142	N/A	0.340	0.340	3.317	NA	NA	NA	0.18	0.164	0.203	U	1.27	0.584	0.896	N/A	2.2	0.30
L12-02-01-P-S-Q-00	0.00	Q	0.956	0.15	0.0723	N/A	-0.114	0.000	-0.0073	0.000	0.059	0.244	U	0.916	0.165	0.142	N/A	-0.084	0.000	1.280	NA	NA	NA	-0.144	0.216	0.676	U	1.28	0.599	0.911	N/A	0.7	0.01
L12-02-11-P-R-Q-00	0.00	Q	1.06	0.144	0.0572	N/A	-0.010	0.000	-0.017	0.000	0.081	0.243	U	1.2	0.191	0.131	N/A	0.200	0.200	0.729	NA	NA	NA	-0.113	0.178	0.51	U	0.729	0.296	0.793	U	0.7	0.11
L12-02-25-P-S-B-00	0.00	B	0.909	0.132	0.064	N/A	-0.161	0.000	0.252	0.252	0.071	0.236	N/A	1.050	0.162	0.095	N/A	0.050	0.050	2.968	NA	NA	NA	0.159	0.139	0.175	U	1.410	0.490	0.706	N/A	1.8	0.06
Systematic Minimum			0.000						0.000					0.000						0.397				-0.136				0.584				1.5	0.02
Systematic Maximum			0.190						0.355					0.340						7.278				0.402				1.380				Average Enrichment (%)	0.30
Systematic Mean			0.025						0.091					0.104						2.319				0.070				1.079					0.09
Systematic Median			0.000						0.064					0.085						1.256				0.040				1.110					0.06
Systematic Standard Deviation			0.063						0.099					0.102						1.945				0.162				0.194					0.08
			With ingrowth, use Ra226 bkg = 1.07											Th232 bkg = 1.0																			

NOTES:

Gross results in units of pCi/g.

* Background with ingrowth (1.07 pCi/g) subtracted from gross result.

**Background (1.0 pCi/g) subtracted from gross result.

U Qualifier: Result is less than the sample detection limit.

All uncertainty values are reported at the 2-sigma confidence level.

14.2.5 Biased Soil Sample Result LSA 12-02

One (1) biased sample was collected from LSA 12-02. The sample collected at location L12-02-25 represented the maximum GWS measurement (11,828 gcpm) within the SU, and had a result of 0.06 Uniform SOF.

14.2.6 Quality Control Soil Sample Result LSA 12-02

Two QC field duplicate sample points were randomly selected for LSA 12-02 which were collected at systematic locations L12-02-01 and L12-012-11.

For the 17 samples (i.e., 16 systematic + 1 biased) collected within LSA 12-02, two field duplicate samples were collected. This frequency equates to 11.8%, (i.e. 2/17). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated warning limits (see Figure 7-5 below).

The statistical assessment of the Laboratory QC sample results indicated that one field duplicate sample exceeded the calculated Warning Limit, but was less than the calculated Control Limit. The one sample result that exceeded the Warning Limit was sample L12-02-11-P-R-S-00 for Th-232. In accordance with procedure HDP-PR-FSS-703, when an exceedance occurs an investigation is performed to determine if corrective actions were necessary. The investigation determined that for Th-232, the calculated statistic (0.287) only slightly exceeded the calculated Warning Limit (0.283). Also, considering the low activity and the errors associated with the sample results, the Th-232 activity of both samples were relatively close. Based upon the investigation of the exceedance and the results of previous Quality Assurance audits of the overall performance of the laboratory, no corrective actions were determined to be necessary.

Figure 14-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 12-02 (1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control		
		Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.:	LSA 12-02				Survey Unit Description:		Class 2 Laydown Land Area in "Area 13"					
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	Ra-226	1.1	0.0801	0.956	0.0723	1.028	1.9	0.144	0.269	0.403	N
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	Tc-99	0.171	0.245	-0.00733	0.244	0.082	25.1	NA	3.552	5.321	NA
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	Th-232	1.18	0.155	0.916	0.142	1.048	2.0	0.264	0.283	0.424	N
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	U-234[1]	4.440	N/A	1.280	N/A	2.860	195.4	3.160	27.649	41.425	N
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	U-235	0.244	0.219	-0.144	0.676	0.050	51.6	NA	7.301	10.939	NA
L12-02-01-P-S-S-00	L12-02-01-P-S-Q-00	U-238	1.23	0.869	1.28	0.911	1.255	168.8	0.050	23.885	35.786	N

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy / [signature]

Date: 11-23-16

Reviewed by: W. Clark Evers / W. Clark Evers

Date: 11/23/16

Quality Record

Figure 14-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 12-02 (1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control		
		Revision: 2	Page 1 of 1

