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Our ref: HEM-17-72
Date: December 13, 2017

Subject: Westinghouse Hematite Decommissioning Project - Request for NRC Review of Final Status Survey Final Report Volume 3, Chapter 6, Survey Area Release Record for Land Survey Area 10, Survey Units Survey Units 05, 06, 07, 08, 09 and 10 (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 6, Survey Area Release Record for Land Survey Area 10, Survey Units Survey Units 05, 06, 07, 08, 09 and 10 (LSA 10-05 through LSA 10-10).

Attachment 1 contains Volume 3, Chapter 6, with a CD containing Appendices.

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

Sincerely,

/Kenneth E. Pallagi/

Kenneth E. Pallagi
Licensing Manager,
Hematite Decommissioning Project

Attachment: 1) Final Status Survey Final Report Volume 3, Chapter 6, Survey Area Release Record for Land Survey Area 10, Survey Units Survey Units 05, 06, 07, 08, 09 and 10, with CD containing Appendices (HDP-RPT-FSS-208)

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

NMSS20

Attachment 1

Final Status Survey Final Report Volume 3, Chapter 6

Survey Area Release Record for Land Survey Area 10, Survey Units 05, 06, 07, 08, 09 and 10
with CD containing Appendices

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Final Status Survey Report

Hematite Decommissioning Project

Final Status Survey Final Report Volume 3, Chapter 6

TITLE: **Survey Area Release Record for Land Survey Area 10, Survey Units 05, 06, 07, 08, 09 and 10 (LSA 10-05 through LSA 10-10)**

REVISION: **0**

EFFECTIVE DATE: DEC 13 2017

Approvals:

Author: _____ 12-13-2017
Kenneth E. Pallagi — Date

Owner/Manager: _____ 12/13/17
W. Clark Evers — Date

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LIST OF ACRONYMS AND SYMBOLS

ALARA	As Low As Reasonably Achievable
bgs	below ground surface
CFR	Code of Federal Regulations
cm	centimeter(s)
cpm	count(s) per minute
CSM	Conceptual Site Model
DCGL	Derived Concentration Guideline Level
$DCGL_W$	DCGL for average concentrations over a survey unit, used with statistical tests. ("W" suffix denotes "Wilcoxon")
DGPS	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
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
SOF	Sum of Fractions
SU	Survey Unit
Tc	Technetium
Th	Thorium
U	Uranium

WRS	Wilcoxon Rank Sum

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) 05 (LSA 10-05), SU 06 (LSA 10-06), SU 07 (LSA 10-07), SU 08 (LSA 10-08), SU 09 (LSA 10-09), and SU 10 (LSA 10-10). As provided in Final Status Survey Final Report (FSSFR), Volume 1, Chapter 1, Section 7.0 {ML15257A307}, the final report summary, FSSFR Volume 7, *Final Status Survey Final Report*, will be submitted at the conclusion of the post-remediation groundwater monitoring period. FSSFR Volume 7 will be submitted to demonstrate that the site has met the requirements for unrestricted release consistent with the requirements of the Title 10 Code of Federal Regulations (CFR) 20 Subpart E, "Criteria for License Termination."

All of the land area that comprises SUs LSA 10-05 through LSA 10-10 was designated as Class 1 as presented in Table 14-16 of the HDP Decommissioning Plan (DP) {ML092330123}. The Class 1 designation for all SUs that comprise the land area remained in effect throughout remediation and Final Status Survey (FSS). For SUs LSA 10-05 through LSA 10-10, evaluation of analytical results against the Derived Concentration Guideline Levels (DCGL) for the Uniform Stratum Conceptual Site Model (CSM) was the selected approach. The objective of the FSS for the SUs was to obtain and document measurement results, analytical data, and other supporting information in order to demonstrate that after completion of remediation the residual radioactivity levels in the LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 SUs are below the applicable Uniform Stratum DCGLs and therefore the land area of these SUs meet the criteria for unrestricted release.

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

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

1.0 REPORT BACKGROUND

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

FSSFR Volume 3, Chapter 1, Revision 2, *Land Survey Areas (LSA) Overview* provides the information common to land survey areas. This report, FSSFR Volume 3, Chapter 6, builds upon the general information provided in FSSFR Volume 3, Chapter 1, Revision 3.

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 SUs within a LSA. Figure 2-1 indicates the LSA configurations for the HDP site.

The DP stated that it was expected that the conceptual boundaries of the SUs would be altered based on the actual configuration and condition of the SU at the time of survey design. As expected, it was necessary to modify the boundary of 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 Survey Unit Description and Configuration

Upon completion of remediation, in its final configuration as prepared for FSS, the two dimensional surface area of each SU is listed below.

Table 2-1
LSA 10 Class 1 SU Surface Area Summary

LSA 10-05	LSA 10-06	LSA 10-07	LSA 10-08	LSA 10-09	LSA 10-10
1,341 m^2	888 m^2	1,209 m^2	111 m^2	216 m^2	1,030 m^2

2.3.1 LSA 10-05, LSA 10-06 and LSA 10-07 Survey Unit Description and Configuration

LSA 10-05, LSA 10-06, LSA 10-07 are located within the southern half of LSA 10, the Burial Pit Area. Figure 2-2 indicates the location of the SU's 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 the SU's.

The conceptual SU boundaries for LSA 10-05, LSA 10-06 and LSA 10-07 as originally provided in DP Figure 14-14 were identified as predominantly rectangular SUs. During remediation in the land area that comprises these SUs, as specific areas neared a radiological status that would support performance of FSS site staff at that time opted to reconfigure the boundaries for LSA 10-05, LSA 10-06 and LSA 10-07. Following the remediation approach and strategy in use at that time by the remediation contractor, the reconfiguration of the SUs supported isolation and

control of the land areas that comprised these SUs. The remediation strategy at that time created significantly large berms between these SUs and adjacent areas under remediation. As such the boundary configuration followed the establishment of the berms. There was no reduction in classification of any SU within LSA 10, thus ensuring compliance with the DP.

After the removal of buried materials and the completion of radiological remediation, in the final configuration, the SU's are comprised primarily of an excavated area which consists of native soil. There were no structures, piping, or spent limestone remaining within these SUs. Groundwater monitoring well WS-30 was present in SU LSA 10-07 prior to the start of remediation, and remained undisturbed and in service during the course of remediation. It continues to be monitored on a quarterly basis along with the other existing post-remediation groundwater monitoring wells, and the results reported in the respective Volume 6 chapters of the FSSFR.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 10-05 presents 1,341 square meters (m^2) in planar (2-dimensional) extent; the interior surface area (3-dimensional) was not estimated for LSA 10-05, rather the most conservative assumption was made that the SU also contained the maximum possible 1,341 m^2 of interior surface area.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 10-06 presents 888 m^2 in planar (2-dimensional) extent, within an estimated interior surface area of 914 m^2 (3-dimensional).

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 10-07 presents 1,209 m^2 in planar (2-dimensional) extent, within an interior surface area of 1,341 m^2 (3-dimensional).

2.3.2 LSA 10-08 Survey Unit Description and Configuration

LSA 10-08 is located in the northern most area of LSA 10. LSA 10-08 was not initially identified in the DP. The SU LSA 10-08 SU boundary encompasses a portion of SUs LSA 10-02 and LSA 11-01 as originally identified in the DP.

During preparations for site remediation the Northeast Site Creek Diversion was installed. The Northeast Site Creek Diversion was installed within SU LSA 11-01 a Class 2 survey area. The Northeast Site Creek Diversion served to prevent the transfer of storm water, and minimize the impacts of flooding events into the Burial Pit Area.

As remediation progressed in SU LSA 10-02 it became self-evident that remediation activities would continue in a northward direction beyond the, current at the time, northern boundary of SU LSA 10-02. Based upon the topography in the area, the site established that the remediation would extend into and concluded in the area of the earthen berm that served as part of the Northeast Site Creek Diversion.

In order to minimize potential storm water transfer or flooding into the Burial Pit Area, the site staff planned to perform an intensive short time period remediation of the area. As such the area in which the remediation would occur was defined and designated as LSA 10-08.

After the completion of radiological remediation, in the final configuration, LSA 10-08 was comprised of an excavated area which consisted of native soil. There were no structures, piping, or spent limestone within LSA 10-08.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 10-08 presents 111 m^2 in planar (2-dimensional) extent; as the SU was relatively flat the interior surface area was also estimated to be 111 m^2 (3-dimensional).

2.3.3 LSA 10-09 Survey Unit Description and Configuration

LSA 10-09 is located within the southern half of LSA 10, the Burial Pit Area. LSA 10-09 was not initially identified in the DP. The SU LSA 10-09 SU boundary encompasses a portion of SU LSA 10-06 as originally identified in the DP.

Remediation for both radiological and chemical contaminants in this area provided the site staff an opportunity to gain important information and validate assumptions in regards to chemical remediation. As such, the site staff performed a deep excavation (to the phreatic surface) of this small area to remediate chemical contamination and to observe the characteristics of the chemical contamination.

Upon completion of the deep excavation it became necessary to backfill the excavation to prevent introduction of contamination from the adjacent areas and to level the surface area of LSA 10-06 to allow continued remediation in the Burial Pit Area. As such the excavation in which the remediation occurred was defined and designated as LSA 10-09. Creation of SU LSA 10-09 allowed for the performance of and documentation of FSS prior to backfill of the area. LSA 10-09 is an underlying SU within LSA 10-06 and LSA 10-10.

After the completion of radiological remediation, in the final configuration, LSA 10-09 was comprised of an excavated area which consisted of native soil. There were no structures, piping, or spent limestone within LSA 10-09.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 10-09 presents 216 m^2 in planar (2-dimensional) extent, within an estimated interior surface area of 255 m^2 (3-dimensional).

2.3.4 LSA 10-10 Survey Unit Description and Configuration

LSA 10-10 is located within the southern half of LSA 10, the Burial Pit Area. LSA 10-10 was not initially identified in the DP. The SU LSA 10-10 SU boundary encompasses a portion of SUs LSA 10-05, LSA 10-06 and LSA 10-07 as originally identified in the DP.

As described in section 2.3.1, LSA 10-10 was established and configured to support the remediation strategy implemented at the time of remediation of the area.

After the completion of radiological remediation, in the final configuration, LSA 10-10 was comprised of an excavated area which consisted of native soil. There were no structures, piping, or spent limestone within LSA 10-10.

Upon completion of remediation, in its final excavated configuration as prepared for FSS, LSA 10-10 presents 1,030 m^2 in planar (2-dimensional) extent; as the SU did not contain steep interior sidewalls or slopes that would significantly add area to the SU the interior surface area was also estimated to be 1,030 m^2 (3-dimensional).

Figure 2-1
HDP Land Survey Areas

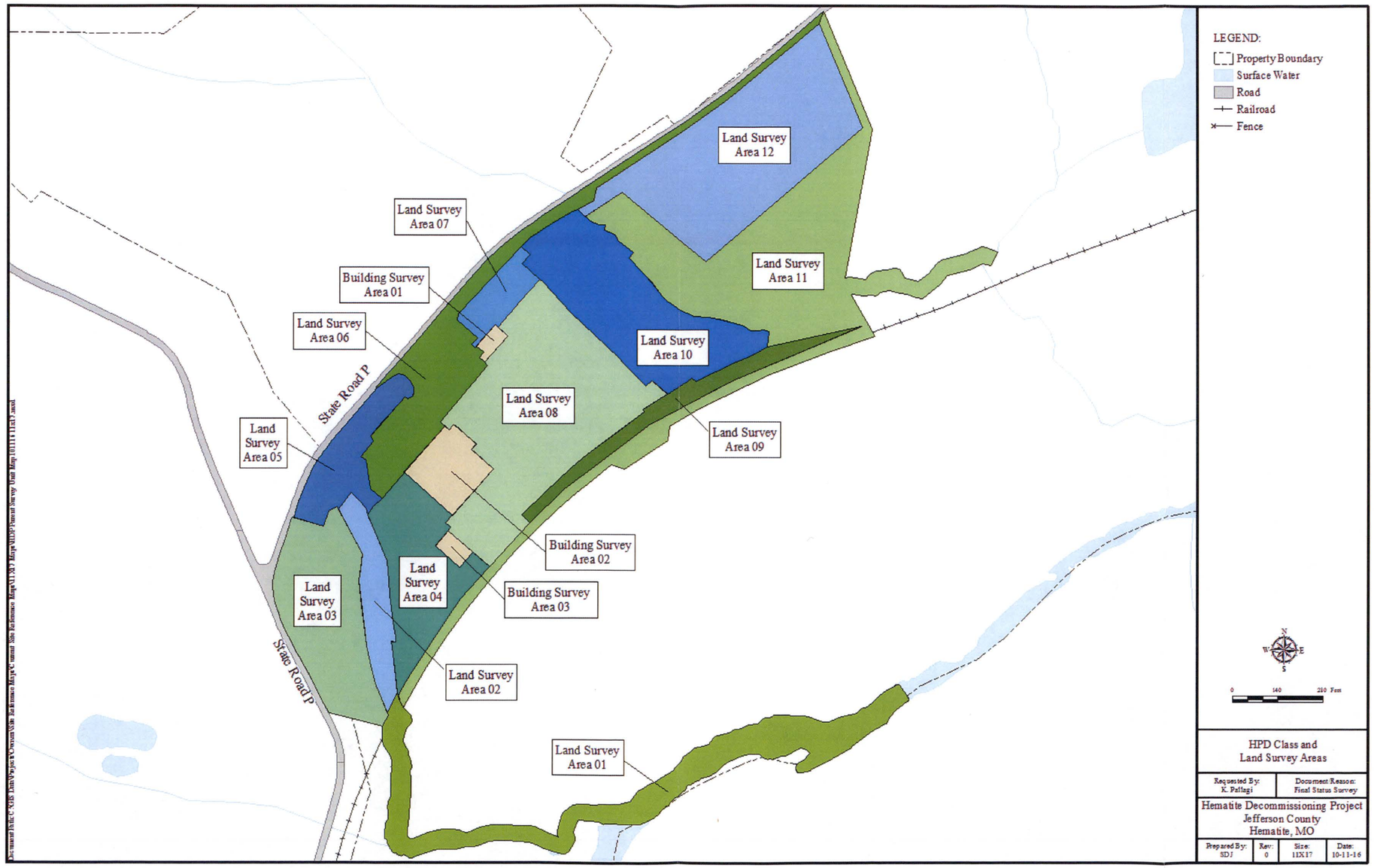


Figure 2-2
Final Configuration of Land Survey Area 10 and Survey Units

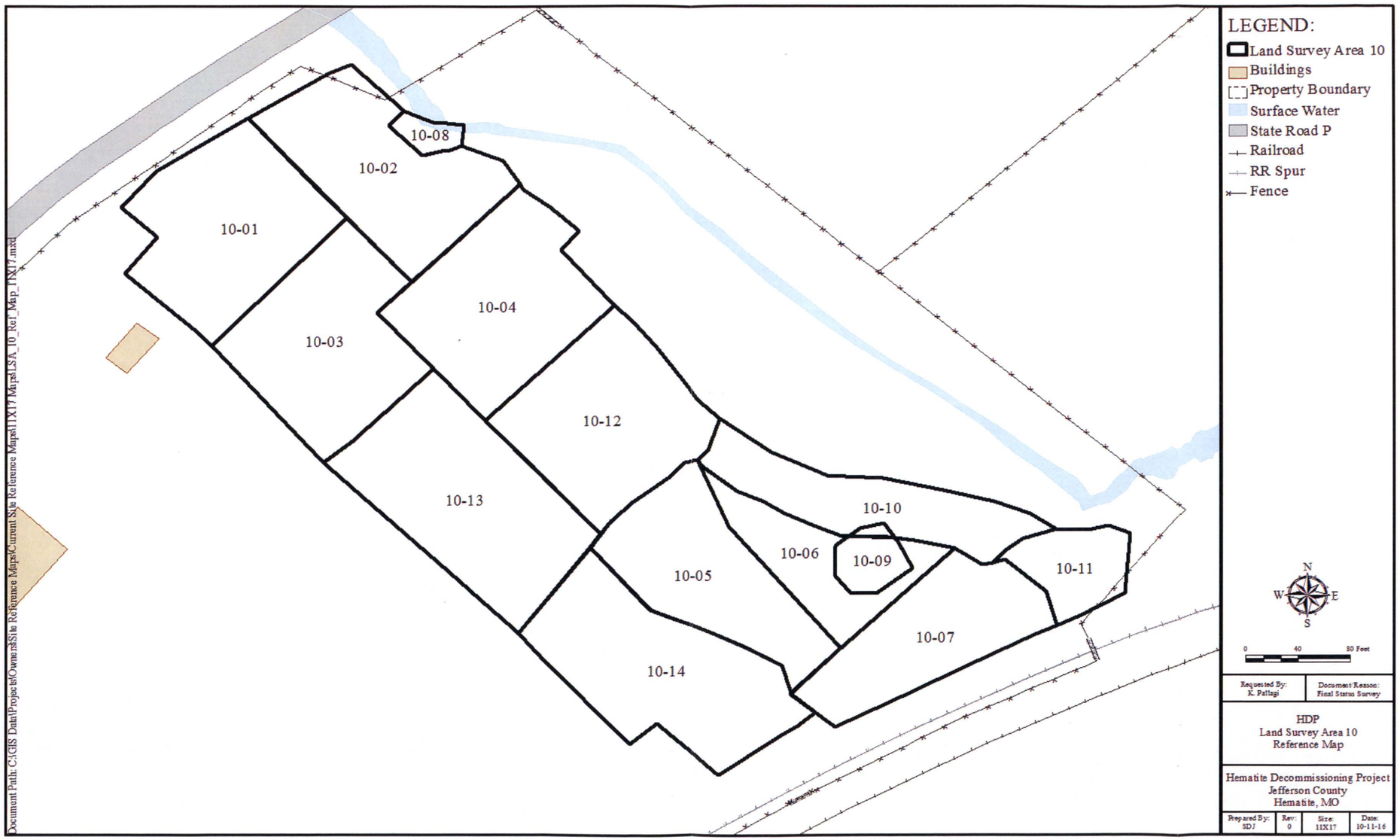
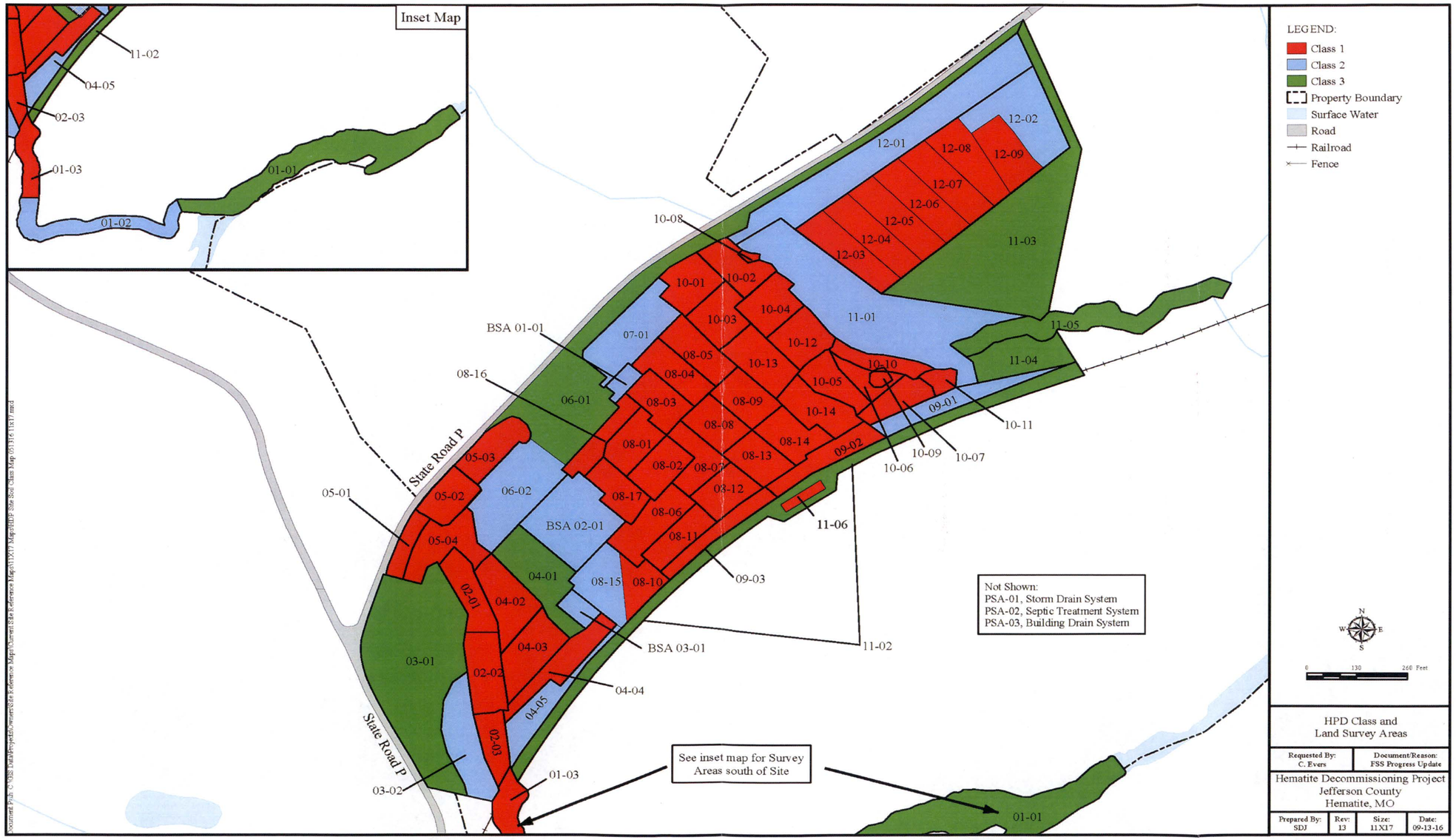


Figure 2-3
Final Configuration of Land Survey Areas and Survey Units



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".

3.1 Radioactive Materials in the LSA 10-05 through LSA 10-10

Radioactive materials within LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 resulted from placement of radioactive contaminated materials below grade and above grade. During the remediation (see Figure 3-1) of these SUs various types of waste materials were encountered, including drums, bags of trash, fuel pellets, construction debris, small quantities of spent limestone, and contaminated soils.

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 (see Figure 3-2). Figure 3-1 and Figure 3-2 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 South Burial Pit Area (2012)

Figure 3-2
Burial Pit becoming Clearly Visible after Overburden Removal

3.2 Reuse Soil Disposition and Characterization

Prior to remediation and removal of contaminated soil and other waste materials within LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, and LSA 10-10, 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

The sections below provide a discussion of the various elements of remediation and the RASS phase of LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 necessary to prepare the SUs for FSS.

3.3.1 Remedial Actions LSA 10-05, LSA 10-06, LSA 10-07 and LSA 10-10

Remedial actions began in LSA 10-05, LSA 10-06, LSA 10-07, and LSA 10-10 in April, 2012, and continued through November, 2013. Types of waste materials encountered during the remediation were detailed in Section 3.1.

There were several indicators inherent in the remediation process of theses SU's 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. LSA 10-05, 10-06, 10-07, and 10-10 were considered "typical" buried waste excavations.

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 3-3 and Figure 3-4). 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 3-3
Example of Burial Pit Soil Discoloration

Figure 3-4
Example of Unearthed Trash and Debris in the Burial Pit Area

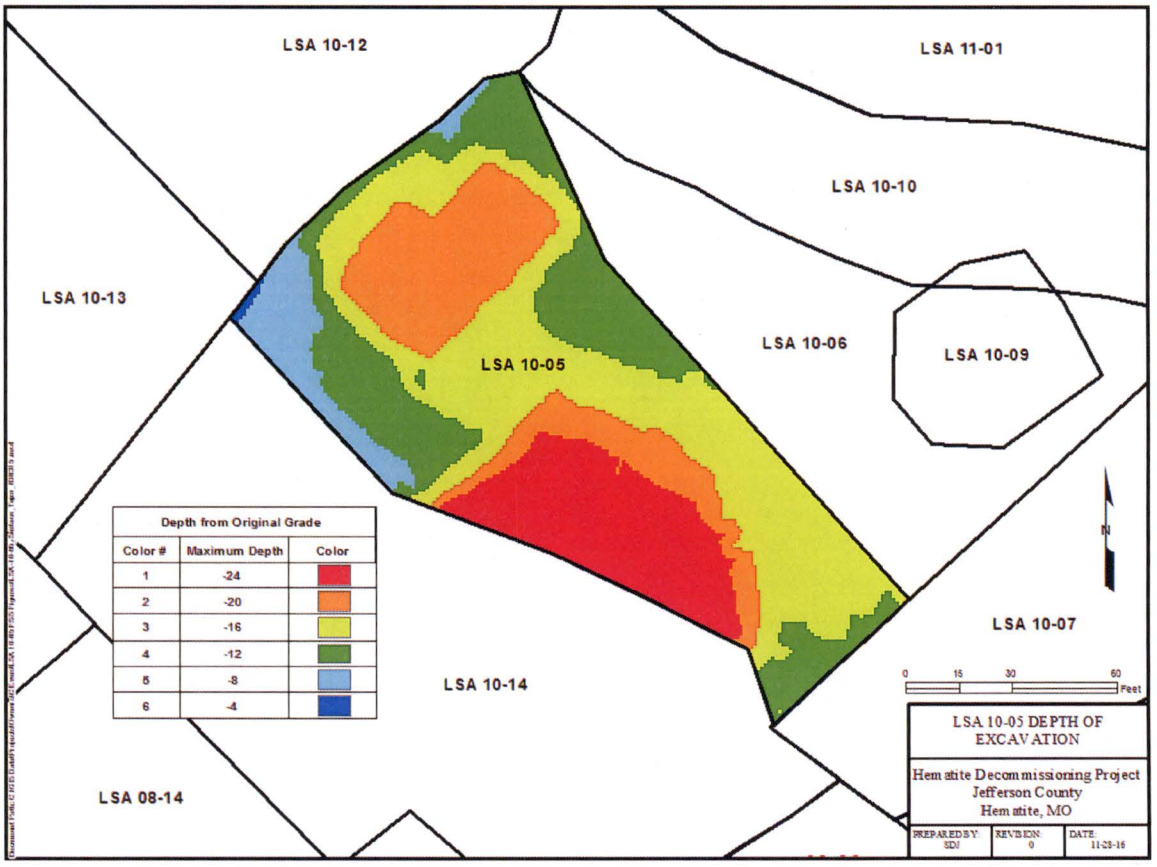
As excavation and remediation of the Burial Pit Area progressed, it became apparent that most of the buried debris was located in the north and south ends of the Burial Pit Area, and typically in closely aligned pits, while the central area had minimal debris and contamination. Since sloping and benching 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 T) contains additional specific information related to the remediation of the Burial Pit Area.

The maximum depth of remedial excavation necessary in portions of LSA 10-05 to ensure all areas identified during site characterization and remedial action survey efforts were adequately remediated relative to the original grade was 24 feet. The estimated volume of excavated waste materials from LSA 10-05 was 6,089 cubic yards. Figure 3-5 provides the depth of excavations for LSA 10-05.

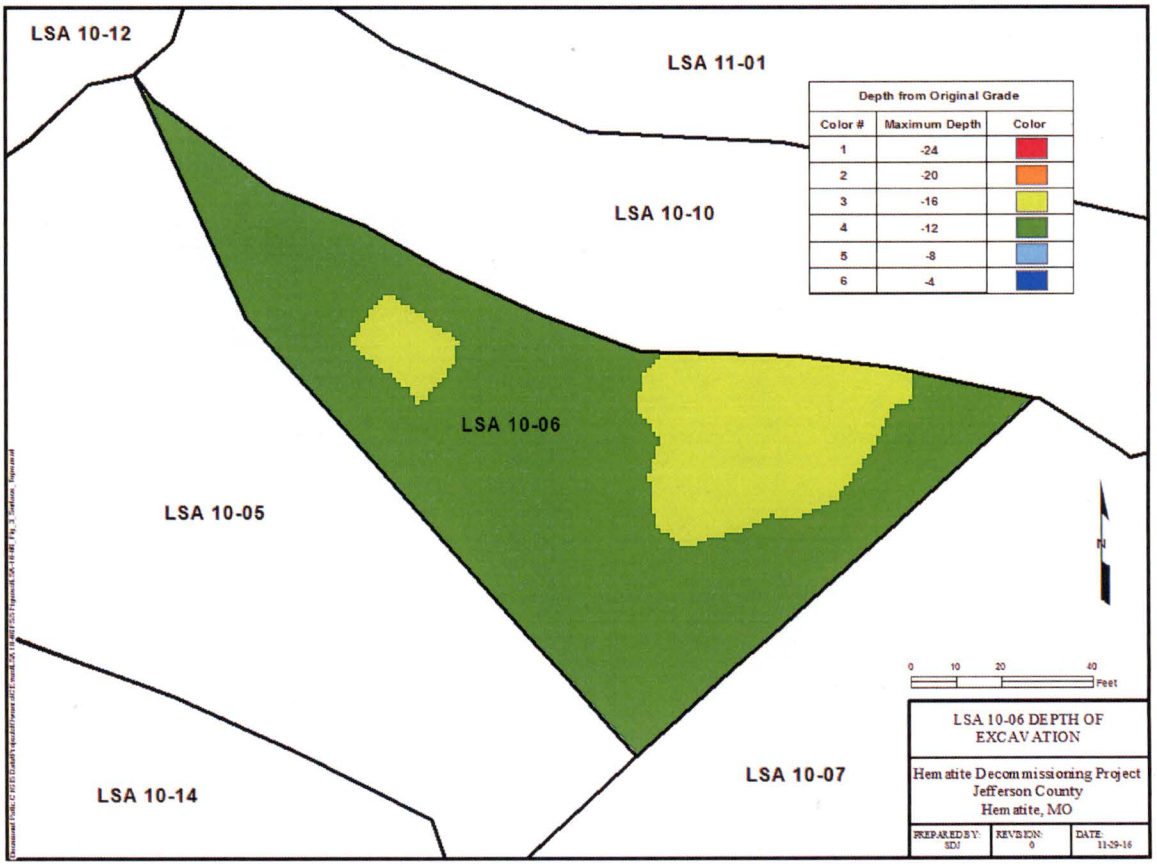
Figure 3-5
LSA 10-05 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 24 feet.

The maximum depth of remedial excavation necessary in portions of LSA 10-06 to ensure all areas identified during site characterization and remedial action survey efforts were adequately remediated relative to the original grade was 16 feet. The estimated volume of excavated waste materials from LSA 10-06 was 3,097 cubic yards. Figure 3-6 provides the depth of excavations for LSA 10-06.

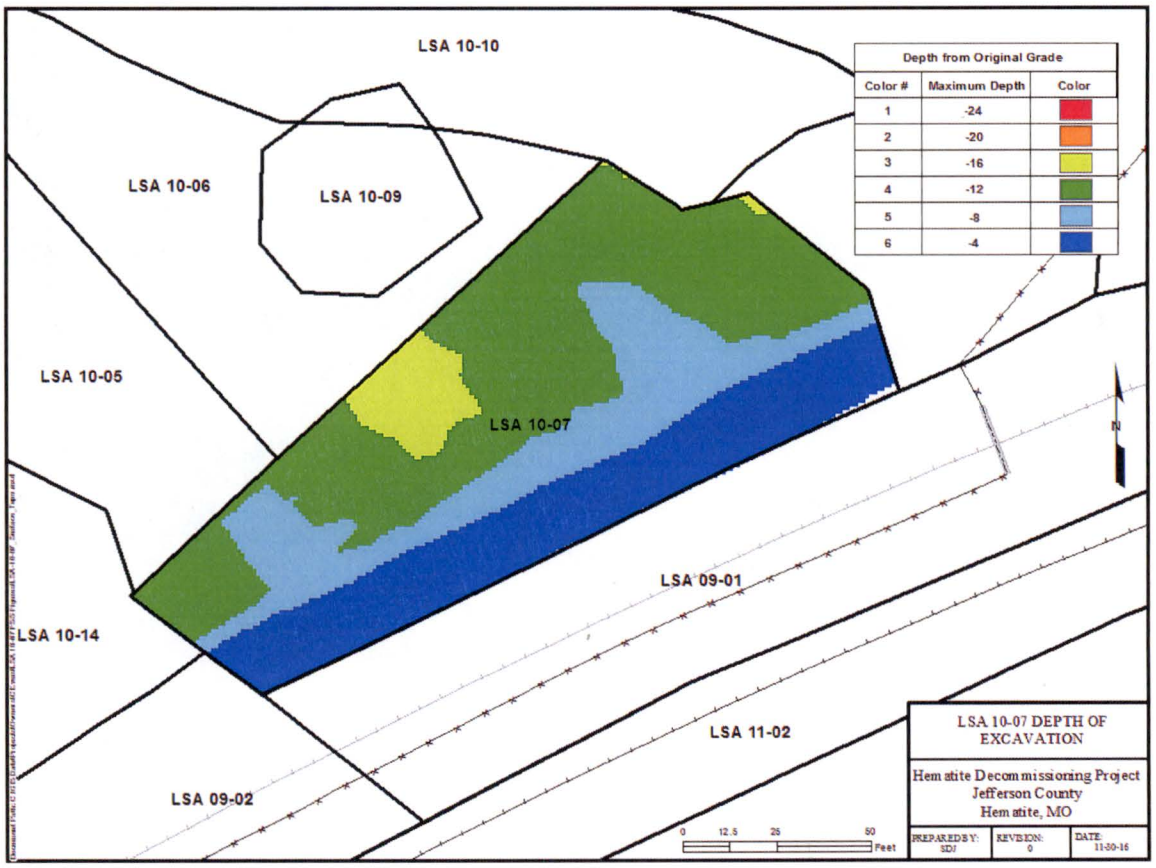
Figure 3-6
LSA 10-06 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 16 feet.

The maximum depth of remedial excavation necessary in portions of LSA 10-07 to ensure all areas identified during site characterization and remedial action survey efforts were adequately remediated relative to the original grade was 16 feet. The estimated volume of excavated waste materials from LSA 10-07 was 1,955 cubic yards. Figure 3-7 provides the depth of excavations for LSA 10-07.

Figure 3-7
LSA 10-07 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 16 feet.

3.3.1.1 Additional Remedial Actions LSA 10-10

After remediation of LSA 10-10 the RASS for FSS design was completed. Subsequently FSS of LSA 10-10 commenced. During FSS the GWS of LSA 10-10 identified an area with an elevated reading that was discrete when compared to the surrounding area. Upon further investigation of the area a fuel pellet was identified near the surface of the excavation just inches below the exposed soil surface. Also, during systematic sampling portion of FSS, some small amounts of rubber and plastic debris were identified within the SU. The rubber and plastic debris were determined to originate from up gradient storm water wattles that were placed in the LSA to stop the migration of storm water from the Northeast Site Creek Diversion into the Burial Pit Area. Due to these findings, FSS in LSA 10-10 was paused while investigative actions took place.

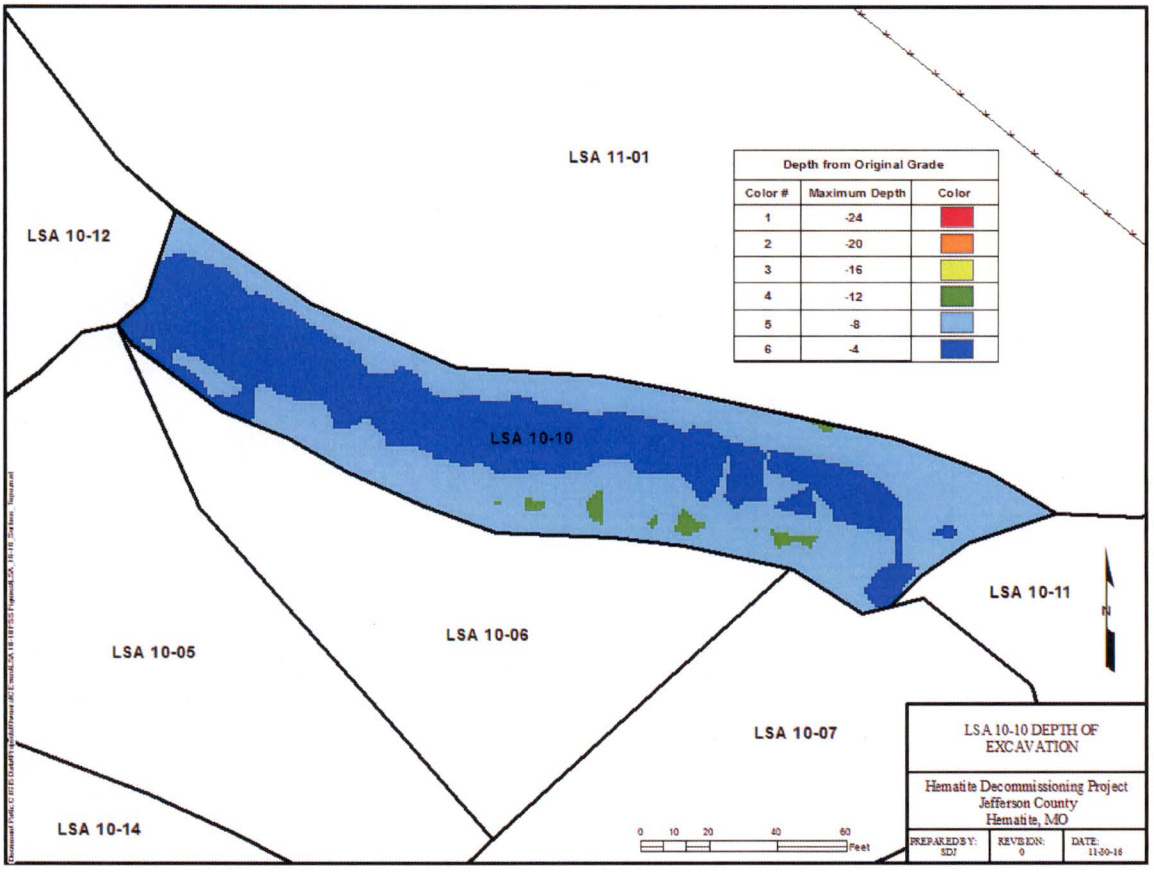
Additional excavations were performed where the material was identified, while no other sources of discrete radioactive material were found, small amounts of miscellaneous debris were identified.

The investigation identified that small amounts of waste soil was stockpiled in LSA 10-10 during remediation of the area. Along with the other radiological survey data and visual inspections it was concluded that small amounts of residual waste soil and radiologically clean debris were not completely removed from LSA 10-10 when transferring the waste to the Waste Hold Area. Based upon the results of the investigation, utilizing the DQO process as implemented by site FSS procedures, the FSS of LSA 10-10 was halted.

The remediation contractor was notified to recommence remediation of LSA 10-10. Based upon the radiological data gathered Radiological Engineering directed the additional excavations in LSA 10-10 to ensure that the area appeared to meet the DCGLs and that all miscellaneous clean debris was identified and removed. Prior to commencement of remediation activities the area that is LSA 10-10 was previously covered by dense brush and trees, and bordered the Northeast Site Creek. To ensure all possible debris was identified and removed the additional remediation excavations also proceeded in the north area of the SU until the roots of the former trees became visible and it was apparent that all remaining soil was the undisturbed native soil that existed prior the creation of the adjacent Burial Pit Area. Upon completion of remediation the FSS Plan was revised, the FSS GWS was re-performed, and a new set of systematic samples were collected.

The maximum depth of remedial excavation necessary in portions of LSA 10-10 to ensure all areas identified during site characterization and remedial action survey efforts were adequately remediated relative to the original grade was 12 feet. The estimated volume of excavated waste materials from LSA 10-10 was 1,191 cubic yards. Figure 3-8 provides the depth of excavations for LSA 10-10.

Figure 3-8
LSA 10-10 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 12 feet.

3.3.2 Remedial Actions LSA 10-08

As remediation progressed in SU LSA 10-02 it became self-evident that remediation activities would continue in a northward direction beyond the, current at the time, northern boundary of SU LSA 10-02. Based upon the topography in the area, the site established that the remediation would extend into and concluded in the area of the earthen berm that served as part of the Northeast Site Creek Diversion.

In order to minimize potential storm water transfer or flooding into the Burial Pit Area, the site staff planned to perform an intensive short time period remediation of the area. As such the area in which the remediation would occur was defined and designated as LSA 10-08 (see Figure 3-9).

Performance of the remediation work for LSA-10-08 was also scheduled for the time of year when the Northeast Site Creek is typically dry and the potential for presence of water is very low (i.e., the summer months of July and August).

Figure 3-9
LSA 10-08 Area of Remediation

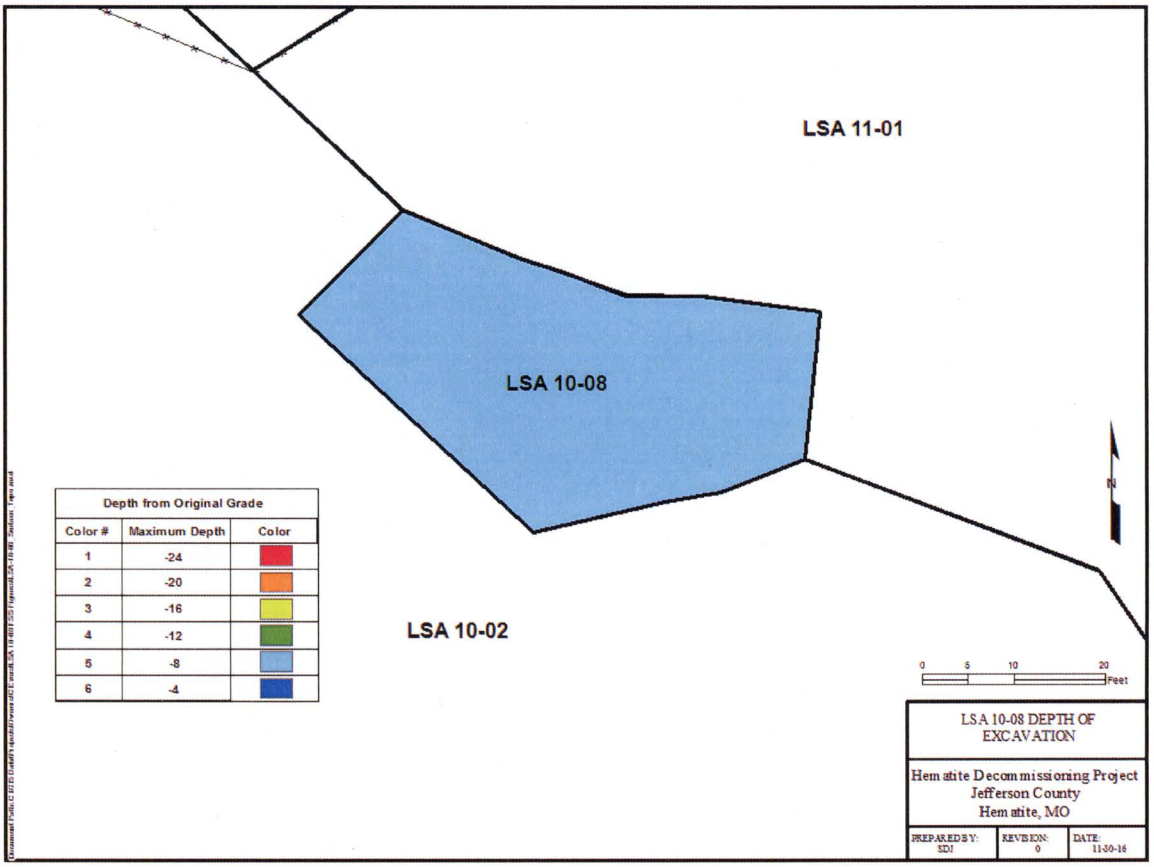
Remediation of the area consisted of removal of the berm which included removal of soil and native rock from the upper portions of the berm. Once the remediation of the upper portion of the berm was completed, very few native rocks were observed. Excavation was completed to a point where the results of the GWS indicated that remediation was complete, the material excavated was observed by Radiological Engineering to be free of debris, and that the excavation consisted predominately of native soil and a minor amount of non-native rock (previously installed rip-rap for the diversion).

Due to the necessity to rapidly restore the Northeast Site Creek Diversion (see Figure 3-10) to an operable condition Westinghouse requested that the NRC Region III Inspector be on site and available to conduct confirmatory sampling once site staff completed remediation and FSS. The NRC Region III completed confirmatory sampling of LSA 10-08. The results of the confirmatory sampling are contained in NRC Inspection Report 07000036/2013003(DNMS) {ML13336A408}.

Figure 3-10
LSA 10-08 Section of Northeast Site Creek Diversion Restored after FSS

The maximum depth of remedial excavation necessary in portions of LSA 10-08 to ensure all areas identified during site characterization and remedial action survey efforts were adequately remediated relative to the original grade was 8 feet. The estimated volume of excavated waste materials from LSA 10-08 was 191 cubic yards. Figure 3-11 provides the depth of excavation for LSA 10-08.

Figure 3-11
LSA 10-08 Depth of Excavation Map (Depths in Feet)*



*Depth of Excavation Map presented in colored bands of feet. Maximum depth is 8 feet.

3.3.3 Remedial Actions LSA 10-09

SU LSA 10-06 (as originally identified in the DP) was one of the first areas within the Burial Pit Area to be remediated. Remediation for both radiological and chemical contaminants in this area provided the site staff an early opportunity to gain important information and validate assumptions in regards to chemical remediation. As such, the site staff performed a deep excavation (to the phreatic surface) of this small area to remediate chemical contamination and to observe the characteristics of the chemical contamination.

