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Our ref: HEM-17-46
Date: July 24, 2017

Subject: Westinghouse Hematite Decommissioning Project - Request for NRC Review of Final Status Survey Final Report Volume 3, Chapter 15, Survey Area Release Record for Land Survey Area 04, Survey Units 01, 02, 03, 04 and 05, and Volume 4, Chapter 13, Survey Release Record for Building Survey Area 04, Survey Unit 09 (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 Final Status Survey document Final Status Survey Final Report Volume 3, Chapter 15, Survey Area Release Record for Land Survey Area 04, Survey Units 01, 02, 03, 04 and 05 (LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05) and Volume 4, Chapter 13, Survey Release Record for Building Survey Area 04, Survey Unit 09 (BSA 04-09).

Attachment 1 contains Final Status Survey Final Report Volume 3, Chapter 15, with a CD containing Appendices.

Attachment 2 contains Final Status Survey Final Report Volume 4, Chapter 13, with a CD containing Appendices.

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 15, Survey Area Release Record for Land Survey Area 04, Survey Units 01, 02, 03, 04 and 05 (LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05), with a CD containing Appendices (HDP-RPT-FSS-217)

2) Final Status Survey Final Report Volume 4, Chapter 13, Survey Area Release Record for Building Survey Area 04, Survey Unit 09 (BSA 04-09), with a CD containing Appendices (HDP-RPT-FSS-313)

cc: J. W. Smetanka, Westinghouse
S. S. Koenick, NRC/DUWP/MDB
J. A. Smith, NRC/DUWP/MDB

Attachment 1

Final Status Survey Final Report Volume 3, Chapter 15

Survey Area Release Record for Land Survey Area 04, Survey Units 01, 02, 03, 04 and 05
with 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 15

TITLE: **Survey Area Release Record for Land Survey Area 4, Survey Units 01, 02, 03, 04 and 05 (LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05)**

REVISION: **0**

EFFECTIVE DATE: JUL 2 4 2017

Approvals:

Author: Kenneth E. Pallagi — 07-24-2017 Date

Owner/Manager: W. Clark Evers — 7/24/17 Date

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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
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

TEDE	Total Effective Dose Equivalent
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) 04, Survey Unit (SU) 01 (LSA 04-01), SU 02 (LSA 04-02), SU 03 (LSA 04-03), SU 04 (LSA 04-04) and SU 05 (LSA 04-05). 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."

All of the land area that comprises SUs LSA 04-01 through LSA 04-05 was designated as a single Class 3 SU (LSA 04-01) as presented in Table 14-16 of the HDP Decommissioning Plan (DP) {ML092330123}. To support remediation activities the original LSA 04-01 was subsequently subdivided into 5 SUs with upgrade to Class 1 or Class 2 as was appropriate. For SUs LSA 04-01 through LSA 04-05, 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 the 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 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05 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 Final Status Survey (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 3, *Land Survey Areas (LSA) Overview* provides the information common to land survey areas. This report, FSSFR Volume 3, Chapter 15, builds upon the general information provided in FSSFR Volume 3, Chapter 1, Revision 3.

2.0 HDP SITE, LSA AND SURVEY UNIT DESCRIPTION

2.1 HDP Site Description

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

2.2 LSA 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 (see Figure 2-1). Figure 2-2 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 LSA 04 to facilitate the remediation process. The minor boundary configuration change of LSA 04 was due to the expansion of SU LSA 02-02 (a Site Pond SU) to accommodate benching and sloping requirements for excavations and also to ensure adequate remediation of specific areas of LSA 02-02 as indicated by the results of visual inspection and radiological survey. As a result of the boundary configuration change of LSA 04 and primarily to support remediation activities, the initial conceptual SU LSA 04-01 was divided into LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05. The land areas of the SUs within LSA 04 that are contained within this report were initially classified as Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 3 survey areas in DP Chapter 14, and were upgraded based upon use during remediation or radiological status identified during remediation activities. There was no reduction in classification of any SUs within LSA 04, thereby assuring compliance with the DP.

2.3 Survey Unit Configuration

2.3.1 Survey Unit Configuration and Classification Change – Establishment of LSA 04-02

Generation of Reuse Stockpile 2 commenced on March 20, 2012. Soil in Reuse Stockpile 2 originated primarily from the top four feet of overburden soil in the Burial Pit Area. As this soil was yet to be determined to meet the chemical remediation requirements as established by the Missouri Department of Natural Resources, it was prohibited from being located in the Reuse Soil Laydown Area until such time that chemical sampling and analysis was complete. To preclude stoppage of work excavating the overburden soil, Reuse Stockpile 2 was located in a laydown area established within LSA 04-01.

As the newly established laydown area would be the recipient of reuse soil from the Burial Pit Area the laydown area was designated as LSA 04-02 and designated a Class 1 area.

2.3.2 Survey Unit Configuration and Classification Change – Establishment of LSA 04-03

Continued generation of potential reuse soil from LSA 05 created the need to expand the size of LSA 04-02. As the expanded laydown area surface would exceed the 2000 m^2 (for a Class 1 SU), the expanded laydown area, for the purpose of FSS was configured into LSA 04-02 and LSA 04-03, both Class 1 SUs. The remaining area of LSA 04 continued to be designated as LSA 04-01 a Class 3 SU.

2.3.3 Survey Unit Configuration and Classification Change – Establishment of LSA 04-04 and LSA 04-05

As required by HDP-PO-FSS-800, prior to determining the appropriate remediation methodology for the SWTP Discharge Line, Westinghouse performed radiological surveys and visual inspection by remote control camera of potential piping to remain in place to determine the integrity of the piping and to conduct the cost-benefit evaluation (as described in the DP). Based upon the results of the evaluation, a combination of removal, and remediation was selected.

A downstream section of the SWTP discharge pipe was designated for removal and was located in the southern section of LSA 04-01. To accommodate the removal of the SWTP Discharge Line section by excavation, and any required remediation of the soil in the area of the SWTP Discharge Line, LSA 04-04 and LSA 04-05 were established. LSA 04-04, which would contain the area in which the excavation would occur, was designated as a Class 1 SU. LSA 04-05, which was previously the remaining portion of LSA 04-01 remained a Class 3 SU as was LSA 04-01.

2.3.4 Reclassification – LSA 04-05

In support of FSS Plan design, LSA 04-05 was subject to Remedial Action Support Surveys (RASS) and soil sampling during December 2015. The RASS included a ~50% gamma walkover survey (GWS), and a total of 14 systematic and biased samples were collected. The original Class 3 design was approved in January 2016 and Class 3 FSS performed in April and May of 2016.

During the FSS in April 2016, a small elevated area (6 m^2) was identified to have elevated activity levels (0.51 – 0.71 x DCGL). Since activity levels were above a Sum of Fractions (SOF) of 0.5 but did not exceed an SOF of 1.0, the LSA 04-05 SU was reclassified from a Class 3 to a Class 2 SU.

2.4 Survey Unit Description and Configuration

2.4.1 LSA 04-01 Survey Unit Description and Configuration

LSA 04-01 is located within the north and eastern section of LSA 04. Figure 2-3 indicates the location of LSA 04-01 within LSA 04. Figure 2-4 presents the Final Configuration of the HDP Land Survey Areas and SUs which indicates the location of the boundaries of LSA 04-01.

After the necessary subdivision and establishment of the LSA 04 SUs, the LSA 04-01 land area is the remaining land area within LSA 04 designated a Class 3 area. LSA 04-01 consisted primarily of the "Sally Port" area of the physical security boundary utilized for entrance and egress of vehicular traffic into the Controlled Access Area. A small portion of LSA 04-01 consists of native soil and ground cover, and a gravel road surface. A larger portion of LSA 04-01 remains covered by a concrete curb, and a portion of a former asphalt road way that served as the Sally Port and is designated as structural SU BSA 04-09. The SU also contains the

remaining storm drain piping section designated as PSA 01-08. The dose associated with the remaining structure and piping will be added to the dose estimate for LSA 04-01.

LSA 04-01 also contains two in service groundwater monitoring wells WS-33 and WS-34 (see Section 3.3.4.2).

In its final configuration as prepared for FSS, LSA 04-01 presents 2,779 square meters (m^2) in planar (2-dimensional) extent.

2.4.2 LSA 04-02 Survey Unit Description and Configuration

LSA 04-02 is located within the northwestern section of LSA 04. Figure 2-4 presents the Final Configuration of the HDP Land Survey Areas and SUs which indicates the location of the boundaries of LSA 04-02.

After use as a reuse soil stockpile storage area during site remediation operations and subsequent removal from the SU, in the final configuration, LSA 04-02 consisted of native soil. There was no process piping, groundwater monitoring wells, or spent limestone present within the SU.

In its final configuration as prepared for FSS, LSA 04-02 presents 2,064 m^2 in planar (2-dimensional) extent.

2.4.3 LSA 04-03 Survey Unit Description and Configuration

LSA 04-03 is located within the central section of LSA 04. Figure 2-4 presents the Final Configuration of the HDP Land Survey Areas and SUs which indicates the location of the boundaries of LSA 04-03.

After use as a reuse soil stockpile storage area during site remediation operations and subsequent removal from the SU, in the final configuration, LSA 04-03 consisted of native soil. There was no process piping, groundwater monitoring wells, or spent limestone present within the SU.

In its final configuration as prepared for FSS, LSA 04-03 presents 2,061 m^2 in planar (2-dimensional) extent.

2.4.4 LSA 04-04 Survey Unit Description and Configuration

LSA 04-04 is located within the southern half of LSA 04. Figure 2-4 presents the Final Configuration of the HDP Land Survey Areas and SUs which indicates the location of the boundaries of LSA 04-04.

After the removal of a portion of the Sanitary Wastewater Treatment Plant (SWTP) Discharge Line and completion of radiological remediation, in the final configuration, LSA 04-04 consisted of the SWTP Discharge Line excavated area and the undisturbed surface of the SU both of which consisted of native soil.

A portion of the SWTP Discharge Line (PSA 02-01) remains within the soil of LSA 04-04. As such, the dose associated with the PSA 02-01 will be added to the dose estimate for LSA 04-04.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 04-04 presents 1,801 m^2 in planar (2-dimensional) extent, within an interior surface area of 2,063 m^2 (3-dimensional).

2.4.5 LSA 04-05 Survey Unit Description and Configuration

LSA 04-05 is located within the southern half of LSA 04. Figure 2-4 presents the Final Configuration of the HDP Land Survey Areas and SUs which indicates the location of the boundaries of LSA 04-05.

LSA 04-05 consists primarily of a wooded area and a small area experiencing surface soil disturbance in support of remediation of the Site Pond. There was no process piping, groundwater monitoring wells, or spent limestone present within the SU. As prepared for FSS, LSA 04-05 consisted of native soil, trees and a minor amount of ground vegetation.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 04-05 presents 1,694 m^2 in planar (2-dimensional).

Figure 2-1
Initial Configuration of Land Survey Areas and Survey Units as provided in DP (Figure 14-14)

Figure 2-2
HDP Land Survey Areas

Figure 2-3
Final Configuration of Land Survey Area 04 and Survey Units

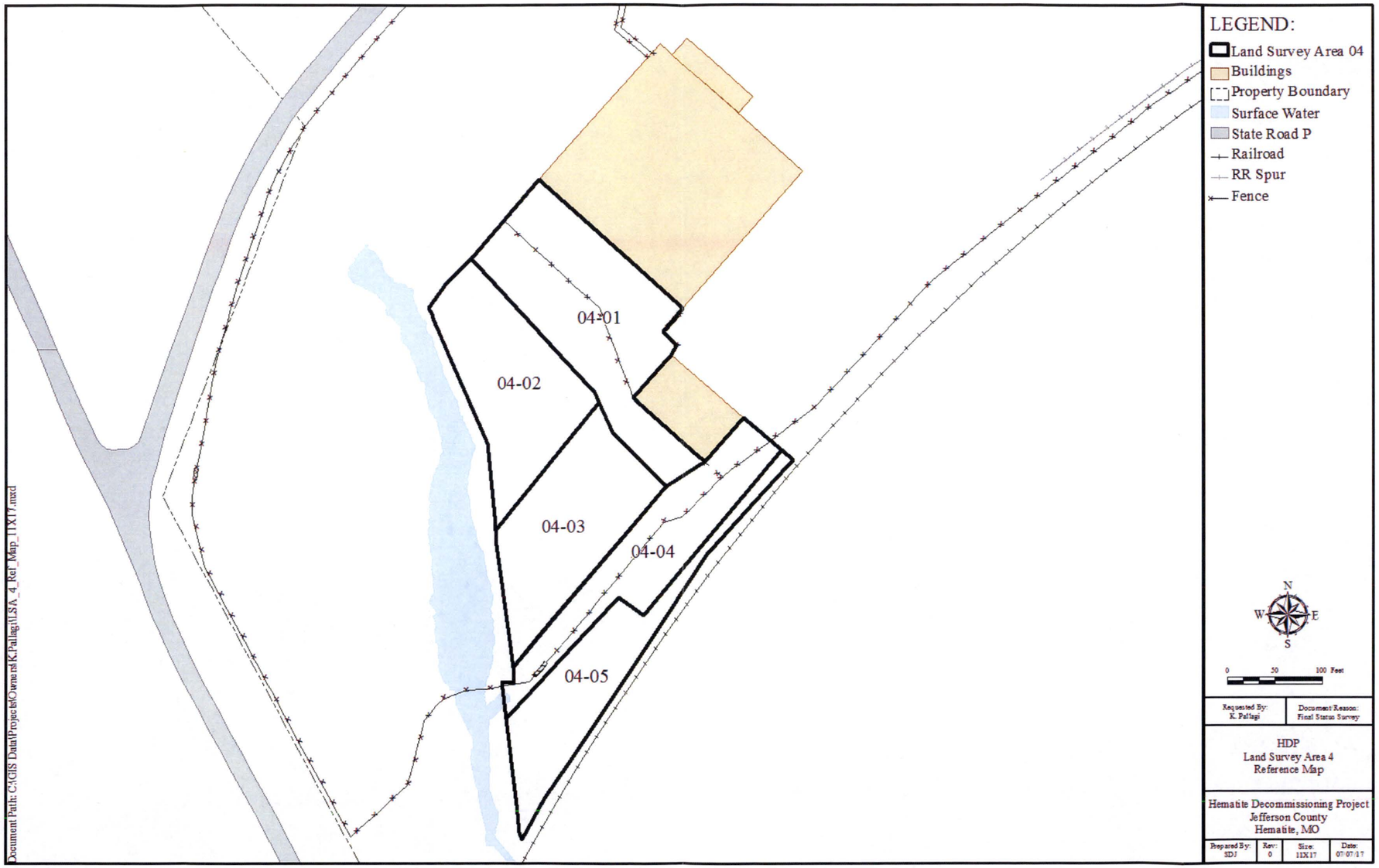
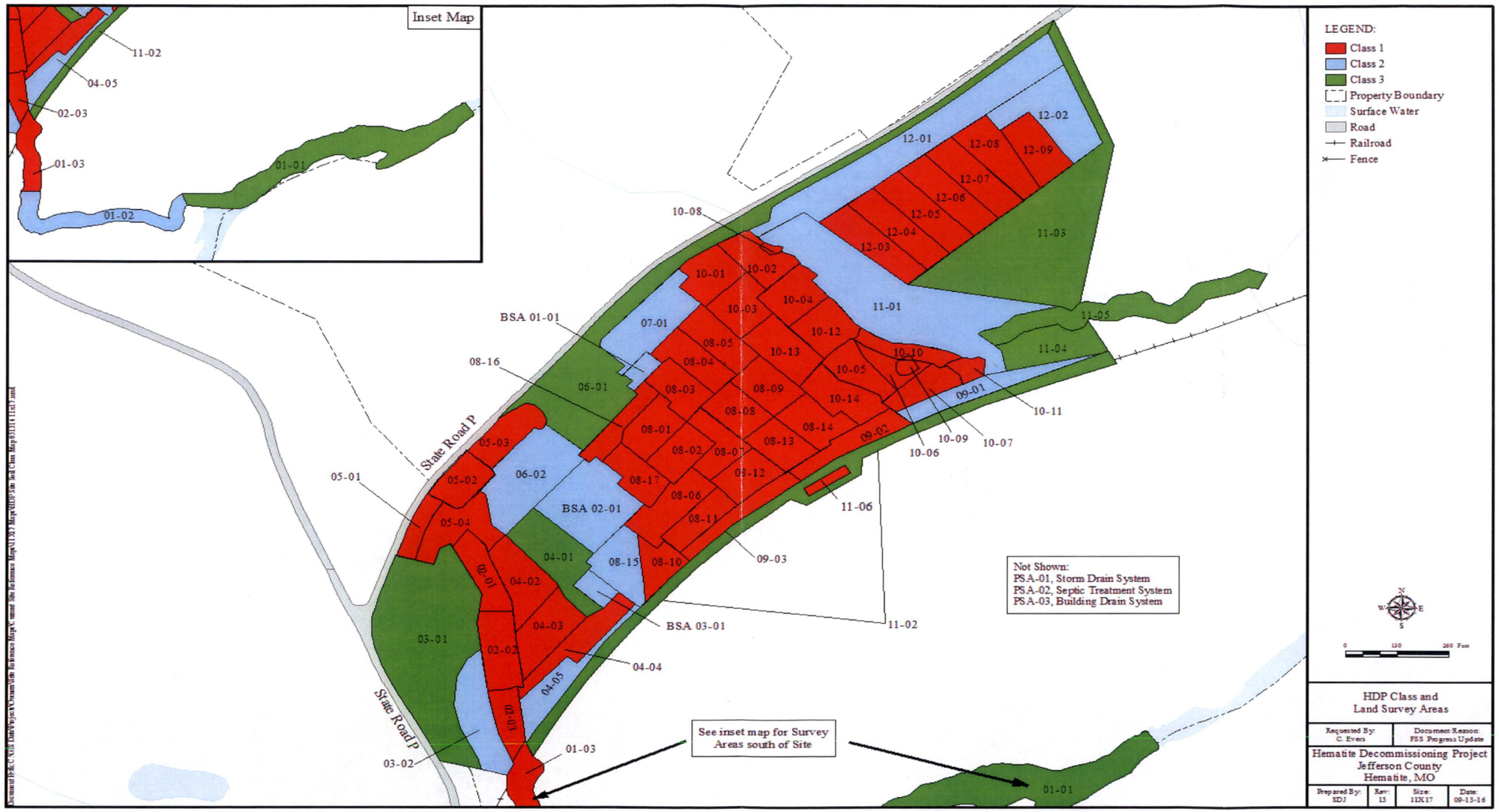


Figure 2-4
Final Configuration of Land Survey Areas and Survey Units



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 Radioactive Materials in LSA 04

The radioactive material in LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05 consisted of those Radionuclides of Concern described in FSSFR Volume 1, Chapter 1.

3.1.1 Radioactive Materials in LSA 04-01 and LSA 04-05

As a Class 3 SU there was no expectation of identification of radioactive materials in LSA 04-01. Radioactive materials that would be identified on the surface of LSA 04-01 would have been deposited by environmental effluent.

3.1.2 Radioactive Materials in LSA 04-02 and LSA 04-03

Radioactive materials on the surface and within LSA 04-02 and LSA 04-03 during site operations would have originated from transfer of suspended material in the Site Pond water during periods in which the Site Pond experienced high water levels. Radioactive materials on the surface of LSA 04-02 and LSA 04-03 would have originated from use of the land areas as a reuse soil laydown area and deposited by environmental effluent.

3.1.3 Radioactive Materials in LSA 04-04

Radioactive materials that would be identified on the surface of LSA 04-04 would have been deposited by environmental effluent.

3.2 Reuse Soil Disposition and Characterization

As LSA 04 was originally designated as a Class 3 area in the DP, it was not designated as a location for generation of reuse soil. As such no reuse soil was generated from LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 or LSA 04-05.

3.3 Remediation and Remedial Action Support Surveys (RASS) Phase of LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05

Site radiological characterization and site history provided no expectation of discovery of Documented Burial Pits in LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05. As expected there were no burials identified in the SUs.

3.3.1 Remedial Actions LSA 04-01, LSA 04-02, LSA 04-03 and LSA 04-05

No remediation was required or performed in LSA 04-01, LSA 04-02, LSA 04-03 and LSA 04-05.

3.3.2 Remedial Actions LSA 04-04

Remedial actions began in LSA 04-04 in January, 2015, and continued through December, 2015. Remediation was performed in LSA 04-04 for two purposes; 1) a trench (known as the SWTP Trench) was dug up to 12 feet in depth to remove portions of the former SWTP Discharge Line that connected the onsite SWTP to the discharge point ant Outfall #001, and 2) shallow excavations were performed adjacent to the SWTP Trench to remediate areas of elevated Tc-99 contamination (up to 30 pCi/g of Tc-99 activity) that were identified through ongoing RASS surveys.

To minimize the amount of soil that was required to remove the designated section of SWTP Discharge Line Pipe, a deep trench was dug.

During remediation planning it was expected that all of the SWTP Discharge Line piping in LSA 04-04 would be removed. Once excavation of the SWTP Trench began and proximity to the Natural Gas Pipe Line was verified it was determined that rather than risk a potentially unsafe attempt at removal of the SWTP Discharge Line piping the remediation efforts were paused and a piping FSS plan was initiated to demonstrate that the remaining portion of the SWTP discharge line under the Natural Gas Pipe Line would be suitable for unrestricted release. Excavation work to remove of the designated section of the SWTP Discharge Line piping resumed. Figure 3-1 is a photograph of the completed SWTP Trench with trench boxes installed.

It is important to note that due to the presence of the SWTP Trench in LSA 04-04, the area could not be safely traversed by equipment or personnel because of the potential for trench collapse. As such, trench boxes were installed to support the integrity of the trench walls.

Once the section of piping was removed the trench was surveyed using remote survey techniques (personnel in a "man-basket" type areal lift, using probes held on poles for remote scanning) to the maximum extent practical. All systematic samples that fell inside the SWTP Trench were collected in a similar fashion.

Upon completion of the survey and sampling of the SWTP Trench interior and the trench boxes were removed and the SWTP trench was immediately backfilled. Once the SWTP Trench was backfilled, and the area could be safely accessed again, normal FSS operations resumed in the SU.

Figure 3-1
SWTP Trench with Trench Boxes Installed

3.3.3 Nuclear Criticality Safety (NCS) Borings

NCS Borings were not required within LSA 04 as the land area of the SUs was determined not to be in an area of the site that would require 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 the site, four groundwater monitoring wells were installed within the SU boundary of LSA 04-01 and LSA 04-04. No groundwater monitoring wells were installed within the SU boundaries of LSA 04-02, LSA 04-03, or LSA 04-05.

3.3.4.1 Abandoned Wells

Important to the planning and execution of remediation of the soils under the former Process Buildings was the information provided in Westinghouse letter HEM-11-56 to the NRC which contained the "Evaluation of Technetium-99 Under the Process Building" report. The relevant

requirements of HEM-11-56 for remediation of LSA 08-11 in regards to groundwater monitoring wells is provided below.

> *"The following actions shall be taken to investigate the potential for a preferential pathway of Tc-99 and uranium along a monitoring well screen that crosses both the Silty Clay Aquitard HSU and the Sand/Gravel HSU (hybrid well), and to determine whether contaminated soil exists in proximity to a hybrid monitoring well:*
>
> - *When hybrid wells are abandoned they will be over drilled using hollow stem augers of sufficient outside diameter to remove approximately two inches of surrounding soil, the well riser, well screen, and screened filter pack. The auger will continue until reaching refusal, which indicates bedrock. The soil cuttings that are removed during the boring process will be surveyed for indications of elevated radioactivity as a qualitative measure and sampled for laboratory analysis. Within each 5 foot interval, sample(s) of soil indicating elevated concentrations will be collected for laboratory analysis. In the event that an elevated count is not observed, one composite sample of the cuttings collected within each 5 foot interval will be collected for laboratory analysis.*
> - *When completing remediation actions in the area of a hybrid well screen that extends beyond the depth of soil excavation, any water sample taken over the history of that well will be assessed for results that exceed the MDC+Error for Tc-99 or exceed the Background Threshold Value for total uranium. For such an exceedance, four borings will be made in close proximity (e.g., approximately equidistant within a 2-4 foot radius) to each monitoring well that is not excavated to the bottom of the well. The borings shall extend down to refusal, which indicates bedrock. Composite samples will be collected as follows:*
>
> - *From each 5 foot increment of depth to the top of the screened/filtered interval;*
> - *From the increment that is equivalent to the top half of the screened/filtered interval; and*
> - *From the increment that is equivalent to the bottom half of the screened/filtered interval.*
>
> *Should a sample result from the investigation sampling described in this subsection exceed the applicable DCGL, then remediation of the subsurface soil represented by the sample is required. If remediation was by overboring, then sampling borings as described in the preceding paragraph may be used to demonstrate compliance. If remediation was by excavation, a final status survey (FSS) per Chapter 14 will be completed."*

PL-06

Within the boundary of LSA 04-04 hybrid monitoring well PL-06 (total depth 34 ft) was installed on June 18, 2004 in the land area designated as LSA 04-04. PL-06 was abandoned on April 8, 2011 in accordance with the requirements of HEM-11-56 and the MDNR. Abandonment of monitoring well PL-06 included overdrilling with 8 inch diameters augers to remove well materials and tremie grouting the hole from the bottom to top.

A review of the historical radiological water sample data for PL-06 indicates that there were no historic exceedances of uranium above the uranium background threshold value of 8.6 pCi/l. The Tc-99 results exceeded the MDC+Error for the water samples collected from this well. The maximum Tc-99 result was 170 pCi/l, well below the EPA drinking water standard of 900 pCi/l.

During the well abandonment in April 2011, a radiological survey of the soil cuttings was performed in the field and composite samples were submitted for laboratory analysis. The radiological survey of the soil cuttings did not demonstrate indications of elevated radioactivity. The maximum SOF result from the nine (9) soil cuttings samples collected from PL-06 during abandonment was 0.20 of the Uniform $DCGL_W$. Samples that exhibited a SOF of 0.20 were collected from 0 to 4 feet bgs, 16 to 20 feet bgs, and 20 to 24 feet bgs.

On August 8, 2013, four close proximity supplemental investigation soil borings were advanced at the location of the previously abandoned well PL-06. The laboratory analysis of the soil samples for PL-06 indicated that the highest interval Uniform DCGL SOF was 0.51 at 8 to 12 feet bgs.

No soil was removed from the area of abandoned well PL-06 during the SU soil remediation as all soil samples collected met the release criteria. Therefore the highest interval soil Uniform DCGL SOF remaining in the area of PL-06 is 0.51 (PL06-SW depth interval of 8 to 12 ft).

3.3.4.2 In Service Groundwater Monitoring Wells

The two following groundwater monitoring wells are located in the land area of LSA 04-01 and remain in service for the purpose of gathering water level data during quarterly sampling events:

WS-33

Monitoring well WS-33 (total depth 17.9 ft) was installed on September 22, 1998 with a screen isolated in the silty clay overburden zone and therefore does not meet the definition of a hybrid well. This existing monitoring well is located near the southern end of LSA 04-01.

A review of the radiological water sample data from WS-33 indicates there were no Tc-99 results exceeding the MDC+Error for water samples collected from this well. The maximum Tc-99 result was 1.1 pCi/l, well below the EPA drinking water standard of 900 pCi/l. There were no uranium results available for water samples collected from this well.

WS-34

Hybrid monitoring well WS-34 (total depth 35.6 ft) was installed on September 21, 1998. This existing monitoring well is located near the southern end of LSA 04-01.

A review of the radiological water sample data from WS-34 indicates there were no historic exceedances of uranium above the uranium background threshold value of 8.6 pCi/l and no Tc-99 results exceeding the MDC+Error. The maximum Tc-99 result was 2.67 pCi/l, well below the EPA drinking water standard of 900 pCi/l.

3.3.4.3 Post-remediation Groundwater Monitoring Well

GW-X

Groundwater monitoring well GW-X (total depth 34 ft) located in LSA 04-04 was installed on September 17, 2009 with a screen isolated in the sand/gravel overburden zone and therefore does not meet the definition of a hybrid well. This existing monitoring well is located near the northeast boundary of LSA 04-04.

A review of the historical radiological water sample data for GW-X indicates that there were no historic exceedances of uranium above the uranium background threshold value of 8.6 pCi/l. The Tc-99 results exceeded the MDC+Error for the water samples collected from this well. The maximum Tc-99 result was 157 pCi/l, well below the EPA drinking water standard of 900 pCi/l.

3.3.5 Subterranean Piping

Preliminary remediation planning activities indicated that subterranean process piping (the SWTP Discharge Line) would be encountered in LSA 04-01 as well as Stormwater Drain System piping.

As stated in Section 3.3.2 excavation remediation activities were conducted to remove a section of the SWTP Discharge Line piping and LSA 04-04 was the SU established as a Class 1 SU to ensure adequate survey of the area. As a portion of the SWTP Discharge Line piping remains in LSA 04-04 the dose contribution of the SWTP piping will be added to the dose summation for LSA 04-04.

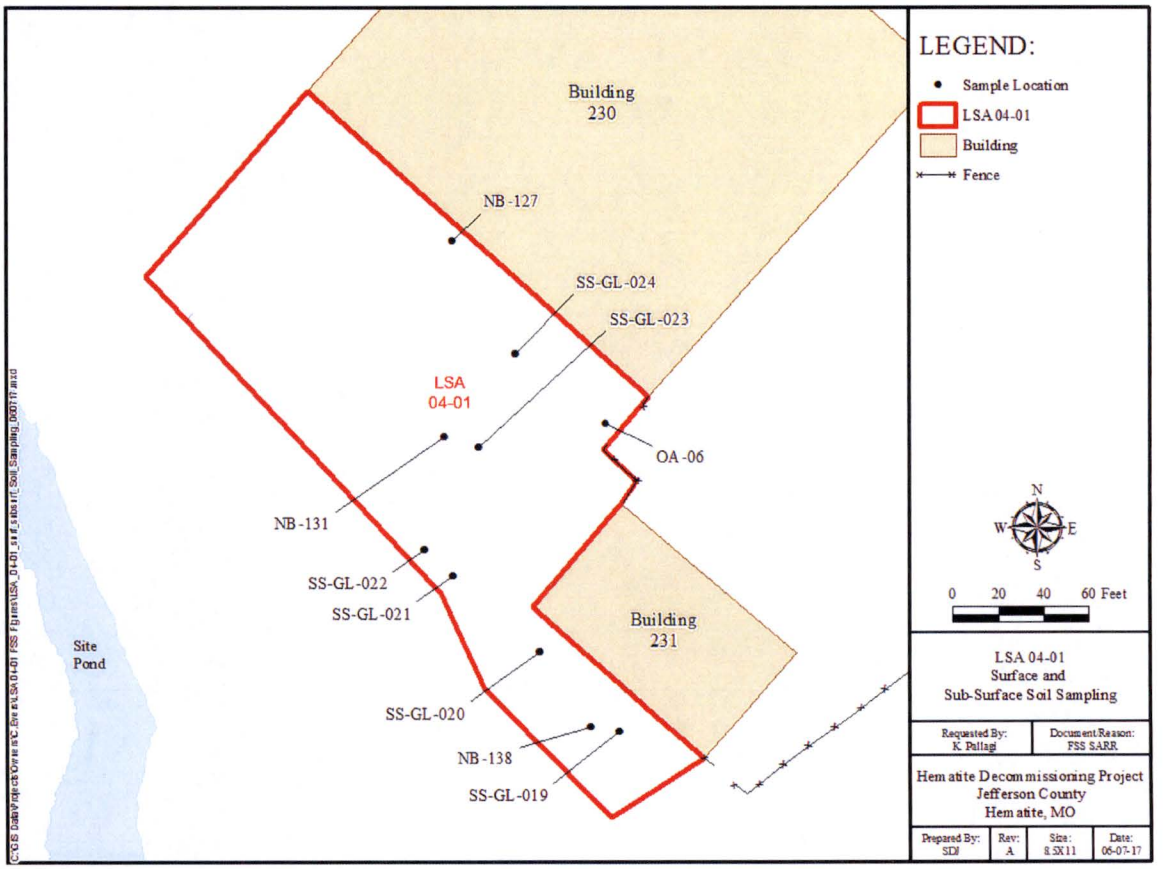
There is no subterranean piping in LSA 04-02, LSA 04-03 and LSA 04-05. As no buried piping remains under the footprint of LSA 04-02, LSA 04-03 and LSA 04-05 there is no dose contribution from this pathway.

3.3.6 Characterization History

Radiological characterization surveys for the HDP were conducted in several phases by multiple contractors over several years prior to the issuance of the DP. A total of twenty six (26) core borings to depths as deep as 35 feet bgs were performed for characterization within LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05 prior to remediation.

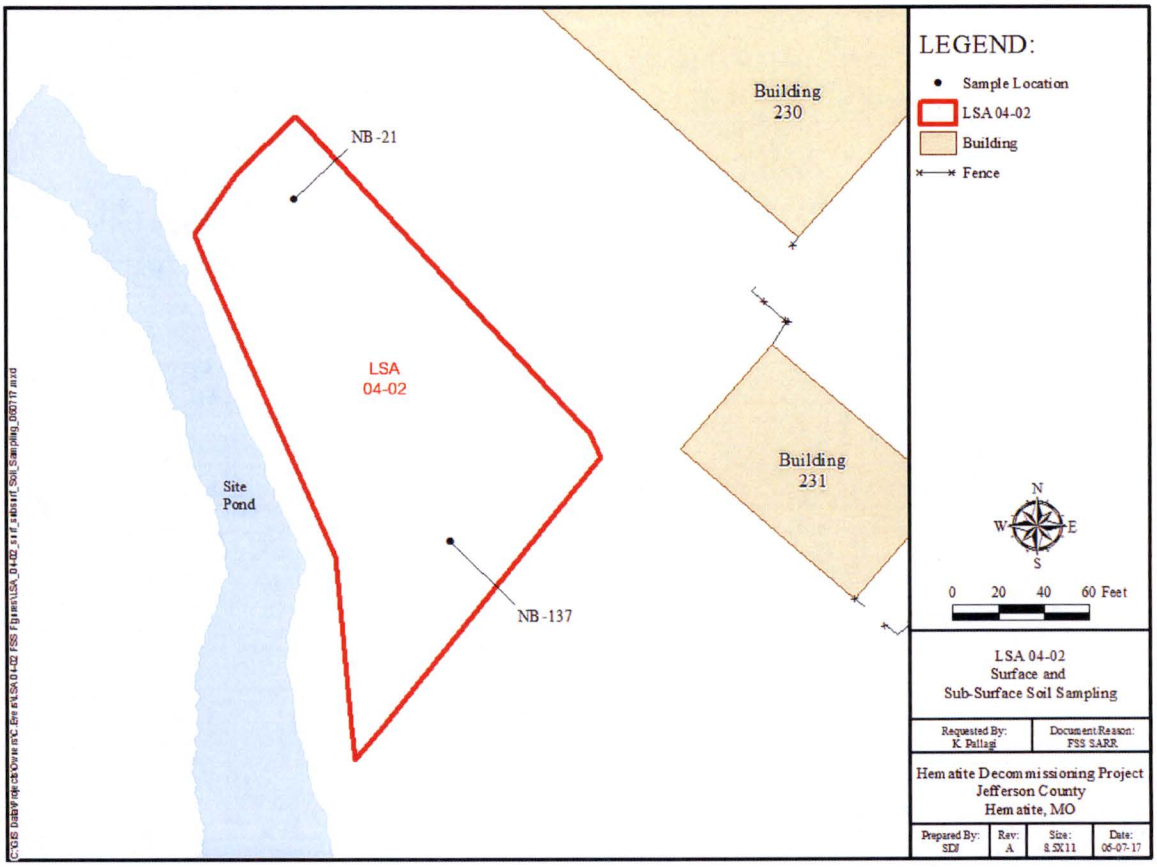
Within LSA 04-01, none of the ten characterization samples exceeded the Uniform $DCGL_W$. Figure 3-2 indicates the radiological characterization boring locations within LSA 04-01.

Figure 3-2
Site Characterization Borings within LSA 04-01



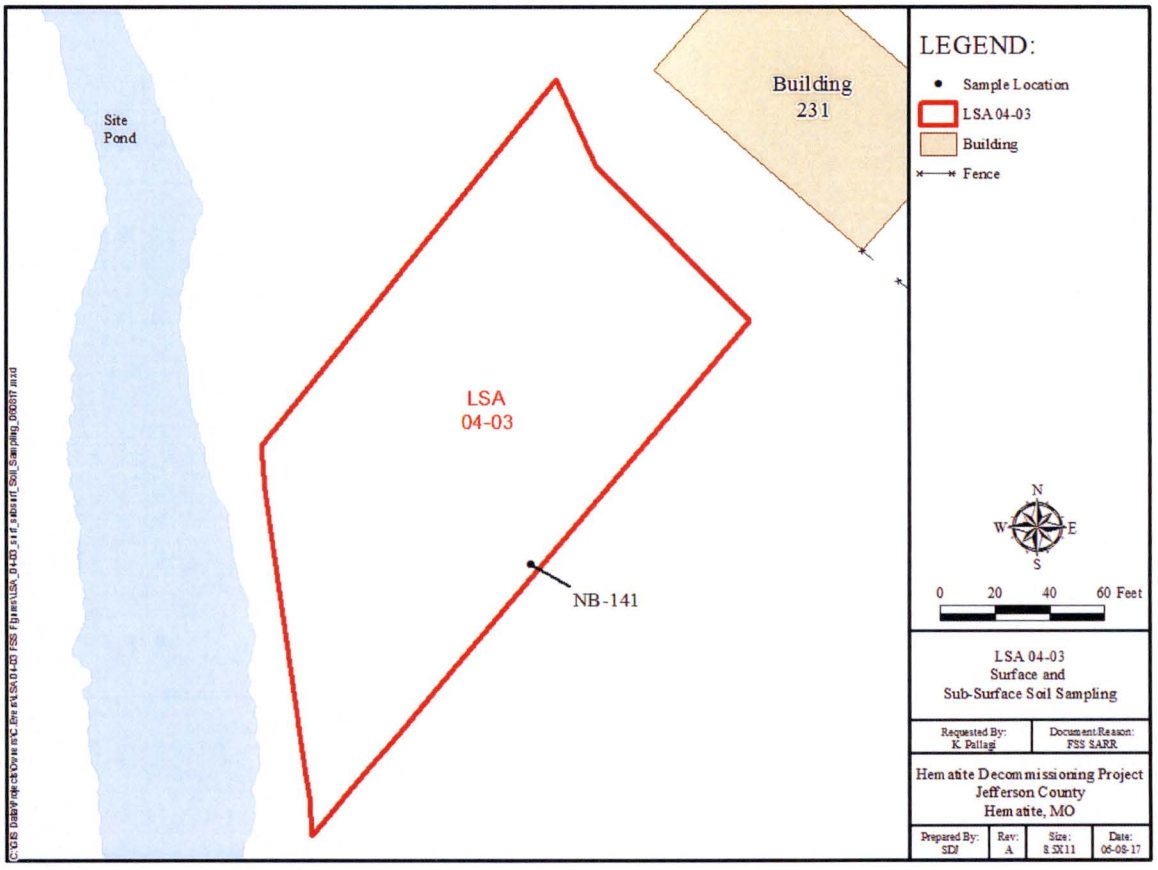
Within LSA 04-02, neither of the two characterization samples exceeded the Uniform $DCGL_W$. Figure 3-3 indicates the radiological characterization boring locations within LSA 04-02.