FORM HDP-PR-FSS-703-1
FIELD DUPLICATE SAMPLE ASSESSMENT

Survey Unit No.:	LSA 12-02				Survey Unit Description:		Class 2 Laydown Land Area in "Area 13"					
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
			Activity (x_i)	MDC	Activity (x_i)	MDC						
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	Ra-226	0.882	0.0899	1.06	0.0572	0.971	1.9	0.178	0.269	0.403	N
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	Tc-99	-0.0174	0.249	-0.017	0.243	-0.017	25.1	NA	3.552	5.321	NA
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	Th-232	0.913	0.13	1.2	0.131	1.057	2.0	0.287	0.283	0.424	Y
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	U-234[1]	2.724	N/A	0.729	N/A	1.727	195.4	1.995	27.649	41.425	N
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	U-235	0.147	0.605	-0.113	0.51	0.017	51.6	NA	7.301	10.939	NA
L12-02-11-P-R-S-00	L12-02-11-P-R-Q-00	U-238	1.18	0.918	0.729	0.793	0.955	168.8	NA	23.885	35.786	NA

Comments:
1. U-234 is inferred, no MDC available.
2. Duplicate assessment is not necessary if the result of either sample is < MDC.

Performed by: Thomas Yardy / [signature]

Date: 11-23-16

Reviewed by: W. Clark Evers / [signature]

Date: 11/23/16

Quality Record

14.3 Tc-99 Hot Spot Assessment LSA 12-02

A review of the available data shows that as a Class 2 LSA SU there is no history of a Tc-99 sample result ever exceeding the Tc-99 Uniform $DCGL_w$. The highest Tc-99 sample result collected from both Final RASS and FSS was 0.355 pCi/g.

15.0 ALARA EVALUATION LSA 12-02

All samples collected within LSA 12-02 were evaluated against the Uniform Stratum $DCGL_w$. For LSA 12-02 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.09 for LSA 12-02. The average SOF equates to residual activity contributions from the survey unit area of 2.25 mrem/yr for LSA 12-02. Groundwater Monitoring Well data provided in FSSFR Volume 6, Chapters 2 and 3, indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/yr based upon the EPA MCLs will be added to the total estimated dose for LSA 12-02. Adding these dose contributions together, the total estimated dose for LSA 12-02 is 6.25 mrem/yr.

Since the estimated Total Effective Dose Equivalent is well below the regulatory release criterion of 25 mrem/yr, the conclusion of the ALARA evaluation is that the FSS of LSA 12-02 was successful and that there would be no discernable benefit to the health and safety of the public in attempting to further reduce the results of FSS by performing remediation of LSA 12-02.

16.0 FSS PLAN DEVIATIONS LSA 12-02

16.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 12-02.

16.2 Adjustments to Scan MDC Calculations

As previously stated in Section 5.1.5, Scan MDCs for LSA 12-01 were calculated in accordance with HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development* and HDP-TBD-FSS-002, Revision 3, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*. The assumed LSA background count rate of 9,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 9,470 cpm. Therefore the calculated Scan MDCs are appropriate, and no adjustments need to be made.

17.0 DATA QUALITY ASSESSMENT

The DQO process is thoroughly integrated within the DP and Hematite FSS procedures. The steps of the DQO process are presented in Volume 3, Chapter 1, Section 4.0 of the FSSFR and correspond to the DQO steps described in Chapter 14, Section 4.2.1 of the DP. The HDP DQO process reflects the recommendations given in MARSSIM, Chapter 2, Figure 2-2.

17.1 Data Quality Assessment for LSA 12-02

The Data Quality Assessment of the survey methodology, sampling and sample analysis results, and the Quality Control sampling and analysis results to ascertain the validity of the conclusion for LSA 12-02 (see Figure 17-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 12-02 survey and sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721 *Final Status Survey Data Validation*.
- The WRS Test is not necessary when the difference between the maximum SU data set measurement SOF and the minimum background area measurement SOF is less than or equal to one. For LSA 12-02, no individual gross SOF result in the FSS data set exceeded the SOF of the minimum background reference area measurement by more than one using the Uniform Stratum criteria. Therefore, the WRS Test was not required for LSA 12-02. However, the WRS Test was performed for illustrative purposes. Since the test statistic, WR (1040) exceeded the critical value (860), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix B.
- ~~For LSA 12-02, the WRS statistical test was not necessary since the difference between the maximum SU gross SOF and the minimum background area adjusted~~

~~SOF was less than one. However the WRS Test was still performed for illustrative purposes and the worksheet is presented in Appendix B.~~

