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Our ref: HEM-17-71
Date: December 5, 2017

Subject: Westinghouse Hematite Decommissioning Project - Request for NRC Review of Final Status Survey Final Report Volume 3, Chapter 2, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02, Revision 1 (License No. SNM-00033, Docket No. 070-00036)

The purpose of this letter is to provide for the U.S. Nuclear Regulatory Commission (NRC) review of Final Status Survey Final Report (FSSFR) Volume 3, Chapter 2, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02, Revision 1.

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

Attachment 1 contains FSSFR Volume 3, Chapter 2, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02, Revision 1.

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

Sincerely,

Kenneth E. Pallagi
Licensing Manager,
Hematite Decommissioning Project

NM5520

Attachment: 1) Final Status Survey Final Report Volume 3, Chapter 2, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02, Revision 1 (HDP-RPT-FSS-204 Revision 1)

cc: V. J. Kelmeckis, Westinghouse
S. S. Koenick, NRC/DUWP/MDB
J. A. Smith, NRC/DUWP/MDB

Attachment 1

Final Status Survey Final Report Volume 3, Chapter 2, Revision 1

Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02, Revision 1

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 2

TITLE: **Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02 (LSA 10-01 and LSA 10-02)**

REVISION: **1**

EFFECTIVE DATE: DEC 0 4 2017

Approvals:

Author: Kenneth E. Pallagi — 12-04-2017 Date

Owner/Manager: W. Clark Evers — 12/4/17 Date

REVISION LOG	
Revision No. Effect. Date	**Revision**
0 10/25/2016	Revision 0 is the initial issuance of the Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02.
1 See Cover Page	The NRC provided feedback during recurring weekly publicly noticed teleconferences in regards to the application of the WRS Test when applied to the Three Stratum approach. Westinghouse and the NRC discussed the path forward and resolution of the NRC comments. Revision 3 to FSSFR Volume 3 Chapter 1 implemented the resolution of the comments. Revision 1 of this Survey Area Release Record implements Revision 3 to FSSFR Volume 3 Chapter 1 within this report. Additionally this report has been reformatted in its entirety along with other minor editorial changes to align this survey area release record with subsequent survey area release records submitted to the NRC.

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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	Differential Global Positioning System
DP	Hematite Decommissioning Plan
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
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HDP	Hematite Decommissioning Project
HP	Health Physics
HRCR	Hematite Radiological Characterization Report
I & C	Isolation and Control
IAL	Investigation Action Level
LSA	Land Survey Area
m	meter(s)
m^2	square meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Concentration Limit
MDC	Minimum Detectable Concentration
mrem	milliroentgen equivalent man
NAD	North American Datum
NaI	Sodium Iodide
ncpm	net count(s) per minute
NCS	Nuclear Criticality Safety
NRC	U.S. Nuclear Regulatory Commission
pCi/g	picocurie(s) per gram
QC	Quality Control
Ra	Radium
RASS	Remedial Action Support Survey
RSO	Radiation Safety Officer
SOF	Sum of Fractions

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

EXECUTIVE SUMMARY

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

Both LSA 10-01 and LSA 10-02 were designated as Class 1 SUs as presented in Table 14-16 of the HDP DP {ML092330123}. The Class 1 designation for both SUs remained in effect throughout remediation and Final Status Survey (FSS). For both SUs, evaluation of analytical results against the Derived Concentration Guideline Levels (DCGL) for the Uniform Stratum Conceptual Site Model (CSM) was the selected approach. The objective of the FSS for both SUs was to obtain and document measurement results, analytical data, and other supporting information in order to demonstrate that after completion of remediation the residual radioactivity levels in the LSA 10-01 and LSA 10-02 SUs are below the applicable Uniform Stratum DCGLs and therefore the land area of these SUs meet the criteria for unrestricted release.

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

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

1.0 REPORT BACKGROUND

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

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

2.0 HDP SITE, LSA AND SURVEY UNIT DESCRIPTIONS

2.1 HDP Site Description

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

2.2 LSA Configuration

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

The DP stated that it was expected that the conceptual boundaries of the SUs would be altered based on the actual configuration and condition of the SU at the time of survey design. As expected, it was necessary to modify the boundary of LSA 10 to facilitate the remediation process. The expansion of LSA 10 was due in part to benching and sloping requirements for excavations and also to ensure adequate remediation of specific areas as indicated by the results of visual inspection and radiological survey. As a result of the expansion of LSA 10, the individual SUs within LSA 10 were also modified. All SUs within LSA 10 were initially classified as Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) Class 1 survey areas in DP Chapter 14. Therefore, for FSS, all SUs within LSA 10 remained classified as MARSSIM Class 1 survey areas, thereby ensuring compliance with the DP.

LSA 10 encompasses the entire "Documented Burial Pit Area" footprint within the Central Tract. LSA 10 consists of SUs LSA 10-01 through LSA 10-14.

2.3 LSA 10-01 and LSA 10-02 Survey Unit Description and Configuration

LSA 10-01 and LSA 10-02 are located within the northern half of LSA 10, the Burial Pit Area. Figure 2-2 indicates the location of LSA 10-01 and LSA 10-02 within LSA 10. Figure 2-3 presents the Final Configuration of the HDP Land Survey Areas and SUs which indicate the location of the boundaries of LSA 10-0 and LSA 10-02.

Figure 2-1
HDP Land Survey Areas

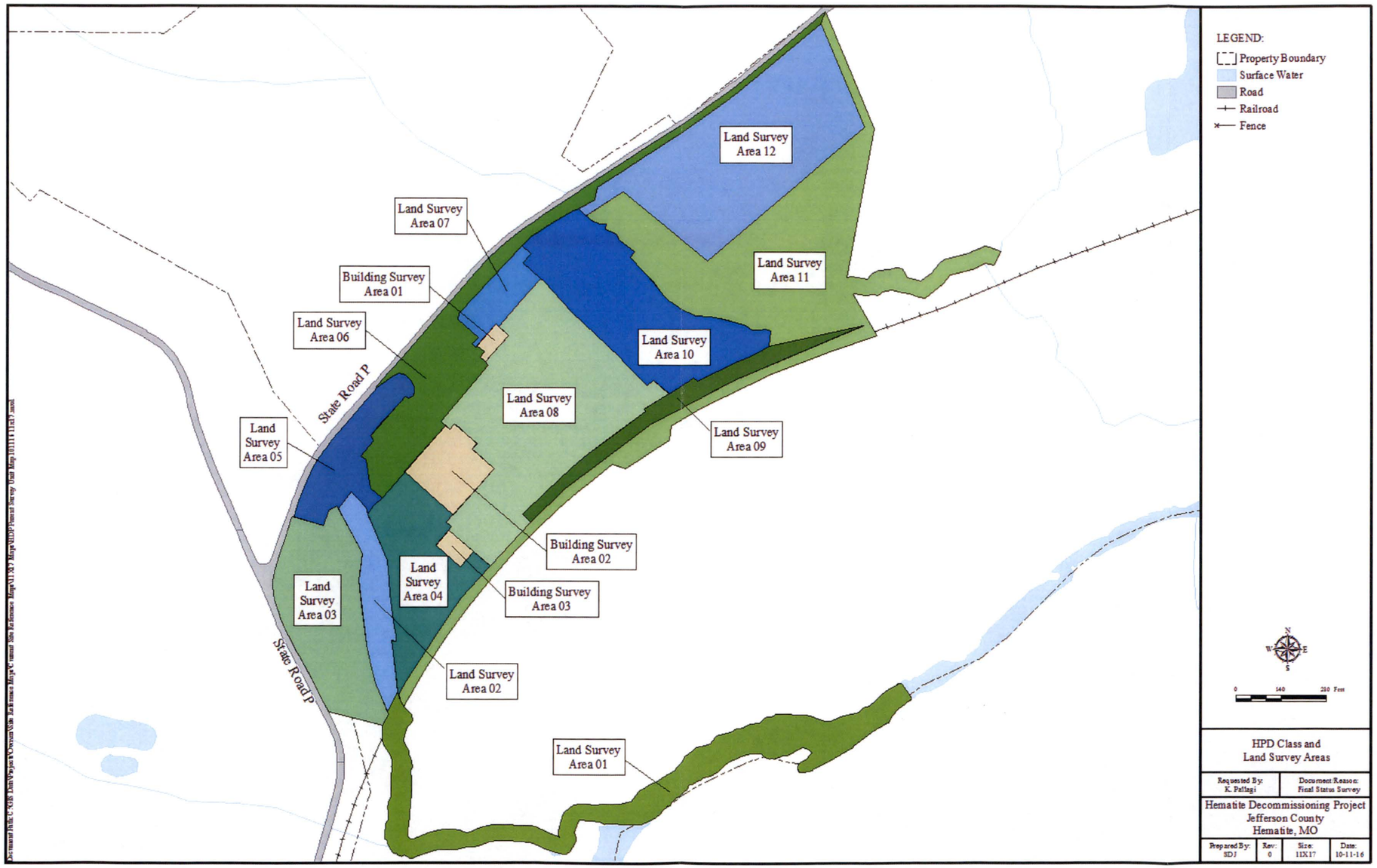


Figure 2-2
Final Configuration of Land Survey Area 10 and Survey Units

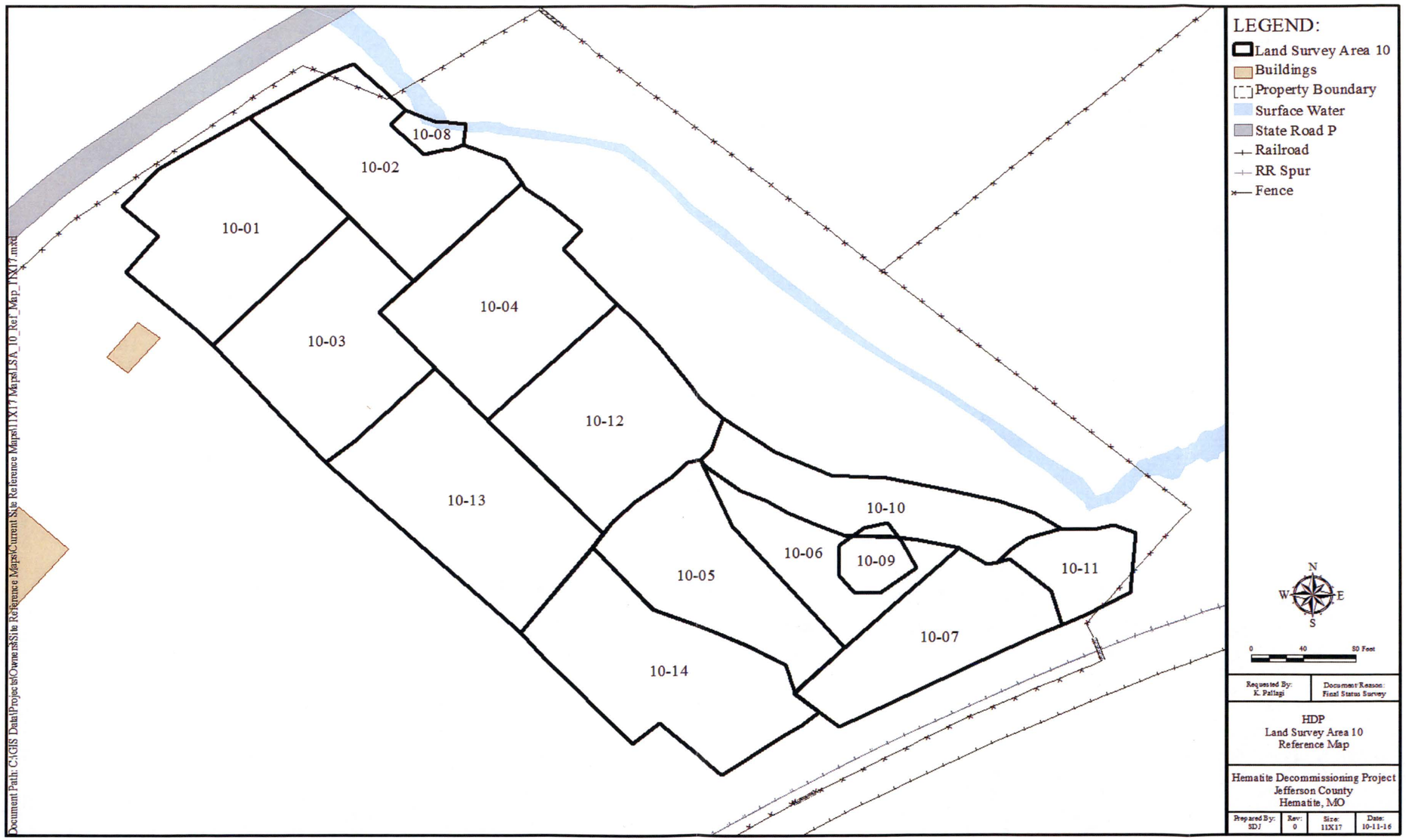
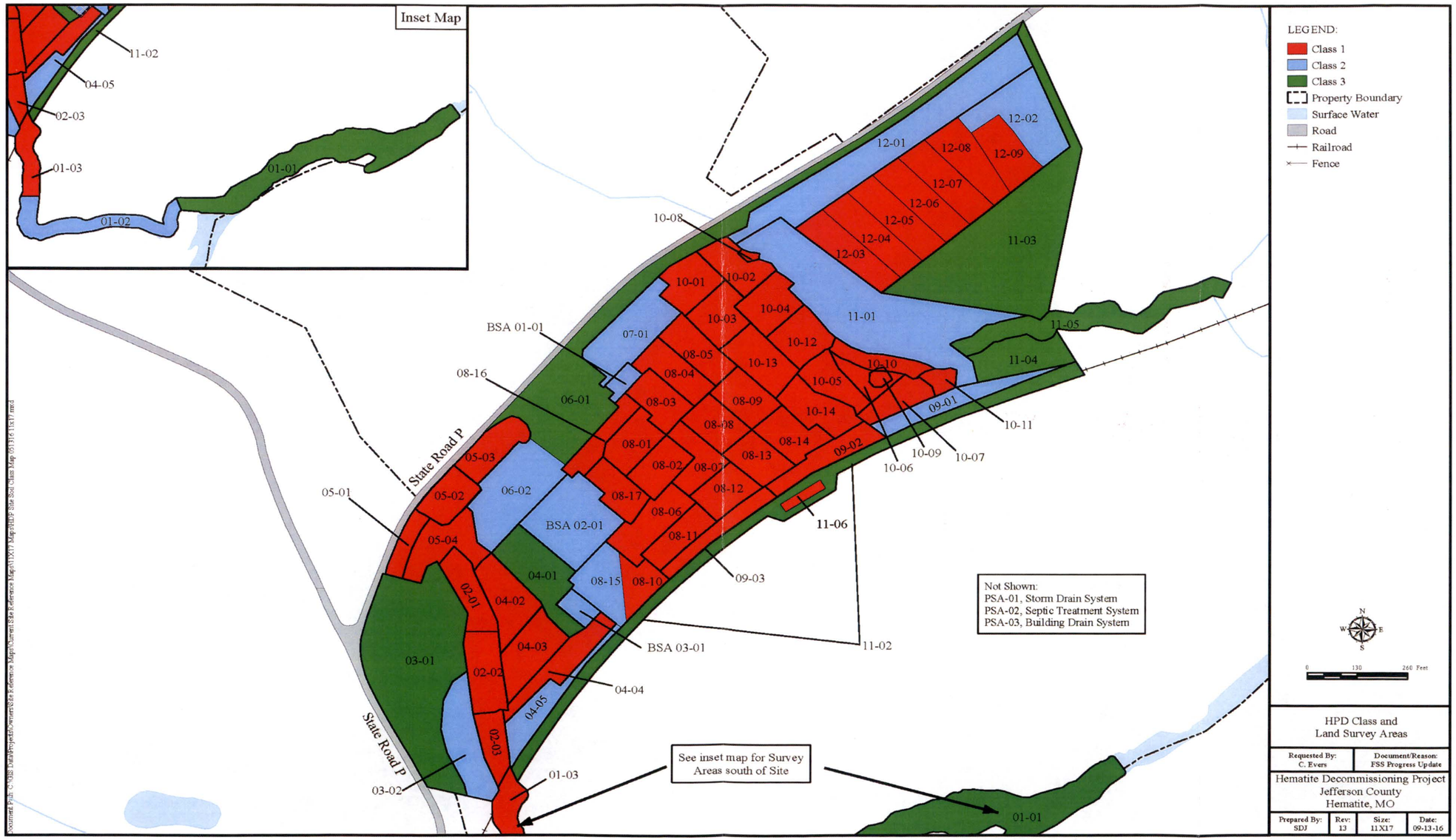


Figure 2-3
Final Configuration of Land Survey Areas and Survey Units



After the removal of buried materials and the completion of radiological remediation, in the final configuration, LSA 10-01 and LSA 10-02 consisted of primarily original surface area with an excavated area in each of the SUs which consisted of native soil. There were no structures, piping, groundwater monitoring wells, or spent limestone remaining within the SUs.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 10-1 presents 1,593 square meters (m^2) in planar (2-dimensional) extent, within an interior surface area of 1,970 m^2 (3-dimensional).

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 10-02 presents 1,477 m^2 in planar extent, with an interior surface area of 1,937 m^2.

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 documented burial pits in the Burial Pit Area is presented in the FSSFR Volume 3, Chapter 1, Section 2.1, "Documented Burial Pits".

A detailed discussion of the historical background information related to undocumented burials within the HDP site proper is presented in the FSSFR Volume 3, Chapter 1, Section 2.2, "Undocumented Burials".

3.1 Radioactive Materials in LSA 10-01 and LSA 10-02

Radioactive materials within LSA 10-01 and 10-02 resulted from placement of radioactive contaminated materials below grade and above grade. During the remediation (see Figure 3-1), various types of waste materials were encountered, including drums, bags of trash, a tank (see Figure 3-2), filter press plates, fuel pellets, construction debris, small quantities of spent limestone, and contaminated soils. The filter press plates (see Figure 3-3) are of special interest in that they bore significant amounts of Radium-226 contamination and were determined to not have originated from historic Hematite fuel cycle operations. It was determined that these were brought to the Hematite site from an offsite entity and did not originate from any onsite process or operation. The radium contaminated filter press plates proved to be the source term of the Radium-226 impacted area, as identified in the Hematite Radiological Characterization Report (HRCR), DO-08-003 {ML092870496},that was situated near the southeast corner of LSA 10-01. Also a somewhat larger section of the LSA 10-02 area near its southwestern corner fell inside the radium impacted footprint.

Remedial actions within the Burial Pit Area revealed that although the underlying burial pits were nearly contiguous, individual burial pits were readily identifiable based on changes in soil color, soil hardness, visibly obvious items of non-native debris, and elevated gamma readings as measured by field instrumentation. Figure 3-11 shows that all intervening soils between individual pits were removed during the remedial excavation regardless of radioactivity concentration.

Figure 3-1
Early Stage of Remedial Excavation in Burial Pit Area (2012)

Figure 3-2
Removal of Buried Tank

Figure 3-3
Removal of Filter Press Plate

3.2 Reuse Soil Disposition and Characterization

Prior to remediation and removal of contaminated soil and other waste materials within LSA 10-01 and LSA 10-02, overburden soils which exhibited characteristics suitable for potential reuse as onsite backfill material were removed, segregated, and subjected to reuse soil criteria requirements.

A detailed discussion of reuse soils, including general description, segregation, surveys, sorting technology, and technical requirements may be found in the FSSFR Volume 2, Chapter 1.

3.3 Remediation and Remedial Action Support Surveys (RASS) Phase of LSA 10-01 and LSA 10-02

The sections below provide a discussion of the various elements of remediation and the RASS phase of LSA 10-01 and LSA 10-02 necessary to prepare the SUs for FSS.

3.3.1 Remedial Actions

Remedial actions began in LSA 10-01 and LSA 10-02 in April, 2012, and continued through December, 2014. Types of waste materials encountered during the remediation were detailed in Section 3.1.