Figure 3-3
Site Characterization Borings within LSA 04-02



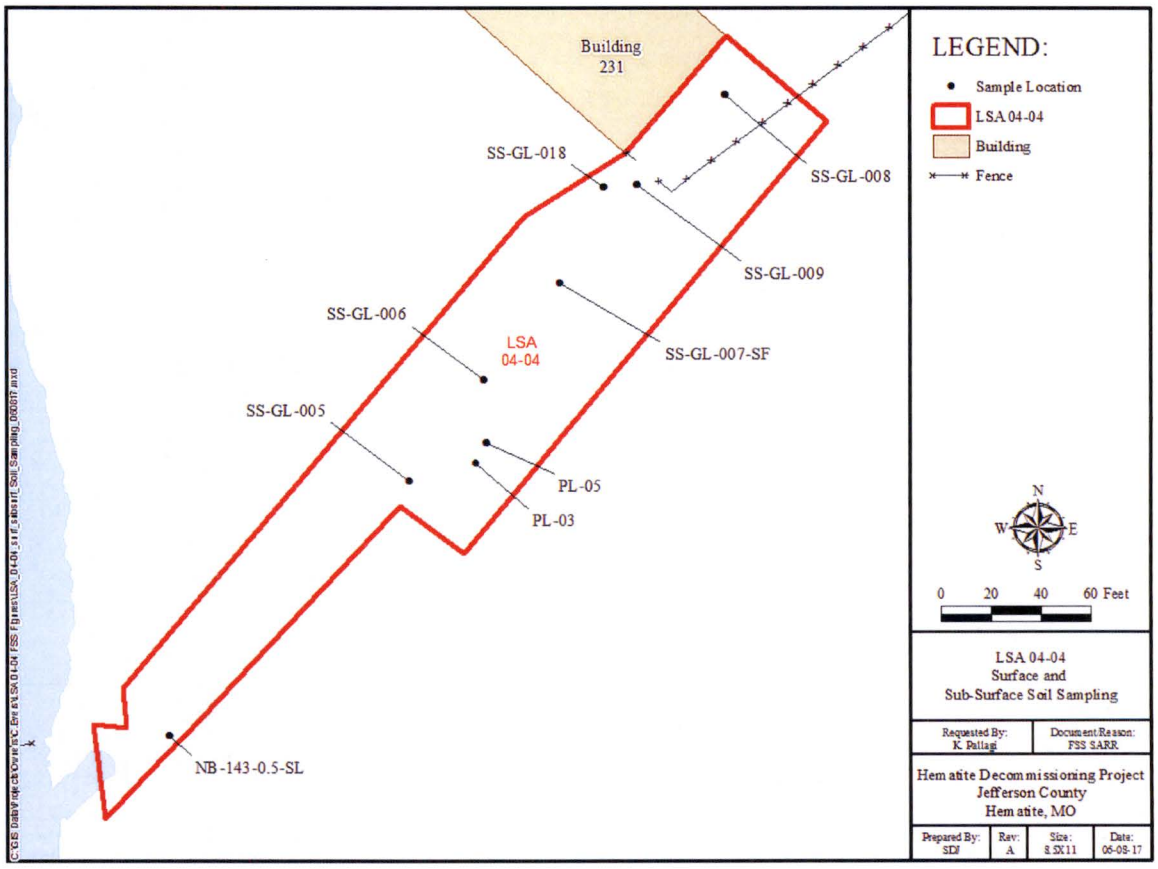
Within LSA 04-03, the lone characterization sample did not exceed the Uniform $DCGL_W$. Figure 3-4 indicates the radiological characterization boring locations within LSA 04-03.

Figure 3-4
Site Characterization Borings within LSA 04-03



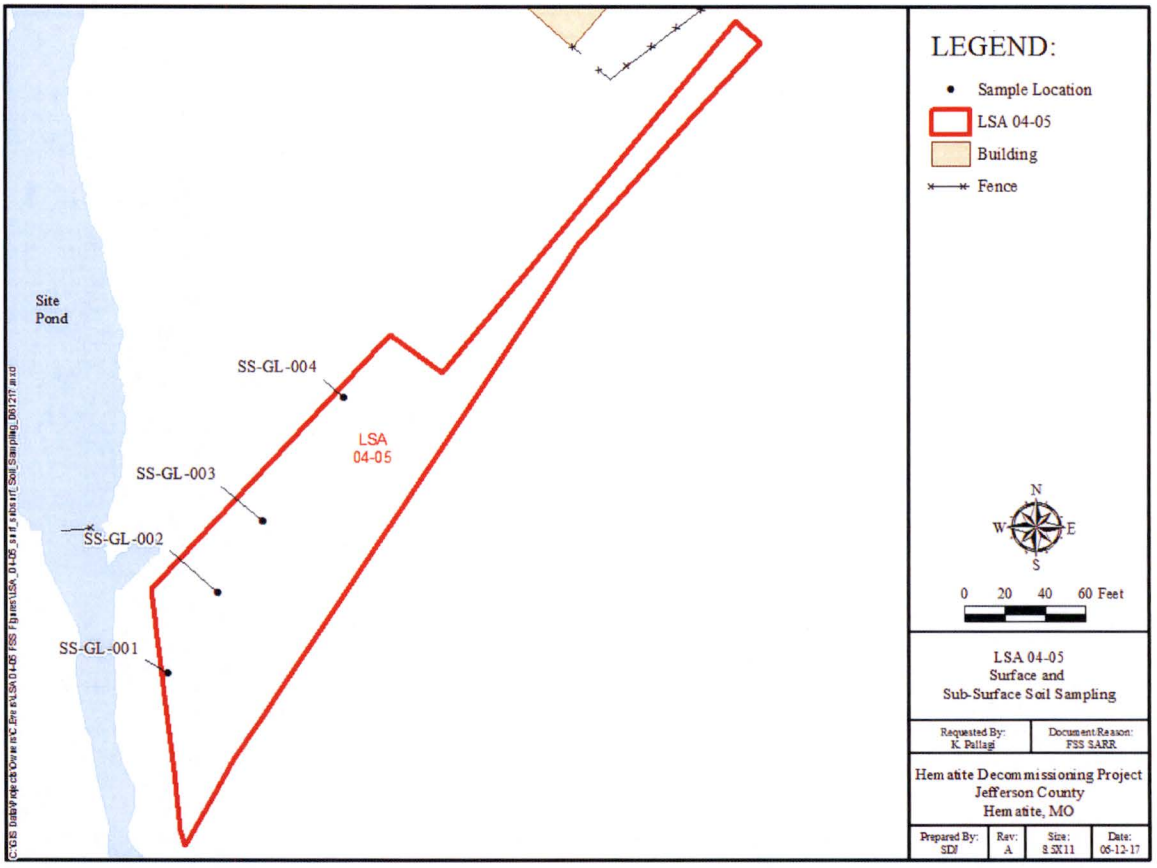
Within LSA 04-04, none of the nine characterization samples exceeded the Uniform $DCGL_W$. Figure 3-5 indicates the radiological characterization boring locations within LSA 04-04.

Figure 3-5
Site Characterization Borings within LSA 04-04



Within LSA 04-05, none of the four characterization samples exceeded the Uniform $DCGL_W$. Figure 3-6 indicates the radiological characterization boring locations within LSA 04-05.

Figure 3-6
Site Characterization Borings within LSA 04-05



3.3.7 Remedial Action Support Survey for FSS Design

The RASS was conducted 1) to guide remediation activities, 2) to determine when an area or survey unit had been adequately prepared for FSS, and 3) to provide updated estimates of the parameters to be used for planning the FSS. Upon completion of remediation within the SU 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 LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05 was completed in February, 2016.

The RASS included a GWS, systematic surface sample collection based on an eight (8) -point triangular grid, and biased surface sampling. 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 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05

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
04-01	0.00	0.00	0.15	0.42	0.00	0.00	2.63	6.65	0.14	0.37	0.65	1.02
04-02	0.06	0.20	0.93	4.11	0.05	0.20	7.93	23.36	0.44	1.29	1.75	4.24
04-03	0.07	0.34	0.22	0.42	0.06	0.25	3.04	6.55	0.17	0.36	1.03	1.73
04-04	0.05	0.26	0.50	1.23	0.03	0.13	3.58	6.70	0.20	0.37	0.93	2.00
04-05	0.00	0.00	1.61	13.80	0.02	0.16	5.90	35.51	0.32	1.96	1.24	5.91
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.

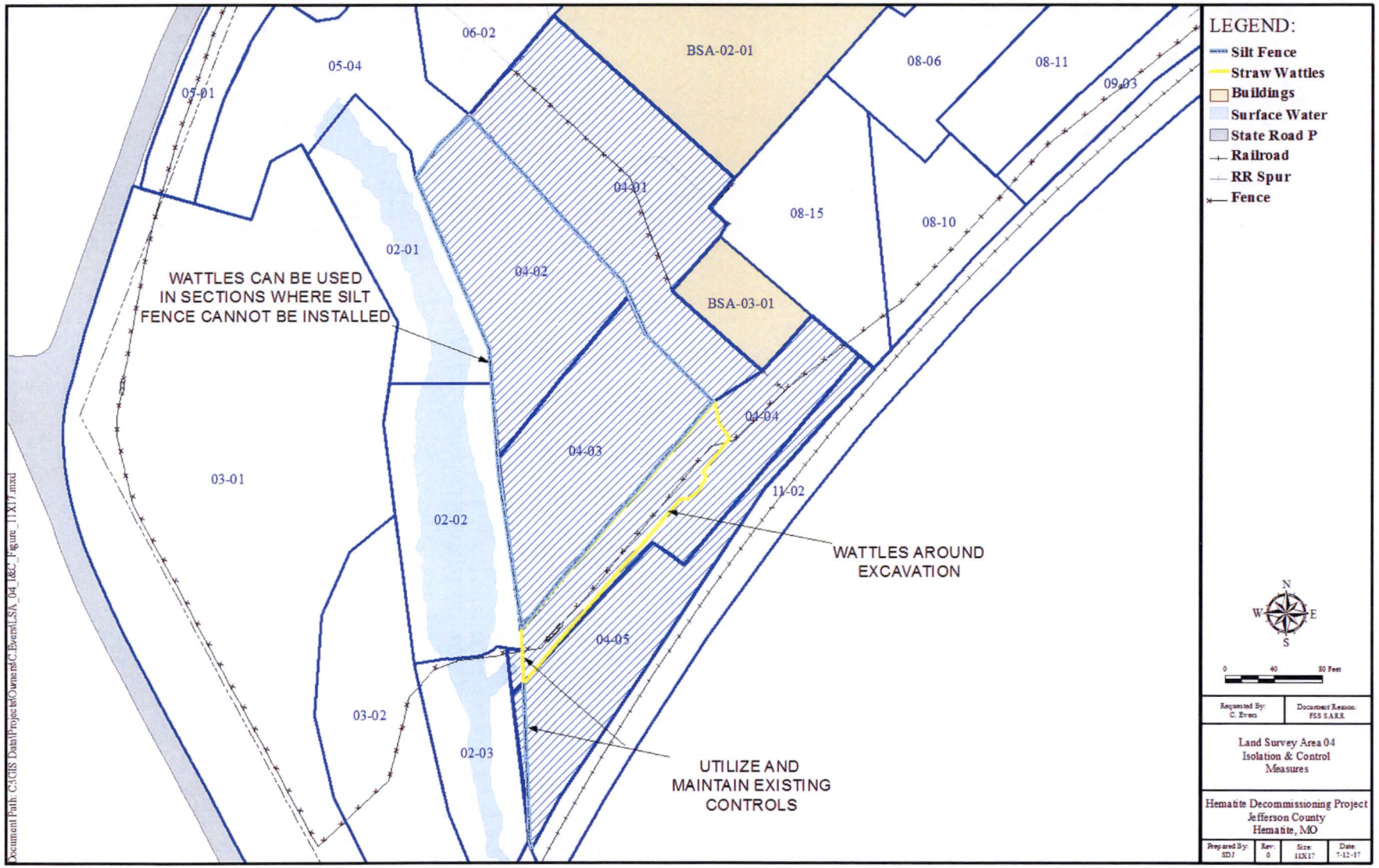
3.3.8 Isolation and Control

As directed by HDP-PR-HP-602, *Data Package Development and Isolation and Control Measures to Support Final Status Survey,* on March 11, 2015, LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05 were isolated and controlled in accordance with Work Package HDP-WP-ENG-803, *Isolation and Control Measures,* (See Figure 3-7) Isolation and control measures included silt fence, straw wattle, and soil berms between these SUs and the adjacent remediation area to ensure that cross-contamination of these LSAs undergoing FSS did not occur.

The administrative control of distinctive green and white rope with 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 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05 are located within the fenced security perimeter of the HDP which therefore prevents access by the general public.

Figure 3-7

Isolation and Control of Area Containing LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05



3.4 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 includes the routine visual inspection of the integrity of the I & C measures implemented for LSA 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05. 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 the start of backfill, LSA 04-04 did not evidence an event that would cause them to be suspect and thus require investigation. LSA 04-01, LSA 04-02, LSA 04-03 and LSA 04-05 did not receive backfill material after FSS.

3.5 Backfill of Survey Units

Although not a function of remediation, but as described in the DP Section 8.8 and FSSFR Volume 2 Chapter 1, the SUs will be backfilled using backfill obtained from on-site material determined to be suitable for reuse (e.g., excavated soil overburden), and/or backfill material from an off-site location.

LSA 04-01, LSA 04-02, LSA 04-03 and LSA 04-05 did not receive backfill material after FSS.

LSA 04-04 was backfilled with off-site "borrow" soil from the Horine Road site in Festus, MO. Further details on off-site "borrow" soil can be found in FSSFR Volume 2, Chapter 8 {ML16285A375}. As only off-site backfill material was used in LSA 04-04, no dose will be added to LSA 04-04 for the backfill material used.

3.6 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/year 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 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05 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 04-01, LSA 04-02, LSA 04-03, LSA 04-04 and LSA 04-05. 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 04-01

This section of the report describes the method for determining the number of samples required for the FSS of LSA 04-01 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 04-01 and the detection sensitivities are also discussed.

5.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 04-01 were driven by the type (Open Land) and Class (Class 3) of the SU 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 historic characterization data for LSA 04-01. 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.

5.1.3 GWS Coverage

As a Class 3 SU, LSA 04-01 was required to undergo a 1-10% GWS.

5.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 04-01 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 04-01 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 6,000 counts per minute (cpm) within LSA 04-01, the Scan MDC calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{2834\,pCi/g}\right)+\left(\frac{f_{U-235}}{1.80\,pCi/g}\right)+\left(\frac{f_{U-238}}{23.7\,pCi/g}\right)\right)}$$

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 04-01, the average enrichment for the SU was 3.4%. 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 04-01 are shown below:

Table 5-1
Scan MDCs for 2" x 2" NaI detector, 6,000 cpm background: LSA 04-01

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 04-01	31.7	45.6	0.93	2.8	0.67	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 Plan 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 04-01 was established at 1,624 ncpm. This value is equivalent to the Uniform $DCGL_W$ for 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 04-01 FSS Design Summary

The FSS Plan for LSA 04-01 can be found in Appendix A. Table 5-2 presents an overall FSS design and implementation summary for LSA 04-01.

Table 5-2
FSS Design Summary for LSA 04-01

Gamma Walkover Survey (GWS):		
Scan Coverage	Minimum 10% of SU surface area	
Scan MDC	31.7 pCi/g total Uranium (based on a 6,000 cpm background); 0.67 pCi/g Th-232; 0.93 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	All sample locations were located randomly. ***Excavation stratum samples to be archived and analyzed only if overlying root stratum sample exceeds a SOF of 0.5.
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 FSS Supervisor.		
Sidewall Sampling Locations:		
Not applicable.		
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 (3.4%) 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 04-01

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 04-01 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 surface of the SU were 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 SU 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 SU surface.

Health Physics (HP) Technicians performing GWS in LSA 04-01 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), HP 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, HP Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to geometry and relative distance from contaminated materials in nearby areas, the average background rate (measured at waist level) within the LSA ranged between 6,000 and 8,000 gross counts per minute (gcpm). Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 7,624 to 9,624 gcpm, HP Technicians slowed or paused the GWS for careful investigation of the small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

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 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 04-01.

Table 6-1
Systematic Sampling Summary by Stratum for LSA 04-01

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
04-01	2,779	8	8	0	2

6.2.2 Systematic Sampling LSA 04-01

Within LSA 04-01, there were eight systematic locations in which portions of the surface stratum [0 – 15 centimeters (cm)] remained in the SU after remediation. The root stratum (15 cm – 150 cm) also remained at all of the eight systematic locations. At these locations the remaining root stratum interval was collected using a hand auger and composited. Where necessary overlying asphalt was removed to access the soil.

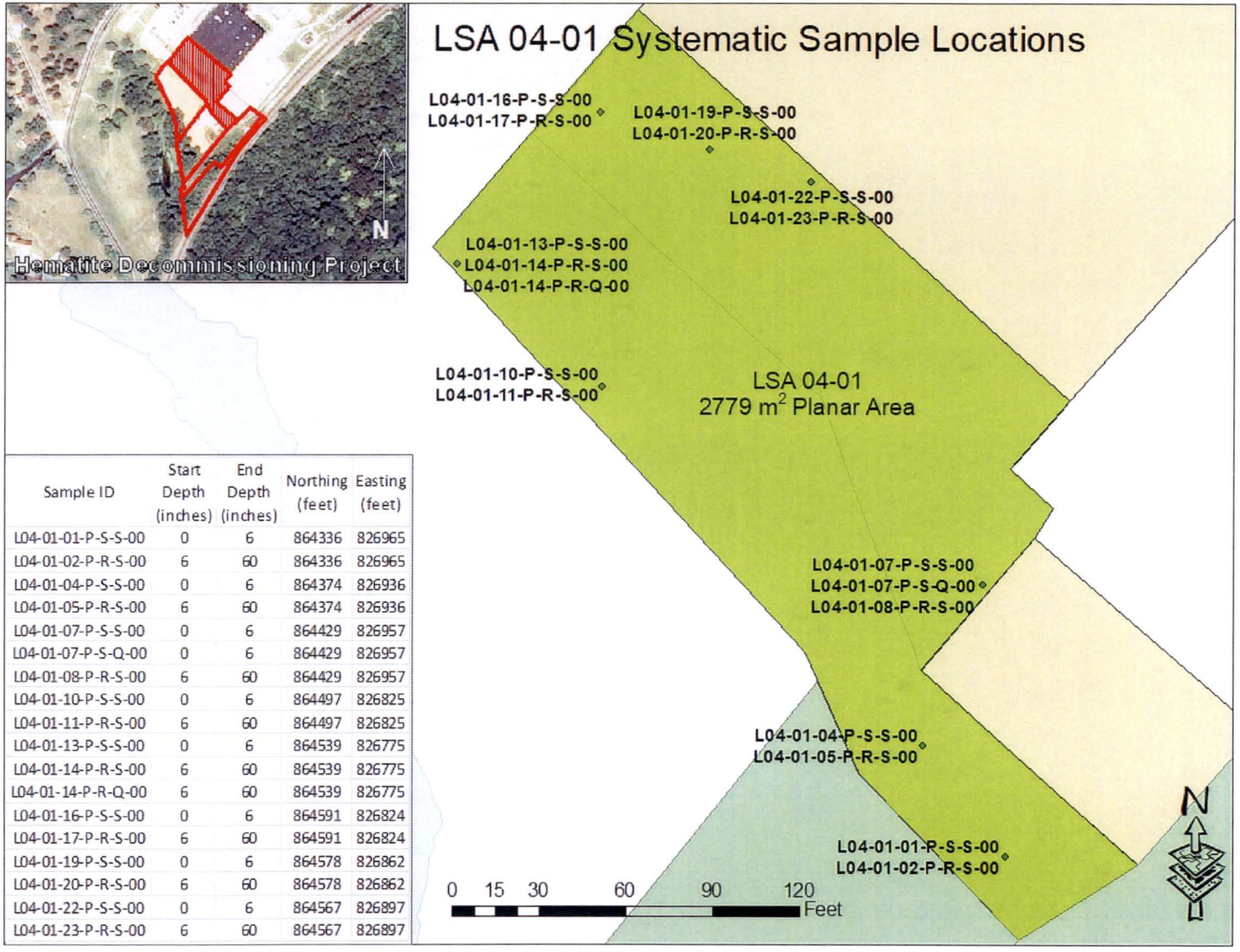
As a Class 3 SU, the systematic sample locations were randomly selected across the SU.

While there were eight (8) systematic locations on the LSA 04-01 sampling grid, a total of eighteen (18) samples were collected at these locations, including:

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

Figure 6-1 presents the map of the eight random systematic sample locations which were sampled within LSA 04-01. 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 04-01 Random Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L04-01-01-P-S-S-00	0	6	864336	826965
L04-01-02-P-R-S-00	6	60	864336	826965
L04-01-04-P-S-S-00	0	6	864374	826936
L04-01-05-P-R-S-00	6	60	864374	826936
L04-01-07-P-S-S-00	0	6	864429	826957
L04-01-07-P-S-Q-00	0	6	864429	826957
L04-01-08-P-R-S-00	6	60	864429	826957
L04-01-10-P-S-S-00	0	6	864497	826825
L04-01-11-P-R-S-00	6	60	864497	826825
L04-01-13-P-S-S-00	0	6	864539	826775
L04-01-14-P-R-S-00	6	60	864539	826775
L04-01-14-P-R-Q-00	6	60	864539	826775
L04-01-16-P-S-S-00	0	6	864591	826824
L04-01-17-P-R-S-00	6	60	864591	826824
L04-01-19-P-S-S-00	0	6	864578	826862
L04-01-20-P-R-S-00	6	60	864578	826862
L04-01-22-P-S-S-00	0	6	864567	826897
L04-01-23-P-R-S-00	6	60	864567	826897

Table 6-2 below presents a tabular listing of all FSS samples collected within LSA 04-01 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 6-2
FSS Sample Locations and Coordinates for LSA 04-01

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 04 **Description:** Plant Soils Open Land Area

Survey Unit: 01 **Description:** SU in "Area 14" adjacent to west side of Bld 230

Survey Type: FSS **Classification:** Class 3

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L04-01-01-P-S-S-00	Uniform	S	433.78	433.3	864336.0	826965.0	Surface 6-inch grab
L04-01-02-P-R-S-00	Uniform	S	433.29	428.9	864336.0	826965.0	Root 4.4-ft composite
L04-01-04-P-S-S-00	Uniform	S	434.2	433.7	864374.0	826936.0	Surface 6-inch grab
L04-01-05-P-R-S-00	Uniform	S	433.71	429.3	864374.0	826936.0	Root 4.4-ft composite
L04-01-07-P-S-S-00	Uniform	S	434.18	433.7	864429.0	826957.0	Surface 6-inch grab
L04-01-08-P-R-S-00	Uniform	S	433.69	429.3	864429.0	826957.0	Root 4.4-ft composite
L04-01-10-P-S-S-00	Uniform	S	431.74	431.3	864497.0	826825.0	Surface 6-inch grab
L04-01-11-P-R-S-00	Uniform	S	431.25	426.8	864497.0	826825.0	Root 4.4-ft composite
L04-01-13-P-S-S-00	Uniform	S	430.9	430.4	864539.0	826775.0	Surface 6-inch grab
L04-01-14-P-R-S-00	Uniform	S	430.4	426.0	864539.0	826775.0	Root 4.4-ft composite
L04-01-16-P-S-S-00	Uniform	S	431.9	431.4	864591.0	826824.0	Surface 6-inch grab
L04-01-17-P-R-S-00	Uniform	S	431.4	427.0	864591.0	826824.0	Root 4.4-ft composite
L04-01-19-P-S-S-00	Uniform	S	432.6	432.1	864578.0	826862.0	Surface 6-inch grab
L04-01-20-P-R-S-00	Uniform	S	432.1	427.7	864578.0	826862.0	Root 4.4-ft composite
L04-01-22-P-S-S-00	Uniform	S	433.3	432.8	864567.0	826897.0	Surface 6-inch grab
L04-01-23-P-R-S-00	Uniform	S	432.8	428.3	864567.0	826897.0	Root 4.4-ft composite
L04-01-07-P-S-Q-00	Uniform	Q	434.2	433.7	864429.0	826957.0	Surface 6-inch grab
L04-01-14-P-R-Q-00	Uniform	Q	430.4	426.0	864539.0	826775.0	Root 4.4-ft composite
L04-01-25-P-S-B-00	Uniform	B	430.9	430.4	864561.0	826822.0	Biased 6-inch grab
L04-01-26-P-S-B-00	Uniform	B	430.9	430.4	864526.0	826855.0	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 04-01 two biased sample locations were selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. This biased location that represented the maximum GWS measurement encountered within the SU was collected at location L04-01-26.

6.4 Judgmental/Sidewall Sampling for Tc-99

As an unexcavated SU, no sidewalls were present within LSA 04-01, and therefore no sidewall sampling was necessary.

6.5 Quality Control Soil Sampling

Two QC field duplicate sample points were randomly selected and collected at systematic locations L04-01-07 and L04-01-14 for LSA 04-01.

7.0 FINAL STATUS SURVEY RESULTS LSA 04-01

7.1 Gamma Walkover Survey

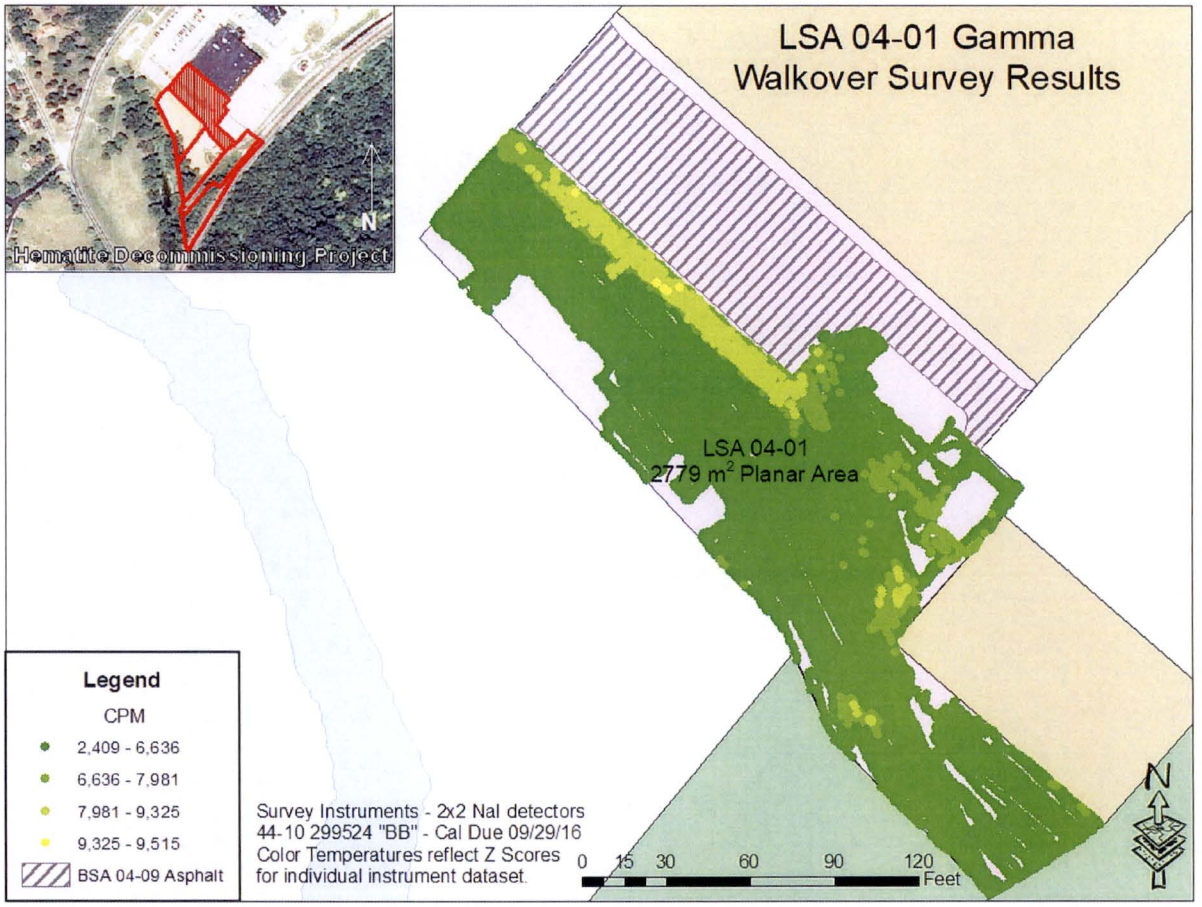
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 04-01 between February 29, 2016, and March 2, 2016.

7.1.1 GWS Results for LSA 04-01

For LSA 04-01, GWS count rates ranged between 2,409 gcpm and 9,515 gcpm, with a mean count rate of 5,312 gcpm. The median count rate was 5,312 gcpm and the standard deviation was 1,348 cpm. Figure 7-1 below presents a map of the complete GWS data set.

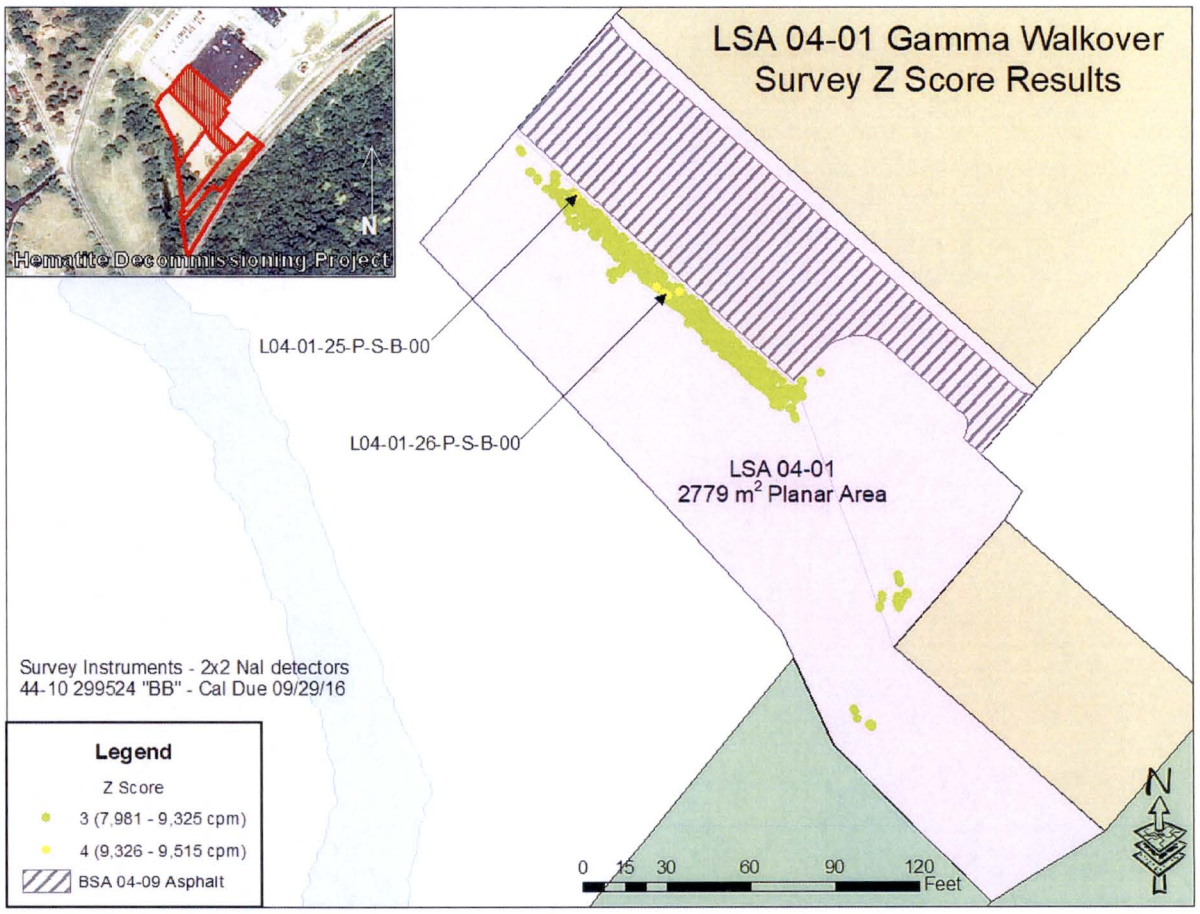
Figure 7-1
Colorimetric GWS Plot for LSA 04-01



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"). Two locations were selected for biased sample collection, and biased location L04-01-26 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 04-01, including the selected biased sampling locations.

Figure 7-2
Colorimetric GWS Plot for LSA 04-01 (Measurements > Z-score of 3)



All GWS data collected in LSA 04-01 was datalogged and post-processed in Graphical Information Software (GIS).

7.1.2 GWS Coverage Results LSA 04-01

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS. As a Class 3 SU the GWS requirement is that a minimum of 1-10% of the SU surface be assessed by GWS. The post survey processing of the GPS data indicated that the GWS was 58.6% of the SU.

7.2 Soil Sample Results LSA 04-01

Appendix A presents the analytical results and associated statistics for all FSS surface samples collected within LSA 04-01.

7.2.1 Surface Soil Sample Results LSA 04-01

There were eight systematic samples collected within the surface stratum (0 – 15 cm) of LSA 04-01. However there were a total of eleven (11) samples collected from the exposed SU surface layer, including 8 systematic samples, 1 QC sample, and 2 biased samples. The maximum Uniform SOF result for the surface samples collected in the SU was 0.06.

7.2.2 Subsurface Soil Sample Results LSA 04-01

There were eight systematic locations within LSA 04-01 where subsurface samples were collected. Root stratum composite sampling was performed at all eight systematic locations. The root stratum zone is between 0.15 and 1.50 m below the surface. Additionally there was one QC sample collected from the root stratum. The maximum SOF result of the subsurface samples collected in LSA 04-01 was 0.30.

7.2.3 WRS Test Evaluation LSA 04-01

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 04-01 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 Test evaluation was still performed for LSA 04-01. 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 04-01 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 Test Evaluation is also included in Appendix A.

7.2.4 Graphical Data Review LSA 04-01

Table 7-1 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 04-01, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.08.

Table 7-1
LSA 04-01 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	0.052	0.118	0.057	2.194	0.118	0.913	**0.08**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.393	0.021	0.070	0.004
Maximum	0.280	0.647	0.310	5.431	0.297	1.740	0.30

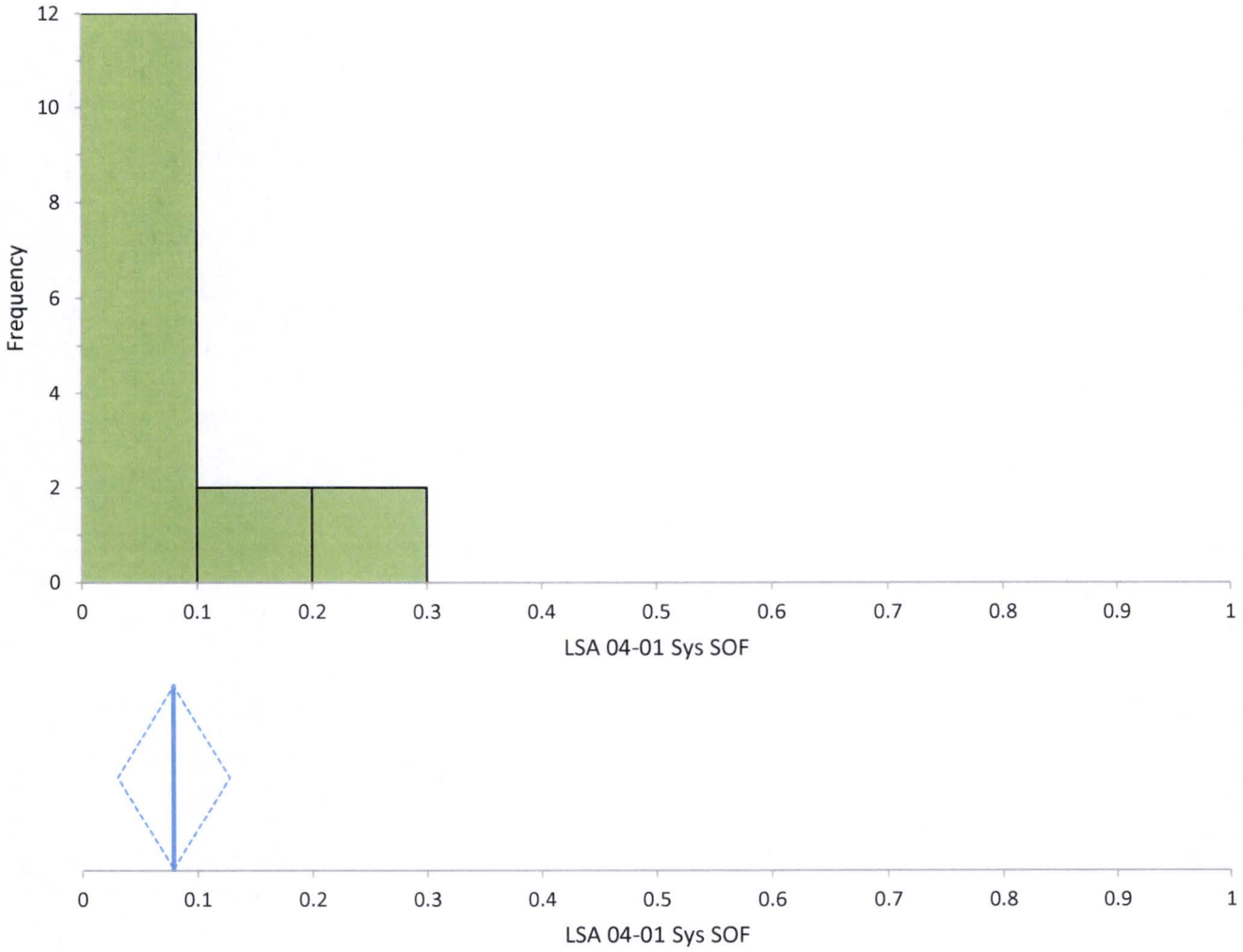
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide 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 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 04-01. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 04-01. The middle graph presents the mean SOF (0.08 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 0.03 to 0.13. The 97.87% confidence interval based on the median (0.05) of the sample results is 0.01 to 0.11. The bottom two charts present the various statistical metrics of the LSA 04-01 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 04-01 data associated with the systematically collected measurement locations.