Upon completion of the observations in the deep excavation it became necessary to backfill the excavation to prevent introduction of contamination from the adjacent areas and to level the surface area of LSA 10-06 to allow continued remediation in the Burial Pit Area. The remediation contractor opted to take GPS topography measurements of the excavation and plastic sheeting was placed in the excavation as a visual aid prior to backfilling.

As the general area of the south Burial Pit Area (LSA 10-06, LSA 10-07 and subsequent LSA 10-10) remediation appeared to be complete the remediation contractor advised Westinghouse of

the intent to turn the area over for FSS activities. At that time, Westinghouse notified the remediation contractor that to ensure compliance with the DP in regard to FSS that the area where the deep excavation for chemical characteristic observation was conducted was required to be re-excavated to the excavation elevation that existed prior to backfilling. To accommodate FSS of the deep excavation, the area of the excavation was defined and designated as LSA 10-09.

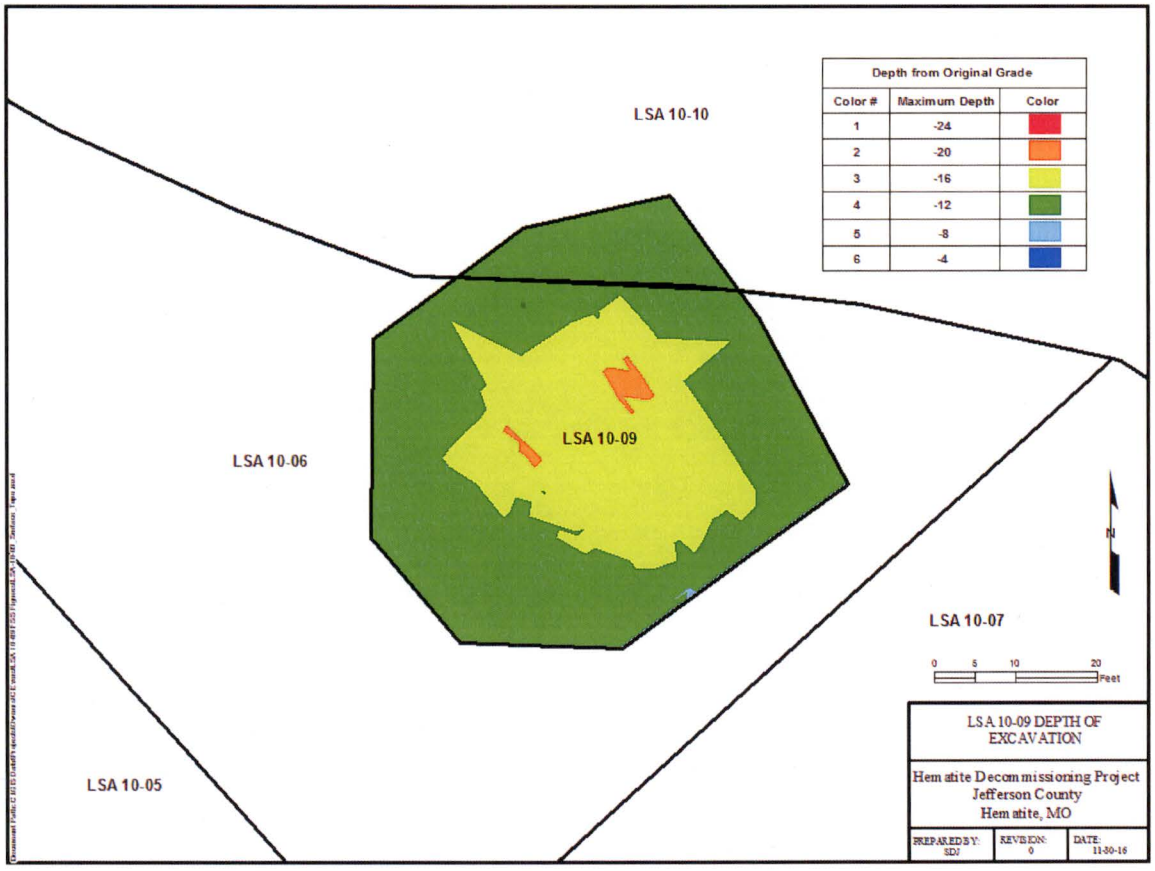
The remediation contractor excavated the LSA 10-09 area and turned it over to Westinghouse for FSS. FSS activities commenced with HP Technicians identifying pieces of plastic sheeting within the soil. FSS activities were halted. Subsequent to the identification of the plastic sheeting the NRC Region III Inspector conducting confirmatory sampling in LSA 10-9 also identified the plastic sheeting (NRC Inspection Report 07000036/2013003(DNMS) {ML13336A408}.

Upon determination that the plastic sheeting was the plastic sheeting placed by the remediation contractor and not material indicative of buried waste, the remediation contractor was dispatched to continue the excavation of LSA 10-09 to ensure all plastic sheeting previous placed under the clean backfill was removed, thus ensuring that the deep excavation elevation had been exposed.

Site staff completed FSS planning activities and subsequently completed FSS. Upon completion of FSS the remediation contractor backfilled LSA 10-09 to the elevation of -16 feet as indicated on Figure 3-6, *LSA 10-06 Depth of Excavation Map.*

The maximum depth of remedial excavation conducted relative to original grade was 20 feet. The estimated volume of excavated waste materials from LSA 10-09 was 780 cubic yards. Figure 3-12 provides the depth of excavations for LSA 10-09.

Figure 3-12
LSA 10-09 Depth of Excavation Map (Depths in Feet)*



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

3.3.4 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.

3.3.5 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 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10, 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 3-13 through Figure 3-18) 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.

The survey measurements from all of the spoils material and boreholes for LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10, 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 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10. 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 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10.

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Figure 3-13
NCS Core Bore Locations in LSA 10-05

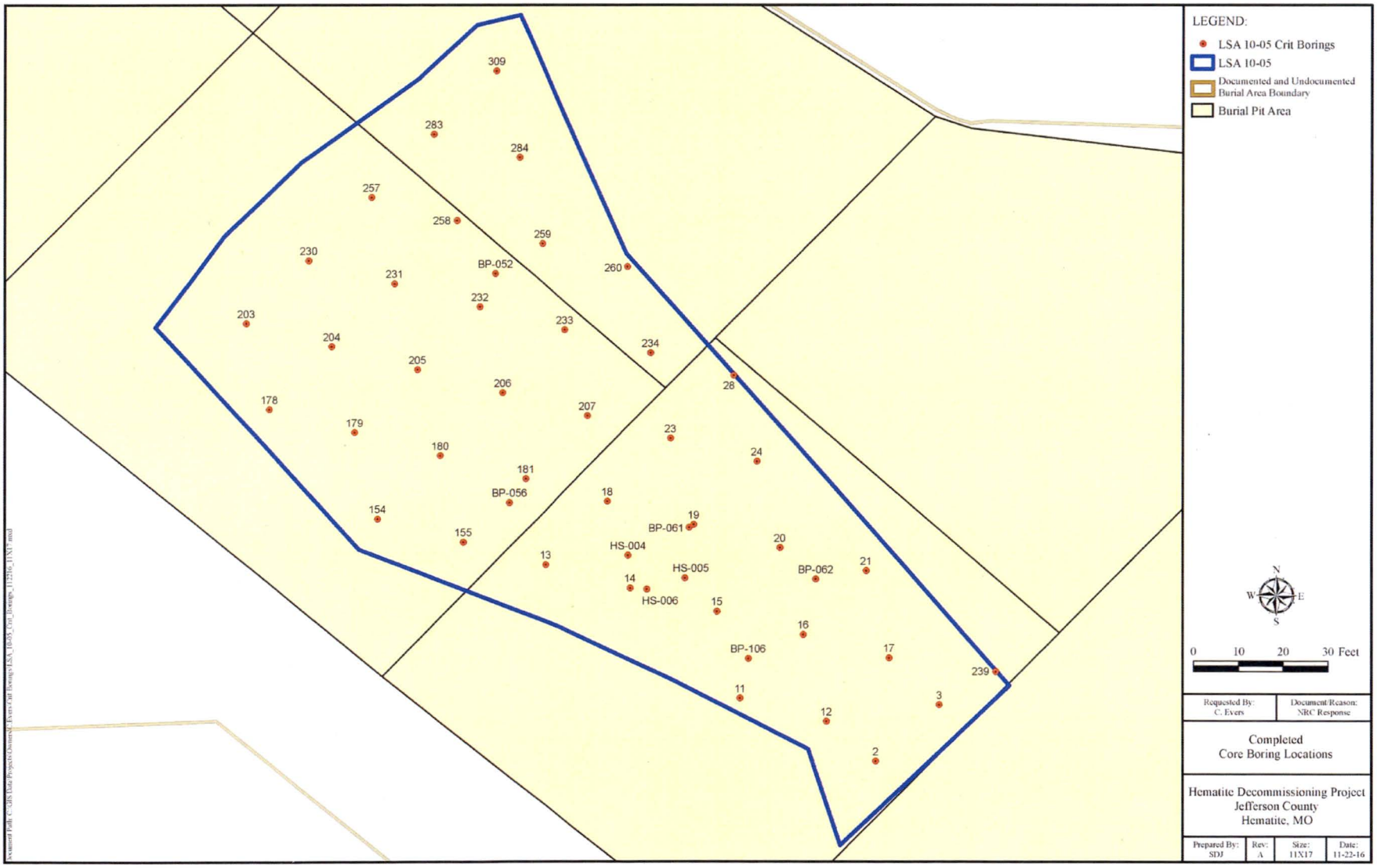


Figure 3-14
NCS Core Bore Locations in LSA 10-06

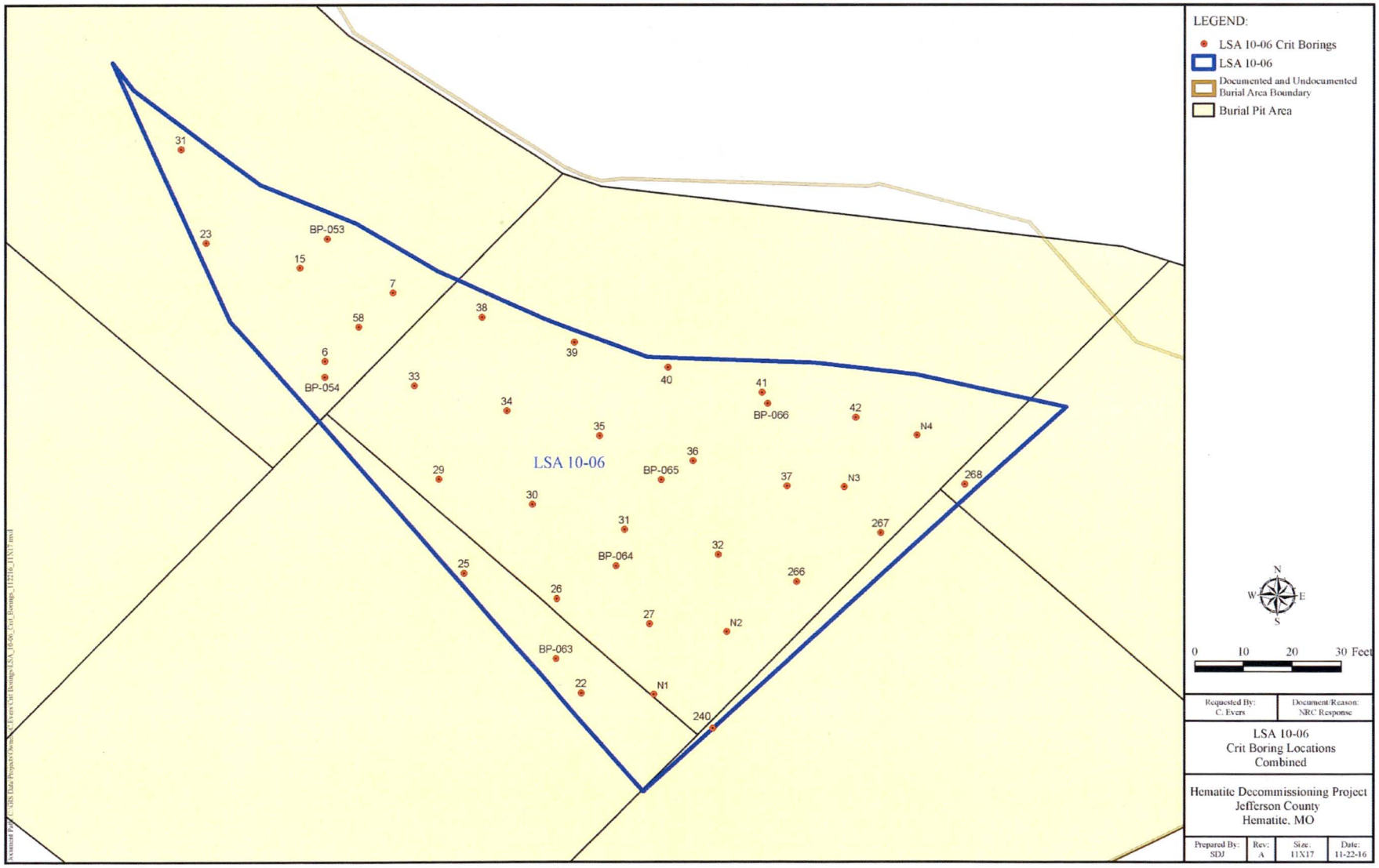


Figure 3-15
NCS Core Bore Locations in LSA 10-07

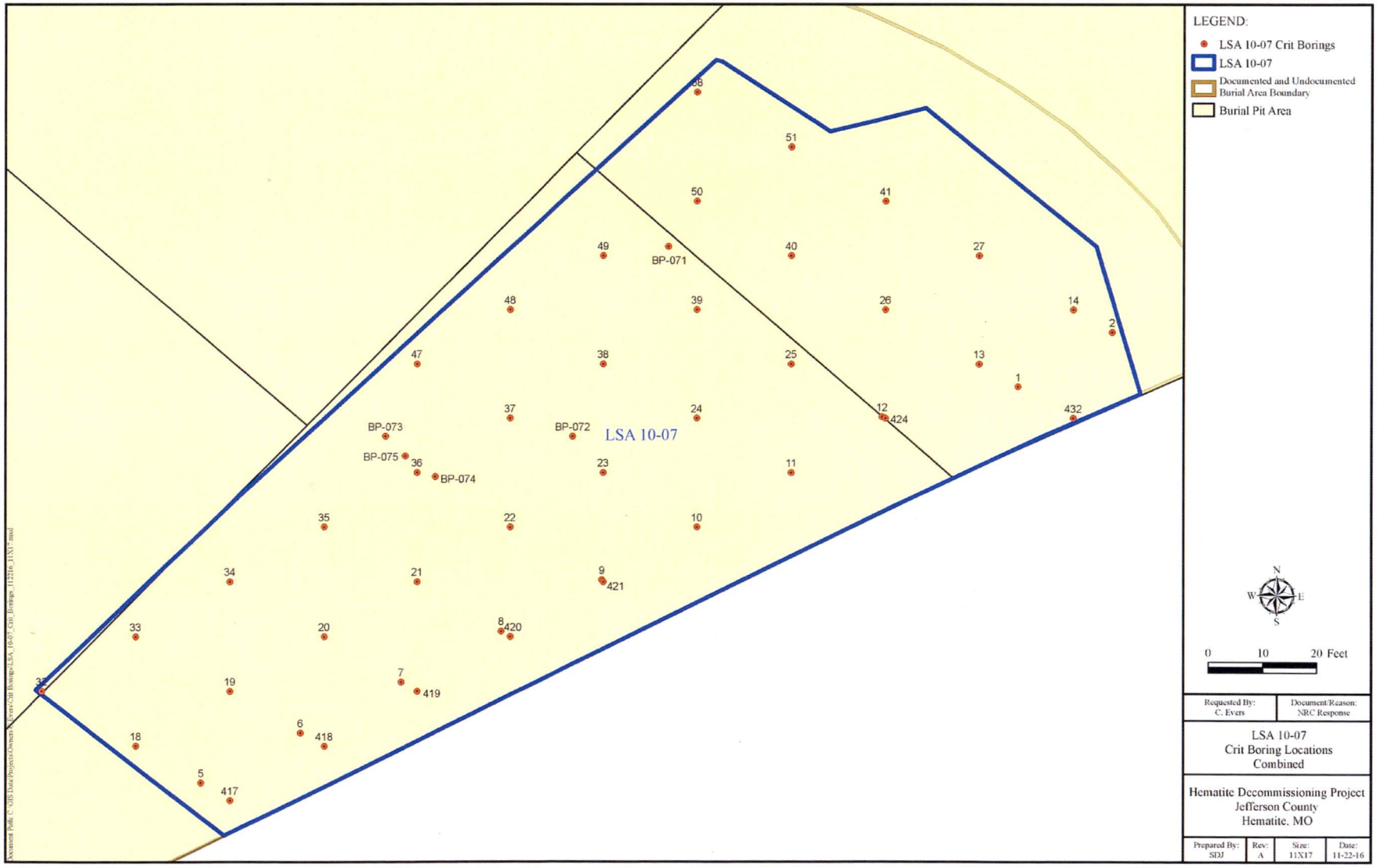


Figure 3-16
NCS Core Bore Locations in LSA 10-08

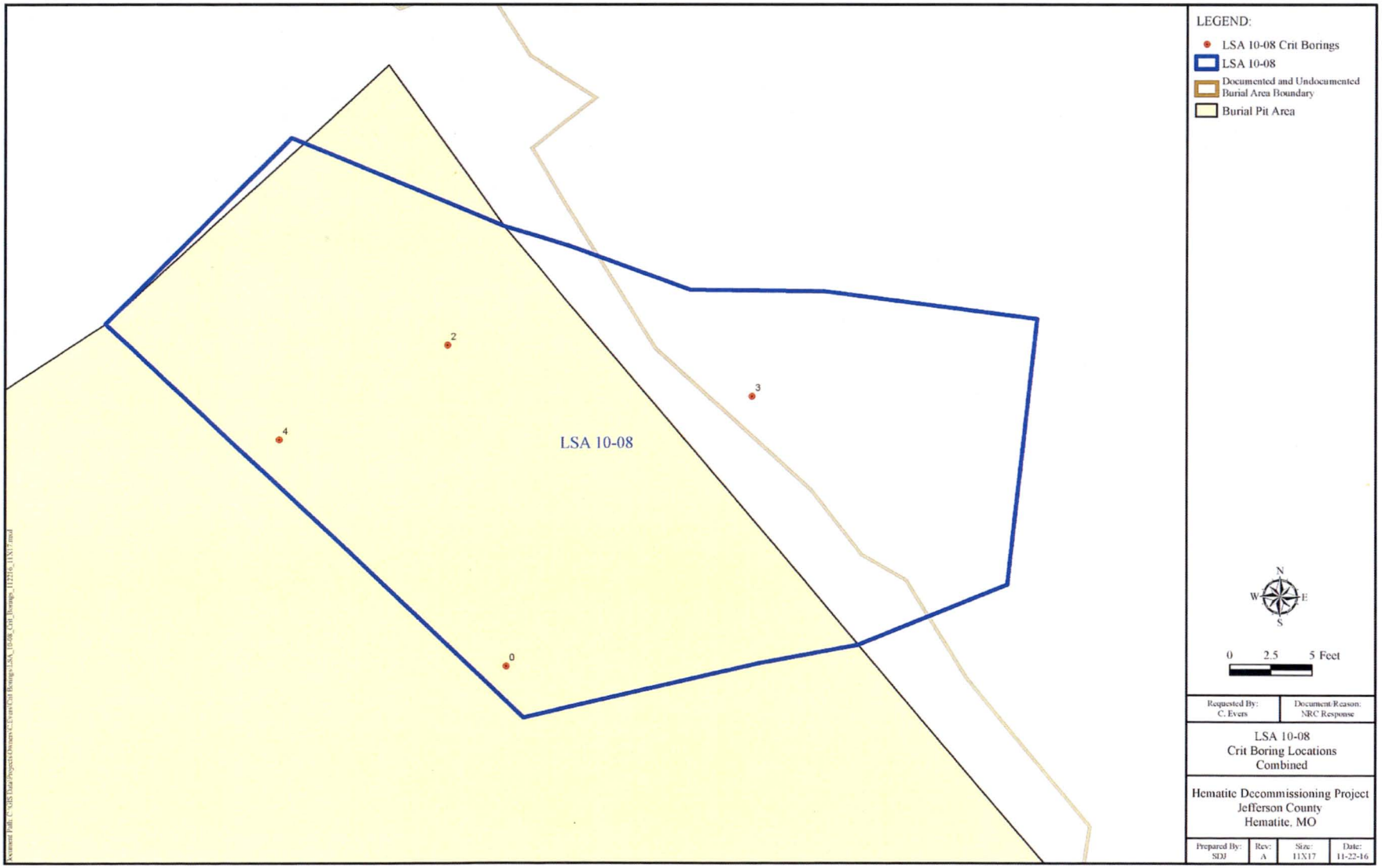


Figure 3-17
NCS Core Bore Locations in LSA 10-09

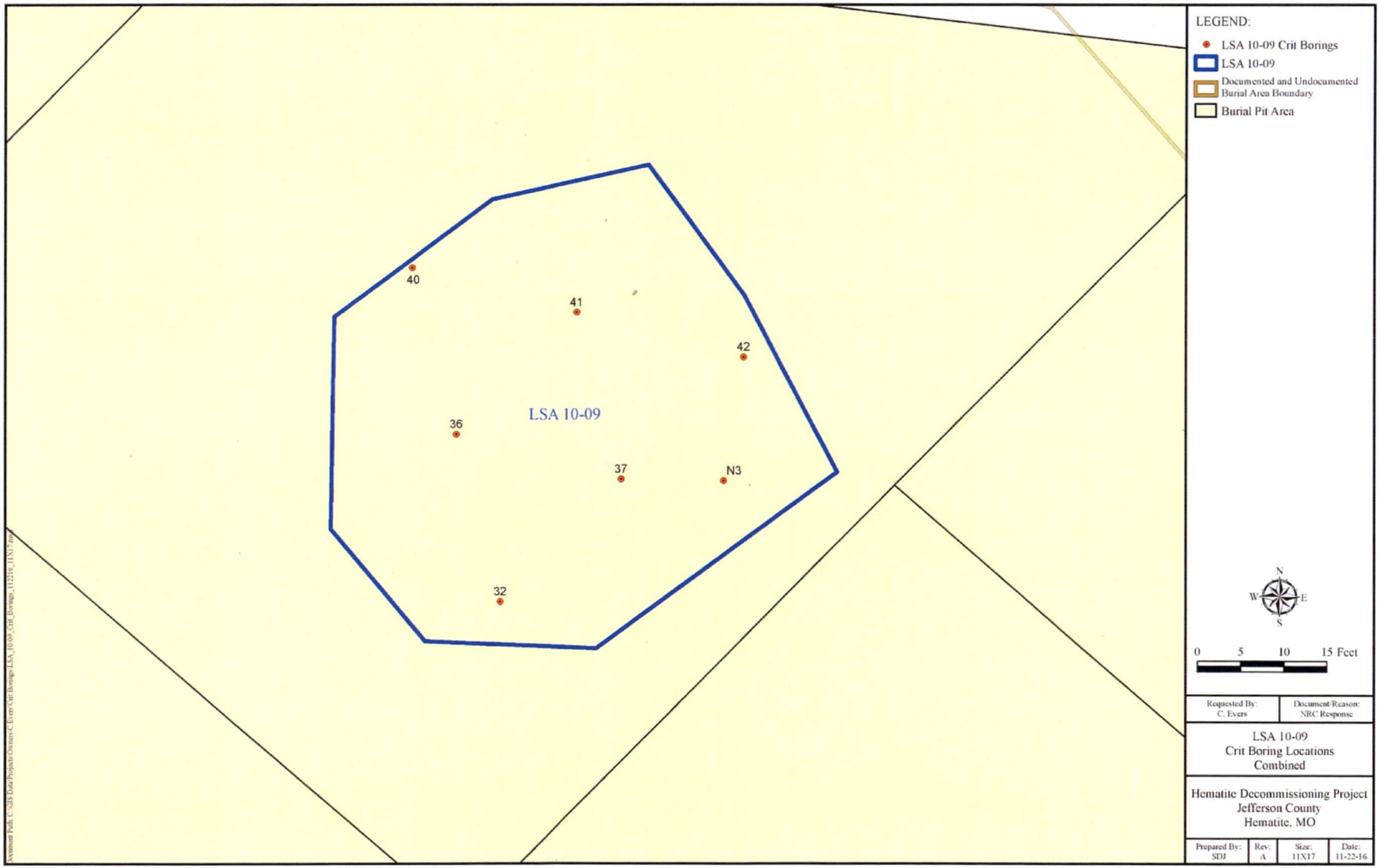
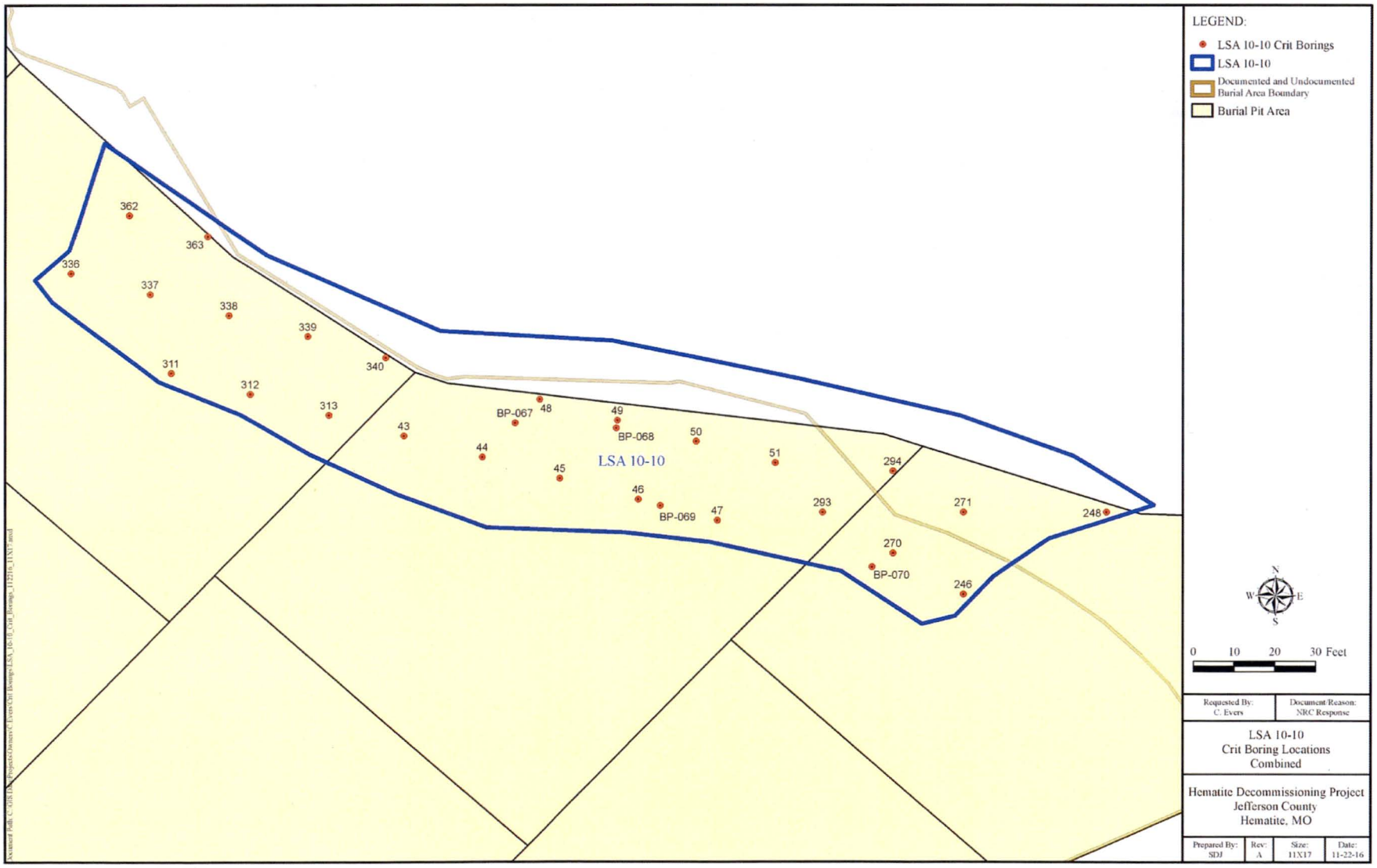


Figure 3-18
NCS Core Bore Locations in LSA 10-10



3.3.6 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 no groundwater monitoring wells were located within the boundary limits of LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, and LSA 10-09.

Groundwater monitoring wells WS-30 and WS-31 were located within LSA 10-10 prior to remediation and remain in place and operable. WS-30 is monitored on a quarterly basis for groundwater elevation of the Jefferson City – Cotter Hydrostratigraphic Unit, and the elevations provided in the respective FSSFR Volume 6 chapter. WS-31 is monitored on a quarterly basis for chemical contaminants only, as part of the Interim Groundwater Monitoring Plan.

3.3.7 Subterranean Piping

Preliminary remediation planning activities indicated that no subterranean process piping should be encountered in LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10. During remediation of LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 no subterranean process piping was encountered.

As no buried piping remains under the footprint of LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 there is no dose contribution from this pathway.

3.3.8 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 fifty four (54) core borings to depths as deep as 35 feet bgs were performed for characterization within LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-09 and LSA 10-10 prior to remediation. Due to the small size of LSA 10-08, and the fact that it was originally part of the larger LSA 10-02, there were no characterization sample locations that specifically fell inside the boundaries of LSA 10-08.

Within LSA 10-05, four (4) of the fifteen (15) characterization boring locations within the SU exceeded a SOF of 1 as compared to the Uniform Stratum criteria (samples SS-BP-052, SS-HS-005, SS-HS-004, and SS-HS-006-EL) up to a maximum depth of 15 ft bgs. Remediation progress was reviewed to ensure that these areas were adequately removed during remediation with excavation occurring to average depths of 16 to 24 feet bgs at these locations.

Within LSA 10-06, none of the nine characterization boring locations within the SU exceeded a SOF of 1 as compared to the Uniform Stratum criteria.

Within LSA 10-07, two (2) of the fourteen (14) characterization boring locations within the SU exceeded a SOF of 1 as compared to the Uniform Stratum criteria (samples SS-BP-075, WS-BP8A-10) up to a maximum depth of 10 ft bgs. Remediation progress was reviewed to ensure that these areas were adequately removed during remediation with excavation occurring to average depths of 12 to 16 feet bgs at these locations.

Within LSA 10-09, two of the six characterization boring locations within the SU exceeded a SOF of 1 as compared to the Uniform Stratum criteria (samples SS-BP-065, SS-BP-066) up to a maximum depth of 5 feet bgs. Remediation progress was reviewed to ensure that these areas were adequately removed during remediation with excavation occurring to average depths of 12 to 20 feet bgs at these locations.

Within LSA 10-10, none of the ten (10) characterization boring locations within the SU exceeded a SOF of 1 as compared to the Uniform Stratum criteria.

Figures 3-19 through Figure 3-23 provide the location of the characterization samples taken in each SU.

Figure 3-19
Site Characterization Borings within LSA 10-05

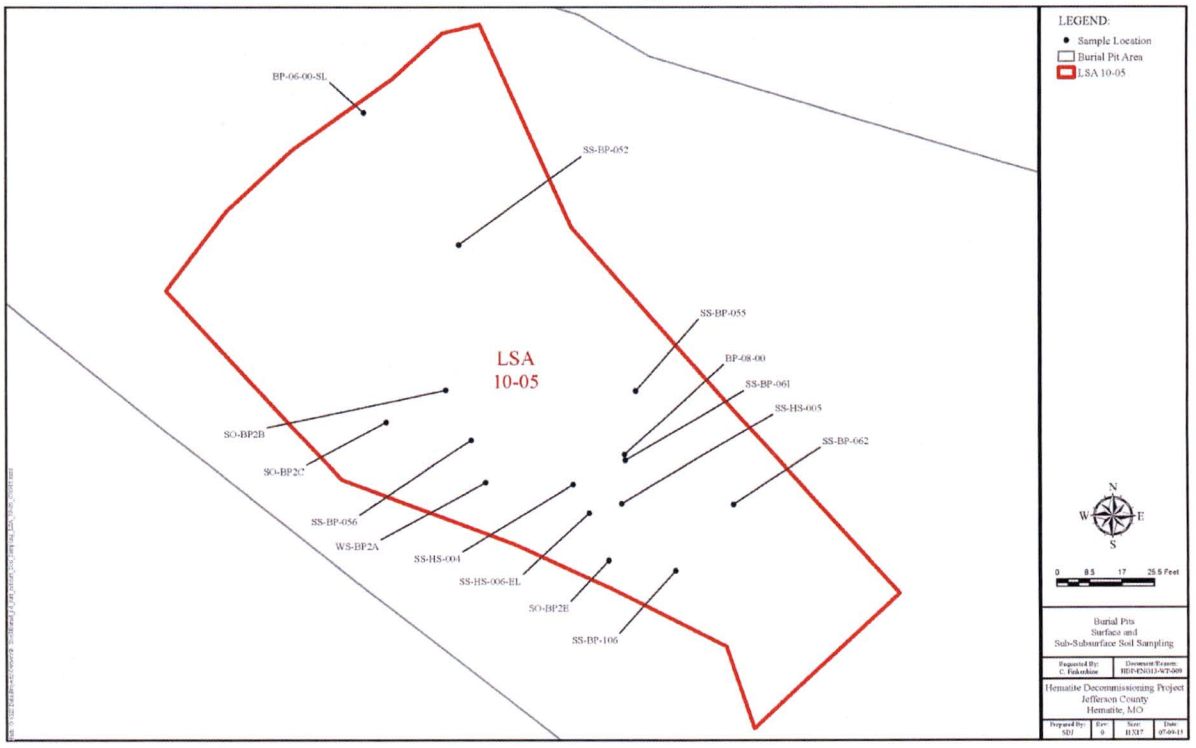


Figure 3-20
Site Characterization Borings within LSA 10-06

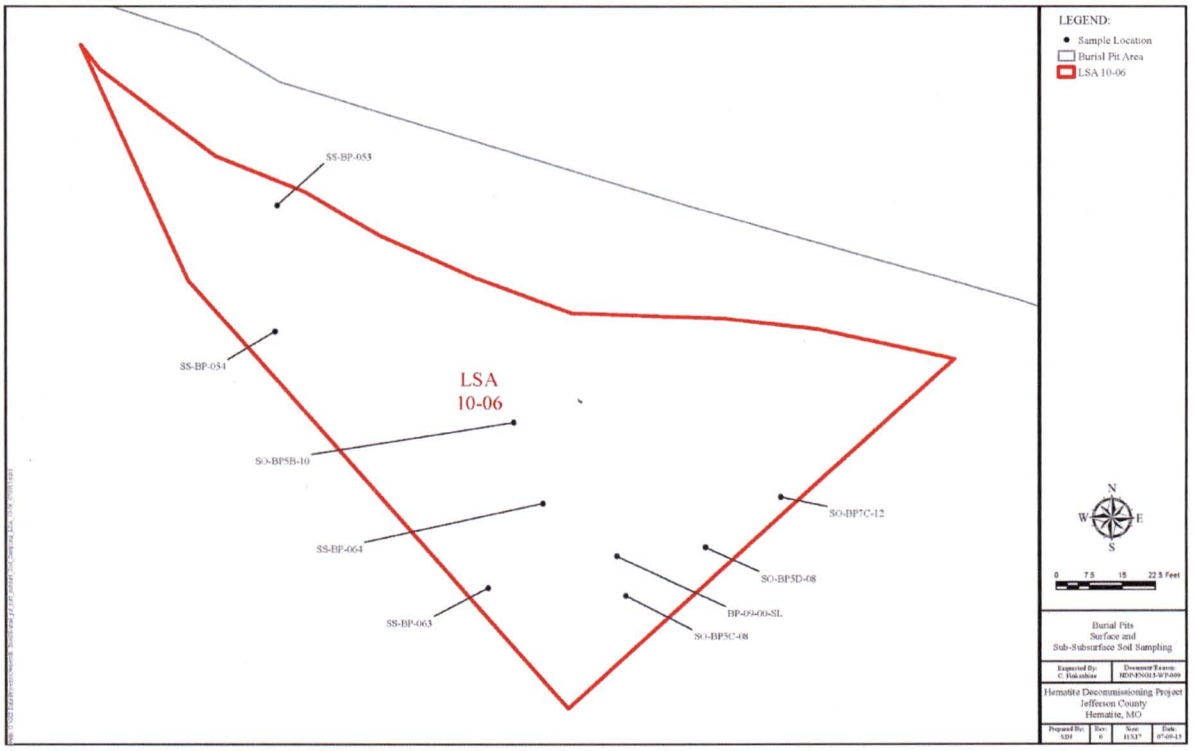


Figure 3-21
Site Characterization Borings within LSA 10-07

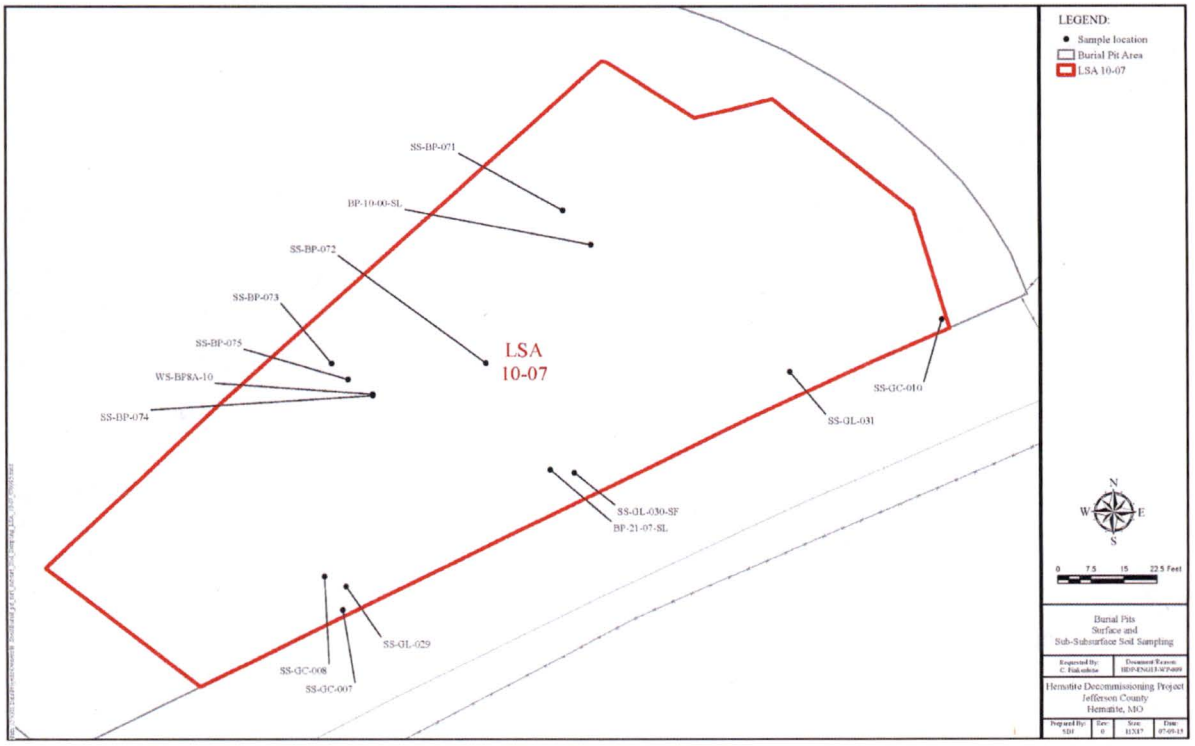


Figure 3-22
Site Characterization Borings within LSA 10-09

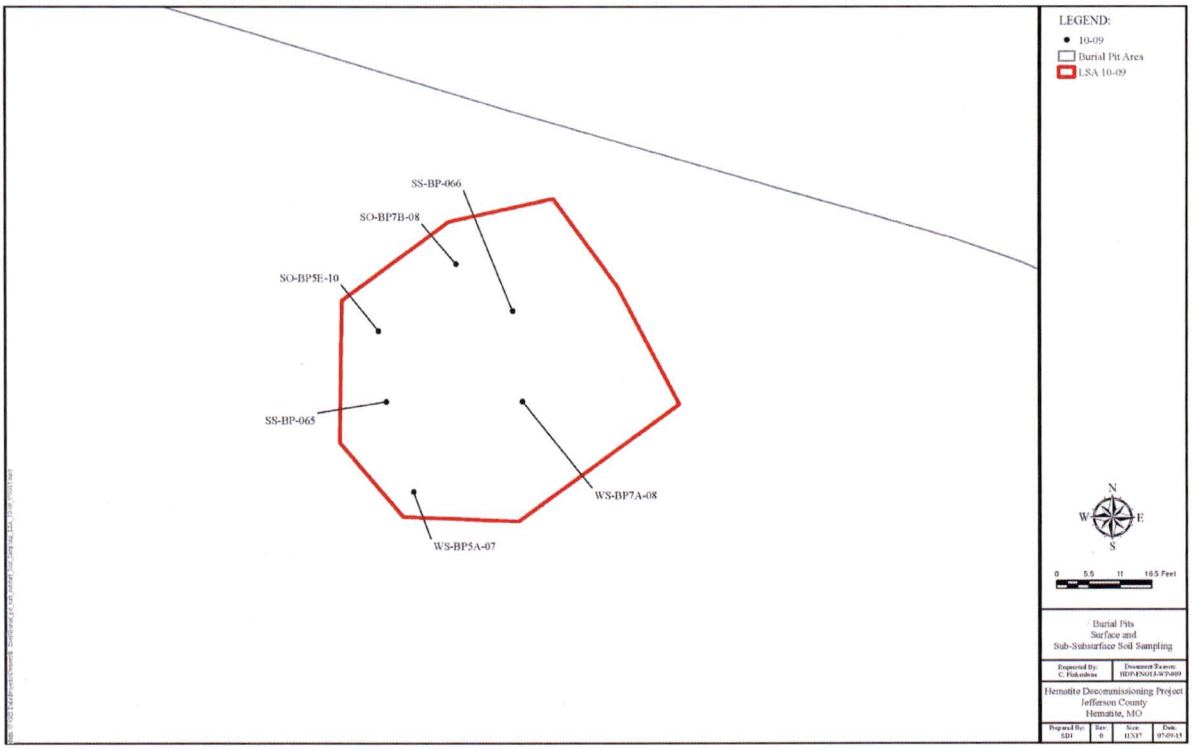
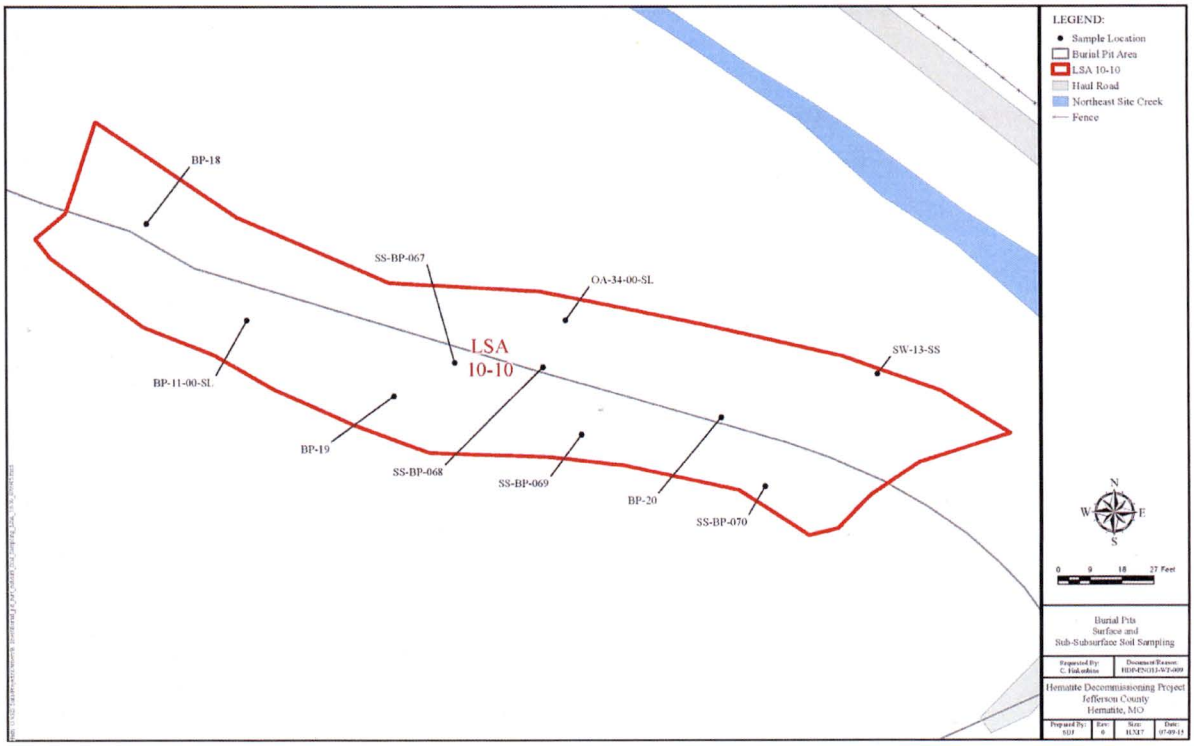


Figure 3-23
Site Characterization Borings within LSA 10-10



3.3.9 Remedial Action Support Survey for FSS Design

The RASS was conducted 1) to guide remediation activities, 2) to determine when an area or survey unit had been adequately prepared for FSS, and 3) to provide updated estimates of the parameters to be used for planning the FSS. Upon completion of remediation within the SU and prior to implementation of FSS activities, a final RASS was performed to validate the status of the SU prior to implementing Isolation and Control (I & C) postings. The I & C posting for LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-09 and LSA 10-10 were completed on various dates ranging from July 2013 to November 2013. Figure 3-24 is a photograph provided as an example, which shows LSA 10-09 ready for final RASS to support FSS Design. Figure 3-25 is a photograph provided as an example, which shows LSA 10-06, LSA 10-07 and LSA 10-10 ready for final RASS to support FSS Design.