There were several indicators inherent in the remediation process of LSA 10-01 and LSA 10-02 in which a portion of the Burial Pit Area was located that provided assurance that all wastes were

removed prior to the initiation of FSS. As discussed in FSSFR Volume 3, Chapter 1, there was ample historical evidence to confidently delineate the spatial boundary of the Burial Pit Area. As the overburden soil was removed it was easy to visually identify the location of a burial pit based on a change in soil color. Even the undocumented burials were easily identified by a change in soil color even though their size and shape was not as well defined as the documented burial pits (see Figure 3-4 and Figure 3-5). Additionally, the equipment operators conducting the excavation could distinguish when they were digging in a burial pit based on the difference in the hardness of the soil. Workers could even detect the difference in the soil hardness when walking over burial pits, which tended to be soft and spongy. Adding to the visual and soil hardness cues, the burial pits were also radiologically identifiable based on gamma walkover surveys (GWS) once the contaminated layers were reached. In summary, both documented and undocumented burials were easy to distinguish once excavation activities commenced.

Figure 3-4
Example of Burial Pit Soil Discoloration

Figure 3-5
Example of Unearthed Trash and Debris in the Burial Pit Area

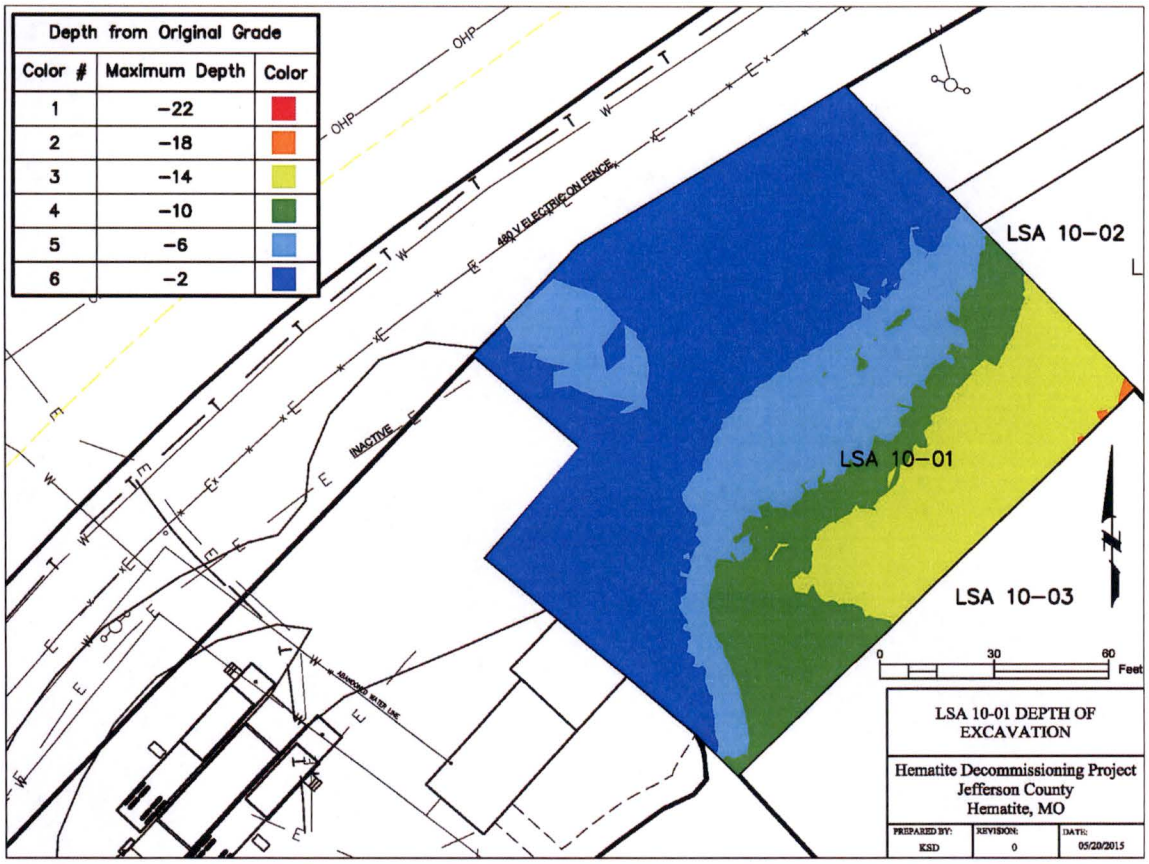
As excavation and remediation of the Burial Pit Area progressed, it became apparent that most of the buried debris was located in the north and south ends of the Burial Pit Area, and typically in closely aligned pits, while the central area had minimal debris and contamination. Since sloping and benching practices were employed, and due to the close nature of the pits, a larger than expected quantity of soil was removed. This resulted in a larger single excavation area as opposed to individual standalone pits.

As excavation progressed for the removal of contaminated wastes and debris in the Burial Pit Area, five activities came into play that determined the extent of remediation in a given survey unit. These were: 1) in process Remedial Action Support Surveys (RASS), 2) conducting core bores to support moving out of nuclear criticality safety controls, 3) performing a final RASS, 4) sampling for VOC remediation, and 5) conducting FSS. These will be discussed in later sections.

The HDP Technical Report HDP-RPT-FSS-303 *Summary Report for Burial Pit Area Remediation* (Appendix H) contains additional specific information related to the remediation of the Burial Pit Area.

The maximum depth of remedial excavation necessary in portions of LSA 10-01 to ensure all areas identified during site characterization and remedial action survey efforts were adequately remediated relative to the original grade was 15 feet. The estimated volume of excavated waste materials from LSA 10-01 was 2,870 cubic yards. Figure 3-6 provides the depth of excavations for LSA 10-01.

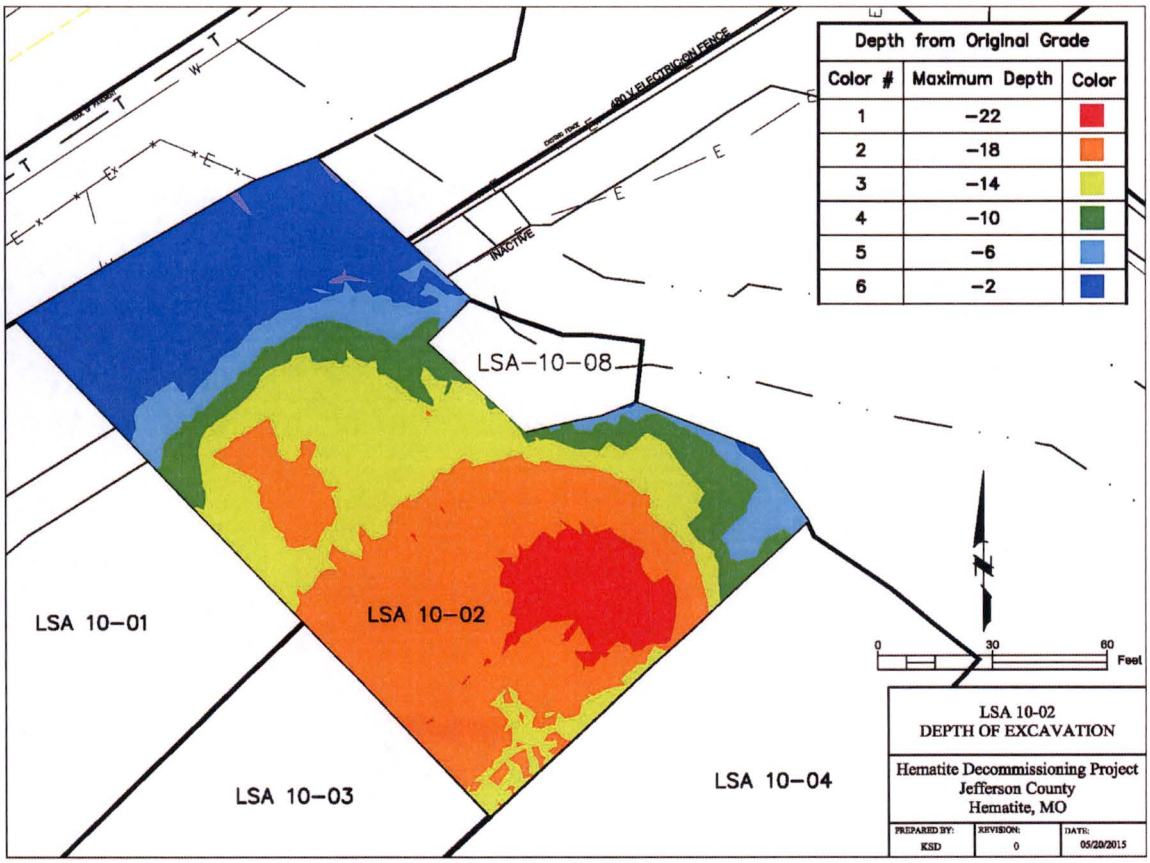
Figure 3-6
LSA 10-01 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 15 feet.

The maximum depth of remedial excavation necessary in portions of LSA 10-02 to ensure all areas identified during site characterization and remedial action survey efforts were adequately remediated relative to the original grade was 20 feet. The estimated volume of excavated waste materials from LSA 10-02 was 6,088 cubic yards. Figure 3-7 provides the depth of excavations for LSA 10-02.

Figure 3-7
LSA 10-02 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 20 feet.

3.3.2 In Process Remedial Action Support Surveys

During excavation and remediation of the Burial Pit Area, remedial action support surveys were conducted in accordance with procedure HDP-PR-HP-601, *Remedial Action Support Surveys*. The radiological information obtained from the surveys served the purpose of categorizing the soil/debris into one of four categories; 1) Soil/debris potentially exceeding the Nuclear Criticality Safety Exempt Material Limit, 2) Soil/debris potentially containing radioactivity concentrations above the Reuse Material Screening Level (RML), 3) Soil expected to contain radioactivity concentrations that were less than the RML but requiring removal in order to access additional soil/debris having radioactivity concentrations above the RML, and 4) Soil expected to contain radioactivity concentrations that are less than the RML and not requiring removal.

3.3.3 Nuclear Criticality Safety (NCS) Borings

In addition to the visual inspection and radiological measurements conducted to determine when removal of buried waste was complete and NCS controls could be removed during remediation of LSA 10-01 and LSA 10-02, a series of borings were performed within the NCS Controlled areas of the SUs.

As directed by NSA-TR-09-15, *Nuclear Criticality Safety Assessment of Buried Waste Exhumation and Contaminated Soil Remediation at the Hematite Site* (Reference 12.3), borings were performed for the purpose of downgrading from NCS controls and included an inspection of the core bore soil to confirm that no burial pit debris was present below the excavation surface. The NSA-TR-09-15 Administrative CSC 23 required that these borings (see Figure 3-8 and Figure 3-9) would be performed to 3 feet (ft) below the deepest identified buried waste item in an excavation or 7 ft below ground surface (representative of 4 ft of overburden soil and an additional 3 ft into the soil that could have potential burial pit waste). In addition to performing a boring below the deepest identified waste item in an excavation, a grid with maximum spacing of 20 ft between boreholes was conducted within the entire documented burial pit area. The grid spacing chosen was based upon the nominal size of a documented burial pit. The spacing was chosen to provide a high probability that material from an unidentified burial pit would be intercepted.

In a small section of LSA 10-01 and LSA 10-02 an area of very dense construction debris was encountered. In order to release this small area from NCS controls to allow for the complete removal of all construction debris, and under the guidance of the Nuclear Criticality Safety Specialist, a denser spacing grid of approximately 5 ft between boreholes was implemented prior to the removal of all construction debris. Radiological surveys were reviewed to ensure that there was no indication of significant quantities of Special Nuclear Material present in the area, and NCS controls were released in this isolated area to allow for the complete and adequate removal of all construction debris. Later borings were performed on the remaining areas of LSA 10-01 and LSA 10-02 with maximum spacing of 20 ft between boreholes to release the area from NCS controls.

The survey measurements from the spoils material and boreholes for LSA 10-01 and LSA 10-02, along with the results of the visual inspection, were then reviewed by the NCS Specialist and the area released from NCS controls. The visual inspection of the cores provided evidence that no materials indicative of burial pit waste were encountered below the excavation surface within LSA 10-01 and LSA 10-02. Once the area was released from NCS controls, excavation continued, as necessary, for additional remediation of radiological and/or VOC contamination.

No materials indicative of burial pit waste were encountered below the excavation surface within LSA 10-01 and LSA 10-02.

Figure 3-8
NCS Core Bore Locations in LSA 10-01

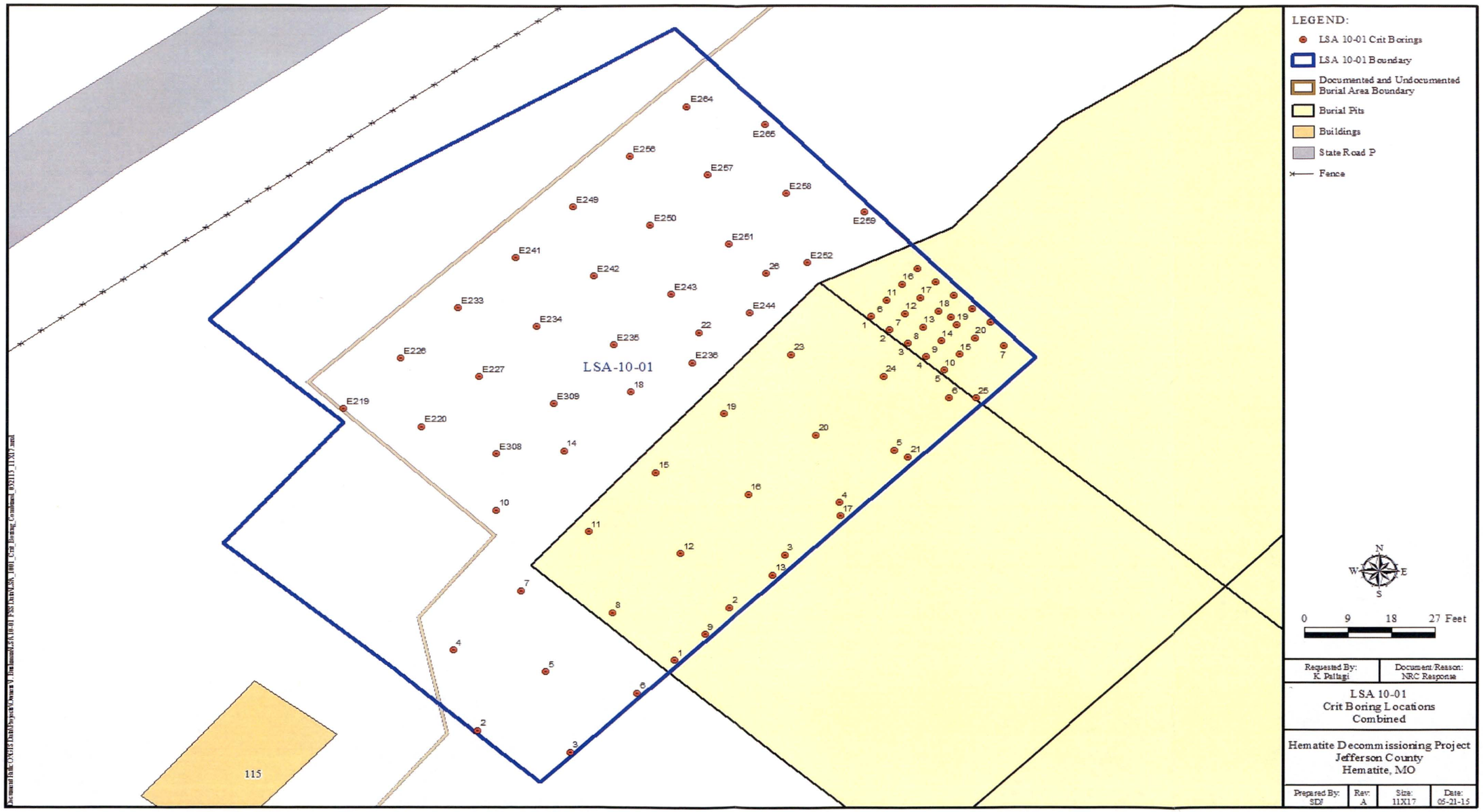
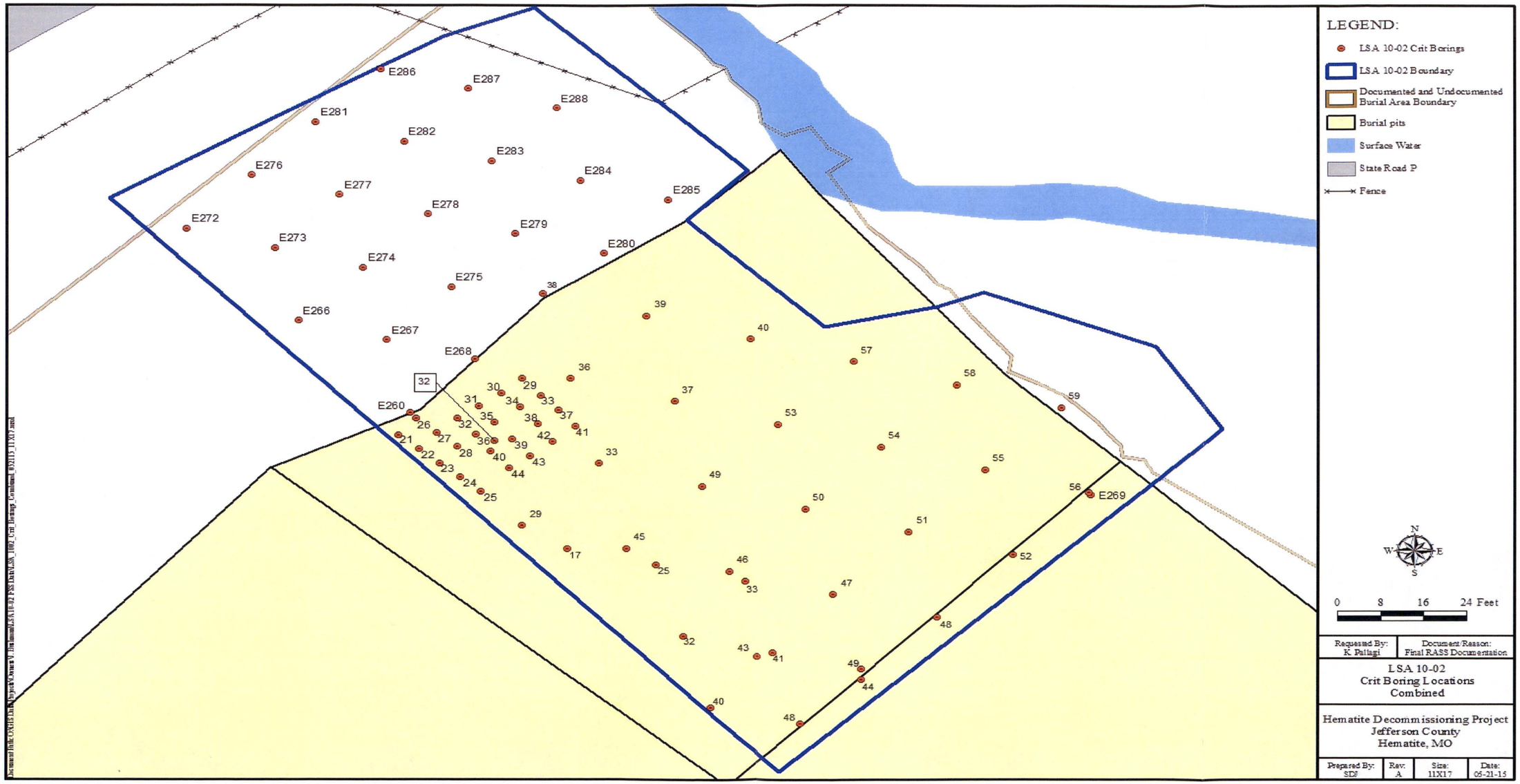


Figure 3-9
NCS Core Bore Locations in LSA 10-02



3.3.4 Groundwater Monitoring Wells

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

During the history of site operations and remediation five groundwater monitoring wells were located within the boundary limits of LSA 10-01 and LSA 10-02 and all have since been abandoned in accordance with State of Missouri requirements. Groundwater monitoring wells PZ-04 and WS-22 were formerly located within LSA 10-01. Groundwater monitoring wells BP-015, WS-24, and WS-25 were formerly located within LSA 10-02.