Figure 7-3
Graphic Statistical Summary for LSA 04-01 (SOF parameter)



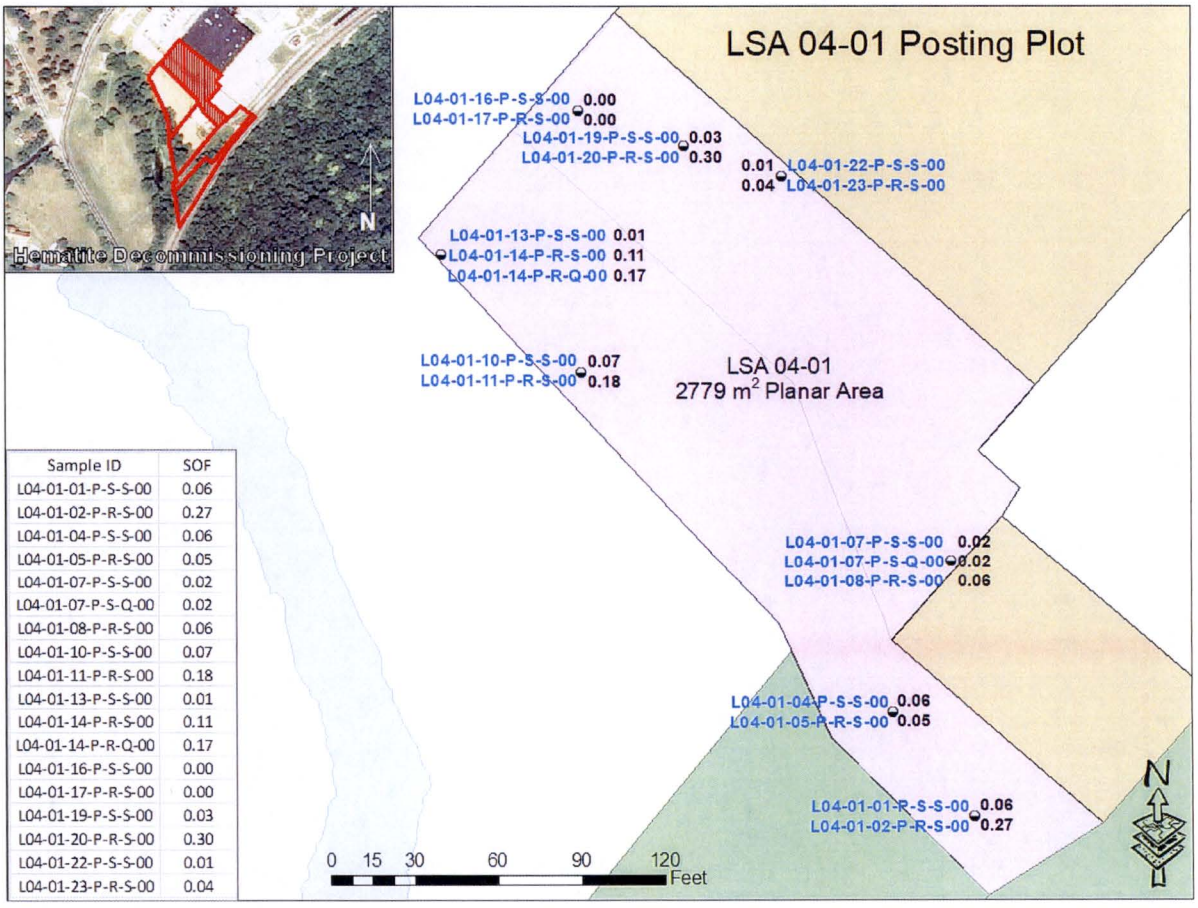
N	16

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 04-01 Sys SOF	0.08	0.03	to 0.13	0.023	0.09	0.01	1.6	1.70

	Minimum	1st quartile	Median	97.87% CI		3rd quartile	Maximum	IQR
LSA 04-01 Sys SOF	0.004	0.01	0.05	0.01	to 0.11	0.10	0.3	0.08

A posting plot is simply a map of the SU 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 04-01 is presented below in Figure 7-4. Figure 7-4 shows no unusual patterns in the data.

Figure 7-4
Posting Plot for LSA 04-01 Random Systematic Measurement Locations



Sample ID	SOF
L04-01-01-P-S-S-00	0.06
L04-01-02-P-R-S-00	0.27
L04-01-04-P-S-S-00	0.06
L04-01-05-P-R-S-00	0.05
L04-01-07-P-S-S-00	0.02
L04-01-07-P-S-Q-00	0.02
L04-01-08-P-R-S-00	0.06
L04-01-10-P-S-S-00	0.07
L04-01-11-P-R-S-00	0.18
L04-01-13-P-S-S-00	0.01
L04-01-14-P-R-S-00	0.11
L04-01-14-P-R-Q-00	0.17
L04-01-16-P-S-S-00	0.00
L04-01-17-P-R-S-00	0.00
L04-01-19-P-S-S-00	0.03
L04-01-20-P-R-S-00	0.30
L04-01-22-P-S-S-00	0.01
L04-01-23-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 K to this report presents the TestAmerica Analytical Laboratory soil sample reports.

Table 7-2
Final Status Survey Analytical Data: LSA 04-01

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
L04-01-01-P-S-S-00	0.00	S	0.934	0.143	0.073	N/A	-0.136	0.000	0.412	0.412	0.104	0.212	N/A	0.950	0.143	0.122	N/A	-0.050	0.000	5.431	NA	NA	NA	0.297	0.147	0.197	N/A	1.740	0.371	0.869	N/A	2.6	0.06
L04-01-02-P-R-S-00	0.50	S	1.240	0.180	0.089	N/A	0.170	0.170	0.091	0.091	0.015	0.213	U	1.310	0.196	0.108	N/A	0.310	0.310	2.035	NA	NA	NA	0.108	0.157	0.259	U	1.060	0.316	0.821	N/A	1.6	0.27
L04-01-04-P-S-S-00	0.00	S	0.894	0.126	0.052	N/A	-0.176	0.000	0.647	0.647	0.115	0.218	N/A	0.874	0.136	0.101	N/A	-0.126	0.000	4.987	NA	NA	NA	0.275	0.142	0.172	N/A	1.190	0.627	0.781	N/A	3.5	0.06
L04-01-05-P-R-S-00	0.50	S	1.060	0.175	0.087	N/A	-0.010	0.000	0.066	0.066	0.015	0.212	U	1.050	0.186	0.111	N/A	0.050	0.050	1.833	NA	NA	NA	0.094	0.126	0.251	U	1.370	0.563	0.841	N/A	1.1	0.05
L04-01-07-P-S-S-00	0.00	S	0.799	0.119	0.060	N/A	-0.271	0.000	0.244	0.244	0.042	0.208	N/A	0.738	0.124	0.111	N/A	-0.262	0.000	1.002	NA	NA	NA	0.051	0.100	0.203	U	0.760	0.250	0.700	N/A	1.1	0.02
L04-01-08-P-R-S-00	0.50	S	1.090	0.160	0.081	N/A	0.020	0.020	0.152	0.152	0.047	0.205	U	1.010	0.154	0.116	N/A	0.010	0.010	4.018	NA	NA	NA	0.218	0.132	0.243	U	1.510	0.539	0.801	N/A	2.2	0.06
L04-01-10-P-S-S-00	0.00	S	1.050	0.142	0.050	N/A	-0.020	0.000	0.027	0.027	0.034	0.216	U	1.110	0.164	0.096	N/A	0.110	0.110	2.057	NA	NA	NA	0.111	0.138	0.215	U	0.877	0.314	0.782	N/A	2.0	0.07
L04-01-11-P-R-S-00	0.50	S	1.320	0.195	0.087	N/A	0.250	0.250	0.014	0.014	0.004	0.225	U	1.060	0.179	0.145	N/A	0.060	0.060	1.443	NA	NA	NA	0.074	0.125	0.279	U	1.050	0.398	1.020	N/A	1.1	0.18
L04-01-13-P-S-S-00	0.00	S	0.303	0.053	0.031	N/A	-0.767	0.000	0.031	0.031	0.011	0.184	U	0.100	0.031	0.061	N/A	-0.900	0.000	0.632	NA	NA	NA	0.035	0.048	0.102	U	0.166	0.108	0.326	U	3.2	0.01
L04-01-14-P-R-S-00	0.50	S	1.180	0.168	0.071	N/A	0.110	0.110	0.034	0.034	0.028	0.227	U	1.080	0.166	0.124	N/A	0.080	0.080	1.215	NA	NA	NA	0.061	0.157	0.245	U	0.993	0.512	0.801	N/A	1.0	0.11
L04-01-16-P-S-S-00	0.00	S	0.181	0.040	0.030	N/A	-0.889	0.000	0.008	0.008	0.024	0.162	U	0.055	0.029	0.058	N/A	-0.945	0.000	0.595	NA	NA	NA	0.033	0.048	0.073	U	0.070	0.097	0.303	U	6.8	0.00
L04-01-17-P-R-S-00	0.50	S	0.237	0.051	0.027	N/A	-0.833	0.000	-0.008	0.000	0.039	0.151	U	0.084	0.053	0.093	N/A	-0.916	0.000	0.393	NA	NA	NA	0.021	0.057	0.098	U	0.237	0.142	0.323	U	1.4	0.00
L04-01-19-P-S-S-00	0.00	S	0.926	0.147	0.070	N/A	-0.144	0.000	0.066	0.066	0.061	0.219	U	0.866	0.144	0.133	N/A	-0.134	0.000	3.191	NA	NA	NA	0.175	0.168	0.204	U	0.965	0.503	0.784	N/A	2.8	0.03
L04-01-20-P-R-S-00	0.50	S	1.350	0.181	0.060	N/A	0.280	0.280	0.034	0.034	0.013	0.193	U	1.260	0.190	0.151	N/A	0.260	0.260	2.204	NA	NA	NA	0.117	0.140	0.229	U	1.130	0.523	0.808	N/A	1.6	0.30
L04-01-22-P-S-S-00	0.00	S	0.541	0.083	0.037	N/A	-0.529	0.000	0.033	0.033	0.009	0.144	U	0.387	0.076	0.044	N/A	-0.613	0.000	1.042	NA	NA	NA	0.057	0.072	0.131	U	0.375	0.162	0.425	U	2.4	0.01
L04-01-23-P-R-S-00	0.50	S	1.020	0.139	0.060	N/A	-0.050	0.000	0.027	0.027	0.015	0.201	U	1.030	0.156	0.093	N/A	0.030	0.030	3.034	NA	NA	NA	0.165	0.116	0.181	U	1.110	0.467	0.716	N/A	2.3	0.04
L04-01-07-P-S-Q-00	0.00	Q	0.639	0.107	0.061	N/A	-0.431	0.000	0.130	0.130	0.054	0.183	U	0.417	0.100	0.089	N/A	-0.583	0.000	2.304	NA	NA	NA	0.127	0.101	0.161	U	0.565	0.234	0.607	U	3.4	0.02
L04-01-14-P-R-Q-00	0.50	Q	1.290	0.168	0.060	N/A	0.220	0.220	0.044	0.044	0.032	0.224	U	1.080	0.185	0.095	N/A	0.080	0.080	1.586	NA	NA	NA	0.081	0.145	0.243	U	1.140	0.619	0.793	N/A	1.1	0.17
L04-01-25-P-S-B-00	0.00	B	1.010	0.144	0.062	N/A	-0.060	0.000	0.209	0.209	0.071	0.234	U	0.907	0.155	0.099	N/A	-0.093	0.000	3.383	NA	NA	NA	0.184	0.125	0.188	U	1.230	0.497	0.747	N/A	2.3	0.04
L04-01-26-P-S-B-00	0.00	B	0.504	0.087	0.024	N/A	-0.566	0.000	0.226	0.226	0.028	0.209	N/A	0.360	0.097	0.064	N/A	-0.640	0.000	1.218	NA	NA	NA	0.066	0.061	0.162	U	0.505	0.221	0.567	U	2.0	0.02
Systematic Minimum			0.000						0.000					0.000						0.393				0.021				0.070				**2.3**	0.00
Systematic Maximum			0.280						0.647					0.310						5.431				0.297				1.740				**Average Enrichment (%)**	0.30
Systematic Mean			0.052						0.118					0.057						2.194				0.118				0.913					0.08
Systematic Median			0.000						0.034					0.005						1.934				0.101				1.022					0.05
Systematic Standard Deviation			0.096						0.177					0.096						1.549				0.086				0.483					0.09
			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 04-01

Two biased sample were collected from LSA 04-01. The sample collected at location L04-01-26 represented the maximum GWS measurement (9,515 gcpm) within the SU, and had a result of 0.02 Uniform SOF.

7.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 04-01

As an unexcavated Class 3 SU, there were no sidewalls present in LSA 04-01, and therefore no sidewall sampling was necessary.

7.2.7 Quality Control Soil Sample Result LSA 04-01

Two QC field duplicate sample points were randomly selected for LSA 04-01 which were collected at systematic locations L04-01-07 and L04-01-14.

For the 18 samples (i.e., 16 systematic + 2 biased) collected within LSA 04-01, Two field duplicate samples were collected. This frequency equates to 11.1%, (i.e. 2/18). 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 with ne exception (see Figure 7-5 below).

The statistical assessment of the Laboratory QC sample results indicated that one field duplicate sample (L04-04-07-P-S-Q-00) exceeded the calculated Warning Limit for Th-232. In accordance with procedure HDP-PR-FSS-703, *Final Status Survey Quality Control*, 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 (0.321) slightly exceeded the Warning Limit (0.283). 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 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-01 (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 04-01				Survey Unit Description:		SU in "Area 14" adjacent to west side of Bld 230					
			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)
L04-01-14-P-R-S-00	L04-01-14-P-R-Q-00	Ra-226	1.18	0.0707	1.29	0.0595	1.235	1.9	0.11	0.269	0.403	N
L04-01-14-P-R-S-00	L04-01-14-P-R-Q-00	Tc-99	0.0336	0.227	0.0444	0.224	0.039	25.1	NA	3.552	5.321	NA
L04-01-14-P-R-S-00	L04-01-14-P-R-Q-00	Th-232	1.08	0.124	1.08	0.0945	1.080	2.0	0.000	0.283	0.424	N
L04-01-14-P-R-S-00	L04-01-14-P-R-Q-00	U-234[1]	1.215	N/A	1.586	N/A	1.400	195.4	0.371	27.649	41.425	N
L04-01-14-P-R-S-00	L04-01-14-P-R-Q-00	U-235	0.0612	0.243	0.0809	0.243	0.071	51.6	NA	7.301	10.939	NA
L04-01-14-P-R-S-00	L04-01-14-P-R-Q-00	U-238	0.993	0.793	1.14	0.793	1.067	168.8	0.147	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/17/17

Quality Record

Figure 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-01 (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 04-01				Survey Unit Description:		SU in "Area 14" adjacent to west side of Bld 230					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$)	Nuclide DCGL		Warning	Control	Statistic Exceeds Limit?
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	(pCi/g)	(pCi/g)	Statistic[2]	Limit	Limit	(Y/N)
L04-01-07-P-S-S-00	L04-01-07-P-S-Q-00	Ra-226	0.799	0.0595	0.639	0.0608	0.719	1.9	0.16	0.269	0.403	N
L04-01-07-P-S-S-00	L04-01-07-P-S-Q-00	Tc-99	0.244	0.208	0.13	0.183	0.187	25.1	NA	3.552	5.321	NA
L04-01-07-P-S-S-00	L04-01-07-P-S-Q-00	Th-232	0.738	0.111	0.417	0.0893	0.578	2.0	0.321	0.283	0.424	Y
L04-01-07-P-S-S-00	L04-01-07-P-S-Q-00	U-234[1]	1.002	N/A	2.304	N/A	1.653	195.4	1.303	27.649	41.425	N
L04-01-07-P-S-S-00	L04-01-07-P-S-Q-00	U-235	0.0511	0.203	0.127	0.161	0.089	51.6	NA	7.301	10.939	NA
L04-01-07-P-S-S-00	L04-01-07-P-S-Q-00	U-238	0.76	0.7	0.565	0.607	0.663	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/12/17

Quality Record

7.3 Tc-99 Hot Spot Assessment LSA 04-01

Within LSA 04-01, there is no history of any sample from the SU exceeding the Tc-99 $DCGL_W$, or a SOF of 1.0. The highest Tc-99 sample result collected from both Final RASS and FSS was 4.11 pCi/g. There is no indication of a potential Tc-99 hot spot exceeding the $DCGL_W$ of 25.1 pCi/g, and therefore a Tc-99 hot spot assessment is not required.

8.0 ALARA EVALUATION LSA 04-01

All samples collected within LSA 04-01 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 04-01 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.08 for LSA 04-01. The average SOF equates to residual activity contributions from the SU area of 2.0 mrem/year for LSA 04-01. Groundwater monitoring well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356} indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the U.S. Environmental Protection Agency (EPA) MCLs will be added to the total estimated dose for LSA 04-01. Additionally, dose contributions for the remaining structure (BSA 04-09) will be added contributing an additional 0.75 mrem/year in total. While PSA 01-08 is also present within the SU, the piping has been determined to add 0.0 mrem/yr additional dose. Adding all of the dose contributions together, the total estimated dose for LSA 04-01 is 6.75 mrem/year.

Since the estimated Total Effective Dose Equivalent (TEDE) is well below the regulatory release criterion of 25 mrem/year, the conclusion of the As Low As Reasonably Achievable (ALARA) evaluation is that the remediation of LSA 04-01 was successful and that there would be no discernable benefit to the health and safety of the public in discounting the results of FSS and performing further remediation of LSA 04-01.

9.0 FSS PLAN DEVIATIONS LSA 04-01

9.1 Remedial Actions during FSS

There were no remedial actions of any kind in the Class 3 LSA 04-01 SU.

9.2 Adjustments to Scan MDC Calculations

Scan MDCs for LSA 04-01 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 6,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 5,312 cpm. Therefore the calculated Scan MDCs are appropriate, 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 04-01

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 04-01 (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 grid pattern) 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 04-01 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 SU data set measurement SOF and the minimum background area measurement SOF is less than or equal to one. For LSA 04-01, 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 04-01. 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 systematic surface samples within LSA 04-01 was 0.06. The maximum SOF result for the all systematic subsurface samples within LSA 04-01 was 0.30. The average SOF result for all systematically collected samples within LSA 04-01 was 0.08, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.13.
- No FSS sample result in LSA 04-01 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an elevated measurement comparisons (EMC) or supplemental investigations were 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 04-01. The successful result of the retrospective power evaluation presented in Table 10-1 for LSA 04-01 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 04-01. 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 was 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 04-01

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.09
$DCGL_{SOF}$	1
LBGR (Mean)	0.08
Shift	0.92
Relative Shift (Δ/σ)	10.07
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 10-1
Data Evaluation Checklists prepared for LSA 04-01 (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 04 **Description:** Plant Soils Open Land Area
Survey Unit: 01 **Description:** SU in "Area14" adjacent to west side of Bldg. 230

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 ☐	NA ☐
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	NA ☐

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 sample result for Th-232 exceeded the Control Limit, however the results were reviewed by the RSO and the FSS QC results are still considered acceptable. This review is documented in the FSS report.

Quality Record

Figure 10-1
Data Evaluation Checklists prepared for LSA 04-01 (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: No. LSA 04 **Description:** Plant Soils Open Land Area
Survey Unit: No. 01 **Description:** SU in "Area14" adjacent to west side of Bldg. 230

Discrepancy: None

Corrective Actions Taken: None

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 Yardy (Print Name)	(Signature)	7-17-17 (Date)
Approved by (RSO):	Clark Evers (Print Name)	(Signature)	7/17/17 (Date)

Quality Record

11.0 SURVEILLANCE FOLLOWING FSS

FSS GWS activities in LSA 04-01 were completed in March, 2016. There were no events after the completion of FSS that would have the potential to cause contamination above the DCGLs in the SU.

12.0 CONCLUSION LSA 04-01

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 04-01 of 6.75 mrem/year does not exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 12-1
LSA 04-01 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	BSA 04-12 STRUCTURE	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.08	0.03	0.16	0.0	N/A	**0.27**
DOSE	2.0 mrem/year	0.75 mrem/year	4.0 mrem/year	0.0 mrem/year	N/A	**6.75 mrem/year**

13.0 FINAL STATUS SURVEY DESIGN LSA 04-02

This section describes the method for determining the number of samples required for the FSS of LSA 04-02 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 04-02 and their detection sensitivities are also discussed.

13.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 04-02 were driven by the type (Open Land) and Class (Class 1) of the survey unit and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

13.1.1 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.*

13.1.2 $DCGL_W$

During the FSS design process a review was performed of the historic characterization data for LSA 04-02. 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.

13.1.3 GWS Coverage

As a Class 1 SU, LSA 04-02 was required to undergo a 100% GWS.

13.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 04-02 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

13.1.5 Scan Minimum Detectable Concentration

Scan MDCs for LSA 04-02 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 10,000 cpm within LSA 04-02, the Scan MDC calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3659\ pCi/g}\right)+\left(\frac{f_{U-235}}{2.32\ pCi/g}\right)+\left(\frac{f_{U-238}}{30.6\ pCi/g}\right)\right)}$$

Equation 13-1

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 04-02, the average enrichment for the SU was 3.5%. 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 04-02 are shown below:

Table 13-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 04-02

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 04-02	40.9	26.9	1.21	2.8	0.87	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. $DCGL_W$ values are based on the Uniform Stratum release criteria.

The values in Table 13-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

13.1.6 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 basis of the IAL is detailed in HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*". The IAL used during the GWS of LSA 04-02 was established at 4,000 ncpm.

13.1.7 LSA 04-02 FSS Design Summary

The FSS Plan for LSA 04-02 can be found in Appendix G. Table 13-2 presents an overall FSS design and implementation summary for LSA 04-02.

Table 13-2
FSS Design Summary for LSA 04-02

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed floors and walls	
Scan MDC	40.9 pCi/g total Uranium (based on a 10,000 cpm background); 0.87 pCi/g Th-232; 1.21 pCi/g Ra-226*	
Investigation Action Level (IAL)	4,000 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Samples	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 (3.5%) 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.		

14.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 04-02

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

14.1 Gamma Walkover Survey

14.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 04-02 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 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*.

14.1.2 GWS Performance

All GWS measurements on the surface of the SU were 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 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 surface.

HP Technicians performing GWS in LSA 04-02 used the 4,000 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), HP 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, HP Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to geometry and relative distance from contaminated materials in nearby areas, the average background rate (measured at waist level) within the LSA ranged between 10,000 and 11,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 15,000 gcpm, HP 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.

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.

14.2 Soil Sampling

14.2.1 Systematic Soil Sampling Summary

Table 14-1 provides a summary of systematic sampling by stratum for LSA 04-02.

Table 14-1
Systematic Sampling Summary by Stratum for LSA 04-02

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
04-02	2,064	8	8	0	2

14.2.2 Systematic Sampling LSA 04-02

Within LSA 04-02, the surface stratum [0 – 15 centimeters (cm)] remained in the SU at all eight systematic locations. The root stratum (15 cm – 150 cm) also remained at all of the eight systematic locations. At these locations the remaining root stratum interval was collected using a hand auger and composited. Excavation stratum samples were collected at eight locations using hand augers, but these samples were archived as excavation stratum samples were not required to be sampled since no root stratum sample exceeded 0.5 SOF.

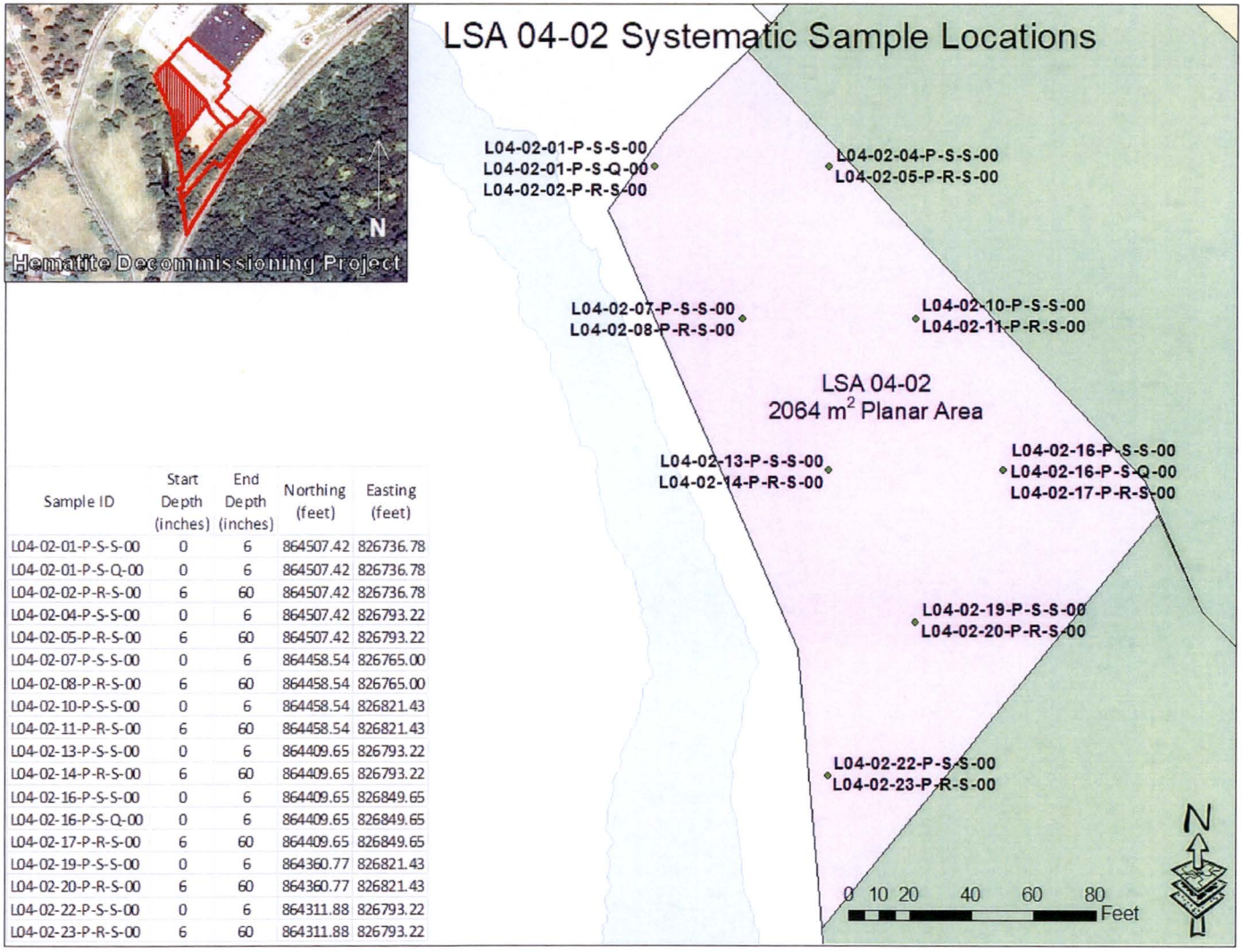
Given a planar area of 2,064 m^2 for LSA 04-02 and an eight - point systematic triangular grid, the point-to-point distance within each row was 17.2 m.

While there were eight systematic locations on the LSA 04-02 sampling grid, a total of eighteen (18) samples were collected at these locations, including:

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

Figure 14-1 presents the map of the eight systematic sample locations which were sampled within LSA 04-02. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 14-1
LSA 04-02 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L04-02-01-P-S-S-00	0	6	864507.42	826736.78
L04-02-01-P-S-Q-00	0	6	864507.42	826736.78
L04-02-02-P-R-S-00	6	60	864507.42	826736.78
L04-02-04-P-S-S-00	0	6	864507.42	826793.22
L04-02-05-P-R-S-00	6	60	864507.42	826793.22
L04-02-07-P-S-S-00	0	6	864458.54	826765.00
L04-02-08-P-R-S-00	6	60	864458.54	826765.00
L04-02-10-P-S-S-00	0	6	864458.54	826821.43
L04-02-11-P-R-S-00	6	60	864458.54	826821.43
L04-02-13-P-S-S-00	0	6	864409.65	826793.22
L04-02-14-P-R-S-00	6	60	864409.65	826793.22
L04-02-16-P-S-S-00	0	6	864409.65	826849.65
L04-02-16-P-S-Q-00	0	6	864409.65	826849.65
L04-02-17-P-R-S-00	6	60	864409.65	826849.65
L04-02-19-P-S-S-00	0	6	864360.77	826821.43
L04-02-20-P-R-S-00	6	60	864360.77	826821.43
L04-02-22-P-S-S-00	0	6	864311.88	826793.22
L04-02-23-P-R-S-00	6	60	864311.88	826793.22

Table 14-2 below presents a tabular listing of all FSS samples collected within LSA 04-02 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 14-2
FSS Sample Locations and Coordinates for LSA 04-02

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 04 **Description:** Plant Soils SEA Open Land Area

Survey Unit: 02 **Description:** Central Open Land Area

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

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L04-02-01-P-S-S-00	Uniform	S	430.4	429.9	864507.4	826736.8	Surface 6-inch grab
L04-02-02-P-R-S-00	Uniform	S	429.91	425.5	864507.4	826736.8	Root 4.4-ft composite
L04-02-04-P-S-S-00	Uniform	S	431.4	430.9	864507.4	826793.2	Surface 6-inch grab
L04-02-05-P-R-S-00	Uniform	S	430.91	426.5	864507.4	826793.2	Root 4.4-ft composite
L04-02-07-P-S-S-00	Uniform	S	431.8	431.3	864458.5	826765.0	Surface 6-inch grab
L04-02-08-P-R-S-00	Uniform	S	431.31	426.9	864458.5	826765.0	Root 4.4-ft composite
L04-02-10-P-S-S-00	Uniform	S	432.2	431.7	864458.5	826821.4	Surface 6-inch grab
L04-02-11-P-R-S-00	Uniform	S	431.71	427.3	864458.5	826821.4	Root 4.4-ft composite
L04-02-13-P-S-S-00	Uniform	S	432	431.5	864409.7	826793.2	Surface 6-inch grab
L04-02-14-P-R-S-00	Uniform	S	431.5	427.1	864409.7	826793.2	Root 4.4-ft composite
L04-02-16-P-S-S-00	Uniform	S	432.7	432.2	864409.7	826849.6	Surface 6-inch grab
L04-02-17-P-R-S-00	Uniform	S	432.2	427.8	864409.7	826849.6	Root 4.4-ft composite
L04-02-19-P-S-S-00	Uniform	S	431.8	431.3	864360.8	826821.4	Surface 6-inch grab
L04-02-20-P-R-S-00	Uniform	S	431.3	426.9	864360.8	826821.4	Root 4.4-ft composite
L04-02-22-P-S-S-00	Uniform	S	429.1	428.6	864311.9	826793.2	Surface 6-inch grab
L04-02-23-P-R-S-00	Uniform	S	428.6	424.2	864311.9	826793.2	Root 4.4-ft composite
L04-02-01-P-S-Q-00	Uniform	Q	430.4	429.9	864507.4	826736.8	Surface 6-inch grab
L04-02-16-P-S-Q-00	Uniform	Q	432.7	432.2	864409.7	826849.6	Surface 6-inch grab
L04-02-25-P-S-B-00	Uniform	B	431.8	431.3	864441.9	826761.2	Sidewall 6-inch grab
L04-02-26-P-S-B-00	Uniform	B	431.8	431.3	864362.1	826802.8	Biased 6-inch grab
L04-02-27-P-S-B-00	Uniform	B	430.4	429.9	864481.9	826733.1	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

14.3 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 04-02 several sample locations were selected within the SU based on the evaluation of the GWS survey data. Biased location L04-02-26-P-S-B-00 represents the maximum GWS measurement encountered within in LSA 04-02 and has a Uniform SOF value of 0.26.

14.4 Judgmental/Sidewall Sampling for Tc-99

While no remedial excavations were necessary in LSA 04-02, a small amount of soil removal was performed for "grading" purposes to create a flat surface for equipment to traverse the area supporting the remedial excavations in the adjacent Site Pond (LSA 02-01 and LSA 02-02). Since sidewalls were present in LSA 04-02, one sidewall sample was collected.

14.5 Quality Control Soil Sampling

Two QC field duplicate sample points were randomly selected and collected at systematic locations L04-02-01 and L04-02-16 for LSA 04-02.

15.0 FINAL STATUS SURVEY RESULTS LSA 04-02

15.1 Gamma Walkover Survey

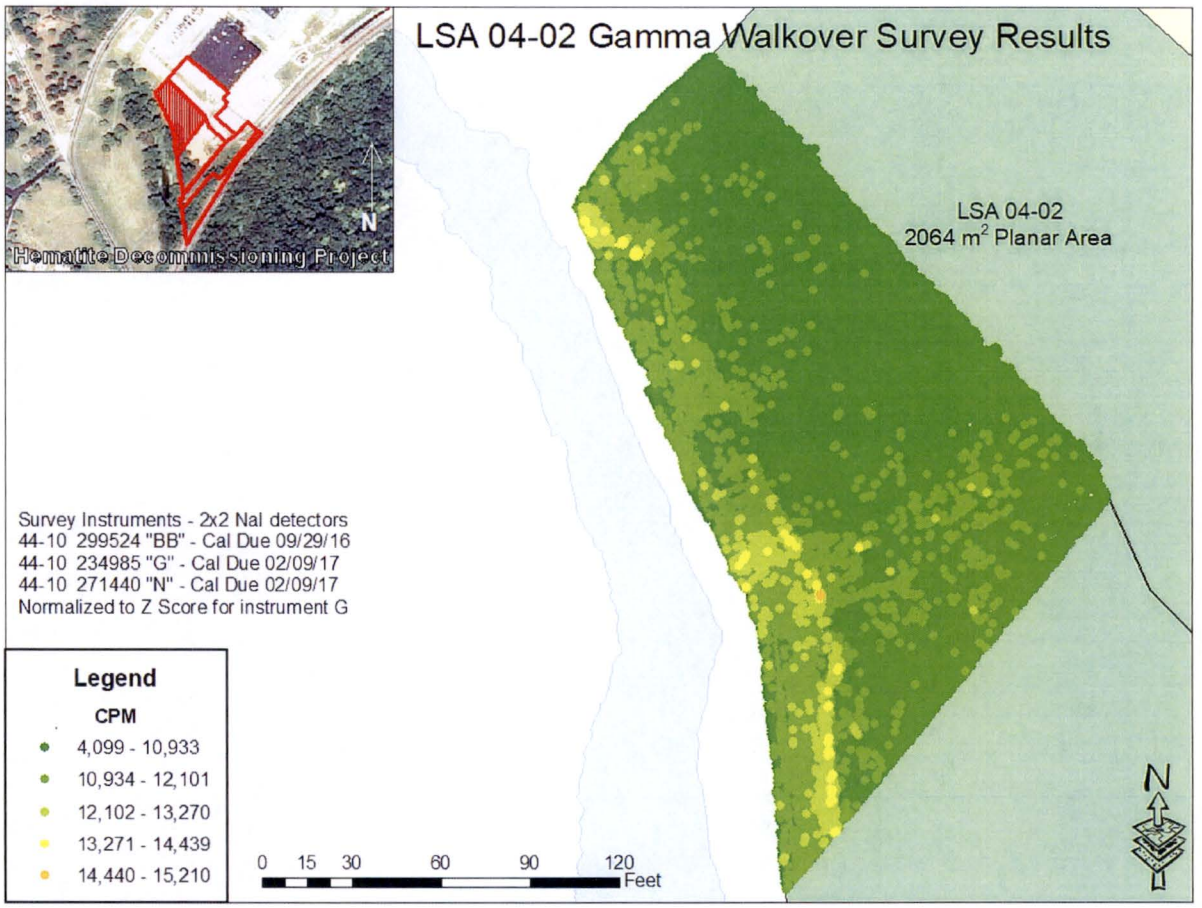
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 04-02 between March 17, 2016, and April 1, 2016.

15.1.1 GWS Results for LSA 04-02

For LSA 04-02, GWS count rates ranged between 4,099 gcpm and 14,289 gcpm, with a mean count rate of 8,636 gcpm. The median count rate was 8,743 gcpm with a standard deviation of 1,403 cpm. Figure 15-1 below presents a map of the complete GWS data set.

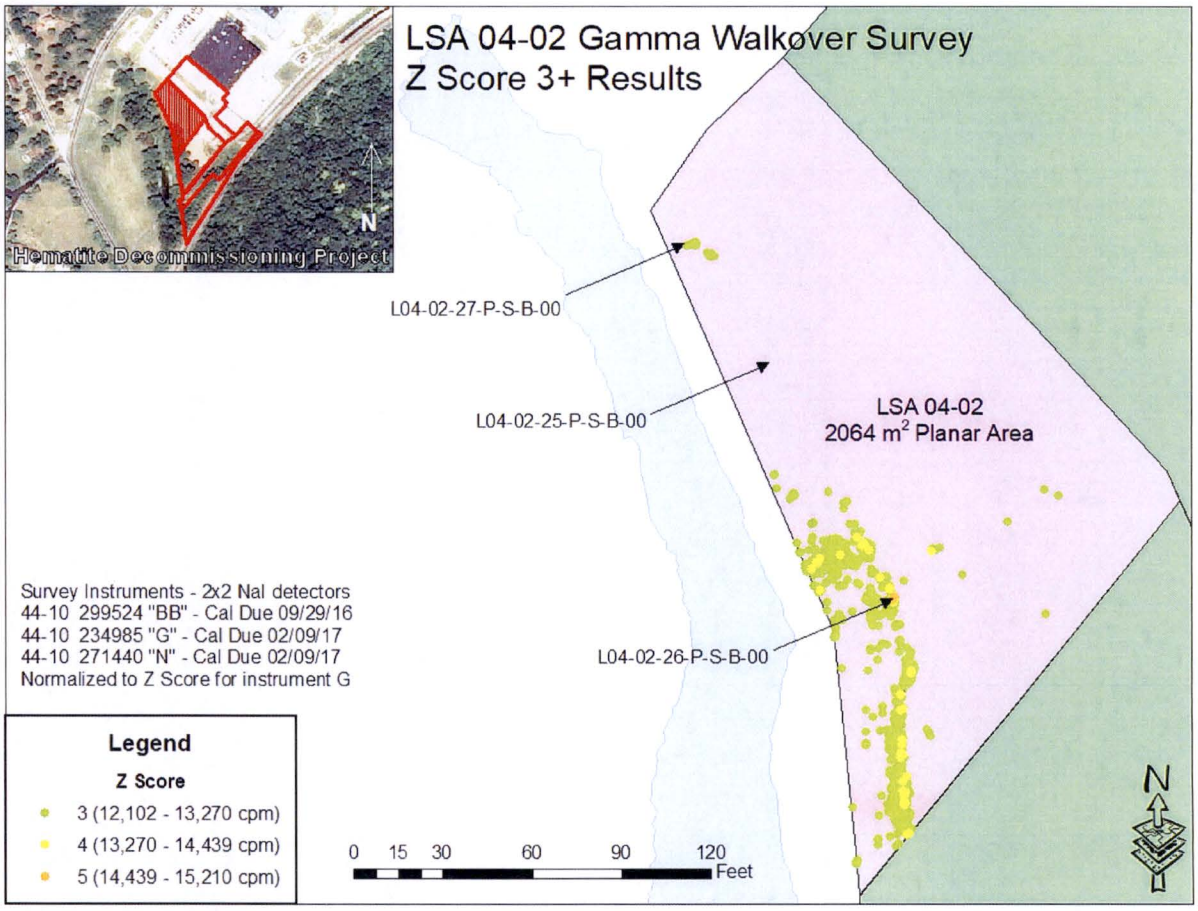
Figure 15-1
Colorimetric GWS Plot for LSA 04-02



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"). Two locations were selected for biased sample collection, and biased location L04-02-26 represented the maximum GWS measurement encountered within the SU.