Figure 3-24
LSA 10-09 Isolated and Prepared for FSS Design

Figure 3-25
LSA 10-06, LSA 10-07 and LSA 10-10 Isolated and Prepared for FSS Design

The RASS of each SU included a GWS, systematic surface sample collection based on a random start triangular grid (ranging from 5 to 39 samples per LSA), and biased surface sampling. Soil samples were analyzed onsite by gamma spectroscopy, no Tc-99 sampling was performed during the RASS of these SUs. Instead, historic Tc-99 data was reviewed to determine the potential for residual Tc-99 contamination. The Final RASS systematic sample results used to develop the FSS sampling grid are summarized in Table 3-1 below.

Table 3-1
Summary of Final RASS Results for LSA 10-05 Through LSA 10-10

LSA	Ra-226 (net)		Tc-99		Th-232 (net)		U-234		U-235		U-238	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
10-05	0.31	0.46	-	-	0.35	0.61	5.5	10.2	0.30	0.57	1.7	2.6
10-06	0.28	0.38	-	-	0.22	0.34	4.0	8.7	0.22	0.47	1.8	1.3
10-07	0.34	0.69	-	-	0.09	0.31	4.6	9.3	0.14	0.27	<MDA	<MDA
10-08	<BKG	0.18	-	-	<BKG	0.04	23.3	67.6	1.27	3.72	5.3	9.9
10-09	0.23	0.46	-	-	<BKG	0.11	3.5	5.8	0.12	0.18	0.84	2.3
10-10	0.46	.073	-	-	0.12	0.26	5.2	6.8	0.16	0.21	1.1	10.2
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)

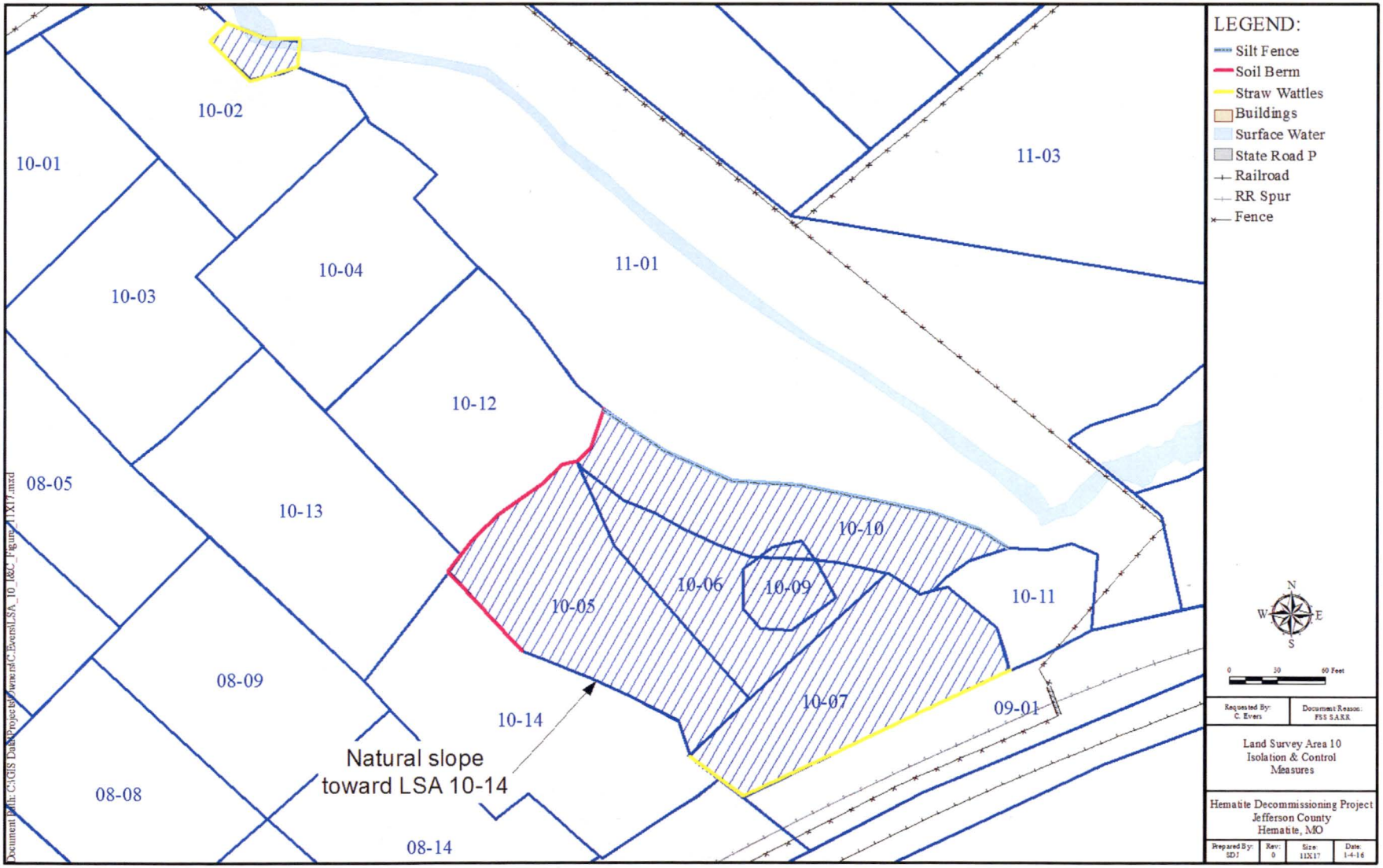
All Final RASS systematic sample and biased sample results were less than the appropriate $DCGL_W$ (Uniform Stratum) and the Final RASS data set was considered sufficient to support FSS design.

3.3.10 Isolation and Control

As directed by HDP-PR-HP-602, *Data Package Development and Isolation and Control Measures to Support Final Status Survey,* LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 were isolated and controlled in accordance with Work Package HDP-WP-ENG-803, *Isolation and Control Measures,* (See Figure 3-26) 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 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 are located within the fenced security perimeter of the HDP which therefore prevents access by the general public.

Figure 3-26
Isolation and Control of Area Containing LSA 10-05 through LSA 10-10



3.3.11 Surveillance Following FSS

Following the completion of a FSS, the DP requires continued surveillance to minimize the potential to re-contaminate a SU (e.g., surface water transport of potentially contaminated sediment or a soil pile that was not present during FSS). The surveillance includes the routine visual inspection of the integrity of the I & C measures implemented for LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10. If a SU is suspected of having been re-contaminated then an investigation survey will be performed to reconfirm the FSS survey validity.

3.3.12 Backfill of Survey Units

Although not a function of remediation, but as described in the DP Section 8.8, LSA 10-05 through LSA 10-10 were backfilled with off-site "borrow" soil. 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 LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 for backfill material.

3.3.13 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 LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10 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 10-05, LSA 10-06, LSA 10-07, LSA 10-08, LSA 10-09 and LSA 10-10. 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 10-05

This section of the report describes the method for determining the number of samples required for the FSS of LSA 10-05 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 10-05 and the detection sensitivities are also discussed.

5.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 10-05 were driven by the type (Open Land) and Class (Class 1) of the SU and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 2, *Final Status Survey Plan Development*, February 2013.

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 10-05. The review identified several areas that were previously found to exceed a Uniform SOF of 1.0 (discussed in Section 3.3.8). Next the remediation history was reviewed to confirm that the area was 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 a Class 1 SU, LSA 10-05 was required to undergo a 100% GWS.

5.1.4 Instrumentation

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

5.1.5 Scan Minimum Detectable Concentration (MDC)

As background levels were approximately 10,000 counts per minute (cpm) within LSA 10-05, 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 10-05, the average enrichment for the SU was 2.91%.

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 10-05 are shown below.

Table 5-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 10-05

	Scan MDC (Total U)	$DCGL_W$ (Total U)	Scan MDC (Ra-226)	$DCGL_W$* (Ra-226)	Scan MDC (Th-232)	$DCGL_W$* (Th-232)
LSA 10-05	83.8	82.4	2.8	2.8	1.8	3.0

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

The values in Table 5-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS. See Section 9.2 for a discussion of the changes made to Scan MDC calculations after FSS was originally performed based on commitments made to the NRC.

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 FSS in LSA 10-05 was performed prior to the development of HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 Areas at the Westinghouse Hematite Site*" which established a standard Scan IAL for all Class 1 SU's at the Hematite Site. The IAL used during the GWS of LSA 10-05 was established at 4,562 net counts per minute (ncpm) which was a calculated value equivalent to the expected scan rate for a potential hot spot representing the $DCGL_{EMC}$ for Total Uranium of 253 pCi/g (using a U-235 enrichment of 2.91%). Given that this Scan IAL is very close to the value of 4,000 ncpm prescribed by the revised HDP FSS program, and that all FSS data is post processed and evaluated as described in FSSFR Volume 3, Chapter 1, Section 6.1.3, the Scan IAL for LSA 10-05 of 4,562 is considered acceptable.

5.1.7 LSA 10-05 FSS Design Summary

The FSS Plan for LSA 10-05 can be found in Appendix G. Table 5-2 presents an overall FSS design and implementation summary for LSA 10-05.

Table 5-2
FSS Design Summary for LSA 10-05

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed excavation floors and walls	
Scan MDC	83.8 pCi/g total Uranium (1,512 ncpm)	
Investigation Action Level (IAL)	4,562 net cpm	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	0	These samples were collected on a systematic grid.
15 cm – 1.5 m (Root)	0	
> 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 Radiological Engineering.		
Instrumentation		
Ludlum 2221 with 44-10 (2" x 2" NaI) detector.	Used for GWS and to obtain static count rates at biased measurement locations.	

6.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 10-05

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

6.1 Gamma Walkover Survey

6.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 10-05 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS (Digital Global Positioning System) and handheld data logger.

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

6.1.2 GWS Performance

All GWS measurements on the 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, 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 10-05 used the 4,562 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 12,000 gross counts per minute (gcpm). Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,562 to 16,562 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 Health Physics (HP) Technician performing the survey to determine if possible areas of elevated residual activity remained within the SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

6.2 Soil Sampling

6.2.1 Systematic Soil Sampling Summary

Table 6-1 provides a summary of systematic sampling by stratum for LSA 10-05.

Table 6-1
Systematic Sampling Summary by Stratum for LSA 10-05

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
10-05	1,341	0	0	8	1

6.2.2 Systematic Sampling LSA 10-05

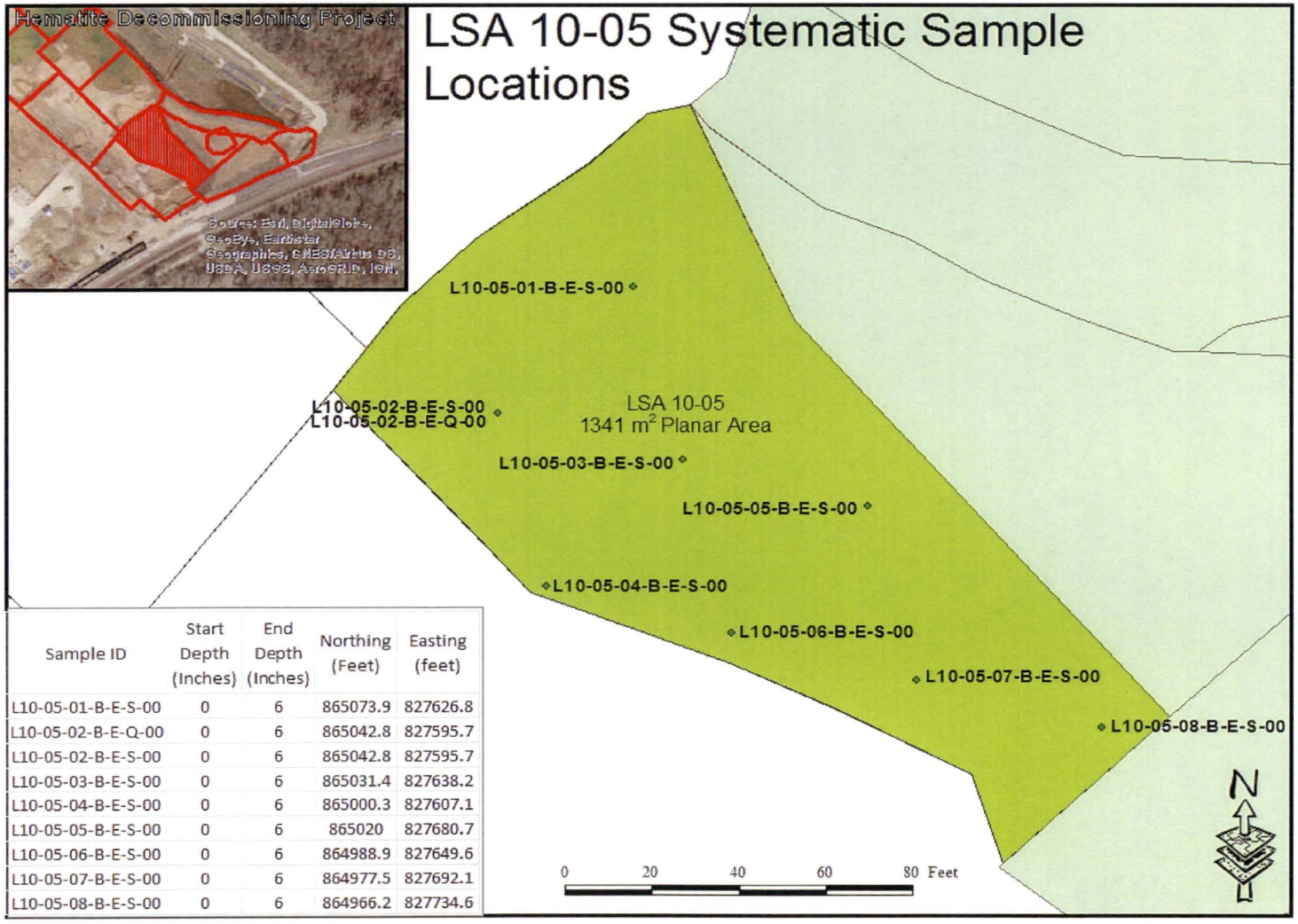
Within LSA 10-05, there were no systematic locations in which portions of the surface stratum [0 – 15 centimeters (cm)] remained in the SU after remediation. Also, there were no systematic locations in which portions of the root stratum (15 cm – 150 cm) remained in the SU after remediation. Excavation stratum samples were collected at all eight locations using hand trowels for six-inch grabs below the existing excavation surface. Given a planar area of 1,341 m^2 for LSA 10-05 and an eight - point systematic triangular grid, the point-to-point distance within each row was 13.4 m.

While there were eight systematic locations on the LSA 10-05 sampling grid, a total of nine (9) samples were collected at these locations, including:

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

Figure 6-1 presents the map of the eight systematic sample locations which were sampled within LSA 10-05. The inset table notes the location coordinates (Missouri East, North American Datum (NAD) 1983) and collection intervals for each systematic location.

Figure 6-1
LSA 10-05 Systematic Soil Sample Locations



Sample ID	Start Depth (Inches)	End Depth (Inches)	Northing (Feet)	Easting (feet)
L10-05-01-B-E-S-00	0	6	865073.9	827626.8
L10-05-02-B-E-Q-00	0	6	865042.8	827595.7
L10-05-02-B-E-S-00	0	6	865042.8	827595.7
L10-05-03-B-E-S-00	0	6	865031.4	827638.2
L10-05-04-B-E-S-00	0	6	865000.3	827607.1
L10-05-05-B-E-S-00	0	6	865020	827680.7
L10-05-06-B-E-S-00	0	6	864988.9	827649.6
L10-05-07-B-E-S-00	0	6	864977.5	827692.1
L10-05-08-B-E-S-00	0	6	864966.2	827734.6

Table 6-2 below presents a tabular listing of all FSS samples collected within LSA 10-05 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 6-2
FSS Sample Locations and Coordinates for LSA 10-05

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

APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

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

Survey Unit: 05 **Description:** South Eastern Survey Unit in "Area 9"

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
L100501BES00	Uniform	S	418.217	417.7	865073.9	827626.8	Excavation 6-inch grab
L100502BEQ00	Uniform	Q	423.203	422.7	865042.8	827595.7	Excavation 6-inch grab
L100502BES00	Uniform	S	423.203	422.7	865042.8	827595.7	Excavation 6-inch grab
L100503BES00	Uniform	S	421.87	421.4	865031.4	827638.2	Excavation 6-inch grab
L100504BES00	Uniform	S	426.368	425.9	865000.3	827607.1	Excavation 6-inch grab
L100505BES00	Uniform	S	422.075	421.6	865020.0	827680.7	Excavation 6-inch grab
L100506BES00	Uniform	S	415.291	414.8	864988.9	827649.6	Excavation 6-inch grab
L100507BES00	Uniform	S	415.278	414.8	864977.5	827692.1	Excavation 6-inch grab
L100508BES00	Uniform	S	422.806	422.3	864966.2	827734.6	Excavation 6-inch grab
L100509BSS00	Uniform	B	418.9	418.9	864973.3	827705.0	Sidewall 6-inch grab
L100510BSS00	Uniform	B	423.2	423.2	865001.2	827615.1	Sidewall 6-inch grab
L100511BSS00	Uniform	B	420.7	420.7	865026.7	827646.8	Sidewall 6-inch grab
L100512BSS00	Uniform	B	421.4	421.4	864989.3	827694.6	Sidewall 6-inch grab
L100513BSS00	Uniform	B	418.3	418.3	864989.3	827694.6	Sidewall 6-inch grab
L100514BSS00	Uniform	B	418.6	418.6	865016.5	827639.8	Sidewall 6-inch grab
L100515BSS00	Uniform	B	417.8	417.8	865017.6	827665.2	Sidewall 6-inch grab
L100516BSS00	Uniform	B	418.2	418.2	865006.5	827683.4	Sidewall 6-inch grab
L100517BSS00	Uniform	B	419.4	419.4	865078.9	827603.6	Sidewall 6-inch grab
L100518BSS00	Uniform	B	419.8	419.8	865056.0	827632.4	Sidewall 6-inch grab
L100519BSS00	Uniform	B	419.1	419.1	865045.2	827623.0	Sidewall 6-inch grab
L100520BSS00	Uniform	B	420.0	420.0	865050.5	827594.7	Sidewall 6-inch grab
L100521BSS00	Uniform	B	420.9	420.9	865086.1	827642.5	Sidewall 6-inch grab
L100522BSS00	Uniform	B	420.4	420.4	865071.3	827649.5	Sidewall 6-inch grab
L100523BSS00	Uniform	B	419.8	419.8	865077.5	827616.6	Sidewall 6-inch grab
L100524BSS00	Uniform	B	419.7	419.7	865086.3	827624.2	Sidewall 6-inch grab

Measurement or Sample ID	Surface or CSM	Type	Start Elevation*	End Elevation*	Northing** (Y Axis)	Easting** (X Axis)	Remarks / Notes
L100525BUB00	Uniform	B	418.0	417.5	864960.9	827711.7	Biased 6-inch grab
L100526BUB00	Uniform	B	414.0	413.5	864964.7	827685.6	Biased 6-inch grab
L100527BUB00	Uniform	B	426.0	425.5	865002.4	827599.2	Biased 6-inch grab
L100528BUB00	Uniform	B	422.0	421.5	865082.4	827591.4	Biased 6-inch grab
L100529BSB00	Uniform	B	424.0	423.5	865030.1	827584.7	Investigation 6-inch grab
L100530BSB00	Uniform	B	418.0	417.5	865061.2	827615.8	Investigation 6-inch grab
L100531BSB00	Uniform	B	424.0	423.5	865092.3	827646.9	Investigation 6-inch grab
L100532BSB00	Uniform	B	422.0	421.5	865018.7	827627.2	Investigation 6-inch grab
L100533BSB00	Uniform	B	424.0	423.5	865049.8	827658.3	Investigation 6-inch grab
L100534BSB00	Uniform	B	416.0	415.5	865007.3	827669.7	Investigation 6-inch grab
L100535BSB00	Uniform	B	422.0	421.5	864995.9	827712.2	Investigation 6-inch grab
L100536BSB00	Uniform	B	422.0	421.5	864953.4	827723.6	Investigation 6-inch grab

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

*Elevations are in feet above mean sea level.

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

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

CSM: Three-Layer (Surface-Root-Excavation) or Uniform DCGLs used

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

Quality Record

6.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 10-05 a significant number of biased locations were selected within the SU, 20 samples in total. These biased samples were based on the evaluation of the GWS survey, or based on the judgment of the Radiological Engineering. Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

Note that the samples labeled as "Investigation" in Table 6-2 above are the eight post flood event samples collected after a significant storm event. These results are discussed in greater detail in Section 11.3. The results of these investigation samples are being included in the LSA 10-05 data set as biased samples since they are not part of the systematically collected samples prescribed under the FSS Plan.

The biased location that represented the maximum GWS measurement encountered within the SU was L10-05-25-B-U-B-00 with a result of 0.17 Uniform SOF.

6.4 Judgmental/Sidewall Sampling for Tc-99

During the commencement of FSS activities in early 2015, during a NRC Region III inspection, the NRC Inspector questioned the site staff in regards to the FSS program requirements for excavation side wall sampling. The NRC Inspector was specifically interested in sampling for Tc-99. The site staff reiterated the requirements as provided in the HDP DP Chapter 14.4.4.1.6.2, *Subsurface Soil*, and provided an explanation of how the requirements were implemented within the FSS program and procedures. This topic was conveyed to NRC Headquarters and subsequently Westinghouse was provided with three options for addressing the issue. After discussions held on Publicly Noticed Teleconference Call {ML1520A324}, Westinghouse and the NRC agreed on a path forward.

> *"NRC staff concluded that the method described in HEM-15-MEMO-039 was acceptable, with the exception that the NRC staff had concerns with the first bullet (i.e., samples would only be taken if the systematic or biased samples from the survey unit exceeded 10% of the applicable DCGLw). Westinghouse committed to revising the memo to delete this bullet and to revise its procedure to include this information. NRC staff also noted that it would also be clearer if a definition of "vertical or near vertical" were included in these documents."*
>
> *"Westinghouse stated that this process would be used in the future and had been used in the past. Westinghouse noted, however, that there are some survey units that have already been backfilled for which this process was not followed. These survey units had shallower excavations and had low Tc-99. Westinghouse will provide justification for the characterization of Tc-99 in the FSSRs for these survey units. NRC staff stated that it will evaluate the information available for those survey units when those FSS reports are submitted to determine if they have been characterized adequately."*

See FSSFR Volume 3, Chapter 1, Section 5.2, *Tc-99 Side Wall Sampling* for further discussion.

The FSS field activities for LSA 10-05 predated the agreed upon path forward. At the time of FSS of LSA 10-05, site FSS procedures implemented the requirements for sampling side walls for Tc-99 as provided in DP Chapter 14.4.4.1.6.2, *Subsurface Soil.*

During FSS of LSA 10-05, sixteen (16) of the 20 biased sample locations sampled were collected from sidewalls. See section 7.2.5, *Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 10-05* for further discussion.

6.5 Quality Control Soil Sampling

One QC field duplicate sample point was randomly selected and collected at systematic location L10-05-02 for LSA 10-05.

7.0 FINAL STATUS SURVEY RESULTS LSA 10-05

7.1 Gamma Walkover Survey

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

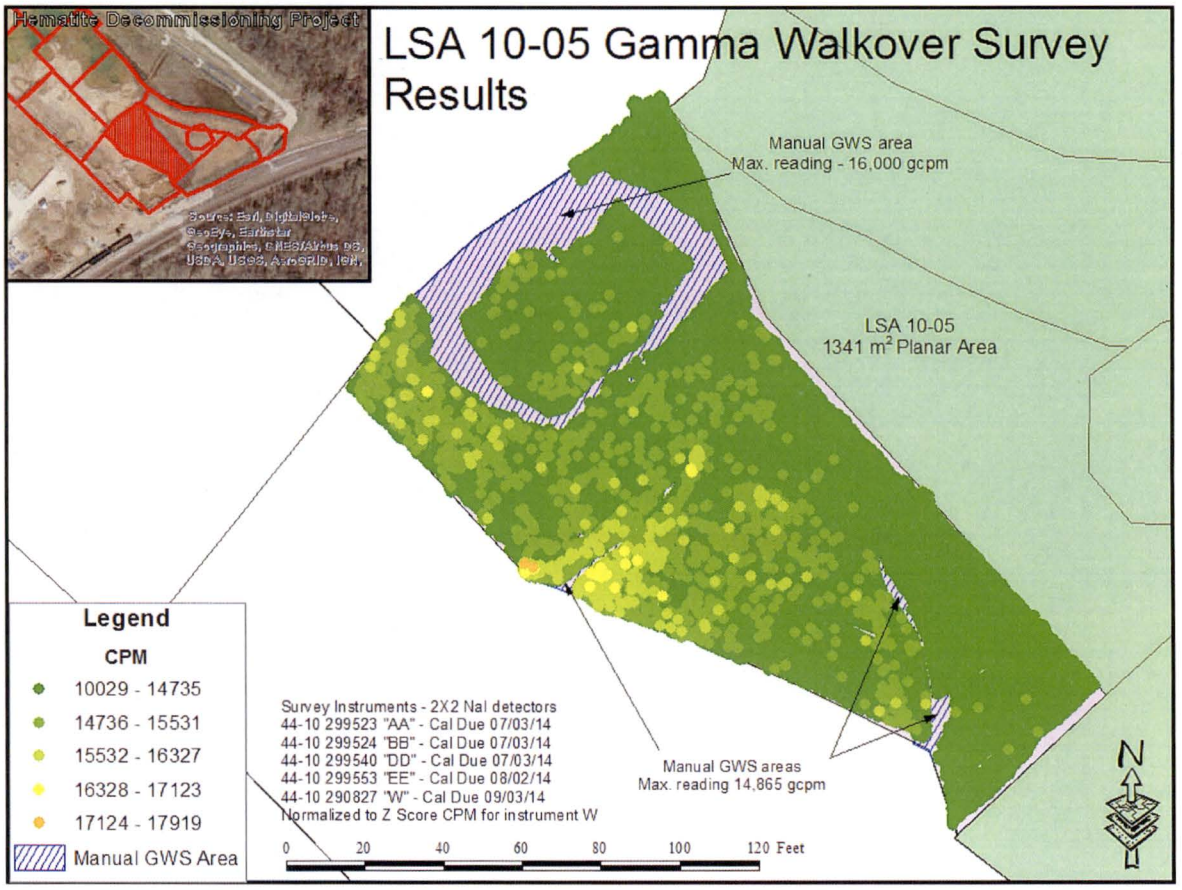
elevated readings than the floor directly below, the sidewall radiological measurements would overlie the lower floor readings).

GWS measurements were collected in LSA 10-05 from December 18, 2013, to January 19, 2014.

7.1.1 GWS Results for LSA 10-05

For the datalogged survey data collected in LSA 10-05, GWS count rates ranged between 10,029 gcpm and 17,228 gcpm, with a mean count rate of 13,444 gcpm. The median count rate was 13,437 gcpm and the standard deviation was 839 cpm. Figure 7-1 below presents a map of the complete GWS data set.

Figure 7-1
Colorimetric GWS Plot for LSA 10-05

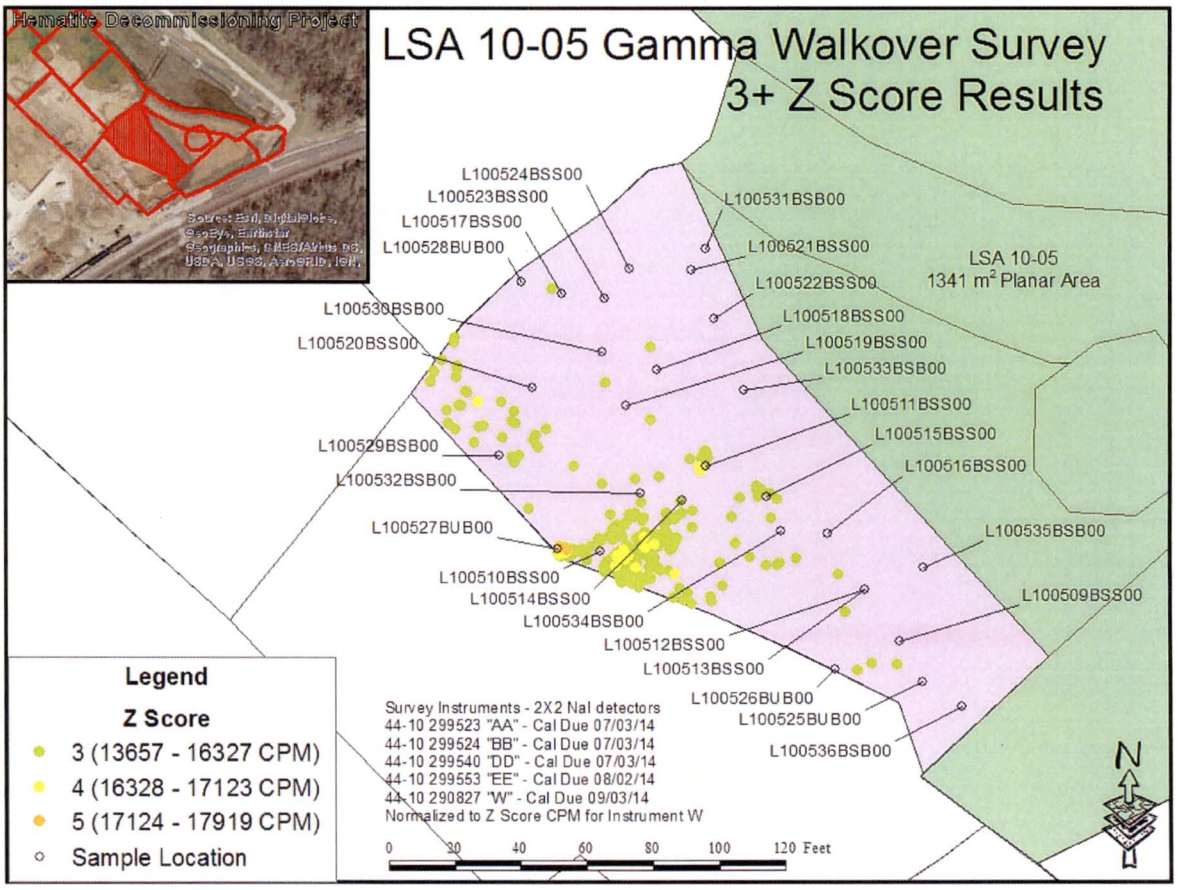


Due to the presence of steep interior sidewalls, some areas of LSA 10-05 were not able to be surveyed using the preferred method of GWS using GPS data logging. These areas (the pink gaps in Figure 7-1 above) were surveyed manually by HP Technicians. The results of the manual surveys were reviewed and it was determined that the sidewalls did not present any elevated readings, and that the GWS readings for the surrounding areas that were surveyed by GWS using GPS datalogging were equivalent to the results of the manual sidewall surveys. The manual sidewall surveys are presented in Appendix U.

An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). Several locations were selected for biased sample collection based on the evaluation of the GWS data, the judgment of Radiological Engineering, and due to the presence of sidewalls.

Figure 7-2 below presents a map of the +3 Z-score GWS measurements within LSA 10-05, including the selected, investigation, biased and sidewall sampling locations.

Figure 7-2
Colorimetric GWS Plot for LSA 10-05 (Measurements > Z-score of 3)



Since the majority of the GWS data collected in LSA 10-05 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. While manual surveys were also performed within LSA 10-05, the data collected from the manual surveys is considered to be equivalent to the data collected using GPS datalogging from the surrounding areas. Additionally an elevated 13,000 gcpm general area background was used for the calculation of Scan MDC due to the elevated background count rates within the LSA, in part due to the deep excavation, and the presence of steep sidewalls creating an elevated background due to the excavation surface geometry. Using these parameters, a Scan MDC of approximately 46.7 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 10-05, 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:

$$\text{Scan MDC}_{Total\ Uranium} = \quad 1 \Big/ \left(\left(\frac{0.7928}{4172}\right) + \left(\frac{0.0438}{2.65}\right) + \left(\frac{0.1634}{34.9}\right) \right) = 46.7 \frac{pCi}{g}$$

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 1.37 pCi/g and 0.99 pCi/g, respectively using a two inch air gap. A two inch (2") 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 10-05

FSSFR Volume 3, Chapter 1, Section 6.1.4, *Exposed Surfaces versus Accessible Surfaces*, provides a discussion and the criteria for evaluating the GWS coverage of a SU during FSS. Although 100% of accessible areas underwent GWS, certain portions of the LSA 10-05 interior could not be accessed by GPS datalogging due to especially tall interior excavation sidewalls. These areas appear as greyish-pink blanks in the Figure 7-1 above.

The post survey processing of the GPS data and manual survey records indicated that the GWS covered 95.3% of the SU (see Table 7-1). As the evaluation indicates that the GWS coverage (GPS coverage + manual coverage) exceeded 95%, and the readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of the apparent GPS coverage gaps were investigated and found to be satisfactory, 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 10-05

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 10-05	238,895	11,254	4.7%	95.3%	1

7.2 Soil Sample Results LSA 10-05

Appendix A presents the analytical results and associated statistics for all FSS samples collected within LSA 10-05.

7.2.1 Surface Soil Sample Results LSA 10-05

There were no samples collected within the surface stratum (0 – 15 cm), or the root stratum (15 cm – 1.5 m) of LSA 10-05 as the soil in these stratums were removed by excavation. There were a total of eight (8) systematic soil samples collected within the topmost soil layer of the excavation surface (deep stratum, greater than 1.5 m), twenty-eight (28) biased samples (including sixteen (16) from sidewalls), and one QC field duplicate sample. The maximum SOF result for the "topmost" samples was 0.97 corresponding to the systematic sample L10-05-02-B-E-S-00.

The WRS evaluation is also included in Appendix A.

7.2.2 Subsurface Soil Sample Results LSA 10-05

As the surface and root stratums were completely removed from LSA 10-05, all of the samples collected for analysis were collected either from the excavation stratum, biased locations, or sidewalls, all of which are collected to a depth of 6 inches. Therefore no subsurface samples were collected from LSA 10-05.

7.2.3 WRS Test Evaluation for LSA 10-05

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 10-05 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 eight systematically collected samples in LSA 10-05 were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The SU passed the WRS Test since the ranked sum of the reference area ranks, or test statistic WR, (772) was greater than the critical value (705) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected.

7.2.4 Graphical Data Review LSA 10-05

Table 7-2 below presents summary results for the all systematically collected samples (includes surface [none collected in this SU], root [none collected in this SU], and excavation stratum samples, but not biased or QC samples) collected within LSA 10-05, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.29.

Table 7-2
LSA 10-05 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Uniform DCGL)
Average	0.208	0.287	0.295	2.904	0.156	1.262	**0.29**
Minimum	0.09	0.00 (NEG)	0.12	0.092	0.002	0.792	0.12
Maximum	0.690	1.990	1.110	5.651	0.312	2.860	0.97

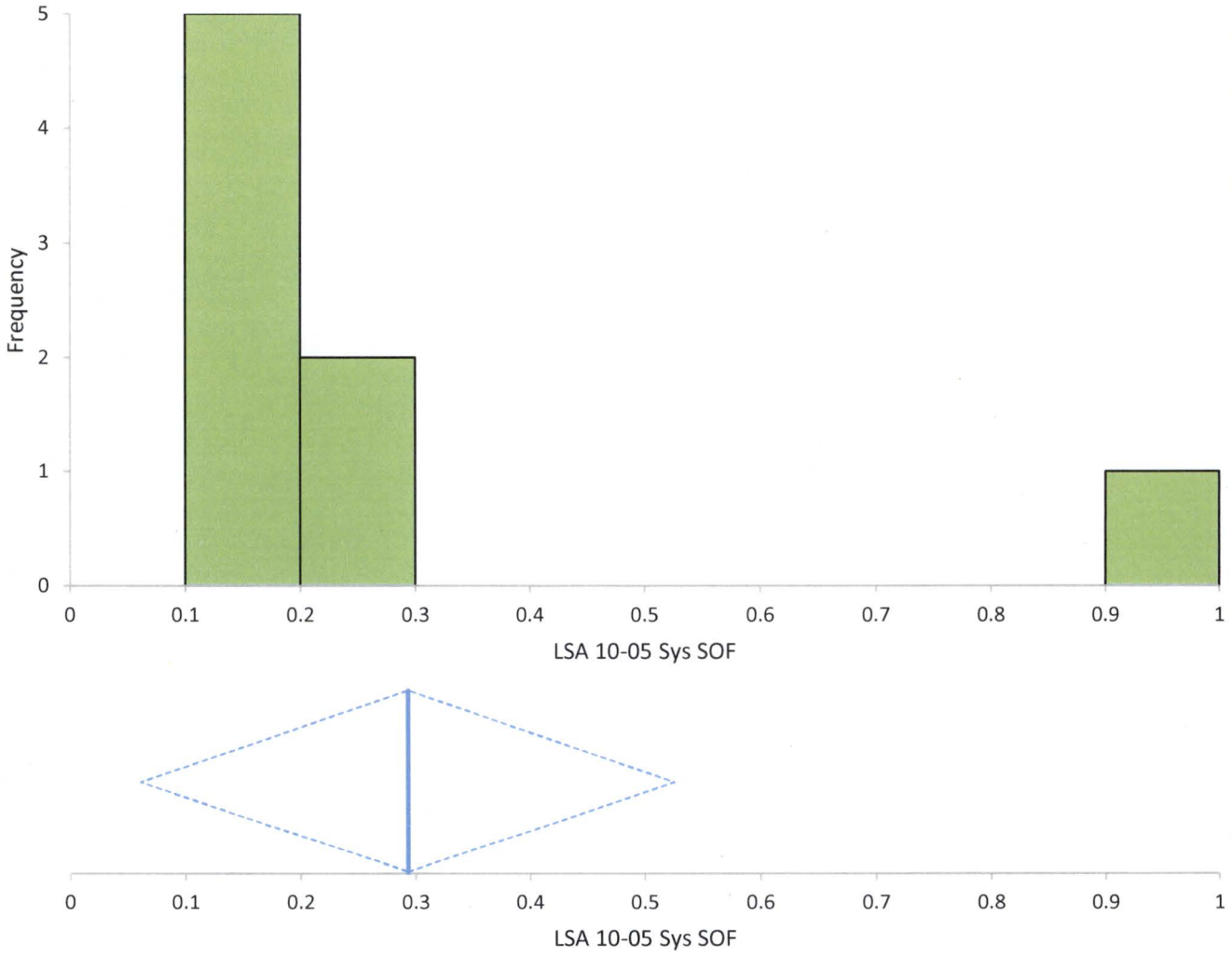
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide 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 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 8 systematically collected samples from LSA 10-05. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-05. The middle graph presents the mean SOF (0.29 as indicated by the blue vertical line) of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.06 to 0.53. The 99.22% confidence interval based on the median (0.18) of the sample results is 0.12 to 0.97. The bottom two charts present the various statistical metrics of the LSA 10-05 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 10-05 data associated with the systematically collected measurement locations.

Figure 7-3
Graphic Statistical Summary for LSA 10-05 (SOF parameter)



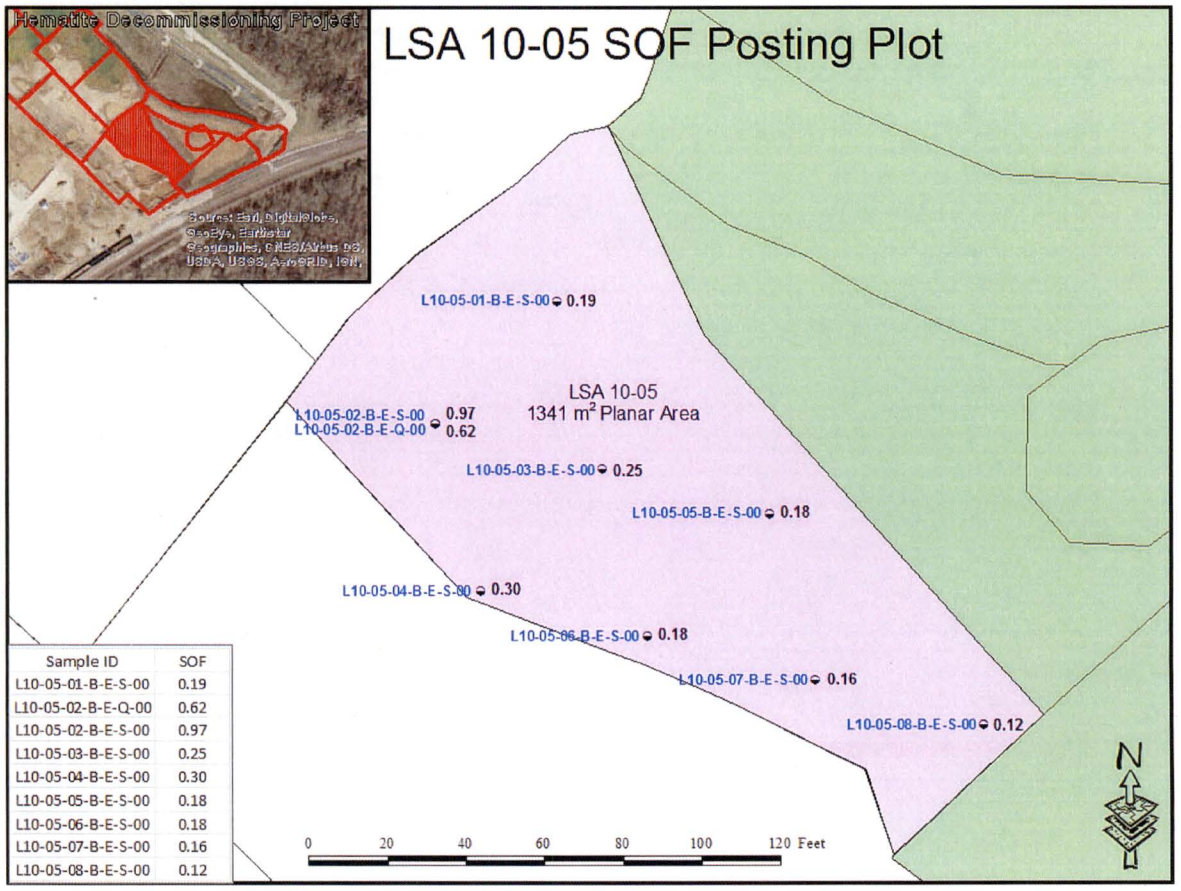
	N
	8

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 10-05 Sys SOF	0.29	0.06	to 0.53	0.098	0.28	0.08	2.6	7.11

	Minimum	1st quartile	Median	99.22% CI		3rd quartile	Maximum	IQR
LSA 10-05 Sys SOF	0.1	0.17	0.18	0.12	to 0.97	0.28	1.0	0.11

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 10-05 is presented below in Figure 7-4. Figure 7-4 shows no unusual patterns in the data.