As discussed in FSSFR Volume 6, Chapter 1, the installation of hybrid monitoring wells can create a potential pathway for shallow contamination to migrate into deeper strata around the well because hybrid wells contain a screen extending from the overburden to the underlying sand/gravel layer. As such, HDP has a license commitment associated with the DP to perform soil sampling in the vicinity of hybrid monitoring wells, as described in Section 7.0 of Attachment 1 to Westinghouse letter HEM-11-56 {ML111260624}which states:

> *"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."*

WS-25 was the only hybrid monitoring well within the two survey units. Site records indicate that WS-25 was abandoned and sampled in January 2012, in accordance with the requirements as specified above. The maximum SOF result of the soil samples collected from WS-25 during abandonment was 0.09 of the Uniform $DCGL_W$.

Section 7.0 of Attachment 1 to HEM-11-56 also states:

> *"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."*

A review of the radiological water sample data from WS-25 prior to abandonment indicated that there was no historical exceedance of uranium above the uranium background threshold value of 8.6 pCi/l and no Technetium (Tc)-99 results that exceeded the MDC+Error for any water samples collected from these wells. Therefore, it was not necessary to perform supplemental investigation borings proximal to WS-25.

3.3.5 Subterranean Piping

Preliminary remediation planning activities indicated that no subterranean process piping should be encountered in LSA 10-01 and LSA 10-02. During remediation of LSA 10-01 and LSA 10-02 no subterranean process piping was encountered.

LSA 10-01 and LSA 10-02 contained drain tile piping from the Building 115 roof drains. This piping was removed in its entirety from LSA 10-01 and LSA 10-02. As no buried piping remains under the footprint of LSA 10-01 and LSA 10-02, therefore there is no dose contribution from this pathway.

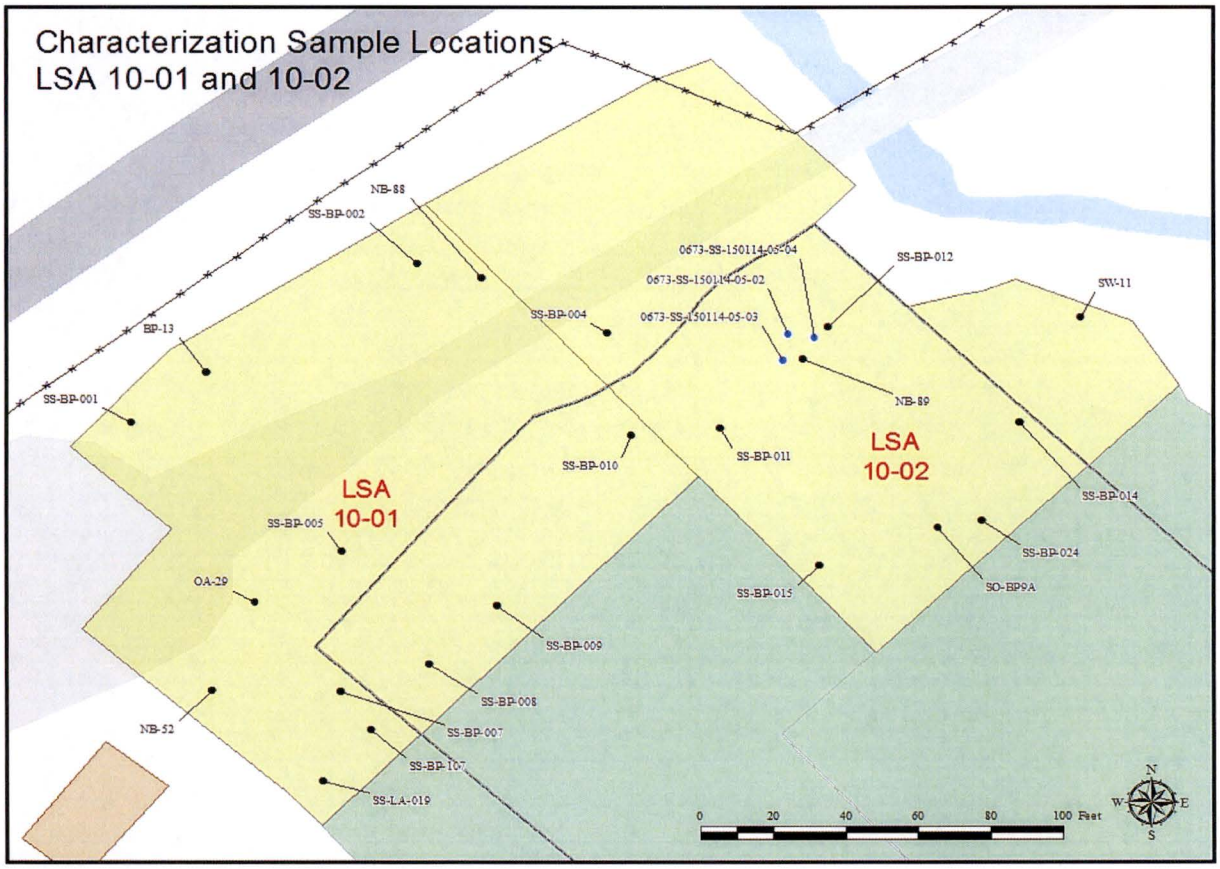
3.3.6 Characterization Core Bores

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-two (22) core borings to depths as deep as 35 feet bgs were performed for characterization within both LSA 10-01 and LSA 10-02 prior to remediation.

One sample (SS-BP-007-EL-10) of the thirteen boring locations within LSA 10-01 exceeded a SOF of 1 (SOF of 2.97) as compared to the Uniform Stratum criteria at a depth of 9.5-10 ft bgs. This boring location was removed from LSA 10-01 during remediation with excavation occurring to a depth of 10 ft bgs at this location. Two samples within LSA 10-02 exceeded a SOF of 1 (SS-BP-024-SV a SOF of 1.12 and NB-89-19.5-SL a SOF of 3.86) as compared to the Uniform Stratum criteria. Sample SS-BP-024-SV exceeded a SOF of 1 at a depth of 5 ft bgs, with this location being excavated to a depth of 15.4 ft bgs.

The contamination depth [total Uranium ~ 650 picocuries per gram (pCi/g)] at NB-89 was listed as 19.5 ft bgs in the HRCR. After completion of remedial actions and final RASS, it was determined that the excavation surface depth at the NB-89 coordinates was approximately 18 ft bgs, or 1.5 ft above the potential depth of exceedance. Because this was a sample collected between 4.5 ft and 19.5 ft with the highest gamma reading from each depth in 6-inch intervals selected for analyses, it was indeterminate as to whether the area of contamination had been remediated or not. In order to rule out the potential presence of underlying contamination, four additional soil corings were collected on January 14, 2015, using hand augers at the original NB-89 coordinates as well as three nearby locations to a depth of 20 ft. bgs. All of these supplemental investigation samples collected at and around NB-89 were well below the Uniform Stratum criteria (0673-SS-150114-05-02 SOF of 0.17, 0673-SS-150114-05-03 SOF of 0.35, and 0673-SS-150114-05-04 SOF of 0.21), therefore no additional remediation was required. Figure 3-10 below presents the characterization boring locations within LSA 10-01 and LSA 10-02, including the supplemental investigation corings.

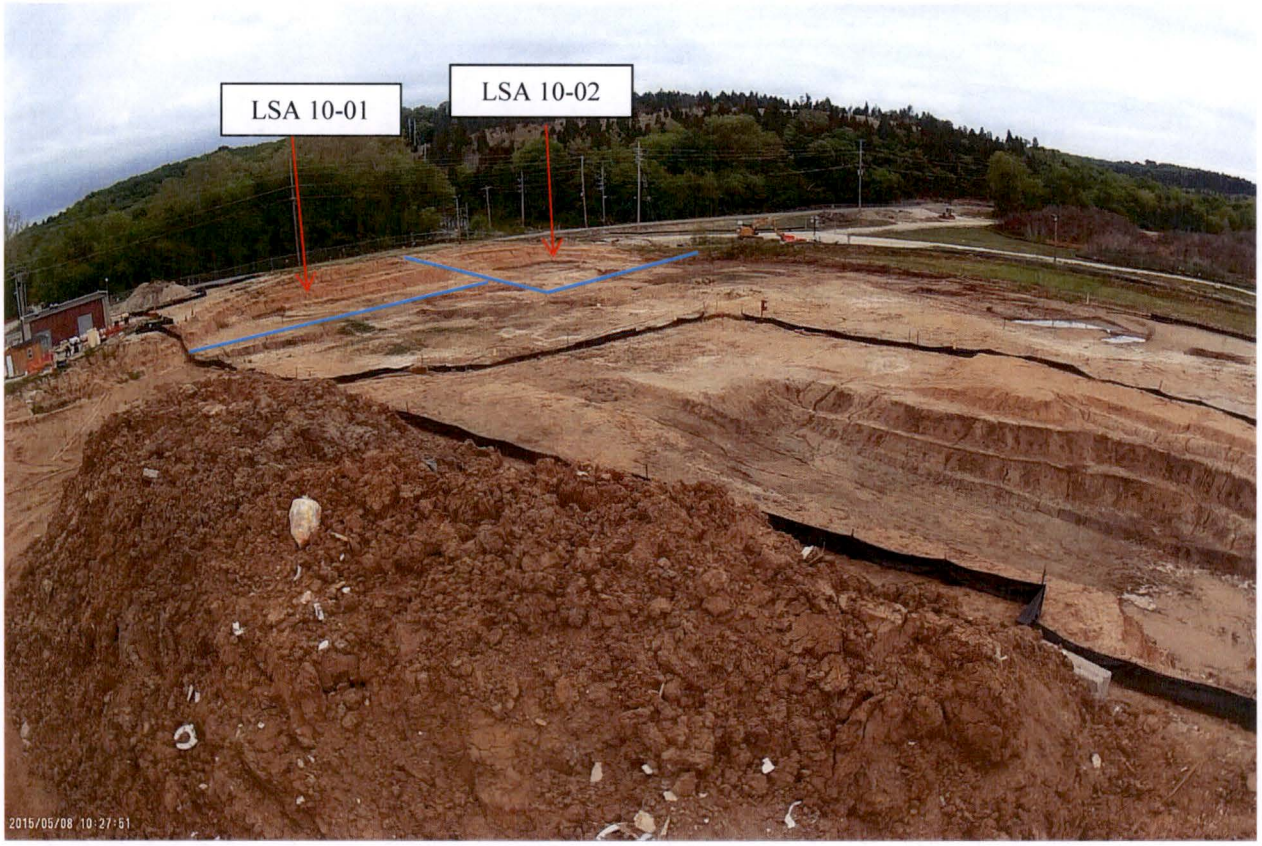
Figure 3-10
Site Characterization Borings within LSA 10-01 and LSA 10-02



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 survey unit and prior to implementation of FSS activities, a final RASS was performed to validate the status of the SU prior to implementing Isolation and Control (I & C) postings. The I & C posting for both LSA 10-01 and LSA 10-02 was completed on December 12, 2014. Figure 3-11 is a photograph which shows LSA 10-01 and LSA 10-02 ready for the final RASS.

Figure 3-11
LSA 10-01 and LSA 10-02 Prepared for RASS FSS Design



The RASS included a GWS, systematic surface sample collection based on an eight (8) -point triangular grid, and biased surface sampling. 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 Systematic Sample Results[1] for LSA 10-01 and LSA 10-02

LSA	Ra-226[2]		Tc-99		Th-232[2]		U-234		U-235		U-238	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
10-01	0.01	0.05	0.08	0.42	0.11	0.28	2.66	5.42	0.14	0.30	1.13	1.86
10-02	0.01	0.09	0.43	1.33	0.04	0.15	3.88	10.44	0.21	0.57	1.35	2.83
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)

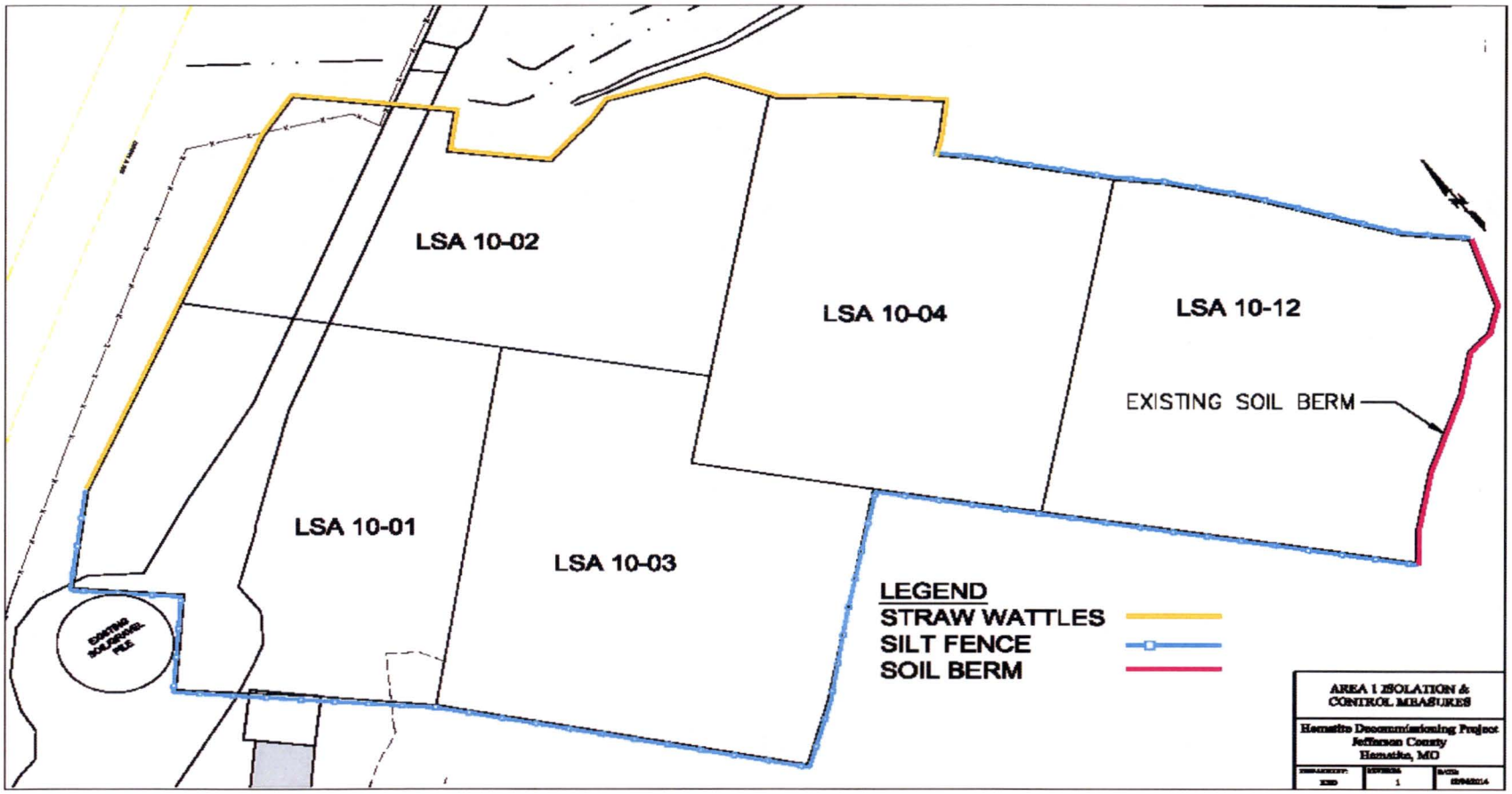
All Final RASS systematic sample and biased sample results were less than the appropriate $DCGL_W$ (Uniform Stratum) and the Final RASS data set was considered sufficient to support FSS design.

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 December 12, 2014, LSA 10-01, LSA 10-02, LSA 10-03, LSA 10-04, and LSA 10-12 were isolated and controlled in accordance with Work Package HDP-WP-ENG-803, *Isolation and Control Measures,* (See Figure 3-12) 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 10-01 and LSA 10-02 are located within the fenced security perimeter of the HDP which therefore prevents access by the general public.

Figure 3-12
Isolation and Control of Area Containing LSA 10-01 and LSA 10-02



3.3.9 Surveillance Following FSS

Following the completion of a FSS, the DP requires continued surveillance to minimize the potential to re-contaminate a survey unit (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 10-01 and LSA 10-02. If a SU is suspected of having been re-contaminated then an investigation survey will be performed to reconfirm the FSS survey validity. This requirement remained in place until FSS of the adjacent SUs had been completed and backfill of the area was performed, which occurred in August, 2015.

3.3.10 Backfill of Survey Units

Although not a function of remediation, but as described in the DP Section 8.8, both LSA 10-01 and LSA 10-02 were 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. As only off-site backfill material was used, no dose will be added to LSAs 10-01 and 10-02 for backfill material.

3.3.11 Groundwater Monitoring

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

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

As stated in the Executive Summary section the exposure results of this report will be combined with the dose attributed to groundwater to demonstrate that the site has met the requirements for unrestricted release consistent with the requirements of the Title 10 CFR 20 Subpart E, "Criteria for License Termination." As such, for the purpose of this report, groundwater will be assigned a conservative SOF of 0.16 which equates to 4 mrem/year (milliroentgen equivalent man/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 LSAs 10-01 and 10-02 will be reported in FSSFR Volume 7 reflecting the updated results of the post-remediation groundwater monitoring.

4.0 LSA RELEASE CRITERIA

As the release criteria for all LSA SUs is common, FSSFR Volume 3, Chapter 1, Section 3.0, *Release Criteria*, provides a detailed discussion on the release criteria that is applicable to LSA 10-01 and LSA 10-02. Table 4-1 provides the applicable DCGLs.

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

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

[a] Table as presented in FSSFR Volume 3, Chapter 1.
[b] The reported DCGLw's are the activities for the parent radionuclide and were calculated to account for the dose contribution from insignificant radionuclides.
[c] +D indicates the $DCGL_w$ includes short-lived (half-life $\leq$ 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 10-01

This section describes the method for determining the number of samples required for the FSS of LSA 10-01 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 10-01 and the detection sensitivity is also discussed.

5.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 10-01 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 4, *Final Status Survey Plan Development*, January 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 10-01. The review identified several areas that were previously found to exceed a Uniform SOF of 1.0 (discussed in Section 3.3.6). Subsequently the remediation history was reviewed to confirm that these areas were adequately addressed, and the RASS data was used as confirmation that no known areas of residual radioactivity remained within the survey areas that exceeded the Uniform $DCGL_W$. Therefore the Uniform $DCGL_W$ was selected for use in demonstrating compliance with the release criteria.

5.1.3 GWS Coverage

As Class 1 SU, LSA 10-01 was required to undergo a 100% GWS.

5.1.4 Instrumentation

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

5.1.5 Scan Minimum Detectable Concentration (MDC)

As background levels were approximately 10,000 counts per minute (cpm) in LSA 10-01, the scan minimal detection concentration (MDC) calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{7383\ pCi/g}\right)+\left(\frac{f_{U-235}}{4.9 pCi/g}\right)+\left(\frac{f_{U-238}}{62.8 pCi/g}\right)\right)}$$

Equation 5-1

In order to calculate the Scan MDC for total uranium using the above equation, an average enrichment for the SU must be known which in turn will provide relative isotopic fractions for

U-234, U-235, and U-238 as given in Appendix G of HDP-PR-FSS-701, Revision 4, *Final Status Survey Plan Development*. Based on the systematically collected RASS samples in LSA 10-01, the average enrichment for LSA 10-01 was 2.0%.