Figure 15-2 presents a map of the +3 Z-score GWS measurements within LSA 04-02, including the selected biased sampling locations.

Figure 15-2
Colorimetric GWS Plot for LSA 04-02 (Measurements > Z-score of 3)



All GWS data collected in LSA 04-02 was datalogged and post-processed GIS.

15.1.2 GWS Coverage Results LSA 04-02

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS. Although 100% of accessible areas underwent GWS, it is rare that GPS coverage achieves the same level, primarily due to limitations within the GPS technology.

The post survey processing of the GPS data indicated that the GWS was 99.98% of the SU (see Table 15-1). As the evaluation indicates that the GPS coverage exceeded 95% with no readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of any apparent GPS coverage gaps, the GWS coverage for the SU has been evaluated to meet the intent of the "100% GWS coverage" requirement.

Table 15-1
GWS Gap Analysis LSA 04-02

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 04-02	185,038	46	0.02%	99.98%	1

15.2 Soil Sample Results LSA 04-02

Appendix B presents the analytical results and associated statistics for all FSS surface samples collected within LSA 04-02.

15.2.1 Surface Soil Sample Results LSA 04-02

There were eight systematic samples collected within the surface stratum (0 – 15 cm) of LSA 04-02. There were a total of thirteen (13) samples collected from the exposed ground surface layer, including 8 systematic samples, 2 QC samples, 2 biased samples, and 1 sidewall sample. The maximum Uniform SOF result for the surface samples was 0.76.

15.2.2 Subsurface Soil Sample Results LSA 04-02

There were eight systematic locations within LSA 04-02 where subsurface samples were collected. Root stratum composite sampling was performed at all eight locations. The root stratum zone is between 0.15 and 1.50 m below the surface. The maximum SOF result of the subsurface samples collected in LSA 04-02 was 0.24.

15.2.3 WRS Test Evaluation LSA 04-02

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was not required for LSA 04-02 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 Test was still performed for LSA 04-02. 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 04-02 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.

15.2.4 Graphical Data Review LSA 04-02

Table 15-2 below presents summary results for the all systematically collected samples (includes surface, and root, stratum samples, but not biased or QC samples) collected within LSA 04-02, and the associated SOF when compared to the Uniform Stratum $DCGL_Ws$. The arithmetic average concentration resulted in a SOF of 0.11.

Table 15-2
LSA 04-02 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	0.026	0.622	0.089	3.775	0.205	1.224	**0.11**
Minimum	0.00 (<BKG)	0.020	0.00 (<BKG)	0.746	0.033	0.932	0.03
Maximum	0.120	3.130	0.300	9.912	0.547	2.230	0.32

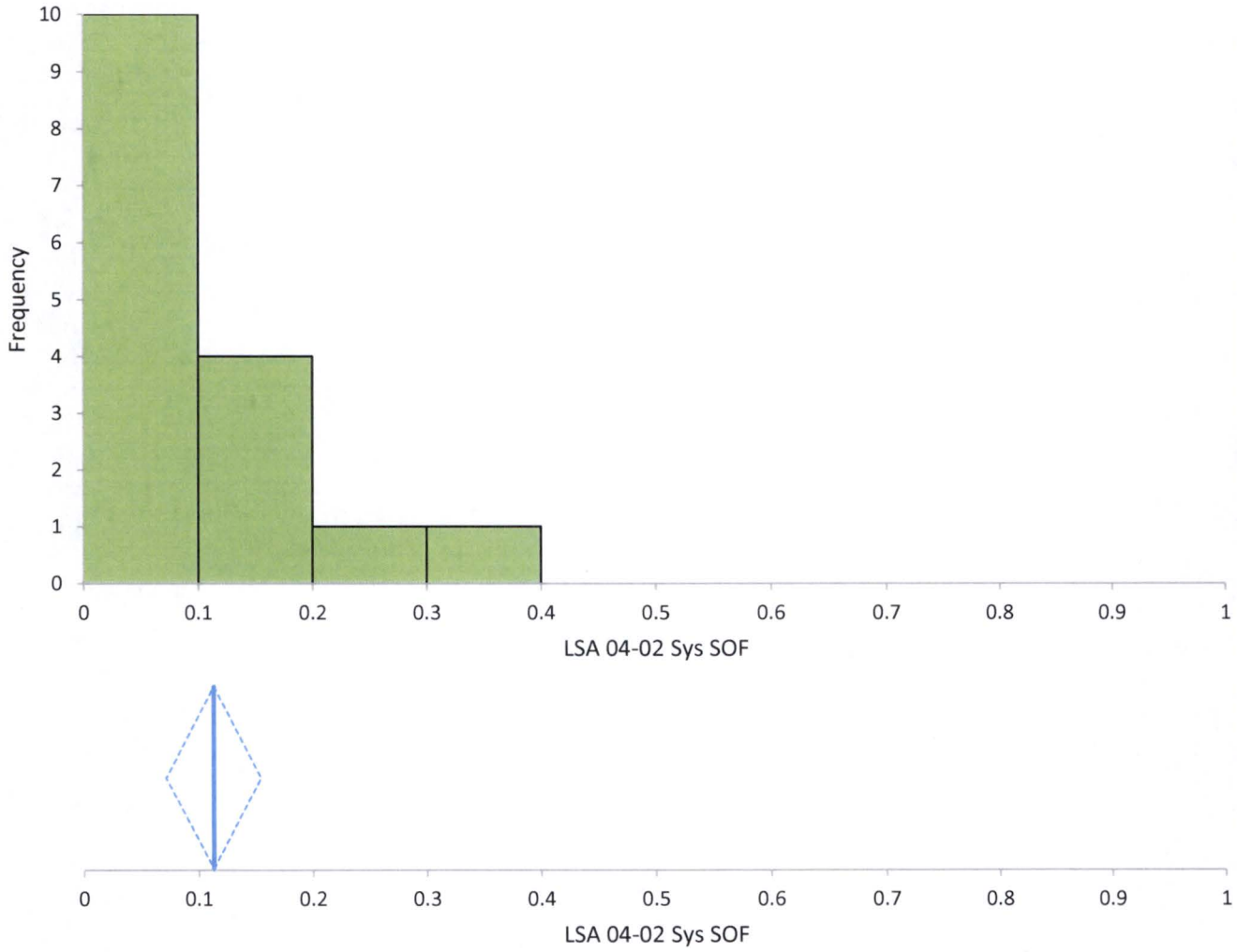
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide 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 SU. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 15-3 presents the overall statistical metrics for the SOF parameter for the 16 systematically collected samples from LSA 04-02. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 04-02. The middle graph presents the mean SOF (0.11) 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 0.07 to 0.15. The 97.87% confidence interval based on the median (0.09) of the sample results is 0.06 to 0.15. The bottom two charts present the various statistical metrics of the LSA 04-02 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 15-3 exhibits no unusual symmetry or bimodality concerns for the LSA 04-02 data associated with the systematically collected measurement locations.

Figure 15-3
Graphic Statistical Summary for LSA 04-02 (SOF parameter)



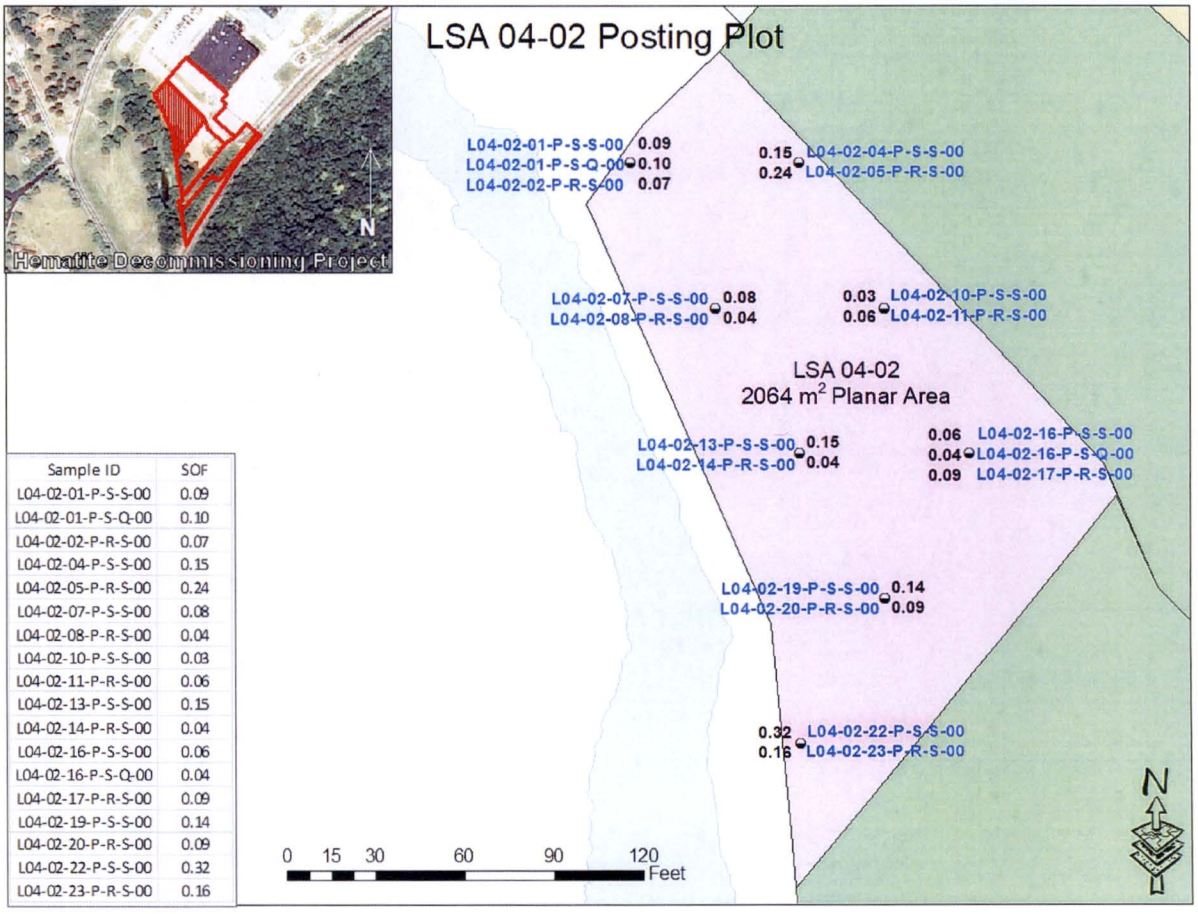
N	16

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 04-02 Sys SOF	0.11	0.07	to 0.15	0.019	0.08	0.01	1.5	2.21

	Minimum	1st quartile	Median	97.87% CI		3rd quartile	Maximum	IQR
LSA 04-02 Sys SOF	0.03	0.06	0.09	0.06	to 0.15	0.15	0.3	0.09

A posting plot is simply a map of the SU 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 04-02 is presented below in Figure 15-4. Figure 15-4 shows no unusual patterns in the data.

Figure 15-4
Posting Plot for LSA 04-02 Systematic Measurement Locations



Sample ID	SOF
L04-02-01-P-S-S-00	0.09
L04-02-01-P-S-Q-00	0.10
L04-02-02-P-R-S-00	0.07
L04-02-04-P-S-S-00	0.15
L04-02-05-P-R-S-00	0.24
L04-02-07-P-S-S-00	0.08
L04-02-08-P-R-S-00	0.04
L04-02-10-P-S-S-00	0.03
L04-02-11-P-R-S-00	0.06
L04-02-13-P-S-S-00	0.15
L04-02-14-P-R-S-00	0.04
L04-02-16-P-S-S-00	0.06
L04-02-16-P-S-Q-00	0.04
L04-02-17-P-R-S-00	0.09
L04-02-19-P-S-S-00	0.14
L04-02-20-P-R-S-00	0.09
L04-02-22-P-S-S-00	0.32
L04-02-23-P-R-S-00	0.16

Appendix B to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 15-2, Figure 15-3, and Figure 15-4 above. A summary of the analytical data is presented in Table 15-3 below. Appendix L to this report presents the Test America Analytical Laboratory soil sample reports.

Table 15-3
Final Status Survey Analytical Data: LSA 04-02

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
L04-02-01-P-S-S-00	0.00	S	0.837	0.134	0.068	N/A	-0.233	0.000	0.493	0.493	0.085	0.223	N/A	0.888	0.167	0.097	N/A	-0.112	0.000	9.912	NA	NA	NA	0.547	0.171	0.208	N/A	2.230	0.584	0.790	N/A	3.7	0.09
L04-02-02-P-R-S-00	0.50	S	1.000	0.149	0.063	N/A	-0.070	0.000	0.213	0.213	0.061	0.237	U	1.050	0.163	0.094	N/A	0.050	0.050	5.083	NA	NA	NA	0.280	0.172	0.219	N/A	1.310	0.563	0.861	N/A	3.3	0.07
L04-02-04-P-S-S-00	0.00	S	0.953	0.133	0.057	N/A	-0.117	0.000	0.818	0.818	0.159	0.212	N/A	1.190	0.173	0.132	N/A	0.190	0.190	2.138	NA	NA	NA	0.115	0.146	0.257	U	0.932	0.317	0.915	N/A	1.9	0.15
L04-02-05-P-R-S-00	0.50	S	1.190	0.160	0.068	N/A	0.120	0.120	0.089	0.089	0.076	0.222	U	1.300	0.202	0.132	N/A	0.300	0.300	2.706	NA	NA	NA	0.146	0.139	0.240	U	1.150	0.515	0.799	N/A	2.0	0.24
L04-02-07-P-S-S-00	0.00	S	0.859	0.131	0.067	N/A	-0.211	0.000	1.050	1.050	0.206	0.225	N/A	0.997	0.150	0.098	N/A	-0.003	0.000	4.851	NA	NA	NA	0.267	0.152	0.196	N/A	1.260	0.348	0.813	N/A	3.2	0.08
L04-02-08-P-R-S-00	0.50	S	0.904	0.140	0.052	N/A	-0.166	0.000	0.113	0.113	0.051	0.228	U	0.778	0.164	0.087	N/A	-0.222	0.000	5.359	NA	NA	NA	0.296	0.164	0.189	N/A	0.989	0.300	0.792	N/A	4.5	0.04
L04-02-10-P-S-S-00	0.00	S	0.466	0.086	0.056	N/A	-0.604	0.000	0.204	0.204	0.046	0.211	U	0.606	0.109	0.067	N/A	-0.394	0.000	3.009	NA	NA	NA	0.164	0.102	0.141	N/A	1.050	0.379	0.558	N/A	2.4	0.03
L04-02-11-P-R-S-00	0.50	S	0.996	0.149	0.067	N/A	-0.074	0.000	0.026	0.026	0.018	0.231	U	1.080	0.162	0.124	N/A	0.080	0.080	1.543	NA	NA	NA	0.080	0.134	0.224	U	0.995	0.516	0.805	N/A	1.3	0.06
L04-02-13-P-S-S-00	0.00	S	0.975	0.132	0.052	N/A	-0.095	0.000	1.820	1.820	0.173	0.206	N/A	1.090	0.170	0.077	N/A	0.090	0.090	4.363	NA	NA	NA	0.240	0.155	0.224	N/A	1.170	0.293	0.752	N/A	3.1	0.15
L04-02-14-P-R-S-00	0.50	S	1.050	0.149	0.066	N/A	-0.020	0.000	0.025	0.025	0.046	0.223	U	1.040	0.151	0.114	N/A	0.040	0.040	2.053	NA	NA	NA	0.109	0.123	0.223	U	1.100	0.501	0.778	N/A	1.6	0.04
L04-02-16-P-S-S-00	0.00	S	0.979	0.152	0.075	N/A	-0.091	0.000	0.482	0.482	0.131	0.209	N/A	1.040	0.187	0.159	N/A	0.040	0.040	1.584	NA	NA	NA	0.080	0.143	0.264	U	1.270	0.545	0.829	N/A	1.0	0.06
L04-02-17-P-R-S-00	0.50	S	1.170	0.169	0.080	N/A	0.100	0.100	0.090	0.090	0.067	0.226	U	1.050	0.194	0.103	N/A	0.050	0.050	0.746	NA	NA	NA	0.033	0.140	0.235	U	1.100	0.507	0.780	N/A	0.5	0.09
L04-02-19-P-S-S-00	0.00	S	0.932	0.127	0.048	N/A	-0.138	0.000	1.310	1.310	0.150	0.217	N/A	1.100	0.170	0.102	N/A	0.100	0.100	5.056	NA	NA	NA	0.279	0.143	0.171	N/A	1.140	0.300	0.712	N/A	3.7	0.14
L04-02-20-P-R-S-00	0.50	S	1.100	0.162	0.079	N/A	0.030	0.030	0.069	0.069	0.077	0.224	U	1.110	0.165	0.098	N/A	0.110	0.110	1.529	NA	NA	NA	0.078	0.133	0.213	U	1.100	0.529	0.828	N/A	1.1	0.09
L04-02-22-P-S-S-00	0.00	S	1.150	0.171	0.071	N/A	0.080	0.080	3.130	3.130	□.33	0.218	N/A	1.180	0.189	0.144	N/A	0.180	0.180	8.545	NA	NA	NA	0.472	0.177	0.285	N/A	1.600	0.383	0.936	N/A	4.4	0.32
L04-02-23-P-R-S-00	0.50	S	1.150	0.156	0.062	N/A	0.080	0.080	0.020	0.020	0.007	0.223	U	1.190	0.175	0.101	N/A	0.190	0.190	1.926	NA	NA	NA	0.101	0.141	0.238	U	1.190	0.498	0.761	N/A	1.4	0.16
L04-02-01-P-S-Q-00	0.00	Q	0.980	0.141	0.066	N/A	-0.090	0.000	0.523	0.523	0.155	0.217	N/A	0.993	0.150	0.108	N/A	-0.007	0.000	10.645	NA	NA	NA	0.585	0.147	0.175	N/A	2.950	0.780	0.846	N/A	3.0	0.10
L04-02-16-P-S-Q-00	0.00	Q	0.969	0.130	0.048	N/A	-0.101	0.000	0.467	0.467	0.062	0.205	N/A	0.890	0.136	0.097	N/A	-0.110	0.000	3.299	NA	NA	NA	0.182	0.121	0.162	N/A	0.759	0.269	0.713	N/A	3.6	0.04
L04-02-25-P-S-B-00	0.00	B	1.070	0.148	0.060	N/A	0.000	0.000	0.848	0.848	0.126	0.200	N/A	0.970	0.166	0.088	N/A	-0.030	0.000	6.293	NA	NA	NA	0.347	0.149	0.169	N/A	1.520	0.497	0.718	N/A	3.5	0.08
L04-02-26-P-S-B-00	0.00	B	1.320	0.198	0.080	N/A	0.250	0.250	0.324	0.324	0.068	0.225	N/A	1.190	0.193	0.144	N/A	0.190	0.190	3.206	NA	NA	NA	0.176	0.195	0.242	U	0.924	0.396	1.060	U	2.9	0.26
L04-02-27-P-S-B-00	0.00	B	1.140	0.150	0.054	N/A	0.070	0.070	7.060	7.060	0.695	0.207	N/A	1.150	0.158	0.083	N/A	0.150	0.150	51.285	NA	NA	NA	2.830	0.375	0.272	N/A	8.210	1.410	1.200	N/A	5.1	0.76
Systematic Minimum			0.000						0.020					0.000						0.746				0.033				0.932				2.7	0.03
Systematic Maximum			0.120						3.130					0.300						9.912				0.547				2.230				Average Enrichment (%)	0.32
Systematic Mean			0.026						0.622					0.089						3.775				0.205				1.224					0.11
Systematic Median			0.000						0.209					0.065						2.857				0.155				1.145					0.09
Systematic Standard Deviation			0.043						0.857					0.087						2.615				0.147				0.311					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.

15.2.5 Biased Soil Sample Result LSA 04-02

Two biased samples were collected from LSA 04-02. The sample collected at location L04-02-26 represented the maximum GWS measurement (14,289 gcpm) within the SU, and had a result of 0.26 Uniform SOF.

15.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 04-02

One sample was collected from the sidewall of LSA 04-02. Table 15-4 provides the data summary for the sample.

Table 15-4
LSA 04-02 Sidewall Sample Data Summary and Calculated SOF Values

Sample ID	Ra-226 DCGL = 1.9 BKG = 0.9 (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)
L04-02-25-P-S-B-00	1.070	0.848	0.970	6.293	0.347	1.520	0.08

15.2.7 Quality Control Soil Sample Result LSA 04-02

Two QC field duplicate sample point was randomly selected for LSA 04-02 which was collected at systematic locations L04-02-01 and L04-02-16.

For the 19 samples (i.e., 16 systematic + 2 biased + 1 sidewall) collected within LSA 04-02, one field duplicate sample was collected. This frequency equates to 5.5%, (i.e. 2/19). 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 15-5 below).

Figure 15-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-02 (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 04-02				Survey Unit Description:		Central Open Land Area					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$)	Nuclide DCGL		Warning	Control	Statistic Exceeds Limit?
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	(pCi/g)	(pCi/g)	Statistic[2]	Limit	Limit	(Y/N)
L04-02-01-P-S-S-00	L04-02-01-P-S-Q-00	Ra-226	0.837	0.0681	0.98	0.0655	0.909	1.9	0.143	0.269	0.403	N
L04-02-01-P-S-S-00	L04-02-01-P-S-Q-00	Tc-99	0.493	0.223	0.523	0.217	0.508	25.1	0.03	3.552	5.321	N
L04-02-01-P-S-S-00	L04-02-01-P-S-Q-00	Th-232	0.888	0.0974	0.993	0.108	0.941	2.0	0.105	0.283	0.424	N
L04-02-01-P-S-S-00	L04-02-01-P-S-Q-00	U-234[1]	9.912	N/A	10.645	N/A	10.279	195.4	0.733	27.649	41.425	N
L04-02-01-P-S-S-00	L04-02-01-P-S-Q-00	U-235	0.547	0.208	0.585	0.175	0.566	51.6	0.038	7.301	10.939	N
L04-02-01-P-S-S-00	L04-02-01-P-S-Q-00	U-238	2.23	0.79	2.95	0.846	2.590	168.8	0.720	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/17/17

Quality Record

Figure 15-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-02 (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 04-02				Survey Unit Description:		Central Open Land Area					
			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)
L04-02-16-P-S-S-00	L04-02-16-P-S-Q-00	Ra-226	0.979	0.0747	0.969	0.0476	0.974	1.9	0.01	0.269	0.403	N
L04-02-16-P-S-S-00	L04-02-16-P-S-Q-00	Tc-99	0.482	0.209	0.467	0.205	0.475	25.1	0.015	3.552	5.321	N
L04-02-16-P-S-S-00	L04-02-16-P-S-Q-00	Th-232	1.04	0.159	0.89	0.0971	0.965	2.0	0.150	0.283	0.424	N
L04-02-16-P-S-S-00	L04-02-16-P-S-Q-00	U-234[1]	1.584	N/A	3.299	N/A	2.442	195.4	1.715	27.649	41.425	N
L04-02-16-P-S-S-00	L04-02-16-P-S-Q-00	U-235	0.0798	0.264	0.182	0.162	0.131	51.6	NA	7.301	10.939	NA
L04-02-16-P-S-S-00	L04-02-16-P-S-Q-00	U-238	1.27	0.829	0.759	0.713	1.015	168.8	0.511	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/17/17

Quality Record

15.3 Tc-99 Hot Spot Assessment LSA 04-02

Within LSA 04-02, there were no previous characterization samples found to exceed the Tc-99 $DCGL_W$, and RASS surveys and sampling indicated no additional contamination was identified. The highest Tc-99 sample result collected from both Final RASS and FSS was 4.11 pCi/g. There is no indication of a potential Tc-99 hot spot exceeding the $DCGL_W$ of 25.1 pCi/g, and therefore a Tc-99 hot spot assessment is not required.

16.0 ALARA EVALUATION LSA 04-02

All samples collected within LSA 04-02 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 04-02 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.11 for LSA 04-02. The average SOF equates to residual activity contributions from the SU area of 2.75 mrem/year for LSA 04-02. Groundwater monitoring well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356} indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 04-02. Adding all of the dose contributions together, the total estimated dose for LSA 04-02 is 6.75 mrem/year.

Since the estimated TEDE is well below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 04-02 was successful and that there would be no discernable benefit to the health and safety of the public in discounting the results of FSS and performing remediation of LSA 04-02.

17.0 FSS PLAN DEVIATIONS LSA 04-02

17.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 04-02.

17.2 Adjustments to Scan MDC Calculations

Scan MDCs for LSA 04-02 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 10,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 8,636 cpm. Therefore the calculated Scan MDCs are appropriate, and no adjustments need to be made.

18.0 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.

18.1 Data Quality Assessment for LSA 04-02

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 04-02 (see Figure 18-1) 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 04-02 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 survey unit data set measurement SOF and the minimum background area measurement SOF is less than or equal to one. For LSA 04-02, 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 04-02, 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 evaluation worksheet is presented in Appendix B.
- The maximum systematic SOF result for all surface samples within LSA 04-02 was 0.32. The maximum systematic SOF result for the all subsurface samples

within LSA 04-02 was 0.24. The average SOF result for all systematically collected samples within LSA 04-02 was 0.11, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.15.

- No FSS sample result in LSA 04-02 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an EMC or supplemental investigations were 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 sample locations actually collected within LSA 04-02. The successful result of the retrospective power evaluation presented in Table 18-1 for LSA 04-02 indicates that the minimum number of sample locations required (8) for the WRS Test was equal to the number of sampling locations actually collected within LSA 04-02. 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 was 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 18-1
Retrospective Sample Size Verification for LSA 04-02

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)	0.11
Shift	0.89
Relative Shift (Δ/σ)	11.39
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 18-1
Data Evaluation Checklists prepared for LSA 04-02 (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 04 **Description:** Plant Soils SEA Open Land Area
Survey Unit: 02 **Description:** Central Open Land Area

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 ☐	NA ☐
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	NA ☐

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 18-1
Data Evaluation Checklists prepared for LSA 04-02 (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: No. LSA 04 **Description:** Plant Soils SEA Open Land Area
Survey Unit: No. 02 **Description:** Central Open Land Area

Discrepancy: None

Corrective Actions Taken: None

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 Yardy (Print Name)	(Signature)	7-17-17 (Date)
Approved by (RSO):	Clark Evers (Print Name)	(Signature)	7/17/17 (Date)

Quality Record

19.0 SURVEILLANCE FOLLOWING FSS

FSS GWS activities in LSA 04-02 were completed in April, 2016 There were no events after the completion of FSS that would have the potential to cause contamination above the DCGLs in the SU.

20.0 CONCLUSION LSA 04-02

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 04-02 of 6.75 mrem/year does not exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 20-1
LSA 04-02 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	REUSE SOIL	STRUCTURE	**TOTAL**
SOF	0.11	N/A	0.16	N/A	N/A	**0.27**
DOSE	2.75 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**6.75 mrem/year**

21.0 FINAL STATUS SURVEY DESIGN LSA 04-03

This section describes the method for determining the number of samples required for the FSS of LSA 04-03 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 04-03 and their detection sensitivities are also discussed.

21.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 04-03 were driven by the type (Open Land) and Class (Class 1) of the survey unit and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

21.1.1 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.*

21.1.2 $DCGL_W$

During the FSS design process a review was performed of the historic characterization data for LSA 04-017. 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.

21.1.3 GWS Coverage

As a Class 1 SU, LSA 04-03 was required to undergo a 100% GWS.

21.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 04-03 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

21.1.5 Scan Minimum Detectable Concentration

Scan MDCs for LSA 04-03 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 10,000 cpm within LSA 04-03, the Scan MDC calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3659\,pCi/g}\right)+\left(\frac{f_{U-235}}{2.32\,pCi/g}\right)+\left(\frac{f_{U-238}}{30.6\,pCi/g}\right)\right)}$$

Equation 21-1

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 04-03, the average enrichment for the SU was 2.6%. 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 04-03 are shown below:

Table 21-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 04-03

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 04-03	40.9	47.9	1.26	2.8	0.87	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. $DCGL_W$ values are based on the Uniform Stratum release criteria.

The values in Table 21-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

21.1.6 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 basis of the IAL is detailed in HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*". The IAL used during the GWS of LSA 04-03 was established at 4,000 ncpm.

21.1.7 LSA 04-03 FSS Design Summary

The FSS Plan for LSA 04-03 can be found in Appendix H. Table 21-2 presents an overall FSS design and implementation summary for LSA 04-03.

Table 21-2
FSS Design Summary for LSA 04-03

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed floors and walls	
Scan MDC	40.9 pCi/g total Uranium (based on a 10,000 cpm background); 0.87 pCi/g Th-232; 1.21 pCi/g Ra-226*	
Investigation Action Level (IAL)	4,000 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Samples	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 (if any sidewalls exist) 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 (2.6%) 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.		

22.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 04-03

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

22.1 Gamma Walkover Survey

22.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 04-03 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 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*.

22.1.2 GWS Performance

All GWS measurements on the surface of the SU were 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 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 surface.

HP Technicians performing GWS in LSA 04-03 used the 4,000 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), HP 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, HP Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to geometry and relative distance from contaminated materials in nearby areas, the average background rate (measured at waist level) within the LSA ranged between 10,000 and 11,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 15,000 gcpm, HP 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.

Sidewalls, hard to reach areas, and non-typical areas were surveyed manually to the maximum extent practical in order to assess the potential for an area of elevated residual activity over 100% 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.

22.2 Soil Sampling

22.2.1 Systematic Soil Sampling Summary

Table 22-1 provides a summary of systematic sampling by stratum for LSA 04-03.

Table 22-1
Systematic Sampling Summary by Stratum for LSA 04-03

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
04-03	2,061	8	8	0	2

22.2.2 Systematic Sampling LSA 04-03

Within LSA 04-03, the surface stratum [0 – 15 centimeters (cm)] remained in the SU at all eight systematic locations. The root stratum (15 cm – 150 cm) also remained at all of the eight systematic locations. At these locations the remaining root stratum interval was collected using a hand auger and composited. Excavation stratum samples were collected at eight locations using hand augers, but these samples were archived as excavation stratum samples were not required to be sampled since no root stratum sample exceeded 0.5 SOF.

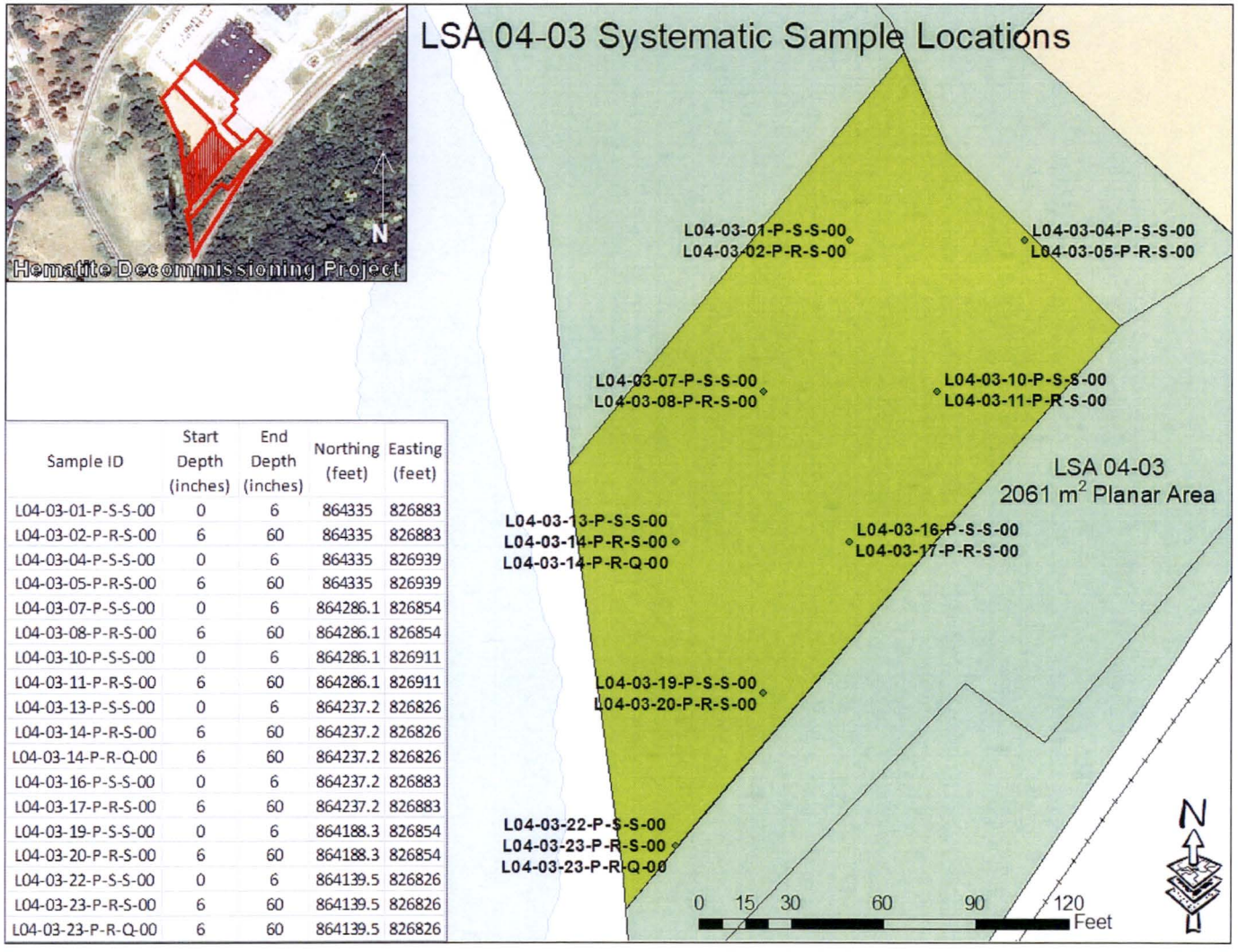
Given a planar area of 2,061 m^2 for LSA 04-03 and an eight - point systematic triangular grid, the point-to-point distance within each row was 17.2 m.

While there were eight systematic locations on the LSA 04-03 sampling grid, a total of eighteen (18) samples were collected at these locations, including:

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

Figure 22-1 presents the map of the eight systematic sample locations which were sampled within LSA 04-03. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 22-1
LSA 04-03 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L04-03-01-P-S-S-00	0	6	864335	826883
L04-03-02-P-R-S-00	6	60	864335	826883
L04-03-04-P-S-S-00	0	6	864335	826939
L04-03-05-P-R-S-00	6	60	864335	826939
L04-03-07-P-S-S-00	0	6	864286.1	826854
L04-03-08-P-R-S-00	6	60	864286.1	826854
L04-03-10-P-S-S-00	0	6	864286.1	826911
L04-03-11-P-R-S-00	6	60	864286.1	826911
L04-03-13-P-S-S-00	0	6	864237.2	826826
L04-03-14-P-R-S-00	6	60	864237.2	826826
L04-03-14-P-R-Q-00	6	60	864237.2	826826
L04-03-16-P-S-S-00	0	6	864237.2	826883
L04-03-17-P-R-S-00	6	60	864237.2	826883
L04-03-19-P-S-S-00	0	6	864188.3	826854
L04-03-20-P-R-S-00	6	60	864188.3	826854
L04-03-22-P-S-S-00	0	6	864139.5	826826
L04-03-23-P-R-S-00	6	60	864139.5	826826
L04-03-23-P-R-Q-00	6	60	864139.5	826826

Table 22-2 below presents a tabular listing of all FSS samples collected within LSA 04-03 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 22-2
FSS Sample Locations and Coordinates for LSA 04-03

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 04 **Description:** Plant Soils SEA Open Land Area

Survey Unit: 03 **Description:** Central Open Land Area

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

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L04-03-01-P-S-S-00	Uniform	S	433.8	433.3	864335.0	826882.6	Surface 6-inch grab
L04-03-02-P-R-S-00	Uniform	S	433.31	428.9	864335.0	826882.6	Root 4.4-ft composite
L04-03-04-P-S-S-00	Uniform	S	434.1	433.6	864335.0	826939.0	Surface 6-inch grab
L04-03-05-P-R-S-00	Uniform	S	433.61	429.2	864335.0	826939.0	Root 4.4-ft composite
L04-03-07-P-S-S-00	Uniform	S	433.6	433.1	864286.1	826854.4	Surface 6-inch grab
L04-03-08-P-R-S-00	Uniform	S	433.11	428.7	864286.1	826854.4	Root 4.4-ft composite
L04-03-10-P-S-S-00	Uniform	S	433.7	433.2	864286.1	826910.8	Surface 6-inch grab
L04-03-11-P-R-S-00	Uniform	S	433.21	428.8	864286.1	826910.8	Root 4.4-ft composite
L04-03-13-P-S-S-00	Uniform	S	430.9	430.4	864237.2	826826.1	Surface 6-inch grab
L04-03-14-P-R-S-00	Uniform	S	430.4	426.0	864237.2	826826.1	Root 4.4-ft composite
L04-03-16-P-S-S-00	Uniform	S	434.5	434.0	864237.2	826882.6	Surface 6-inch grab
L04-03-17-P-R-S-00	Uniform	S	434.0	429.6	864237.2	826882.6	Root 4.4-ft composite
L04-03-19-P-S-S-00	Uniform	S	433.8	433.3	864188.3	826854.4	Surface 6-inch grab
L04-03-20-P-R-S-00	Uniform	S	433.3	428.9	864188.3	826854.4	Root 4.4-ft composite
L04-03-22-P-S-S-00	Uniform	S	433.2	432.7	864139.5	826826.1	Surface 6-inch grab
L04-03-23-P-R-S-00	Uniform	S	432.7	428.3	864139.5	826826.1	Root 4.4-ft composite
L04-03-14-P-R-Q-00	Uniform	Q	433.8	433.3	864237.2	826826.1	Root 4.4-ft composite
L04-03-23-P-R-Q-00	Uniform	Q	434.5	434.0	864139.5	826826.1	Root 4.4-ft composite
L04-03-25-P-S-B-00	Uniform	B	430.9	430.4	864221.8	826823.6	Sidewall Sample
L04-03-26-P-S-B-00	Uniform	B	430.9	430.4	864258.1	826814.7	Biased 6-inch grab
L04-03-27-P-S-B-00	Uniform	B	430.9	430.4	864242.3	826820.1	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

22.3 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 04-03 two sample locations were selected within the SU based on the evaluation of the GWS survey data. Biased location L04-03-26 represents the maximum GWS measurement encountered within in LSA 04-03 and has a Uniform SOF value of 0.17.