Figure 7-4
Posting Plot for LSA 10-05 Systematic Measurement Locations



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

Table 7-3
Final Status Survey Analytical Data: LSA 10-05

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF
L100501BES00	11.65	S	1.210	0.179	0.085	N/A	0.140	0.140	-0.024	0.000	0.064	0.263	U	1.180	0.203	0.071	N/A	0.180	0.180	2.156	N/A	N/A	N/A	0.110	0.170	0.283	U	1.640	0.849	1.050	N/A	1.1	0.19
L100502BEQ00	7.55	Q	1.810	0.275	0.146	N/A	0.740	0.740	-0.003	0.000	0.056	0.298	U	1.430	0.246	0.149	N/A	0.430	0.430	0.975	N/A	N/A	N/A	0.045	0.230	0.390	U	1.320	0.499	1.240	N/A	0.6	0.62
L100502BES00	7.55	S	1.760	0.363	0.264	N/A	0.690	0.690	0.014	0.014	0.046	0.282	U	2.110	0.374	0.148	N/A	1.110	1.110	5.313	N/A	N/A	N/A	0.282	0.441	0.726	U	2.860	2.490	3.290	U	1.6	0.97
L100503BES00	8.71	S	1.200	0.173	0.072	N/A	0.130	0.130	1.990	1.990	0.260	0.229	N/A	1.150	0.178	0.150	N/A	0.150	0.150	2.993	N/A	N/A	N/A	0.162	0.163	0.212	U	1.180	0.734	0.952	N/A	2.1	0.25
L100504BES00	5.42	S	1.310	0.193	0.058	N/A	0.240	0.240	0.247	0.247	0.038	0.228	N/A	1.280	0.228	0.098	N/A	0.280	0.280	2.794	N/A	N/A	N/A	0.153	0.148	0.269	U	0.858	0.392	1.350	U	2.7	0.30
L100505BES00	8.40	S	1.160	0.161	0.075	N/A	0.090	0.090	-0.047	0.000	0.033	0.234	U	1.190	0.182	0.107	N/A	0.190	0.190	5.651	N/A	N/A	N/A	0.312	0.151	0.208	N/A	0.966	0.332	0.815	N/A	4.8	0.18
L100506BES00	16.07	S	1.170	0.163	0.074	N/A	0.100	0.100	0.044	0.044	0.060	0.250	U	1.200	0.207	0.118	N/A	0.200	0.200	3.097	N/A	N/A	N/A	0.170	0.115	0.179	U	0.905	0.350	0.857	N/A	2.9	0.18
L100507BES00	16.06	S	1.230	0.183	0.087	N/A	0.160	0.160	-0.017	0.000	0.052	0.242	U	1.130	0.224	0.168	N/A	0.130	0.130	1.136	N/A	N/A	N/A	0.057	0.059	0.276	U	0.891	0.379	0.992	U	1.0	0.16
L100508BES00	8.52	S	1.180	0.191	0.097	N/A	0.110	0.110	-0.014	0.000	0.029	0.249	U	1.120	0.185	0.158	N/A	0.120	0.120	0.092	N/A	N/A	N/A	0.002	0.164	0.279	U	0.792	0.363	1.070	U	0.1	0.12
L100509BSS00	12.56	B	1.030	0.151	0.072	N/A	-0.040	ol	-0.025	0.000	0.041	0.235	U	1.150	0.171	0.081	N/A	0.150	0.150	1.739	N/A	N/A	N/A	0.090	0.122	0.231	U	1.150	0.635	0.835	N/A	1.2	0.09
L100510BSS00	9.01	B	1.240	0.187	0.072	N/A	0.170	0.170	0.546	0.546	0.092	0.227	N/A	1.110	0.245	0.141	N/A	0.110	0.110	0.794	N/A	N/A	N/A	0.033	0.168	0.284	U	1.530	0.814	1.040	N/A	0.4	0.18
L100511BSS00	10.47	B	1.300	0.170	0.061	N/A	0.230	0.230	0.274	0.274	0.050	0.219	N/A	1.170	0.161	0.097	N/A	0.170	0.170	2.979	N/A	N/A	N/A	0.155	0.101	0.163	U	1.900	0.828	0.943	N/A	1.3	0.25
L100512BSS00	8.92	B	1.260	0.171	0.068	N/A	0.190	0.190	-0.053	0.000	0.062	0.229	U	1.200	0.202	0.091	N/A	0.200	0.200	2.899	N/A	N/A	N/A	0.152	0.117	0.187	U	1.690	0.737	0.897	N/A	1.4	0.23
L100513BSS00	13.28	B	1.330	0.186	0.074	N/A	0.260	0.260	-0.021	0.000	0.045	0.231	U	1.310	0.191	0.114	N/A	0.310	0.310	1.709	N/A	N/A	N/A	0.090	0.145	0.264	U	0.958	0.357	0.926	N/A	1.5	0.31
L100514BSS00	12.43	B	1.120	0.172	0.082	N/A	0.050	0.050	0.057	0.057	0.023	0.228	U	1.040	0.203	0.169	N/A	0.040	0.040	2.713	N/A	N/A	N/A	0.144	0.176	0.306	U	1.380	0.705	0.943	N/A	1.6	0.07
L100515BSS00	13.36	B	1.120	0.166	0.076	N/A	0.050	0.050	-0.056	0.000	0.018	0.236	U	1.210	0.190	0.108	N/A	0.210	0.210	3.363	N/A	N/A	N/A	0.182	0.121	0.165	N/A	1.350	0.710	0.907	N/A	2.1	0.16
L100516BSS00	12.71	B	1.150	0.179	0.104	N/A	0.080	0.080	0.000	0.000	0.012	0.234	U	1.130	0.178	0.133	N/A	0.130	0.130	2.994	N/A	N/A	N/A	0.161	0.168	0.260	U	1.300	0.776	0.957	N/A	1.9	0.13
L100517BSS00	10.27	B	1.350	0.188	0.073	N/A	0.280	0.280	0.039	0.039	0.076	0.235	U	1.250	0.213	0.134	N/A	0.250	0.250	0.898	N/A	N/A	N/A	0.037	0.149	0.249	U	1.690	0.791	0.992	N/A	0.4	0.29
L100518BSS00	10.19	B	1.620	0.176	0.048	N/A	0.550	0.550	-0.004	0.000	0.020	0.278	U	1.370	0.177	0.081	N/A	0.370	0.370	3.696	N/A	N/A	N/A	0.200	0.074	0.115	N/A	1.450	0.423	0.514	N/A	2.1	0.51
L100519BSS00	11.75	B	1.940	0.239	0.080	N/A	0.870	0.870	-0.056	0.000	0.061	0.270	U	1.370	0.197	0.147	N/A	0.370	0.370	1.944	N/A	N/A	N/A	0.099	0.178	0.274	U	1.450	0.641	0.871	N/A	1.1	0.66
L100520BSS00	10.75	B	1.750	0.246	0.083	N/A	0.680	0.680	-0.055	0.000	0.017	0.256	U	1.410	0.244	0.091	N/A	0.410	0.410	2.484	N/A	N/A	N/A	0.137	0.190	0.311	U	0.604	0.385	1.370	U	3.5	0.58
L100521BSS00	7.73	B	1.810	0.243	0.112	N/A	0.740	0.740	-0.047	0.000	0.007	0.279	U	1.320	0.228	0.151	N/A	0.320	0.320	2.572	N/A	N/A	N/A	0.142	0.188	0.324	U	0.545	0.390	1.090	U	3.9	0.57
L100522BSS00	8.95	B	1.490	0.206	0.080	N/A	0.420	0.420	0.110	0.110	0.143	0.266	U	1.630	0.286	0.124	N/A	0.630	0.630	2.999	N/A	N/A	N/A	0.160	0.202	0.301	U	1.510	0.724	0.960	N/A	1.7	0.57
L100523BSS00	9.97	B	1.430	0.210	0.094	N/A	0.360	0.360	0.059	0.059	0.051	0.254	U	1.220	0.235	0.195	N/A	0.220	0.220	2.184	N/A	N/A	N/A	0.117	0.164	0.268	U	1.030	0.402	1.110	U	1.8	0.32
L100524BSS00	9.45	B	1.840	0.224	0.064	N/A	0.770	0.770	-0.048	0.000	0.142	0.264	U	1.270	0.210	0.167	N/A	0.270	0.270	2.761	N/A	N/A	N/A	0.151	0.166	0.278	U	0.890	0.401	1.030	U	2.6	0.56
L100525BUB00	11.70	B	1.160	0.170	0.082	N/A	0.090	0.090	-0.005	0.000	0.016	0.231	U	1.110	0.170	0.103	N/A	0.110	0.110	9.319	N/A	N/A	N/A	0.512	0.207	0.228	N/A	1.200	0.742	0.956	N/A	6.3	0.17
L100526BUB00	16.10	B	1.170	0.169	0.086	N/A	0.100	0.100	0.013	0.013	0.025	0.244	U	1.260	0.198	0.119	N/A	0.260	0.260	1.686	N/A	N/A	N/A	0.090	0.143	0.262	U	0.862	0.369	0.897	U	1.6	0.20
L100527BUB00	5.40	B	1.220	0.178	0.059	N/A	0.150	0.150	0.283	0.283	0.030	0.232	N/A	1.300	0.201	0.084	N/A	0.300	0.300	3.779	N/A	N/A	N/A	0.208	0.146	0.230	U	1.010	0.450	1.240	U	3.2	0.27
L100528BUB00	8.40	B	1.400	0.190	0.088	N/A	0.330	0.330	-0.014	0.000	0.075	0.268	U	1.450	0.208	0.083	N/A	0.450	0.450	2.857	N/A	N/A	N/A	0.156	0.177	0.292	U	0.985	0.403	1.160	U	2.5	0.42
L100529BSB00	7.55	B	0.975	0.151	0.088	N/A	-0.095	0.000	0.080	0.080	0.071	0.236	U	1.180	0.190	0.128	N/A	0.180	0.180	1.922	N/A	N/A	N/A	0.100	0.169	0.294	U	1.210	0.576	0.894	N/A	1.3	0.11
L100530BSB00	11.65	B	0.829	0.139	0.082	N/A	-0.241	0.000	0.074	0.074	0.087	0.223	U	1.190	0.193	0.142	N/A	0.190	0.190	1.466	N/A	N/A	N/A	0.078	0.184	0.296	U	0.730	0.349	0.883	U	1.7	0.11
L100531BSB00	7.55	B	1.030	0.149	0.068	N/A	-0.040	0.000	0.114	0.114	0.014	0.216	U	1.400	0.211	0.081	N/A	0.400	0.400	3.315	N/A	N/A	N/A	0.182	0.153	0.205	U	0.980	0.325	0.839	N/A	2.9	0.23
L100532BSB00	8.40	B	1.050	0.155	0.070	N/A	-0.020	0.000	0.133	0.133	0.075	0.225	U	1.130	0.186	0.111	N/A	0.130	0.130	5.150	N/A	N/A	N/A	0.283	0.129	0.193	N/A	1.450	0.547	0.810	N/A	3.0	0.11
L100533BSB00	7.55	B	0.944	0.146	0.071	N/A	-0.126	0.000	0.033	0.033	0.099	0.225	U	1.050	0.177	0.117	N/A	0.050	0.050	2.854	N/A	N/A	N/A	0.154	0.139	0.230	U	1.220	0.557	0.854	N/A	2.0	0.05
L100534BSB00	16.07	B	0.982	0.143	0.062	N/A	-0.088	0.000	0.566	0.566	0.178	0.208	N/A	1.180	0.193	0.089	N/A	0.180	0.180	3.211	N/A	N/A	N/A	0.175	0.134	0.224	U	1.140	0.321	0.789	N/A	2.4	0.14
L100535BSB00	8.40	B	1.170	0.177	0.065	N/A	0.100	0.100	0.240	0.240	0.053	0.219	N/A	1.300	0.215	0.140	N/A	0.300	0.300	4.249	N/A	N/A	N/A	0.232	0.210	0.254	U	1.410	0.655	1.010	N/A	2.5	0.25
L100536BSB00	8.40	B	1.130	0.166	0.084	N/A	0.060	0.060	0.076	0.076	0.140	0.264	U	1.300	0.191	0.104	N/A	0.300	0.300	3.248	N/A	N/A	N/A	0.179	0.116	0.180	U	0.812	0.302	0.837	U	3.4	0.21
Systematic Minimum			0.090						0.000					0.120						0.092				0.002				0.792				**2.1**	0.12
Systematic Maximum			0.690						1.990					1.110						5.651				0.312				2.860				Average Enrichment (%)	0.97
Systematic Mean			0.208						0.287					0.295						2.904				0.156				1.262					0.29
Systematic Median			0.135						0.007					0.185						2.894				0.158				0.936					0.18
Systematic Standard Deviation			0.201						0.693					0.333						1.890				0.104				0.701					0.28
			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 10-05

The highest biased sample collected from LSA 10-05 had a Uniform SOF result of 0.66, this sample was collected from a sidewall at location L100519BSS00.

7.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 10-05

As previously discussed in Section 6.4, the Westinghouse and NRC agreed upon protocol for sidewall sampling for Tc-99 predated the performance of FSS in LSA 10-05. However, following the guidance of HEM-15-MEMO-039, as implemented in procedure HDP-PR-FSS-701, Final Status Survey Plan Development, for a SU of 1,341 m^2, and using the conservative assumption that a 1 to 1 ratio of excavated surfaces to sidewalls exists within the SU, then the FSS Plan for the SU would require that 8 sidewall samples would be collected in addition to the 8 systematically collected soil samples. The 16 sidewall samples collected in LSA 10-05 far exceed the postulated 8 required samples.

Guidance in HEM-15-MEMO-039 states to "*Collect a judgmental sample(s) at sidewall location(s) not based on radiological scans, but selected at the discretion of the Health Physics Technician performing soil sampling*" but for LSA 10-05 the 16 samples collected were based upon identified biased locations by the HP Technician. A review of the location of the 16 samples collected relative to the configuration of LSA 10-05 (See Figure 7-2) indicates that the distribution is such that the 16 samples are indicative of, and are representative of Tc-99 concentration within the soil of the SU.

Furthermore, the intent of sidewall sampling is to address the NRC's concern that the potential lateral migration of Tc-99 contamination is not appropriately addressed. Since 100% of excavated surfaces are subjected to GWS in Class 1 areas, any areas of elevated gamma contamination on sidewall surfaces would be identified for biased sampling. However Tc-99 is a hard to detect nuclide that is not easily identified by field instrumentation, which led the NRC to conclude that sidewall sampling to identify the potential for Tc-99 lateral migration was necessary. As discussed in more detail in Section 7.3, a review of the sample history for LSA 10-05 has concluded that there is no potential for a Tc-99 hot spot to exist within the SU that exceeds the DCGLw, and that the trace amounts of Tc-99 residual activity that remain within the SU do not pose a threat to public health and safety.

The review indicates that although FSS field activities for LSA 10-05 predated the agreement between the NRC and Westinghouse in regards to Tc-99 sidewall sampling, there is sufficient data to conclude that the sidewall sampling that was conducted meets the intent of the agreement between the NRC and Westinghouse.

Sixteen samples were collected from the sidewalls of LSA 10-05. Table 7-4 provides the data summary for the samples.

Table 7-4
LSA 10-05 Sidewall Sample Data Summary and Calculated SOF Values

Sample ID	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)
L100509BSS00	1.030	-0.025	1.150	1.739	0.090	1.150	0.09
L100510BSS00	1.240	0.546	1.110	0.794	0.033	1.530	0.18
L100511BSS00	1.300	0.274	1.170	2.979	0.155	1.900	0.25
L100512BSS00	1.260	-0.053	1.200	2.899	0.152	1.690	0.23
L100513BSS00	1.330	-0.021	1.310	1.709	0.090	0.958	0.31
L100514BSS00	1.120	0.057	1.040	2.713	0.144	1.380	0.07
L100515BSS00	1.120	-0.056	1.210	3.363	0.182	1.350	0.16
L100516BSS00	1.150	0.000	1.130	2.994	0.161	1.300	0.13
L100517BSS00	1.350	0.039	1.250	0.898	0.037	1.690	0.29
L100518BSS00	1.620	-0.004	1.370	3.696	0.200	1.450	0.51
L100519BSS00	1.940	-0.056	1.370	1.944	0.099	1.450	0.66
L100520BSS00	1.750	-0.055	1.410	2.484	0.137	0.604	0.58
L100521BSS00	1.810	-0.047	1.320	2.572	0.142	0.545	0.57
L100522BSS00	1.490	0.110	1.630	2.999	0.160	1.510	0.57
L100523BSS00	1.430	0.059	1.220	2.184	0.117	1.030	0.32
L100524BSS00	1.840	-0.048	1.270	2.761	0.151	0.890	0.56

7.2.7 Quality Control Soil Sample Result LSA 10-05

One QC field duplicate sample point was randomly selected for LSA 10-05 which was collected at systematic location L10-05-02.

For the 28 samples (i.e., 8 systematic + 4 biased + 16 sidewall) collected within LSA 10-05, one field duplicate sample was collected. This frequency equates to 3.6%, (i.e. 1/28). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated Warning Limits with one exception (see Figure 7-6 below). While the overall quality control frequency considering all samples was less than 5%, the quality control frequency considering only systematically collected samples equates to 12.5%, (i.e. 1/8). And the overall project quality control sample frequency for Class 1 SUs remains well above 5%.

The statistical assessment of the Laboratory QC sample results indicated that one field duplicate sample (L10-05-02-B-E-Q-00) exceeded the calculated Control Limit for Th-232. In accordance

with procedure HDP-PR-FSS-703, *Final Status Survey Quality Control*, when an exceedance occurs an investigation is performed to determine if corrective actions were necessary. The investigation determined that for Th-232 the calculated statistic (0.680) only slightly exceeded the Control Limit (0.424). Additionally, while the sample results were evaluated against the Uniform DCGL criteria, all samples collected within LSA 10-05 were collected from the excavation stratum. If the excavation stratum DCGL's are substituted for the calculation of the sample statistics then the calculated statistic (0.680) is easily less than both the Warning Limit (0.736) and the Control Limit (1.102). Also, considering the low activity and the errors associated with the sample results, the Th-232 activity of both samples were relatively close. Based upon the investigation of the exceedance and the results of previous Quality Assurance audits of the overall performance of the laboratory, no corrective actions were determined to be necessary.

Figure 7-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 10-05

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

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

Survey Unit No.:	LSA 10-05				Survey Unit Description:		Burial Pits Open Land Area South Eastern Survey Unit in "Area 9"					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$)	Nuclide DCGL		Warning	Control	Statistic Exceeds Limit?
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	(pCi/g)	(pCi/g)	Statistic[2]	Limit	Limit	(Y/N)
L100502BES00	L100502BEQ00	Ra-226	1.76	0.264	1.81	0.146	1.785	1.9	0.05	0.269	0.403	N
L100502BES00	L100502BEQ00	Tc-99	0.0144	0.282	-0.00268	0.298	0.006	25.1	NA	3.552	5.321	NA
L100502BES00	L100502BEQ00	Th-232	2.11	0.148	1.43	0.149	1.770	2.0	0.680	0.283	0.424	Y
L100502BES00	L100502BEQ00	U-234[1]	5.313	NA	0.975	NA	3.144	195.4	4.338	27.649	41.425	N
L100502BES00	L100502BEQ00	U-235	0.282	0.726	0.0448	0.39	0.163	51.6	NA	7.301	10.939	NA
L100502BES00	L100502BEQ00	U-238	2.86	3.29	1.32	1.24	2.090	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.
Th-232 statistic exceeds Control Limit, RSO notified, review concludes results area acceeptable.

Performed by: Thomas Yardy

Date: 1-11-17

Reviewed by: W Clark Ervis/W Clark Ervis

Date: 1/11/17

Quality Record

7.3 Tc-99 Hot Spot Assessment LSA 10-05

During site characterization studies a total of 15 samples were collected and analyzed for Tc-99 in LSA 10-05. Four of the 15 characterization samples exceeded a Uniform SOF of 1.0 prior to remediation. However, none of the 15 sample results were elevated for Tc-99.

The RASS samples collected from LSA 10-05 were analyzed on-site via gamma spectroscopy, and therefore Tc-99 data was not available. However, no samples (systematic, biased, or sidewall) exceeded the Tc-99 DCGL during FSS. Within LSA 10-05, the maximum sample identified for Tc-99 was 6.5 pCi/g which is below the Tc-99 Uniform DCGL of 25.1 pCi/g.

8.0 ALARA EVALUATION LSA 10-05

All samples collected within LSA 10-05 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 10-05 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.29 for LSA 10-05. The average SOF equates to residual activity contributions from the SU area of 7.25 mrem/year for LSA 10-05.

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, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the U.S. Environmental Protection Agency (EPA) MCLs will be added to the total estimated dose for LSA 10-05. As only offsite borrow soil was used as backfill, no dose will be added to LSA 10-05 for backfill soil. Summing the dose contributions together, the total estimated dose for LSA 10-05 is 11.25 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 10-05 was successful and that there would be no discernable benefit to the health and safety of the public in discounting the results of FSS and performing further remediation of LSA 10-05.

9.0 FSS PLAN DEVIATIONS LSA 10-05

9.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 10-05.

9.2 Adjustments to Scan MDC Calculations

As previously stated in Section 5.1.5, adjustments were made to the Scan MDC calculations for instrumentation used for the GWS in LSA 10-05. 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 10-05, 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 s majority of the GWS data collected in LSA 10-05 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 10-05

	Scan MDC (Total U)	**$DCGL_W$ (Total U)**	**Scan MDC (Ra-226)**	**$DCGL_W$ (Ra-226)**	**Scan MDC (Th-232)**	**$DCGL_W$ (Th-232)**
LSA 10-05	46.7	82.4	1.37	1.9	0.99	2.0

10.0 DATA QUALITY ASSESSMENT

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

10.1 Data Quality Assessment for LSA 10-05

The Data Quality Assessment of the survey methodology, sampling and sample analysis results, and the Quality Control sampling and analysis results to ascertain the validity of the conclusion for LSA 10-05 (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 result (See section 7.2.6).
- LSA 10-05 survey and sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721 *Final Status Survey Data Validation.*
- The WRS Test is 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 10-05, one 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 required for LSA 10-05. Since the test statistic, WR (772) exceeded the critical value (705), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix A.
- A biased soil sample was collected from the location of the highest gamma count rate within the SU (L100527BUB00), and the result was a 0.27 Uniform SOF. Note that higher biased results were found within the SU, but these biased results did not exhibit count rates higher than location L100527BUB00.
- The maximum SOF result for all surface samples within LSA 10-05 was 0.97. The average SOF result for all systematically collected samples within LSA 10-05 was 0.29, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.53.
- No FSS sample result in LSA 10-05 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 sample locations actually collected within LSA 10-05. The result of the retrospective power evaluation presented in Table 10-1 for LSA 10-05 indicates that the minimum number of sample locations required (8) for the WRS Test were equal to the number of sampling locations actually collected within LSA 10-05, however the "optimal" number of sample locations including the + 20% allowance indicates 9 sample locations. Given that 36 samples in total were collected within the LSA, and that the additional 20% allowance is considered optional to ensure adequate power for the test, the results of the retrospective power evaluation are still considered acceptable. Additionally the retrospective power evaluation is only procedurally required when the WRS Test fails, in the case of LSA 10-05 the WRS Test passed with the 8 systematically

collected samples. 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.

- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures for LSA 10-05 was completed prior to the commencement of backfill operations.

Table 10-1
Retrospective Sample Size Verification for LSA 10-05

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.28
$DCGL_{SOF}$	1
LBGR (Mean)	0.29
Shift	0.71
Relative Shift (Δ/σ)	2.54
MARSSIM Table 5.1 (P_r)	0.961428
N	14
N + 20%	16.8
N/2	9
FSS N/2	8
Verification Check	**ADDITIONAL DATA REVIEW REQUIRED**
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test	

MARSSIM Table 5.1

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

MARSSIM Table 5.2, α = 0.05, β = 0.10

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

α
β

Figure 10-1
Data Evaluation Checklists prepared for LSA 10-05 (page 1 of 2)

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

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

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: 05 **Description:** South Eastern Survey Unit in "Area 9"

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

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

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

Quality Record

Figure 10-1
Data Evaluation Checklists prepared for LSA 10-05 (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. 05 **Description:** South Eastern Survey Unit in "Area 9"

Discrepancy: N/A

Corrective Actions Taken: N/A

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

Prepared by (HP Staff):	Thomas Purdy (Print Name)	(Signature)	1-11-17 (Date)
Approved by (RSO):	W. Clark Cross (Print Name)	W Clark Cross (Signature)	1/11/17 (Date)

Quality Record

11.0 SURVEILLANCE FOLLOWING FSS

FSS GWS for LSA 10-05 was completed on January 19, 2014. The sections below provide a description of those storm events that occurred prior to backfill of the SU that had a potential to impact the radiological status of the SU. Additional discussion in regards to the evaluations conducted to determine LSA 10-05 and other SUs were acceptable for backfill are provided in Westinghouse letter HEM-17-30 to the NRC {ML17123A381}.

11.1 April 3, 2014, Storm Event

Due to a storm event that occurred on April 3, 2014, that produced higher than anticipated rainfall which led to subsequent flooding, the LSA 10-05 isolation controls were overrun by storm water. The storm water had the potential to carry contamination from other active remediation areas near LSA 10-05 into LSA 10-05. Because of this storm water event the radiological status of LSA 10-05 needed to be determined to verify the integrity of the FSS surveys that were previously performed in LSA 10-05. As such, the Radiation Safety Officer instructed that confirmatory surveys be performed in LSA 10-05 to determine if the previously performed FSS surveys were still valid.

A Radiological Survey Instruction (Form HDP-PR-HP-311-4) was prepared to provide direction to the HP Technicians performing the confirmatory surveys. The instructions stated that 100% of low lying flat areas that were potentially impacted by flooding would be subject to a 100% GWS, and elevated surfaces that were not subject to flooding (e.g. slopes and sidewalls) would be subject to a 50% coverage GWS. Additionally 8 surface soil samples would be collected, these soil samples were assigned on a random start point grid, but are not systematically collected samples under the FSS Plan therefore these samples are reported as biased results.

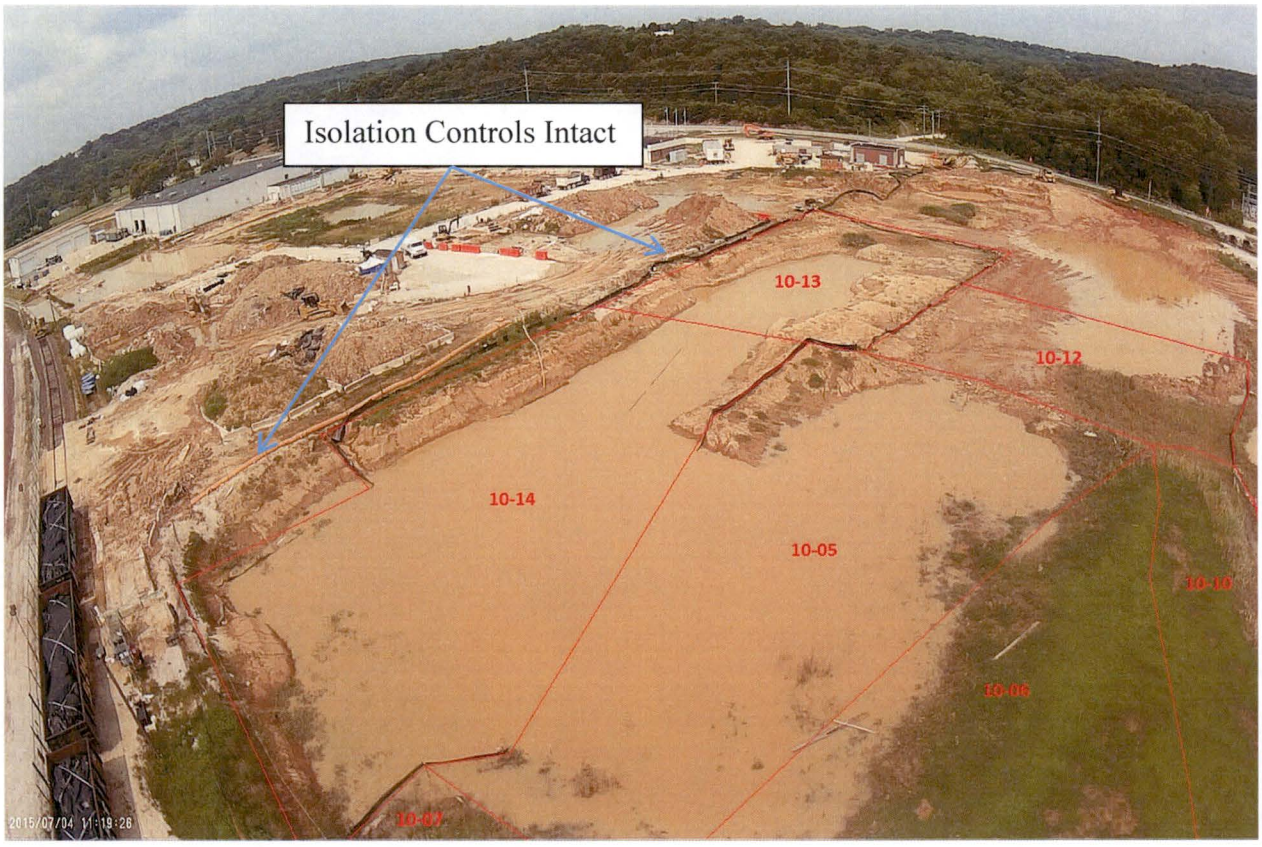
A review of the confirmatory GWS results conducted on May 5 and May 6, 2014, and the 8 new biased sample results were reviewed and it was determined that the FSS of LSA 10-05 had not been negatively impacted by the flooding that occurred within the LSA. The results of the 8 new biased samples are included in Table 7-3. The Radiological Survey Instructions and the Radiological Survey Reports are provided in Appendix V.

11.2 July 3, 2015, Storm Event

Due to a storm event that occurred on July 3, 2015 that produced higher than anticipated rainfall which led to subsequent accumulation of storm water that encompassed LSA 10-05, LSA 10-06, LSA 10-07, LSA 10-13, LSA 10-14.

Prior to the July 3, 2015, storm event, remediation had been completed in all of the SUs adjacent to LSA 10-05 (LSA 10-06, LSA 10-07, LSA 10-10, LSA 10-12, LSA 10-13 and LSA 10-14). The source of the large quantity of storm water in the area was storm water runoff from up-gradient areas above the site via the Northeast Site Creek Diversion. The storm water backed up and traveled from the Northeast Site Creek Diversion across LSA 10-06 and LSA 10-10 into the area shown in Figure 11-1. As can be seen in Figure 11-1, SUs LSA 10-06 and LSA 10-10 had been previously backfilled and the isolation controls between the remediation completed SUs in LSA 10 and the remediation not yet completed in the adjacent LSA 08 SUs remained uncompromised as they resided at a higher elevation.

Figure 11-1
Storm Water Accumulation from July 3, 2015 Storm Event
(Photograph Date – July 4, 2016)



The determination of no impact from the July 3, 2015, storm event and visual inspection of the Burial Pit Area once the storm water was removed from the Burial Pit Area allowed for the approval of the commencement of backfilling the Burial Pit Area on August 4, 2015.

12.0 CONCLUSION LSA 10-05

An adequate quantity and quality of radiological surveys and samples, as well as the corresponding laboratory analysis has been performed, evaluated and documented to demonstrate that the dose associated with all sources within SU LSA 10-05 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 12-1
LSA 10-05 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.29	N/A	0.16	N/A	N/A	**0.45**
DOSE	7.25 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**11.25 mrem/year**

13.0 FINAL STATUS SURVEY DESIGN LSA 10-06

This section describes the method for determining the number of samples required for the FSS of LSA 10-06 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 10-06 and their detection sensitivities are also discussed.

13.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 10-06 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 2, *Final Status Survey Plan Development*, February 2013.

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 10-06. Next the remediation history was reviewed, 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 10-06 was required to undergo a 100% GWS.

13.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 10-06 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

13.1.5 Scan Minimum Detectable Concentration

As background levels were approximately 10,000 cpm within LSA 10-06, 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 10-06, the average enrichment for the SU was 1.85%.

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. Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 10-06 are shown below.

Table 13-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 10-06

	Scan MDC (Total U)	$DCGL_W$ (Total U)	Scan MDC (Ra-226)	$DCGL_W$* (Ra-226)	Scan MDC (Th-232)	$DCGL_W$* (Th-232)
LSA 10-06	81.9	88.5	2.8	2.8	1.8	3.0

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

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

13.1.6 Investigation Action Level

The FSS in LSA 10-06 was performed prior to the development of HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*" which established a standard Scan IAL for all Class 1 SU's at the Hematite Site. The IAL used during the GWS of LSA 10-06 was established at 5,395 ncpm which was a calculated value equivalent to the expected scan rate for a potential hot spot representing the $DCGL_{EMC}$ for Total Uranium of 283 pCi/g (using a U-235 enrichment of 1.85%). Given that this Scan IAL is similar to the value of 4,000 ncpm prescribed by the revised HDP FSS program, and that all FSS data is post processed and evaluated as described in FSSFR Volume 3, Chapter 1, Section 6.1.3, the Scan IAL for LSA 10-06 of 5,395 is considered acceptable.

13.1.7 LSA 10-06 FSS Design Summary

The FSS Plan for LSA 10-06 can be found in Appendix H. Table 13-2 presents an overall FSS design and implementation summary for LSA 10-06.

Table 13-2
FSS Design Summary for LSA 10-06

Gamma Walkover Survey (GWS):		
Scan Coverage	100% accessible excavation floors and walls	
Scan MDC	81.9 pCi/g total Uranium (1,512 ncpm)	
Investigation Action Level (IAL)	5,395 net cpm	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	0	These samples were collected on a systematic grid.
15 cm – 1.5 m (Root)	1	
> 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 Radiological Engineering.		
Instrumentation		
Ludlum 2221 with 44-10 (2" x 2" NaI) detector.	Used for GWS and to obtain static count rates at biased measurement locations.	

14.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 10-06

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 10-06 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS and handheld data logger.

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

14.1.2 GWS Performance

All GWS measurements on the 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 one (1) GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

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

HP Technicians performing GWS in LSA 10-06 used the 5,395 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 12,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 15,395 to 17,395gcpm, 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 SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

14.2 Soil Sampling

14.2.1 Systematic Soil Sampling Summary

Table 14-1 provides a summary of systematic sampling by stratum for LSA 10-06.

Table 14-1
Systematic Sampling Summary by Stratum for LSA 10-06

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
10-06	888	0	1	8	1

14.2.2 Systematic Sampling LSA 10-06

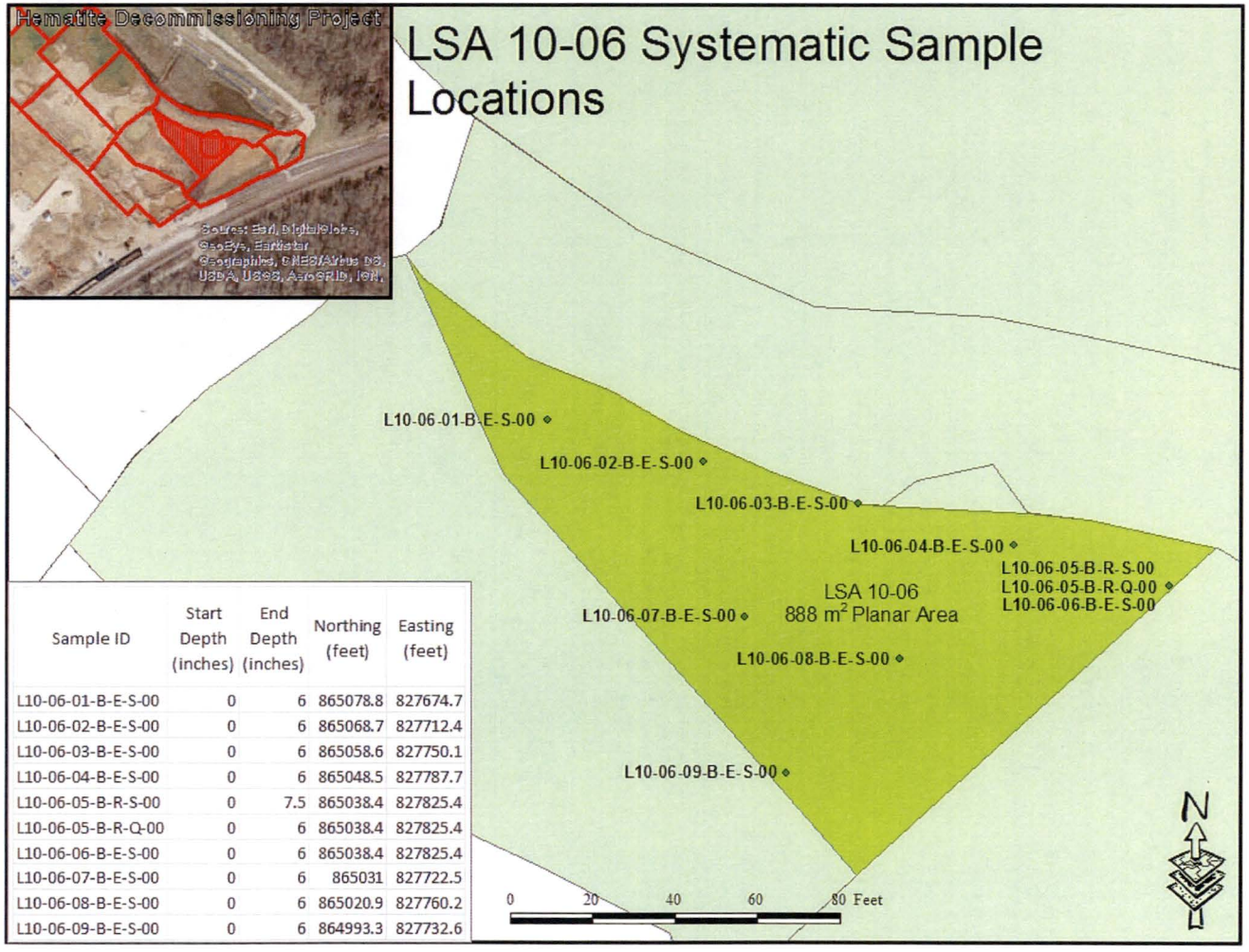
Within LSA 10-06, there were no systematic locations in which portions of the surface stratum (0 – 15 cm) remained in the SU after remediation. Portions of the root stratum (15 cm – 150 cm) remained at one (1) of the eight systematic locations. At this location the remaining root stratum interval was collected using a hand auger and composited. Excavation stratum samples were collected at all eight locations using either hand trowels for six-inch grabs below the existing excavation surface or hand augers where necessary. Given a planar area of 888 m^2 for LSA 10-06 and an eight - point systematic triangular grid, the point-to-point distance within each row was 11.7 m.

While there were eight (8) systematic locations on the LSA 10-06 sampling grid, a total of ten (10) samples were collected at these locations, including:

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

Figure 14-1 presents the map of the nine (9) systematic sample locations which were sampled within LSA 10-06. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 14-1
LSA 10-06 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L10-06-01-B-E-S-00	0	6	865078.8	827674.7
L10-06-02-B-E-S-00	0	6	865068.7	827712.4
L10-06-03-B-E-S-00	0	6	865058.6	827750.1
L10-06-04-B-E-S-00	0	6	865048.5	827787.7
L10-06-05-B-R-S-00	0	7.5	865038.4	827825.4
L10-06-05-B-R-Q-00	0	6	865038.4	827825.4
L10-06-06-B-E-S-00	0	6	865038.4	827825.4
L10-06-07-B-E-S-00	0	6	865031	827722.5
L10-06-08-B-E-S-00	0	6	865020.9	827760.2
L10-06-09-B-E-S-00	0	6	864993.3	827732.6

Table 14-2 below presents a tabular listing of all FSS samples collected within LSA 10-06 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 14-2
FSS Sample Locations and Coordinates for LSA 10-06

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

APPENDIX P-4

FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

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

Survey Unit: 06 **Description:** South Eastern Survey Unit in "Area 9"

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
L100601BES00	Uniform	S	423.339	422.8	865078.8	827674.7	Excavation 6-inch grab
L100602BES00	Uniform	S	422.534	422.0	865068.7	827712.4	Excavation 6-inch grab
L100603BES00	Uniform	S	421.09	420.6	865058.6	827750.1	Excavation 6-inch grab
L100604BES00	Uniform	S	420.315	419.8	865048.5	827787.7	Excavation 6-inch grab
L100605BRQ00	Uniform	Q	424.134	423.6	865038.4	827825.4	Root 6-inch grab
L100605BRS00	Uniform	S	424.134	423.5	865038.4	827825.4	Root 6-inch grab
L100606BES00	Uniform	S	423.5	423.0	865038.4	827825.4	Excavation 6-inch grab
L100607BES00	Uniform	S	422.343	421.8	865031.0	827722.5	Excavation 6-inch grab
L100608BES00	Uniform	S	420.05	419.6	865020.9	827760.2	Excavation 6-inch grab
L100609BES00	Uniform	S	422.373	421.9	864993.3	827732.6	Excavation 6-inch grab
L100610BUB00	Uniform	B	418.0	417.5	865069.0	827698.2	Biased 6-inch grab
L100611BUB00	Uniform	B	422.0	421.5	865011.1	827715.5	Biased 6-inch grab
L100612BUB00	Uniform	B	418.0	417.5	865027.1	827789.4	Biased 6-inch grab

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

*Elevations are in feet above mean sea level.

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

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

CSM: Three-Layer (Surface-Root-Excavation) or Uniform DCGLs used

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

Quality Record

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 10-06 several sample locations were selected within the SU based on the evaluation of the GWS survey data. Biased location L10-06-11-B-E-B-00 represents the maximum GWS measurement encountered within in LSA 10-06 and has a Uniform SOF value of 0.16.

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

During the FSS planning for LSA 10-06, in accordance with procedure HDP-PR-FSS-701, *Final Status Survey Plan Development*, it was determined that sidewall sampling was not necessary for LSA 10-06.

As previously discussed in Section 6.4, Westinghouse and the NRC agreed upon a protocol for sidewall sampling for Tc-99 that predated the performance of FSS in LSA 10-06. A retrospective review is provided for sidewall sampling below utilizing the criteria of HEM-15-MEMO-039 which that demonstrates that Tc-99 sidewall sampling was not required for LSA 10-06 had the agreed upon protocol been in effect at the time of FSS of LSA 10-06.

Figure 14-2, *Area of LSA 10-06 Containing Sidewalls at Time of FSS*, provides photographic evidence of the results of the inspection for the presence of sidewall areas in LSA 10-06 at the time of FSS. As can be seen in Figure 14-2 and by review of Figure 3-6, *LSA 10-06 Depth of Excavation Map,* the only area that exhibited a sidewall with greater than a 45 degree angle and exceeded 12 inches in height is the excavated area in the northeast section of the SU. The perimeter of the excavation is 21.31 meters. The height of sidewall is assigned 1.22 meters (4 foot maximum gradient distance). The sidewall area is calculated to be 26 m^2.

$$21.31 \text{ m (length)} \times 1.22 \text{ m (height)} = 26 \text{ m}^2 \text{ (area)}$$

Equation 14-1

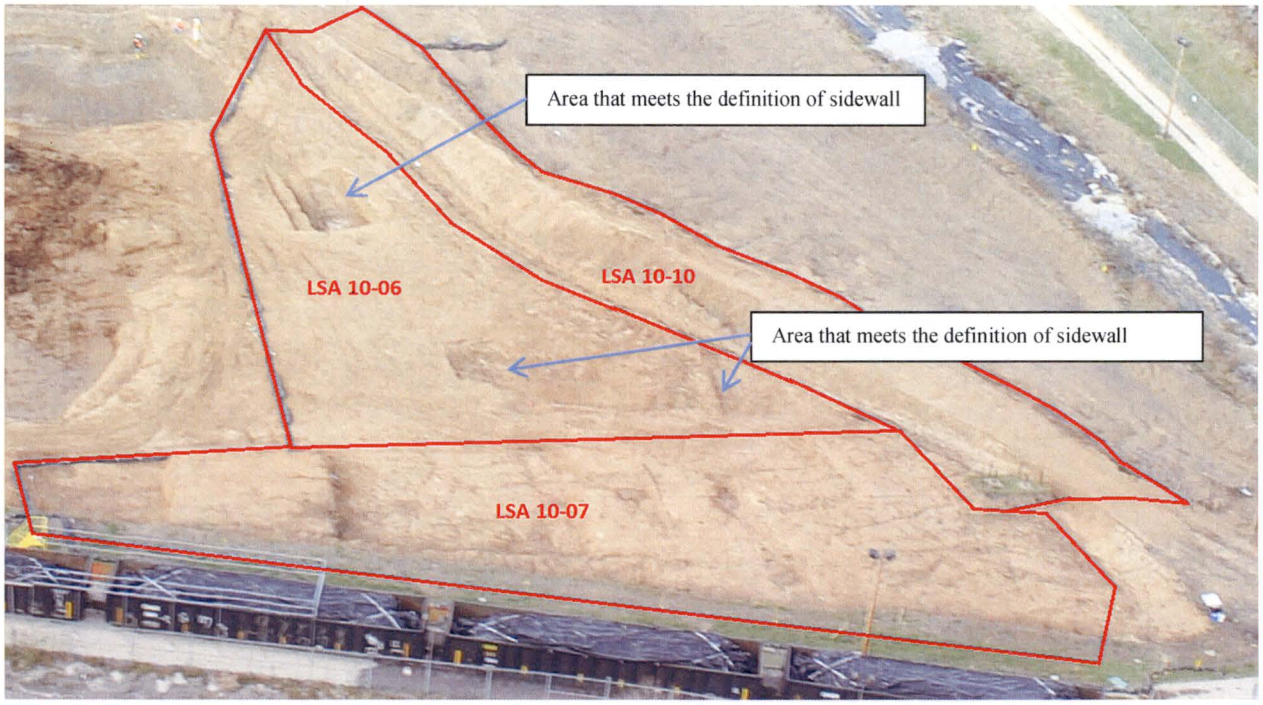
If the sidewall area exceeds 5 % of the SU area then sidewall sampling is required. The sidewall area is 26 m^2. The SU area is 888 m^2. The percentage of sidewall area in regards to the SU area is 2.93%.

$$26 \text{ m}^2 \text{ (sidewall area)} / 888 \text{ m}^2 \text{ (SU area)} = 2.93 \%$$

Equation 14-2

As 2.93% does not exceed 5% if the agreed upon protocol would have been applied to LSA 10-06 at the time of FSS Tc-99 sidewall sampling would not have been required under the agreed upon protocol.

Figure 14-2
Area of LSA 10-06 Containing Sidewalls at Time of FSS



14.5 Quality Control Soil Sampling

One QC field duplicate sample point was randomly selected and collected at systematic location L10-06-05 for LSA 10-06.