Standard Scan MDCs for Radium-226 and Thorium-232 using a 2" x 2" NaI detector are found in Table 6.4 of NUREG-1507 and are shown in Table 5-1. Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 10-01 are shown below:

Table 5-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 10-01

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 10-01	82.6	87.7	2.8	2.8	1.8	3.0

*DCGLw 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 LSA 10-01 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 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 10-01 was established at 4,000 net counts per minute (ncpm).

5.1.7 LSA 10-01 FSS Design Summary

The FSS Plan for LSA 10-01 can be found in Appendix C. Table 5-2 presents the overall FSS design and implementation summary for LSA 10-01.

Table 5-2
FSS Design Summary for LSA 10-01

Gamma Walkover Survey (GWS):		
Scan Coverage	100% accessible excavation floors, benches, pits, and sidewalls	
Scan MDC	82.6 pCi/g total Uranium (based on a 10,000 cpm background)	
Investigation Action Level (IAL)	4,000 net cpm*	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	3	The samples are collected on a systematic grid.** Analysis of excavation stratum samples is not required if there was surface stratum collected at sample grid location and the overlying root stratum SOF result was less than 0.5.
15 cm – 1.5 m (Root)	6	
> 1.5m (Excavation)	8**	
Biased Survey/Sampling Locations:		
Biased samples may be collected during GWS at the discretion of the HP Technician, after statistical analysis of the survey data, or at the direction of the FSS Supervisor.		
Instrumentation		
Ludlum 2221 with 44-10 (2" x 2" NaI) detector; with collimation for investigations.	Used for GWS and to obtain static count rates at biased measurement locations.	
*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 2015.		

6.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 10-01

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

6.1 Gamma Walkover Surveys

6.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 10-01 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble Pro 6H DGPS (Digital Global Positioning System) and Nomad 800XL 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 excavation floor and sidewalls 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 1 GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, North American Datum (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 10-01 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 10,000 and 11,000 gross counts per minute (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.

6.2 Soil Sampling

6.2.1 Systematic Soil Sampling Summary

Table 6-1 provides a summary of systematic sampling by stratum for LSA 10-01.

Table 6-1
Systematic Sampling Summary by Stratum for LSA 10-01

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep	
10-01	1,593	3	6	8	1

6.2.2 Systematic Sampling LSA 10-01

Within LSA 10-01, there were three systematic locations in which portions of the surface stratum [0 – 15 centimeters (cm)] remained in the SU after remediation. At these locations, the remaining surface stratum interval was collected using a hand trowel. Portions of the root stratum (15 cm – 150 cm) remained at six (6) 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. However, since both surface and root samples were collected at three locations and no root stratum composite samples exceeded a SOF of 0.5, it was not necessary to analyze excavation stratum samples collected at those three locations which had successful surface and root stratum results.

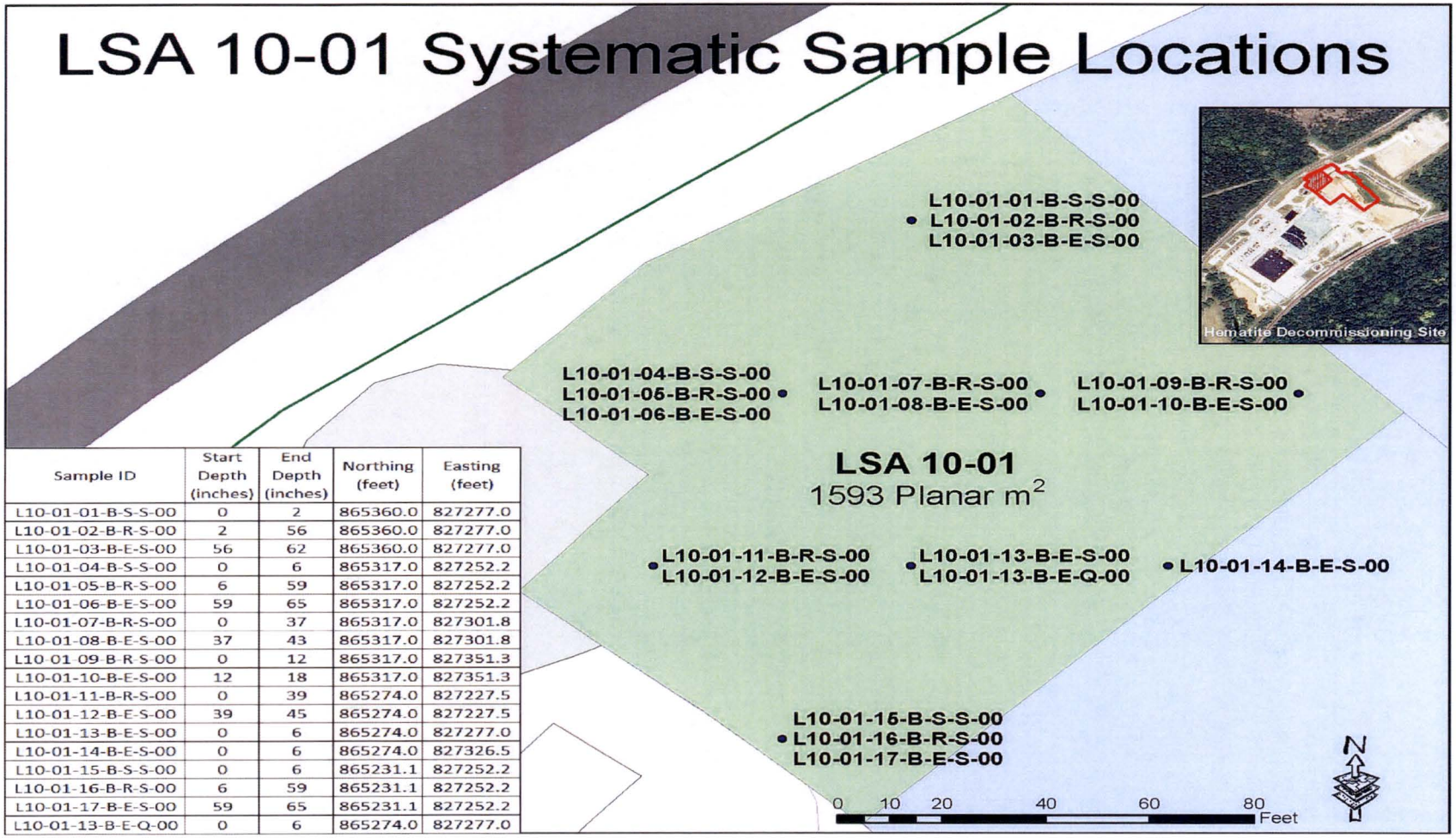
Given a planar area of 1,593 m^2 for LSA 10-01 and an eight - point systematic triangular grid, the point-to-point distance within each row was 14.3 m with spacing of 12.4 m between each of the parallel grid rows within the SU.

While there were eight systematic locations on the LSA 10-01 sampling grid, a total of 18 samples were collected at these locations, including:

- Three (3) samples collected within the remaining surface stratum
- Six (6) samples collected within the remaining root stratum
- Eight (8) samples collected within the excavation, or "deep", stratum, although it was only necessary to analyze and report five (5) of these samples since three (3) of the eight locations were sampled in both the surface and root strata without any result exceeding a SOF value of 0.5
- One (1) Quality Control (QC) field replicate

Figure 6-1 presents the map of the eight systematic sample locations which were sampled within LSA 10-01. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 6-1
LSA 10-01 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L10-01-01-B-S-S-00	0	2	865360.0	827277.0
L10-01-02-B-R-S-00	2	56	865360.0	827277.0
L10-01-03-B-E-S-00	56	62	865360.0	827277.0
L10-01-04-B-S-S-00	0	6	865317.0	827252.2
L10-01-05-B-R-S-00	6	59	865317.0	827252.2
L10-01-06-B-E-S-00	59	65	865317.0	827252.2
L10-01-07-B-R-S-00	0	37	865317.0	827301.8
L10-01-08-B-E-S-00	37	43	865317.0	827301.8
L10-01-09-B-R-S-00	0	12	865317.0	827351.3
L10-01-10-B-E-S-00	12	18	865317.0	827351.3
L10-01-11-B-R-S-00	0	39	865274.0	827227.5
L10-01-12-B-E-S-00	39	45	865274.0	827227.5
L10-01-13-B-E-S-00	0	6	865274.0	827277.0
L10-01-14-B-E-S-00	0	6	865274.0	827326.5
L10-01-15-B-S-S-00	0	6	865231.1	827252.2
L10-01-16-B-R-S-00	6	59	865231.1	827252.2
L10-01-17-B-E-S-00	59	65	865231.1	827252.2
L10-01-13-B-E-Q-00	0	6	865274.0	827277.0

Table 6-2 below presents a tabular listing of all FSS samples collected within LSA 10-01 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 6-2
FSS Sample Locations and Coordinates for LSA 10-01

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
	Westinghouse Non-Proprietary Class 3	Revision: 4	Appendix P-4, Page 1 of 1

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: 01 **Description:** North West Corner Survey Unit (North Burial Pit)
Survey Type: FSS **Classification:** Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation	End Elevation	Northing (Y Axis) *	Easting (X Axis) *	Remarks / Notes
L10-01-01-B-S-S-00	Uniform	S	437.0	436.8	865360.0	827277.0	Surface 2-inch grab
L10-01-02-B-R-S-00	Uniform	S	436.8	432.3	865360.0	827277.0	Root 4.4-foot composite
L10-01-04-B-S-S-00	Uniform	S	436.9	436.5	865317.0	827252.2	Surface 6-inch grab
L10-01-05-B-R-S-00	Uniform	S	436.5	432.0	865317.0	827252.2	Root 4.4-foot composite
L10-01-07-B-R-S-00	Uniform	S	433.2	430.1	865317.0	827301.8	Root 3.1-foot composite
L10-01-08-B-E-S-00	Uniform	S	430.1	429.7	865317.0	827301.8	Excavation 6-inch grab
L10-01-09-B-R-S-00	Uniform	S	427.6	426.6	865317.0	827351.3	Root 1-foot composite
L10-01-10-B-E-S-00	Uniform	S	426.6	426.2	865317.0	827351.3	Excavation 6-inch grab
L10-01-11-B-R-S-00	Uniform	S	436.3	433.1	865274.0	827227.5	Root 3.3-foot composite
L10-01-12-B-E-S-00	Uniform	S	433.1	432.6	865274.0	827227.5	Excavation 6-inch grab
L10-01-13-B-E-S-00	Uniform	S	429.1	428.6	865274.0	827277.0	Excavation 6-inch grab
L10-01-14-B-E-S-00	Uniform	S	425.1	424.7	865274.0	827326.5	Excavation 6-inch grab
L10-01-15-B-S-S-00	Uniform	S	436.9	436.5	865231.1	827252.2	Surface 6-inch grab
L10-01-16-B-R-S-00	Uniform	S	436.5	432.0	865231.1	827252.2	Root 4.4-foot composite
L10-01-13-B-E-Q-00	Uniform	Q	429.1	428.6	865274.0	827277.0	Excavation 6-inch grab
L10-01-18-B-E-B-00	Uniform	B	435.5	422.2	865276.8	827272.7	Excavation 6-inch grab

Elevations are in feet above mean sea level.

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

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

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

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

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

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 10-01 one biased sample location was selected based on the evaluation of the GWS survey data. The biased location in LSA 10-01 represented the maximum GWS measurement encountered within the SU unit. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

6.4 Judgmental/Sidewall Sampling for Tc-99

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 from each 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 10-01. These samples were collected from locations selected by the HP Technician at random, and were not based on gamma survey readings (not biased).

6.5 Quality Control Soil Sampling

One QC field duplicate sample point was randomly selected for LSA 10-01 and collected at systematic location L10-01-13.

7.0 FINAL STATUS SURVEY RESULTS LSA 10-01

7.1 Gamma Walkover Survey

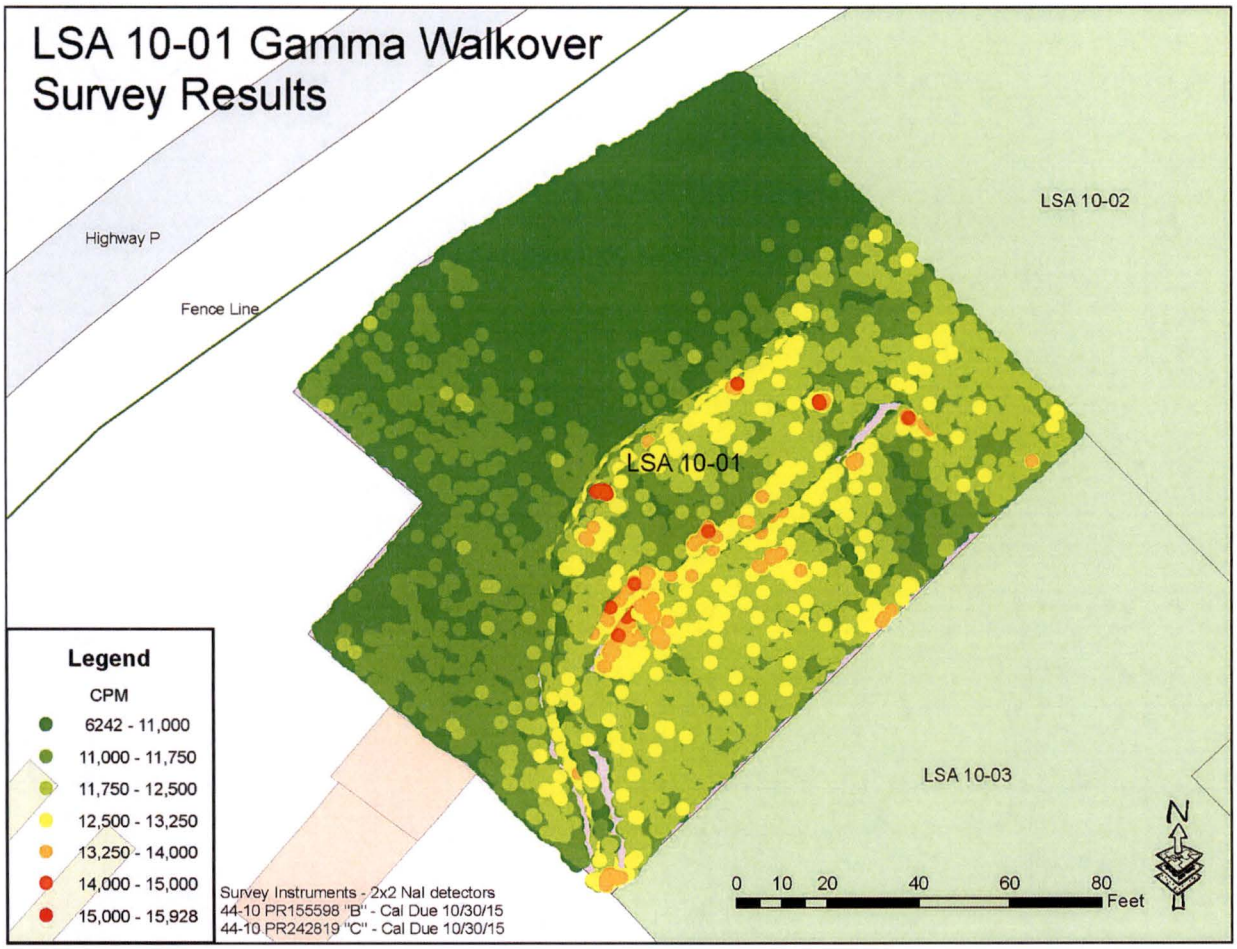
Post-processed GPS coordinate data is accurate to within ± 0.1m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are 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 10-01 and LSA 10-02 between January 22, 2015, and February 2, 2015.

7.1.1 GWS Results for LSA 10-01

For LSA 10-01, GWS count rates ranged between 6,242 gcpm and 15,928 gcpm, with a mean count rate of 10,919 gcpm. The median count rate was 10,972 gcpm and the standard deviation was 991 cpm. Figure 7-1 below presents a map of the complete GWS data set.

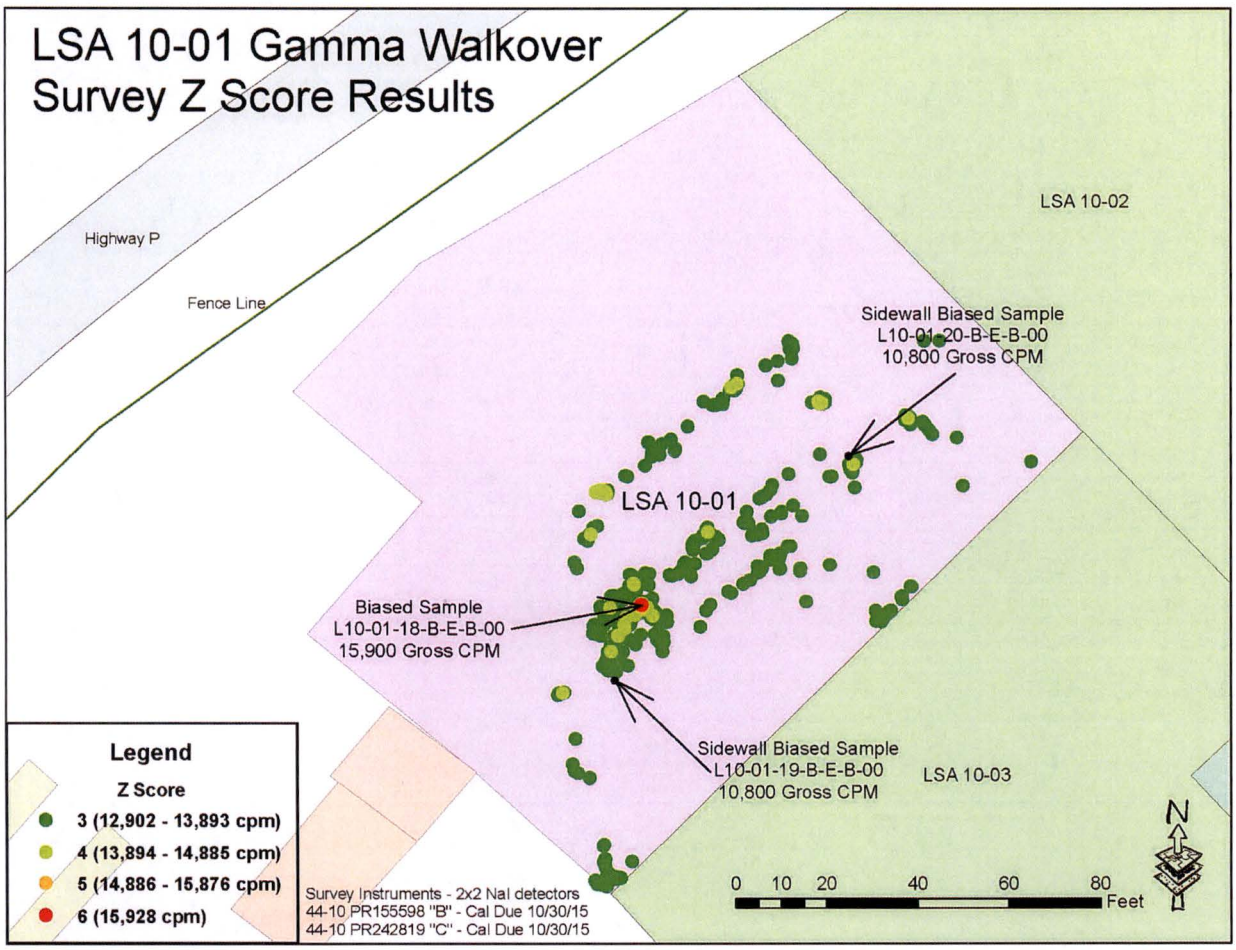
Figure 7-1
Colorimetric GWS Plot for LSA 10-01



An evaluation of the GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location, L10-01-18, was selected for biased sample collection. This biased location represented the maximum GWS measurement encountered within the survey unit. Also, this single biased location was the only point which exceeded both the IAL based on the local background readings and a Z-score of 3. Therefore, no additional biased locations were selected for sampling.