- The maximum systematic SOF result for all surface samples within LSA 12-02 was 0.15. The maximum systematic SOF result for all subsurface samples within LSA 12-02 was 0.30. The average SOF result for all systematically collected samples within LSA 12-02 was 0.09, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.13.
- No FSS sample result in LSA 12-02 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an EMC or supplemental investigations was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number of systematic samples actually collected within LSA 12-02. The successful result of the retrospective power evaluation presented in Table 17-1 for LSA 12-02 indicates that the minimum number of samples required (8) for the WRS Test was equal to the number of sampling locations actually collected within LSA 12-02. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight topmost excavation surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.
- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures were performed periodically, and confirmed that there were no instances of potential cross contamination from weather events until the FSS of all remaining areas at HDP were completed.

Table 17-1
Retrospective Sample Size Verification for LSA 12-02

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.08
$DCGL_{SOF}$	1
LBGR (Mean)	0.09
Shift	0.91
Relative Shift (Δ/σ)	11.65
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS 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	α
0.10	1.282	β
0.15	1.036	
0.2	0.842	
0.25	0.674	
0.30	0.524	

Figure 17-1
Data Evaluation Checklists prepared for LSA 12-02 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
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APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA
Survey Unit: 02 **Description:** Class 2 Laydown Land Area in "Area 13"

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FSS been individually reviewed and validated in accordance with Section 8.1 of this procedure?	Yes ☒	No ☐	
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
3.	Have all scans surveys been performed of the areas specified as required in the FSSP and the FSS Sample Instructions?	Yes ☒	No ☐	
4.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FSSP & the FSS Sample Instructions?	Yes ☒	No ☐	NA ☐
5.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☒	No ☐	NA ☐
6.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the appropriate investigation level?	Yes ☒	No ☐	
7.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use and were those calibrations performed using a NIST traceable source?	Yes ☒	No ☐	
8.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☒	No ☐	
9.	Do the samples match those identified on the chain of custody?	Yes ☒	No ☐	NA ☐
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒*	No ☐	
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	

If "No" was the response to any of the questions above, then document the discrepancy as well as any corrective actions that were taken to resolve the discrepancy.

Comments: *One QC duplicate sample L12-02-11-P-R-Q-00 exceeded Warning Limit for Th-232, but did not exceed Control Limit, results acceptable.

Quality Record

Figure 17-1
Data Evaluation Checklists prepared for LSA 12-02 (page 2 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation	Revision: 10	Appendix G-1, Page 2 of 2

APPENDIX G-1
FINAL STATUS SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: LSA 12 **Description:** Laydown Area, Plant Soils SEA
Survey Unit: 02 **Description:** Class 2 Laydown Land Area in "Area 13"

Discrepancy: N/A

Corrective Actions Taken: N/A

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐ NA ☒
    a. If "No", then forward this form to the RSO.
12. The following questions will be answered by the RSO.
    a. If the answer to question 11 was "No", then is the affected data still valid? Yes ☐ No ☐ NA ☒
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ NA ☒
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

	(Print Name)	(Signature)	(Date)
Prepared by (HP Staff):	Thomas Yardy		11-23-16
Approved by (RSO):	W. Clark Evans		11/23/16

Quality Record

18.0 CONCLUSION LSA 12-02

An adequate quantity and quality of radiological surveys and samples, as well as the corresponding laboratory analysis has been performed, evaluated and documented to demonstrate that the dose associated with all sources within SU LSA 12-02 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402.

Table 18-1
LSA 12-02 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.09	N/A	0.16	N/A	N/A	**0.25**
DOSE	2.25 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**6.25 mrem/year**

19.0 REFERENCES

19.1 DO-08-004, Hematite Decommissioning Plan {ML092330123}.

19.2 DO-08-003, Radiological Characterization Report, July 2009 {ML092870496}

19.3 Westinghouse letter HEM-11-96, dated July 5, 2011, *Final Supplemental Response to NRC Request for Additional Information on the Hematite Decommissioning Plan and Related Revision to a Pending License Amendment Request* {ML111880290}

19.4 HDP-TBD-FSS-002, "*Evaluation and Documentation of the Scanning Minimum Detectable Concentrations (MDC) for Final Status Surveys (FSS)*

20.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A: Analytical Data Evaluation Spreadsheets for LSA 12-01

APPENDIX B: Analytical Data Evaluation Spreadsheets for LSA 12-02

APPENDIX C: FSS Plan Development for LSA 12-01

APPENDIX D: FSS Plan Development for LSA 12-02

APPENDIX E: TestAmerica Laboratory Analytical Data Reports for LSA 12-01

APPENDIX F: TestAmerica Laboratory Analytical Data Reports for LSA 12-02