15.0 FINAL STATUS SURVEY RESULTS LSA 10-06

15.1 Gamma Walkover Survey

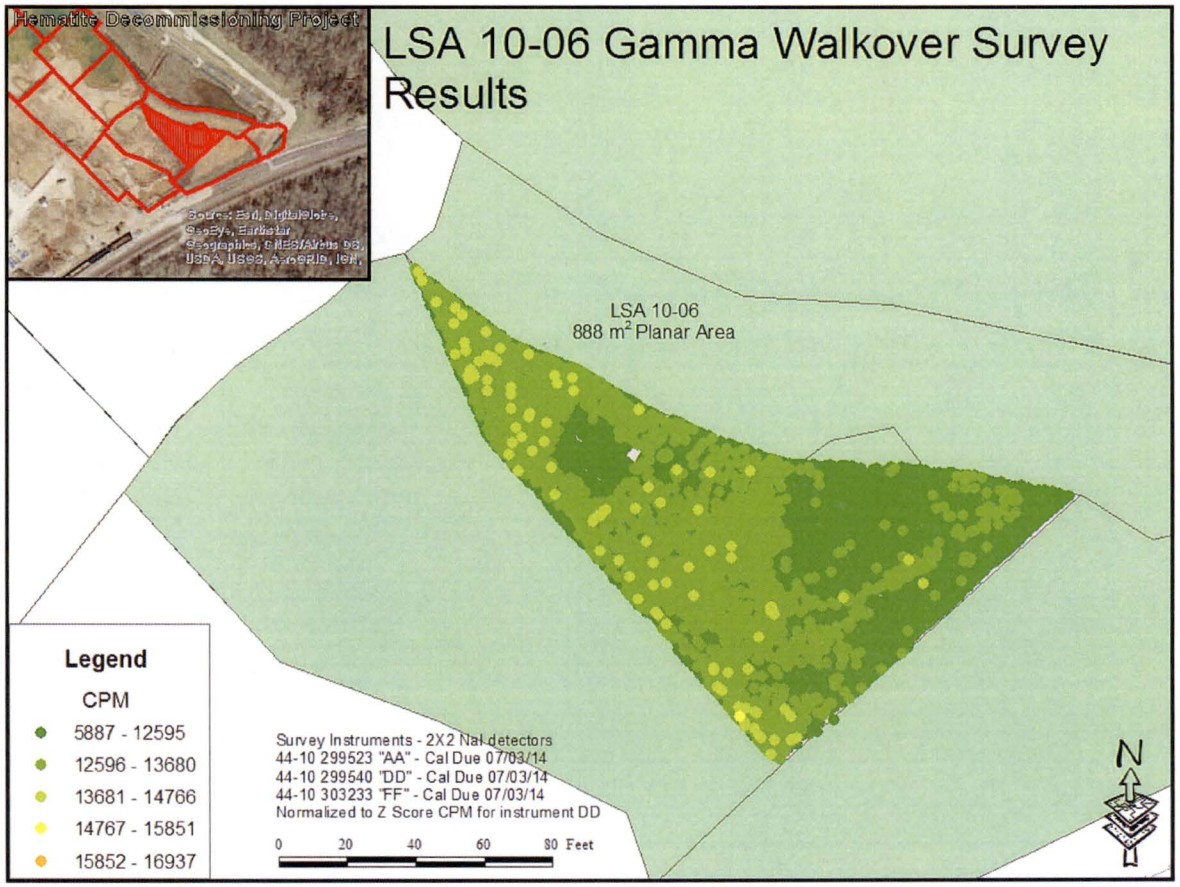
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 10-06 between October 28, 2013, and November 18, 2013.

15.1.1 GWS Results for LSA 10-06

For LSA 10-06, GWS count rates ranged between 5,887 gcpm and 14,860 gcpm, with a mean count rate of 11,780 gcpm. The median count rate was 11,852 gcpm with a standard deviation of 893 cpm. Figure 15-1 below presents a map of the complete GWS data set.

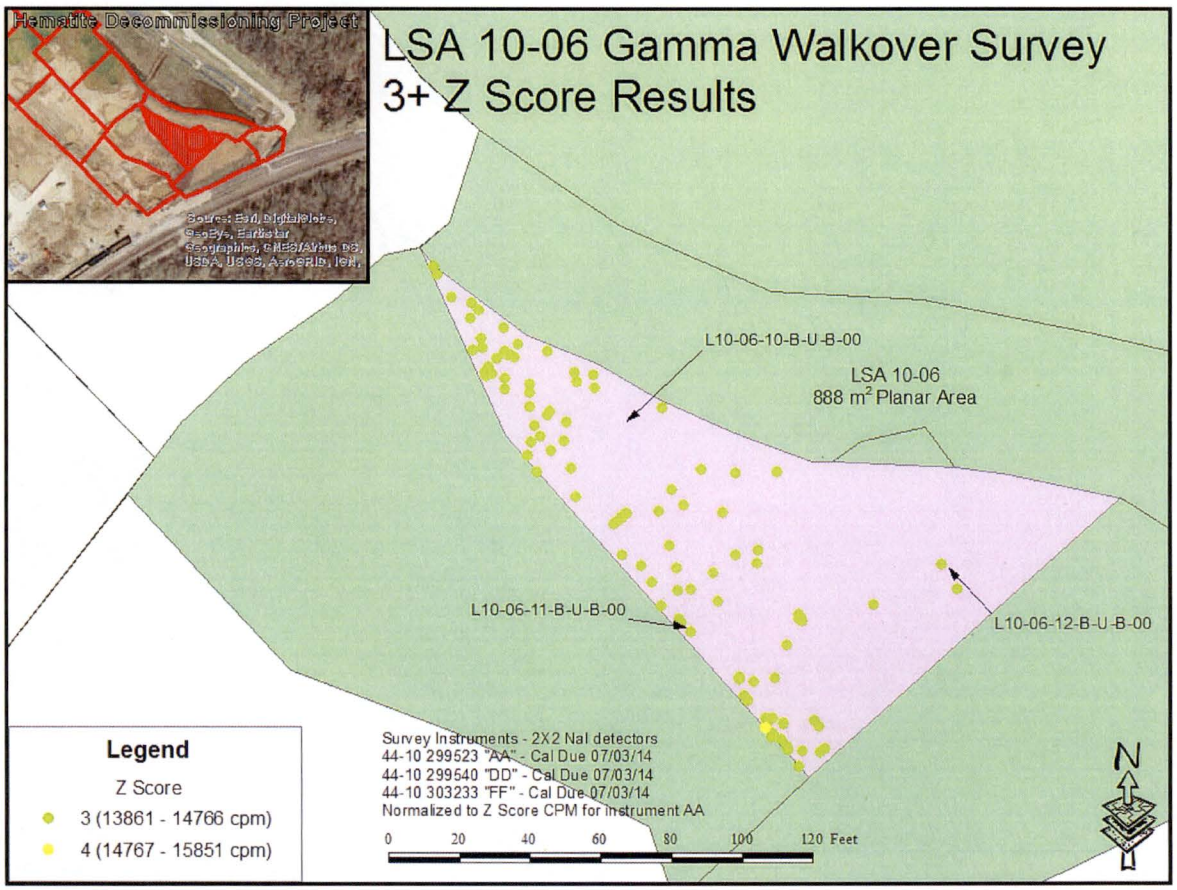
Figure 15-1
Colorimetric GWS Plot for LSA 10-06



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). Three locations (L10-06-10, L10-06-11, and L10-06-12) were selected for biased sample collection. The sample collected at location L10-06-11 represented the maximum GWS measurement within the SU and had a Uniform SOF result of 0.16.

Figure 15-2 presents a map of the +3 Z-score GWS measurements within LSA 10-06, including the three selected biased sampling locations. Note that there are several locations along the western boarder of the LSA that were not selected for biased sampling. These areas were eliminated upon further investigation, it was determined that the anomalies were cause by the close proximity to the sloped walls of LSA 10-05 (e.g. due to counting geometry).

Figure 15-2
Colorimetric GWS Plot for LSA 10-06 (Measurements > Z-score of 3)



Since all GWS data collected in LSA 10-06 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. Also, the mean background count rate during the FSS of LSA 10-06 was shown to be 12,000 gcpm. Using these parameters, a new Scan MDC of approximately 44.9 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 10-06, 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:

$$\text{Scan MDC}_{Total\ Uranium} = \quad 1 \Big/ \left(\left(\frac{0.7928}{4008} \right) + \left(\frac{0.0438}{2.54} \right) + \left(\frac{0.1634}{33.5} \right) \right) = 44.9 \frac{pCi}{g}$$

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 1.32 pCi/g and 0.95 pCi/g, respectively using a two inch air gap. A two inch (2") 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 10-06

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, very small areas of the LSA 10-06 interior were not accessed by GPS due primarily to limitations of the GPS technology. These areas appear as small pink blanks or "slivers" in the Figure 15-1 above.

The post survey processing of the GPS data indicated that the GWS was 98.95% of the SU (see Table 15-1). As the evaluation indicates that the GPS coverage exceeded 95%, and the readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of the apparent GPS coverage gaps were investigated and found to be satisfactory, 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 10-06

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 10-06	118,906	1,250	1.05%	98.95%	1

15.2 Soil Sample Results LSA 10-06

Appendix B presents the analytical results and associated statistics for all FSS samples collected within LSA 10-06.

15.2.1 Surface Soil Sample Results LSA 10-06

There were zero (0) samples collected within the surface stratum (0 – 15 cm) of LSA 10-06. However, there were a total of twelve (12) soil samples collected within the topmost soil layer of the excavation surface including eight (8) systematic samples, three (3) biased samples, and one (1) QC field duplicate sample. The maximum SOF result for "topmost" samples in LSA 10-06 was 0.17 corresponding to the systematic sample L10-06-07-B-E-S-00.

15.2.2 Subsurface Soil Sample Results LSA 10-06

There was one systematic location within LSA 10-06 where root stratum composite sampling was performed. The root stratum zone is between 0.15 and 1.50 m below final grade surface. At this sole root stratum composite sampling location, the top six inches (1.50 – 1.65 m below final

grade surface) of the underlying excavation stratum was collected. This excavation stratum sample where there was overlying root stratum remaining is considered a "subsurface" sample. The SOF result of the subsurface sample collected in LSA 10-06 was 0.09. This sample (L10-06-06) was the excavation stratum sample collected directly underneath the root stratum sample L10-06-05.

15.2.3 WRS Test Evaluation for LSA 10-06

Per Step 7.8.3 of HDP-PR-FSS-721, Final Status Survey Data Evaluation, the WRS statistical test was not necessary for LSA 10-06, since the difference between the maximum SU gross SOF and the minimum background area SOF was less than one using the Uniform Stratum criteria. However, for illustrative purposes, the WRS evaluation was still performed for LSA 10-06 and is included in Appendix B. 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 nine systematically collected samples in LSA 10-06 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 WR, (816) was greater than the critical value (725) 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 10-06

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 10-06, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.11.

Table 15-2
LSA 10-06 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	0.071	0.020	0.086	2.934	0.158	1.282	**0.11**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.04	1.705	0.088	0.949	0.06
Maximum	0.190	0.083	0.200	16.094	0.385	3.010	0.17

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

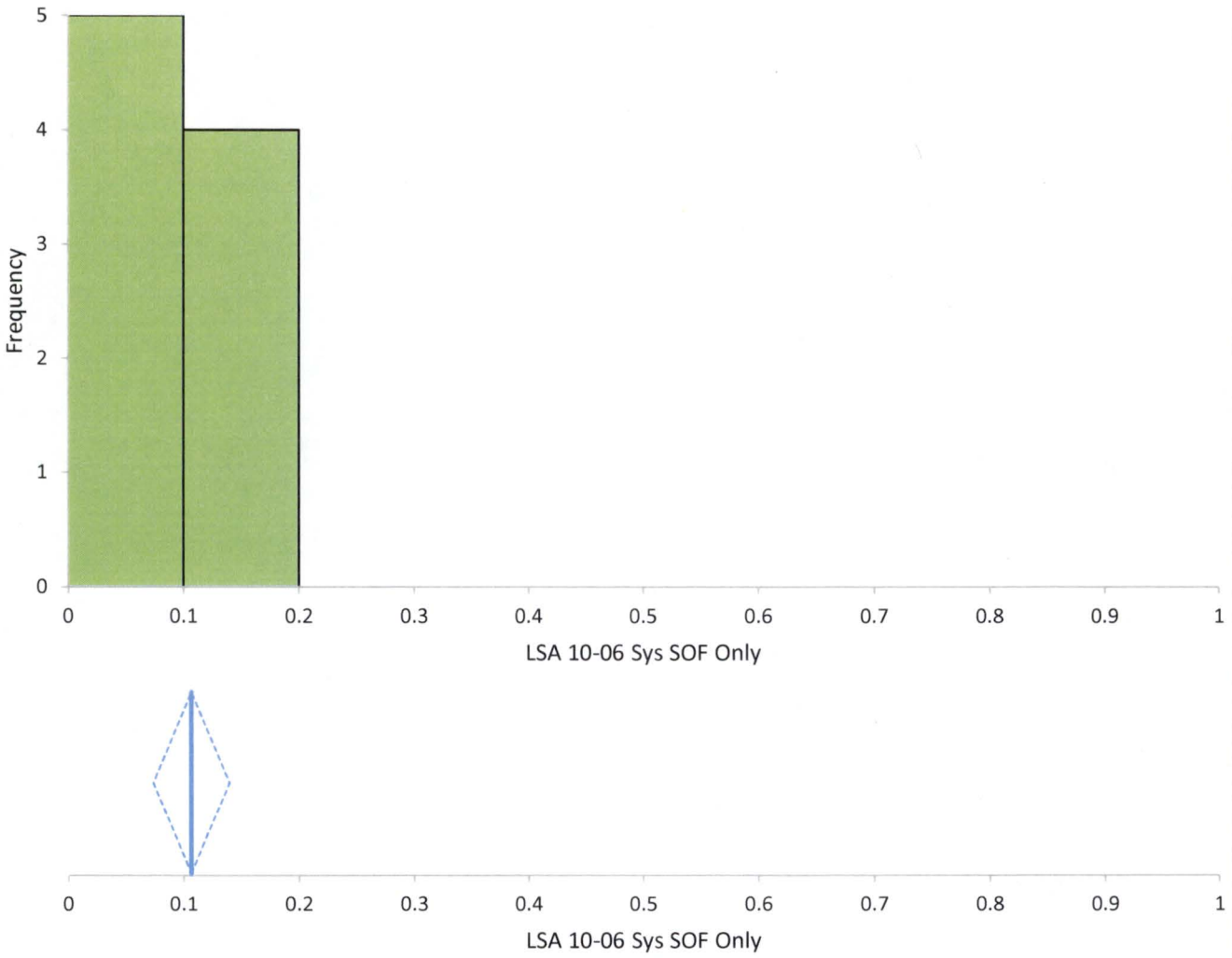
Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within a certain range of values. The frequency plot will reveal any obvious

departures from symmetry, such as skewness or bimodality (two peaks), in the data distribution for the survey unit. The presence of two peaks in the SU frequency plot may indicate the existence of isolated areas of residual radioactivity.

Figure 15-3 presents the overall statistical metrics for the SOF parameter for the 10 systematically collected samples from LSA 10-06. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-06. The middle graph presents the mean SOF (0.11) as indicated by the blue vertical line of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.07 to 0.14. The 96.09% confidence interval based on the median (0.09) of the sample results is 0.06 to 0.15. The bottom two charts present the various statistical metrics of the LSA 10-06 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 10-06 data associated with the systematically collected measurement locations.

Figure 15-3
Graphic Statistical Summary for LSA 10-06 (SOF parameter)



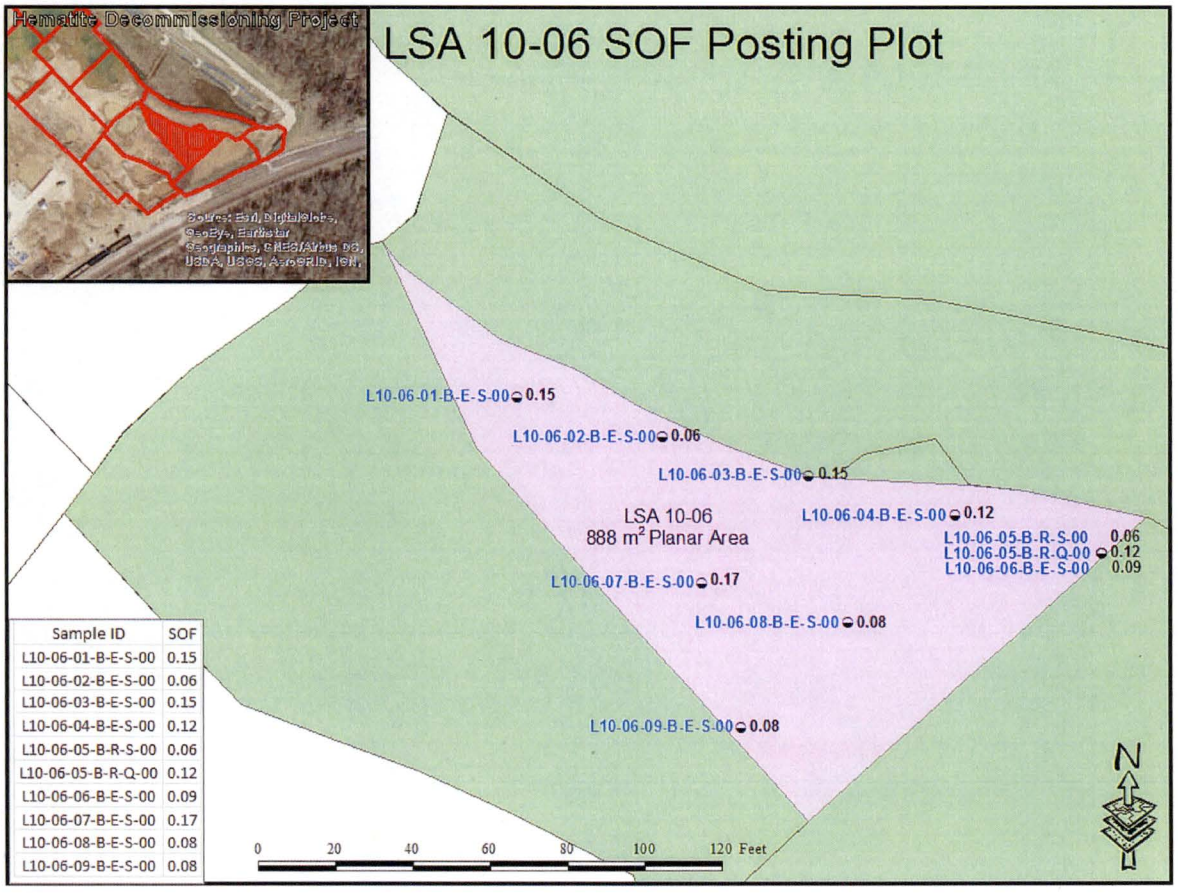
	N	9

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 10-06 Sys SOF Only	0.11	0.07	to 0.14	0.014	0.04	0.00	0.4	-1.53

	Minimum	1st quartile	Median	96.09% CI		3rd quartile	Maximum	IQR
LSA 10-06 Sys SOF Only	0.1	0.07	0.09	0.06	to 0.15	0.15	0.2	0.08

A posting plot is simply a map of the SU with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 10-06 is presented below in Figure 15-4. Figure 15-4 shows no unusual patterns in the data.

Figure 15-4
Posting Plot for LSA 10-06 Systematic Measurement Locations



Sample ID	SOF
L10-06-01-B-E-S-00	0.15
L10-06-02-B-E-S-00	0.06
L10-06-03-B-E-S-00	0.15
L10-06-04-B-E-S-00	0.12
L10-06-05-B-R-S-00	0.06
L10-06-05-B-R-Q-00	0.12
L10-06-06-B-E-S-00	0.09
L10-06-07-B-E-S-00	0.17
L10-06-08-B-E-S-00	0.08
L10-06-09-B-E-S-00	0.08

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

Table 15-3
Final Status Survey Analytical Data: LSA 10-06

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF
L100601BES00	5.51	S	1.260	0.188	0.086	N/A	0.190	0.190	0.047	0.047	0.075	0.220	U	1.040	0.189	0.184	N/A	0.040	0.040	2.754	N/A	N/A	N/A	0.142	0.160	0.278	U	1.840	0.861	1.010	N/A	1.2	0.15
L100602BES00	5.56	S	1.030	0.147	0.070	N/A	-0.040	0.000	0.013	0.013	0.128	0.227	U	1.060	0.153	0.113	N/A	0.060	0.060	3.028	N/A	N/A	N/A	0.165	0.130	0.171	U	1.060	0.342	0.813	N/A	2.4	0.06
L100603BES00	6.17	S	1.220	0.187	0.088	N/A	0.150	0.150	0.011	0.011	0.081	0.225	U	1.040	0.236	0.145	N/A	0.040	0.040	6.977	N/A	N/A	N/A	0.385	0.183	0.227	N/A	1.580	0.432	1.010	N/A	3.7	0.15
L100604BES00	7.45	S	1.170	0.178	0.076	N/A	0.100	0.100	-0.003	0.000	0.076	0.248	U	1.090	0.176	0.134	N/A	0.090	0.090	2.094	N/A	N/A	N/A	0.108	0.147	0.249	U	1.480	0.740	0.936	N/A	1.2	0.12
L100605BRS00	4.38	S	1.070	0.162	0.093	N/A	0.000	0.000	0.083	0.083	0.095	0.224	U	1.070	0.186	0.187	N/A	0.070	0.070	2.849	N/A	N/A	N/A	0.152	0.150	0.196	U	1.430	0.869	1.040	N/A	1.7	0.06
L100606BES00	5.00	S	1.120	0.156	0.065	N/A	0.050	0.050	0.057	0.057	0.042	0.222	U	1.090	0.154	0.082	N/A	0.090	0.090	1.705	N/A	N/A	N/A	0.088	0.116	0.186	U	1.220	0.680	0.874	N/A	1.2	0.09
L100607BES00	7.24	S	1.170	0.184	0.092	N/A	0.100	0.100	0.024	0.024	0.052	0.224	U	1.200	0.193	0.137	N/A	0.200	0.200	2.194	N/A	N/A	N/A	0.118	0.191	0.301	U	1.000	0.410	1.090	U	1.9	0.17
L100608BES00	9.01	S	1.080	0.151	0.064	N/A	0.010	0.010	-0.004	0.000	0.042	0.238	U	1.110	0.187	0.113	N/A	0.110	0.110	2.242	N/A	N/A	N/A	0.121	0.154	0.240	U	0.949	0.353	0.949	N/A	2.0	0.08
L100609BES00	8.38	S	1.110	0.164	0.085	N/A	0.040	0.040	-0.041	0.000	0.099	0.270	U	1.070	0.187	0.116	N/A	0.070	0.070	2.562	N/A	N/A	N/A	0.139	0.157	0.257	U	0.981	0.395	0.985	U	2.2	0.08
L100605BRQ00	4.38	Q	1.150	0.164	0.061	N/A	0.080	0.080	-0.018	0.000	0.036	0.231	U	1.140	0.190	0.135	N/A	0.140	0.140	0.675	N/A	N/A	N/A	0.030	0.150	0.254	U	0.960	0.328	0.807	N/A	0.5	0.12
L100610BUB00	7.50	B	1.050	0.155	0.068	N/A	-0.020	0.000	-0.005	0.000	0.057	0.229	U	1.260	0.188	0.139	N/A	0.260	0.260	2.273	N/A	N/A	N/A	0.123	0.161	0.244	U	0.924	0.326	0.807	N/A	2.1	0.15
L100611BUB00	5.50	B	1.130	0.165	0.065	N/A	0.060	0.060	0.013	0.013	0.018	0.221	U	1.030	0.205	0.137	N/A	0.030	0.030	16.094	N/A	N/A	N/A	0.889	0.271	0.265	N/A	3.010	0.940	1.060	N/A	4.4	0.16
L100612BUB00	7.50	B	0.997	0.143	0.066	N/A	-0.073	0.000	0.009	0.009	0.062	0.224	U	1.080	0.174	0.119	N/A	0.080	0.080	2.681	N/A	N/A	N/A	0.143	0.136	0.221	U	1.340	0.709	0.886	N/A	1.7	0.06
Systematic Minimum			0.000						0.000					0.040						1.705				0.088				0.949				**2.0**	0.06
Systematic Maximum			0.190						0.083					0.200						16.094				0.385				3.010				Average Enrichment (%)	0.17
Systematic Mean			0.071						0.020					0.086						2.934				0.158				1.282					0.11
Systematic Median			0.050						0.013					0.070						2.562				0.139				1.220					0.09
Systematic Standard Deviation			0.068						0.026					0.049						1.572				0.222				0.315					0.04
			With ingrowth, use Ra226 bkg = 1.07											Th232 bkg = 1.0																				

NOTES:

Gross results in units of pCi/g.

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

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

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

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

15.2.5 Biased Soil Sample Result LSA 10-06

Three (3) biased samples were collected from LSA 10-06. The sample collected at location L10-06-11 represented the maximum GWS measurement (14,860 gcpm) within the SU, and had a result of 0.16 Uniform SOF.

15.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 10-06

Utilizing FSS procedural guidance, based upon the NRC approval of the content of the DP, at the time of FSS the FSS Plan did not require sidewall samples to be taken in LSA 10-06. (See Section 14.4)

15.2.7 Quality Control Soil Sample Result LSA 10-06

One QC field duplicate sample point was randomly selected for LSA 10-06 which was collected at systematic locations L10-06-05.

For the 11 samples (i.e., 8 systematic + 3 biased) collected within LSA 10-06, one field duplicate sample was collected. This frequency equates to 7.7%, (i.e. 1/13). 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 10-06

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

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

Survey Unit No.:	LSA 10-06				Survey Unit Description:		Burial Pits Open Land Area South Eastern Survey Unit in "Area 9"					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$)	Nuclide DCGL				Statistic Exceeds Limit?
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	(pCi/g)	(pCi/g)	Statistic[2]	Warning Limit	Control Limit	(Y/N)
L100605BRS00	L100605BRQ00	Ra-226	1.07	0.0931	1.15	0.0609	1.110	1.9	0.08	0.269	0.403	N
L100605BRS00	L100605BRQ00	Tc-99	0.0829	0.224	-0.0176	0.231	0.033	25.1	NA	3.552	5.321	NA
L100605BRS00	L100605BRQ00	Th-232	1.07	0.187	1.14	0.135	1.105	2.0	0.070	0.283	0.424	N
L100605BRS00	L100605BRQ00	U-234[1]	2.849	N/A	0.675	N/A	1.762	195.4	2.174	27.649	41.425	N
L100605BRS00	L100605BRQ00	U-235	0.152	0.196	0.0297	0.254	0.091	51.6	NA	7.301	10.939	NA
L100605BRS00	L100605BRQ00	U-238	1.43	1.04	0.96	0.807	1.195	168.8	0.470	23.885	35.786	N

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

Performed by: Thomas Yardy / [illegible]

Date: 1-11-17

Reviewed by: W. ClarEvans / W. ClarEvans

Date: 1/11/17

Quality Record

15.3 Tc-99 Hot Spot Assessment LSA 10-06

During site characterization studies a total of 9 samples were collected and analyzed for Tc-99 in LSA 10-06. None of the 9 characterization samples exceeded a Uniform SOF result of 1.0. No samples exceeded the Tc-99 DCGL during FSS. Within LSA 10-06, the maximum sample identified was 0.83 pCi/g which is well below Uniform DCGL of the 25.1 pCi/g.

16.0 ALARA EVALUATION LSA 10-06

All samples collected within LSA 10-06 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 10-06 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.11 for LSA 10-06. The average SOF equates to residual activity contributions from the survey unit area of 2.75 mrem/year for LSA 10-06.

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, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 10-06. Summing the dose contributions together, the total estimated dose for LSA 10-06 is 6.75 mrem/year.

Since the estimated TEDE is below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 10-06 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 10-06.

17.0 FSS PLAN DEVIATIONS LSA 10-06

17.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 10-06.

17.2 Adjustments to Scan MDC Calculations

As previously stated in Section 13.1.5, adjustments were made to the Scan MDC calculations for instrumentation used for the GWS in LSA 10-06. 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 10-06, 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 10-06 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 10-06

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw (Ra-226)	Scan MDC (Th-232)	DCGLw (Th-232)
LSA 10-06	44.9	88.5	1.32	1.9	0.95	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 10-06

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 10-06 (see Figure 18-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 10-06 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 10-06, 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 10-06, however the WRS Test was still performed for illustrative purposes. Since the test statistic, WR (816) exceeded the critical value (725), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix B.
- The maximum systematic SOF result for all surface samples within LSA 10-06 was 0.17. The SOF result for the single subsurface sample within LSA 10-06 was 0.09. The average SOF result for all systematically collected samples within LSA 10-06 was 0.11, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.14.
- No FSS sample result in LSA 10-06 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 sample locations actually collected within LSA 10-06. The successful result of the retrospective power evaluation presented in Table 17-1 for LSA 10-06 indicates that the minimum number of sample locations required (8) for the WRS Test was equal to the number of sampling locations actually collected within LSA 10-06. 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.
- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures for LSA 10-06 was completed prior to the commencement of backfill operations.

Table 18-1
Retrospective Sample Size Verification for LSA 10-06

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.04
$DCGL_{SOF}$	1
LBGR (Mean)	0.11
Shift	0.89
Relative Shift (Δ/σ)	20.85
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 10-06 (page 1 of 2)

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

Survey Area: 10 **Description:** Burial Pits Open Land Area
Survey Unit: 06 **Description:** Section 6

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 step 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 ☐
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 (Reference 5.11)	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;

Ludlum 2221 meters AA (299523), DD (299540) and FF (303233) were used to conduct the FSS scanning in LSA-10-06. All QC measurements were within specification. While within specification, all pre and post QC checks measure above the mean for all meters. The QC charts were reviewed for all meters and no indication of the meters drifting out of the acceptable range was identified.

Figure 18-1
Data Evaluation Checklists prepared for LSA 10-06 (page 2 of 2)

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

Survey Area: No. 10 **Description:** Burial Pits Open Land Area
Survey Unit: No. 06 **Description:** Section 6

Discrepancy; None

Corrective Actions Taken; None

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐
    a. If "No", then forward this form to the RSO. **N/A**
12. The following questions will be answered by the RSO.
    a. If the answer to question ~~13~~ 11 was "No", then is the affected data still valid? Yes ☐ No ☐
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐
    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):	Michelle Bresnahan		2/18/14
Approved by (RSO):	Joseph Guzo		2/18/14

19.0 SURVEILLANCE FOLLOWING FSS

FSS of SU LSA 10-06 was completed on November 18, 2013 as well as FSS of adjacent SUs LSA 10-05 (January 19, 2014), LSA 10-07 (November 25, 2013) and LSA 10-10 (January 25, 2014). As such, the radiological status of all of the SUs adjacent to LSA 10-06 did not present a possibility of recontamination of LSA 10-06 as a consequence of a storm event. Figure 19-1 is a photograph of SU LSA 10-06 being backfilled on February 24, 2014. Additional discussion in regards to the evaluations conducted to determine LSA 10-06 and other SUs were acceptable for backfill are provided in Westinghouse letter HEM-17-30 to the NRC {ML17123A381}.

Figure 19-1
Backfill of SUs LSA 10-06, LSA 10-07 and LSA 10-10

20.0 CONCLUSION LSA 10-06

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 10-06 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 10-06 SOF and Dose Summation

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

21.0 FINAL STATUS SURVEY DESIGN LSA 10-07

This section of the report describes the method for determining the number of samples required for the FSS of LSA 10-07 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 10-07 and the detection sensitivities are also discussed.

21.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 10-07 were driven by the type (Open Land) and Class (Class 1) of the SU and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 2, *Final Status Survey Plan Development*, February 2013.

21.1.1 Surrogate Evaluation Areas

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

21.1.2 $DCGL_W$

During the FSS design process a review was performed of the historic characterization data for LSA 10-07. The review identified several areas were previously found to exceed a Uniform SOF of 1.0 (discussed in Section 3.3.8). Next the remediation history was reviewed to confirm that the area was 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.

21.1.3 GWS Coverage

As a Class 1 SU, LSA 10-07 was required to undergo a 100% GWS.

21.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 10-07 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

21.1.5 Scan Minimum Detectable Concentration

As background levels were approximately 10,000 cpm within LSA 10-07, 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 21-1

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 10-07, the average enrichment for the SU was 97%. Note that this is a conservatively high estimate of enrichment. Since all of the RASS soil samples for LSA 10-07 were analyzed on-site, the low activity samples were not able to identify U-238 above sample MDC and reported as zero. For this reason the enrichment of 97% was used for Scan MDC calculation. The actual enrichment from all FSS samples was 5.6% when the samples were analyzed at the offsite laboratory.

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 21-1. Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 10-07 are shown below.

Table 21-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 10-07

	Scan MDC (Total U)	**$DCGL_W$ (Total U)**	**Scan MDC (Ra-226)**	**$DCGL_W$* (Ra-226)**	**Scan MDC (Th-232)**	**$DCGL_W$* (Th-232)**
LSA 10-07	157.0	98.2	2.8	2.8	1.8	3.0

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

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

21.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The FSS in LSA 10-07 was performed prior to the development of HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*" which established a standard Scan IAL for all Class 1 SU's at the Hematite Site. The IAL used during the GWS of LSA 10-07 was established at 3,315 ncpm which was a calculated value equivalent to the expected scan rate for a potential hot spot representing the $DCGL_{EMC}$ for Total Uranium of 344 pCi/g (using a U-235 enrichment of 97%). Given that this Scan IAL is conservative compared to the value of 4,000 ncpm prescribed by the revised HDP FSS program, and that all FSS data is post processed and evaluated as described in FSSFR Volume 3, Chapter 1, Section 6.1.3, the Scan IAL for LSA 10-07 of 3,314 is considered acceptable.

21.1.7 LSA 10-07 FSS Design Summary

The FSS Plan for LSA 10-07 can be found in Appendix I. Table 21-2 presents an overall FSS design and implementation summary for LSA 10-07.

Table 21-2
FSS Design Summary for LSA 10-07

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed excavation floors and walls	
Scan MDC	157 pCi/g total Uranium (1,512 ncpm)	
Investigation Action Level (IAL)	3,315 net cpm	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	1	These samples were collected on a systematic grid.
15 cm – 1.5 m (Root)	5	
> 1.5m (Excavation)	7	
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.	Used for GWS and to obtain static count rates at biased measurement locations.	

22.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 10-07

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

22.1 Gamma Walkover Survey

22.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 10-07 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS and handheld data logger.

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

22.1.2 GWS Performance

All GWS measurements on the 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 10-07 used the 3,315 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 12,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 13,315 to 15,315 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 SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

22.2 Soil Sampling

22.2.1 Systematic Soil Sampling Summary

Table 22-1 provides a summary of systematic sampling by stratum for LSA 10-07.

Table 22-1
Systematic Sampling Summary by Stratum for LSA 10-07

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
10-07	1,209	1	5	7	1

22.2.2 Systematic Sampling LSA 10-07

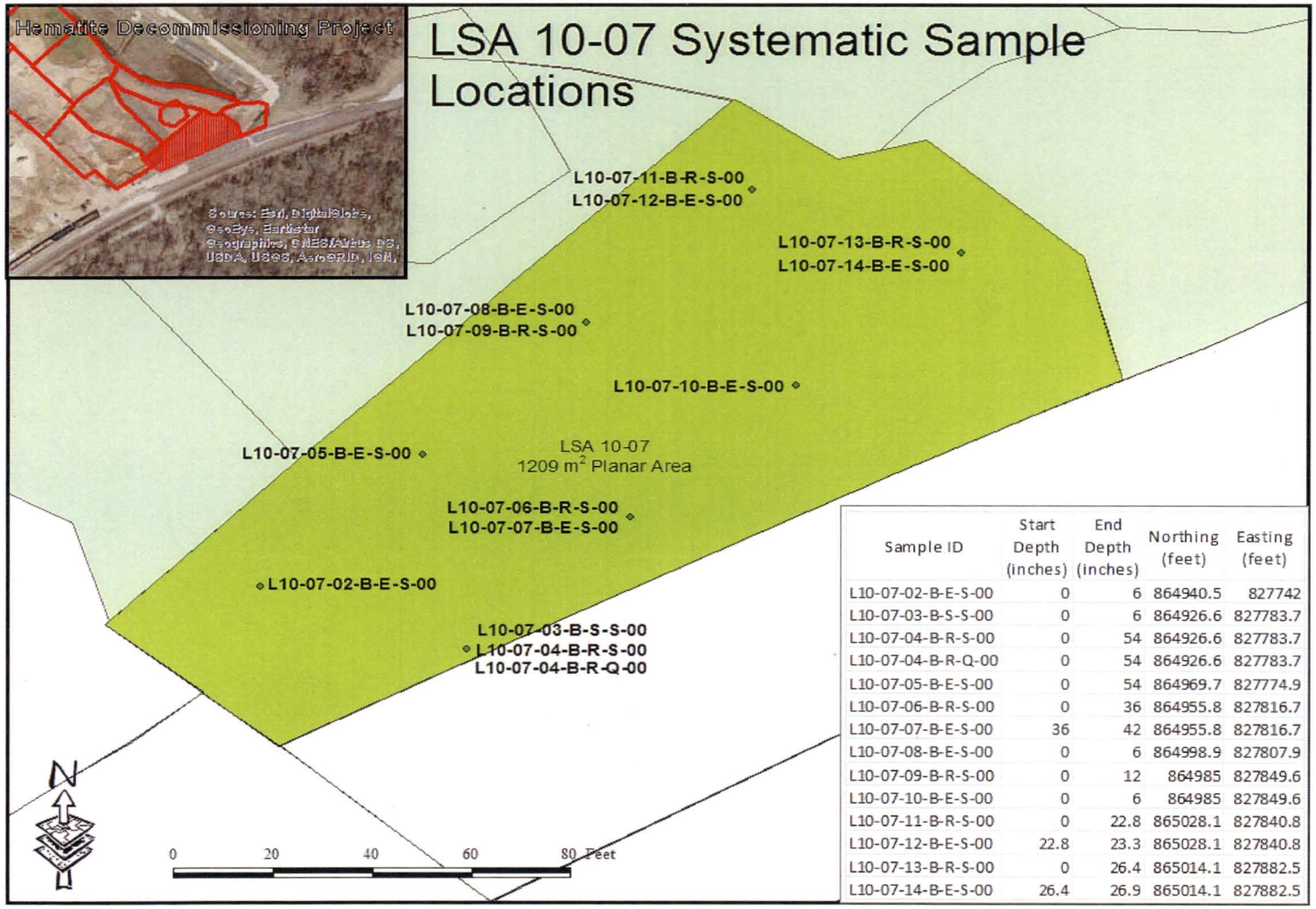
Within LSA 10-07, there was one systematic location in which portions of the surface stratum (0 – 15 cm) remained in the SU after remediation. At this location the underlying root stratum interval was collected using a hand auger and composited. Portions of the root stratum (15 cm – 150 cm) remained at five (5) of the eight systematic locations. Excavation stratum samples were collected at seven (7) locations using either hand trowels for six-inch grabs below the existing excavation surface or hand augers where necessary. Given a planar area of 1,209 m^2 for LSA 10-07 and an eight - point systematic triangular grid, the point-to-point distance within each row was 13.2 m.

While there were eight systematic locations on the LSA 10-07 sampling grid, a total of fourteen (14) samples were collected at these locations, including:

- One (1) samples collected within the remaining surface stratum
- Five (5) samples collected within the remaining root stratum
- Seven (7) samples collected within the excavation, or "deep"
- One (1) Quality Control (QC) field replicate

Figure 22-1 presents the map of the eight (8) systematic sample locations which were sampled within LSA 10-07. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 22-1
LSA 10-07 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L10-07-02-B-E-S-00	0	6	864940.5	827742
L10-07-03-B-S-S-00	0	6	864926.6	827783.7
L10-07-04-B-R-S-00	0	54	864926.6	827783.7
L10-07-04-B-R-Q-00	0	54	864926.6	827783.7
L10-07-05-B-E-S-00	0	54	864969.7	827774.9
L10-07-06-B-R-S-00	0	36	864955.8	827816.7
L10-07-07-B-E-S-00	36	42	864955.8	827816.7
L10-07-08-B-E-S-00	0	6	864998.9	827807.9
L10-07-09-B-R-S-00	0	12	864985	827849.6
L10-07-10-B-E-S-00	0	6	864985	827849.6
L10-07-11-B-R-S-00	0	22.8	865028.1	827840.8
L10-07-12-B-E-S-00	22.8	23.3	865028.1	827840.8
L10-07-13-B-R-S-00	0	26.4	865014.1	827882.5
L10-07-14-B-E-S-00	26.4	26.9	865014.1	827882.5

Table 22-2 below presents a tabular listing of all FSS samples collected within LSA 10-07 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 22-2

FSS Sample Locations and Coordinates for LSA 10-07

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

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area:	LSA 10	**Description:**	Burial Pits Open Land Area
Survey Unit:	07	**Description:**	South Eastern Survey Unit in "Area 9"
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
L100702BES00	Uniform	S	426.6	426.1	864940.5	827742.0	Excavation 6-inch grab
L100703BSS00	Uniform	S	432.3	431.9	864926.6	827783.7	Surface 6-inch grab
L100704BRS00	Uniform	S	431.9	427.4	864926.6	827783.7	Root Zone Composite
L100705BES00	Uniform	S	423.2	422.7	864969.7	827774.9	Excavation 6-inch grab
L100706BRS00	Uniform	S	429.4	426.4	864955.8	827816.7	Root Zone Composite
L100707BES00	Uniform	S	426.4	425.9	864955.8	827816.7	Excavation 6-inch grab
L100708BES00	Uniform	S	424.6	424.1	864998.9	827807.9	Excavation 6-inch grab
L100709BRS00	Uniform	S	426.3	425.3	864985.0	827849.6	Root Zone Composite
L100710BES00	Uniform	S	425.3	424.8	864985.0	827849.6	Excavation 6-inch grab
L100711BRS00	Uniform	S	425.2	423.3	865028.1	827840.8	Root Zone Composite
L100712BES00	Uniform	S	423.3	422.8	865028.1	827840.8	Excavation 6-inch grab
L100713BRS00	Uniform	S	424.3	422.1	865014.1	827882.5	Root Zone Composite
L100714BES00	Uniform	S	422.1	421.6	865014.1	827882.5	Excavation 6-inch grab
L100704BRQ00	Uniform	Q	431.9	427.4	864926.6	827783.7	Root Zone Composite
L100701BUB00	Uniform	B	422.0	421.5	864980.1	827783.2	Biased 6-inch grab
L100715BUB00	Uniform	B	421.5	421.0	864980.1	827783.2	Biased 6-inch grab
L100716BUB00	Uniform	B	422.0	421.5	864940.0	827740.3	Biased 6-inch grab
L100701BUI01	Uniform	I	422.0	421.5	864976.6	827785.0	Investigation 6-inch grab
L100701BUI02	Uniform	I	422.0	421.5	864976.6	827788.9	Investigation 6-inch grab
L100701BUI03	Uniform	I	422.0	421.5	864972.9	827787.9	Investigation 6-inch grab
L100701BUI04	Uniform	I	422.0	421.5	864975.0	827783.9	Investigation 6-inch grab

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

*Elevations are in feet above mean sea level.

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

Distance in feet from lower left corner of the surface (Structures); each surface has it's own (X,Y) = (0,0); OR

For piping the distance from the beginning of the survey unit.

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

CSM: Three-Layer (Surface-Root-Deep) or Uniform

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

Quality Record

22.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 10-7 several biased sample locations were selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. One biased sample was collected within LSA 10-07 that exceeded a Uniform SOF of 1.0, and an EMC was performed at this location to demonstrate compliance with the release criteria. Several Investigation samples were also collected surrounding this elevated biased sample location. For the purposes of FSS, Investigation samples are considered Biased samples. This issue is discussed further in Section 23.2.3, Elevated Measurement Comparison.

Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

22.4 Judgmental/Sidewall Sampling for Tc-99

During the FSS planning for LSA 10-07, in accordance with procedure HDP-PR-FSS-701, *Final Status Survey Plan Development*, it was determined that sidewall sampling was not necessary for LSA 10-07.

As previously discussed in Section 6.4, Westinghouse and the NRC agreed upon a protocol for sidewall sampling for Tc-99, which predated the performance of FSS in LSA 10-07. As such, a retrospective review is provided utilizing the criteria of HEM-15-MEMO-039 that demonstrates that Tc-99 sidewall sampling was not required for LSA 10-07 had the agreed upon protocol been in effect at the time of FSS of LSA 10-07.

Figure 22-2, *Area of LSA 10-07 Containing Sidewalls at Time of FSS*, provides evidence of what the results of the inspection for the presence of sidewall areas in LSA 10-07 at the time of FSS. As can be seen by review of Figure 3-8, *LSA 10-07 Depth of Excavation Map*, and as can be seen in Figure 22-2, LSA 10-07 presented a number of areas containing sidewalls.

Figure 22-2
Area of LSA 10-07 Containing Sidewalls at Time of FSS

The sidewalls are summarized in Table 22-3 utilizing the formula below.

length x height = area

Equation 22-1

Table 22-3
LSA 10-07 Sidewall Area Summary

	Length (m)	x	Height (m)	=	Area (m^2)
Wall 1	11.58	x	.61	=	7.06
Wall 2	13.41	x	.61	=	8.18
Wall 3	9.14	x	.76	=	6.95
Wall 4	8.84	x	.76	=	6.72
Wall 5	7.01	x	.76	=	5.33
Wall 6	7.62	x	.76	=	5.79
Wall 7	59.74	x	1.52	=	90.80
		Total Sidewall Area			130.83

If the sidewall area exceeds 5 % of the SU area then sidewall sampling is required. The sidewall area for LSA 10-07 is 130.83 m^2. The SU area is 1209 m^2. The percentage of sidewall area in regards to the SU area is 10.82%.