Figure 7-2 below presents a map of the +3 Z-score GWS measurements within LSA 10-01, including the selected biased sampling location (ID: L10-01-18-B-E-B-00). Also shown are the two discretionary sidewall samples (IDs: L10-01-19-B-E-B-00 and L10-01-20-B-E-B-00).

Figure 7-2
Colorimetric GWS Plot for LSA 10-01 (Measurements > Z-score of 3)



A total of 39,381 individual GWS measurements were collected in LSA 10-01. Using a conservative side-to-side movement distance of 1 foot, and given the internal SU surface area of LSA 10-01 of approximately 21,000 square feet, the average estimated surveyor speed during GWS of LSA 10-01 was approximately 0.5 ft/sec. Since this retrospectively estimated scanning speed was less than the 1.0 ft/second FSS Plan requirement and the fact that the NaI probe was maintained as close as possible to the surface, actual Scan MDCs based on real field conditions would have been considerably less than the 82.6 pCi/g total Uranium Scan MDC estimate determined during the FSS planning phase for this SU. It should also be noted that the 82.6 pCi/g Scan MDC prospectively estimated for LSA 10-01 assumed a surveyor efficiency of 0.5.

Since all GWS data collected in LSA 10-01 was datalogged and post-processed in GIS software, the surveyor efficiency can effectively be set to 0.75 as agreed upon with NRC during a Public Teleconference Meeting held on August 12, 2015. Using these parameters, a more realistic Scan MDC of approximately 40.9 pCi/g is determined. The technical basis document, HDP-TBD-FSS-002 *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations for Final Status Surveys*, prepared after the completion of field FSS activities in LSA 10-01, presents the modeling assumptions and evaluation of Scan MDCs for FSS reflecting actual

technical implementation of the GWS, rather than using default parameters such as presented in NUREG-1507. The equation used to derive the revised Total Uranium Scan MDC (with a conservative estimate of 4% enrichment) from Section 1.1.5 of HDP-TBD-FSS-002 (Revision 3, August 2015) is as follows:

$$\text{Scan MDC}_{Total\ Uranium} = \quad 1 \Big/ \left(\left(\frac{0.7928}{3659}\right) + \left(\frac{0.0438}{2.32}\right) + \left(\frac{0.1634}{30.6}\right) \right) = 40.9 \frac{pCi}{g}$$

Equation 7-1

HDP-TBD-FSS-002 also modeled Radium-226 and Thorium-232 Scan MDCs to reflect the technical implementation requirements of FSS at the HDP. Using the same parameters as discussed above for total Uranium, the retrospectively estimated Scan MDCs for Radium-226 and Thorium-232 are 1.21 pCi/g and 0.87 pCi/g, respectively using a two inch air gap. A two inch air gap is utilized as a conservative measure considering NUREG-1507 states that the position relates to the average height of the detector. The HP Technicians are instructed to survey as close as possible to the ground surface, (nominally 1", but not to exceed 3" distance from the surface). As such, the use of a two inch air gap is conservative.

7.1.2 GWS Coverage Results LSA 10-01

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. Although 100% of accessible areas underwent GWS, certain small areas of the LSA 10-01 interior could not be accessed for GWS due to especially tall interior sidewalls. These areas appear as greyish-pink blanks in the Figure 7-1 above.

The post survey processing of the GPS data indicated that the GWS was 99.03% of the SU (see Table 7-1). 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 7-1
GWS Gap Analysis LSA 10-01

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 10-01	661,379	6,447	0.97%	99.03%	1

7.2 Soil Sample Results LSA 10-01

Appendix A presents the analytical results and associated statistics for all FSS samples collected within LSA 10-01.

7.2.1 Surface Soil Sample Results LSA 10-01

There were three (3) samples collected within the surface stratum (0 – 15 cm) of LSA 10-01. However, there were a total of ten (10) soil samples collected within the topmost soil layer of the excavation surface including eight systematic samples, one biased sample, and one QC field duplicate sample. The maximum SOF result for the "topmost" samples was 0.40 corresponding to the QC field replicate sample L10-01-13-B-E-Q-00, with the biased sample (L10-01-18-B-E-B-00) resulting in a 0.28 SOF.

7.2.2 Subsurface Soil Sample Results LSA 10-01

There were six systematic locations within LSA 10-01 where root stratum composite sampling was necessary. The root stratum zone is between 0.15 and 1.50 m below final grade surface. However, at three of the root stratum sampling locations, there was also remaining soil in the surface stratum (0 – 0.15 m) which was collected. At each of the six root stratum composite sampling locations, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was also collected. The three root stratum samples where there was overlying surface stratum remaining and the three excavation stratum samples underlying root stratum samples which had no overlying surface stratum are considered "subsurface" samples and therefore would not factor into the WRS test evaluation. The maximum SOF result of the subsurface samples collected in LSA 10-01 was 0.25. This sample (L10-01-16) was the root stratum sample collected directly underneath the surface stratum sample L10-01-15.

7.2.3 WRS Test Evaluation LSA 10-01

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was required for LSA 10-01 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was greater than one using the Uniform Stratum criteria. 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 14 systematically collected samples in LSA 10-01 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, (974) was greater than the critical value (821) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix A.

7.2.4 Graphical Data Review LSA 10-01

Table 7-2 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 10-01, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.19.

Table 7-2
LSA 10-01 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	0.14	0.09	0.17	2.64	0.14	1.27	**0.19**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.74	0.03	0.69	0.02
Maximum	0.40	0.53	0.37	4.33	0.24	1.68	0.40*

* The QC replicate sample collected at location L10-01-13 produced a SOF result of 0.40, the highest SOF of all samples collected within LSA 10-01; however QC replicate samples are not included in MARSSIM statistical evaluations (e.g., WRS Test).

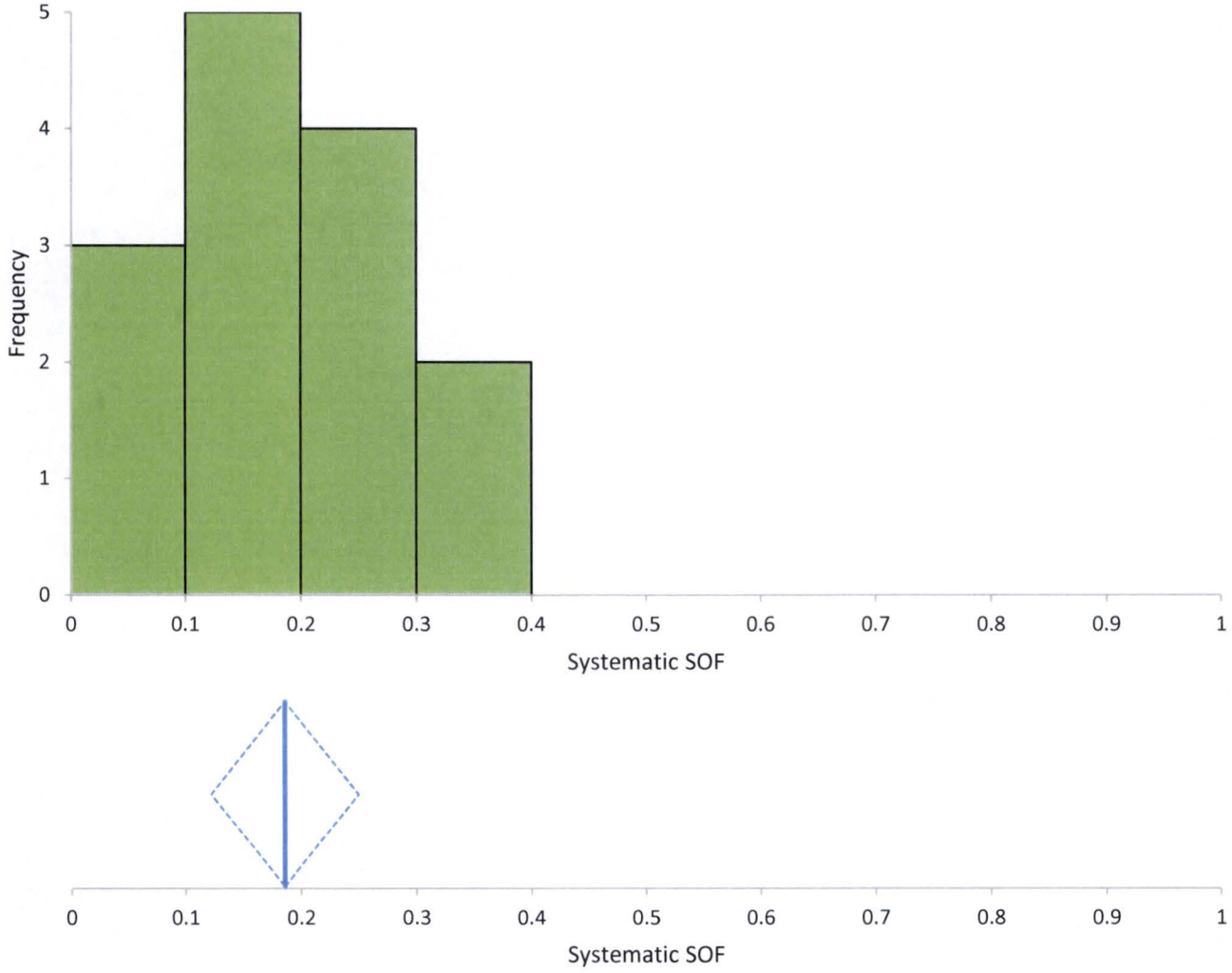
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide 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 7-3 presents the overall statistical metrics for the SOF parameter for the 14 systematically collected samples from LSA 10-01. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-01. The middle graph presents the mean SOF (0.19 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 0.12 to 0.25. The 99% confidence interval based on the median (0.17) of the sample results is 0.07 to 0.25. The bottom two charts present the various statistical metrics of the LSA 10-01 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 10-01 data associated with the systematically collected measurement locations.

Figure 7-3
Graphic Statistical Summary for LSA 10-01 (SOF parameter)



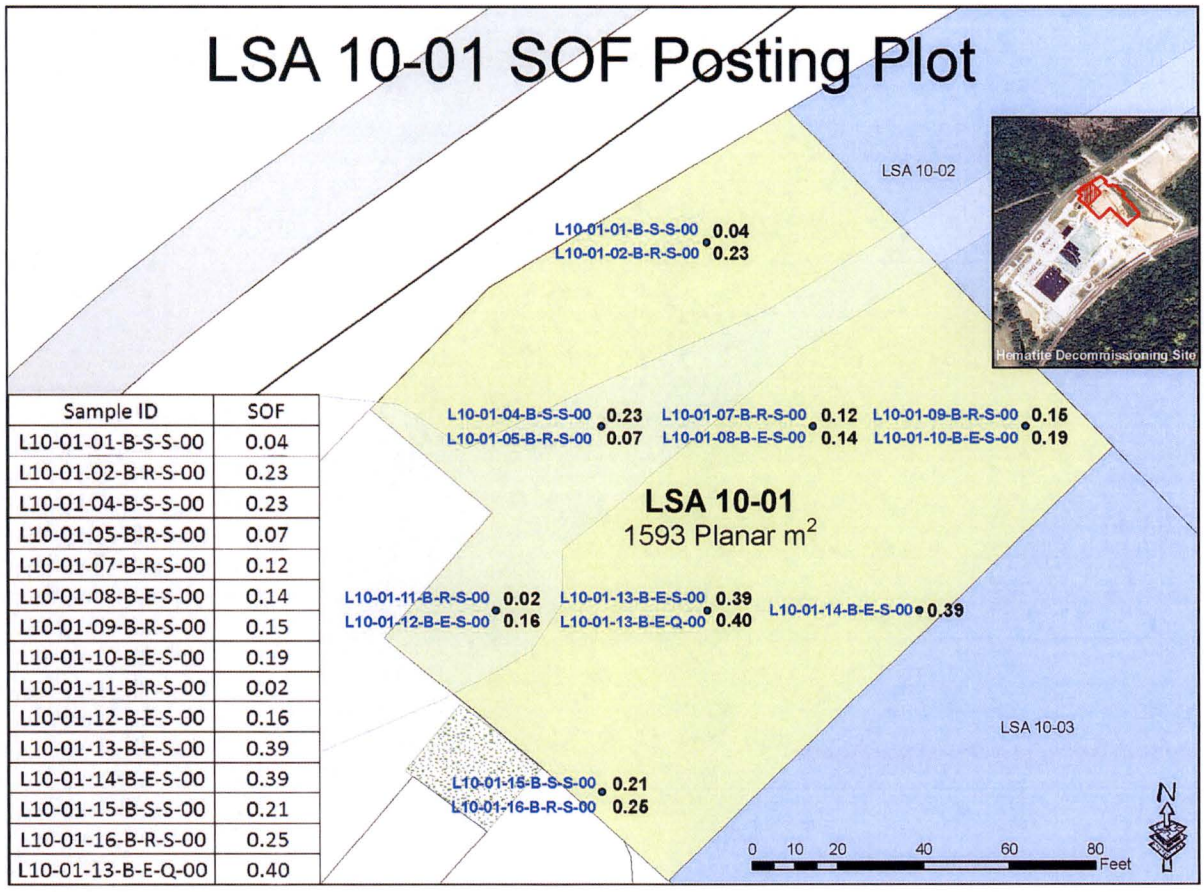
N	14

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
Systematic SOF	0.19	0.12	to 0.25	0.030	0.11	0.01	0.6	0.03

	Minimum	1st quartile	Median	98.71% CI		3rd quartile	Maximum	IQR
Systematic SOF	0.0	0.11	0.17	0.07	to 0.25	0.23	0.4	0.12

A posting plot is simply a map of the survey unit with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 10-01 is presented below in Figure 7-4. Figure 7-4 shows no unusual patterns in the data.

Figure 7-4
Posting Plot for LSA 10-01 Systematic Measurement Locations



Sample ID	SOF
L10-01-01-B-S-S-00	0.04
L10-01-02-B-R-S-00	0.23
L10-01-04-B-S-S-00	0.23
L10-01-05-B-R-S-00	0.07
L10-01-07-B-R-S-00	0.12
L10-01-08-B-E-S-00	0.14
L10-01-09-B-R-S-00	0.15
L10-01-10-B-E-S-00	0.19
L10-01-11-B-R-S-00	0.02
L10-01-12-B-E-S-00	0.16
L10-01-13-B-E-S-00	0.39
L10-01-14-B-E-S-00	0.39
L10-01-15-B-S-S-00	0.21
L10-01-16-B-R-S-00	0.25
L10-01-13-B-E-Q-00	0.40

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

Table 7-3
Final Status Survey Analytical Data: LSA 10-01

Sample ID	Sample Start Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF_N
			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_N
L10-01-01-B-S-S-00	0.29	S	1.010	0.170	0.087	NA	-0.060	0.000	0.363	0.363	0.094	0.249	NA	0.673	0.150	0.175	NA	-0.327	0.000	3.521	NA	NA	NA	0.190	0.148	0.214	U	1.450	0.675	1.030	NA	2.0	0.04
L10-01-02-B-R-S-00	0.49	S	1.270	0.179	0.078	NA	0.200	0.200	0.019	0.019	0.069	0.227	U	1.200	0.185	0.112	NA	0.200	0.200	3.150	NA	NA	NA	0.172	0.140	0.245	U	1.070	0.572	0.904	NA	2.5	0.23
L10-01-04-B-S-S-00	0.01	S	1.160	0.170	0.075	NA	0.090	0.090	0.530	0.530	0.054	0.220	NA	1.250	0.216	0.079	NA	0.250	0.250	4.331	NA	NA	NA	0.235	0.151	0.252	U	1.680	0.544	0.771	NA	2.2	0.23
L10-01-05-B-R-S-00	0.49	S	1.080	0.164	0.068	NA	0.010	0.010	0.016	0.016	0.016	0.220	U	1.090	0.190	0.109	NA	0.090	0.090	2.587	NA	NA	NA	0.140	0.190	0.319	U	1.020	0.559	0.878	NA	2.1	0.07
L10-01-07-B-R-S-00	1.86	S	1.200	0.167	0.070	NA	0.130	0.130	0.010	0.010	0.052	0.212	U	1.040	0.187	0.134	NA	0.040	0.040	2.882	NA	NA	NA	0.153	0.161	0.253	U	1.500	0.735	0.933	NA	1.6	0.12
L10-01-08-B-E-S-00	4.92	S	1.140	0.161	0.071	NA	0.070	0.070	0.001	0.001	0.028	0.220	U	1.160	0.172	0.102	NA	0.160	0.160	3.009	NA	NA	NA	0.165	0.138	0.188	U	0.905	0.385	1.110	U	2.8	0.14
L10-01-09-B-R-S-00	3.93	S	1.240	0.179	0.079	NA	0.170	0.170	0.047	0.047	0.052	0.219	U	1.060	0.169	0.097	NA	0.060	0.060	3.806	NA	NA	NA	0.207	0.181	0.232	U	1.380	0.561	0.841	NA	2.3	0.15
L10-01-10-B-E-S-00	4.92	S	1.210	0.197	0.103	NA	0.140	0.140	0.033	0.033	0.075	0.224	U	1.190	0.206	0.115	NA	0.190	0.190	1.603	NA	NA	NA	0.082	0.151	0.334	U	1.210	0.672	1.060	NA	1.1	0.19
L10-01-11-B-R-S-00	1.67	S	1.030	0.155	0.081	NA	-0.040	0.000	0.132	0.132	0.020	0.215	U	1.000	0.160	0.099	NA	0.000	0.000	2.072	NA	NA	NA	0.110	0.137	0.242	U	1.100	0.673	0.873	NA	1.6	0.02
L10-01-12-B-E-S-00	4.92	S	0.763	0.140	0.148	NA	-0.307	0.000	-0.015	0.000	0.039	0.210	U	1.270	0.201	0.106	NA	0.270	0.270	3.621	NA	NA	NA	0.200	0.116	0.178	NA	0.689	0.341	0.943	U	4.4	0.16
L10-01-13-B-E-S-00	6.14	S	1.470	0.200	0.069	NA	0.400	0.400	-0.004	0.000	0.028	0.230	U	1.340	0.203	0.132	NA	0.340	0.340	0.738	NA	NA	NA	0.028	0.083	0.266	U	1.440	0.609	0.926	NA	0.3	0.39
L10-01-14-B-E-S-00	7.95	S	1.400	0.183	0.074	NA	0.330	0.330	0.021	0.021	0.030	0.252	U	1.370	0.200	0.136	NA	0.370	0.370	2.928	NA	NA	NA	0.158	0.164	0.272	U	1.260	0.600	0.935	NA	2.0	0.39
L10-01-15-B-S-S-00	0.01	S	1.210	0.178	0.090	NA	0.140	0.140	0.023	0.023	0.026	0.224	U	1.240	0.189	0.093	NA	0.240	0.240	1.084	NA	NA	NA	0.050	0.162	0.286	U	1.540	0.898	1.070	NA	0.6	0.21
L10-01-16-B-R-S-00	0.49	S	1.300	0.181	0.067	NA	0.230	0.230	0.017	0.017	0.052	0.228	U	1.220	0.188	0.128	NA	0.220	0.220	1.571	NA	NA	NA	0.078	0.152	0.270	U	1.500	0.573	0.852	NA	0.9	0.25
L10-01-13-B-E-Q-00	6.14	Q	1.400	0.219	0.121	NA	0.330	0.330	-0.010	0.000	0.011	0.235	U	1.400	0.227	0.130	NA	0.400	0.400	3.370	NA	NA	NA	0.185	0.185	0.300	U	0.997	0.638	1.020	U	2.9	0.40
L10-01-18-B-E-B-00	13.25	B	1.270	0.199	0.099	NA	0.200	0.200	0.038	0.038	0.014	0.225	U	1.310	0.221	0.166	NA	0.310	0.310	2.922	NA	NA	NA	0.160	0.196	0.333	U	0.912	0.515	1.390	U	2.7	0.29
Systematic Minimum			0.000						0.000					0.000						0.738				0.028				0.689				1.9	0.02
Systematic Maximum			0.400						0.530					0.370						4.331				0.235				1.680				Average Enrichment (%)	0.39
Systematic Mean			0.136						0.087					0.174						2.636				0.141				1.267					0.19
Systematic Median			0.135						0.020					0.195						2.905				0.156				1.320					0.17
Systematic Standard Deviation			0.124						0.159					0.120						1.077				0.062				0.281					0.11
			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 10-01

The biased sample collected from LSA 10-01 had a Uniform SOF result of 0.28, which is consistent with the gamma survey results of 15,900 gcpm (4,928 ncpm).