22.4 Judgmental/Sidewall Sampling for Tc-99

While no remedial excavations were necessary in LSA 04-02, a small amount of soil removal was performed for "grading" purposes to create a flat surface for equipment to traverse the area supporting the remedial excavations in the adjacent Site Pond (LSA 02-01 and LSA 02-02). Since sidewalls were present in LSA 04-03, one sidewall sample was collected.

22.5 Quality Control Soil Sampling

Two QC field duplicate sample points were randomly selected and collected at systematic locations L04-03-14 and L04-03-23 for LSA 04-03.

23.0 FINAL STATUS SURVEY RESULTS LSA 04-03

23.1 Gamma Walkover Survey

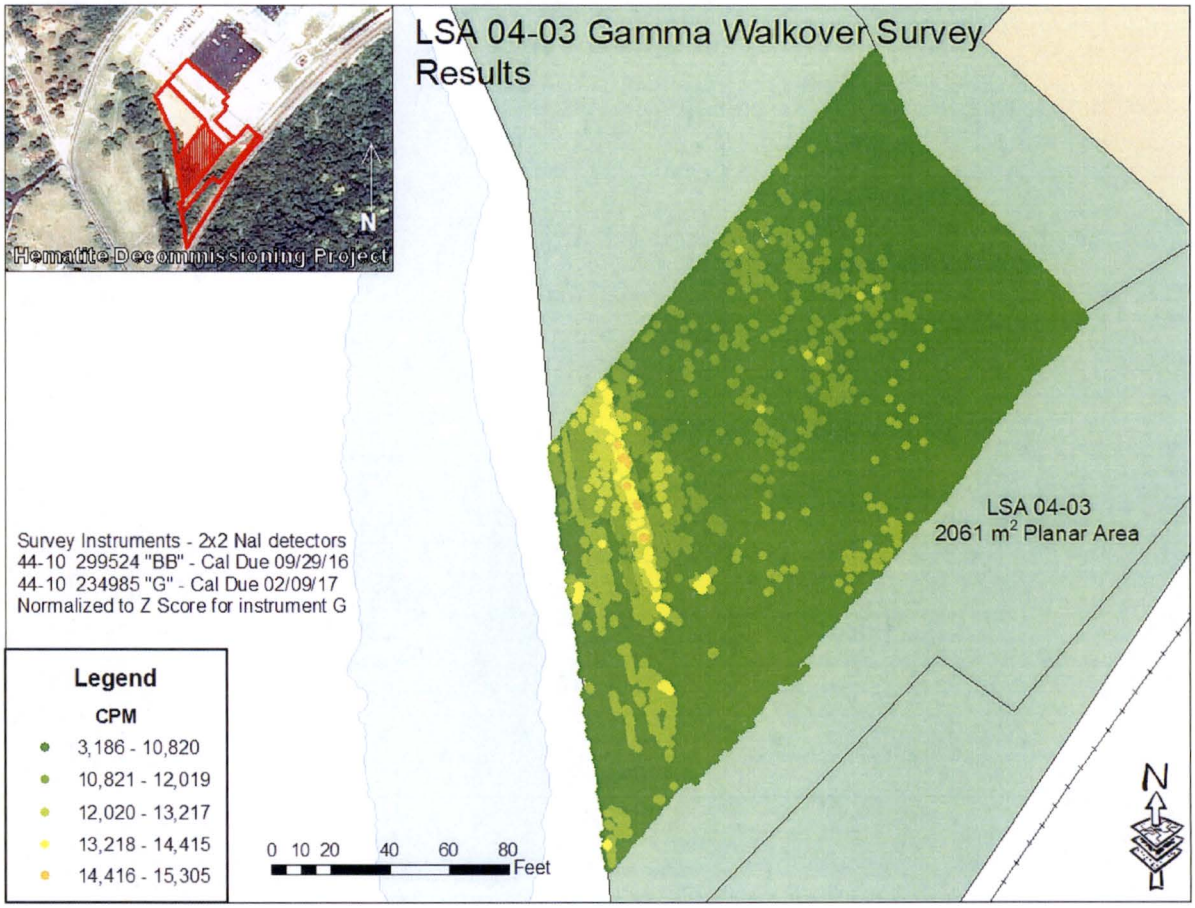
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 04-03 between March 19, 2016, and March 23, 2016.

23.1.1 GWS Results for LSA 04-03

For LSA 04-03, GWS count rates ranged between 3,186 gcpm and 15,305 gcpm, with a mean count rate of 9,048 gcpm. The median count rate was 9,378 gcpm with a standard deviation of 1,639 cpm. Figure 23-1 below presents a map of the complete GWS data set.

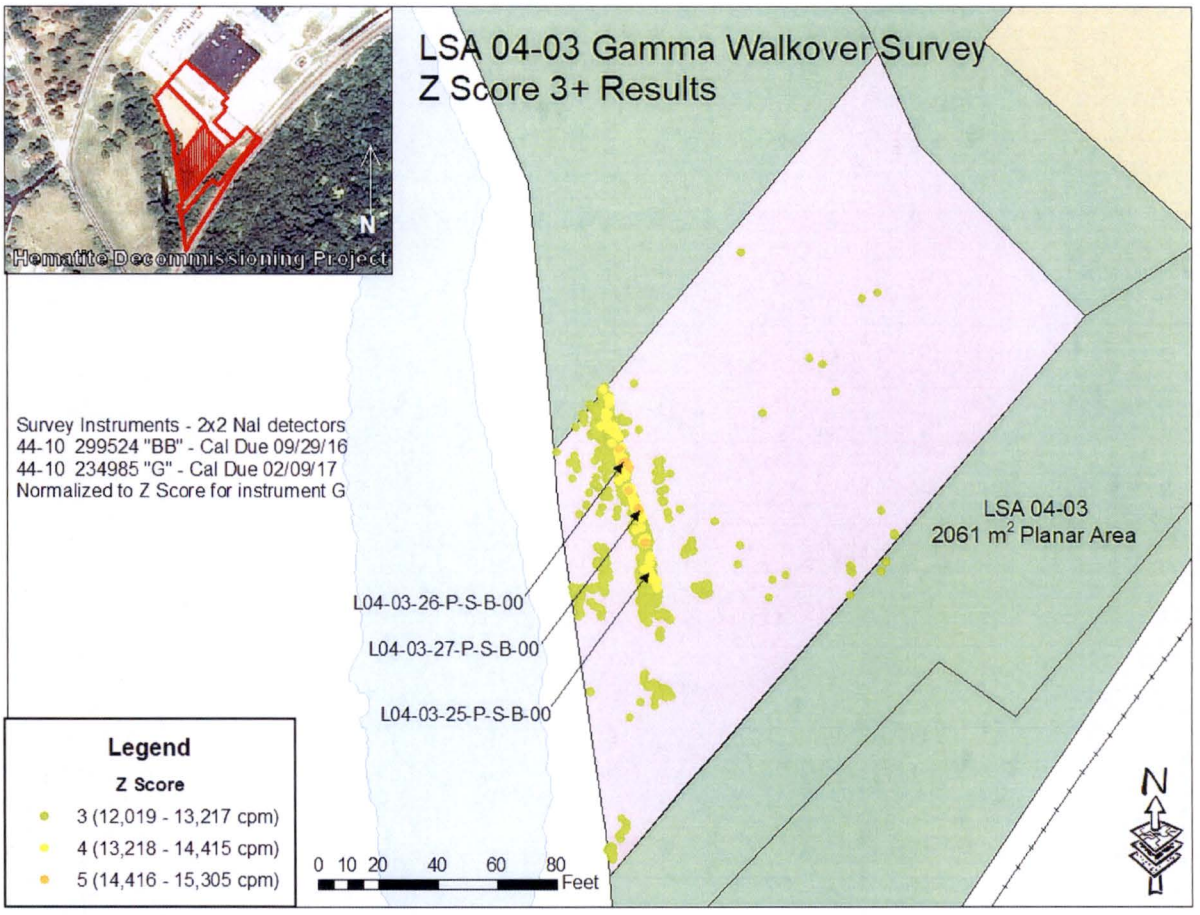
Figure 23-1
Colorimetric GWS Plot for LSA 04-03



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"). Two locations were selected for biased sample collection. The sample collected at location L04-03-26 represented the maximum GWS measurement (15,305 gcpm) within the SU.

Figure 23-2 presents a map of the +3 Z-score GWS measurements within LSA 04-03, including the selected biased sampling locations.

Figure 23-2
Colorimetric GWS Plot for LSA 04-03 (Measurements > Z-score of 3)



All GWS data collected in LSA 04-03 was datalogged and post-processed in GIS.

23.1.2 GWS Coverage Results LSA 04-03

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS.

The post survey processing of the GPS data indicated that the GWS covered 100% of the SU surface area (see Table 23-1). As the evaluation indicates that the GPS coverage exceeded 95% with no readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of any apparent GPS coverage gaps, the GWS coverage for the SU has been evaluated to meet the intent of the "100% GWS coverage" requirement.

Table 23-1
GWS Gap Analysis LSA 04-03

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 04-03	192,954	0	0%	100%	1

23.2 Soil Sample Results LSA 04-03

Appendix C presents the analytical results and associated statistics for all FSS surface samples collected within LSA 04-03.

23.2.1 Surface Soil Sample Results LSA 04-03

There were eight systematic samples collected within the surface stratum (0 – 15 cm) of LSA 04-03. There were a total of eleven (11) samples collected from the exposed ground surface layer, including 8 systematic samples, 1 sidewall sample, and 2 biased samples. The maximum Uniform SOF result for the surface samples was 0.22.

23.2.2 Subsurface Soil Sample Results LSA 04-03

There were eight systematic locations within LSA 04-03 where subsurface samples were collected. The root stratum zone is between 0.15 and 1.50 m below the surface, the excavation stratum contains all soil that is greater than 1.50 m below final grade surface. The maximum SOF result of the subsurface samples collected in LSA 04-03 was 0.16.

23.2.3 WRS Test Evaluation LSA 04-03

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was not required for LSA 04-03 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 Test was still performed for LSA 04-03. 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 04-03 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 C.

23.2.4 Graphical Data Review LSA 04-03

Table 23-2 below presents summary results for the all systematically collected samples (includes root, and excavation stratum samples, but not biased or QC samples) collected within LSA 04-03, 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 23-2
LSA 04-03 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	0.001	0.531	0.066	4.068	0.221	1.318	**0.09**
Minimum	0.00 (<BKG)	0.012	0.00 (<BKG)	0.857	0.043	0.629	0.02
Maximum	0.020	1.510	0.250	8.528	0.471	3.260	0.22

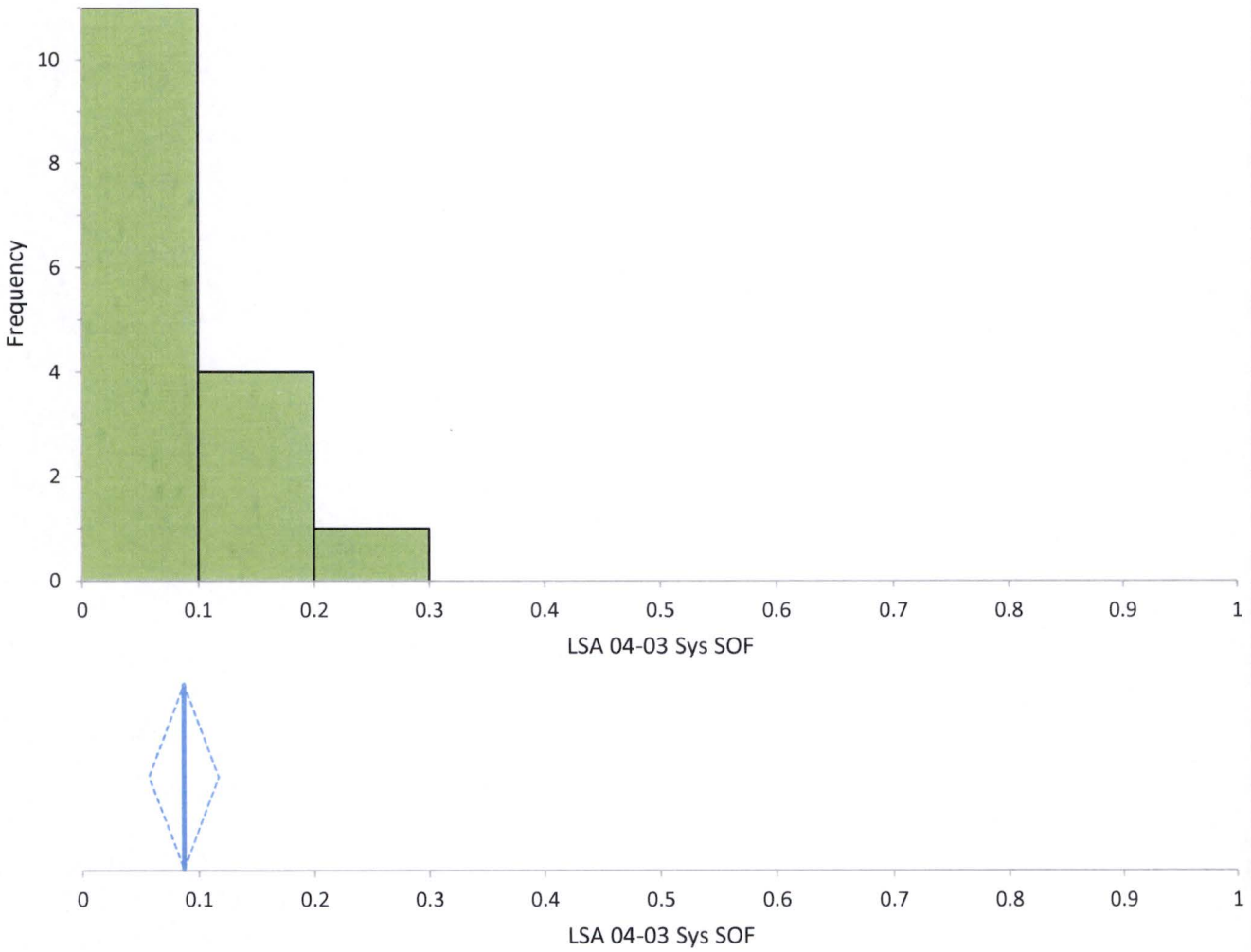
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide 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 SU. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 23-3 presents the overall statistical metrics for the SOF parameter for the 16 systematically collected samples from LSA 04-03. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 04-03. 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 0.06 to 0.12. The 97.87% confidence interval based on the median (0.08) of the sample results is 0.04 to 0.13. The bottom two charts present the various statistical metrics of the LSA 04-03 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 23-3 exhibits no unusual symmetry or bimodality concerns for the LSA 04-03 data associated with the systematically collected measurement locations.

Figure 23-3
Graphic Statistical Summary for LSA 04-03 (SOF parameter)



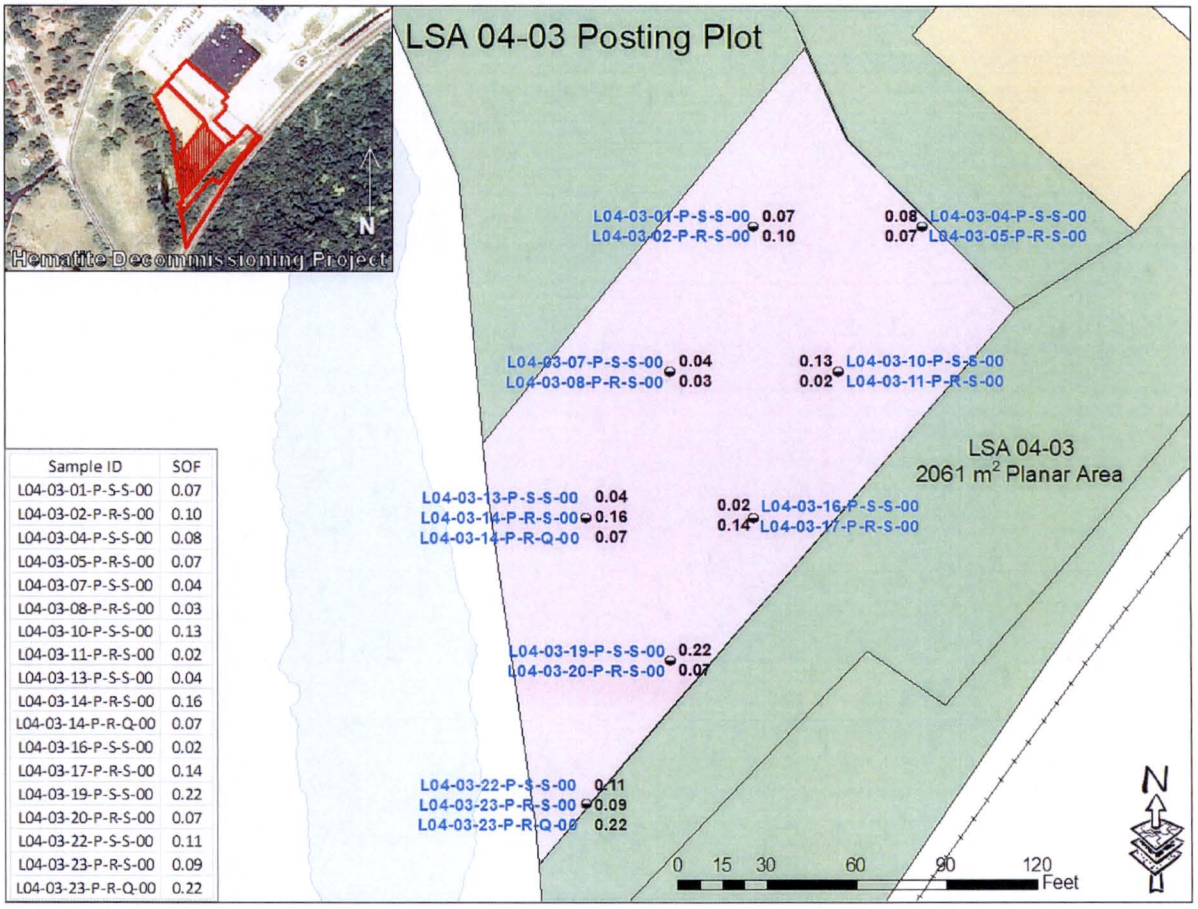
N	16

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 04-03 Sys SOF	0.09	0.06	to 0.12	0.014	0.06	0.00	0.9	0.81

	Minimum	1st quartile	Median	97.87% CI		3rd quartile	Maximum	IQR
LSA 04-03 Sys SOF	0.02	0.04	0.08	0.04	to 0.13	0.12	0.2	0.08

A posting plot is simply a map of the SU 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 04-03 is presented below in Figure 23-4. Figure 23-4 shows no unusual patterns in the data.

Figure 23-4
Posting Plot for LSA 04-03 Systematic Measurement Locations



Sample ID	SOF
L04-03-01-P-S-S-00	0.07
L04-03-02-P-R-S-00	0.10
L04-03-04-P-S-S-00	0.08
L04-03-05-P-R-S-00	0.07
L04-03-07-P-S-S-00	0.04
L04-03-08-P-R-S-00	0.03
L04-03-10-P-S-S-00	0.13
L04-03-11-P-R-S-00	0.02
L04-03-13-P-S-S-00	0.04
L04-03-14-P-R-S-00	0.16
L04-03-14-P-R-Q-00	0.07
L04-03-16-P-S-S-00	0.02
L04-03-17-P-R-S-00	0.14
L04-03-19-P-S-S-00	0.22
L04-03-20-P-R-S-00	0.07
L04-03-22-P-S-S-00	0.11
L04-03-23-P-R-S-00	0.09
L04-03-23-P-R-Q-00	0.22

Appendix C to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 23-2, Figure 23-3, and Figure 23-4 above. A summary of the analytical data is presented in Table 23-3 below. Appendix M to this report presents the Test America Analytical Laboratory soil sample reports.

Table 23-3
Final Status Survey Analytical Data: LSA 04-03

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
L04-03-01-P-S-S-00	0.00	S	0.969	0.135	0.058	N/A	-0.101	0.000	1.030	1.030	0.148	0.238	U	0.936	0.141	0.093	N/A	-0.064	0.000	4.076	NA	NA	NA	0.225	0.113	0.173	N/A	0.904	0.289	0.707	N/A	3.8	0.07
L04-03-02-P-R-S-00	0.50	S	0.924	0.138	0.065	N/A	-0.146	0.000	0.388	0.388	0.087	0.221	U	1.120	0.170	0.115	N/A	0.120	0.120	2.482	NA	NA	NA	0.131	0.142	0.232	U	1.400	0.540	0.812	N/A	1.5	0.10
L04-03-04-P-S-S-00	0.00	S	1.090	0.140	0.061	N/A	0.020	0.020	0.556	0.556	0.108	0.212	U	0.972	0.150	0.095	N/A	-0.028	0.000	7.234	NA	NA	NA	0.398	0.152	0.178	N/A	0.984	0.273	0.718	N/A	6.0	0.08
L04-03-05-P-R-S-00	0.50	S	0.898	0.136	0.069	N/A	-0.172	0.000	0.898	0.898	0.189	0.224	U	0.886	0.139	0.075	N/A	-0.114	0.000	4.854	NA	NA	NA	0.267	0.124	0.144	N/A	1.340	0.501	0.752	N/A	3.1	0.07
L04-03-07-P-S-S-00	0.00	S	0.862	0.125	0.060	N/A	-0.208	0.000	0.273	0.273	0.047	0.206	U	0.865	0.137	0.086	N/A	-0.135	0.000	3.700	NA	NA	NA	0.202	0.127	0.181	N/A	1.230	0.618	0.765	N/A	2.5	0.04
L04-03-08-P-R-S-00	0.50	S	0.897	0.130	0.055	N/A	-0.173	0.000	0.079	0.079	0.053	0.208	U	0.960	0.152	0.078	N/A	-0.040	0.000	3.803	NA	NA	NA	0.210	0.137	0.157	N/A	0.657	0.262	0.698	U	4.8	0.03
L04-03-10-P-S-S-00	0.00	S	1.020	0.135	0.063	N/A	-0.050	0.000	0.962	0.962	0.150	0.219	U	1.110	0.175	0.076	N/A	0.110	0.110	4.599	NA	NA	NA	0.254	0.125	0.220	N/A	0.902	0.269	0.707	N/A	4.2	0.13
L04-03-11-P-R-S-00	0.50	S	0.947	0.135	0.060	N/A	-0.123	0.000	0.156	0.156	0.057	0.216	U	0.957	0.139	0.068	N/A	-0.043	0.000	0.857	NA	NA	NA	0.043	0.112	0.220	U	0.731	0.258	0.721	N/A	0.9	0.02
L04-03-13-P-S-S-00	0.00	S	0.886	0.135	0.066	N/A	-0.184	0.000	0.274	0.274	0.088	0.211	U	0.919	0.152	0.093	N/A	-0.081	0.000	2.838	NA	NA	NA	0.154	0.138	0.179	U	1.110	0.504	0.775	N/A	2.2	0.04
L04-03-14-P-R-S-00	0.50	S	1.060	0.160	0.087	N/A	-0.010	0.000	0.012	0.012	0.044	0.214	U	1.250	0.191	0.102	N/A	0.250	0.250	4.736	NA	NA	NA	0.259	0.129	0.160	N/A	1.560	0.730	0.880	N/A	2.6	0.16
L04-03-16-P-S-S-00	0.00	S	0.725	0.103	0.045	N/A	-0.345	0.000	0.229	0.229	0.143	0.196	U	0.759	0.117	0.090	N/A	-0.241	0.000	1.462	NA	NA	NA	0.079	0.127	0.198	U	0.629	0.224	0.635	U	2.0	0.02
L04-03-17-P-R-S-00	0.50	S	0.959	0.144	0.066	N/A	-0.111	0.000	0.545	0.545	0.195	0.220	U	1.110	0.165	0.120	N/A	0.110	0.110	8.528	NA	NA	NA	0.471	0.148	0.184	N/A	1.740	0.555	0.799	N/A	4.1	0.14
L04-03-19-P-S-S-00	0.00	S	1.040	0.157	0.078	N/A	-0.030	0.000	1.510	1.510	0.266	0.230	U	1.230	0.193	0.063	N/A	0.230	0.230	4.848	NA	NA	NA	0.250	0.138	0.185	N/A	3.260	0.932	0.973	N/A	1.2	0.22
L04-03-20-P-R-S-00	0.50	S	0.978	0.135	0.060	N/A	-0.092	0.000	0.138	0.138	0.054	0.231	U	1.100	0.164	0.107	N/A	0.100	0.100	1.539	NA	NA	NA	0.079	0.114	0.220	U	1.190	0.520	0.667	N/A	1.1	0.07
L04-03-22-P-S-S-00	0.00	S	0.708	0.117	0.068	N/A	-0.362	0.000	1.310	1.310	0.173	0.215	N/A	0.877	0.135	0.072	N/A	-0.123	0.000	7.015	NA	NA	NA	0.383	0.149	0.184	N/A	2.360	0.560	0.728	N/A	2.5	0.11
L04-03-23-P-R-S-00	0.50	S	0.915	0.139	0.068	N/A	-0.155	0.000	0.136	0.136	0.054	0.235	U	1.130	0.191	0.106	N/A	0.130	0.130	2.520	NA	NA	NA	0.136	0.134	0.216	U	1.090	0.471	0.717	N/A	2.0	0.09
L04-03-14-P-R-Q-00	0.50	Q	1.030	0.144	0.056	N/A	-0.040	0.000	0.016	0.016	0.075	0.221	U	1.090	0.161	0.099	N/A	0.090	0.090	2.152	NA	NA	NA	0.112	0.137	0.230	U	1.430	0.521	0.777	N/A	1.3	0.07
L04-03-23-P-R-Q-00	0.50	Q	1.120	0.149	0.060	N/A	0.050	0.050	0.303	0.303	0.029	0.234	N/A	1.290	0.175	0.089	N/A	0.290	0.290	4.870	NA	NA	NA	0.269	0.144	0.178	N/A	0.988	0.277	0.720	N/A	4.1	0.22
L04-03-25-P-S-B-00	0.00	B	1.170	0.159	0.061	N/A	0.100	0.100	-0.007	0.000	0.047	0.237	U	1.150	0.167	0.094	N/A	0.150	0.150	1.790	NA	NA	NA	0.096	0.145	0.225	U	0.840	0.290	0.835	N/A	1.8	0.14
L04-03-26-P-S-B-00	0.00	B	1.170	0.166	0.079	N/A	0.100	0.100	0.178	0.178	0.024	0.243	U	1.180	0.196	0.089	N/A	0.180	0.180	1.924	NA	NA	NA	0.094	0.157	0.269	U	1.810	0.737	0.873	N/A	0.8	0.17
L04-03-27-P-S-B-00	0.00	B	1.100	0.194	0.108	N/A	0.030	0.030	0.270	0.270	0.032	0.235	N/A	1.180	0.212	0.190	N/A	0.180	0.180	2.194	NA	NA	NA	0.118	0.159	0.281	U	1.000	0.431	1.030	U	1.9	0.14
Systematic Minimum			0.000						0.012					0.000						0.857				0.043				0.629				**2.6**	0.02
Systematic Maximum			0.020						1.510					0.250						8.528				0.471				3.260				Average Enrichment (%)	0.22
Systematic Mean			0.001						0.531					0.066						4.068				0.221				1.318					0.09
Systematic Median			0.000						0.331					0.000						3.940				0.218				1.150					0.08
Systematic Standard Deviation			0.005						0.469					0.086						2.171				0.121				0.680					0.06
			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.

23.2.5 Biased Soil Sample Result LSA 04-03

Two (2) biased samples were collected from LSA 04-03. The sample collected at location L00-03-26 represented the maximum GWS measurement (15,305 gcpm) within the SU, and had a result of 0.17 Uniform SOF.

23.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 04-03

One sample was collected from the sidewall of LSA 04-03. Table 23-4 provides the data summary for the sample.

Table 23-4
LSA 04-03 Sidewall Sample Data Summary and Calculated SOF Values

Sample ID	Ra-226 DCGL = 1.9 BKG = 0.9 (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)
L04-03-25-P-S-B-00	1.17	-0.007	1.15	1.79	0.096	0.84	0.14

23.2.7 Quality Control Soil Sample Result LSA 04-03

Two QC field duplicate sample point were randomly selected for LSA 04-03 which was collected at systematic locations L04-03-14 and L04-03-23.

For the 19 samples (i.e., 16 systematic + 2 biased + 1 sidewall) collected within LSA 04-03, two field duplicate samples were collected. This frequency equates to 10.5%, (i.e. 2/19). 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 23-5 below).

Figure 23-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-03(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 04-03 — Survey Unit Description: Central Open Land Area

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						
L04-03-14-P-R-S-00	L04-03-14-P-R-Q-00	Ra-226	1.06	0.0867	1.03	0.0564	1.045	1.9	0.03	0.269	0.403	N
L04-03-14-P-R-S-00	L04-03-14-P-R-Q-00	Tc-99	0.012	0.214	0.0159	0.221	0.014	25.1	NA	3.552	5.321	NA
L04-03-14-P-R-S-00	L04-03-14-P-R-Q-00	Th-232	1.25	0.102	1.09	0.0994	1.170	2.0	0.160	0.283	0.424	N
L04-03-14-P-R-S-00	L04-03-14-P-R-Q-00	U-234[1]	4.736	N/A	2.152	N/A	3.444	195.4	2.584	27.649	41.425	N
L04-03-14-P-R-S-00	L04-03-14-P-R-Q-00	U-235	0.259	0.16	0.112	0.23	0.186	51.6	NA	7.301	10.939	NA
L04-03-14-P-R-S-00	L04-03-14-P-R-Q-00	U-238	1.56	0.88	1.43	0.777	1.495	168.8	0.130	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 — Reviewed by: Clark Evers

Date: 7-17-17 — Date: 7/17/17

Quality Record

Figure 23-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-03 (2 of 2)

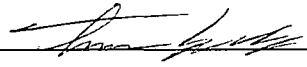
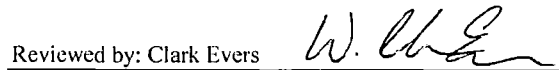
Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control	Revision: 2	Page 1 of 1

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

Survey Unit No.: LSA 04-03 — Survey Unit Description: Central Open Land Area

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						
L04-03-23-P-R-S-00	L04-03-23-P-R-Q-00	Ra-226	0.915	0.0676	1.12	0.0596	1.018	1.9	0.205	0.269	0.403	N
L04-03-23-P-R-S-00	L04-03-23-P-R-Q-00	Tc-99	0.136	0.235	0.303	0.234	0.220	25.1	NA	3.552	5.321	NA
L04-03-23-P-R-S-00	L04-03-23-P-R-Q-00	Th-232	1.13	0.106	1.29	0.0889	1.210	2.0	0.160	0.283	0.424	N
L04-03-23-P-R-S-00	L04-03-23-P-R-Q-00	U-234[1]	2.520	N/A	4.870	N/A	3.695	195.4	2.350	27.649	41.425	N
L04-03-23-P-R-S-00	L04-03-23-P-R-Q-00	U-235	0.136	0.216	0.269	0.178	0.203	51.6	NA	7.301	10.939	NA
L04-03-23-P-R-S-00	L04-03-23-P-R-Q-00	U-238	1.09	0.717	0.988	0.72	1.039	168.8	0.102	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  Reviewed by: Clark Evers 

Date: 7-17-17 Date: 7/17/17

Quality Record

23.3 Tc-99 Hot Spot Assessment LSA 04-03

Within LSA 04-03, there were no previous characterization samples found to exceed the Tc-99 $DCGL_W$, and RASS surveys and sampling indicated no additional contamination was identified. The highest Tc-99 sample result collected from both Final RASS and FSS was 1.5 pCi/g. There is no indication of a potential Tc-99 hot spot exceeding the $DCGL_W$ of 25.1 pCi/g, and therefore a Tc-99 hot spot assessment is not required.

24.0 ALARA EVALUATION LSA 04-03

All samples collected within LSA 04-03 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 04-03 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.09 for LSA 04-03. The average SOF equates to residual activity contributions from the SU area of 2.25 mrem/year for LSA 04-03. Groundwater monitoring well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356} indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 04-03. Summing the dose contributions together, the total estimated dose for LSA 04-03 is 6.25 mrem/year.

Since the estimated TEDE is well below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 04-03 was successful and that there would be no discernable benefit to the health and safety of the public in discounting the results of FSS and performing further remediation of LSA 04-03.

25.0 FSS PLAN DEVIATIONS LSA 04-03

25.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 04-03.

25.2 Adjustments to Scan MDC Calculations

Scan MDCs for LSA 04-03 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 10,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 9,048 cpm. Therefore the calculated Scan MDCs are appropriate, and no adjustments need to be made.

26.0 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.

26.1 Data Quality Assessment for LSA 04-03

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 04-03 (see Figure 26-1) 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 04-03 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 04-03, 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 04-03, 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 evaluation worksheet is presented in Appendix C.
- The maximum systematic SOF result for all surface samples within LSA 04-03 was 0.22. The maximum systematic SOF result for the subsurface samples

collected within LSA 04-03 was 0.16. The average SOF result for all systematically collected samples within LSA 04-03 was 0.09, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.12.

- No FSS sample result in LSA 04-03 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 (8) of systematic sample locations actually collected within LSA 04-03. The successful result of the retrospective power evaluation presented in Table 26-1 for LSA 04-03 indicates that the minimum number of sample locations required (8) for the WRS Test was equal to the number of sampling locations actually collected within LSA 04-03. 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 was 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 26-1
Retrospective Sample Size Verification for LSA 04-03

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.06
$DCGL_{SOF}$	1
LBGR (Mean)	0.09
Shift	0.91
Relative Shift (Δ/σ)	16.17
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, $\alpha = 0.05$, $\beta = 0.10$

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 26-1
Data Evaluation Checklists prepared for LSA 04-03 (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 04 **Description:** Plant Soils SEA Open Land Area
Survey Unit: 03 **Description:** Central Open Land Area

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 ☐	NA ☐
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	NA ☐

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 26-1
Data Evaluation Checklists prepared for LSA 04-03 (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: No. LSA 04 **Description:** Plant Soils SEA Open Land Area
Survey Unit: No. 03 **Description:** Central Open Land Area

Discrepancy: None

Corrective Actions Taken: None

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 Yardy (Print Name) (Signature) 7-17-17 (Date)

Approved by (RSO): Clark Evers (Print Name) (Signature) 7/17/17 (Date)

Quality Record

27.0 SURVEILLANCE FOLLOWING FSS

FSS GWS activities in LSA 04-03 were completed in March, 2016. There were no events after the completion of FSS that would have the potential to cause contamination above the DCGLs in the SU.

28.0 CONCLUSION LSA 04-03

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 04-03 of 6.25 mrem/year does not exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 28-1
LSA 04-03 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**

29.0 FINAL STATUS SURVEY DESIGN LSA 04-04

This section describes the method for determining the number of samples required for the FSS of LSA 04-04 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 04-04 and their detection sensitivities are also discussed.

29.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 04-04 were driven by the type (Open Land) and Class (Class 1) of the survey unit and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

29.1.1 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.*

29.1.2 $DCGL_W$

During the FSS design process a review was performed of the historic characterization data for LSA 04-04. 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.

29.1.3 GWS Coverage

As a Class 1 SU, LSA 04-04 was required to undergo a 100% GWS.

29.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 04-04 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

29.1.5 Scan Minimum Detectable Concentration

Scan MDCs for LSA 04-04 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 cpm within LSA 04-04, the Scan MDC calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3659\,pCi/g}\right)+\left(\frac{f_{U-235}}{2.32\,pCi/g}\right)+\left(\frac{f_{U-238}}{30.6\,pCi/g}\right)\right)}$$

Equation 29-1

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 04-04, the average enrichment for the SU was 3.2%. 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 04-04 are shown below:

Table 29-1
Scan MDCs for 2" x 2" NaI detector, 9,000 cpm background: LSA 04-04

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 04-04	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 29-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

29.1.6 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 basis of the IAL is detailed in HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*". The IAL used during the GWS of LSA 04-04 was established at 4,000 ncpm.

29.1.7 LSA 04-04 FSS Design Summary

The FSS Plan for LSA 04-04 can be found in Appendix I. Table 29-2 presents an overall FSS design and implementation summary for LSA 04-04.

Table 29-2
FSS Design Summary for LSA 04-04

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed ground surfaces	
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)	4,000 net cpm **	
Systematic Sampling Locations:		
Depth	Number of Sample	Comments
0 – 15 cm (Surface)	4	These samples will be taken on a systematic grid. Excavation stratum samples collected at locations with remaining surface and root strata will be archived and analyzed only if the overlying root stratum sample exceeds a SOF of 0.5
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 FSS Supervisor.		
Sidewall Sampling Locations:		
Since the difference between the 3-dimensional surface area (2,063 m^2) and the planar area (1,801 m^2) of 262 m^2 slightly exceeds the area bounded by each systematic sample (225 m^2, or 1801/8), **two** (2) discretionary sidewall samples will be collected within LSA 04-04.		
Instrumentation:		
Ludlum 2221 with 44-10 (2 x 2 NaI) detector	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 (3.2%) 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.		

30.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 04-04

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

30.1 Gamma Walkover Survey

30.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 04-04 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 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*.