130.83 m^2 (sidewall area) / 1209 m^2 (SU area) = 10.82 %

Equation 22-2

The total sidewall area for LSA 10-07 is 10.82% which exceeds the agreed upon protocol of 5% or greater of the SU area. As such, if the agreed upon protocol would have been applied to LSA 10-07 at the time of FSS Tc-99 sidewall sampling would have been required. Using the guidance of HEM-15-MEMO-039, if the agreed upon protocol would have been applied to LSA 10-07 at the time of FSS, one (1) sidewall sample would have been required to be taken.

Although a side wall sample was not taken in LSA 10-07 for the evaluation of Tc-99. When consideration is given to the extremely high number of soil samples taken in all of the Burial Pit SUs and the adjacent SUs to the Burial Pit Area and the ensuing Tc-99 analysis results for those samples, they provide a high level of confidence in the overall radiological status of the Burial Pit Area post remediation. The cumulative data indicates that the absence of a sidewall sample in LSA 10-07 for Tc-99 would not preclude accepting the results of FSS in LSA 10-07.

22.5 Quality Control Soil Sampling

One QC field duplicate sample point was randomly selected and collected at systematic location L10-07-04 for LSA 10-07. As discussed in section 6.4 during the commencement of FSS activities in early 2015, during a NRC Region III inspection, the NRC Inspector raised the site staff in regards to the FSS program requirements for excavation side wall sampling

23.0 FINAL STATUS SURVEY RESULTS LSA 10-07

23.1 Gamma Walkover Survey

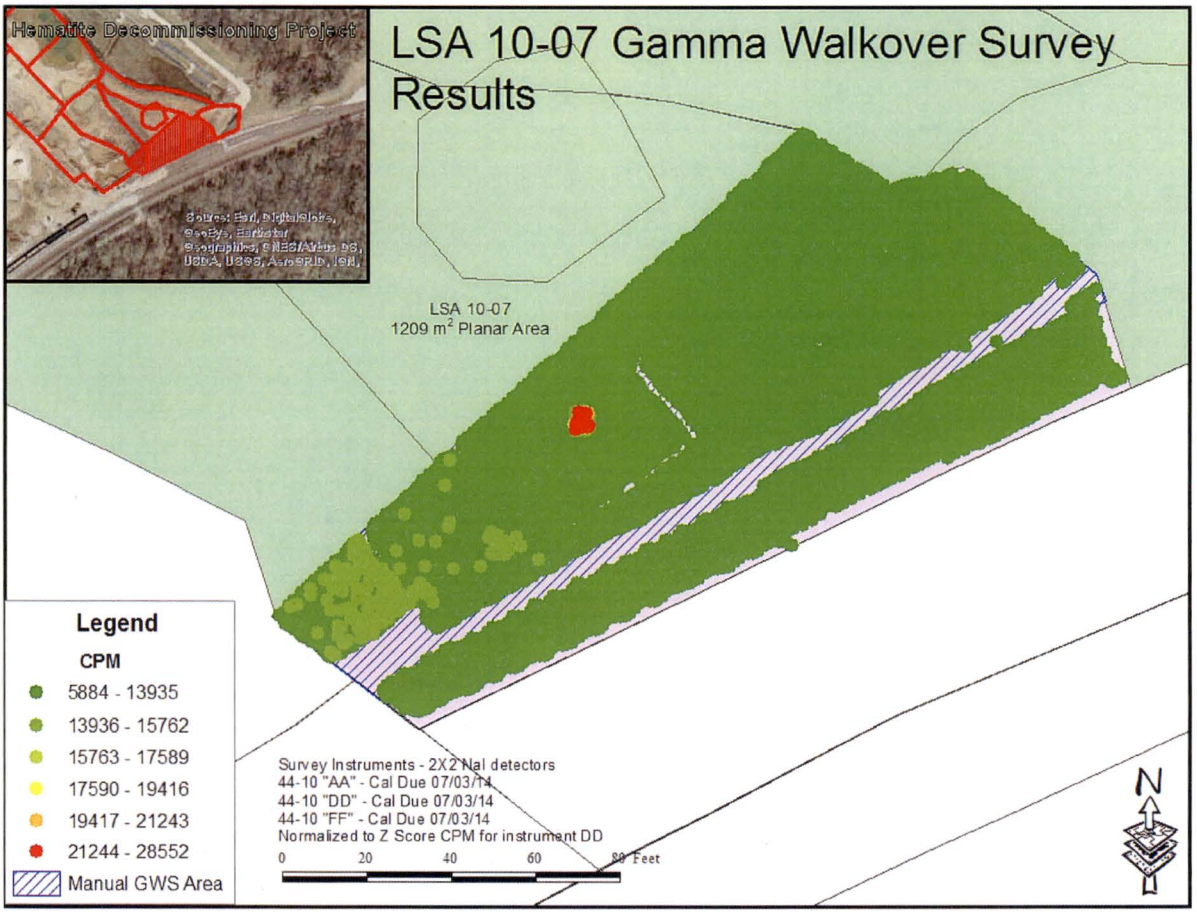
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 10-07 from November 11, 2013, to November 25, 2013.

23.1.1 GWS Results for LSA 10-07

For datalogged GWS data in LSA 10-07, GWS count rates ranged between 8,428 gcpm and 28,552 gcpm, with a mean count rate of 11,847 gcpm. The median count rate was 11,685 gcpm and the standard deviation was 1,407 cpm. Figure 23-1 below presents a map of the complete GWS data set.

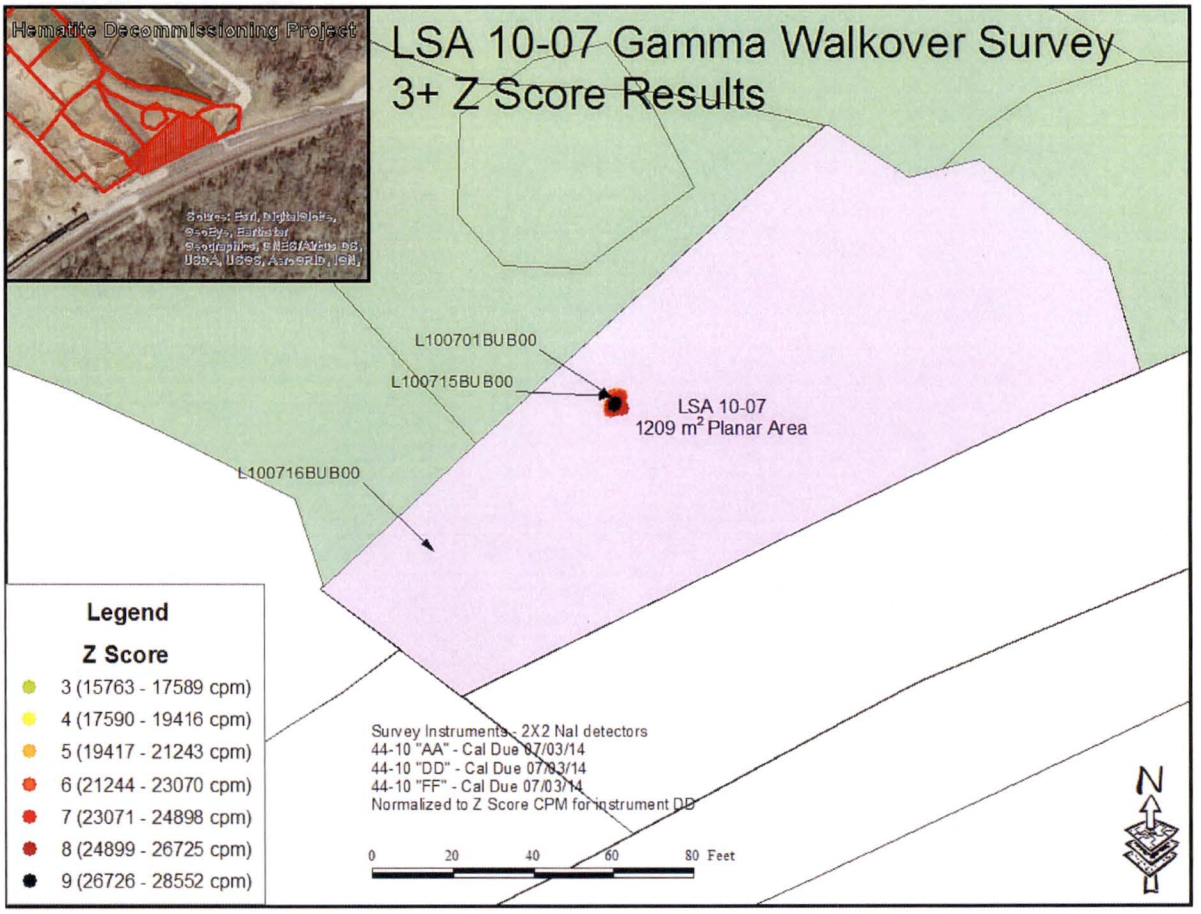
Figure 23-1
Colorimetric GWS Plot for LSA 10-07



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location, L10-07-01, was selected for biased sampling prior to the completion of GWS in the field. This area was clearly elevated, and HP Technicians collected a biased sample at this spot prior to the collection of the systematic soil samples, or the completion of the remaining GWS. After completion of the GWS two additional locations, L10-07-15 and L10-07-16, were selected for biased sample collection. Location L10-07-15 was a follow up sample to the previously collected L10-07-01 collected at the same location.

Figure 23-2 below presents a map of the +3 Z-score GWS measurements within LSA 10-07, including the selected biased sampling locations.

Figure 23-2
Colorimetric GWS Plot for LSA 10-07 (Measurements > Z-score of 3)



Since the majority of GWS data collected in LSA 10-07 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 and a general area FSS background of 12,000 gcpm, a Scan MDC of approximately 44.9 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 10-07, 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:

$$\text{Scan MDC}_{Total\ Uranium} = \quad 1 \Big/ \left(\left(\frac{0.7928}{4008}\right) + \left(\frac{0.0438}{2.54}\right) + \left(\frac{0.1634}{33.5}\right) \right) = 44.9 \frac{pCi}{g}$$

Equation 23-1

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 1.32 pCi/g and 0.95 pCi/g, respectively using a two inch air gap. A two inch (2") 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.

23.1.2 GWS Coverage Results LSA 10-07

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 portions of the LSA 10-07 interior could not be accessed by GPS datalogging due to steep excavation slopes. These areas appear as pink areas in the Figure 21-1 above.

The post survey processing of the GPS data indicated that the datalogged GWS, in addition to the manually recorded surveys, covered 96.41% of the SU (see Table 23-1). However manual surveys were also performed to supplement the areas that were not covered by GPS datalogging, and the evaluation concludes that the manual surveys sufficiently covered the interior sidewalls such that the total area of the LSA surveyed was well in excess of 95%. As the evaluation indicates that the GWS coverage (GPS coverage + manual coverage) exceeded 95%, and the readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of the apparent GPS coverage gaps were investigated and found to be satisfactory, the GWS coverage for the SU has been evaluated to meet the intent of the "100% GWS coverage" requirement.

Table 23-1
GWS Gap Analysis LSA 10-07

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 10-07	234,426	8405	3.59%	96.41%	1

23.2 Soil Sample Results LSA 10-07

Appendix C presents the analytical results and associated statistics for all FSS samples collected within LSA 10-07.

23.2.1 Surface Soil Sample Results LSA 10-07

There was one sample collected within the surface stratum (0 – 15 cm) of LSA 10-07. However, there were a total of fourteen (14) soil samples collected within the topmost soil layer of the excavation surface including eight systematic samples, two biased samples, four follow up investigation samples. The maximum SOF result for the "topmost" samples (excluding the EMC location) was 0.28 corresponding to the systematic sample L10-07-06.

23.2.2 Subsurface Soil Sample Results LSA 10-07

There were five systematic locations within LSA 10-07 where root stratum composite sampling was necessary. The root stratum zone is between 0.15 and 1.50 m below final grade surface. At four of the five 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. At one location the underlying root stratum was collected beneath the remaining surface stratum. These samples where there was an overlying stratum remaining are considered "subsurface" samples. The maximum SOF result of the subsurface samples collected in LSA 10-07 was 0.45 collected at location L10-07-07.

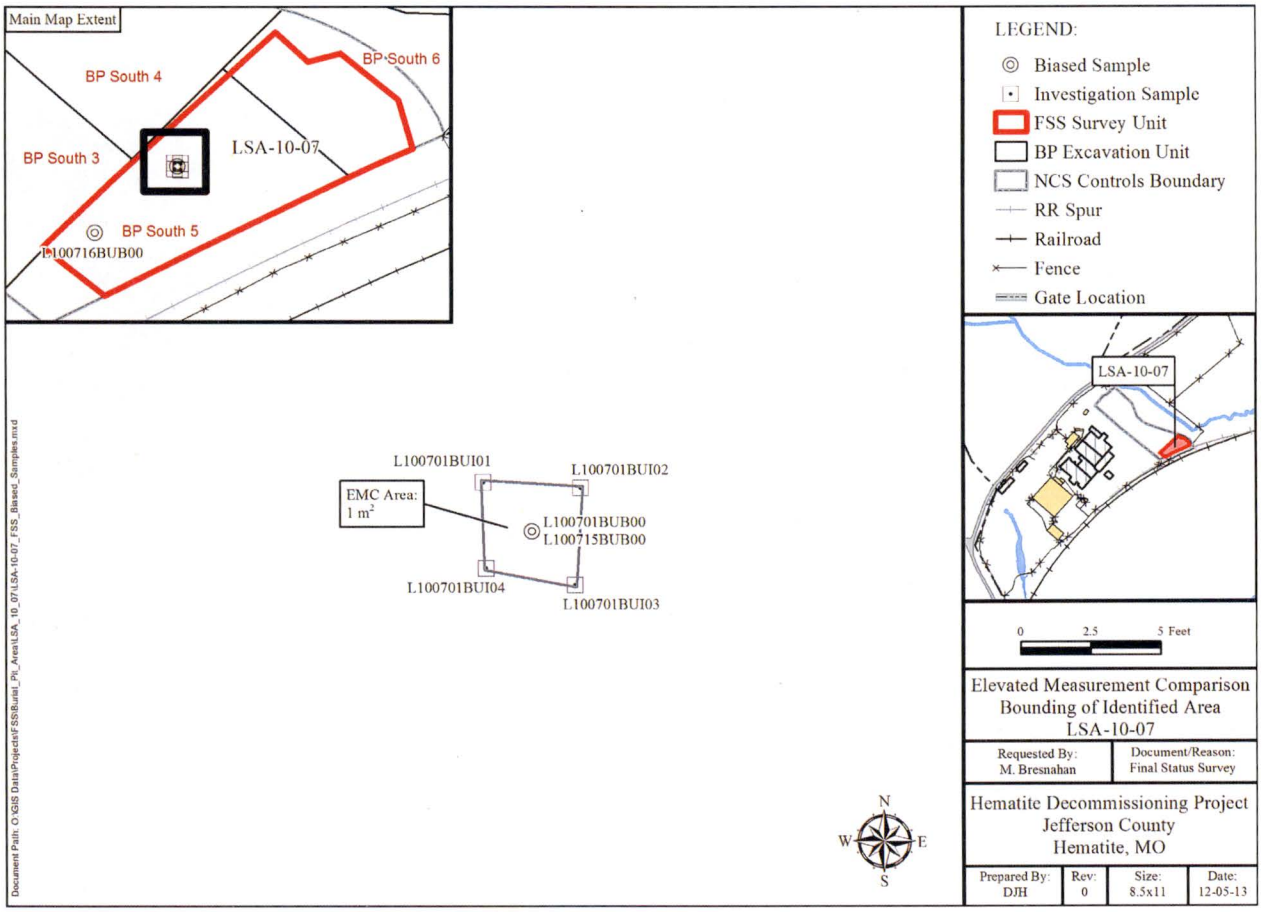
23.2.3 Elevated Measurement Comparison

Since the biased sample L10-07-01-B-U-B-00 exceeded a SOF of 1, an EMC investigation was performed for LSA 10-07 as required by Procedure HDP-PR-FSS-721 *Final Status Survey Data Evaluation.* The size of the associated elevated area surrounding this biased location was determined by "bounding" where four investigation samples were collected in a 1 meter square grid surrounding the sample. As all four investigation samples had SOF results less than 1.0, the area was determined not to exceed 1 m^2. Furthermore, subsequent scanning of the area indicated that the count rates had greatly decreased since the first biased sample was collected. An additional sample (L10-07-15-B-U-B-00) was collected at the exact sample location as the elevated sample, but at a depth of 6 to 12 inches bgs, (where the original sample was collected at 0 to 6 inches bgs). This sample also had a result that was less than a Uniform SOF of 1.0. These sample results indicate a very small area of elevated contamination that was contained within the elevated biased sample (e.g. deconning by sampling), and was no longer present in the SU. Nevertheless, an EMC was performed to demonstrate that the results of the elevated biased sample still meet the release criteria within the LSA.

Following the steps presented in Section 8.6.7 of HDP-PR-FSS-721, the $DCGL_{EMC}$s for all nuclides were calculated based on the nuclide-specific area factors corresponding to 1 m^2. Then the difference between the activity of each nuclide in the elevated area and the average activity of the corresponding nuclide in the general SU area was divided by the nuclide-specific $DCGL_{EMC}$ to determine an activity fraction for each nuclide in the elevated area. These six activity fractions were added together for a total SOF of 0.01 for the EMC area. This SOF is equivalent to a dose of 0.25 mrem/year. Additional information on the EMC calculation can be found in Appendix C.

Figure 23-3 depicts the location of the EMC area in LSA 10-07.

Figure 23-3
EMC Investigation Area within LSA 10-07



23.2.4 WRS Test Evaluation for LSA 10-07

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was required for LSA 10-07 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 13 systematically collected samples in LSA 10-07 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, (943) was greater than the critical value (802) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix C.

23.2.5 Graphical Data Review LSA 10-07

Table 23-2 below presents summary results for the all systematically collected samples (includes surface (none collected in this SU), root, and excavation stratum samples, but not biased or QC samples) collected within LSA 10-07, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.16.

Table 23-2
LSA 10-07 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	0.105	0.027	0.160	2.983	0.160	1.295	**0.16**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.208	0.004	0.744	0.05
Maximum	0.460	0.193	0.360	8.988	0.496	2.030	0.45

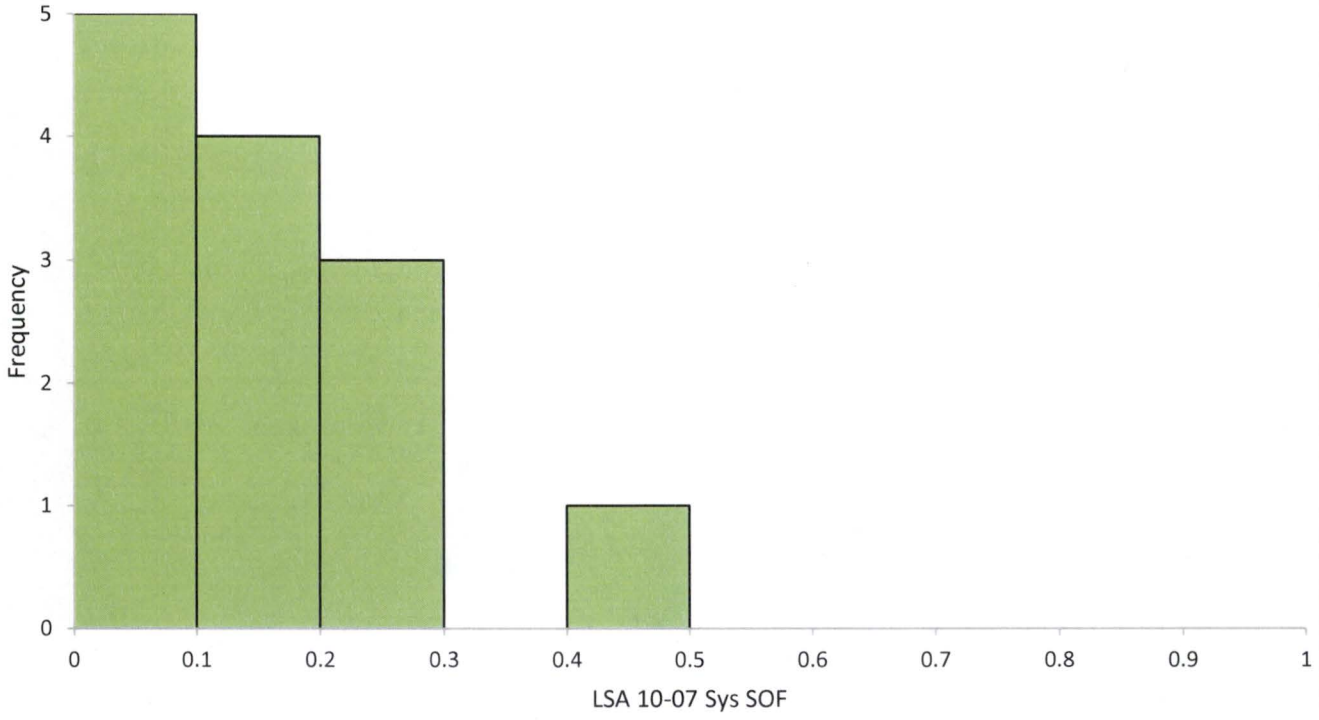
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide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

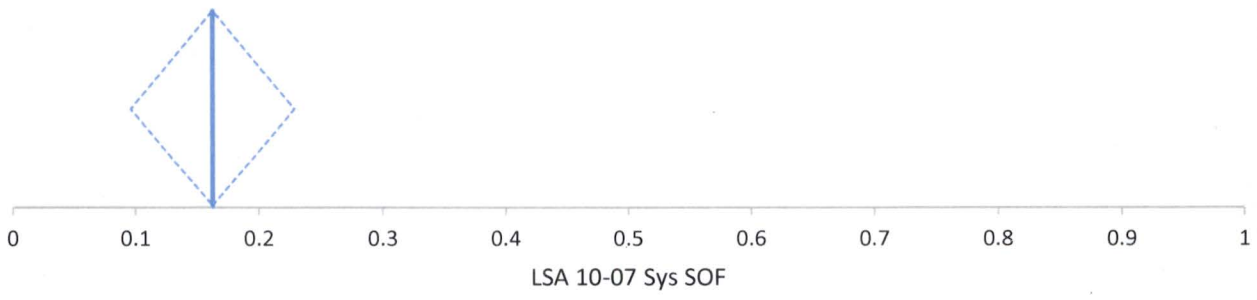
Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within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

Figure 23-4 presents the overall statistical metrics for the SOF parameter for the 8 systematically collected samples from LSA 10-07. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-07. The middle graph presents the mean SOF (0.16 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 0.10 to 0.23. The 97.75% confidence interval based on the median (0.13) of the sample results is 0.09 to 0.25. The bottom two charts present the various statistical metrics of the LSA 10-07 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 23-4 exhibits no unusual symmetry or bimodality concerns for the LSA 10-07 data associated with the systematically collected measurement locations.

Figure 23-4
Graphic Statistical Summary for LSA 10-07 (SOF parameter)





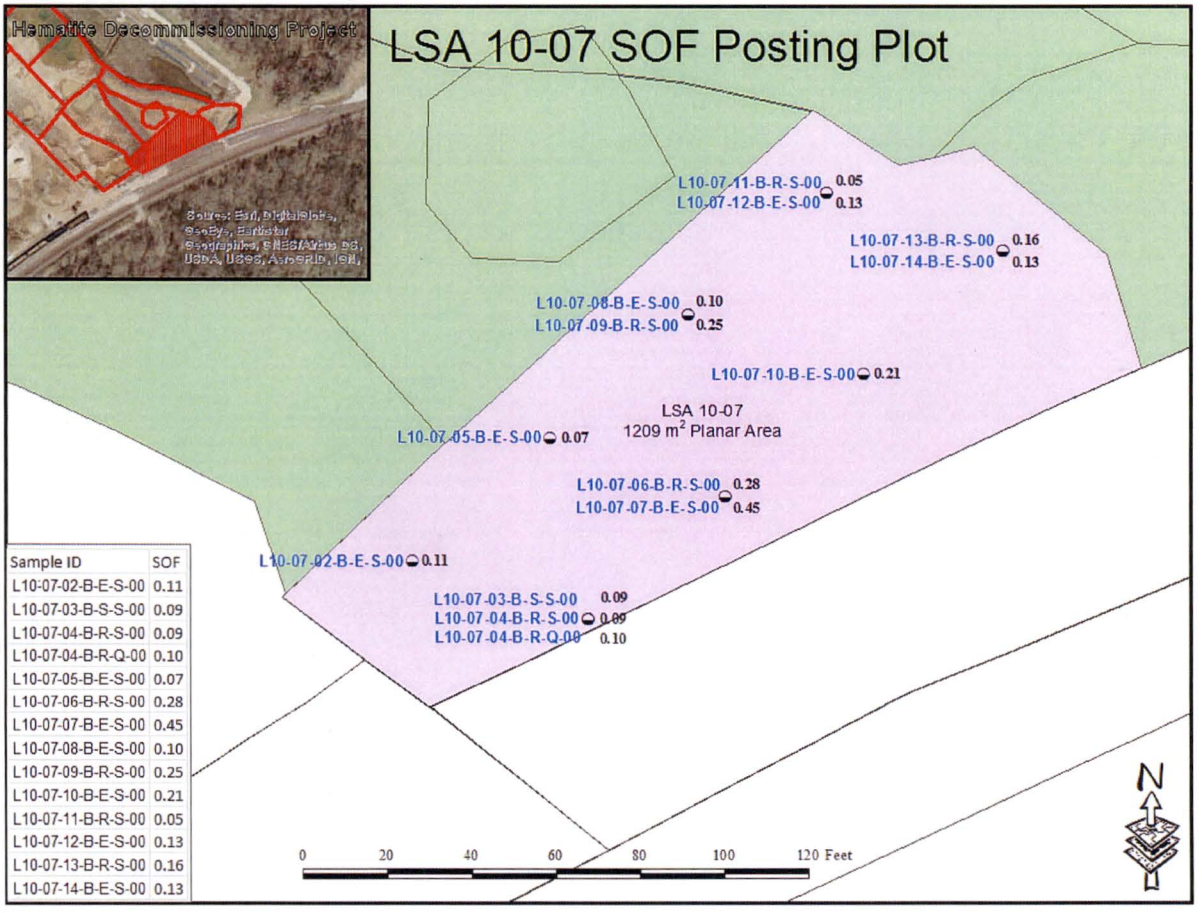
N	13

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 10-07 Sys SOF	0.16	0.10	to 0.23	0.030	0.11	0.01	1.6	2.70

	Minimum	1st quartile	Median	97.75% CI		3rd quartile	Maximum	IQR
LSA 10-07 Sys SOF	0.1	0.09	0.13	0.09	to 0.25	0.22	0.4	0.13

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 10-07 is presented below in Figure 23-5. Figure 23-5 shows no unusual patterns in the data.

Figure 23-5
Posting Plot for LSA 10-07 Systematic Measurement Locations



Sample ID	SOF
L10-07-02-B-E-S-00	0.11
L10-07-03-B-S-S-00	0.09
L10-07-04-B-R-S-00	0.09
L10-07-04-B-R-Q-00	0.10
L10-07-05-B-E-S-00	0.07
L10-07-06-B-R-S-00	0.28
L10-07-07-B-E-S-00	0.45
L10-07-08-B-E-S-00	0.10
L10-07-09-B-R-S-00	0.25
L10-07-10-B-E-S-00	0.21
L10-07-11-B-R-S-00	0.05
L10-07-12-B-E-S-00	0.13
L10-07-13-B-R-S-00	0.16
L10-07-14-B-E-S-00	0.13

Appendix C to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 23-2, Figure 23-4, and Figure 23-5 above. A summary of the analytical data is presented in Table 23-3 below. Appendix O to this report presents the Test America Analytical Laboratory soil sample reports.

Table 23-3
Final Status Survey Analytical Data: LSA 10-07

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF_N
L100702BES00	5.37	S	1.15	0.179	0.0883	N/A	0.080	0.080	-0.0215	0.000	0.067	0.224	U	1.09	0.198	0.187	N/A	0.090	0.090	2.327	N/A	N/A	N/A	0.12	0.15	0.295	N/A	1.64	0.798	0.982	N/A	1.2	0.11
L100703BSS00	0.07	S	1.08	0.151	0.0643	N/A	0.010	0.010	0.193	0.193	0.112	0.232	U	1.09	0.16	0.0831	N/A	0.090	0.090	3.781	N/A	N/A	N/A	0.204	0.146	0.184	N/A	1.56	0.652	0.833	N/A	2.0	0.09
L100704BRS00	0.50	S	1.05	0.143	0.0694	N/A	-0.020	0.000	-0.0066	0.000	0.0104	0.214	U	1.11	0.167	0.117	N/A	0.110	0.110	3.987	N/A	N/A	N/A	0.22	0.154	0.196	U	0.907	0.317	0.778	N/A	3.7	0.09
L100705BES00	0.50	S	0.982	0.14	0.0951	N/A	-0.088	0.000	-0.0315	0.000	0.0207	0.245	U	0.975	0.19	0.125	N/A	-0.025	0.000	8.988	N/A	N/A	N/A	0.496	0.148	0.217	U	2.03	0.813	0.936	N/A	3.7	0.07
L100706BRS00	7.51	S	1.31	0.192	0.0891	N/A	0.240	0.240	0.0983	0.098	0.0622	0.218	U	1.26	0.207	0.0758	N/A	0.260	0.260	2.464	N/A	N/A	N/A	0.134	0.14	0.219	U	0.917	0.367	0.96	N/A	2.3	0.28
L100707BES00	2.02	S	1.53	0.237	0.121	N/A	0.460	0.460	0.0398	0.040	0.0293	0.222	U	1.36	0.301	0.209	N/A	0.360	0.360	2.679	N/A	N/A	N/A	0.146	0.21	0.372	N/A	0.933	0.413	1.05	N/A	2.4	0.45
L100708BES00	5.00	S	1.01	0.151	0.0994	N/A	-0.060	0.000	-0.0348	0.000	0.0582	0.232	U	1.14	0.188	0.0783	N/A	0.140	0.140	2.450	N/A	N/A	N/A	0.125	0.169	0.278	U	1.88	0.866	1.01	U	1.1	0.10
L100709BRS00	5.12	S	1.2	0.167	0.0803	N/A	0.130	0.130	-0.0166	0.000	0.0691	0.224	U	1.34	0.196	0.0817	N/A	0.340	0.340	0.208	N/A	N/A	N/A	0.0045	0.0315	0.295	N/A	0.958	0.39	0.971	N/A	0.1	0.25
L100710BES00	4.04	S	1.28	0.188	0.0869	N/A	0.210	0.210	-0.0149	0.000	0.0748	0.23	U	1.17	0.179	0.111	N/A	0.170	0.170	1.701	N/A	N/A	N/A	0.0885	0.097	0.282	N/A	1.06	0.649	1.04	N/A	1.3	0.21
L100711BRS00	5.00	S	1.07	0.159	0.0682	N/A	0.000	0.000	-0.0293	0.000	0.0503	0.222	U	1.07	0.193	0.111	N/A	0.070	0.070	2.286	N/A	N/A	N/A	0.125	0.132	0.212	U	0.744	0.321	0.801	U	2.6	0.05
L100712BES00	3.11	S	1.13	0.156	0.0711	N/A	0.060	0.060	-0.0202	0.000	0.117	0.224	U	1.16	0.197	0.128	N/A	0.160	0.160	2.669	N/A	N/A	N/A	0.144	0.155	0.268	U	1.15	0.627	0.874	U	2.0	0.13
L100713BRS00	5.00	S	1.19	0.191	0.0958	N/A	0.120	0.120	-0.0074	0.000	0.0755	0.23	U	1.15	0.197	0.176	N/A	0.150	0.150	2.651	N/A	N/A	N/A	0.139	0.151	0.246	U	1.64	0.863	1.07	N/A	1.4	0.16
L100714BES00	2.86	S	1.13	0.158	0.0666	N/A	0.060	0.060	0.0213	0.021	0.0163	0.23	U	1.14	0.172	0.0954	N/A	0.140	0.140	2.596	N/A	N/A	N/A	0.137	0.147	0.261	U	1.41	0.696	0.879	U	1.5	0.13
L100704BRQ00	5.00	Q	1.16	0.178	0.0784	N/A	0.090	0.090	-0.006	0.000	0.0388	0.213	U	1.08	0.195	0.169	N/A	0.080	0.080	1.390	N/A	N/A	N/A	0.0729	0.166	0.294	U	0.806	0.398	1.26	N/A	1.4	0.10
L100701BUB00	5.00	B	1.38	0.195	0.089	N/A	0.310	0.310	-0.028	0.000	0.0361	0.221	U	1.19	0.201	0.0951	N/A	0.190	0.190	833.587	N/A	N/A	N/A	31.8	3.17	0.568	U	3.27	1.14	1.87	N/A	59.9	5.16
L100715BUB00	5.50	B	1.21	0.167	0.0744	N/A	0.140	0.140	0.0018	0.002	0.013	0.223	U	1.15	0.189	0.0908	N/A	0.150	0.150	38.339	N/A	N/A	N/A	1.87	0.297	0.232	U	0.971	0.414	0.985	U	23.1	0.39
L100716BUB00	5.00	B	1.16	0.156	0.0509	N/A	0.090	0.090	0.013	0.013	0.0272	0.228	U	1.14	0.17	0.132	N/A	0.140	0.140	2.995	N/A	N/A	N/A	0.164	0.139	0.201	U	0.949	0.663	0.883	N/A	2.7	0.14
L100701BUI01	5.00	I	1.26	0.176	0.069	N/A	0.190	0.190	0	0.000	0	0.226	U	1.18	0.187	0.0566	N/A	0.180	0.180	3.898	N/A	N/A	N/A	0.214	0.158	0.213	U	1.13	0.36	0.865	N/A	2.9	0.22
L100701BUI02	5.00	I	1.06	0.161	0.0757	N/A	-0.010	0.000	0.0184	0.018	0.0628	0.23	U	1	0.167	0.169	N/A	0.000	0.000	2.537	N/A	N/A	N/A	0.132	0.129	0.213	U	1.62	0.783	0.941	N/A	1.3	0.03
L100701BUI03	5.00	I	1.13	0.154	0.0649	N/A	0.060	0.060	0.0317	0.032	0.0561	0.231	U	1.12	0.17	0.105	N/A	0.120	0.120	1.523	N/A	N/A	N/A	0.0755	0.146	0.229	N/A	1.36	0.634	0.821	U	0.9	0.11
L100701BUI04	5.00	I	1.21	0.181	0.0764	N/A	0.140	0.140	0.0088	0.009	0.0219	0.226	U	1.17	0.202	0.121	N/A	0.170	0.170	1.307	N/A	N/A	N/A	0.0575	0.174	0.269	U	1.82	0.804	1	N/A	0.5	0.18
Systematic Minimum			0.000						0.000					0.000						0.208				0.004				0.744				5.6	0.05
Systematic Maximum			0.460						0.193					0.360						8.988				0.496				2.030				Average Enrichment (%)	0.45
Systematic Mean			0.105						0.027					0.160						2.983				0.160				1.295					0.16
Systematic Median			0.060						0.000					0.140						2.596				0.137				1.150					0.13
Systematic Standard Deviation			0.134						0.057					0.104						2.020				0.113				0.420					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.

23.2.6 Biased Soil Sample Result LSA 10-07

The highest biased sample collected from LSA 10-07 had a Uniform SOF result of 5.16. An EMC investigation was performed at this location and the results were determined to be acceptable. It should be noted that a biased sample was collected directly beneath the EMC sample location with a Uniform SOF result of 0.39 from location L10-07-15.

23.2.7 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 10-07

The FSS plan design as implemented by FSS procedures at the time of FSS determined that sidewall sampling was not necessary in LSA 10-07 (See section 22.4 for additional information).

23.2.8 Quality Control Soil Sample Result LSA 10-07

One QC field duplicate sample point was randomly selected for LSA 10-07 which was collected at systematic locations L10-07-04.

For the 20 "regular" samples (i.e., 13 systematic + 3 biased + 4 EMC investigation) collected within LSA 10-07, one field duplicate sample was collected. This frequency equates to 5%, (i.e. 1/20). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated Warning Limits (see Figure 23-6 below).

Figure 23-6
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 10-07

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

Survey Unit No.:	LSA 10-07				Survey Unit Description:		Burial Pits Open Land Area South Eastern Survey Unit in "Area 9"					
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L100704BRS00	L100704BRQ00	Ra-226	1.05	0.0694	1.16	0.0784	1.105	1.9	0.11	0.269	0.403	N
L100704BRS00	L100704BRQ00	Tc-99	-0.00664	0.214	-0.00597	0.213	-0.006305	25.1	NA	3.552	5.321	NA
L100704BRS00	L100704BRQ00	Th-232	1.11	0.169	1.08	0.169	1.095	2.0	0.030	0.283	0.424	N
L100704BRS00	L100704BRQ00	U-234[1]	3.987	N/A	1.390	N/A	2.688	195.4	2.596	27.649	41.425	N
L100704BRS00	L100704BRQ00	U-235	0.22	0.196	0.0729	0.294	0.146	51.6	NA	7.301	10.939	NA
L100704BRS00	L100704BRQ00	U-238	0.907	0.778	0.806	1.26	0.8565	168.8	NA	23.885	35.786	NA

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

Performed by: Thomas Yardy / [signature]

Date: 1-11-17

Reviewed by: W. Clark Evens / W. Clark Evens

Date: 1/11/17

Quality Record

23.3 Tc-99 Hot Spot Assessment LSA 10-07

During site characterization studies a total of 14 samples were collected and analyzed for Tc-99 in LSA 10-07. Two of these 14 samples exceeded a Uniform SOF result of 1.0 prior to remediation of the SU, however neither sample was elevated due to Tc-99. No sample exceeded the Tc-99 DCGL during FSS. Within LSA 10-07, the maximum sample identified was 0.83 pCi/g, well below the 25.1 pCi/g limit for the Tc-99 Uniform DCGL.

24.0 ALARA EVALUATION LSA 10-07

For LSA 10-07 the average SOF results based on all systematically collected samples was 0.16. For LSA 10-07, one biased sample exceeded a SOF of 1.0 which triggered an EMC investigation. The outcome of the EMC investigation was successful in that compliance with the unity rule (<1) was achieved. The total dose contribution from the bounded EMC area in LSA 10-07 was 0.25 mrem/year which is a SOF of 0.01. The EMC evaluation is discussed in greater detail in Section 23.2.3.

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, an assumed maximum groundwater contribution of 4.0 mrem/year based upon the EPA MCLs will be added to LSA 10-07. Summing the dose contributions together (average systematically collected samples 4.0 mrem/year), the EMC (0.25 mrem/year) and the groundwater contribution (4.0 mrem/year), the total estimated dose for LSA 10-07 is 8.25 mrem/year.

Since the estimated TEDE is well below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 10-07 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 10-07.

25.0 FSS PLAN DEVIATIONS LSA 10-07

25.1 Remedial Actions during FSS

There was no remedial action in LSA 10-07 after FSS had begun.

25.2 Adjustments to Scan MDC Calculations

As previously stated in Section 21.1.5, adjustments were made to the Scan MDC calculations for instrumentation used for the GWS in LSA 10-07. The Scan MDCs presented in the FSS Plan shown in Table 21-1 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 10-07, 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 10-07 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 25-1 below.

Table 25-1

Revised Scan MDCs for 2" x 2" NaI detector: LSA 10-07

	Scan MDC (Total U)	**$DCGL_W$ (Total U)**	**Scan MDC (Ra-226)**	**$DCGL_W$ (Ra-226)**	**Scan MDC (Th-232)**	**$DCGL_W$ (Th-232)**
LSA 10-07	44.9	98.2	1.32	1.9	0.95	2.0

26.0 DATA QUALITY ASSESSMENT

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

26.1 Data Quality Assessment for LSA 10-07

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 10-07 (see Figure 26-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.

- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control.*
- LSA 10-07 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 10-07, 1 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 required for LSA 10-07. Since the test statistic, WR (943) exceeded the critical value (802), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix C.
- A biased sample exceeding a Uniform SOF result of 1.0 was collected from the SU, and an EMC investigation was performed. The result of the EMC investigation concluded that the SU is suitable for release as the sum of all dose contributions to the LSA is still less than 25 mrem/year to a member of the public.
- The maximum SOF result for all surface samples (excluding the EMC) within LSA 10-07 was 0.28. The SOF result for the single subsurface samples within LSA 10-07 was 0.45. The average SOF result for all systematically collected samples within LSA 10-07 was 0.16, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.23.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (8) of systematic sample locations actually collected within LSA 10-07. The successful result of the retrospective power evaluation presented in Table 26-1 for LSA 10-07 indicates that the minimum number of sample locations required (8) for the WRS Test were equal to the number of sampling locations actually collected within LSA 10-07. 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. WRS Test
- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures for LSA 10-07 was completed prior to the commencement of backfill operations.

Table 26-1
Retrospective Sample Size Verification for LSA 10-07

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)	0.16
Shift	0.84
Relative Shift (Δ/σ)	7.63
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 26-1
Data Evaluation Checklists prepared for LSA 10-07 (page 1 of 2)

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

Survey Area: 10 **Description:** Burial Pits Open Land Area
Survey Unit: 07 **Description:** Section 7

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 step 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 ☐
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 (Reference 5.11)	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;

Ludlum 2221 meters AA (299523), DD (299540) and FF (303233) were used to conduct the FSS scanning in LSA-10-06. All QC measurements were within specification. While within specification, all pre and post QC checks measure above the mean for all meters. The QC charts were reviewed for all meters and no indication of the meters drifting out of the acceptable range was identified.

Figure 26-1
Data Evaluation Checklists prepared for LSA 10-07 (page 2 of 2)

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

Survey Area: No. 10 **Description:** Burial Pits Open Land Area
Survey Unit: No. 07 **Description:** Section 7

Discrepancy;

During the FSS GWS on 11/20/2013, an elevated area was found. Sample L100701BUB00, was collected from the area and analyzed by gamma spectroscopy and ICPMS for Tc-99. The resultant SOF for the individual sample was 5.0.

Corrective Actions Taken;

An EMC evaluation was performed because the radionuclide concentration from sample L100701BUB00 exceeded the $DCGL_w$. The area surrounding where sample L100701BUB00 was collected was gamma scanned to bind the region where elevated measurement was detected. The survey confirmed the elevated reading was localized to less than 1 m^2. Samples L100701BUI01, L100701BUI02, L100701BUI03 and L100701BUI04 were collected surrounding the elevated location and one additional sample L100715BUB00 was collected in the same location as sample L100701BUB00. The EMC evaluation was performed in accordance with HDP-PR-FSS-721. LSA-10-07 passed the EMC evaluation and no further action was necessary.

11. Have the corrective actions resolved the discrepancy with the data? Yes ☒ No ☐
    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 ~~13~~ 11 was "No", then is the affected data still valid? Yes ☐ No ☐ N/A
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ N/A
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

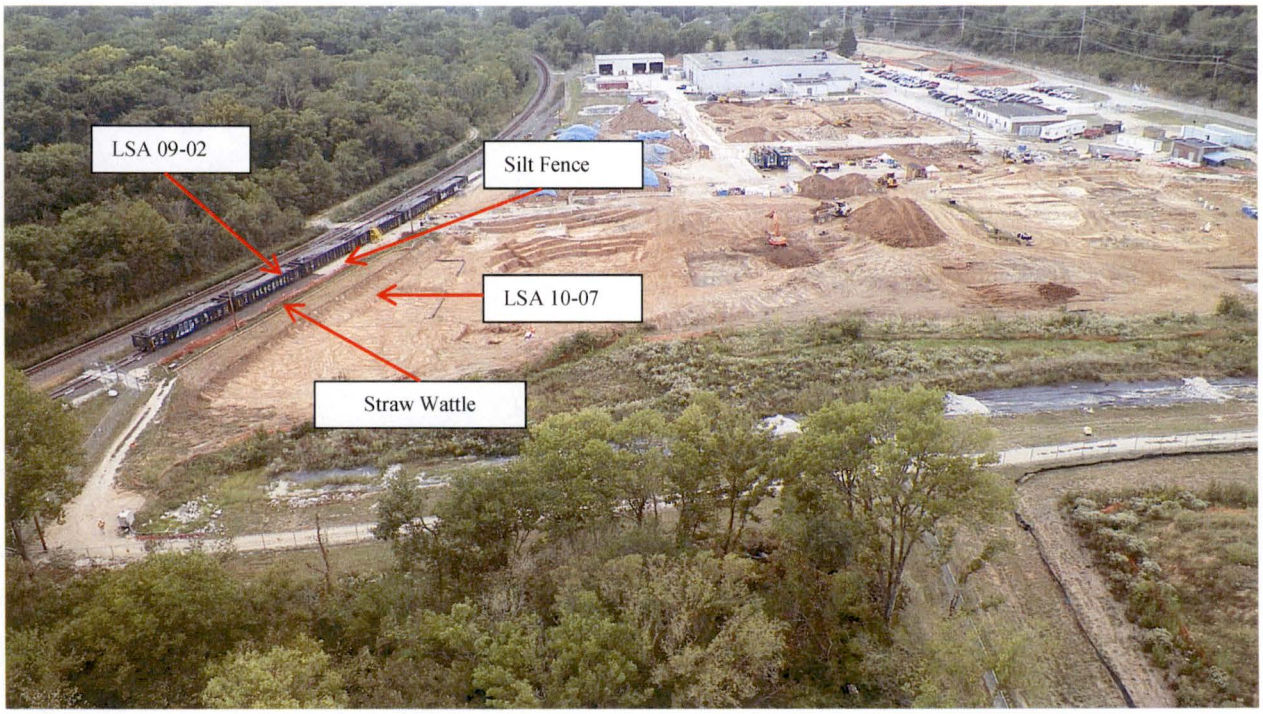
Prepared by (HP Staff): Michelle Bresnahan (Print Name) (Signature) 2/18/14 (Date)
Approved by (RSO): Joseph Bolin (Print Name) (Signature) 2/18/14 (Date)

27.0 SURVIELLENCE FOLLOWING FSS

FSS of SU LSA 10-07 was completed on November 25, 2013 as well as FSS of adjacent SUs LSA 10-05 (January 19, 2014), LSA 10-06 (November 18, 2013) and LSA 10-10 (January 25, 2013) as such they did not pose a source of radioactive material.