7.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 10-01

Two samples were collected from the sidewalls of LSA 10-01. Table 7-4 provides the data summary for the samples.

Table 7-4
LSA 10-01 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)
L10-01-19-B-E-B-00	1.149	0.360	1.023	7.587	0.233	< 4.911	0.20
L10-01-20-B-E-B-00	1.217	0.005	1.022	0.000	< 0.276	< 5.524	0.18

7.2.7 Quality Control Soil Sample Result LSA 10-01

One Quality Control (QC) field duplicate sample point was randomly selected for LSA 10-01 which was collected at systematic locations L10-01-13.

For the 15 "regular" (i.e., 14 systematic + 1 biased) samples collected within LSA 10-01, one field duplicate sample was collected. This frequency equates to 6.7%, (i.e. 1/15). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated warning limits (see Figure 7-5 below).

Figure 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 10-01

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control		
	Westinghouse Non-Proprietary Class 3	Revision: 1	Page 1 of 1

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

Survey Unit No.: LSA 10-01 — Survey Unit Description: North West Corner Survey Unit (North Burial Pit 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						
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Ra-226	1.47	0.0692	1.4	0.121	1.435	1.9	0.07	0.269	0.403	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Tc-99	-0.00436	0.23	0.0376	0.225	0.01662	25.1	NA	3.552	5.321	NA
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Th-232	1.34	0.132	1.4	0.13	1.370	2.0	0.060	0.283	0.424	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-234[1]	0.738	NA	3.370	NA	2.054	195.4	2.632	27.649	41.425	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-235	0.0277	0.266	0.185	0.3	0.106	51.6	NA	7.301	10.939	NA
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-238	1.44	0.926	0.997	1.02	1.2185	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: [signature] 2-27-15 — Reviewed by: [signature]

Date: 2-27-15 — Date: 3/16/15

Quality Record

7.3 LSA 10-01 Tc-99 Hot Spot Assessment

During site characterization studies a total of 62 samples were collected and analyzed for Tc-99 in LSA-10-01 and LSA-10-02. The maximum sample identified was 31.1 pCi/g, with an overall mean and median concentration of 1.38 pCi/g and 0.32 pCi/g respectively. The 31.1 pCi/g result was the only sample result that exceeded the Uniform DCGL of 25.1 pCi/g for Tc-99 during site characterization and no samples exceeded the Tc-99 DCGL during RASS and FSS. It is also noted that the overall average of the entire sample column within the Uniform CSM layer was below the Uniform DCGL for Tc-99.

An area factor of 1.24 would be required to account for any potential hot spots of 31.1 pCi/g. Using the Uniform Area Factor table from the DP and interpolation, 810 m^2 is the area per sample station required to equate to an area factor of 1.24. In both LSA-10-01 and LSA-10-02 the area represented by each systematic location was less than 200 m^2 and is adequate to account for any potential hot spots within the SUs.

8.0 ALARA EVALUATION LSA 10-01

All samples collected within LSA 10-01 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 10-01 no sample result exceeded a SOF of 1.0. The average SOF result based on all systematically collected samples was 0.19 for LSA 10-01. The average SOF equates to residual activity contribution for LSA 10-01 of 4.75 mrem/year. Groundwater Monitoring Well data provided in FSSFR Volume 6, Chapters 2 and 3 ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, Chapter 6 {ML17142A356}, Chapter 7 {ML17250A376} and Chapter 8 {ML17240A168} indicate that the groundwater dose contribution is a fraction of the MCLs. Nevertheless, assuming a maximum groundwater contribution of 4.0 mrem/year based upon the U.S. Environmental Protection Agency (EPA) MCLs the total estimated dose for LSA 10-01 is 8.75 mrem/year.

Since the estimated Total Effective Dose Equivalent (TEDE) is 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 10-01 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 10-01.

9.0 FSS PLAN DEVIATIONS LSA 10-01

9.1 Remedial Actions during FSS

During the GWS of LSA 10-01, a 22,000 gcpm "elevated area" was identified on January 27, 2015. This activity level, well above the 4,000 ncpm IAL and several standard deviations above the mean, was such that a SOF over 1.0 would be likely if it were to be sampled. The elevated area was small and localized, and was easily remediated through manual means on January 29, 2015. On the same date, a post-remediation GWS of the recently remediated area was performed, and a biased sample was collected "L10-01-18-B-E-B-00". After remediation, the maximum count rate was 15,928 gcpm and the SOF of the biased sample was 0.28.

9.2 Adjustments to Scan MDC Calculations

As previously stated in Sections 7.1.1 adjustment was made to the Scan MDC calculation for instrumentation used for the GWS in LSA 10-01. The Scan MDCs presented in the FSS Plan shown in Table 5-1 assumed a surveyor efficiency of 0.5 and did not reflect the information derived from the development of HDP-TBD-FSS-002 which used Microshield modeling of parameters consistent with procedural requirements of GWS implementation at HDP. The technical basis document, HDP-TBD-FSS-002, *Evaluation and Documentation of the Scanning Minimum Detectable Concentrations for Final Status Surveys*, prepared after the completion of field FSS activities in LSA 10-01, presents the modeling assumptions and evaluation of Scan MDCs for FSS reflecting actual technical implementation of the GWS, rather than using default parameters such as presented in NUREG-1507. Since all GWS data collected in LSA 10-01 was datalogged and post-processed in GIS software, the surveyor efficiency can effectively be set to 0.75 as agreed upon with NRC during a Public Teleconference Meeting held on August 12, 2015.

Based on the data presented in HDP-TBD-FSS-002 and using a surveyor efficiency of 0.75 and a conservative enrichment basis of 4%, revised Scan MDCs were developed and are presented in Table 9-1 below:

Table 9-1

Revised Scan MDCs for 2" x 2" NaI detector: LSA 10-01

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw (Ra-226)	Scan MDC (Th-232)	DCGLw (Th-232)
LSA 10-01	40.9	87.7	1.21	1.9	0.87	2.0

10.0 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 FSSFR Volume 3, Chapter 1, Section 4.0 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 10-01

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 10-01 (see Figure 10-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed

using a NIST traceable source. The instruments used were successfully source checked prior to and after use.

- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*, with the exception of one sample (See section 8.1.1 and 8.1.2).
- LSA 10-01 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 necessary when the difference between the maximum survey unit data set measurement SOF and the minimum background area measurement SOF is greater than one. For LSA 10-01, 2 individual gross SOF result(s) 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 required for LSA 10-01. Since the test statistic, WR (974) exceeded the critical value (821), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS evaluation 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 0.28 Uniform SOF.
- The maximum SOF result for all surface samples within LSA 10-01 was 0.40. The maximum SOF result for all subsurface samples within LSA 10-01 was 0.25. The average SOF result for all systematically collected samples within LSA 10-01 was 0.19, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.25.
- No FSS sample result in LSA 10-01 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an elevated measurement comparisons (EMC) or supplemental investigations was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (8) of systematic samples actually collected within LSA 10-01. The successful result of the retrospective power evaluation presented in Table 10-1 for LSA 10-01 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 10-01. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination

performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight topmost excavation surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.

- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures for LSA 10-01 was completed prior to the commencement of backfill operations.

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

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.11
$DCGL_{SOF}$	1
LBGR (Mean)	0.19
Shift	0.81
Relative Shift (Δ/σ)	7.36
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 10-01 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
	Westinghouse Non-Proprietary Class 3	Revision: 7	Appendix G-1, Page 1 of 2

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

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: 01 **Description:** Northern Pits; northwest SU in Area 1

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 ☐	
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 ☐	
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒	No ☐	
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	

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

Comments:

Quality Record

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

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
	Westinghouse Non-Proprietary Class 3	Revision: 7	Appendix G-1, Page 2 of 2

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

Survey Area: No. LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: No. 01 **Description:** Northern Pits; northwest SU in Area 1

Discrepancy: N / A

Corrective Actions Taken: N / A

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

	(Print Name)	(Signature)	(Date)
Prepared by (HP Staff):	Brian A. Miller	Brian Miller	5/20/15
Approved by (RSO):	W. Clark Eves	W Clark Eves	5/27/15

Quality Record

11.0 SURVEILLANCE FOLLOWING FSS

During the timeframe since the completion of FSS field activities to the date of backfill of LSA 10-01, the SU did not evidence an event that would cause them to be suspect and thus require investigation.

12.0 CONCLUSION LSA 10-01

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

Table 11-1
LSA 10-01 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.19	N/A	0.16	N/A	N/A	**0.35**
DOSE	4.75 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**8.75 mrem/year**

13.0 FINAL STATUS SURVEY DESIGN LSA 10-02

This section describes the method for determining the number of samples required for the FSS of LSA 10-02 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 10-02 and the detection sensitivity is also discussed.

13.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 10-02 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 4, *Final Status Survey Plan Development*, January 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 10-02. The review identified several areas that were previously found to exceed a Uniform SOF of 1.0 (discussed in Section 3.3.6). Subsequently the remediation history was reviewed to confirm that these areas were adequately addressed, and the RASS data was used as confirmation that no known areas of residual radioactivity remained within the survey areas that exceeded the Uniform $DCGL_W$. Therefore the Uniform $DCGL_W$ was selected for use in demonstrating compliance with the release criteria.

13.1.3 GWS Coverage

As a Class 1 SU, LSA 10-02 was required to undergo a 100% GWS.

13.1.4 Instrumentation

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

13.1.5 Scan Minimum Detectable Concentration

As background levels were approximately 10,000 cpm in LSA 10-0, 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:

$$\text{Scan MDC}_{\text{(total uranium)}} = \frac{1}{\left(\left(\frac{f_{U-234}}{7383\ pCi/g}\right)+\left(\frac{f_{U-235}}{4.9 pCi/g}\right)+\left(\frac{f_{U-238}}{62.8 pCi/g}\right)\right)}$$

Equation 13-1

In order to calculate the Scan MDC for total uranium using the above equation, an average enrichment for the SU must be known which in turn will provide relative isotopic fractions for U-234, U-235, and U-238 as given in Appendix G of HDP-PR-FSS-701, Revision 4, *Final Status Survey Plan Development*. Based on the systematically collected RASS samples in LSA 10-02 the average enrichment for LSA 10-02 was 2.4%.

Standard Scan MDCs for Radium-226 and Thorium-232 using a 2" x 2" NaI detector are found in Table 6.4 of NUREG-1507 and are shown in Table 13-1. The prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 10-02 are shown below:

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

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 10-02	83.6	84.5	2.8	2.8	1.8	3.0

*DCGLw 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 13-1 reflect those presented in the FSS Plans prepared for these SUs 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 10-02 was established at 4,000 ncpm.

13.1.7 LSA 10-02 FSS Design Summary

The FSS Plan for LSA 10-02 can be found in Appendix D. Table 13-2 presents an overall FSS design and implementation summary for LSA 10-02.

Table 13-2 presents an overall FSS design and implementation summary for LSA 10-02.

Table 13-2
FSS Design Summary for LSA 10-02

Gamma Walkover Survey (GWS):		
Scan Coverage	100% accessible excavation floors, benches, pits, and sidewalls	
Scan MDC	83.6 pCi/g total Uranium (based on a 10,000 cpm background)	
Investigation Action Level (IAL)	4,000 net cpm*	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	2	The samples are collected on a systematic grid.** Analysis of excavation stratum samples is/was not required if there was surface stratum collected at sample grid location and the overlying root stratum SOF result was less than 0.5.
15 cm – 1.5 m (Root)	2	
> 1.5m (Excavation)	8**	
Biased Survey/Sampling Locations:		
Biased samples may be collected during GWS at the discretion of the HP Technician, after statistical analysis of the survey data, or at the direction of the FSS Supervisor.		
Instrumentation		
Ludlum 2221 with 44-10 (2" x 2" NaI) detector; with collimation for investigations.	Used for GWS and to obtain static count rates at biased measurement locations.	
*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 2015.		

14.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 10-02

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 10-02 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble Pro 6H DGPS and Nomad 800XL 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 excavation floor and sidewalls collected with the NaI detector(s) were connected to a Trimble DGPS and with a hand-held data logger. The logging frequency in the survey unit was 1 GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

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

HP Technicians performing GWS in LSA 10-02 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 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 10,000 and 11,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 15,000 gross counts per minute (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.

14.2 Soil Sampling

14.2.1 Systematic Soil Sampling Summary

Table 14-1 provides a summary of systematic sampling by stratum for LSA 10-02.

Table 14-1
Systematic Sampling Summary by Stratum for LSA 10-02

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep	
10-02	1,477	2	2	8	1

14.2.2 Systematic Sampling LSA 10-02

Within LSA 10-02, there were two systematic locations in which portions of the surface stratum (0 – 15 cm) remained in the SU after remediation. At these locations, the remaining surface stratum interval was collected using a hand trowel. Portions of the root stratum (15 cm – 150 cm) remained at two 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. However, since both surface and root samples were collected at two locations and no root stratum composite samples exceeded a SOF of 0.5, it was not necessary to analyze excavation stratum samples collected at those two locations which had successful surface and root stratum results.

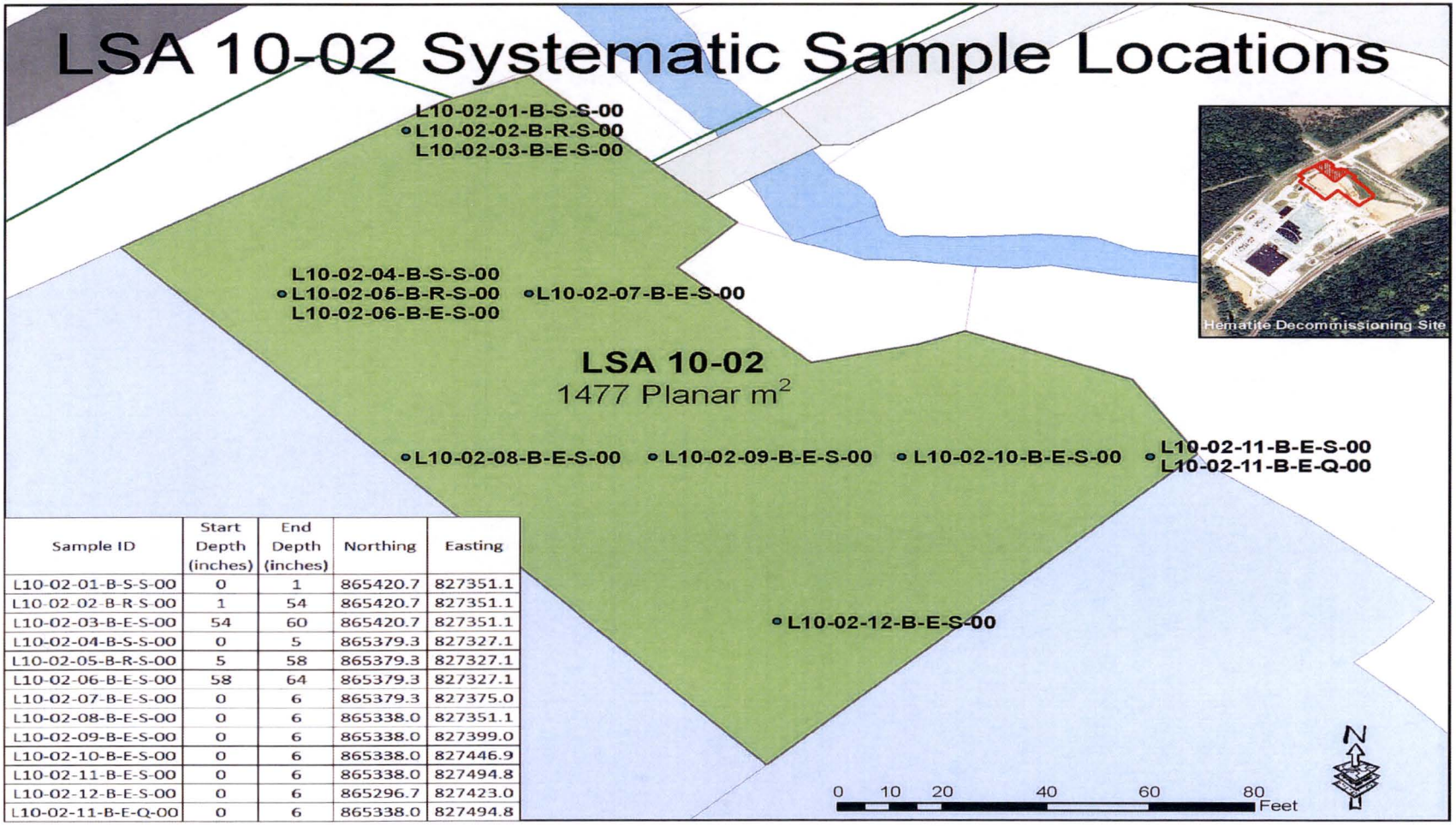
Given a planar area of 1,477 m^2 for LSA 10-02 and an eight - point systematic triangular grid, the point-to-point distance within each row was 14.6 m with spacing of 12.6 m between each of the parallel grid rows within the SU.