30.1.2 GWS Performance

For LSA 04-04, due to the presence of the open trench, large portions of the SU were difficult to access through traditional GWS. Therefore during the development of the FSS plan the previously collected manual GWS surveys of the SWTP Trench were reviewed. These previous RASS surveys were determined to be of sufficient quality to be used to support the ongoing FSS efforts. Additionally, since the manual RASS surveys of the SWTP Trench were performed with the trench boxes in place, and were not removed until the backfill of the SU was eminent it was evident that the radiological survey status of the SU was unchanged from the time of RASS to the time of backfill and subsequent FSS operations.

All GWS measurements on the exposed excavation floor 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.

HP Technicians performing GWS in LSA 04-04 used the 4,000 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), HP 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, HP 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 13,000 to 14,000 gcpm, HP 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.

Sidewalls, hard to reach areas, and non-typical areas were surveyed manually to the maximum extent practical in order to assess the potential for an area of elevated residual activity over 100% of the exposed excavation surface. Review of the previously collected manual RASS surveys were used to ensure that 100% of the SU surface was assessed via GWS.

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.

30.2 Soil Sampling

30.2.1 Systematic Soil Sampling Summary

Table 30-1 provides a summary of systematic sampling by stratum for LSA 04-04.

Table 30-1
Systematic Sampling Summary by Stratum for LSA 04-04

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
04-04	1,801	4	8	8	2

30.2.2 Systematic Sampling LSA 04-04

Within LSA 04-04, there were 4 systematic locations in which portions of the surface stratum [0 – 15 centimeters (cm)] remained in the SU after remediation. Portions of the root stratum (15 cm – 150 cm) remained at all eight of the eight systematic locations. At these locations the remaining root stratum interval was collected using a hand auger and composited. Excavation stratum samples were collected at all eight locations using either hand trowels for six-inch grabs below the existing excavation surface or hand augers where necessary.

Given a planar area of 1,801 m^2 for LSA 04-04 and an eight - point systematic triangular grid, the point-to-point distance within each row was 16.1 m.

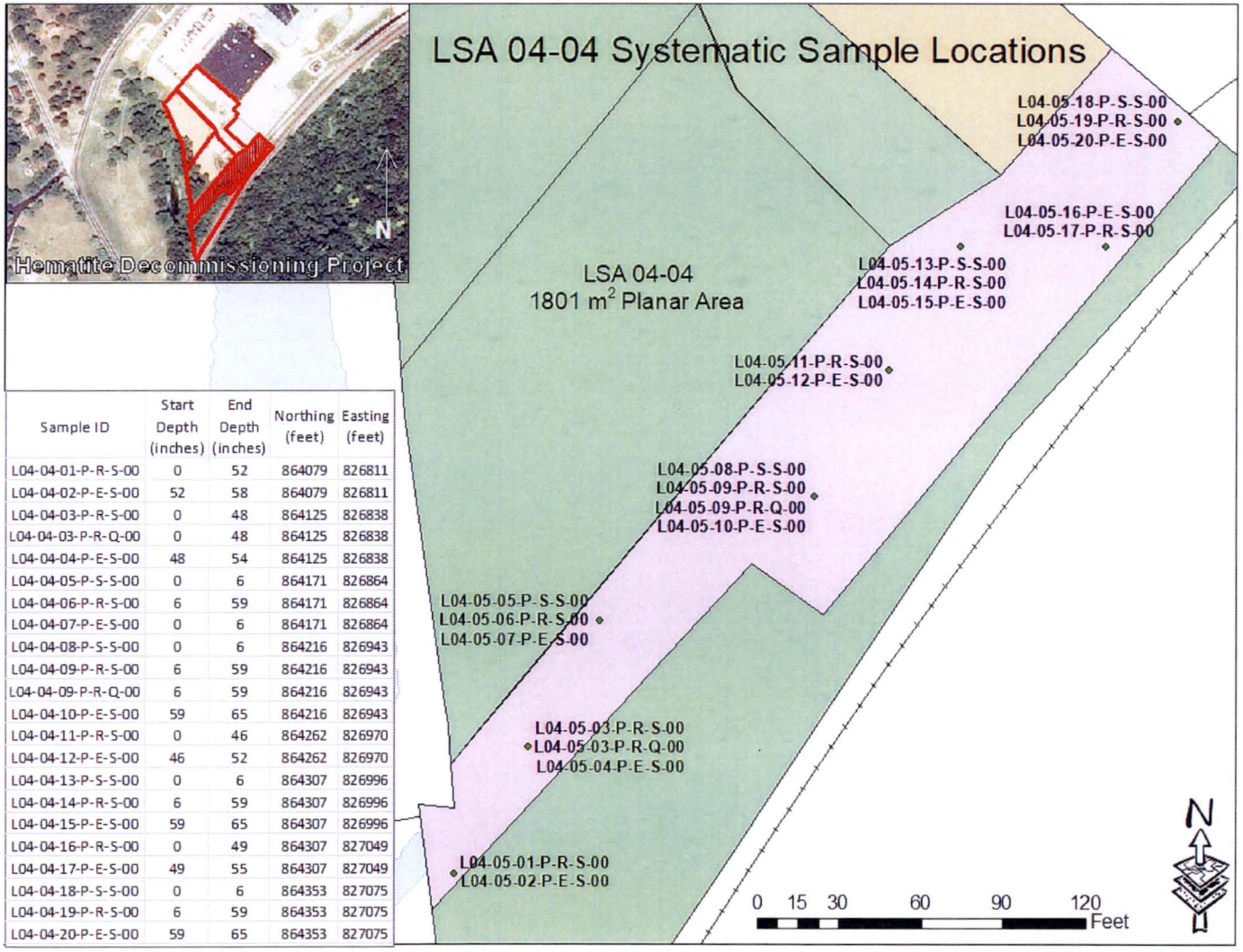
While there were eight systematic locations on the LSA 04-04 sampling grid, a total of twenty two (22) samples were collected at these locations, including:

- Four (4) samples collected within the remaining surface stratum

- Eight (8) sample collected within the remaining root stratum
- Eight (8) samples collected within the excavation, or "deep" stratum
- Two (2) QC field replicate

Figure 30-1 presents the map of the eight systematic sample locations which were sampled within LSA 04-04. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 30-1
LSA 04-04 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L04-04-01-P-R-S-00	0	52	864079	826811
L04-04-02-P-E-S-00	52	58	864079	826811
L04-04-03-P-R-S-00	0	48	864125	826838
L04-04-03-P-R-Q-00	0	48	864125	826838
L04-04-04-P-E-S-00	48	54	864125	826838
L04-04-05-P-S-S-00	0	6	864171	826864
L04-04-06-P-R-S-00	6	59	864171	826864
L04-04-07-P-E-S-00	0	6	864171	826864
L04-04-08-P-S-S-00	0	6	864216	826943
L04-04-09-P-R-S-00	6	59	864216	826943
L04-04-09-P-R-Q-00	6	59	864216	826943
L04-04-10-P-E-S-00	59	65	864216	826943
L04-04-11-P-R-S-00	0	46	864262	826970
L04-04-12-P-E-S-00	46	52	864262	826970
L04-04-13-P-S-S-00	0	6	864307	826996
L04-04-14-P-R-S-00	6	59	864307	826996
L04-04-15-P-E-S-00	59	65	864307	826996
L04-04-16-P-R-S-00	0	49	864307	827049
L04-04-17-P-E-S-00	49	55	864307	827049
L04-04-18-P-S-S-00	0	6	864353	827075
L04-04-19-P-R-S-00	6	59	864353	827075
L04-04-20-P-E-S-00	59	65	864353	827075

Table 30-2 below presents a tabular listing of all FSS samples collected within LSA 04-04 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 30-2
FSS Sample Locations and Coordinates for LSA 04-04

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 04 **Description:** Plant Soils SEA Open Land Area
Survey Unit: 04 **Description:** South Central SU in "Area 14" Surrounding Site Fence Line
Survey Type: FSS **Classification:** Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L04-04-01-P-R-S-00	Uniform	S	428.9	424.6	864079.0	826811.0	Root 4.3-ft composite
L04-04-02-P-E-S-00	Uniform	S	424.6	424.1	864079.0	826811.0	Excavation 6-inch grab
L04-04-03-P-R-S-00	Uniform	S	433.7	429.7	864125.0	826838.0	Root 4.0-ft composite
L04-04-04-P-E-S-00	Uniform	S	429.7	429.2	864125.0	826838.0	Excavation 6-inch grab
L04-04-05-P-S-S-00	Uniform	S	434.7	434.2	864171.0	826864.0	Surface 6-inch grab
L04-04-06-P-R-S-00	Uniform	S	434.2	429.8	864171.0	826864.0	Root 4.4-ft composite
L04-04-07-P-E-S-00	Uniform	S	429.8	429.3	864171.0	826864.0	Excavation 6-inch grab
L04-04-08-P-S-S-00	Uniform	S	432.2	431.7	864216.0	826943.0	Surface 6-inch grab
L04-04-09-P-R-S-00	Uniform	S	431.7	427.3	864216.0	826943.0	Root 4.4-ft composite
L04-04-10-P-E-S-00	Uniform	S	427.3	426.8	864216.0	826943.0	Excavation 6-inch grab
L04-04-11-P-R-S-00	Uniform	S	431.6	427.7	864262.0	826970.0	Root 3.9-ft composite
L04-04-12-P-E-S-00	Uniform	S	427.7	427.2	864262.0	826970.0	Excavation 6-inch grab
L04-04-13-P-S-S-00	Uniform	S	433.9	433.4	864307.0	826996.0	Surface 6-inch grab
L04-04-14-P-R-S-00	Uniform	S	433.4	429.0	864307.0	826996.0	Root 4.4-ft composite
L04-04-15-P-E-S-00	Uniform	S	429.0	428.5	864307.0	826996.0	Excavation 6-inch grab
L04-04-16-P-R-S-00	Uniform	S	430.0	426.4	864307.0	827049.0	Root 3.7-ft composite
L04-04-17-P-E-S-00	Uniform	S	426.4	425.9	864307.0	827049.0	Excavation 6-inch grab
L04-04-18-P-S-S-00	Uniform	S	433.7	433.2	864353.0	827075.0	Surface 6-inch grab
L04-04-19-P-R-S-00	Uniform	S	433.2	428.8	864353.0	827075.0	Root 4.4-ft composite
L04-04-20-P-E-S-00	Uniform	S	428.8	428.3	864353.0	827075.0	Excavation 6-inch grab
L04-04-03-P-R-Q-00	Uniform	Q	433.7	429.7	864125.0	826838.0	Root 4.0-ft composite
L04-04-09-P-R-Q-00	Uniform	Q	431.7	427.3	864216.0	826943.0	Root 4.4-ft composite
L04-04-23-P-E-Q-00	Uniform	Q	427.7	427.2	864255.0	826956.0	Biased 6-inch grab
L04-04-21-P-E-B-00	Uniform	B	434.6	434.1	864171.3	826855.7	Biased 6-inch grab
L04-04-22-P-E-B-00	Uniform	B	432.7	432.2	864163.0	826863.1	Sidewall sample
L04-04-23-P-E-B-00	Uniform	B	427.7	427.2	864255.0	826956.0	Sidewall sample

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

30.3 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 04-04 one sample location was selected within the SU based on the evaluation of the GWS survey data. Biased location L04-04-21 represents the maximum GWS measurement encountered within in LSA 04-04 and has a Uniform SOF value of 0.06.

30.4 Judgmental/Sidewall Sampling for Tc-99

In accordance with the guidance specified in Volume 3, Chapter 1, Section 6.2.3, it was determined that sidewall sampling was necessary. The number of sidewall samples collected for the SU was determined by comparing the sidewall surface area to the two dimensional systematic surface area (e.g., 8 systematic samples were collected over 2,000 m^2, then collect 1 sample per 250 m^2 of sidewall). Two samples were collected in the sidewall of LSA 04-04. These samples were collected from locations selected by the HP Technician at random, and were not based on gamma survey readings (not biased).

30.5 Quality Control Soil Sampling

Two QC field duplicate sample points were randomly selected and collected at systematic locations L04-04-03 and L04-04-09 for LSA 04-04.

31.0 FINAL STATUS SURVEY RESULTS LSA 04-04

31.1 Gamma Walkover Survey

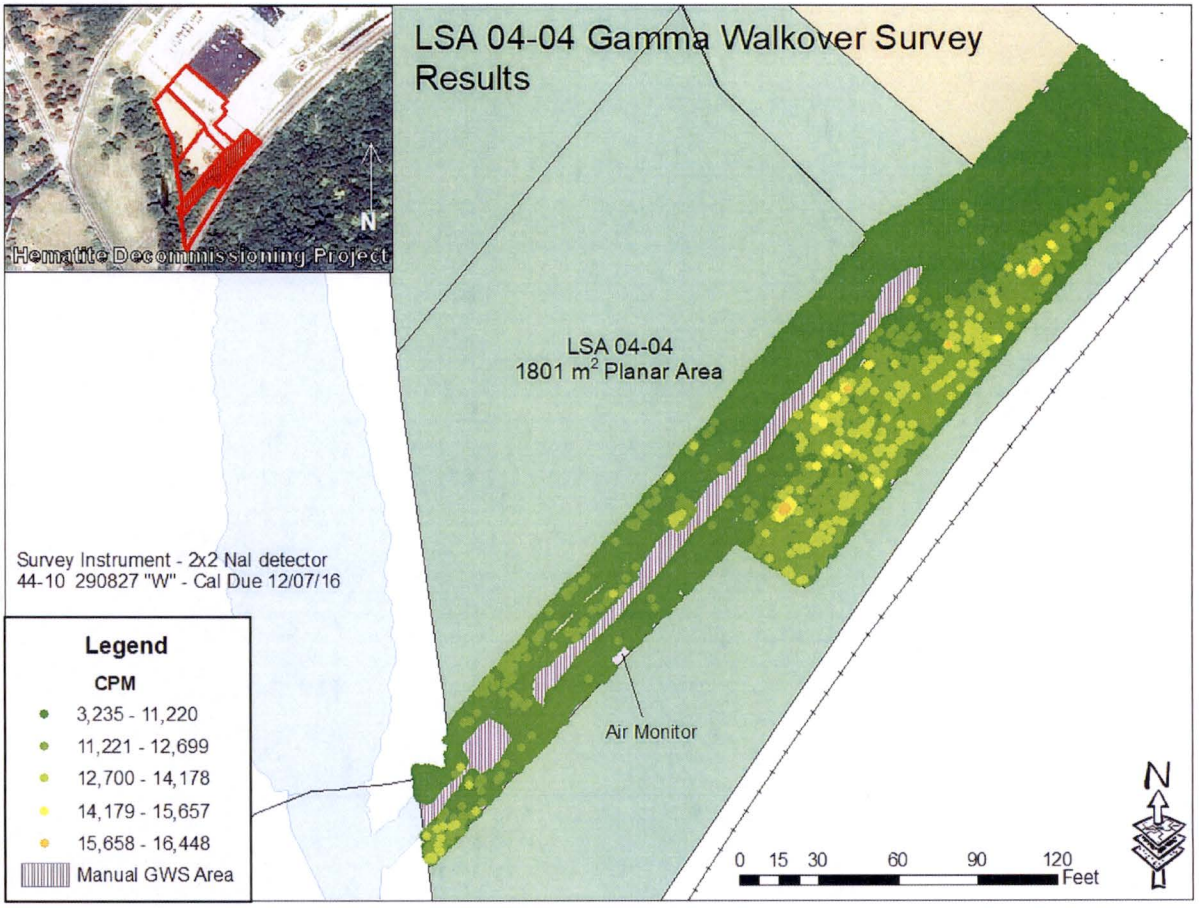
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 04-04 between February 2, 2016, and February 18, 2016.

31.1.1 GWS Results for LSA 04-04

For LSA 04-04, GWS count rates ranged between 3,235 gcpm and 16,448 gcpm, with a mean count rate of 8,462 gcpm. The median count rate was 8,819 gcpm with a standard deviation of 2,395cpm. Figure 31-1 below presents a map of the complete GWS data set.

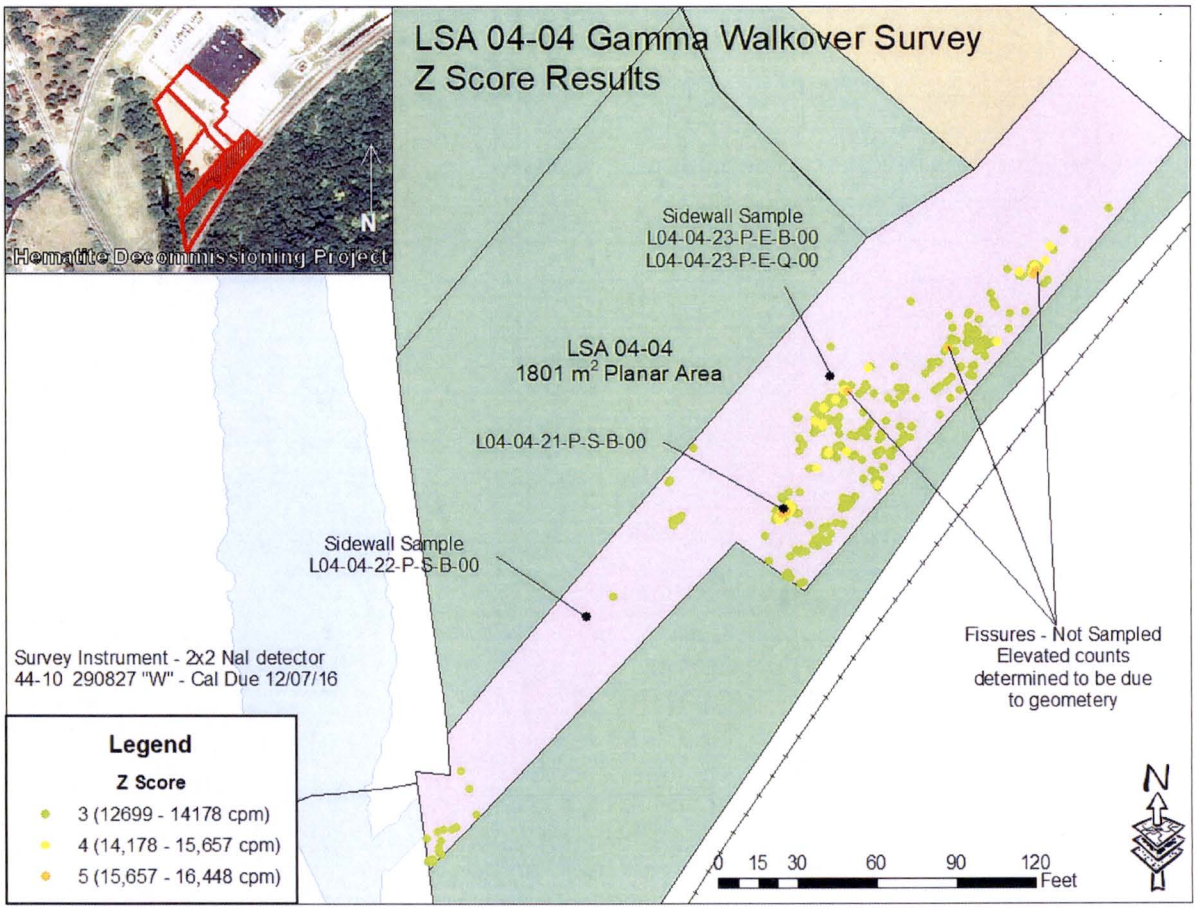
Figure 31-1
Colorimetric GWS Plot for LSA 04-04



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 was selected for biased sample collection. The sample collected at location L04-04-21 represented the maximum GWS measurement (16,448 gcpm) within the SU.

Figure 31-2 presents a map of the +3 Z-score GWS measurements within LSA 04-04 and the selected biased measurement, for completeness, the locations of the supplemental sidewall sample (collected from locations selected by the HP Technician at random) are also shown in Figure 31-2 below.

Figure 31-2
Colorimetric GWS Plot for LSA 04-04 (Measurements > Z-score of 3)



All GWS data collected in LSA 04-04 was datalogged and post-processed in GIS.

31.1.2 GWS Coverage Results LSA 04-04

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS. Although 100% of accessible surfaces underwent GWS using traditional GPS handsets, due to the presence of the trench in the center of the SU, a traditional 100% GPS / GWS survey was not possible. For this reason the trench was surveyed manually prior to the placement of backfill. These manual surveys were reviewed along with the GPS data that was collected to assess the GWS progress of the SU. While slightly elevated count rates were identified during the manual surveys, these elevated count rates were consistent with the counting geometry issues that come with surveying below the ground surface. No isolated pockets of elevated activity were identified, indicating a fairly even gamma count rate across the trench. The manual surveys are provided in Appendix P.

The post survey processing of the GPS data indicated that the GWS was 89.9% of the SU (see Table 31-1), and when combined with the manual surveys the GWS coverage reached 99.68% of

the SU. As the evaluation indicates that the GWS coverage exceeded 95% with no readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of any apparent GPS coverage gaps, the GWS coverage for the SU has been evaluated to meet the intent of the "100% GWS coverage" requirement.

Table 31-1
GWS Gap Analysis LSA 04-04

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 04-04	94,338	301	0.32%	99.68%	1

31.2 Soil Sample Results LSA 04-04

Appendix D presents the analytical results and associated statistics for all FSS surface samples collected within LSA 04-04.

31.2.1 Surface Soil Sample Results LSA 04-04

There were four systematic samples collected within the surface stratum (0 – 15 cm) of LSA 04-04. However there were a total of eleven (11) samples collected from the exposed excavation surface layer, including 8 systematic samples, and 2 QC samples and 1 sidewall sample. The maximum Uniform SOF result for the surface samples was 0.24.

31.2.2 Subsurface Soil Sample Results LSA 04-04

There were eight systematic locations within LSA 04-04 where subsurface samples were collected. Excavation stratum samples were collected directly beneath root stratum composite samples. The root stratum zone is between 0.15 and 1.50 m below the surface, the excavation stratum contains all soil that is greater than 1.50 m below final grade surface. The maximum SOF result of the subsurface samples collected in LSA 04-04 was 0.23.

31.2.3 WRS Test Evaluation LSA 04-04

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was not required for LSA 04-04 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 Test was still performed for LSA 04-04. 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 20 systematically collected samples in LSA 04-04 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, (1168) was greater than the critical value (936) 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 D.

31.2.4 Graphical Data Review LSA 04-04

Table 31-2 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 04-04, and the associated SOF when compared to the Uniform Stratum $DCGL_{WS}$. The arithmetic average concentration resulted in a SOF of 0.11.

Table 31-2
LSA 04-04 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	0.087	0.245	0.065	2.644	0.137	1.136	**0.11**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.656	-0.028	0.241	0.01
Maximum	0.210	1.260	0.230	16.148	0.886	1.980	0.24

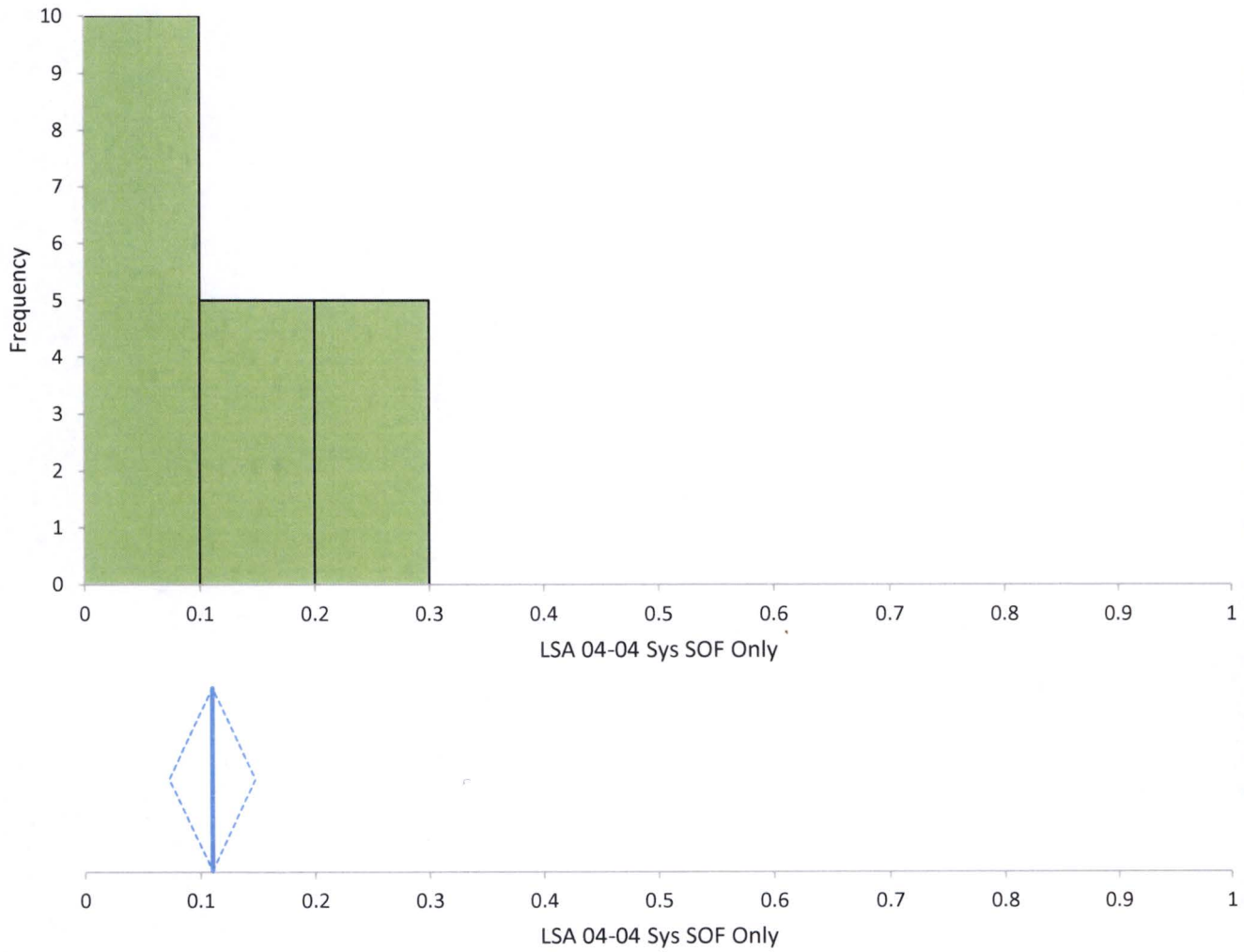
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide 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 SU. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 31-3 presents the overall statistical metrics for the SOF parameter for the 16 systematically collected samples from LSA 04-04. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 04-04. The middle graph presents the mean SOF (0.11) 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 0.07 to 0.15. The 95.86% confidence interval based on the median (0.09) of the sample results is 0.04 to 0.18. The bottom two charts present the various statistical metrics of the LSA 04-04 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 31-3 exhibits no unusual symmetry or bimodality concerns for the LSA 04-04 data associated with the systematically collected measurement locations.

Figure 31-3
Graphic Statistical Summary for LSA 04-04 (SOF parameter)



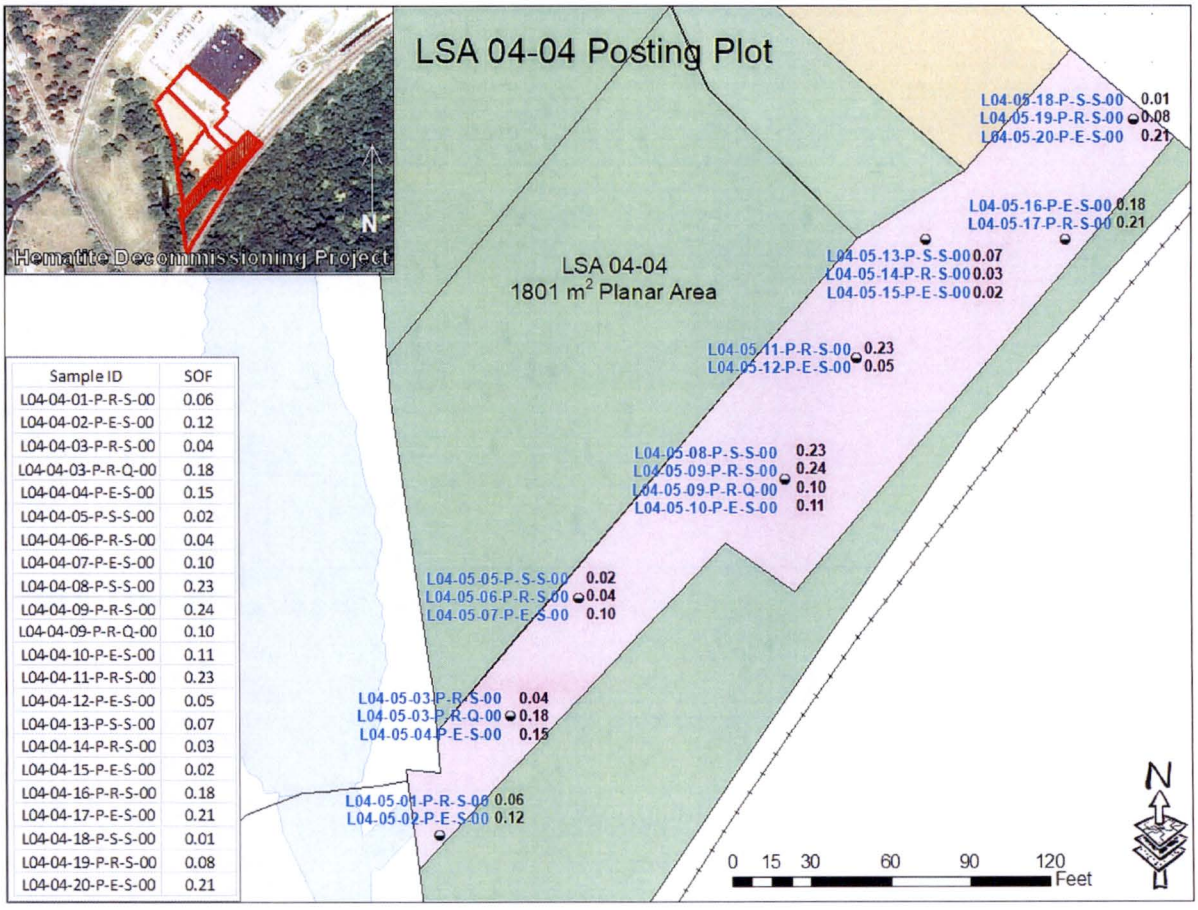
	N
	20

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 04-04 Sys SOF Only	0.11	0.07	to 0.15	0.018	0.08	0.01	0.4	-1.38

	Minimum	1st quartile	Median	95.86% CI		3rd quartile	Maximum	IQR
LSA 04-04 Sys SOF Only	0.01	0.04	0.09	0.04	to 0.18	0.20	0.2	0.16

A posting plot is simply a map of the SU 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 04-04 is presented below in Figure 31-4. Figure 31-4 shows no unusual patterns in the data.

Figure 31-4
Posting Plot for LSA 04-04 Systematic Measurement Locations



Sample ID	SOF
L04-04-01-P-R-S-00	0.06
L04-04-02-P-E-S-00	0.12
L04-04-03-P-R-S-00	0.04
L04-04-03-P-R-Q-00	0.18
L04-04-04-P-E-S-00	0.15
L04-04-05-P-S-S-00	0.02
L04-04-06-P-R-S-00	0.04
L04-04-07-P-E-S-00	0.10
L04-04-08-P-S-S-00	0.23
L04-04-09-P-R-S-00	0.24
L04-04-09-P-R-Q-00	0.10
L04-04-10-P-E-S-00	0.11
L04-04-11-P-R-S-00	0.23
L04-04-12-P-E-S-00	0.05
L04-04-13-P-S-S-00	0.07
L04-04-14-P-R-S-00	0.03
L04-04-15-P-E-S-00	0.02
L04-04-16-P-R-S-00	0.18
L04-04-17-P-E-S-00	0.21
L04-04-18-P-S-S-00	0.01
L04-04-19-P-R-S-00	0.08
L04-04-20-P-E-S-00	0.21

Appendix D to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 31-2, Figure 31-3, and Figure 31-4 above. A summary of the analytical data is presented in Table 31-3 below. Appendix N to this report presents the Test America Analytical Laboratory soil sample reports.

Table 31-3
Final Status Survey Analytical Data: LSA 04-04

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
L04-04-01-P-R-S-00	0.60	S	1.160	0.153	0.050	N/A	0.090	0.090	0.021	0.021	0.067	0.222	U	1.000	0.147	0.096	N/A	0.000	0.000	1.371	NA	NA	NA	0.068	0.134	0.213	U	1.280	0.473	0.707	N/A	0.9	0.06
L04-04-02-P-E-S-00	4.92	S	1.270	0.190	0.086	N/A	0.200	0.200	0.056	0.056	0.051	0.227	U	1.010	0.208	0.114	N/A	0.010	0.010	0.905	NA	NA	NA	-0.028	0.539	0.288	U	0.905	0.340	0.971	U	0.7	0.12
L04-04-03-P-R-S-00	1.50	S	0.847	0.120	0.048	N/A	-0.223	0.000	0.289	0.289	0.040	0.196	N/A	0.818	0.128	0.089	N/A	-0.182	0.000	2.694	NA	NA	NA	0.143	0.128	0.195	U	1.370	0.452	0.658	N/A	1.6	0.04
L04-04-04-P-E-S-00	4.92	S	1.170	0.179	0.082	N/A	0.100	0.100	0.007	0.007	0.011	0.217	U	1.150	0.186	0.111	N/A	0.150	0.150	2.517	NA	NA	NA	0.132	0.154	0.268	U	1.550	0.729	0.936	N/A	1.4	0.15
L04-04-05-P-S-S-00	0.00	S	0.766	0.115	0.056	N/A	-0.304	0.000	0.118	0.118	0.024	0.220	U	0.819	0.133	0.086	N/A	-0.181	0.000	1.825	NA	NA	NA	0.099	0.116	0.213	U	0.700	0.258	0.745	U	2.2	0.02
L04-04-06-P-R-S-00	0.50	S	1.100	0.146	0.061	N/A	0.030	0.030	0.025	0.025	0.011	0.215	U	1.020	0.173	0.096	N/A	0.020	0.020	1.581	NA	NA	NA	0.078	0.137	0.218	U	1.380	0.507	0.762	N/A	0.9	0.04
L04-04-07-P-E-S-00	4.92	S	1.030	0.145	0.064	N/A	-0.040	0.000	-0.008	0.000	0.019	0.221	U	1.160	0.167	0.088	N/A	0.160	0.160	2.488	NA	NA	NA	0.135	0.128	0.198	U	0.947	0.267	0.709	N/A	2.2	0.10
L04-04-08-P-S-S-00	0.00	S	1.240	0.200	0.094	N/A	0.170	0.170	0.643	0.643	0.180	0.233	N/A	0.897	0.185	0.124	N/A	-0.103	0.000	16.148	NA	NA	NA	0.886	0.213	0.251	N/A	1.980	0.707	1.040	N/A	6.6	0.23
L04-04-09-P-R-S-00	0.50	S	1.280	0.172	0.075	N/A	0.210	0.210	0.037	0.037	0.037	0.227	U	1.210	0.195	0.123	N/A	0.210	0.210	1.978	NA	NA	NA	0.102	0.146	0.243	U	1.360	0.514	0.776	N/A	1.2	0.24
L04-04-10-P-E-S-00	4.92	S	1.230	0.165	0.060	N/A	0.160	0.160	0.037	0.037	0.034	0.222	U	1.020	0.154	0.107	N/A	0.020	0.020	1.983	NA	NA	NA	0.104	0.137	0.218	U	1.140	0.498	0.767	N/A	1.4	0.11
L04-04-11-P-R-S-00	1.70	S	1.280	0.198	0.095	N/A	0.210	0.210	-0.003	0.000	0.032	0.222	U	1.210	0.209	0.146	N/A	0.210	0.210	1.680	NA	NA	NA	0.089	0.164	0.281	U	0.906	0.345	0.906	N/A	1.6	0.23
L04-04-12-P-E-S-00	4.92	S	1.120	0.154	0.067	N/A	0.050	0.050	0.002	0.002	0.021	0.222	U	0.934	0.172	0.103	N/A	-0.066	0.000	3.197	NA	NA	NA	0.176	0.129	0.179	U	0.829	0.285	0.688	N/A	3.2	0.05
L04-04-13-P-S-S-00	0.00	S	0.886	0.129	0.064	N/A	-0.184	0.000	1.220	1.220	0.128	0.210	N/A	0.861	0.143	0.080	N/A	-0.139	0.000	2.642	NA	NA	NA	0.143	0.130	0.211	U	1.040	0.462	0.713	N/A	2.1	0.07
L04-04-14-P-R-S-00	0.50	S	1.060	0.146	0.063	N/A	-0.010	0.000	0.419	0.419	0.089	0.223	N/A	1.000	0.161	0.090	N/A	0.000	0.000	1.859	NA	NA	NA	0.100	0.090	0.143	U	0.846	0.259	0.683	N/A	1.9	0.03
L04-04-15-P-E-S-00	4.92	S	1.040	0.158	0.075	N/A	-0.030	0.000	0.095	0.095	0.074	0.216	U	0.911	0.189	0.115	N/A	-0.089	0.000	2.187	NA	NA	NA	0.118	0.151	0.253	U	0.916	0.377	1.120	U	2.0	0.02
L04-04-16-P-R-S-00	1.90	S	1.240	0.169	0.067	N/A	0.170	0.170	0.134	0.134	0.032	0.224	U	1.120	0.162	0.103	N/A	0.120	0.120	2.399	NA	NA	NA	0.128	0.151	0.240	U	1.220	0.654	0.832	N/A	1.7	0.18
L04-04-17-P-E-S-00	4.92	S	1.210	0.161	0.065	N/A	0.140	0.140	0.091	0.091	0.034	0.222	U	1.230	0.173	0.112	N/A	0.230	0.230	1.365	NA	NA	NA	0.066	0.163	0.260	U	1.320	0.522	0.792	N/A	0.8	0.21
L04-04-18-P-S-S-00	0.00	S	0.139	0.038	0.030	N/A	-0.931	0.000	0.055	0.055	0.034	0.194	U	0.137	0.034	0.019	N/A	-0.863	0.000	0.656	NA	NA	NA	0.036	0.053	0.090	U	0.241	0.193	0.289	U	2.3	0.01
L04-04-19-P-R-S-00	0.50	S	1.090	0.149	0.057	N/A	0.020	0.020	1.260	1.260	0.148	0.223	N/A	0.966	0.144	0.109	N/A	-0.034	0.000	1.701	NA	NA	NA	0.086	0.128	0.219	U	1.370	0.462	0.675	N/A	1.0	0.08
L04-04-20-P-E-S-00	4.92	S	1.260	0.191	0.089	N/A	0.190	0.190	0.387	0.387	0.036	0.229	N/A	1.160	0.217	0.142	N/A	0.160	0.160	1.701	NA	NA	NA	0.086	0.122	0.278	U	1.410	0.607	0.926	N/A	1.0	0.21
L04-04-03-P-R-Q-00	0.00	Q	1.240	0.164	0.060	N/A	0.170	0.170	0.006	0.006	0.028	0.219	U	1.150	0.173	0.095	N/A	0.150	0.150	1.007	NA	NA	NA	0.051	0.158	0.248	U	0.845	0.274	0.723	N/A	1.0	0.18
L04-04-09-P-R-Q-00	0.00	Q	1.140	0.160	0.068	N/A	0.070	0.070	0.061	0.061	0.068	0.222	U	1.090	0.161	0.106	N/A	0.090	0.090	1.753	NA	NA	NA	0.094	0.148	0.246	U	0.870	0.295	0.816	N/A	1.7	0.10
L04-04-23-P-E-Q-00	0.00	Q	1.140	0.153	0.065	N/A	0.070	0.070	0.065	0.065	0.068	0.222	U	1.240	0.173	0.096	N/A	0.240	0.240	1.250	NA	NA	NA	0.061	0.156	0.243	U	1.260	0.503	0.767	N/A	0.8	0.17
L04-04-21-P-E-B-00	0.00	B	1.12	0.163	0.0701	N/A	0.050	0.050	0.142	0.142	0.081	0.218	U	1.01	0.165	0.0989	N/A	0.010	0.010	3.419	NA	NA	NA	0.187	0.139	0.188	U	1.13	0.335	0.853	N/A	2.6	0.06
L04-04-22-P-E-B-00	0.00	B	1.02	0.147	0.0676	N/A	-0.050	0.000	0.207	0.207	0.05	0.217	U	1.04	0.202	0.14	N/A	0.040	0.040	4.077	NA	NA	NA	0.22	0.115	0.175	N/A	1.7	0.57	0.839	N/A	2.0	0.06
L04-04-23-P-E-B-00	0.00	B	1.040	0.141	0.055	N/A	-0.030	0.000	0.110	0.110	0.061	0.229	U	1.010	0.151	0.102	N/A	0.010	0.010	1.272	NA	NA	NA	0.066	0.142	0.212	U	0.900	0.264	0.743	N/A	1.2	0.02
Systematic Minimum			0.000						0.000					0.000						0.656				-0.028				0.241				**1.8**	0.01
Systematic Maximum			0.210						1.260					0.230						16.148				0.886				1.980				Average Enrichment (%)	0.24
Systematic Mean			0.087						0.245					0.065						2.644				0.137				1.136					0.11
Systematic Median			0.070						0.074					0.005						1.919				0.101				1.180					0.09
Systematic Standard Deviation			0.085						0.381					0.088						3.238				0.182				0.371					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.