LSA 09-02 is a class 2 SU, in which the rail spur resides, which is also adjacent to LSA 10-07. To prevent recontamination of LSA 10-07 from LSA 09-02 isolation controls included wattles and a silt fence with an intervening grass area between the wattles and silt fence. Figure 27-1 provides the location of the isolation controls between LSA 10-07 and LSA 09-02.

Figure 27-1
Location of Isolation Controls between LSA 10-07 and LSA 09-02



As such, the radiological status of all of the SUs adjacent to LSA 10-07 did not present a possibility of recontamination of LSA 10-07 as a consequence of a storm event.

28.0 CONCLUSION LSA 10-07

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 10-07 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 28-1
LSA 10-07 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.16	0.01	0.16	N/A	N/A	**0.33**
DOSE	4.0 mrem/year	0.25 mrem/year	4.0 mrem/year	N/A	N/A	**8.25 mrem/year**

29.0 FINAL STATUS SURVEY DESIGN LSA 10-08

This section describes the method for determining the number of samples required for the FSS of LSA 10-08 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 10-08 and their detection sensitivities are also discussed.

29.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 10-08 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 2, *Final Status Survey Plan Development*, February 2013.

29.1.1 Surrogate Evaluation Areas

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

29.1.2 $DCGL_W$

During the FSS design process a review was performed of the historic characterization data for LSA 10-02 land area which was designated as LSA 10-08. While no characterization sample data was available for the land area that became LSA 10-08, the adjacent LSA 10-02 data was reviewed to ensure that no elevated samples results remained in the vicinity of LSA 10-08. Next the remediation history was reviewed and the RASS data was used as confirmation that no known areas of residual radioactivity remained within the SU that exceeded the Uniform $DCGL_W$. Therefore the Uniform $DCGL_W$ was selected for use in demonstrating compliance with the release criteria.

29.1.3 GWS Coverage

As a Class 1 SU, LSA 10-08 was required to undergo a 100% GWS.

29.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 10-08 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

29.1.5 Scan Minimum Detectable Concentration

As background levels were approximately 10,000 cpm within both LSA 10-08, 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 29-1

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 10-08, the average enrichment for the SU was 4.28%.

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 29-1. Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 10-08 are shown below:

Table 29-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 10-08

	Scan MDC (Total U)	$DCGL_W$ (Total U)	Scan MDC (Ra-226)	$DCGL_W$* (Ra-226)	Scan MDC (Th-232)	$DCGL_W$* (Th-232)
LSA 10-08	85.5	79.2	2.8	2.8	1.8	3.0

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

The values in Table 29-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

29.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The FSS in LSA 10-08 was performed prior to the development of HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*" which established a standard Scan IAL for all Class 1 SU's at the Hematite Site. However, the IAL was administratively set at 4,000 net cpm for LSA 10-08 as it was determined to be acceptable.

29.1.7 LSA 10-08 FSS Design Summary

The FSS Plan for LSA 10-08 can be found in Appendix J. Table 29-2 presents an overall FSS design and implementation summary for LSA 10-08.

Table 29-2
FSS Design Summary for LSA 10-08

Gamma Walkover Survey (GWS):		
Scan Coverage	100% exposed excavation floors	
Scan MDC	85.5 pCi/g total Uranium (1,512 ncpm)	
Investigation Action Level (IAL)	4,000 net cpm	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	0	These samples were collected on a systematic grid.
15 cm – 1.5 m (Root)	5	
> 1.5m (Excavation)	10	
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.	Used for GWS and to obtain static count rates at biased measurement locations.	

30.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 10-08

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

30.1 Gamma Walkover Survey

30.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 10-08 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS and handheld data logger.

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

30.1.2 GWS Performance

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 one (1) GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

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

HP Technicians performing GWS in LSA 10-08 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 12,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 16,000 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.

While no sidewalls existed within LSA 10-08, the western boundary of the SU bordered LSA 10-02 where a steep sidewall was present. This sidewall of LSA 10-02 was scanned to determine if any elevated readings were present that would affect the FSS of LSA 10-08.

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

30.2 Soil Sampling

30.2.1 Systematic Soil Sampling Summary

Table 30-1 provides a summary of systematic sampling by stratum for LSA 10-08.

Table 30-1
Systematic Sampling Summary by Stratum for LSA 10-08

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
10-08	110.5	0	5	10	1

30.2.2 Systematic Sampling LSA 10-08

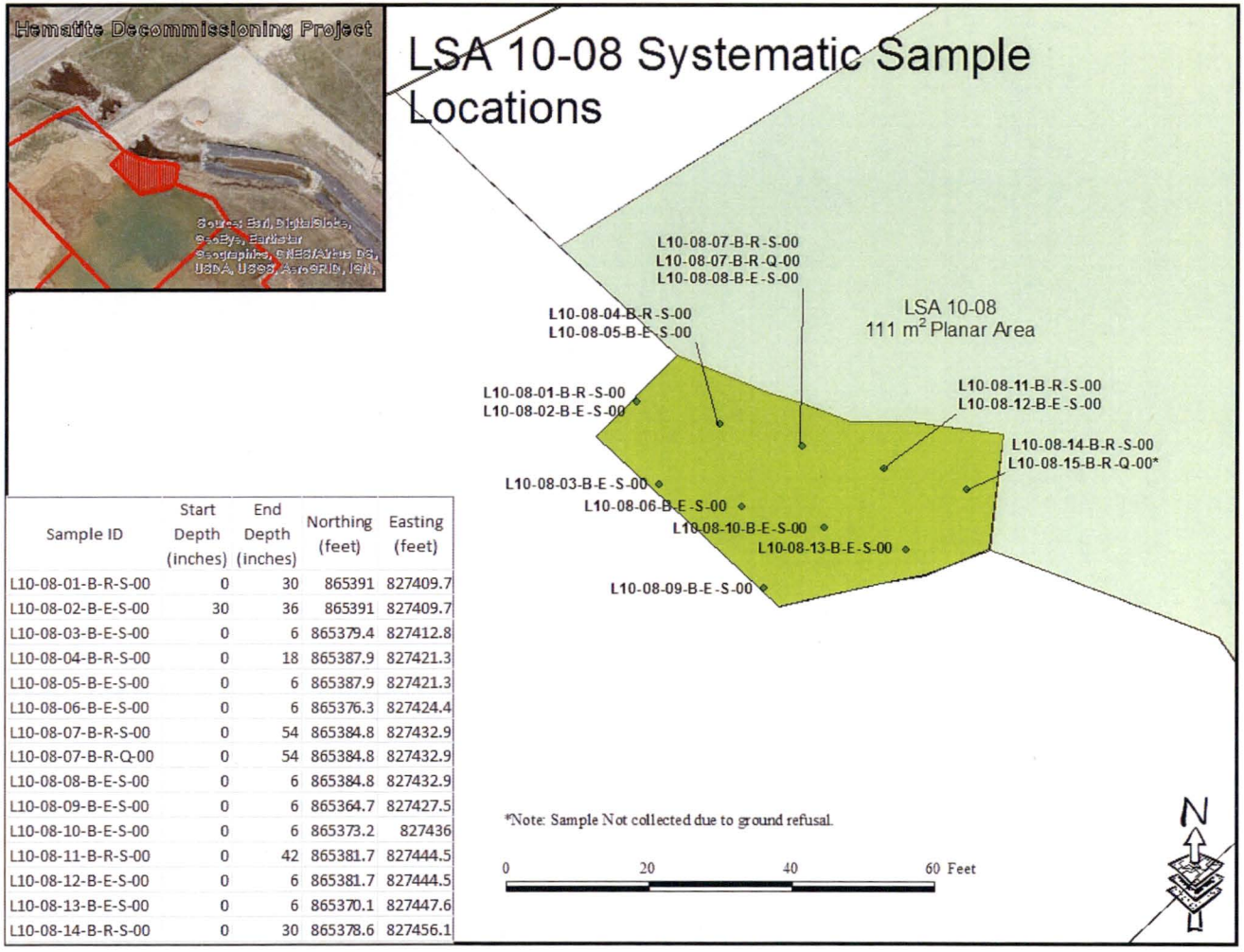
Within LSA 10-08, there were no systematic locations in which portions of the surface stratum (90 – 15 cm) remained in the SU after remediation. Portions of the root stratum (15 cm – 150 cm) remained at five (5) of the ten (10) systematic locations. At these locations the remaining root stratum interval was collected using a hand auger and composited. Excavation stratum samples were collected at all ten locations using either hand trowels for six-inch grabs below the existing excavation surface or hand augers where necessary. Given a planar area of 110.5 m^2 for LSA 10-08 and a ten - point systematic triangular grid, the point-to-point distance within each row was 3.57 m.

While there were ten systematic locations on the LSA 10-08 sampling grid, a total of sixteen (16) samples were collected at these locations, including:

- Zero (0) samples collected within the remaining surface stratum
- Five (5) sample collected within the remaining root stratum
- Nine (9) samples collected within the excavation, or "deep", stratum
- One (1) QC field replicate

Figure 30-1 presents the map of the nine (9) systematic sample locations which were sampled within LSA 10-08. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 30-1
LSA 10-08 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L10-08-01-B-R-S-00	0	30	865391	827409.7
L10-08-02-B-E-S-00	30	36	865391	827409.7
L10-08-03-B-E-S-00	0	6	865379.4	827412.8
L10-08-04-B-R-S-00	0	18	865387.9	827421.3
L10-08-05-B-E-S-00	0	6	865387.9	827421.3
L10-08-06-B-E-S-00	0	6	865376.3	827424.4
L10-08-07-B-R-S-00	0	54	865384.8	827432.9
L10-08-07-B-R-Q-00	0	54	865384.8	827432.9
L10-08-08-B-E-S-00	0	6	865384.8	827432.9
L10-08-09-B-E-S-00	0	6	865364.7	827427.5
L10-08-10-B-E-S-00	0	6	865373.2	827436
L10-08-11-B-R-S-00	0	42	865381.7	827444.5
L10-08-12-B-E-S-00	0	6	865381.7	827444.5
L10-08-13-B-E-S-00	0	6	865370.1	827447.6
L10-08-14-B-R-S-00	0	30	865378.6	827456.1

Table 30-2 below presents a tabular listing of all FSS samples collected within LSA 10-08 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 30-2
FSS Sample Locations and Coordinates for LSA 10-08

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

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: 08 **Description:** North Eastern Survey Unit in "Area 1"
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
L100801BRS00	Uniform	S	430	427.5	827409.7	865391.0	Root Zone Composite
L100802BES00	Uniform	S	427.5	427.0	827409.7	865391.0	Excavation 6-inch grab
L100803BES00	Uniform	S	428	427.5	827412.8	865379.4	Excavation 6-inch grab
L100804BRS00	Uniform	S	428	426.5	827421.3	865387.9	Root Zone Composite
L100805BES00	Uniform	S	426.5	426.0	827421.3	865387.9	Excavation 6-inch grab
L100806BES00	Uniform	S	428	427.5	827424.4	865376.3	Excavation 6-inch grab
L100807BRS00	Uniform	S	426	421.5	827432.9	865384.8	Root Zone Composite
L100808BES00	Uniform	S	421.5	421.0	827432.9	865384.8	Excavation 6-inch grab
L100809BES00	Uniform	S	424.0	423.5	827427.5	865364.7	Excavation 6-inch grab
L100810BES00	Uniform	S	428.0	427.5	827436.0	865373.2	Excavation 6-inch grab
L100811BRS00	Uniform	S	426.0	422.5	827444.5	865381.7	Root Zone Composite
L100812BES00	Uniform	S	422.5	422.0	827444.5	865381.7	Excavation 6-inch grab
L100813BES00	Uniform	S	428.0	427.5	827447.6	865370.1	Excavation 6-inch grab
L100814BRS00	Uniform	S	426.0	423.5	827456.1	865378.6	Root Zone Composite
L100807BRQ00	Uniform	Q	426.0	421.5	827432.9	865384.8	Root Zone Composite
L100816BUB00	Uniform	B	428.0	427.5	827406.1	865383.8	Biased 6-inch grab
L100817BUB00	Uniform	B	427.5	427.0	827406.1	865383.8	Biased 6-inch grab
L100818BUB00	Uniform	B	428.0	427.5	827408.3	865384.4	Biased 6-inch grab
L100819BUB00	Uniform	B	427.5	427.0	827408.3	865384.4	Biased 6-inch grab
L100820BUB00	Uniform	B	426.0	425.5	827416.2	865385.9	Biased 6-inch grab
L100821BUB00	Uniform	B	425.5	425.0	827416.2	865385.9	Biased 6-inch grab
L100822BUB00	Uniform	B	426.0	425.5	827417.2	865390.4	Biased 6-inch grab
L100823BUB00	Uniform	B	425.5	425.0	827417.2	865390.4	Biased 6-inch grab
L100824BUB00	Uniform	B	424.0	423.5	827418.2	865377.0	Biased 6-inch grab
L100825BUB00	Uniform	B	423.5	423.0	827418.2	865377.0	Biased 6-inch grab
L100826BUB00	Uniform	B	426.0	425.5	827419.4	865384.0	Biased 6-inch grab
L100827BUB00	Uniform	B	425.5	425.0	827419.4	865384.0	Biased 6-inch grab
L100828BUB00	Uniform	B	428.0	427.5	827406.8	865384.2	Biased 6-inch grab

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

*Elevations are in feet above mean sea level.
** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983]
Surface: Floor = F; Wall = W; Ceiling = C; Roof = R
CSM: Three-Layer (Surface-Root-Excavation) or Uniform DCGLs used
Type: Systematic = S, Biased = B; QC =Q; Investigation = I
Quality Record

30.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 10-08 several sample locations were selected within the SU based on the evaluation of the GWS survey data, HP Technician professional judgment, and the need to immediately backfill the survey unit in order to support ongoing remediation operations. While there were only two very small and isolated areas in LSA 10-08 that exceeded the 3 sigma Z-score criteria, several other biased sample locations were selected based on professional judgment and biased location L10-08-19-B-U-B-00 represents the maximum measurement encountered within in LSA 10-08 and has a Uniform SOF value of 0.29.

30.4 Judgmental/Sidewall Sampling for Tc-99

The FSS of LSA 10-08 was performed before Westinghouse held discussions with the NRC regarding sidewall sampling. While the evaluation to determine if side wall samples are necessary in LSA 10-08 was not performed prior to the performance of FSS, the evaluation can be performed retrospectively. LSA 10-08 was a relatively small and flat LSA, with no steep vertical sidewalls present as shown by a review of the topographical excavation contour maps, therefore no sidewall sampling is necessary within LSA 10-08 under the guidance specified in Volume 3, Chapter 1, Section 6.2.3.

It is noted that a sidewall was present in the adjacent LSA 10-02, which shared a western border with LSA 10-08. The LSA 10-02 sidewall was scanned to determine if any elevated readings were present that would affect FSS in LSA 10-08, but no sampling was performed as the soil comprising the sidewall was part of another SU. That soil was also subsequently removed during remediation of the area, and the FSS of LSA 10-02 was performed on the final excavated surface.

30.5 Quality Control Soil Sampling

One QC field duplicate sample point was randomly selected and collected at systematic location L10-08-07 for LSA 10-08.

31.0 FINAL STATUS SURVEY RESULTS LSA 10-08

31.1 Gamma Walkover Survey

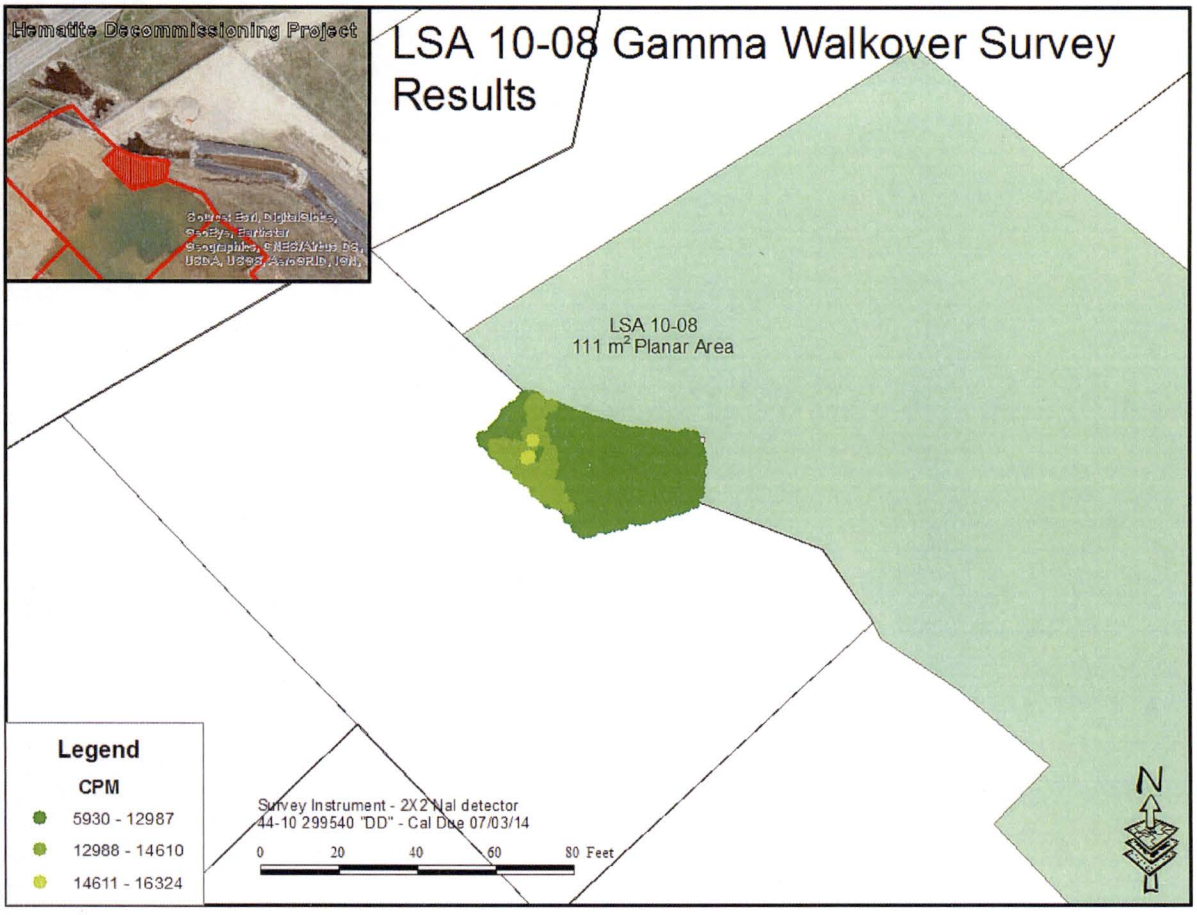
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 10-08 on July 31, 2013.

31.1.1 GWS Results for LSA 10-08

For LSA 10-08, GWS count rates ranged between 5,930 gcpm and 15,071 gcpm, with a mean count rate of 11,201 gcpm. The median count rate was 11,427 gcpm with a standard deviation of 1,701 cpm. Figure 31-1 below presents a map of the complete GWS data set.

Figure 31-1
Colorimetric GWS Plot for LSA 10-08

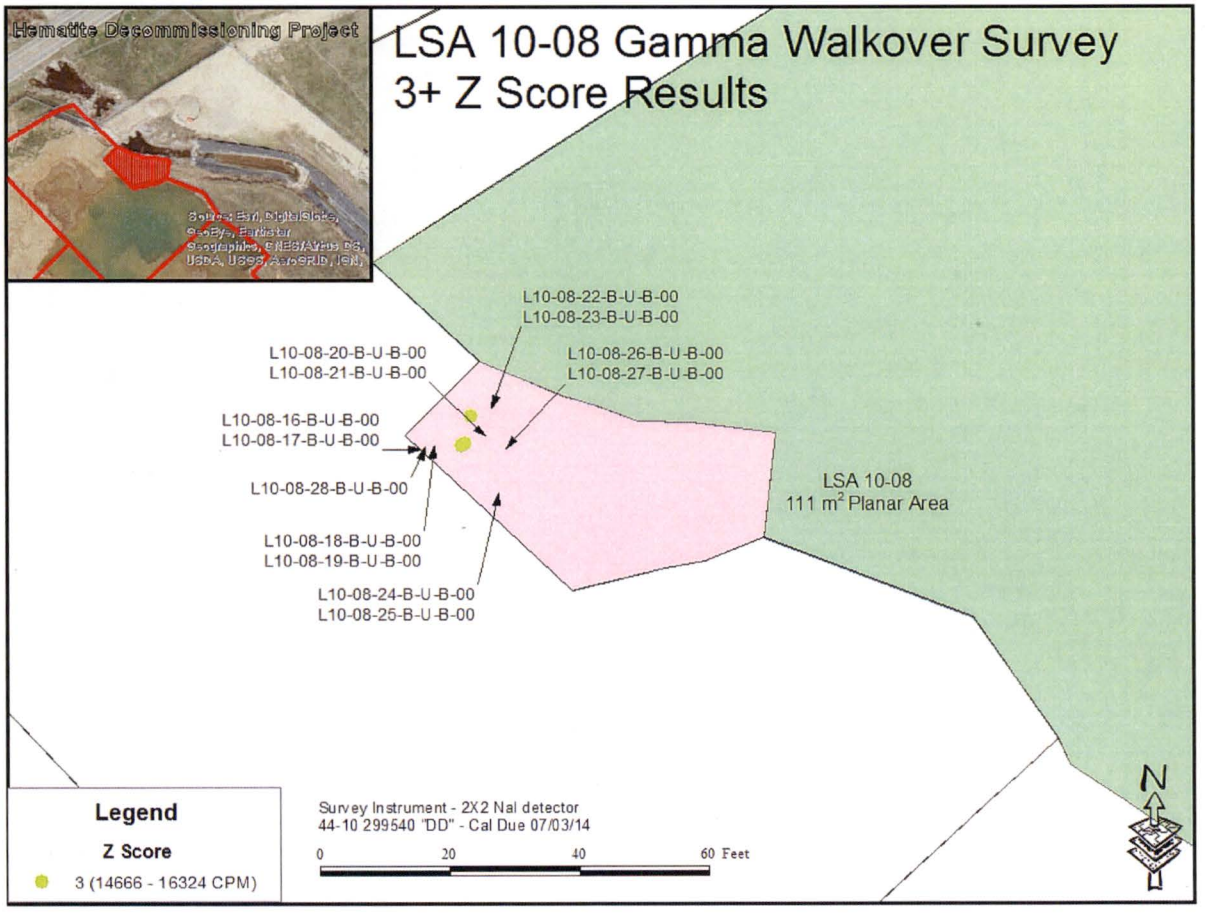


An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded both the IAL (> 4000 ncpm) and three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). While only two small isolated areas appear elevated based on this criteria, several additional areas were selected for biased sampling based on HP Technician professional judgment.

No elevated readings were identified in the LSA 10-02 sidewall, but elevated readings were identified at the base of the sidewall where the vertical surface met the horizontal surface of LSA 10-08. Poor counting geometry was suspected as the reason for the increased count rates, Biased sample L10-08-28-B-U-B-00 was collected at this location.

Figure 31-2 presents a map of the +3 Z-score GWS measurements within LSA 10-08, including the thirteen total selected biased sampling locations.

Figure 31-2
Colorimetric GWS Plot for LSA 10-08 (Measurements > Z-score of 3)



Since all GWS data collected in LSA 10-08 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 and a general area background of 12,000 gcpm, a new Scan MDC of approximately 44.9 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 10-08, 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:

$$\text{Scan MDC}_{Total\ Uranium} = \quad 1 \Big/ \left(\left(\frac{0.7928}{4008}\right) + \left(\frac{0.0438}{2.54}\right) + \left(\frac{0.1634}{33.5}\right) \right) = 44.9 \frac{pCi}{g}$$

Equation 31-1

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 1.32 pCi/g and 0.95 pCi/g, respectively using a two inch air gap. A two inch (2") 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.

31.1.2 GWS Coverage Results LSA 10-08

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, very small area of the LSA 10-08 interior was not accessed by GPS due to limitations in the GPS technology. The area appears as small pink dot in the Figure 31-1 above.

The post survey processing of the GPS data indicated that the GWS was 99.5% of the SU (see Table 31-1). 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 31-1
GWS Gap Analysis LSA 10-08

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 10-08	18,150	91	0.5%	99.5%	1

31.2 Soil Sample Results LSA 10-08

Appendix D presents the analytical results and associated statistics for all FSS samples collected within LSA 10-08.

31.2.1 Surface Soil Sample Results LSA 10-08

There were zero (0) samples collected within the surface stratum (0 – 15 cm) of LSA 10-08. However, there were a total of twenty-four (24) soil samples collected within the topmost soil layer of the excavation surface including ten systematic samples, thirteen biased samples, and one QC field duplicate sample. The maximum SOF result for "topmost" samples in LSA 10-08 was 0.29 corresponding to the biased sample L10-08-19-B-U-B-00. The maximum systematic sample SOF result was 0.23 at L10-08-01-B-R-S-00.

31.2.2 Subsurface Soil Sample Results LSA 10-08

There were five systematic locations within LSA 10-08 where root stratum composite sampling was performed. The root stratum zone is between 0.15 and 1.50 m below final grade surface. At

four of the five 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. One location of the five was not collected due to refusal, after several attempts, the excavation zone sample could not be collected due to rocky soil conditions. This is not unusual due to the close proximity to the Northeast Site Creek. The excavation stratum samples where there was overlying root stratum remaining are considered "subsurface" samples. The maximum SOF result of the subsurface samples collected in LSA 10-08 was sample L10-08-02-B-E-S-00 with a Uniform SOF result of 0.05.

31.2.3 WRS Test Evaluation for LSA 10-08

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was not required for LSA 10-08 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was less than one using the Uniform Stratum criteria. However, for illustrative purposes, the WRS evaluation was still performed for LSA 10-08. 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 10-08 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, (976) 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 D.

31.2.4 Graphical Data Review LSA 10-08

Table 31-2 below presents summary results for the all systematically collected samples (includes root and excavation stratum samples, but not biased or QC samples) collected within LSA 10-08, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.05.

Table 31-2
LSA 10-08 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	0.003	0.266	0.005	4.037	0.218	1.513	**0.05**
Minimum	0.00 (<BKG)	0.030	0.00 (<BKG)	0.699	0.029	0.658	0.02
Maximum	0.030	0.695	0.050	28.073	1.550	5.970	0.23

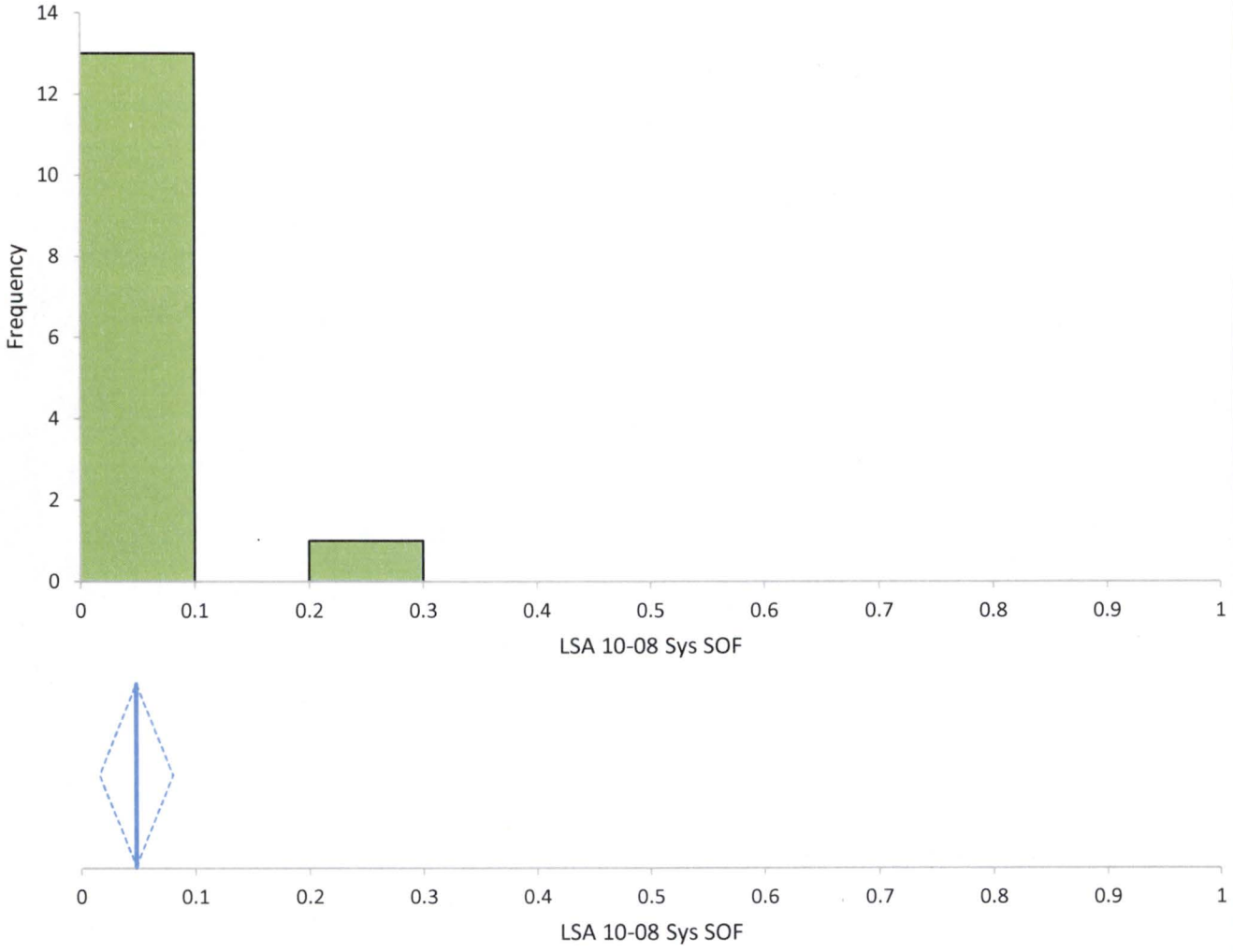
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide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

Figure 31-3 presents the overall statistical metrics for the SOF parameter for the 14 systematically collected samples from LSA 10-08. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-08. The middle graph presents the mean SOF (0.05) as indicated by the blue vertical line of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.02 to 0.08. The 98.71% confidence interval based on the median (0.03) of the sample results is 0.02 to 0.05. The bottom two charts present the various statistical metrics of the LSA 10-08 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 31-3 exhibits no unusual symmetry or bimodality concerns for the LSA 10-08 data associated with the systematically collected measurement locations.

Figure 31-3
Graphic Statistical Summary for LSA 10-08 (SOF parameter)



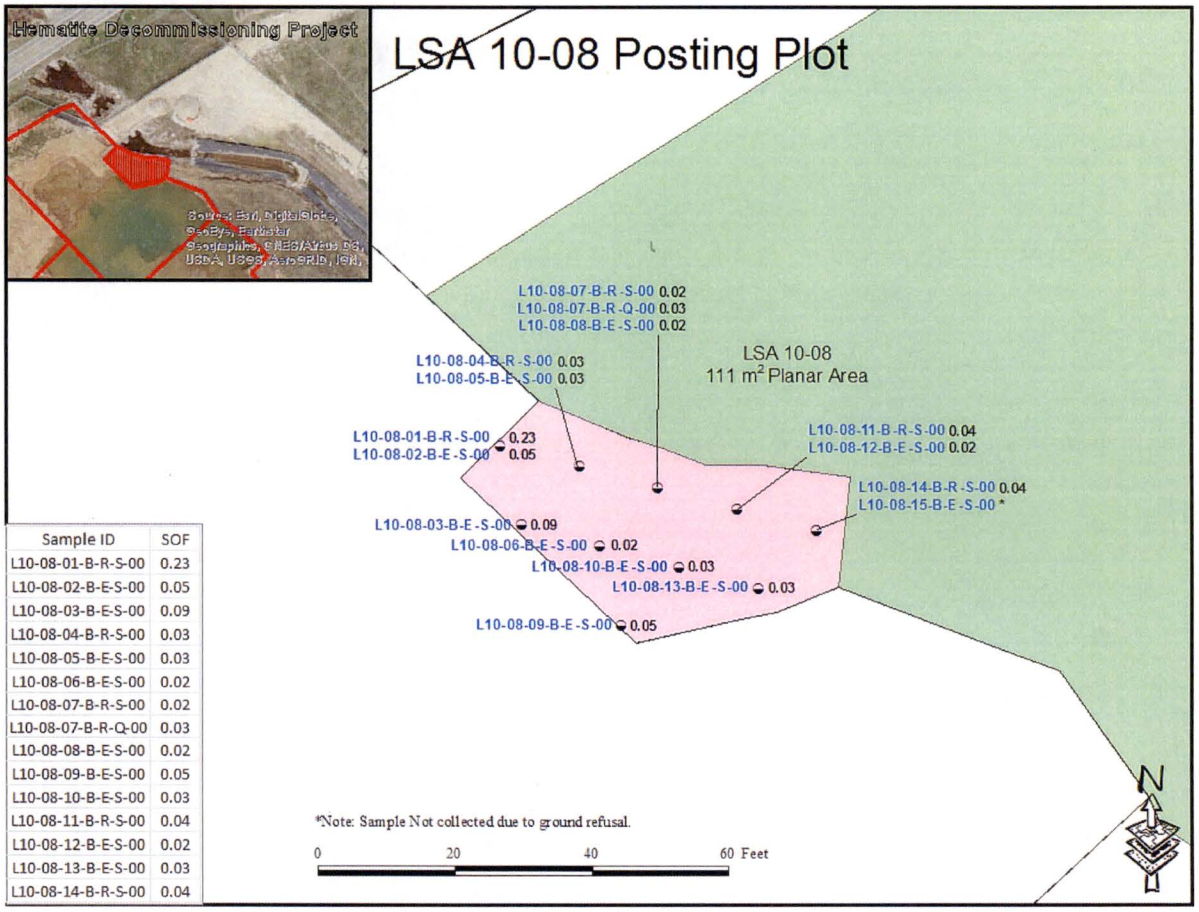
N	14

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 10-08 Sys SOF	0.05	0.02	to 0.08	0.015	0.06	0.00	3.2	10.67

	Minimum	1st quartile	Median	98.71% CI		3rd quartile	Maximum	IQR
LSA 10-08 Sys SOF	0.02	0.02	0.03	0.02	to 0.05	0.05	0.2	0.02

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 10-08 is presented below in Figure 31-4. Figure 31-4 shows no unusual patterns in the data.

Figure 31-4
Posting Plot for LSA 10-08 Systematic Measurement Locations



Sample ID	SOF
L10-08-01-B-R-S-00	0.23
L10-08-02-B-E-S-00	0.05
L10-08-03-B-E-S-00	0.09
L10-08-04-B-R-S-00	0.03
L10-08-05-B-E-S-00	0.03
L10-08-06-B-E-S-00	0.02
L10-08-07-B-R-S-00	0.02
L10-08-07-B-R-Q-00	0.03
L10-08-08-B-E-S-00	0.02
L10-08-09-B-E-S-00	0.05
L10-08-10-B-E-S-00	0.03
L10-08-11-B-R-S-00	0.04
L10-08-12-B-E-S-00	0.02
L10-08-13-B-E-S-00	0.03
L10-08-14-B-R-S-00	0.04

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

Table 31-3
Final Status Survey Analytical Data: LSA 10-08

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF
L100801BRS00	2.50	S	0.973	0.142	0.068	N/A	-0.097	0.000	0.591	0.591	0.065	0.223	N/A	0.952	0.161	0.091	N/A	-0.048	0.000	28.073	N/A	N/A	N/A	1.550	0.308	0.281	N/A	5.970	0.838	1.130	N/A	3.9	0.23
L100802BES00	5.00	S	1.050	0.160	0.077	N/A	-0.020	0.000	0.295	0.295	0.058	0.226	N/A	1.010	0.175	0.157	N/A	0.010	0.010	3.108	N/A	N/A	N/A	0.165	0.148	0.253	U	1.580	0.638	0.822	N/A	1.6	0.05
L100803BES00	5.50	S	0.978	0.161	0.088	N/A	-0.092	0.000	0.255	0.255	0.061	0.220	N/A	1.050	0.173	0.113	N/A	0.050	0.050	6.776	N/A	N/A	N/A	0.373	0.189	0.229	N/A	1.790	0.751	0.928	N/A	3.2	0.09
L100804BRS00	3.50	S	0.943	0.132	0.053	N/A	-0.127	0.000	0.168	0.168	0.075	0.224	U	0.799	0.161	0.098	N/A	-0.201	0.000	2.065	N/A	N/A	N/A	0.109	0.128	0.215	U	1.120	0.623	0.800	N/A	1.5	0.03
L100805BES00	5.00	S	0.993	0.144	0.067	N/A	-0.077	0.000	0.278	0.278	0.071	0.231	N/A	0.869	0.135	0.101	N/A	-0.131	0.000	2.430	N/A	N/A	N/A	0.129	0.118	0.182	U	1.240	0.651	0.806	N/A	1.6	0.03
L100806BES00	5.50	S	1.050	0.151	0.061	N/A	-0.020	0.000	0.188	0.188	0.132	0.221	U	0.829	0.136	0.104	N/A	-0.171	0.000	0.699	N/A	N/A	N/A	0.029	0.127	0.214	U	1.310	0.640	0.786	N/A	0.4	0.02
L100807BRS00	0.50	S	0.923	0.132	0.059	N/A	-0.147	0.000	0.194	0.194	0.136	0.252	U	0.770	0.125	0.072	N/A	-0.230	0.000	0.968	N/A	N/A	N/A	0.050	0.104	0.182	U	0.658	0.430	0.606	N/A	1.2	0.02
L100808BES00	5.00	S	1.080	0.148	0.061	N/A	0.010	0.010	0.030	0.030	0.087	0.241	U	1.010	0.151	0.076	N/A	0.010	0.010	0.782	N/A	N/A	N/A	0.039	0.070	0.231	U	0.737	0.321	0.797	U	0.9	0.02
L100809BES00	8.50	S	0.896	0.134	0.066	N/A	-0.174	0.000	0.695	0.695	0.166	0.218	N/A	0.842	0.150	0.102	N/A	-0.158	0.000	1.758	N/A	N/A	N/A	0.092	0.130	0.205	U	1.120	0.634	0.789	N/A	1.3	0.05
L100810BES00	5.50	S	0.854	0.129	0.058	N/A	-0.216	0.000	0.266	0.266	0.091	0.215	N/A	0.833	0.146	0.099	N/A	-0.167	0.000	1.844	N/A	N/A	N/A	0.095	0.129	0.223	U	1.300	0.574	0.730	N/A	1.2	0.03
L100811BRS00	1.50	S	1.100	0.156	0.062	N/A	0.030	0.030	0.030	0.030	0.074	0.223	U	0.808	0.123	0.095	N/A	-0.192	0.000	1.798	N/A	N/A	N/A	0.093	0.103	0.151	U	1.280	0.644	0.801	N/A	1.2	0.04
L100812BES00	5.00	S	1.020	0.165	0.087	N/A	-0.050	0.000	0.037	0.037	0.075	0.246	U	0.995	0.168	0.068	N/A	-0.005	0.000	2.166	N/A	N/A	N/A	0.115	0.183	0.273	U	1.140	0.580	0.794	N/A	1.6	0.02
L100813BES00	5.50	S	1.040	0.156	0.073	N/A	-0.030	0.000	0.250	0.250	0.060	0.217	N/A	0.936	0.167	0.099	N/A	-0.064	0.000	1.997	N/A	N/A	N/A	0.106	0.132	0.218	U	1.050	0.523	0.712	N/A	1.6	0.03
L100814BRS00	2.50	S	0.895	0.145	0.070	N/A	-0.175	0.000	0.444	0.444	0.095	0.218	N/A	0.741	0.141	0.089	N/A	-0.259	0.000	2.045	N/A	N/A	N/A	0.110	0.144	0.236	U	0.886	0.601	0.763	N/A	1.9	0.04
L100807BRQ00	0.50	Q	0.907	0.151	0.078	N/A	-0.163	0.000	0.276	0.276	0.038	0.237	N/A	0.817	0.139	0.098	N/A	-0.183	0.000	2.402	N/A	N/A	N/A	0.132	0.144	0.257	U	0.671	0.283	0.757	U	3.0	0.03
L100816BUB00	5.50	B	0.774	0.116	0.053	N/A	-0.296	0.000	0.598	0.598	0.068	0.184	N/A	0.756	0.120	0.094	N/A	-0.244	0.000	13.996	N/A	N/A	N/A	0.773	0.176	0.214	N/A	2.500	0.730	0.792	N/A	4.6	0.13
L100817BUB00	6.00	B	0.690	0.103	0.053	N/A	-0.380	0.000	0.431	0.431	0.277	0.265	U	0.663	0.112	0.078	N/A	-0.337	0.000	7.375	N/A	N/A	N/A	0.407	0.132	0.168	N/A	1.660	0.643	0.734	N/A	3.7	0.07
L100818BUB00	5.50	B	1.040	0.160	0.079	N/A	-0.030	0.000	0.599	0.599	0.169	0.312	U	0.986	0.155	0.108	N/A	-0.014	0.000	9.290	N/A	N/A	N/A	0.510	0.165	0.203	N/A	2.710	0.854	0.941	N/A	2.9	0.10
L100819BUB00	6.00	B	1.110	0.170	0.108	N/A	0.040	0.040	0.231	0.231	0.263	0.321	U	1.390	0.251	0.115	N/A	0.390	0.390	7.169	N/A	N/A	N/A	0.388	0.210	0.326	N/A	2.940	1.030	1.160	N/A	2.1	0.29
L100820BUB00	0.50	B	1.160	0.189	0.093	N/A	0.090	0.090	0.276	0.276	0.044	0.329	U	□.10	0.188	0.165	N/A	0.100	0.100	4.524	N/A	N/A	N/A	0.247	0.155	0.182	N/A	1.560	0.877	1.070	N/A	2.5	0.15
L100821BUB00	1.00	B	0.964	0.141	0.065	N/A	-0.106	0.000	0.222	0.222	0.212	0.292	U	1.120	0.165	0.128	N/A	0.120	0.120	2.713	N/A	N/A	N/A	0.144	0.149	0.226	U	1.450	0.720	0.892	N/A	1.6	0.09
L100822BUB00	0.50	B	1.030	0.155	0.091	N/A	-0.040	0.000	0.431	0.431	0.215	0.260	U	1.100	0.213	0.143	N/A	0.100	0.100	3.681	N/A	N/A	N/A	0.193	0.137	0.216	U	2.150	0.795	0.919	N/A	1.4	0.10
L100823BUB00	1.00	B	1.070	0.170	0.079	N/A	0.000	0.000	0.429	0.429	0.139	0.312	U	0.861	0.199	0.164	N/A	-0.139	0.000	3.751	N/A	N/A	N/A	0.203	0.165	0.236	U	1.520	0.748	0.943	N/A	2.1	0.05
L100824BUB00	8.50	B	1.050	0.155	0.074	N/A	-0.020	0.000	0.326	0.326	0.210	0.307	U	1.120	0.179	0.095	N/A	0.120	0.120	7.421	N/A	N/A	N/A	0.409	0.152	0.195	N/A	1.860	0.794	0.943	N/A	3.4	0.13
L100825BUB00	9.00	B	1.020	0.153	0.075	N/A	-0.050	0.000	0.379	0.379	0.339	0.373	U	1.000	0.166	0.086	N/A	0.000	0.000	3.254	N/A	N/A	N/A	0.175	0.143	0.242	U	1.450	0.717	0.882	N/A	1.9	0.04
L100826BUB00	1.50	B	1.010	0.158	0.082	N/A	-0.060	0.000	0.100	0.100	0.060	0.250	U	1.150	0.195	0.087	N/A	0.150	0.150	1.736	N/A	N/A	N/A	0.090	0.159	0.247	U	1.220	0.688	0.900	N/A	1.2	0.10
L100827BUB00	2.00	B	0.917	0.134	0.063	N/A	-0.153	0.000	0.251	0.251	0.169	0.301	U	1.020	0.172	0.090	N/A	0.020	0.020	1.648	N/A	N/A	N/A	0.087	0.131	0.219	U	0.927	0.302	0.773	N/A	1.5	0.04
L100828BUB00	5.50	B	0.768	0.128	0.063	N/A	-0.302	0.000	0.504	0.504	0.377	0.331	U	0.662	0.128	0.127	N/A	-0.338	0.000	1.282	N/A	N/A	N/A	0.065	0.131	0.221	U	1.000	0.528	0.689	N/A	1.1	0.03
Systematic Minimum			0.000						0.030					0.000						0.699				0.029				0.658				**2.0**	0.02
Systematic Maximum			0.030						0.695					0.050						28.073				1.550				5.970				Average Enrichment (%)	0.23
Systematic Mean			0.003						0.266					0.005						4.037				0.218				1.513					0.05
Systematic Median			0.000						0.253					0.000						2.021				0.108				1.190					0.03
Systematic Standard Deviation			0.008						0.198					0.013						7.073				0.392				1.317					0.06
			With ingrowth, use Ra226 bkg =					1.07						Th232 bkg =			1.0																	

NOTES:
Gross results in units of pCi/g.
* Background with ingrowth (1.07 pCi/g) subtracted from gross result.
**Background (1.0 pCi/g) subtracted from gross result.
U Qualifier: Result is less than the sample detection limit.
All uncertainty values are reported at the 2-sigma confidence level.