While there were eight systematic locations on the LSA 10-02 sampling grid, a total of 13 samples were collected at these locations, including:

- Two (2) samples collected within the remaining surface stratum
- Two (2) samples collected within the remaining root stratum
- Eight (8) samples collected within the excavation, or "deep", stratum, although it was only necessary to analyze and report only six (6) of these samples, since two of the eight locations were sampled in both the surface and root strata without any result exceeding a SOF value of 0.5
- One (1) QC field replicate

Figure 14-1 below presents the map of the eight systematic sample locations which were collected within LSA 10-02. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 14-1
LSA 10-02 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing	Easting
L10-02-01-B-S-S-00	0	1	865420.7	827351.1
L10-02-02-B-R-S-00	1	54	865420.7	827351.1
L10-02-03-B-E-S-00	54	60	865420.7	827351.1
L10-02-04-B-S-S-00	0	5	865379.3	827327.1
L10-02-05-B-R-S-00	5	58	865379.3	827327.1
L10-02-06-B-E-S-00	58	64	865379.3	827327.1
L10-02-07-B-E-S-00	0	6	865379.3	827375.0
L10-02-08-B-E-S-00	0	6	865338.0	827351.1
L10-02-09-B-E-S-00	0	6	865338.0	827399.0
L10-02-10-B-E-S-00	0	6	865338.0	827446.9
L10-02-11-B-E-S-00	0	6	865338.0	827494.8
L10-02-12-B-E-S-00	0	6	865296.7	827423.0
L10-02-11-B-E-Q-00	0	6	865338.0	827494.8

Table 14-2 below presents a tabular listing of all FSS samples collected within LSA 10-02 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 14-2
FSS Sample Locations and Coordinates for LSA 10-02

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-701, Final Status Survey Plan Development		
	Westinghouse Non-Proprietary Class 3	Revision: 4	Appendix P-4, Page 1 of 1

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: 02 **Description:** North East Corner Survey Unit (North Burial Pit)
Survey Type: FSS **Classification:** Class 1

Measurement or Sample ID	Surface or CSM	Type	Start Elevation	End Elevation	Northing (Y Axis) *	Easting (X Axis) *	Remarks / Notes
L10-02-01-B-S-S-00	Uniform	S	432.6	432.5	865420.7	827351.1	Surface 1-inch grab
L10-02-02-B-R-S-00	Uniform	S	432.5	428.1	865420.7	827351.1	Root 4.4-foot composite
L10-02-04-B-S-S-00	Uniform	S	436.2	435.8	865379.3	827327.1	Surface 5-inch grab
L10-02-05-B-R-S-00	Uniform	S	435.8	431.3	865379.3	827327.1	Root 4.4-foot composite
L10-02-07-B-E-S-00	Uniform	S	424.7	424.2	865379.3	827375.0	Excavation 6-inch grab
L10-02-08-B-E-S-00	Uniform	S	426.9	426.4	865338.0	827351.1	Excavation 6-inch grab
L10-02-09-B-E-S-00	Uniform	S	423.5	423.0	865338.0	827399.0	Excavation 6-inch grab
L10-02-10-B-E-S-00	Uniform	S	418.9	418.4	865338.0	827446.9	Excavation 6-inch grab
L10-02-11-B-E-S-00	Uniform	S	422.3	421.8	865338.0	827494.8	Excavation 6-inch grab
L10-02-12-B-E-S-00	Uniform	S	422.3	421.8	865296.7	827423.0	Excavation 6-inch grab
L10-02-11-B-E-Q-00	Uniform	Q	422.3	421.8	865338.0	827494.8	Excavation 6-inch grab
L10-02-13-B-E-B-00	Uniform	B	429.5	419.6	865341.1	827408.1	Excavation 6-inch grab

Elevations are in feet above mean sea level.

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

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

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

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

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

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 10-02, one biased sample location was selected based on the evaluation of the GWS survey data. The biased location in LSA 10-02 represented

the maximum GWS measurement encountered within the SU. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

14.4 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 from each 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). Three samples were collected in the sidewall of LSA 10-02. These samples were collected from locations selected by the HP Technicians at random, and were not based on gamma survey readings (not biased).

14.5 Quality Control Soil Sampling

One QC field duplicate sample point was randomly selected for LSA 10-02 and collected at systematic location L10-02-11.

15.0 FINAL STATUS SURVEY RESULTS LSA 10-02

15.1 Gamma Walkover Survey

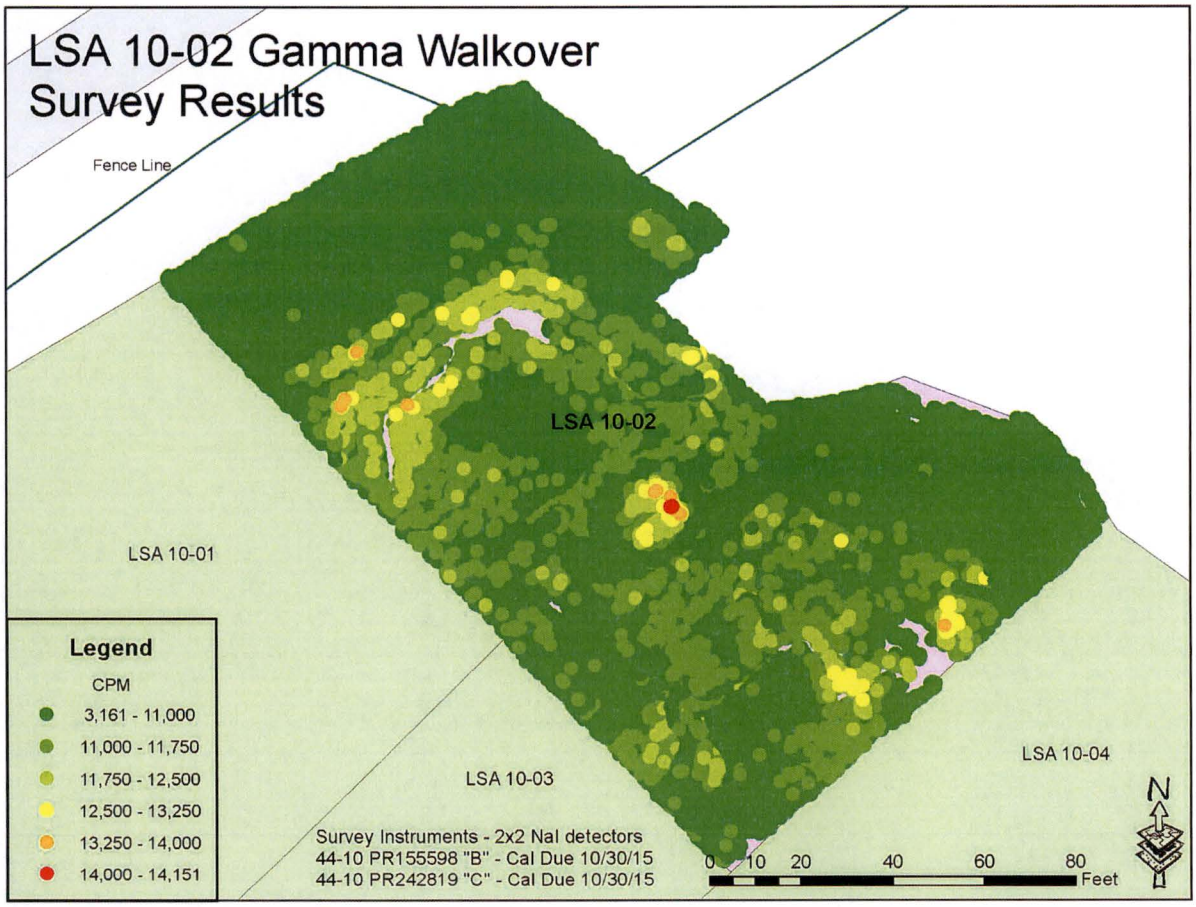
Post-processed GPS coordinate data is accurate to within ± 0.1m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are 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 10-02 between January 22, 2015, and February 2, 2015.

15.1.1 GWS Results for LSA 10-02

For LSA 10-02, GWS count rates ranged between 3,161 gcpm and 14,151 gcpm, with a mean count rate of 9,781 gcpm. The median count rate was 10,184 gcpm with a standard deviation of 1,284 cpm. Figure 15-1 below presents a map of the complete GWS data set.

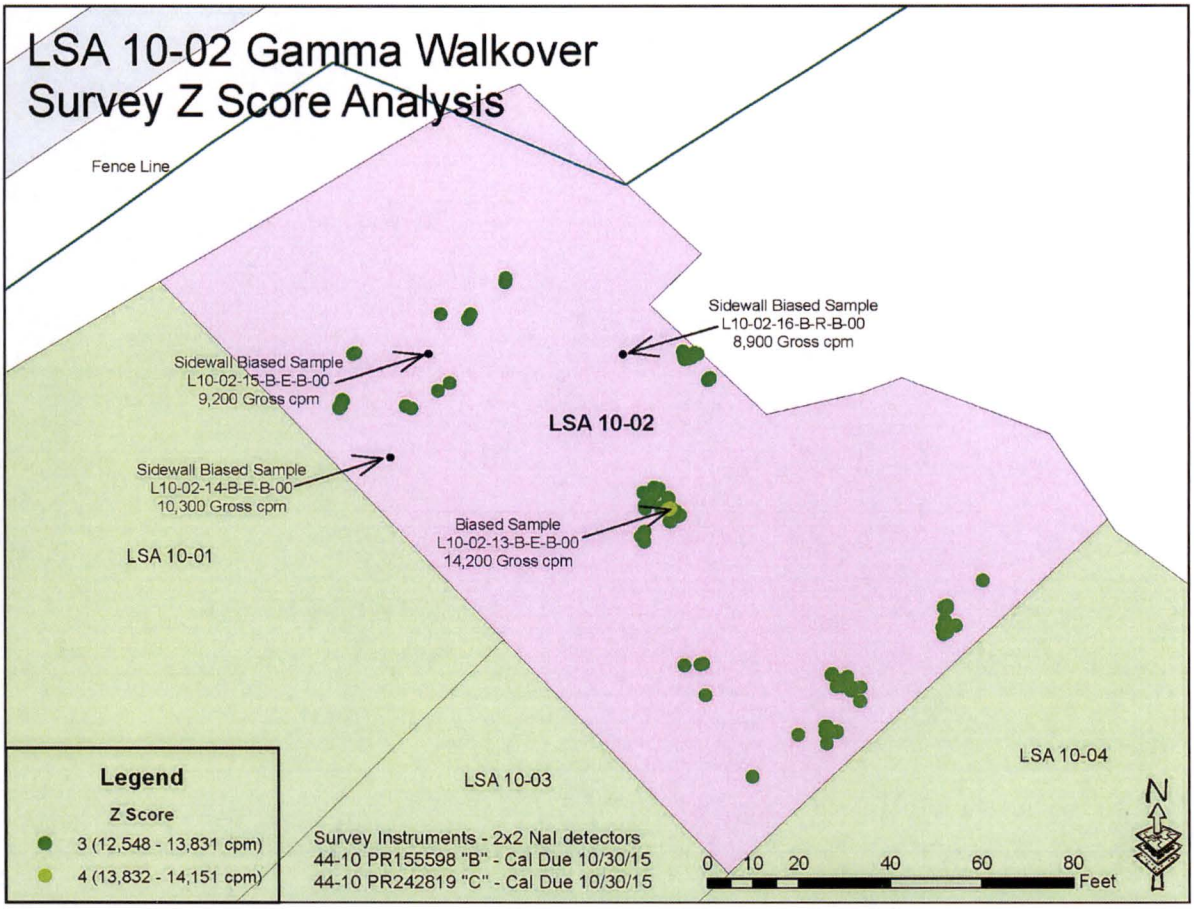
Figure 15-1
Colorimetric GWS Plot for LSA 10-02



An evaluation of the GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location, L10-02-13, was selected for biased sample collection. This biased location represented the maximum GWS measurement encountered within the survey unit. Also, this single biased location was the only point which exceeded both the IAL based on the local background readings and a Z-score of 3. Therefore, no additional biased locations were selected for sampling.

Figure 15-2 below presents a map of the +3 Z-score GWS measurements within LSA 10-02, including the selected biased sampling location (ID: L10-02-13-B-E-B-00). Also shown are the three discretionary sidewall samples collected within the SU (IDs: L10-02-14-B-E-B-00, L10-02-15-B-E-B-00, and L10-02-16-B-E-B-00).

Figure 15-2
Colorimetric GWS Plot for LSA 10-02 (Measurements > Z-score of 3)



A total of 37,199 GWS measurements were collected in LSA 10-02. Using a conservative side-to-side movement distance of 1 foot, and given the internal SU surface areas of LSA 10-02 of approximately 21,000 square feet, the average estimated surveyor speed during GWS of LSA 10-02 was approximately 0.5 ft/sec. Since this retrospectively estimated scanning speed was less than the 1.0 ft/second FSS Plan requirement and the fact that the NaI probe was maintained as close as possible to the surface, actual Scan MDCs based on real field conditions would have been considerably less than the 83.6 pCi/g total Uranium Scan MDC estimate determined during the FSS planning phase for this SU. It should also be noted that the 83.6 pCi/g Scan MDC prospectively estimated for LSA 10-02 assumed a surveyor efficiency of 0.5.

Since all GWS data collected in LSA 10-02 was datalogged and post-processed in GIS software, the surveyor efficiency can effectively be set to 0.75 as agreed upon with NRC during a Public Teleconference Meeting held on August 12, 2015. Using these parameters, a more realistic Scan MDC of approximately 40.9 pCi/g is determined. The technical basis document, HDP-TBD-FSS-002, prepared after the completion of field FSS activities in LSA 10-02, presents the modeling assumptions and evaluation of Scan MDCs for FSS reflecting actual technical implementation of the GWS, rather than using default parameters such as presented in NUREG-

1507. The equation used to derive the revised Total Uranium Scan MDC (with a conservative estimate of 4% enrichment) from Section 1.1.5 of HDP-TBD-FSS-002 (Revision 3, August 2015) is as follows:

$$\text{Scan MDC}_{Total\ Uranium} = \quad 1 \Big/ \left(\left(\frac{0.7928}{3659}\right) + \left(\frac{0.0438}{2.32}\right) + \left(\frac{0.1634}{30.6}\right)\right) = 40.9\,\frac{pCi}{g}$$

Equation 15-1

HDP-TBD-FSS-002 also modeled Radium-226 and Thorium-232 Scan MDCs to reflect the technical implementation requirements of FSS at the HDP. Using the same parameters as discussed above for total Uranium, the retrospectively estimated Scan MDCs for Radium-226 and Thorium-232 are 1.21 pCi/g and 0.87 pCi/g, respectively using a two inch air gap. A two inch air gap is utilized as a conservative measure considering NUREG-1507 states that the position relates to the average height of the detector. The HP Technicians are instructed to survey as close as possible to the ground surface, (nominally 1", but not to exceed 3" distance from the surface). As such, the use of a two inch air gap is conservative.

15.1.2 GWS Coverage Results LSA 10-02

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, certain small areas of the LSA 10-02 interior could not be accessed for GWS due to overly steep side slopes or especially tall interior sidewalls. These areas appear as greyish-pink blanks in the Figure 15-1 above.

The post survey processing of the GPS data indicated that the GWS was 98.53% 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 10-02

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 10-02	336,552	4,952	1.47%	98.53%	1

15.2 Soil Sample Results LSA 10-02

Appendix B presents the analytical results and associated statistics for all FSS samples collected within LSA 10-02.

15.2.1 Surface Soil Sample Results LSA 10-02

There were two (2) samples collected within the surface stratum (0 – 15 cm) of LSA 10-02. However, there were a total of ten (10) soil samples collected within the topmost soil layer of the excavation surface including eight systematic samples, one biased sample, and one QC field duplicate sample. The maximum SOF result for "topmost" samples in LSA 10-02 was 0.10 corresponding to the systematic sample L10-02-08-B-E-B-00, with the biased sample (L10-02-13-B-E-B-00) resulting in a 0.08 SOF.

15.2.2 Subsurface Soil Sample Results LSA 10-02

There were two systematic locations within LSA 10-02 where root stratum composite sampling was performed. The root stratum zone is between 0.15 and 1.50 m below final grade surface. However, at these two root stratum sampling locations, there was also remaining soil in the overlying surface stratum (0 – 0.15 m). Also, at the two root stratum composite sampling locations, the top six inches (1.50 – 1.65 m below final grade surface) of the underlying excavation stratum was collected, but analysis of these samples was not necessary since the overlying root stratum sample results did not exceed a SOF of 0.5. The two root stratum samples are considered "subsurface" samples and therefore would not factor into the WRS test evaluation. The maximum SOF result of the subsurface samples collected in LSA 10-02 was 0.14. This sample (L10-02-04) was the root stratum sample collected directly underneath the surface stratum sample L10-02-05.

15.2.3 WRS Test Evaluation LSA 10-02

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was not required for LSA 10-02 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 10-02. 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 10 systematically collected samples in LSA 10-02 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, (848) was greater than the critical value (744) 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 10-02

Table 15-2 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 10-02, and the associated SOF when compared to the Uniform $DCGL_W$. The arithmetic average concentration resulted in a SOF of 0.07.

Table 15-2
LSA 10-02 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	0.05	0.27	0.03	2.65	0.14	1.09	**0.07**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.89	0.04	0.52	0.03
Maximum	0.14	0.87	0.11	5.94	0.33	1.71	0.14

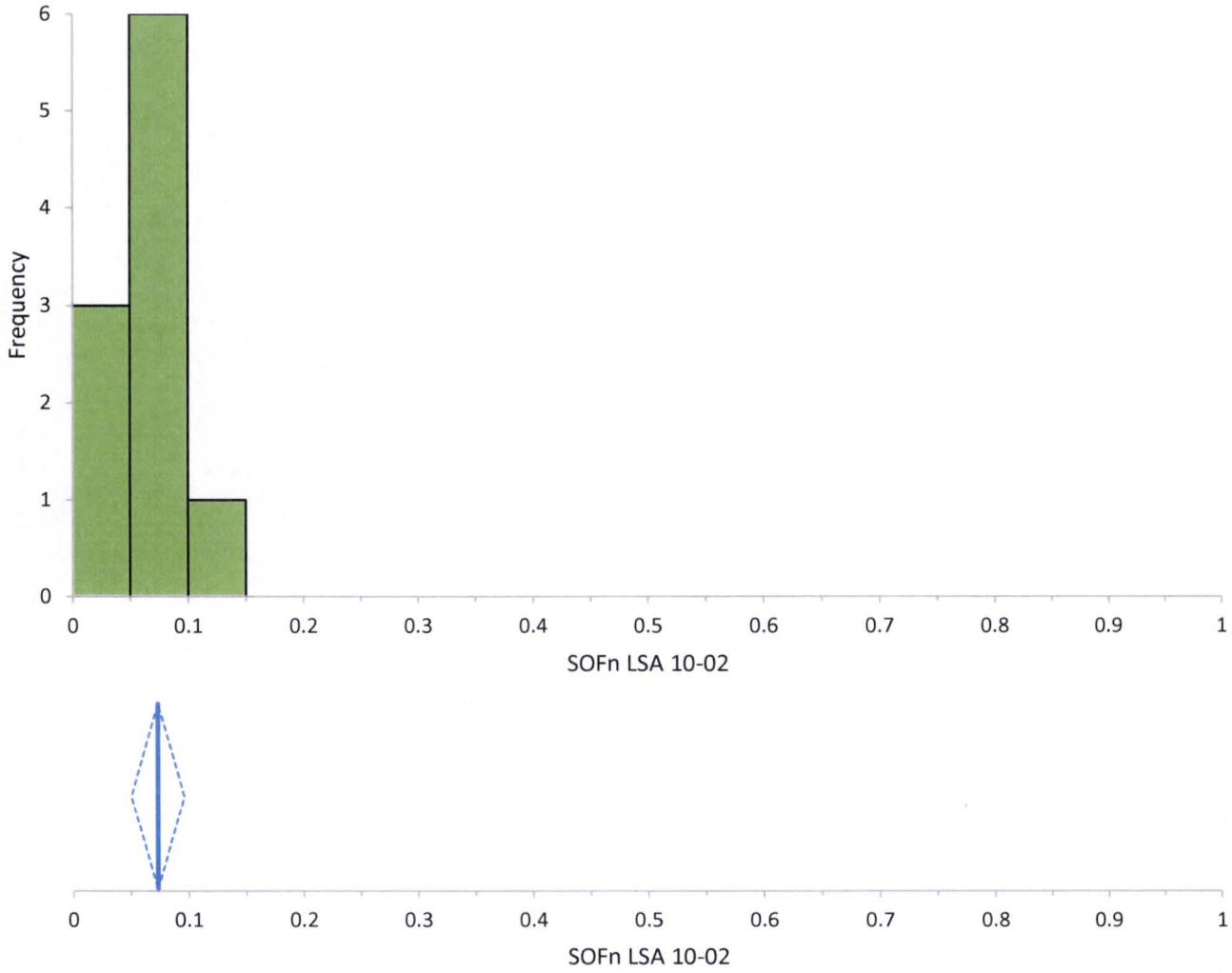
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide 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 (based on the SOF parameter) for the ten systematically samples collected within LSA 10-02. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-02. The middle graph presents the mean SOF (0.07 as indicated by the blue vertical line) of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.05 to 0.10. The 98% confidence interval based on the median (0.07) of the sample results is 0.04 to 0.10. The bottom two charts present the various statistical metrics of the LSA 10-02 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 10-02 data associated with the systematically collected measurement locations.