31.2.5 Biased Soil Sample Result LSA 04-04

One (1) biased sample was collected from LSA 04-04. The sample collected at location L04-04-21 represented the maximum GWS measurement (16,448 gcpm) within the SU, and had a result of 0.06 Uniform SOF.

31.2.5.1 Biased Soil Samples Surrounding the SWTP

As stated in Volume 5, Chapter 2, a portion of the former SWTP discharge pipe line remains within LSA 04-04. All biased measurements collected inside PSA 02-01 in the pipe indicated that there was a negligible potential for contamination to escape the piping and into the surrounding soil of LSA 04-04. Additionally all effluent discharge that was sent through the piping was monitored at Outfall #001, and a review of the effluent monitoring history at Outfall #001 indicated that all discharges were below regulatory limits. Therefore there is no concern that the surrounding soils could have become contaminated during the operation of the SWTP.

However, to meet MDNR requirements the HDP Environmental department did determine that it was necessary to sample the soil surrounding PSA 02-01 in the vicinity of observed pipe breaks for potential VOC contamination. As the soil was already being sampled, radiological samples were also collected in those locations.

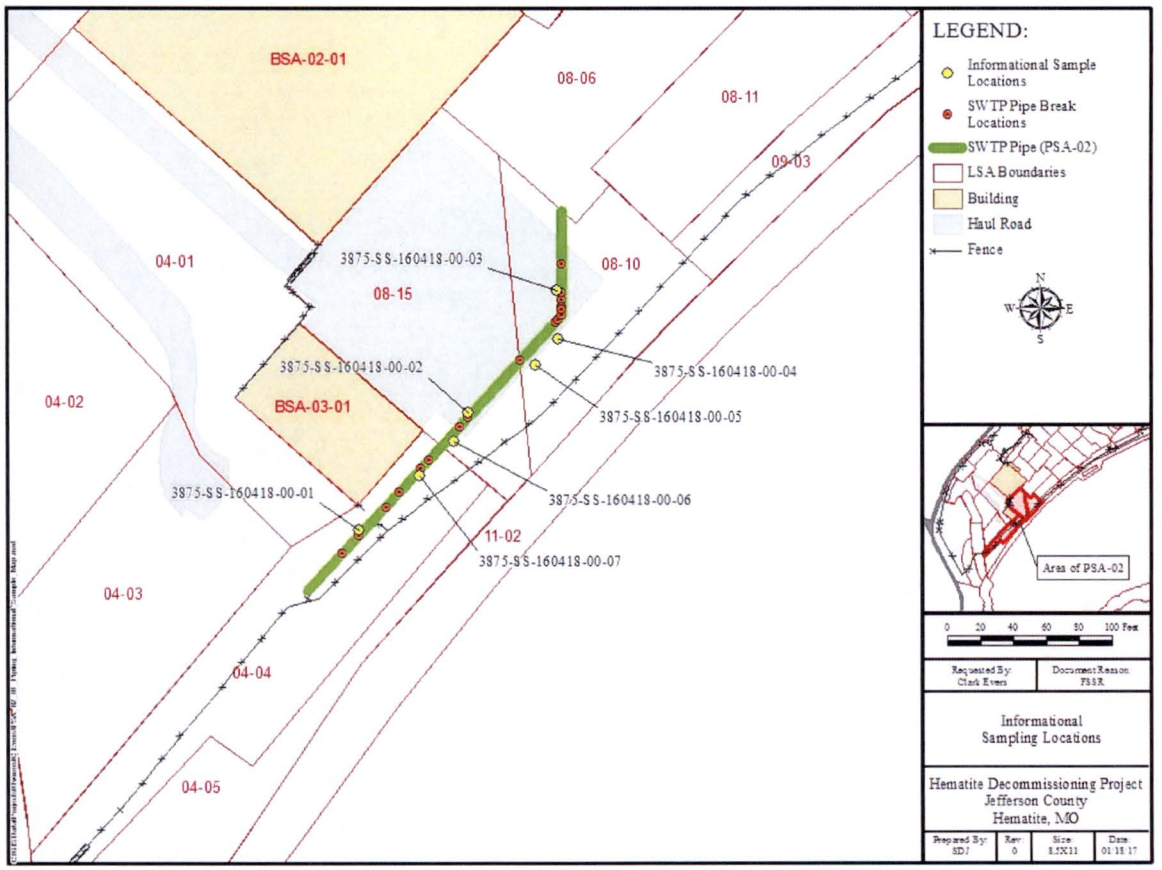
Seven sampling locations were selected by the HDP Environmental department along the length of PSA 02-01 (Figure 31-5), two of which fell inside LSA 04-04. These sample locations were selected to be representative of the soil surrounding the piping comprising PSA 02-01. It is important to note that these samples were collected for informational purposes only, and were not prescribed by the FSS Plan therefore they are not FSS samples. These informational samples provide data that supports the conclusion the soil surrounding PSA 02-01 is not contaminated. As informational samples they are not intended to be used to demonstrate the compliance of PSA 02-01 release criteria ($DCGL_{SO}$), of the LSA 04-04 release criteria.

Table 31-4
Biased Soil Sample Results for Soil Surrounding PSA 02-01

Sample ID	Ra-226 (net)		Tc-99		Th-232 (net)		U-234[3]		U-235		U-238		Uniform SOF
	Result		Result		Result		Result		Result		Result		
3875-SS-160418-00-01	0.02	0.08	0.12	0.21	0.03	0.13	1.57	-	0.08	0.59	1.39	0.95	0.05
3875-SS-160418-00-07	0.11	0.06	0.27	0.21	0.13	0.11	1.51	-	0.00	0.56	1.51	0.75	0.15
DCGL[4]	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 = 1.07 pCi/g; Th-232 bkg = 1.0 pCi/g).
3. U-234 values are inferred from U-235/U-238 Ratio.
4. Uniform Stratum DCGLs provided for context only, soil results will not be used to demonstrate compliance for PSA 02-01.
5. Negative Values are set to Zero.

Figure 31-5
Biased Soil Sample Locations for Soil Surrounding PSA 02-01



31.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 04-04

Two samples were collected from the sidewalls of LSA 04-04. Table 31-5 provides the data summary for the samples.

Table 31-5
LSA 04-04 Sidewall Sample Data Summary and Calculated SOF Values

Sample ID	Ra-226 DCGL = 1.9 BKG = 0.9 (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)
L04-04-23-P-E-B-00	1.02	0.207	1.04	4.077	0.115	1.7	0.06
L04-04-23-P-E-B-00	1.040	0.111	1.010	1.272	0.066	0.900	0.02

31.2.7 Quality Control Soil Sample Result LSA 04-04

Three QC field duplicate sample points were randomly selected for LSA 04-04 which were collected at systematic locations L04-04-03, and L04-04-09, as well as one collected from biased location L04-04-23.

For the 23 samples (i.e., 20 systematic + 1 biased + 2 sidewall) collected within LSA 04-04, three field duplicate sample were collected. This frequency equates to 13%, (i.e. 3/23). 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 with one exception (see Figure 31-6 below).

The statistical assessment of the Laboratory QC sample results indicated that one field duplicate sample (L04-04-03-P-R-Q-00) exceeded the calculated Warning Limit for both Ra-226 and Th-232. In accordance with procedure HDP-PR-FSS-703, *Final Status Survey Quality Control*, when an exceedance occurs an investigation is performed to determine if corrective actions were necessary. The investigation determined that for Ra-226 the calculated statistic (0.393) only slightly exceeded the Warning Limit (0.269), and for Th-232 the calculated statistic (0.307) only slightly exceeded the Warning Limit (0.283). Considering the low activity and the errors associated with the sample results, the Ra-226 and 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 31-6
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-04 (1 of 3)

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 04-04				Survey Unit Description:		South Central SU in "Area 14" Surrounding Site Fence Line					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)							
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	Average Activity ($\bar{x}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L04-04-03-P-R-S-00	L04-04-03-P-R-Q-00	Ra-226	0.847	0.0475	1.24	0.0603	1.044	1.9	0.393	0.269	0.403	Y
L04-04-03-P-R-S-00	L04-04-03-P-R-Q-00	Tc-99	0.289	0.196	0.00613	0.219	0.148	25.1	NA	3.552	5.321	NA
L04-04-03-P-R-S-00	L04-04-03-P-R-Q-00	Th-232	0.818	0.0886	1.15	0.095	0.984	2.0	0.332	0.283	0.424	Y
L04-04-03-P-R-S-00	L04-04-03-P-R-Q-00	U-234[1]	2.694	N/A	1.007	N/A	1.850	195.4	1.687	27.649	41.425	N
L04-04-03-P-R-S-00	L04-04-03-P-R-Q-00	U-235	0.143	0.195	0.0507	0.248	0.097	51.6	NA	7.301	10.939	NA
L04-04-03-P-R-S-00	L04-04-03-P-R-Q-00	U-238	1.37	0.658	0.845	0.723	1.108	168.8	0.525	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/17/17

Quality Record

Figure 31-6
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-04 (2 of 3)

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 04-04				Survey Unit Description:		South Central SU in "Area 14" Surrounding Site Fence Line					
			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)
L04-04-09-P-R-S-00	L04-04-09-P-R-Q-00	Ra-226	1.28	0.0748	1.14	0.0684	1.210	1.9	0.14	0.269	0.403	N
L04-04-09-P-R-S-00	L04-04-09-P-R-Q-00	Tc-99	0.0365	0.227	0.0613	0.222	0.049	25.1	NA	3.552	5.321	NA
L04-04-09-P-R-S-00	L04-04-09-P-R-Q-00	Th-232	1.21	0.123	1.09	0.106	1.150	2.0	0.120	0.283	0.424	N
L04-04-09-P-R-S-00	L04-04-09-P-R-Q-00	U-234[1]	1.978	N/A	1.753	N/A	1.865	195.4	0.225	27.649	41.425	N
L04-04-09-P-R-S-00	L04-04-09-P-R-Q-00	U-235	0.102	0.243	0.0935	0.246	0.098	51.6	NA	7.301	10.939	NA
L04-04-09-P-R-S-00	L04-04-09-P-R-Q-00	U-238	1.36	0.776	0.87	0.816	1.115	168.8	0.490	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/17/17

Quality Record

Figure 31-6
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-04 (3 of 3)

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 04-04				Survey Unit Description:		South Central SU in "Area 14" Surrounding Site Fence Line					
			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)
L04-04-23-P-E-B-00	L04-04-23-P-E-Q-00	Ra-226	1.04	0.0551	1.14	0.0651	1.090	1.9	0.1	0.269	0.403	N
L04-04-23-P-E-B-00	L04-04-23-P-E-Q-00	Tc-99	0.11	0.229	0.0648	0.222	0.087	25.1	NA	3.552	5.321	NA
L04-04-23-P-E-B-00	L04-04-23-P-E-Q-00	Th-232	1.01	0.102	1.24	0.0962	1.125	2.0	0.230	0.283	0.424	N
L04-04-23-P-E-B-00	L04-04-23-P-E-Q-00	U-234[1]	1.272	N/A	1.250	N/A	1.261	195.4	0.022	27.649	41.425	N
L04-04-23-P-E-B-00	L04-04-23-P-E-Q-00	U-235	0.0656	0.212	0.0608	0.243	0.063	51.6	NA	7.301	10.939	NA
L04-04-23-P-E-B-00	L04-04-23-P-E-Q-00	U-238	0.9	0.743	1.26	0.767	1.080	168.8	0.360	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

Date: 7-17-17

Reviewed by: W. Clark Crews / W. Clark Crews

Date: 7/17/17

Quality Record

31.3 Tc-99 Hot Spot Assessment LSA 04-04

Within LSA 04-04, there was an area at the surface where characterization samples were found to exceed the Tc-99 $DCGL_W$ with results up to 30 pCi/g for Tc-99, however these areas were remediated and no additional areas of elevated Tc-99 activity were ever identified. The highest Tc-99 sample result collected from both Final RASS and FSS was 1.26 pCi/g. There is no indication of a potential Tc-99 hot spot exceeding the $DCGL_W$ of 25.1 pCi/g, and therefore a Tc-99 hot spot assessment is not required.

32.0 ALARA EVALUATION LSA 04-04

All samples collected within LSA 04-04 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 04-04 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.11 for LSA 04-04. The average SOF equates to residual activity contributions from the SU area of 2.75 mrem/year for LSA 04-04. Groundwater monitoring well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356} indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 04-04. Additionally, dose contribution for the remaining SWTP piping PSA 02-01 will be added contributing an additional 6.5 mrem/year in total. Adding all of the dose contributions together, the total estimated dose for LSA 04-04 is 13.25 mrem/year.

Since the estimated TEDE is well below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 04-04 was successful and that there would be no discernable benefit to the health and safety of the public in discounting the results of FSS and performing further remediation of LSA 04-04.

33.0 FSS PLAN DEVIATIONS LSA 04-04

33.1 Remedial Actions during FSS

There were no remedial actions in LSA 04-04 after the start of FSS activities.

33.2 Adjustments to Scan MDC Calculations

Scan MDCs for LSA 04-04 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 8,462 cpm. Therefore the calculated Scan MDCs are appropriate, and no adjustments need to be made.

34.0 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.

34.1 Data Quality Assessment for LSA 04-04

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 04-04 (see Figure 34-1) 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*, with one exception.
- LSA 04-04 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 04-04, 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 04-04, however the WRS Test was still performed for illustrative purposes. Since the test statistic, WR (1168) exceeded the critical value (936), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS evaluation worksheet is presented in Appendix D.

- The maximum systematic SOF result for all surface samples within LSA 04-04 was 0.24. The maximum systematic SOF result for the single subsurface sample within LSA 04-04 was 0.23. The average SOF result for all systematically collected samples within LSA 04-04 was 0.11, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.15.
- No FSS sample result in LSA 04-04 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 (8) of systematic sample locations actually collected within LSA 04-04. The successful result of the retrospective power evaluation presented in Table 34-1 for LSA 04-04 indicates that the minimum number of sample locations required (8) for the WRS Test was equal to the number of sampling locations actually collected within LSA 04-04. 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, the Isolation & Control measures and the Pre-backfill GWS was completed for LSA 04-04 prior to the commencement of backfill operations. Additionally a confirmatory GWS was performed of the SU within 72 hours prior to the commencement of backfill operations. The results of the confirmatory GWS were compared to the results of the FSS GWS and the comparison determined that there were no changes within the LSA since FSS was performed.

Table 34-1
Retrospective Sample Size Verification for LSA 04-04

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)	0.11
Shift	0.89
Relative Shift (Δ/σ)	11.13
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 34-1
Data Evaluation Checklists prepared for LSA 04-04 (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 04 **Description:** Plant Soils SEA Open Land Area
Survey Unit: 04 **Description:** South Central SU in "Area 14" Surrounding Site Fence Line

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 ☐	NA ☐
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	NA ☐

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: *Two QC sample results for Ra-226 and Th-232 exceeded the calculated Control Limits, however the results were reviewed by the RSO and the FSS QC results are still considered acceptable. This review is documented in the FSS report.

Quality Record

Figure 34-1
Data Evaluation Checklists prepared for LSA 04-04 (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: No. LSA 04 **Description:** Plant Soils SEA Open Land Area
Survey Unit: No. 04 **Description:** South Central SU in "Area 14" Surrounding Site Fence Line

Discrepancy: None

Corrective Actions Taken: None

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 Yardy (Print Name)	(Signature)	7-17-17 (Date)
Approved by (RSO):	Clark Evers (Print Name)	(Signature)	7/17/17 (Date)

Quality Record

35.0 SURVEILLANCE FOLLOWING FSS

FSS GWS activities in LSA 04-04 were completed in February, 2016. A GWS survey was performed on February 18, 2016 to verify no radiological status change in the SU prior to the start of backfill operations in the SU on the same day. There were no events after the completion of FSS that would have the potential to cause contamination above the DCGLs in the SU.

36.0 CONCLUSION LSA 04-04

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 04-04 of 13.25 mrem/year does not exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 36-1
LSA 04-04 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	SWTP PIPING	GROUND WATER	PUBLIC WATER PIPING	STRUCTURE	**TOTAL**
SOF	0.11	0.26	0.16	N/A	N/A	**0.53**
DOSE	2.75 mrem/year	6.5 mrem/year	4.0 mrem/year	N/A	N/A	**13.25 mrem/year**

37.0 FINAL STATUS SURVEY DESIGN LSA 04-05

This section describes the method for determining the number of samples required for the FSS of LSA 04-05 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 04-05 and their detection sensitivities are also discussed.

37.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 04-05 were driven by the type (Open Land) and Class (Class 2) of the SU and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 10, *Final Status Survey Plan Development*, November 2015.

37.1.1 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.*

37.1.2 $DCGL_W$

During the FSS design process a review was performed of the historic characterization data for LSA 04-05. 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.

37.1.3 GWS Coverage

As a Class 2 SU, LSA 04-05 was required to undergo a minimum 10% GWS.

37.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 04-05 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

37.1.5 Scan Minimum Detectable Concentration

Scan MDCs for LSA 04-04 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 10,000 cpm within LSA 04-05, the Scan MDC calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{3659\ pCi/g}\right)+\left(\frac{f_{U-235}}{2.32\ pCi/g}\right)+\left(\frac{f_{U-238}}{30.6\ pCi/g}\right)\right)}$$

Equation 37-1

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 04-047, the average enrichment for the SU was 3.5%. 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 04-05 are shown below:

Table 37-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 04-05

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 04-05	40.9	45.4	1.21	2.8	0.87	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 37-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

37.1.6 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 basis of the IAL is detailed in HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*". The IAL used during the GWS of LSA 04-05 was established at 4,000 ncpm.

37.1.7 LSA 04-05 FSS Design Summary

The FSS Plan for LSA 04-05 can be found in Appendix J. Table 37-2 presents an overall FSS design and implementation summary for LSA 04-05.

Table 37-2
FSS Design Summary for LSA 04-05

Gamma Walkover Survey (GWS):		
Scan Coverage	Minimum 10% exposed ground surfaces	
Scan MDC	40.9 pCi/g total Uranium (based on a 10,000 cpm background); 0.87 pCi/g Th-232; 1.21 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.		
Sidewall Sampling Locations:		
Not applicable to this SU.		
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 (3.5%) 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.		

38.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 04-05

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

38.1 Gamma Walkover Survey

38.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 04-05 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 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*.

38.1.2 GWS Performance

All GWS measurements on the surface of the SU were 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 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 surface.

HP Technicians performing GWS in LSA 04-05 used the 4,000 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), HP 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, HP Technicians first determined the local background count rate before starting the GWS. Although the ambient gamma level may vary across the SU due to geometry and relative distance from contaminated materials in nearby areas, the average background rate (measured at waist level) within the LSA ranged between 10,000 and 11,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 15,000 gcpm, HP 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.

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 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.

38.2 Soil Sampling

38.2.1 Systematic Soil Sampling Summary

Table 38-1 provides a summary of systematic sampling by stratum for LSA 04-05.

Table 38-1
Systematic Sampling Summary by Stratum for LSA 04-05

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
04-05	1,694	8	8	0	1

38.2.2 Systematic Sampling LSA 04-05

Within LSA 04-05, as a Class 2 SU there was no remediation, so the surface stratum [0 – 15 centimeters (cm)] remained in the SU. The root stratum (15 cm – 150 cm) also remained at all eight of the eight systematic locations. At these locations the remaining root stratum interval was collected using a hand auger and composited. Excavation stratum samples were collected at all eight locations using hand augers, and then archived; no analysis of excavation stratum samples was required as no Root stratum samples were identified to exceed a 0.5 SOF.

Given a planar area of 1,694 m^2 for LSA 04-05 and an eight - point systematic triangular grid, the point-to-point distance within each row was 15.6 m.

While there were eight systematic locations on the LSA 04-05 sampling grid, a total of seventeen (17) samples were collected at these locations, including:

- Eight (8) samples collected within the remaining surface stratum
- Eight (8) sample collected within the remaining root stratum
- Zero (0) samples collected within the excavation, or "deep" stratum
- One (1) QC field replicate

Figure 38-1 presents the map of the eight systematic sample locations which were sampled within LSA 04-05. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 38-1
LSA 04-05 Random Systematic Soil Sample Locations

Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L04-05-25-P-S-S-00	0	6	863997	826829
L04-05-26-P-R-S-00	6	59	863997	826829
L04-05-27-P-E-S-00	59	65	863997	826829
L04-05-28-P-S-S-00	0	6	864042	826854
L04-05-29-P-R-S-00	6	59	864042	826854
L04-05-30-P-E-S-00	59	65	864042	826854
L04-05-31-P-S-S-00	0	6	864086	826829
L04-05-32-P-R-S-00	6	59	864086	826829
L04-05-33-P-E-S-00	59	65	864086	826829
L04-05-34-P-S-S-00	0	6	864086	826880
L04-05-35-P-R-S-00	6	59	864086	826880
L04-05-36-P-E-S-00	59	65	864086	826880
L04-05-37-P-S-S-00	0	6	864130	826906
L04-05-38-P-R-S-00	6	59	864130	826906
L04-05-39-P-E-S-00	59	65	864130	826906
L04-05-40-P-S-S-00	0	6	864174	826931
L04-05-40-P-S-Q-00	0	6	864174	826931
L04-05-41-P-R-S-00	6	59	864174	826931
L04-05-42-P-E-S-00	59	65	864174	826931
L04-05-43-P-S-S-00	0	6	864263	827034
L04-05-44-P-R-S-00	6	59	864263	827034
L04-05-45-P-E-S-00	59	65	864263	827034
L04-05-46-P-S-S-00	0	6	864307	827059
L04-05-47-P-R-S-00	6	59	864307	827059
L04-05-48-P-E-S-00	59	65	864307	827059

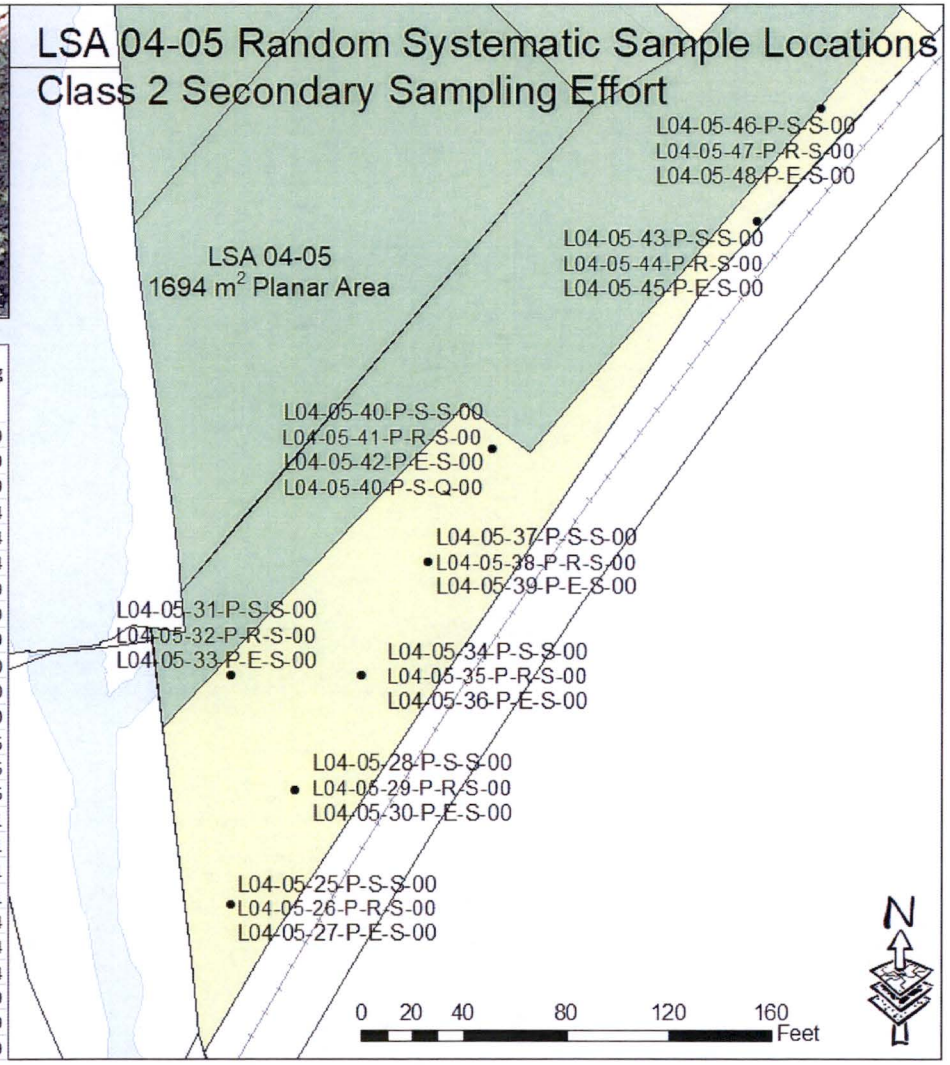


Table 38-2 below presents a tabular listing of all FSS samples collected within LSA 04-05 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 38-2
FSS Sample Locations and Coordinates for LSA 04-05

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 04	**Description:**	Plant Soils Open Land Area
Survey Unit:	05	**Description:**	Survey Unit in "Area 14" along railroad fenceline
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
L04-05-01-P-R-S-00	Uniform	S***	425.4	421.5	864027	826827	Root 4-ft composite
L04-05-02-P-E-S-00	Uniform	S***	421.5	421.0	864027	826827	Excavation 6-inch grab
L04-05-03-P-S-S-00	Uniform	S***	429.7	429.2	864049	826837	Surface 6-inch grab
L04-05-04-P-R-S-00	Uniform	S***	429.2	424.8	864049	826837	Root 4.4-ft composite
L04-05-06-P-S-S-00	Uniform	S***	429.2	429.0	864071	826827	Surface 2-inch grab
L04-05-07-P-R-S-00	Uniform	S***	429	424.6	864071	826827	Root 4.4-ft composite
L04-05-09-P-S-S-00	Uniform	S***	432.7	432.2	864069	826855	Surface 6-inch grab
L04-05-10-P-R-S-00	Uniform	S***	432.2	427.8	864069	826855	Root 4.4-ft composite
L04-05-12-P-S-S-00	Uniform	S***	433	432.5	864102	826848	Surface 6-inch grab
L04-05-13-P-R-S-00	Uniform	S***	432.5	428.1	864102	826848	Root 4.4-ft composite
L04-05-15-P-R-S-00	Uniform	S***	433.9	429.5	864118	826857	Root 9-inch composite
L04-05-16-P-E-S-00	Uniform	S***	429.5	429.0	864118	826857	Excavation 6-inch grab
L04-05-17-P-S-S-00	Uniform	S***	429.3	428.8	864136	826912	Surface 6-inch grab
L04-05-18-P-R-S-00	Uniform	S***	428.8	424.4	864136	826912	Root 4.4-ft composite
L04-05-20-P-S-S-00	Uniform	S***	432.6	432.1	864251	827015	Surface 6-inch grab
L04-05-21-P-R-S-00	Uniform	S***	432.1	427.7	864251	827015	Root 4.4-ft composite
L04-05-03-P-S-Q-00	Uniform	Q	429.7	429.2	864049	826837	Surface 6-inch grab
L04-05-18-P-R-Q-00	Uniform	Q	428.8	424.4	864136	826912	Root 4.4-ft composite
L04-05-23-P-S-B-00	Uniform	B	429.7	429.2	864049	826837	Biased 6-in grab
L04-05-24-P-S-B-00	Uniform	B	428.8	424.4	864136	826912	Biased 6-in grab
L04-05-25-P-S-S-00	Uniform	S	429.0	428.5	863997	826829	Surface 6-inch grab
L04-05-26-P-R-S-00	Uniform	S	428.5	424.1	863997	826829	Root 4.4-ft composite
L04-05-28-P-S-S-00	Uniform	S	430.0	429.5	864042	826854	Surface 6-inch grab
L04-05-29-P-R-S-00	Uniform	S	429.5	425.1	864042	826854	Root 4.4-ft composite
L04-05-31-P-S-S-00	Uniform	S	431.0	430.5	864086	826829	Surface 6-inch grab
L04-05-32-P-R-S-00	Uniform	S	430.5	426.1	864086	826829	Root 4.4-ft composite
L04-05-34-P-S-S-00	Uniform	S	431.0	430.5	864086	826880	Surface 6-inch grab
L04-05-35-P-R-S-00	Uniform	S	430.5	426.1	864086	826880	Root 4.4-ft composite
L04-05-37-P-S-S-00	Uniform	S	430.0	429.5	864130	826906	Surface 6-inch grab
L04-05-38-P-R-S-00	Uniform	S	429.5	425.1	864130	826906	Root 4.4-ft composite
L04-05-40-P-S-S-00	Uniform	S	432.0	431.5	864174	826931	Surface 6-inch grab
L04-05-41-P-R-S-00	Uniform	S	431.5	427.1	864174	826931	Root 4.4-ft composite
L04-05-43-P-S-S-00	Uniform	S	433.0	432.5	864263	827034	Surface 6-inch grab
L04-05-44-P-R-S-00	Uniform	S	432.5	428.1	864263	827034	Root 4.4-ft composite
L04-05-46-P-S-S-00	Uniform	S	433.0	432.5	864307	827059	Surface 6-inch grab
L04-05-47-P-R-S-00	Uniform	S	432.5	428.1	864307	827059	Root 4.4-ft composite
L04-05-40-P-S-Q-00	Uniform	Q	432.0	431.5	864174	826931	Surface 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]
*** Systematic samples from previous iteration of FSS are provided for information only
CSM: Three-Layer (Surface-Root-Excavation) or Uniform DCGLs used
Type: Systematic = S, Biased = B; QC =Q; Investigation = I
Quality Record

38.3 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 04-05 two sample locations were selected within the SU based on the evaluation of the GWS survey data. Biased location (Investigation Sample) L04-05-23 represents the maximum GWS measurement encountered within in LSA 04-05 and has a Uniform SOF value of 0.60.

Both biased samples L04-05-23 and L04-05-24 were collected prior to upgrading the LSA 04-05 classification from Class 3 to Class 2. As these biased samples were identified to exceed a Uniform SOF value of 0.5, the MARRSIM classification of the SU was increased. However, the results of the biased samples were maintained as part of the FSS data set, and no additional biased sampling was determined to be necessary.

38.4 Judgmental/Sidewall Sampling for Tc-99

As an unexcavated SU, no sidewalls were present within LSA 04-05, and therefore no sidewall sampling was necessary.

38.5 Quality Control Soil Sampling

One QC field duplicate sample point was randomly selected and collected at systematic location L04-05-40 for LSA 04-05. Additionally, from the previously collected set of systematic samples, two QC field duplicate samples were collected at systematic locations L04-05-03 and L04-05-18.

39.0 FINAL STATUS SURVEY RESULTS LSA 04-04

39.1 Gamma Walkover Survey

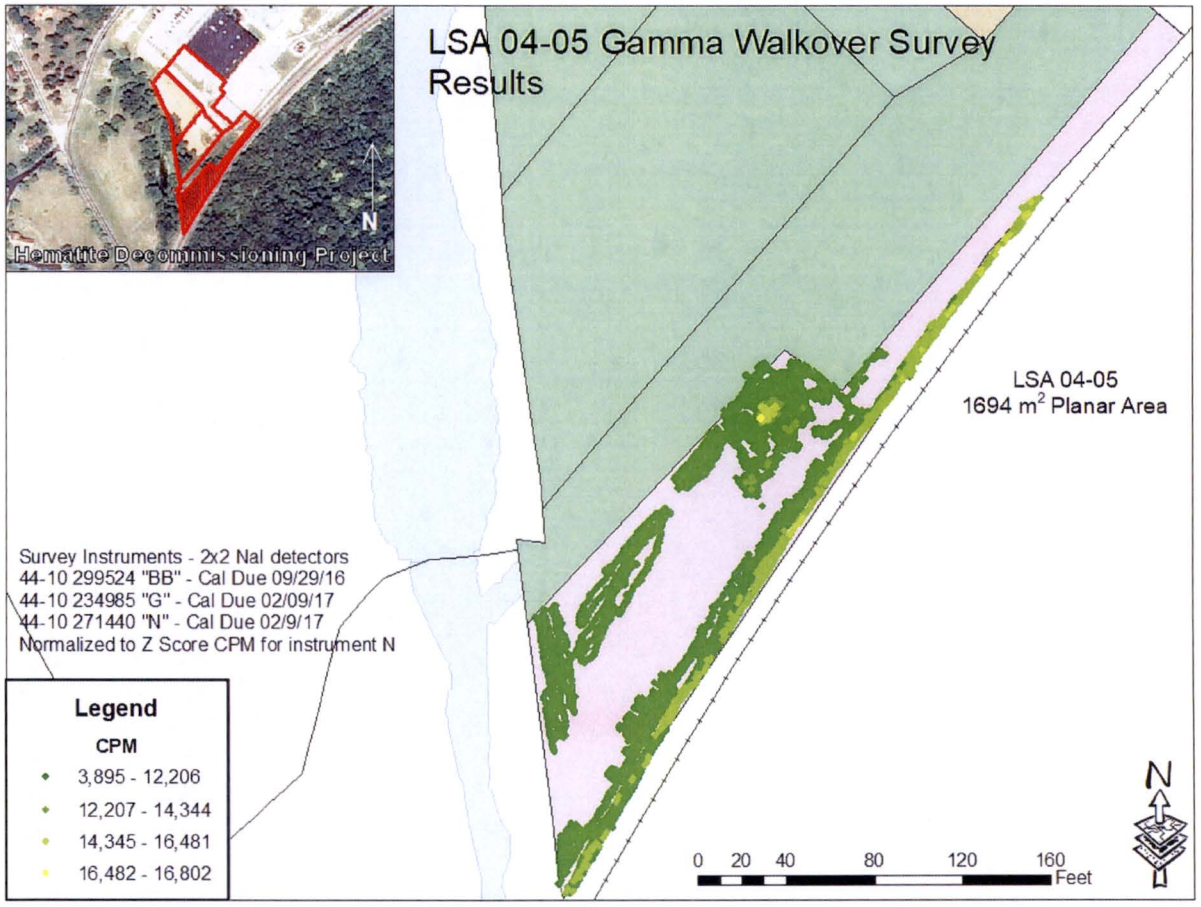
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 04-05 between May 4, 2016, and May 18, 2016.

39.1.1 GWS Results for LSA 04-05

For LSA 04-05, GWS count rates ranged between 3,895 gcpm and 16,802 gcpm, with a mean count rate of 9,593 gcpm. The median count rate was 9,443 gcpm with a standard deviation of 2,197 cpm. Figure 39-1 below presents a map of the complete GWS data set.

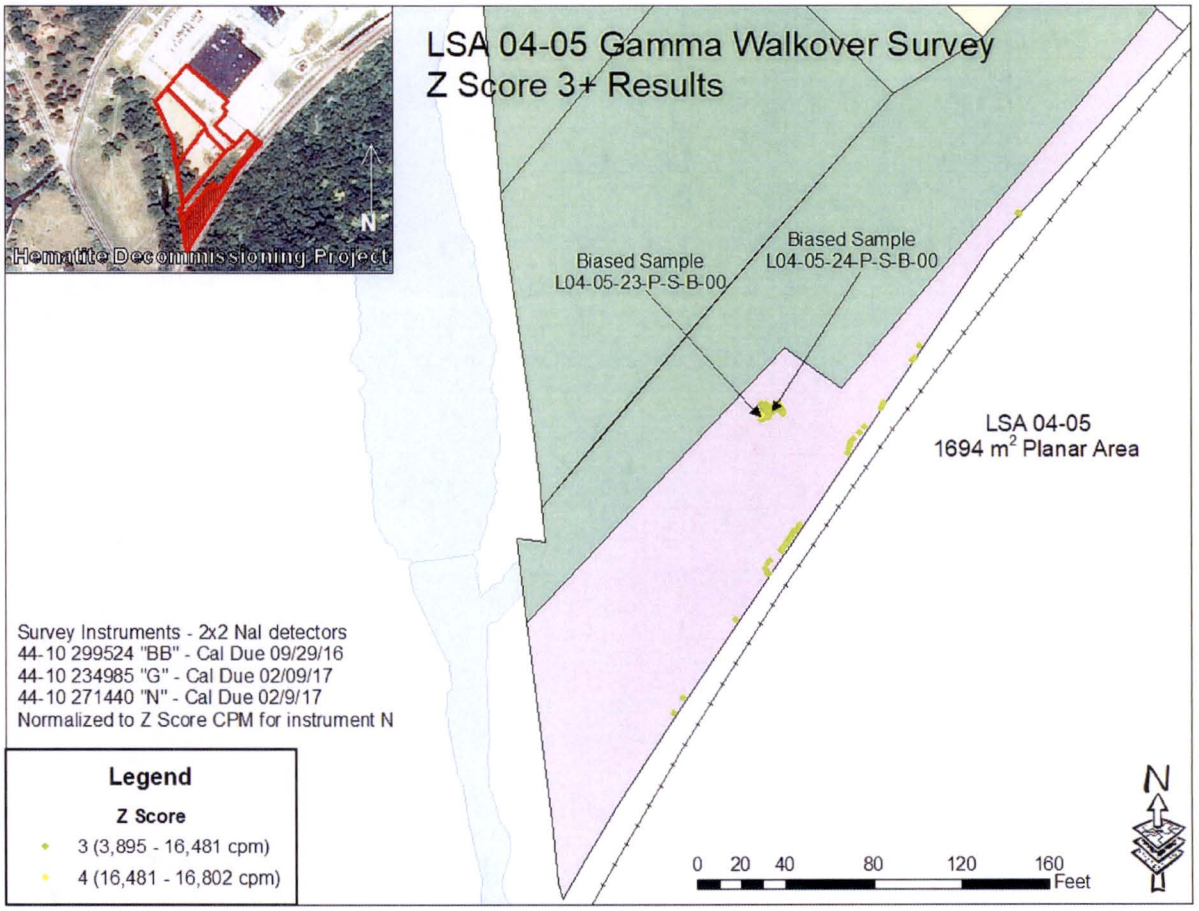
Figure 39-1
Colorimetric GWS Plot for LSA 04-05



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"). Two locations were selected for biased sample collection. The sample collected at location L04-05-23 represented the maximum GWS measurement (16,802 gcpm) within the SU.

Figure 39-2 presents a map of the +3 Z-score GWS measurements within LSA 04-05, including the selected biased sampling locations. For completeness, the locations of the supplemental sidewall sample (collected from locations selected by the HP Technician at random) is also shown in Figure 39-2 below.

Figure 39-2
Colorimetric GWS Plot for LSA 04-05 (Measurements > Z-score of 3)



All GWS data collected in LSA 04-05 was datalogged and post-processed in GIS.

39.1.2 GWS Coverage Results LSA 04-05

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS. As a Class 2 SU LSA 04-05 was required to be subjected to a minimum of a 10% GWS. The post survey processing of the GPS data indicated that the GWS was 40% of the SU.

39.2 Soil Sample Results LSA 04-05

Appendix E presents the analytical results and associated statistics for all FSS surface samples collected within LSA 04-05.

Note that for LSA 04-05 two separate sets of systematic samples were collected. The first set was collected as part of a Class 3 random grid. The MARRSIM class of the SU was then upgraded to Class 2, the FSS plans were revised, and a new set of systematic samples were collected on a random start grid pattern. The first set of systematic samples (Class 3) are being

presented for informational purposes only. The second set of samples (Class 2) will be used to demonstrate compliance with the release criteria.

39.2.1 Surface Soil Sample Results LSA 04-05

There were eight systematic samples collected within the surface stratum (0 – 15 cm) of LSA 04-05. There were a total of eleven (11) samples collected from the exposed surface layer, including 8 systematic samples, 1 QC sample, and 2 biased samples. The maximum Uniform SOF result for the surface samples was 0.60 (biased).

39.2.2 Subsurface Soil Sample Results LSA 04-05

There were eight systematic locations within LSA 04-05 where subsurface samples were collected. The root stratum zone is between 0.15 and 1.50 m below the surface. The maximum SOF result of the subsurface samples collected in LSA 04-05 was 0.27.

39.2.3 WRS Test Evaluation LSA 04-05

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was not required for LSA 04-05 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 Test was still performed for LSA 04-05. 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 04-05 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 E.

39.2.4 Graphical Data Review LSA 04-05

Table 39-1 below presents summary results for the all systematically collected samples (includes surface, and root stratum samples, but not biased or QC samples) collected within LSA 04-05, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.06.

Table 39-1
LSA 04-05 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	0.042	0.257	0.033	1.559	0.010	0.839	**0.06**
Minimum	0.00 (<BKG)	0.005	0.00 (<BKG)	0.406	-0.150	0.256	0.01
Maximum	0.300	0.966	0.200	4.528	0.248	1.450	0.27

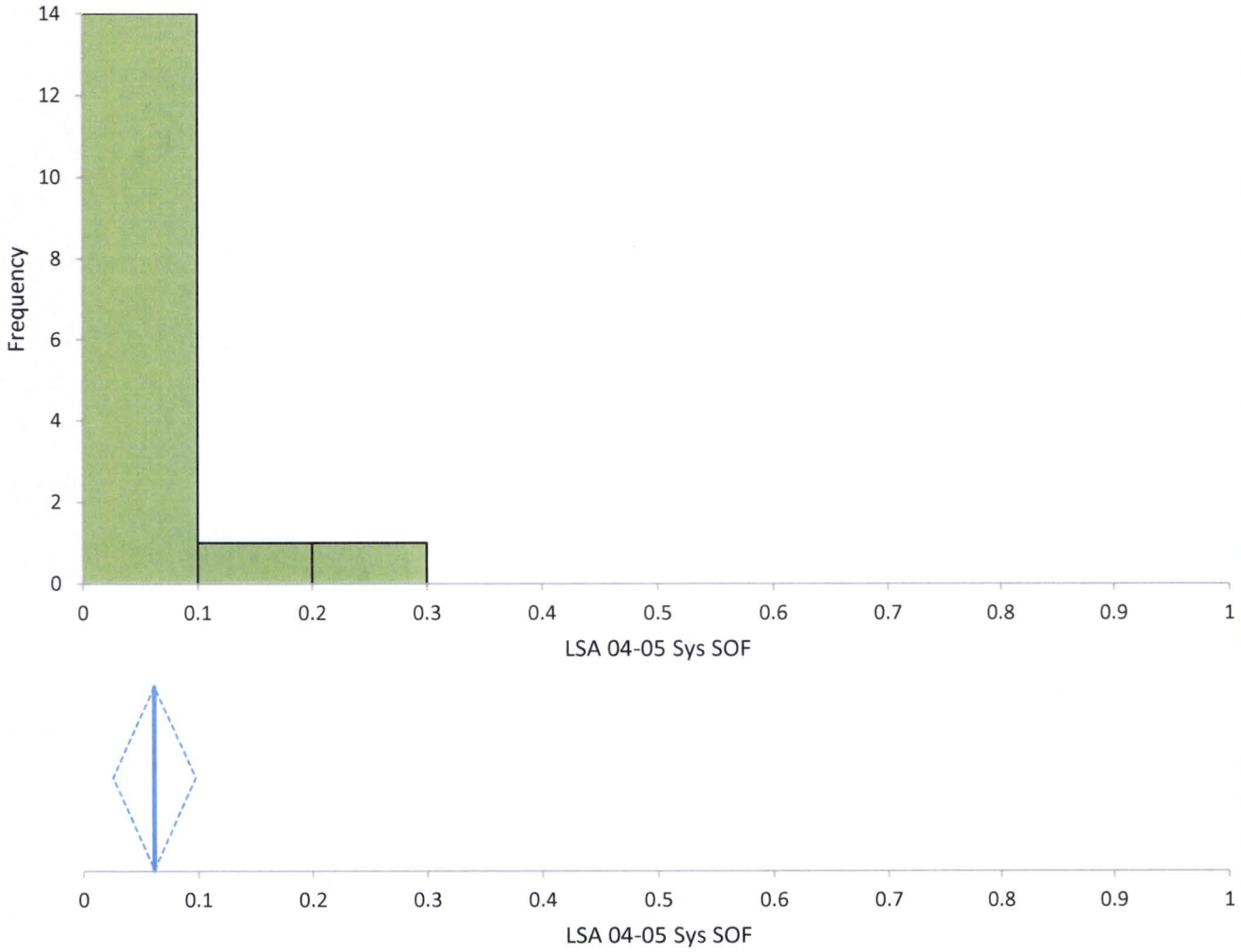
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide 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 SU. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 39-3 presents the overall statistical metrics for the SOF parameter for the 16 systematically collected samples from LSA 04-05. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 04-05. The middle graph presents the mean SOF (0.06) 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 0.03 to 0.10. The 97.87% confidence interval based on the median (0.03) of the sample results is 0.02 to 0.09. The bottom two charts present the various statistical metrics of the LSA 04-05 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 39-3 exhibits no unusual symmetry or bimodality concerns for the LSA 04-05 data associated with the systematically collected measurement locations.

Figure 39-3
Graphic Statistical Summary for LSA 04-05 (SOF parameter)



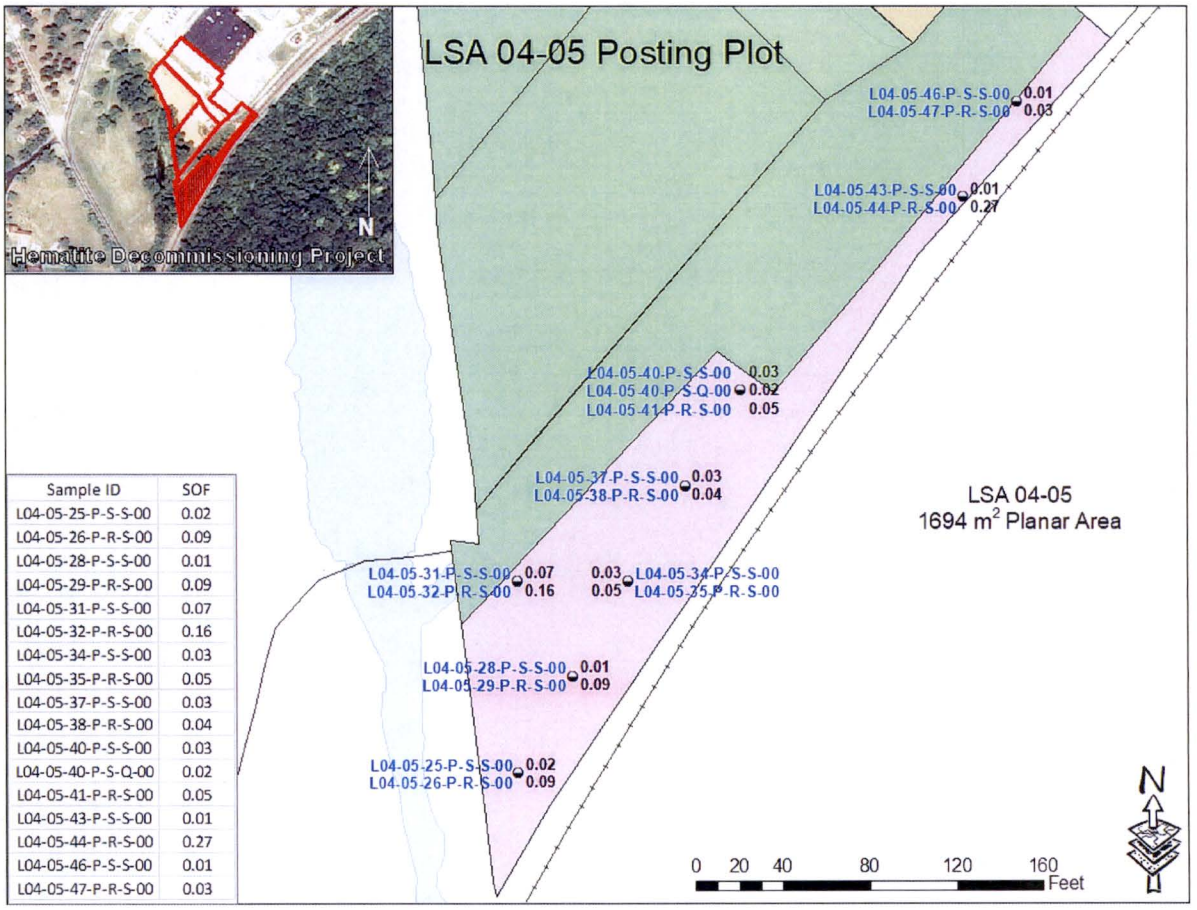
	N
	16

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 04-05 Sys SOF	0.06	0.03	to 0.10	0.017	0.07	0.00	2.2	5.20

	Minimum	1st quartile	Median	97.87% CI		3rd quartile	Maximum	IQR
LSA 04-05 Sys SOF	0.01	0.02	0.03	0.02	to 0.09	0.09	0.3	0.06

A posting plot is simply a map of the SU 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 04-05 is presented below in Figure 39-4. Figure 39-4 shows no unusual patterns in the data.

Figure 39-4
Posting Plot for LSA 04-05 Random Systematic Measurement Locations



Sample ID	SOF
L04-05-25-P-S-S-00	0.02
L04-05-26-P-R-S-00	0.09
L04-05-28-P-S-S-00	0.01
L04-05-29-P-R-S-00	0.09
L04-05-31-P-S-S-00	0.07
L04-05-32-P-R-S-00	0.16
L04-05-34-P-S-S-00	0.03
L04-05-35-P-R-S-00	0.05
L04-05-37-P-S-S-00	0.03
L04-05-38-P-R-S-00	0.04
L04-05-40-P-S-S-00	0.03
L04-05-40-P-S-Q-00	0.02
L04-05-41-P-R-S-00	0.05
L04-05-43-P-S-S-00	0.01
L04-05-44-P-R-S-00	0.27
L04-05-46-P-S-S-00	0.01
L04-05-47-P-R-S-00	0.03

Appendix E to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 39-1, Figure 39-3, and Figure 39-4 above. A summary of the analytical data is presented in Table 39-2 below. Appendix O to this report presents the Test America Analytical Laboratory soil sample reports.

Table 39-2
Final Status Survey Analytical Data: LSA 04-05

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
L04-05-01-P-R-S-00	1.50	S***	1.140	0.164	0.065	N/A	0.070	0.070	0.154	0.154	0.027	0.244	U	1.020	0.175	0.148	N/A	0.020	0.020	3.059	NA	NA	NA	0.166	0.186	0.222	U	1.190	0.531	0.801	N/A	2.2	0.08
L04-05-02-P-E-S-00	5.00	S***	1.200	0.173	0.081	N/A	0.130	0.130	0.476	0.476	0.075	0.235	N/A	1.090	0.187	0.123	N/A	0.090	0.090	3.034	NA	NA	NA	0.165	0.160	0.673	U	1.120	0.557	0.850	N/A	2.3	0.16
L04-05-03-P-S-S-00	0.00	S***	0.976	0.137	0.059	N/A	-0.094	0.000	-0.026	0.000	0.053	0.240	U	1.010	0.154	0.100	N/A	0.010	0.010	4.129	NA	NA	NA	0.225	0.131	0.168	N/A	1.470	0.515	0.747	N/A	2.4	0.04
L04-05-04-P-R-S-00	0.50	S***	0.989	0.139	0.064	N/A	-0.081	0.000	-0.012	0.000	0.019	0.231	U	1.200	0.165	0.099	N/A	0.200	0.200	4.066	NA	NA	NA	0.222	0.159	0.202	N/A	1.350	0.495	0.728	N/A	2.5	0.13
L04-05-06-P-S-S-00	0.00	S***	0.968	0.148	0.058	N/A	-0.102	0.000	1.910	1.910	0.320	0.225	N/A	1.070	0.208	0.098	N/A	0.070	0.070	7.857	NA	NA	NA	0.434	0.161	0.199	N/A	1.530	0.389	0.930	N/A	4.3	0.17
L04-05-07-P-R-S-00	0.50	S***	0.927	0.137	0.064	N/A	-0.143	0.000	-0.039	0.000	0.032	0.246	U	1.030	0.150	0.086	N/A	0.030	0.030	1.110	NA	NA	NA	-0.044	0.121	0.543	U	1.110	0.300	0.764	N/A	0.7	0.03
L04-05-09-P-S-S-00	0.00	S***	0.889	0.153	0.091	N/A	-0.181	0.000	0.118	0.118	0.064	0.236	U	1.040	0.181	0.112	N/A	0.040	0.040	3.273	NA	NA	NA	0.179	0.154	0.196	U	1.070	0.326	0.766	N/A	2.6	0.05
L04-05-10-P-R-S-00	0.50	S***	1.170	0.180	0.080	N/A	0.100	0.100	0.075	0.075	0.164	0.249	U	1.020	0.174	0.134	N/A	0.020	0.020	1.360	NA	NA	NA	-0.146	0.207	0.661	U	1.360	0.588	0.881	N/A	0.7	0.08
L04-05-12-P-S-S-00	0.00	S***	1.050	0.153	0.067	N/A	-0.020	0.000	0.236	0.236	0.134	0.227	N/A	1.100	0.179	0.115	N/A	0.100	0.100	0.952	NA	NA	NA	-0.014	0.025	0.562	U	0.952	0.311	0.794	N/A	0.7	0.07
L04-05-13-P-R-S-00	0.50	S***	0.830	0.147	0.081	N/A	-0.240	0.000	0.074	0.074	0.058	0.231	U	1.040	0.187	0.175	N/A	0.040	0.040	2.043	NA	NA	NA	0.109	0.202	0.583	U	1.030	0.354	0.932	N/A	1.7	0.04
L04-05-15-P-R-S-00	4.00	S***	0.881	0.124	0.052	N/A	-0.189	0.000	0.172	0.172	0.071	0.239	U	0.984	0.183	0.113	N/A	-0.016	0.000	3.388	NA	NA	NA	0.185	0.151	0.186	U	1.130	0.316	0.780	N/A	2.5	0.03
L04-05-16-P-E-S-00	4.92	S***	0.877	0.135	0.072	N/A	-0.193	0.000	0.028	0.028	0.014	0.236	U	0.889	0.185	0.132	N/A	-0.111	0.000	3.118	NA	NA	NA	0.171	0.156	0.193	U	0.952	0.552	0.860	N/A	2.8	0.03
L04-05-17-P-S-S-00	0.00	S***	0.823	0.136	0.076	N/A	-0.247	0.000	0.738	0.738	0.087	0.211	N/A	0.781	0.141	0.166	N/A	-0.219	0.000	1.338	NA	NA	NA	0.070	0.134	0.598	U	0.881	0.328	0.802	N/A	1.3	0.04
L04-05-18-P-R-S-00	0.50	S***	0.716	0.102	0.045	N/A	-0.354	0.000	0.281	0.281	0.100	0.228	N/A	0.614	0.098	0.074	N/A	-0.386	0.000	0.432	NA	NA	NA	-0.031	0.060	0.370	U	0.432	0.183	0.473	U	0.7	0.02
L04-05-20-P-S-S-00	0.00	S***	0.594	0.103	0.053	N/A	-0.476	0.000	0.304	0.304	0.050	0.254	N/A	0.513	0.107	0.056	N/A	-0.487	0.000	0.816	NA	NA	NA	-0.089	0.130	0.464	U	0.816	0.386	0.581	N/A	0.7	0.02
L04-05-21-P-R-S-00	0.50	S***	0.956	0.141	0.068	N/A	-0.114	0.000	0.002	0.002	0.087	0.237	U	0.880	0.141	0.106	N/A	-0.120	0.000	1.043	NA	NA	NA	0.050	0.123	0.519	U	1.260	0.532	0.796	N/A	0.7	0.01
L04-05-03-P-S-Q-00	0.00	Q	1.040	0.164	0.082	N/A	-0.030	0.000	0.081	0.081	0.067	0.239	U	1.190	0.196	0.101	N/A	0.190	0.190	0.182	NA	NA	NA	-0.009	0.123	0.411	U	0.182	0.749	1.250	U	0.7	0.10
L04-05-18-P-R-Q-00	0.50	Q	1.090	0.180	0.091	N/A	0.020	0.020	0.236	0.236	0.057	0.231	N/A	1.080	0.185	0.100	N/A	0.080	0.080	2.191	NA	NA	NA	0.120	0.193	0.329	U	0.683	0.312	0.863	U	2.7	0.08
L04-05-23-P-S-B-00	0.00	B	1.030	0.159	0.078	N/A	-0.040	0.000	0.867	0.867	0.104	0.234	N/A	1.140	0.196	0.108	N/A	0.140	0.140	74.083	NA	NA	NA	4.000	0.514	0.275	N/A	6.130	1.070	1.160	N/A	9.3	0.60
L04-05-24-P-S-B-00	0.00	B	0.960	0.159	0.111	N/A	-0.110	0.000	0.308	0.308	0.115	0.233	N/A	1.180	0.202	0.099	N/A	0.180	0.180	69.227	NA	NA	NA	3.780	0.495	0.353	N/A	7.310	1.210	1.270	N/A	7.5	0.57
L04-05-25-P-S-S-00	0.00	S	0.561	0.093	0.048	N/A	-0.509	0.000	0.102	0.102	0.064	0.212	U	0.369	0.081	0.069	N/A	-0.631	0.000	2.293	NA	NA	NA	0.126	0.092	0.145	U	0.638	0.216	0.579	N/A	3.0	0.02
L04-05-26-P-R-S-00	0.50	S	1.220	0.167	0.068	N/A	0.150	0.150	0.014	0.014	0.069	0.240	U	1.000	0.156	0.118	N/A	0.000	0.000	1.450	NA	NA	NA	-0.143	0.459	0.591	U	1.450	0.583	0.876	N/A	0.7	0.09
L04-05-28-P-S-S-00	0.00	S	0.664	0.110	0.057	N/A	-0.406	0.000	0.145	0.145	0.042	0.219	U	0.314	0.114	0.265	N/A	-0.686	0.000	0.406	NA	NA	NA	-0.103	0.132	0.500	U	0.406	0.175	1.100	U	0.7	0.01
L04-05-29-P-R-S-00	0.50	S	1.050	0.141	0.067	N/A	-0.020	0.000	0.057	0.057	0.019	0.236	U	1.130	0.172	0.098	N/A	0.130	0.130	3.360	NA	NA	NA	0.184	0.146	0.181	U	1.040	0.305	0.772	N/A	2.7	0.09
L04-05-31-P-S-S-00	0.00	S	0.971	0.141	0.053	N/A	-0.099	0.000	0.966	0.966	0.091	0.231	N/A	0.822	0.149	0.086	N/A	-0.178	0.000	4.528	NA	NA	NA	0.248	0.145	0.189	N/A	1.430	0.636	0.784	N/A	2.7	0.07
L04-05-32-P-R-S-00	0.50	S	1.150	0.183	0.094	N/A	0.080	0.080	0.103	0.103	0.066	0.240	U	1.200	0.213	0.167	N/A	0.200	0.200	0.969	NA	NA	NA	0.046	0.057	0.626	U	1.100	0.368	0.954	N/A	0.7	0.16
L04-05-34-P-S-S-00	0.00	S	0.638	0.090	0.037	N/A	-0.432	0.000	0.545	0.545	0.128	0.211	N/A	0.340	0.072	0.060	N/A	-0.660	0.000	0.712	NA	NA	NA	0.039	0.086	0.306	U	0.256	0.128	0.665	U	2.3	0.03
L04-05-35-P-R-S-00	0.50	S	0.845	0.131	0.060	N/A	-0.225	0.000	0.558	0.558	0.160	0.230	N/A	0.717	0.125	0.085	N/A	-0.283	0.000	3.410	NA	NA	NA	0.187	0.152	0.182	N/A	1.040	0.451	0.677	N/A	2.8	0.05
L04-05-37-P-S-S-00	0.00	S	0.757	0.109	0.052	N/A	-0.313	0.000	0.583	0.583	0.079	0.205	N/A	0.788	0.135	0.100	N/A	-0.212	0.000	0.668	NA	NA	NA	-0.094	0.117	0.386	U	0.668	0.333	0.513	N/A	0.7	0.03
L04-05-38-P-R-S-00	0.50	S	1.130	0.169	0.084	N/A	0.060	0.060	0.104	0.104	0.017	0.236	U	0.952	0.165	0.104	N/A	-0.048	0.000	0.545	NA	NA	NA	-0.088	0.145	0.338	U	0.545	0.266	0.732	U	0.7	0.04
L04-05-40-P-S-S-00	0.00	S	0.856	0.128	0.065	N/A	-0.214	0.000	0.489	0.489	0.242	0.240	N/A	0.704	0.133	0.107	N/A	-0.296	0.000	0.749	NA	NA	NA	-0.104	0.119	0.531	U	0.749	0.294	0.730	N/A	0.7	0.03
L04-05-41-P-R-S-00	0.50	S	1.150	0.167	0.072	N/A	0.080	0.080	0.040	0.040	0.071	0.247	U	0.979	0.154	0.110	N/A	-0.021	0.000	0.880	NA	NA	NA	0.042	0.067	0.386	U	0.907	0.325	0.810	N/A	0.7	0.05
L04-05-43-P-S-S-00	0.00	S	0.687	0.112	0.056	N/A	-0.383	0.000	0.188	0.188	0.075	0.218	U	0.424	0.111	0.095	N/A	-0.576	0.000	0.787	NA	NA	NA	-0.096	0.126	0.453	U	0.787	0.348	0.518	N/A	0.7	0.01
L04-05-44-P-R-S-00	0.50	S	1.370	0.183	0.063	N/A	0.300	0.300	0.005	0.005	0.026	0.239	U	1.200	0.191	0.159	N/A	0.200	0.200	1.000	NA	NA	NA	-0.150	0.213	0.637	U	1.000	0.346	0.899	N/A	0.7	0.27
L04-05-46-P-S-S-00	0.00	S	0.718	0.115	0.054	N/A	-0.352	0.000	0.137	0.137	0.018	0.210	U	0.509	0.104	0.093	N/A	-0.491	0.000	0.408	NA	NA	NA	-0.089	0.092	0.441	U	0.408	0.209	0.546	U	0.7	0.01
L04-05-47-P-R-S-00	0.50	S	0.947	0.136	0.060	N/A	-0.123	0.000	0.074	0.074	0.086	0.232	U	0.979	0.146	0.091	N/A	-0.021	0.000	2.776	NA	NA	NA	0.151	0.161	0.167	U	1.000	0.290	0.712	N/A	2.3	0.03
L04-05-40-P-S-Q-00	0.00	Q	0.965	0.126	0.055	N/A	-0.105	0.000	0.376	0.376	0.146	0.231	N/A	0.767	0.132	0.109	N/A	-0.233	0.000	0.762	NA	NA	NA	0.000	0.096	0.425	U	0.762	0.240	0.628	N/A	0.7	0.02
Systematic Minimum			0.000						0.005					0.000						0.406				-0.150				0.256				2.0	0.01
Systematic Maximum			0.300						0.966					0.200						4.528				0.248				1.450					0.27
Systematic Mean			0.042						0.257					0.033						1.559				0.010				0.839				Average Enrichment (%)	0.06
Systematic Median			0.000						0.121					0.000						0.925				-0.025				0.847					0.03
Systematic Standard Deviation			0.082						0.281					0.073						1.293				0.134				0.347					0.07
			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.

39.2.5 Biased Soil Sample Result LSA 04-05

Two (2) biased samples were collected from LSA 04-05. The sample collected at location L04-05-23 represented the maximum GWS measurement (16,802 gcpm) within the SU, and had a result of 0.60 Uniform SOF.

39.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 04-05

As an unexcavated Class 2 SU, no sidewalls were present in LSA 04-05, and therefore no sidewall sampling was necessary.

39.2.7 Quality Control Soil Sample Result LSA 04-05

Three QC field duplicate sample points were randomly selected for LSA 04-05 which were collected at systematic locations L04-05-03, L04-05-18, and L04-05-40.

For the 34 samples (i.e., 16 systematic + 2 biased + 16 previous systematic) collected within LSA 04-05, three field duplicate samples were collected. This frequency equates to 8.8%, (i.e. 3/34). 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, with one exception (see Figure 39-5 below).

The statistical assessment of the Laboratory QC sample results indicated that one field duplicate sample (L04-05-18-P-R-Q-00) exceeded the calculated Warning Limit for both Ra-226 and Th-232. In accordance with procedure HDP-PR-FSS-703, *Final Status Survey Quality Control*, when an exceedance occurs an investigation is performed to determine if corrective actions were necessary. The investigation determined that for Ra-226 the calculated statistic (0.374) only slightly exceeded the Warning Limit (0.269), and for Th-232 the calculated statistic (0.466) only slightly exceeded the Control Limit (0.424). Considering the low activity and the errors associated with the sample results, the Ra-226 and 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 39-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-05 (1 of 3)

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 04-05				Survey Unit Description:		Survey Unit in "Area 14" along railroad fenceline					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$)	Nuclide DCGL		Warning	Control	Statistic Exceeds Limit?
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	(pCi/g)	(pCi/g)	Statistic[2]	Limit	Limit	(Y/N)
L04-05-18-P-R-S-00	L04-05-18-P-R-Q-00	Ra-226	0.716	0.045	1.09	0.0911	0.903	1.9	0.374	0.269	0.403	Y
L04-05-18-P-R-S-00	L04-05-18-P-R-Q-00	Tc-99	0.281	0.228	0.236	0.231	0.259	25.1	0.045	3.552	5.321	N
L04-05-18-P-R-S-00	L04-05-18-P-R-Q-00	Th-232	0.614	0.0737	1.08	0.1	0.847	2.0	0.466	0.283	0.424	Y
L04-05-18-P-R-S-00	L04-05-18-P-R-Q-00	U-234[1]	0.432	N/A	2.191	N/A	1.312	195.4	1.759	27.649	41.425	N
L04-05-18-P-R-S-00	L04-05-18-P-R-Q-00	U-235	-0.0314	0.37	0.12	0.329	0.044	51.6	NA	7.301	10.939	NA
L04-05-18-P-R-S-00	L04-05-18-P-R-Q-00	U-238	0.432	0.473	0.683	0.863	0.558	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/17/17

Quality Record

Figure 39-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-05 (2 of 3)

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 04-05 | Survey Unit Description: Survey Unit in "Area 14" along railroad fenceline

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)
L04-05-40-P-S-S-00	L04-05-40-P-S-Q-00	Ra-226	0.856	0.0652	0.965	0.0552	0.911	1.9	0.109	0.269	0.403	N
L04-05-40-P-S-S-00	L04-05-40-P-S-Q-00	Tc-99	0.489	0.24	0.376	0.231	0.433	25.1	0.113	3.552	5.321	N
L04-05-40-P-S-S-00	L04-05-40-P-S-Q-00	Th-232	0.704	0.107	0.767	0.109	0.736	2.0	0.063	0.283	0.424	N
L04-05-40-P-S-S-00	L04-05-40-P-S-Q-00	U-234[1]	0.749	N/A	0.762	N/A	0.756	195.4	0.013	27.649	41.425	N
L04-05-40-P-S-S-00	L04-05-40-P-S-Q-00	U-235	-0.104	0.531	0	0.425	-0.052	51.6	NA	7.301	10.939	NA
L04-05-40-P-S-S-00	L04-05-40-P-S-Q-00	U-238	0.749	0.73	0.762	0.628	0.756	168.8	0.013	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/17/17

Quality Record

Figure 39-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 04-05 (3 of 3)

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 04-05 | Survey Unit Description: Survey Unit in "Area 14" along railroad fenceline

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)
L04-05-03-P-S-S-00	L04-05-03-P-S-Q-00	Ra-226	0.976	0.0587	1.04	0.0816	1.008	1.9	0.064	0.269	0.403	N
L04-05-03-P-S-S-00	L04-05-03-P-S-Q-00	Tc-99	-0.0264	0.24	0.0811	0.239	0.027	25.1	NA	3.552	5.321	NA
L04-05-03-P-S-S-00	L04-05-03-P-S-Q-00	Th-232	1.01	0.1	1.19	0.101	1.100	2.0	0.180	0.283	0.424	N
L04-05-03-P-S-S-00	L04-05-03-P-S-Q-00	U-234[1]	4.129	N/A	0.182	N/A	2.155	195.4	3.947	27.649	41.425	N
L04-05-03-P-S-S-00	L04-05-03-P-S-Q-00	U-235	0.225	0.168	-0.00894	0.411	0.108	51.6	NA	7.301	10.939	NA
L04-05-03-P-S-S-00	L04-05-03-P-S-Q-00	U-238	1.47	0.747	0.182	1.25	0.826	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

Date: 7-17-17

Reviewed by: Clark Evers

Date: 7/17/17

Quality Record

39.3 Tc-99 Hot Spot Assessment LSA 04-05

Within LSA 04-05, there is no history of Tc-99 exceeding the $DCGL_W$. The highest Tc-99 sample result collected from both Final RASS and FSS was 13.8 pCi/g. There is no indication of a potential Tc-99 hot spot exceeding the $DCGL_W$ of 25.1 pCi/g, and therefore a Tc-99 hot spot assessment is not required.

40.0 ALARA EVALUATION LSA 04-05

All samples collected within LSA 04-05 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 04-05 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.06 for LSA 04-05. The average SOF equates to residual activity contributions from the SU area of 1.25 mrem/year for LSA 04-05. Groundwater monitoring well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356} indicate that the groundwater dose contribution will be a fraction of the MCLs. Nevertheless, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 04-05. Adding all of the dose contributions together, the total estimated dose for LSA 04-05 is 5.25 mrem/year.

Since the estimated TEDE is well below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 04-05 was successful and that there would be no discernable benefit to the health and safety of the public in discounting the results of FSS and performing further remediation of LSA 04-05.

41.0 FSS PLAN DEVIATIONS LSA 04-05

41.1 Remedial Actions during FSS

No remedial actions were performed during FSS, however the MARRSIM classification of the SU was raised from Class 3 to Class 2 based on the identification of two elevated biased samples (maximum of 0.6 Uniform SOF).

41.2 Adjustments to Scan MDC Calculations

Scan MDCs for LSA 04-05 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 10,000 cpm was applied to determine the prospective Scan MDCs, and the actual mean count rate from the FSS survey was 9,593 cpm. Therefore the calculated Scan MDCs are appropriate, and no adjustments need to be made.

42.0 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.

42.1 Data Quality Assessment for LSA 04-05

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 04-05 (see Figure 42-1) 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*, with one exception (See Section 39.2.7).
- LSA 04-05 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 04-05, 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 04-05, 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 evaluation worksheet is presented in Appendix E.

- The maximum systematic SOF result for all surface samples within LSA 04-05 was 0.07. The maximum systematic SOF result for the all subsurface samples within LSA 04-05 was 0.27. The average SOF result for all systematically collected samples within LSA 04-05 was 0.06, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.10.
- No FSS sample result in LSA 04-05 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 (8) of systematic sample locations actually collected within LSA 04-05. The successful result of the retrospective power evaluation presented in Table 42-1 for LSA 04-05 indicates that the minimum number of sample locations required (8) for the WRS Test was equal to the number of sampling locations actually collected within LSA 04-05. 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 was performed periodically, and confirmed that there were no instances of potential cross contamination from events until the FSS of all remaining areas at HDP were completed.

Table 42-1
Retrospective Sample Size Verification for LSA 04-05

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.07
$DCGL_{SOF}$	1
LBGR (Mean)	0.06
Shift	0.94
Relative Shift (Δ/σ)	13.89
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 42-1
Data Evaluation Checklists prepared for LSA 04-05 (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 04 **Description:** Plant Soils Open Land Area
Survey Unit: 05 **Description:** Survey Unit in "Area 14" along Railroad Fence Line

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 ☐ NA ☐
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒ No ☐ NA ☐

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: *Two QC sample results for Ra-226 and Th-232 exceeded the calculated Control Limits, however the results were reviewed by the RSO and the FSS QC results are still considered acceptable. This review is documented in the FSS report.

Quality Record

Figure 42-1
Data Evaluation Checklists prepared for LSA 04-05 (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: No. LSA 04 **Description:** Plant Soils SEA Open Land Area
Survey Unit: No. 05 **Description:** Survey Unit in "Area 14" along Railroad Fence Line

Discrepancy: None

Corrective Actions Taken: None

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 Yardy (Print Name)	(Signature)	7-17-17 (Date)
Approved by (RSO):	Clark Evers (Print Name)	(Signature)	7/17/17 (Date)

Quality Record

43.0 SURVEILLANCE FOLLOWING FSS

FSS GWS activities in LSA 04-05 were completed in May, 2016. There were no events after the completion of FSS that would have the potential to cause contamination above the DCGLs in the SU.

44.0 CONCLUSION LSA 04-05

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 04-05 of 5.25 mrem/year does not exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 44-1
LSA 04-05 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	REMAINING STRUCTURE	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.06	N/A	0.16	N/A	N/A	**0.22**
DOSE	1.25 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**5.25 mrem/year**

45.0 REFERENCES

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

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

45.3 NSA-TR-09-15, Nuclear Criticality Safety Assessment of Buried Waste Exhumation and Contaminated Soil Remediation at the Hematite Site

45.4 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}

45.5 Westinghouse Internal Memorandum HEM-15-MEMO-021, *Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site* (FSSFR Volume 3, Chapter 1, Appendix D)

45.6 Westinghouse letter HEM-11-56, dated May 5, 2011, *Evaluation of Technetium-99 Under the Process Buildings* {ML111260624}

46.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A: Analytical Data Evaluation Spreadsheets for LSA 04-01

APPENDIX B: Analytical Data Evaluation Spreadsheets for LSA 04-02

APPENDIX C: Analytical Data Evaluation Spreadsheets for LSA 04-03

APPENDIX D: Analytical Data Evaluation Spreadsheets for LSA 04-04

APPENDIX E: Analytical Data Evaluation Spreadsheets for LSA 04-05

APPENDIX F: FSS Plan Development for LSA 04-01

APPENDIX G: FSS Plan Development for LSA 04-02

APPENDIX H: FSS Plan Development for LSA 04-03

APPENDIX I: FSS Plan Development for LSA 04-04

APPENDIX J: FSS Plan Development for LSA 04-05

APPENDIX K: TestAmerica Laboratory Analytical Data Reports for LSA 04-01

APPENDIX L: TestAmerica Laboratory Analytical Data Reports for LSA 04-02

APPENDIX M: TestAmerica Laboratory Analytical Data Reports for LSA 04-03

APPENDIX N: TestAmerica Laboratory Analytical Data Reports for LSA 04-04

APPENDIX O: TestAmerica Laboratory Analytical Data Reports for LSA 04-05

APPENDIX P: Manual RASS Surveys of the LSA 04-04 SWTP Trench

APPENDIX Q: Completed Field Logs (Appendix P-6 from HDP-PR-FSS-701)