Figure 15-3
Graphic Statistical Summary for LSA 10-02 (SOF parameter)



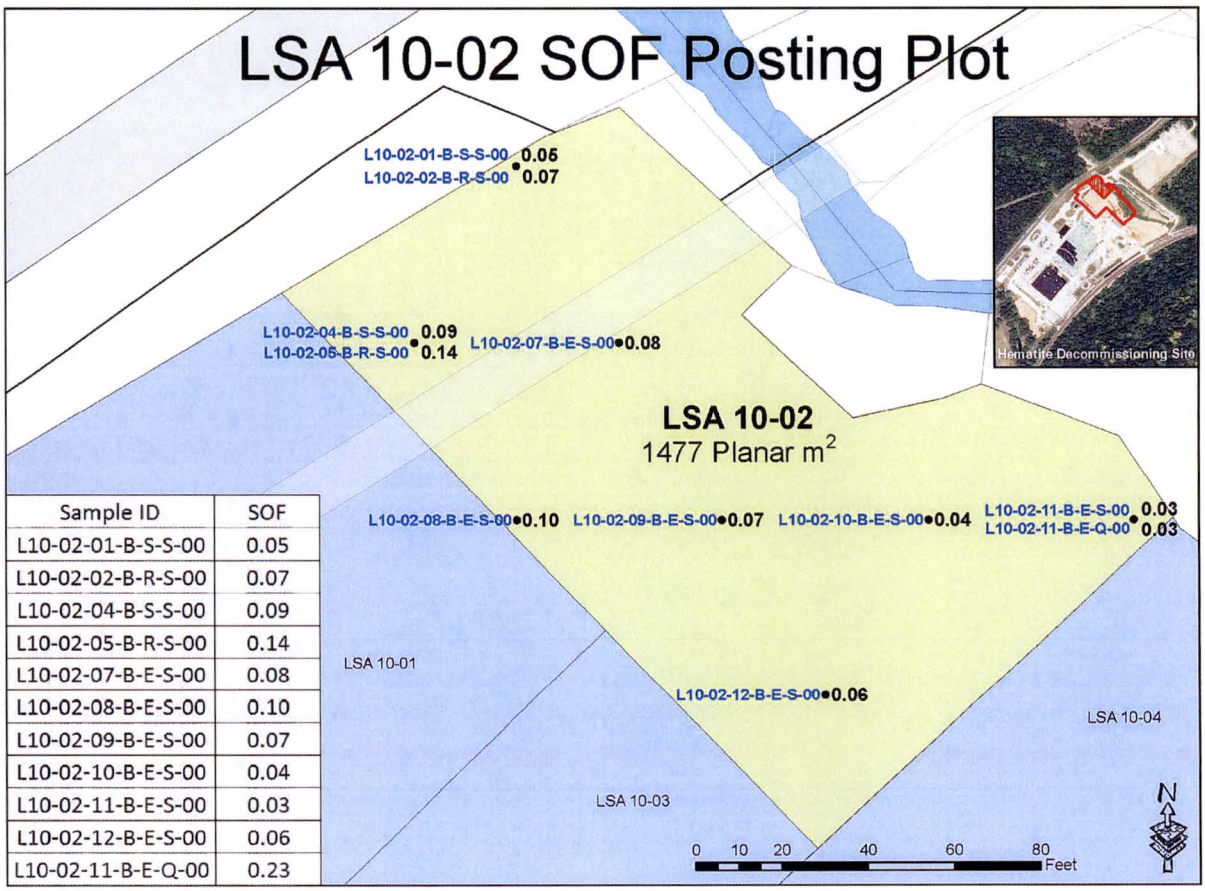
N	10

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
SOFn LSA 10-02	0.07	0.05	to 0.10	0.010	0.03	0.00	0.8	0.91

	Minimum	1st quartile	Median	97.85% CI		3rd quartile	Maximum	IQR
SOFn LSA 10-02	0.0	0.05	0.07	0.04	to 0.10	0.09	0.1	0.04

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 10-02 is presented below in Figure 15-4 and shows no unusual patterns in the data.

Figure 15-4
Posting Plot for LSA 10-02 Systematic Measurement Locations



Sample ID	SOF
L10-02-01-B-S-S-00	0.05
L10-02-02-B-R-S-00	0.07
L10-02-04-B-S-S-00	0.09
L10-02-05-B-R-S-00	0.14
L10-02-07-B-E-S-00	0.08
L10-02-08-B-E-S-00	0.10
L10-02-09-B-E-S-00	0.07
L10-02-10-B-E-S-00	0.04
L10-02-11-B-E-S-00	0.03
L10-02-12-B-E-S-00	0.06
L10-02-11-B-E-Q-00	0.23

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 F to this report presents the Test America Analytical Laboratory soil sample reports.

Table 15-3
Final Status Survey Analytical Data: LSA 10-02

Sample ID	Sample Start Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF_N
			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_N
L10-02-01-B-S-S-00	0.39	S	0.998	0.146	0.067	NA	-0.072	0.000	0.443	0.443	0.079	0.243	NA	0.987	0.161	0.108	NA	-0.013	0.000	4.381	NA	NA	NA	0.242	0.115	0.159	NA	0.858	0.308	0.826	NA	4.3	0.05
L10-02-02-B-R-S-00	0.49	S	1.110	0.172	0.083	NA	0.040	0.040	0.130	0.130	0.095	0.231	U	1.050	0.191	0.127	NA	0.050	0.050	1.905	NA	NA	NA	0.099	0.161	0.286	U	1.190	0.355	0.929	NA	1.3	0.07
L10-02-04-B-S-S-00	0.06	S	1.160	0.181	0.055	NA	0.090	0.090	0.303	0.303	0.041	0.232	U	0.936	0.222	0.133	NA	-0.064	0.000	3.433	NA	NA	NA	0.188	0.195	0.310	U	1.080	0.699	1.120	NA	2.7	0.09
L10-02-05-B-R-S-00	0.49	S	1.210	0.165	0.067	NA	0.140	0.140	0.019	0.019	0.090	0.240	NA	1.110	0.172	0.137	NA	0.110	0.110	0.889	NA	NA	NA	0.042	0.159	0.268	U	0.911	0.316	0.900	U	0.7	0.14
L10-02-07-B-E-S-00	6.09	S	1.170	0.211	0.134	NA	0.100	0.100	0.042	0.042	0.129	0.256	U	1.040	0.192	0.161	NA	0.040	0.040	1.125	NA	NA	NA	0.059	0.183	0.320	U	0.626	0.440	1.310	NA	1.5	0.08
L10-02-08-B-E-S-00	5.17	S	1.160	0.159	0.066	NA	0.090	0.090	-0.008	0.000	0.059	0.239	U	1.060	0.170	0.119	NA	0.060	0.060	2.268	NA	NA	NA	0.118	0.153	0.261	U	1.410	0.534	0.800	NA	1.3	0.10
L10-02-09-B-E-S-00	6.32	S	1.030	0.167	0.083	NA	-0.040	0.000	0.871	0.871	0.119	0.237	U	1.050	0.207	0.084	NA	0.050	0.050	1.760	NA	NA	NA	0.097	0.167	0.256	U	0.515	0.670	1.110	U	2.9	0.07
L10-02-10-B-E-S-00	9.53	S	0.941	0.151	0.086	NA	-0.129	0.000	0.353	0.353	0.119	0.290	U	0.939	0.170	0.127	NA	-0.061	0.000	2.274	NA	NA	NA	0.116	0.135	0.246	U	1.680	0.636	0.807	NA	1.1	0.04
L10-02-11-B-E-S-00	4.93	S	0.956	0.154	0.074	NA	-0.114	0.000	0.274	0.274	0.038	0.249	NA	0.843	0.160	0.084	NA	-0.157	0.000	2.477	NA	NA	NA	0.135	0.117	0.163	U	0.875	0.498	0.785	U	2.4	0.03
L10-02-12-B-E-S-00	7.88	S	0.734	0.107	0.041	NA	-0.336	0.000	0.301	0.301	0.086	0.214	NA	0.336	0.068	0.042	NA	-0.664	0.000	5.938	NA	NA	NA	0.326	0.109	0.119	U	1.710	0.441	0.582	NA	2.9	0.06
L10-02-11-B-E-Q-00	4.93	Q	0.812	0.125	0.059	NA	-0.258	0.000	0.453	0.453	0.210	0.243	NA	0.577	0.127	0.065	NA	-0.423	0.000	1.840	NA	NA	NA	0.101	0.119	0.195	U	0.536	0.244	0.712	NA	2.9	0.03
L10-02-13-B-E-B-00	9.86	B	0.953	0.173	0.101	NA	-0.117	0.000	0.265	0.265	0.024	0.287	NA	1.080	0.220	0.115	NA	0.080	0.080	4.085	NA	NA	NA	0.224	0.184	0.320	NA	1.240	0.700	1.100	NA	2.8	0.08
Systematic Minimum			0.000						0.000					0.000						0.889				0.042				0.515				**2.1**	0.03
Systematic Maximum			0.140						0.871					0.110						5.938				0.326				1.710				Average Enrichment (%)	0.14
Systematic Mean			0.046						0.274					0.031						2.645				0.142				1.086					0.07
Systematic Median			0.020						0.288					0.020						2.271				0.117				0.996					0.07
Systematic Standard Deviation			0.054						0.260					0.038						1.546				0.087				0.411					0.03
			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 10-02

The biased sample collected from LSA 10-02 had a Uniform SOF result of 0.08, which is consistent with the gamma survey results of 14,200 gcpm (4,419 ncpm).

15.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 10-02

Three samples were collected from the sidewalls of LSA 10-02. Table 15-4 provides the data summary for the samples. Although the collection of the sidewall samples was not driven by elevated gamma measurements, these samples will be treated as biased samples for the purposes of FSS data evaluation.

Table 15-4
LSA 10-02 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)
L10-02-14-B-E-B-00	1.361	-0.003	1.259	0.000	< 0.300	< 6.065	0.37
L10-02-15-B-E-B-00	1.415	-0.009	1.101	0.000	< 0.307	< 5.214	0.32
L10-02-16-B-R-B-00	1.334	-0.019	1.296	5.507	0.169	< 5.291	0.41

Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Th-232 background = 1.0 pCi/g.
2. Negative SOF components are set to zero in SOF calculations.
3. U-234 values are inferred from the U-235/U-238 ratio. If neither U-235 nor U-238 are detected above MDA, then U-234 values are set to zero.
4. Results reported less than analytical MDA's are reported as "<" the analytical MDA value and are set to zero in SOF calculations.

15.2.7 Quality Control Soil Sample Result LSA 10-02

One QC field duplicate sample point was randomly selected for LSA 10-02 which was collected at systematic locations L10-02-11.

For the 11 "regular" (i.e., 10 systematic + 1 biased) samples collected within LSA 10-02, one field duplicate sample was collected. This frequency equates to 9.0%, (i.e. 1/11). 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 10-02

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-703, Final Status Survey Quality Control		
	Westinghouse Non-Proprietary Class 3	Revision: 1	Page 1 of 1

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

Survey Unit No.:	LSA 10-02				Survey Unit Description:		North East Corner Survey Unit (North Burial Pits)					
			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)
L10-02-11-B-E-S-00	L10-02-11-B-E-Q-00	Ra-226	0.956	0.0738	0.812	0.0586	0.884	1.9	0.144	0.269	0.403	N
L10-02-11-B-E-S-00	L10-02-11-B-E-Q-00	Tc-99	0.274	0.249	0.453	0.243	0.3635	25.1	0.179	3.552	5.321	N
L10-02-11-B-E-S-00	L10-02-11-B-E-Q-00	Th-232	0.843	0.0839	0.577	0.0649	0.710	2.0	0.266	0.283	0.424	N
L10-02-11-B-E-S-00	L10-02-11-B-E-Q-00	U-234[1]	2.477	NA	1.840	NA	2.158	195.4	0.637	27.649	41.425	N
L10-02-11-B-E-S-00	L10-02-11-B-E-Q-00	U-235	0.135	0.163	0.101	0.195	0.118	51.6	NA	7.301	10.939	NA
L10-02-11-B-E-S-00	L10-02-11-B-E-Q-00	U-238	0.875	0.785	0.536	0.712	0.706	168.8	NA	23.885	35.786	NA

Comments:
1. U-234 is inferred, no MDC available.
2. U-235 results are less than the related MDC, therefore duplicate assessment is not necessary.

Performed by: [signature]
Date: 2-26-15

Reviewed by: [signature]
Date: 3/16/15

Quality Record

15.3 Tc-99 Hot Spot Assessment LSA 10-02

During site characterization studies a total of 62 samples were collected and analyzed for Tc-99 in LSA-10-01 and LSA-10-02. The maximum sample identified was 31.1 pCi/g, with an overall mean and median concentration of 1.38 pCi/g and 0.32 pCi/g respectively. The 31.1 pCi/g result was the only sample result that exceeded the Uniform DCGL of 25.1 pCi/g for Tc-99 during site characterization and no samples exceeded the Tc-99 DCGL during RASS and FSS. It is also noted that the overall average of the entire sample column within the Uniform conceptual site model layer was below the Uniform DCGL for Tc-99.

An area factor of 1.24 would be required to account for any potential hot spots of 31.1 pCi/g. Using the Uniform Area Factor table from the DP and interpolation, 810 m^2 is the area per sample station required to equate to an area factor of 1.24. In both LSA-10-01 and LSA-10-02 the area represented by each systematic location was less than 200 m^2 and is adequate to account for any potential hot spots within the SUs.

16.0 ALARA EVALUATION LSA 10-02

All samples collected within LSA 10-02 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 10-02 no sample result exceeded a SOF of 1.0. The average SOF result based on all systematically collected samples was 0.07 for LSA 10-02. The average SOF equates to a residual activity contribution of 1.75 mrem/year for LSA 10-02. Groundwater Monitoring Well data provided in FSSFR Volume 6, Chapters 2 and 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, Chapter 6 {ML17142A356}, Chapter 7 {ML17250A376} and Chapter 8 {ML17240A168} indicate that the groundwater dose contribution is a fraction of the MCLs. Nevertheless, assuming a maximum groundwater contribution of 4.0 mrem/year based upon the EPA MCLs the total estimated dose for LSA 10-02 is 5.75 mrem/year.

Since these estimated TEDE is below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 10-02 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 further remediation of LSA 10-02.

17.0 FSS PLAN DEVIATIONS LSA 10-02

17.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 10-02.

17.2 Adjustments to Scan MDC Calculations

As previously stated in Sections 15.1.1, adjustments were made to the Scan MDC calculations for instrumentation used for the GWS in LSA 10-02. The Scan MDCs presented in the FSS Plan shown in Table 13-1 assumed a surveyor efficiency of 0.5 and did not reflect the information derived from the development of HDP-TBD-FSS-002 which used Microshield modeling of parameters consistent with procedural requirements of GWS implementation at HDP. The technical basis document, HDP-TBD-FSS-002 *Evaluation and Documentation of the Scanning*

Minimum Detectable Concentrations for Final Status Surveys, prepared after the completion of field FSS activities in LSA 10-02, presents the modeling assumptions and evaluation of Scan MDCs for FSS reflecting actual technical implementation of the GWS, rather than using default parameters such as presented in NUREG-1507. Since all GWS data collected in LSA 10-02 was datalogged and post-processed in GIS software, the surveyor efficiency can effectively be set to 0.75 as agreed upon with NRC during a Public Teleconference Meeting held on August 12, 2015.

Based on the data presented in HDP-TBD-FSS-002 and using a surveyor efficiency of 0.75 and a conservative enrichment basis of 4%, revised Scan MDCs were developed and are presented in Table 17-1 below:

Table 17-1

Revised Scan MDCs for 2" x 2" NaI detector: LSA 10-02

	Scan MDC (Total U)	**DCGLw (Total U)**	**Scan MDC (Ra-226)**	**DCGLw (Ra-226)**	**Scan MDC (Th-232)**	**DCGLw (Th-232)**
LSA 10-02	40.9	84.5	1.21	1.9	0.87	2.0

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 10-02

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 10-02 (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*, with the exception of one sample (See section 8.1.1 and 8.1.2).
- LSA 10-02 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 10-02, 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 10-02, however the WRS Test was still performed for illustrative purposes. Since the test statistic, WR (848) exceeded the critical value (744), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS evaluation worksheet is presented in Appendix B.
- A biased soil sample was collected from the location of the highest gamma count rate within the SU, and the result was a 0.08 Uniform SOF.
- The maximum SOF result for all surface samples within LSA 10-02 was 0.10. The maximum SOF result for all subsurface samples within LSA 10-02 was 0.14. The average SOF result for all systematically collected samples within LSA 10-01 was 0.07, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.10.
- No FSS sample result in LSA 10-02 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria. Therefore, an EMC or supplemental investigation was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (8) of systematic samples actually collected within LSA 10-02. The successful result of the retrospective power evaluation presented in Table 18-1 for LSA 10-02 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 10-02. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results and statistics are used in the sample size verification. Specifically, the mean and standard deviation of the eight topmost excavation surface samples (i.e., the WRS Test sample data set) are used to derive the relative shift for each LSA. Given the HDP Type I and Type II errors of 0.05 and 0.10, respectively, the calculated

relative shift is then correlated to a minimum sample size number as provided in Table 5-1 of MARSSIM.

- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures for LSA 10-02 was completed prior to the commencement of backfill operations.

Table 18-1
Retrospective Sample Size Verification for LSA 10-02

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.03
$DCGL_{SOF}$	1
LBGR (Mean)	0.07
Shift	0.93
Relative Shift (Δ/σ)	28.87
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 18-1
Data Evaluation Checklists prepared for LSA 10-02 (page 1 of 2)

Hematite Decommissioning Project	Procedure: HDP-PR-FSS-721, Final Status Survey Data Evaluation		
	Westinghouse Non-Proprietary Class 3	Revision: 7	Appendix G-1, Page 1 of 2

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

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: 02 **Description:** Northern Pits; northeast SU in Area 1

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 ☐	
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 ☐	
10.	Do the QC Sample Results meet the acceptance criteria as specified in HDP-PR-FSS-703, Final Status Survey Quality Control?	Yes ☒	No ☐	
11.	Are all Laboratory QC parameters within acceptable limits?	Yes ☒	No ☐	

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

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Figure 18-1
Data Evaluation Checklists prepared for LSA 10-02 (page 2 of 2)

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

Survey Area: No. LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: No. 02 **Description:** Northern Pits; northeast SU in Area 1

Discrepancy: N / A

Corrective Actions Taken: N / A

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

	(Print Name)	(Signature)	(Date)
Prepared by (HP Staff):	BRIAN A. MILLER		5/20/15
Approved by (RSO):	W. Clark Evans		5/27/15

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19.0 SURVEILLANCE FOLLOWING FSS

FSS GWS activities in LSA 10-02 were completed in February 2, 2015. During the timeframe since the completion of FSS field activities to the date of backfill of LSA 10-02, the SU did not evidence an event that would cause them to be suspect and thus require investigation.

20.0 CONCLUSION LSA 10-02

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

Table 20-1
LSA 10-02 SOF and Dose Summation

	AVERAGE SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.07	N/A	0.16	N/A	N/A	**0.23**
DOSE	1.75 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**5.75 mrem/year**

21.0 REFERENCES

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

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

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

21.4 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}

21.5 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)

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

22.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A: Analytical Data Evaluation Spreadsheets for LSA 10-01

APPENDIX B: Analytical Data Evaluation Spreadsheets for LSA 10-02

APPENDIX C: FSS Plan Development for LSA 10-01

APPENDIX D: FSS Plan Development for LSA 10-02

APPENDIX E: TestAmerica Laboratory Analytical Data Reports for LSA 10-01

APPENDIX F: TestAmerica Laboratory Analytical Data Reports for LSA 10-02

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

APPENDIX H: HDP-RPT-FSS-303, Summary Report for Burial Pit Area Remediation