31.2.5 Biased Soil Sample Result LSA 10-08

For LSA 10-08 several sample locations were selected within the SU based on the evaluation of the GWS survey data, HP Technician professional judgment, and the need to immediately backfill the survey unit in order to support ongoing remediation operations. While there were only two very small and isolated areas in LSA 10-08 that exceeded the 3 sigma Z-score criteria, several other biased sample locations were selected based on professional judgment and biased location L10-08-19-B-U-B-00 represents the maximum measurement encountered within in LSA 10-08 and has a Uniform SOF value of 0.29.

31.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 10-08

The FSS plan design as implemented by FSS procedures at the time of FSS determined that sidewall sampling was not necessary in LSA 10-08. Furthermore, evaluation of the SU has determined that no surfaces meeting the definition of a sidewall were present within the SU at the time FSS was performed.

31.2.7 Quality Control Soil Sample Result LSA 10-08

One QC field duplicate sample point was randomly selected for LSA 10-08 which was collected at systematic locations L10-08-07.

For the 27 "regular" samples (i.e., 14 systematic + 13 biased) collected within LSA 10-08, one field duplicate sample was collected. This frequency equates to 3.7%, (i.e. 1/27). 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 31-5 below). While the overall quality control frequency considering all samples was less than 5%, the quality control frequency considering only systematically collected samples equates to 7.1%, (i.e. 1/14). And the overall project quality control sample frequency for Class 1 LSA's remains above 5%.

Figure 31-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 10-08

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

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

Survey Unit No.:	LSA 10-08				Survey Unit Description:		Burial Pits Open Land Area South Eastern Survey Unit in "Area 9"					
			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)
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC						
L100807BRS00	L100807BRQ00	Ra-226	0.923	0.0591	0.907	0.0783	0.915	1.9	0.016	0.269	0.403	N
L100807BRS00	L100807BRQ00	Tc-99	0.194	0.252	0.276	0.237	0.235	25.1	NA	3.552	5.321	NA
L100807BRS00	L100807BRQ00	Th-232	0.77	0.0715	0.817	0.0976	0.794	2.0	0.047	0.283	0.424	N
L100807BRS00	L100807BRQ00	U-234[1]	0.968	N/A	2.402	N/A	1.685	195.4	1.434	27.649	41.425	N
L100807BRS00	L100807BRQ00	U-235	0.0499	0.182	0.132	0.257	0.091	51.6	NA	7.301	10.939	NA
L100807BRS00	L100807BRQ00	U-238	0.658	0.606	0.671	0.757	0.665	168.8	NA	23.885	35.786	NA

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

Performed by: Thomas Yardley / Thomas Yardley

Date: 1-11-17

Reviewed by: W. Clark Ervin / W. Clark Ervin

Date: 1/11/17

Quality Record

31.3 Tc-99 Hot Spot Assessment LSA 10-08

During site characterization studies there were no samples collected for Tc-99 in LSA-10-08. Therefore, the historic Tc-99 data from the neighboring LSA 10-02 was reviewed to determine if there is a potential for Tc-99 hotspots in the area near LSA 10-08. LSA 10-02 did display one characterization sample with a Tc-99 result of 31.1 pCi/g in the vicinity of LSA 10-08. No samples exceeded the Tc-99 DCGL during FSS. Within LSA 10-08, the maximum sample identified was 0.695 pCi/g, which is below the 25.1 pCi/g limit for the Uniform DCGL.

Using the data from LSA 10-02, an area factor of 1.24 would be required to account for any potential Tc-99 hot spot of 31.1 pCi/g. Using the Uniform Area Factor Table 14-12 from Chapter 14 of the DP, and interpolation, 810 m^2 is the area per sample station required to equate to an area factor of 1.24. In LSA 10-08 the area represented by each systematic location was 11 m^2 and is adequate to account for any potential hot spots within the SU.

32.0 ALARA EVALUATION LSA 10-08

All samples collected within LSA 10-08 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 10-08 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.05 for LSA 10-08. The average SOF equates to residual activity contributions from the SU of 1.25 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, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 10-08. Summing the dose contributions together, the total estimated dose for LSA 10-08 is 5.25 mrem/year.

Since the estimated TEDE is below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 10-08 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 10-08.

33.0 FSS PLAN DEVIATIONS LSA 10-08

33.1 Remedial Actions during FSS

There were no remedial actions after FSS in LSA 10-08.

33.2 Adjustments to Scan MDC Calculations

As previously stated in Section 29.1.5, adjustments were made to the Scan MDC calculations for instrumentation used for the GWS in LSA 10-08. The Scan MDCs presented in the FSS Plan shown in Table 29-1 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 10-08, 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 10-08 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 33-1 below:

Table 33-1

Revised Scan MDCs for 2" x 2" NaI detector: LSA 10-08

	Scan MDC (Total U)	**$DCGL_W$ (Total U)**	**Scan MDC (Ra-226)**	**$DCGL_W$ (Ra-226)**	**Scan MDC (Th-232)**	**$DCGL_W$ (Th-232)**
LSA 10-08	44.9	79.2	1.32	1.9	0.95	2.0

34.0 DATA QUALITY ASSESSMENT

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

34.1 Data Quality Assessment for LSA 10-08

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 10-08 (see Figure 34-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).
- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with

procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.

- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 10-08 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 10-08, 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 10-08, however the WRS Test was still performed for illustrative purposes. Since the test statistic, WR (976) exceeded the critical value (821), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix D.
- The maximum SOF result for all surface samples within LSA 10-08 was 0.29. The maximum SOF result for all subsurface sample within LSA 10-08 was 0.05. The average SOF result for all systematically collected samples within LSA 10-08 was 0.05, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.08.
- No FSS sample result in LSA 10-08 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an EMC or supplemental investigations was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (10) of systematic sample locations actually collected within LSA 10-08. The successful result of the retrospective power evaluation presented in Table 34-1 for LSA 10-08 indicates that the minimum number of sample locations required (8) for the WRS Test was less than the number of sampling locations actually collected within LSA 10-08. 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.
- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures for LSA 10-08 was completed prior to the commencement of backfill operations.

Table 34-1
Retrospective Sample Size Verification for LSA 10-08

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.06
$DCGL_{SOF}$	1
LBGR (Mean)	0.05
Shift	0.95
Relative Shift (Δ/σ)	17.03
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS N/2	10
Verification Check	**SUFFICIENT MEASUREMENTS**
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test	

MARSSIM Table 5.1

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

MARSSIM Table 5.2, α = 0.05, β = 0.10

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

Figure 34-1
Data Evaluation Checklists prepared for LSA 10-08 (page 1 of 2)

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

Survey Area: 10 **Description:** Burial Pits (North)
Survey Unit: 08 **Description:** Created to support removal of NE berm of LSA10-02

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 step 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 ☐
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 (Reference 5.11)	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:

During the collection of systematic samples, refusal was experienced at the sample station associated with samples L100808BES00 & L100814BRS00 & L100815BES00.

L100808BES00: The survey plan called for collection of soil from 4.5 – 5.0-ft. Sample technicians experienced refusal at full depth (i.e., 5-ft). However, the soil that was collected up to refusal was retained for analysis.

L100814BRS00 & L100815BES00: During the collection of the upper strata (i.e., sample L100814BRS00) technicians experienced refusal at 0.5-ft. Rad. Eng. (R. Neveau) directed sample techs to offset the location approximately 2-ft west of the original location. Refusal was again experienced at a sample depth of 1-ft.

Per Rad. Eng. direction, the material removed from 0 – 1-ft at this off-set location was retained for analysis as Sample No. L100814BRS00. However, due to refusal at 1-ft sample technicians were unable to collect the subsequent strata at this sample location (Sample No. L100815BES00).

See HP Tech Survey Log No. 2944 C130801 and the FSS Field Log for additional details.

Quality Record Westinghouse Non-Proprietary Class 3

Figure 34-1
Data Evaluation Checklists prepared for LSA 10-8 (page 2 of 2)

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

Survey Area: No. 10 **Description:** Burial Pits (North)
Survey Unit: No. 08 **Description:** Created to support removal of NE berm of LSA10-02

Discrepancy: Inability to sample at the locations referenced in the comments section of this checklist due to refusal at the original location and refusal at the alternate location (offset approx. 2-ft to the west). The survey instruction called for collection of soil at the following strata:
L100808BES00: 4.5 – 5.0-ft
L100814BRS00: 0 – 2.5-ft & LSA100815BES: 2.5 – 3-ft
Due to refusal: L100808BES00 collection from 4.5 – < 5.0-ft (collection depth fell slightly less than goal)
L100814BRS00 collection from 0 – 1-ft & LSA100815BES not collected due to refusal @ upper strata.

Corrective Actions Taken: At the alternate (offset) location, Rad. Eng. (R. Neveau & M. Bresnahan) directed the sample technicians to retain the soil collected prior to refusal (sample depth = 1-ft). This soil was logged as Sample No. L100814BRS00. Sample No. L100808BES00 provided soil prior to refusal. The log sheets and survey forms associated with these samples provide sufficient documentation regarding the inability to collect these three samples in accordance with the survey instruction.
Rad. Eng. examined the data associated with the sample analysis and the NaI readings collected within the holes associated with all sample locations. Data collected at these locations is not anomalous to the data associated with all other systematic (and biased) sample locations. Rad. Eng. has determined that although refusal issues did not provide the ability to collect soil per the survey instruction, the survey and sample data that was collected provide adequate characterization of the unit. No further action is required.

11. Have the corrective actions resolved the discrepancy with the data? Yes ☒ No ☐
    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 ☐ N/A
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ N/A
    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):	Rock Neveau		09-17-13
Approved by (RSO):	Joseph Guido		09-18-13

35.0 SURVEILLENCE FOLLOWING FSS

Due to the need to restore the Northeast Site Creek to an operable condition LSA 10-08 was immediately backfilled and the diversion structure was restored (see Figure 3-10). As such, surveillance following FSS was not necessary for LSA 10-08.

36.0 CONCLUSION LSA 10-08

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 10-08 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 36-1
LSA 10-08 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.05	N/A	0.16	N/A	N/A	**0.21**
DOSE	1.25 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**5.25 mrem/year**

37.0 FINAL STATUS SURVEY DESIGN LSA 10-09

This section of the report describes the method for determining the number of samples required for the FSS of LSA 10-09 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 10-09 and the detection sensitivities are also discussed.

37.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 10-09 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 2, *Final Status Survey Plan Development*, February 2013.

37.1.1 Surrogate Evaluation Areas

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

37.1.2 $DCGL_W$

During the FSS design process a review was performed of the historic characterization data for LSA 10-09. Within LSA 10-09, two of the six characterization boring locations within the SU exceeded a SOF of 1 as compared to the Uniform Stratum criteria (samples SS-BP-065, SS-BP-066) up to a maximum depth of 5 feet bgs. Remediation progress was reviewed to ensure that these areas were adequately removed during remediation with excavation occurring to average depths of 12 to 20 feet bgs at these locations. Next 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.

37.1.3 GWS Coverage

As a Class 1 SU, LSA 10-09 was required to undergo a 100% GWS.

37.1.4 Instrumentation

Radiological instrumentation selected for performance of GWS within LSA 10-09 was the Ludlum 44-10 2" x 2" NaI detectors, coupled to a Ludlum 2221 scaler-ratemeter.

37.1.5 Scan Minimum Detectable Concentration

As background levels were approximately 10,000 cpm within LSA 10-09, 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 37-1

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 10-09, the average enrichment for the SU was 77.88%. Note that this estimate of enrichment is conservatively high as the RASS samples used to determine the enrichment were analyzed in the onsite counting laboratory. These low activity samples did not identify U-238 above the MDC of the onsite counting equipment in several of the samples, so a conservatively high U-235 enrichment was assumed. It should also be noted that the average enrichment of the FSS samples when analyzed at the offsite counting laboratory was 1.7%.

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 37-1. Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 10-09 are shown below.

Table 37-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 10-09

	Scan MDC (Total U)	$DCGL_W$ (Total U)	Scan MDC (Ra-226)	$DCGL_W$* (Ra-226)	Scan MDC (Th-232)	$DCGL_W$* (Th-232)
LSA 10-09	142.5	93.5	2.8	2.8	1.8	3.0

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

The values in Table 37-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

37.1.6 Investigation Action Level

FSSFR Volume 3, Chapter 1, Section 6.1.3, *Investigation Action Level (IAL)*, provides a discussion in regards to the IAL. The FSS in LSA 10-09 was performed prior to the development of HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*" which established a standard Scan IAL for all Class 1 SU's at the Hematite Site. An IAL of 5,297 ncpm was calculated based on the average SU enrichment and estimated hot spot size, however, a lower IAL was administratively set at 4,000 net cpm for LSA 10-09, as such the IAL is acceptable.

37.1.7 LSA 10-09 FSS Design Summary

The FSS Plan for LSA 10-09 can be found in Appendix K. Table 37-2 presents an overall FSS design and implementation summary for LSA 10-09.

Table 37-2
FSS Design Summary for LSA 10-09

Gamma Walkover Survey (GWS):		
Scan Coverage	100% accessible excavation floors and walls	
Scan MDC	142.5 pCi/g total Uranium (1,512 ncpm)	
Investigation Action Level (IAL)	5,297 net cpm* *magnitude of IAL is due to small survey unit size, a more restrictive IAL of 4,000 ncpm will be used.	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	3	These samples were collected on a systematic grid.
15 cm – 1.5 m (Root)	6	
> 1.5m (Excavation)	4	
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.	Used for GWS and to obtain static count rates at biased measurement locations.	

Note that Table 37-2 above is presented as it was first developed by the FSS Plan for LSA 10-09, however the depth of systematic samples is determined by the distance to the final grade of the SU after backfill. The systematically collected samples collected as described above were errantly collected based on the "previous" ground surface of the VOC test pit that was dug in LSA 10-09. This deep excavation was an area of high VOC contamination near the phreatic surface. It was excavated to the depth of the phreatic surface to remove all VOC contamination and then temporarily backfilled for excavation safety purposes. The backfill was removed prior to the commencement of the FSS, but the specified sample depths were mistakenly assigned based on the previously backfilled surface, not the designed final grade for the area. However, since all samples were evaluated against the Uniform $DCGL_W$ criteria, the sample depth has no bearing on the final outcome of the sample analysis, nor the evaluation of the release criteria.

Table 37-2 is presented as it was provided in the FSS instructions for LSA 10-09, however to ensure compliance with the DP the post FSS data analysis will be performed on all FSS samples based on the final grade of the LSA which places all of the FSS samples in the excavation stratum. Based on the guidance above from the FSS Plan seven (7) samples were collected from the exposed excavation surface, and six (6) samples were collected from the subsurface.

38.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 10-09

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

38.1 Gamma Walkover Survey

38.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 10-09 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS and handheld data logger.

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

38.1.2 GWS Performance

All GWS measurements on the 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 10-09 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 LSA 10-09 ranged between 10,000 and 12,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 16,000 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 SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

38.2 Soil Sampling

38.2.1 Systematic Soil Sampling Summary

Table 38-1 provides a summary of systematic sampling by stratum for LSA 10-09.

Table 38-1
Systematic Sampling Summary by Stratum for LSA 10-09

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
10-09	216	0	0	13	1

38.2.2 Systematic Sampling LSA 10-09

It is of note that when FSS activities commenced in LSA 10-09 that one set of systematic samples was collected from the SU prior to the discovery some plastic debris that was subsequently determined to be from the material used to line the deep excavation prior to the initial backfilling. After additional excavation was conducted in LSA 10-09 FSS was restarted and a new set of systematic samples were collected. Only the second set of systematically collected samples will be used to calculate residual SU radioactivity and dose. The results of the first set of systematic samples collected will also be presented for informational purposes.

Within LSA 10-09, there were no systematic locations in which portions of the surface stratum (0 – 15 cm), or root stratum (15 cm – 150 cm) remained in the SU after remediation. Excavation stratum samples were collected at seven locations, with an additional 6 subsurface samples collected in the excavation stratum, using either hand trowels for six-inch grabs below the existing excavation surface or hand augers where necessary. Given a planar area of 216 m^2 for LSA 10-09 and a seven - point systematic triangular grid, the point-to-point distance within each row was 5.97 m.

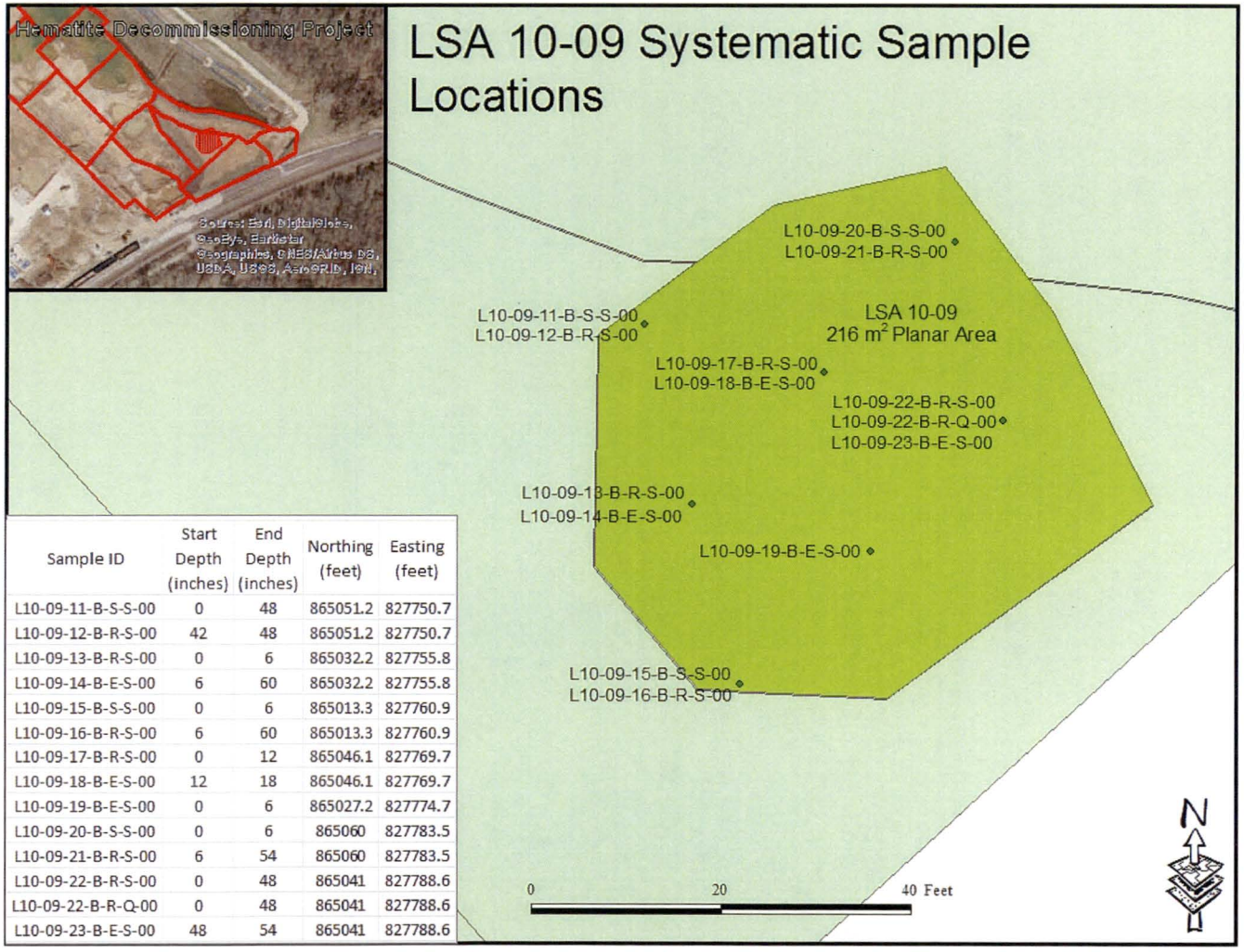
While there were seven systematic locations on the LSA 10-09 sampling grid, a total of thirteen (13) samples were collected at these locations, including:

- Zero (0) samples collected within the remaining surface stratum
- Zero (0) samples collected within the remaining root stratum
- Thirteen (13) samples collected within the excavation, or "deep"

- One (1) Quality Control (QC) field replicate

Figure 38-1 presents the map of the eight systematic sample locations which were sampled within LSA 10-09. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 38-1
LSA 10-09 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L10-09-11-B-S-S-00	0	48	865051.2	827750.7
L10-09-12-B-R-S-00	42	48	865051.2	827750.7
L10-09-13-B-R-S-00	0	6	865032.2	827755.8
L10-09-14-B-E-S-00	6	60	865032.2	827755.8
L10-09-15-B-S-S-00	0	6	865013.3	827760.9
L10-09-16-B-R-S-00	6	60	865013.3	827760.9
L10-09-17-B-R-S-00	0	12	865046.1	827769.7
L10-09-18-B-E-S-00	12	18	865046.1	827769.7
L10-09-19-B-E-S-00	0	6	865027.2	827774.7
L10-09-20-B-S-S-00	0	6	865060	827783.5
L10-09-21-B-R-S-00	6	54	865060	827783.5
L10-09-22-B-R-S-00	0	48	865041	827788.6
L10-09-22-B-R-Q-00	0	48	865041	827788.6
L10-09-23-B-E-S-00	48	54	865041	827788.6

Table 38-2 below presents a tabular listing of all FSS samples collected within LSA 10-09 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 38-2

FSS Sample Locations and Coordinates for LSA 10-09

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

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area: LSA 10 **Description:** Burial Pits Open Land Area
Survey Unit: 09 **Description:** South Eastern Survey Unit in "Area 9"
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
L100901BES00	Uniform	S***	420.4	419.9	865059.5	827780.9	Excavation 6-inch grab
L100902BES00	Uniform	S***	417	416.5	865048.4	827769.8	Excavation 6-inch grab
L100903BES00	Uniform	S***	420.5	420.0	865044.4	827785.0	Excavation 6-inch grab
L100904BEQ00	Uniform	Q	419.6	419.1	865037.3	827758.7	Excavation 6-inch grab
L100904BES00	Uniform	S***	419.6	419.1	865037.3	827758.7	Excavation 6-inch grab
L100905BES00	Uniform	S***	417.2	416.7	865033.3	827773.9	Excavation 6-inch grab
L100906BES00	Uniform	S***	417.2	416.7	865029.2	827789.0	Excavation 6-inch grab
L100907BES00	Uniform	S***	421.7	421.2	865018.1	827777.9	Excavation 6-inch grab
L100908BUB00	Uniform	B	421.5	421.0	865023.9	827779.2	Biased 6-inch grab
L100909BUB00	Uniform	B	421.5	421.0	865047.0	827787.1	Biased 6-inch grab
L100910BUB00	Uniform	B	421.5	421.0	865027.0	827782.8	Biased 6-inch grab
L100911BSS00	Uniform	S	425	421.0	865051.2	827750.7	Excavation 6-inch grab
L100912BRS00	Uniform	S	421.5	421.0	865051.2	827750.7	Excavation zone composite
L100913BRS00	Uniform	S	420.7	420.2	865032.2	827755.8	Excavation zone composite
L100914BES00	Uniform	S	420.2	415.7	865032.2	827755.8	Excavation 6-inch grab
L100915BSS00	Uniform	S	421.5	421.0	865013.3	827760.9	Excavation 6-inch grab
L100916BRS00	Uniform	S	421.0	416.0	865013.3	827760.9	Excavation zone composite
L100917BRS00	Uniform	S	417.0	416.0	865046.1	827769.7	Excavation zone composite
L100918BES00	Uniform	S	416.0	415.5	865046.1	827769.7	Excavation 6-inch grab
L100919BES00	Uniform	S	418.1	417.6	865027.2	827774.7	Excavation 6-inch grab
L100920BSS00	Uniform	S	420.3	419.8	865060.0	827783.5	Excavation 6-inch grab
L100921BRS00	Uniform	S	419.8	415.3	865060.0	827783.5	Excavation zone composite
L100922BRQ00	Uniform	Q	420.7	416.7	865041.0	827788.6	Excavation zone composite
L100922BRS00	Uniform	S	420.7	416.7	865041.0	827788.6	Excavation zone composite
L100923BES00	Uniform	S	416.7	416.2	865041.0	827788.6	Excavation 6-inch grab
L100924BSS00	Uniform	B	421.7	421.2	865012.1	827769.4	Sidewall 6-inch grab
L100925BSS00	Uniform	B	420.7	420.2	865021.7	827790.0	Sidewall 6-inch grab
L100926BSS00	Uniform	B	421.7	421.2	865037.0	827801.7	Sidewall 6-inch grab
L100927BSS00	Uniform	B	420.2	419.7	865057.3	827790.0	Sidewall 6-inch grab
L100928BSS00	Uniform	B	422.7	422.2	865065.7	827773.1	Sidewall 6-inch grab
L100929BSS00	Uniform	B	421.5	421.0	865055.1	827752.6	Sidewall 6-inch grab
L100930BSS00	Uniform	B	421.4	420.9	865035.3	827745.5	Sidewall 6-inch grab

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

*Elevations are in feet above mean sea level.
** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983]
*** First round of samples are presented for information only
CSM: Three-Layer (Surface-Root-Excavation) or Uniform DCGLs used
Type: Systematic = S, Biased = B; QC =Q; Investigation = I
Quality Record

38.3 Biased Soil Sampling

As discussed in FSSFR Volume 3, Chapter 1, Section 6.1.3, there are three key methods for identifying areas for biased soil sampling, the IAL, the Z-score of the FSS GWS, and the professional judgment of the HP Staff. For LSA 10-09 several biased sample locations were selected within the SU based on the evaluation of the GWS survey data and HP Technician professional judgment. These biased locations represented the maximum GWS measurements encountered within the SU.

Biased samples are collected at the prescribed location to a depth of 6 inches below the exposed ground surface.

38.4 Judgmental/Sidewall Sampling for Tc-99

During the FSS planning for LSA 10-09, while it was not procedurally required at the time to perform sidewall sampling, the decision was made to specify that for LSA 10-9 sidewall samples would be collected. This was based on the professional judgment of the Radiological Engineering.

As previously discussed in Section 6.4, Westinghouse and the NRC agreed upon protocol for sidewall sampling for Tc-99 predated the performance of FSS in LSA 10-09. As such, a retrospective review is provided utilizing the criteria of HEM-15-MEMO-039 that demonstrates that Tc-99 sidewall sampling was required for LSA 10-09 had the agreed upon protocol been in effect at the time of FSS of LSA 10-09.

Figure 38-2, *Area of LSA 10-09 Containing Sidewalls at Time of FSS*, provides evidence of what the results of the inspection for the presence of sidewall areas in LSA 10-09 at the time of FSS. As can be seen by review of Figure 3-13, *LSA 10-09 Depth of Excavation Map*, and as can be seen in Figure 38-2 LSA 10-09 presented a number of areas containing sidewalls.

Figure 38-2
Area of LSA 10-09 Containing Sidewalls at Time of FSS

The sidewalls are summarized in Table 38-2 utilizing the formula below.

length x height = area

Equation 38-1

Table 38-2
LSA 10-10 Sidewall Area Summary

	Length (m)	x	Height (m)	=	Area (m^2)
Wall 1	6.50	x	.30	=	1.95
Wall 2	7.84	x	.30	=	2.35
Wall 3	34.2	x	.92	=	31.46
		Total Sidewall Area			35.76

If the sidewall area exceeds 5 % of the SU area then sidewall sampling is required. The sidewall area is 35.76 m^2. The SU area is 216 m^2. The percentage of sidewall area in regards to the SU area is 16.55%.

35.76 m^2 (sidewall area) / 216 m^2 (SU area) = 16.55 %

Equation 38-2

The total sidewall area for LSA 10-09 is 16.55% which exceeds the agreed upon protocol of 5% or greater of the SU. As such, if the agreed upon protocol would have been applied to LSA 10-09 at the time of FSS Tc-99 sidewall sampling would have been required. Using the

guidance of HEM-15-MEMO-039 if the agreed upon protocol would have been applied to LSA 10-09 at the time of FSS three (3) sidewall samples would have been required to be taken.

At the time of FSS, the FSS Plan for LSA 10-09 directed the HP Technicians to take seven (7) biased location samples from sidewalls, which meets the agreed upon protocol. The results of the sidewall samples are presented in Section 39.2.5.

38.5 Quality Control Soil Sampling

Two QC field duplicate sample points were randomly selected and collected at systematic location L10-09-04 and L10-09-22 for LSA 10-09.

39.0 FINAL STATUS SURVEY RESULTS LSA 10-09

39.1 Gamma Walkover Survey

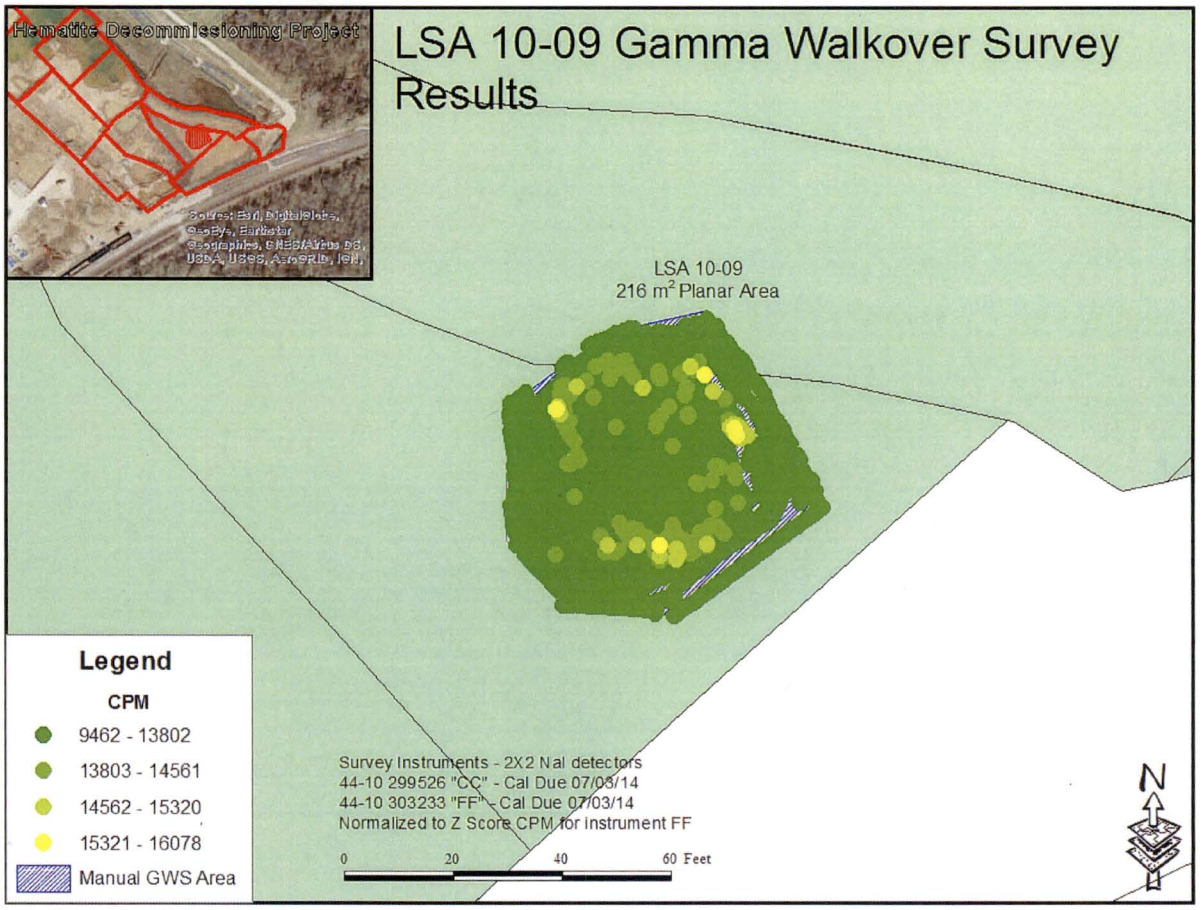
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 10-09 from September 19, 2013 to October 18, 2013.

39.1.1 GWS Results for LSA 10-09

For datalogged GWS data in LSA 10-09, GWS count rates ranged between 9,462 gcpm and 15,916 gcpm, with a mean count rate of 12,526 gcpm. The median count rate was 12,475 gcpm and the standard deviation was 858 cpm. Figure 39-1 below presents a map of the complete GWS data set.

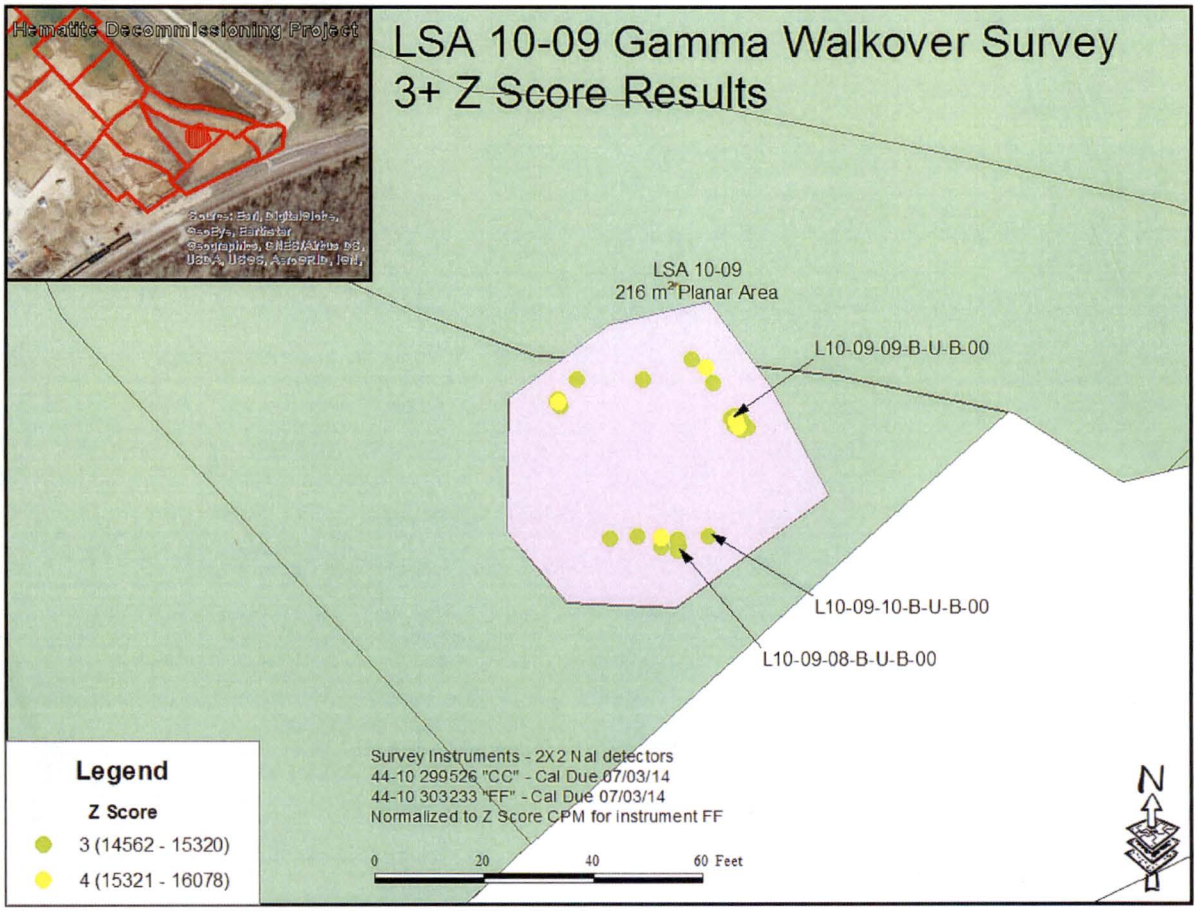
Figure 39-1
Colorimetric GWS Plot for LSA 10-09



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). Three locations were selected for biased sampling; the highest result came from L10-09-10-B-U-B-00 with a Uniform SOF of 0.24. Multiple areas appear as a yellow dot in the figure below, these locations were ruled out for biased sampling upon further investigation, the elevated readings were determined to be caused by close proximity to a steep excavation sidewall (e.g. poor counting geometry).

Figure 39-2 below presents a map of the +3 Z-score GWS measurements within LSA 10-09, including the selected biased sampling locations.

Figure 39-2
Colorimetric GWS Plot for LSA 10-09(Measurements > Z-score of 3)



Since the majority of GWS data collected in LSA 10-09 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 and a general area background of 12,000 gcpm, a Scan MDC of approximately 44.9 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 10-09, 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:

$$\text{Scan MDC}_{Total\ Uranium} = \quad 1 \Big/ \left(\left(\frac{0.7928}{4008}\right) + \left(\frac{0.0438}{2.54}\right) + \left(\frac{0.1634}{33.5}\right) \right) = 44.9 \frac{pCi}{g}$$

Equation 39-1

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 1.32 pCi/g and 0.95 pCi/g, respectively using a two inch air gap. A two inch (2") 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.

39.1.2 GWS Coverage Results LSA 10-09

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 10-09 interior could not be accessed for GWS due to especially tall interior pit sidewalls. These areas appear as greyish-pink blanks in the Figure 39-1 above. Manual surveys were performed to supplement the GPS walkover survey data.

The post survey processing of the GPS data indicated that the GWS was 95.71% of the SU (see Table 39-1), and combined with the manual surveys of the pit sidewalls the GWS coverage reaches 99.79%. As the evaluation indicates that the GPS coverage exceeded 95%, and the readings approaching or exceeding the IAL of 4,000 net cpm in the vicinity of the apparent GPS coverage gaps were investigated and found to be satisfactory, the GWS coverage for the SU has been evaluated to meet the intent of the "100% GWS coverage" requirement.

Table 39-1
GWS Gap Analysis LSA 10-09

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 10-09	70197	149	0.21%	99.79%	1

39.2 Soil Sample Results LSA 10-09

Appendix E presents the analytical results and associated statistics for all FSS samples collected within LSA 10-09.

39.2.1 Surface Soil Sample Results LSA 10-09

There were no samples collected within the surface stratum (0 – 15 cm) or root stratum (15 cm – 1.5 m) of LSA 10-09. However, there were a total of eighteen (18) soil samples collected within the topmost soil layer of the excavation surface including seven systematic samples, ten biased samples (including seven from sidewalls), and one QC field duplicate sample. The maximum SOF result for the "topmost" samples was 0.24 corresponding to the biased sample L10-09-10-B-U-B-00. The maximum systematic sample SOF result was 0.12 at L10-09-13-B-R-S-00.

39.2.2 Subsurface Soil Sample Results LSA 10-09

There were six (6) systematic locations within LSA 10-09 where subsurface sampling was performed. These six excavation stratum samples where there was overlying stratum remaining are considered "subsurface" samples. The maximum SOF result of the subsurface samples collected in LSA 10-09 was 0.23. This sample (L10-09-18) was the excavation stratum sample collected directly underneath the root stratum sample L10-09-17.

39.2.3 WRS Test Evaluation for LSA 10-09

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was not required for LSA 10-09 since the difference between the maximum SU data set gross SOF and the minimum background area SOF was less than one using the Uniform Stratum criteria. However, for illustrative purposes, the WRS evaluation was still performed for LSA 10-09. 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 13 systematically collected samples in LSA 10-09 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, (944) was greater than the critical value (802) for the test. As such, the null hypothesis that the SU average concentration is greater than the $DCGL_W$ was rejected. The WRS evaluation is also included in Appendix E.

39.2.4 Graphical Data Review LSA 10-09

Table 39-2 below presents summary results for the all systematically collected samples (includes surface (none collected in this SU), root, and excavation stratum samples, but not biased or QC samples) collected within LSA 10-09, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.09.

Table 39-2
LSA 10-09 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	0.056	0.029	0.069	2.094	0.110	1.237	**0.09**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	1.100	0.052	0.689	0.03
Maximum	0.330	0.104	0.140	3.372	0.178	1.910	0.23

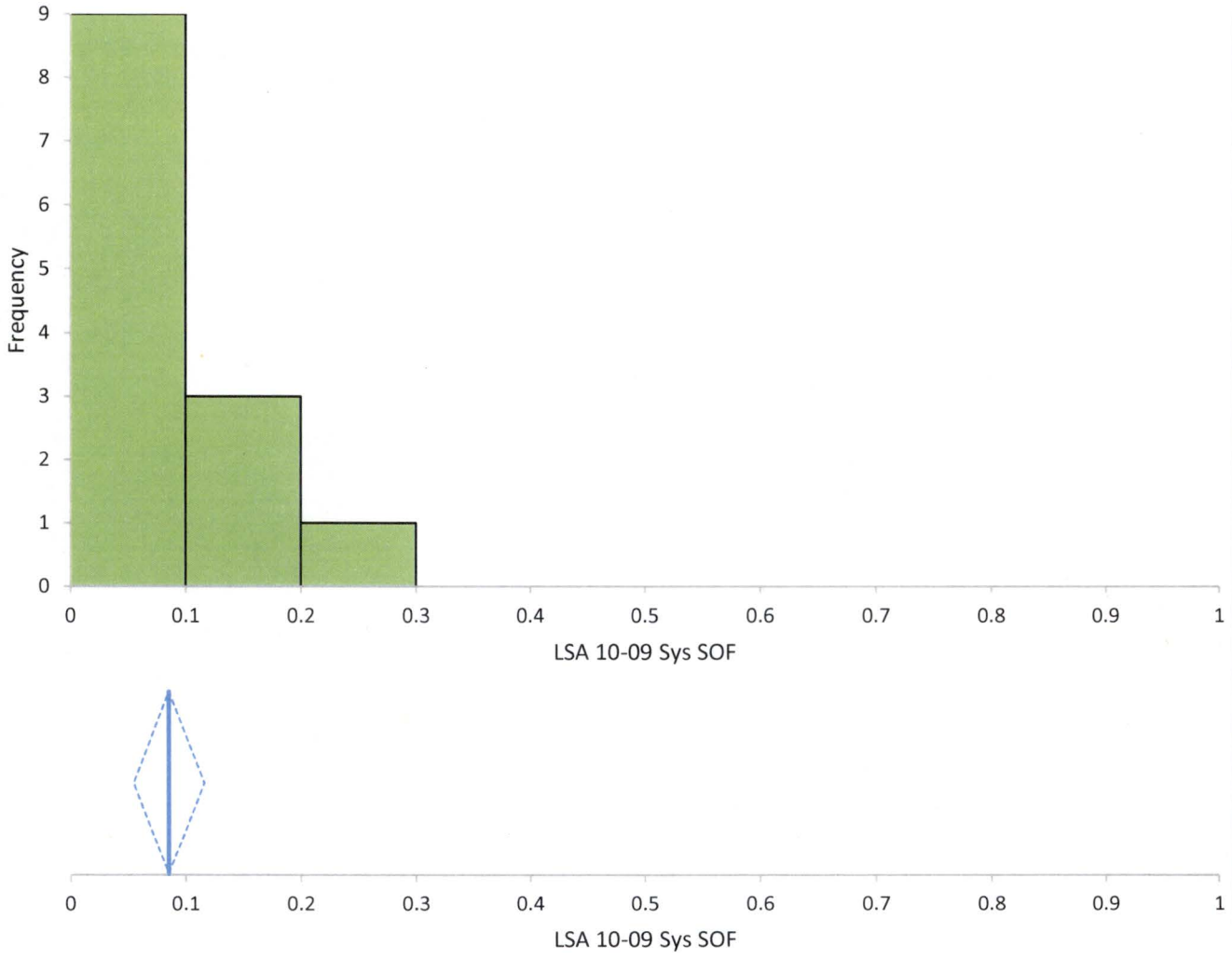
Notes:
1. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
2. Average SOF for data set calculated using average radionuclide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

Figure 39-3 presents the overall statistical metrics for the SOF parameter for the 9 systematically collected samples from LSA 10-09. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-09. The middle graph presents the mean SOF (0.09 as indicated by the blue vertical line) of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.05 to 0.12. The 97.75% confidence interval based on the median (0.07) of the sample results is 0.05 to 0.12. The bottom two charts present the various statistical metrics of the LSA 10-09 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 39-3 exhibits no unusual symmetry or bimodality concerns for the LSA 10-09 data associated with the systematically collected measurement locations.

Figure 39-3
Graphic Statistical Summary for LSA 10-09 (SOF parameter)



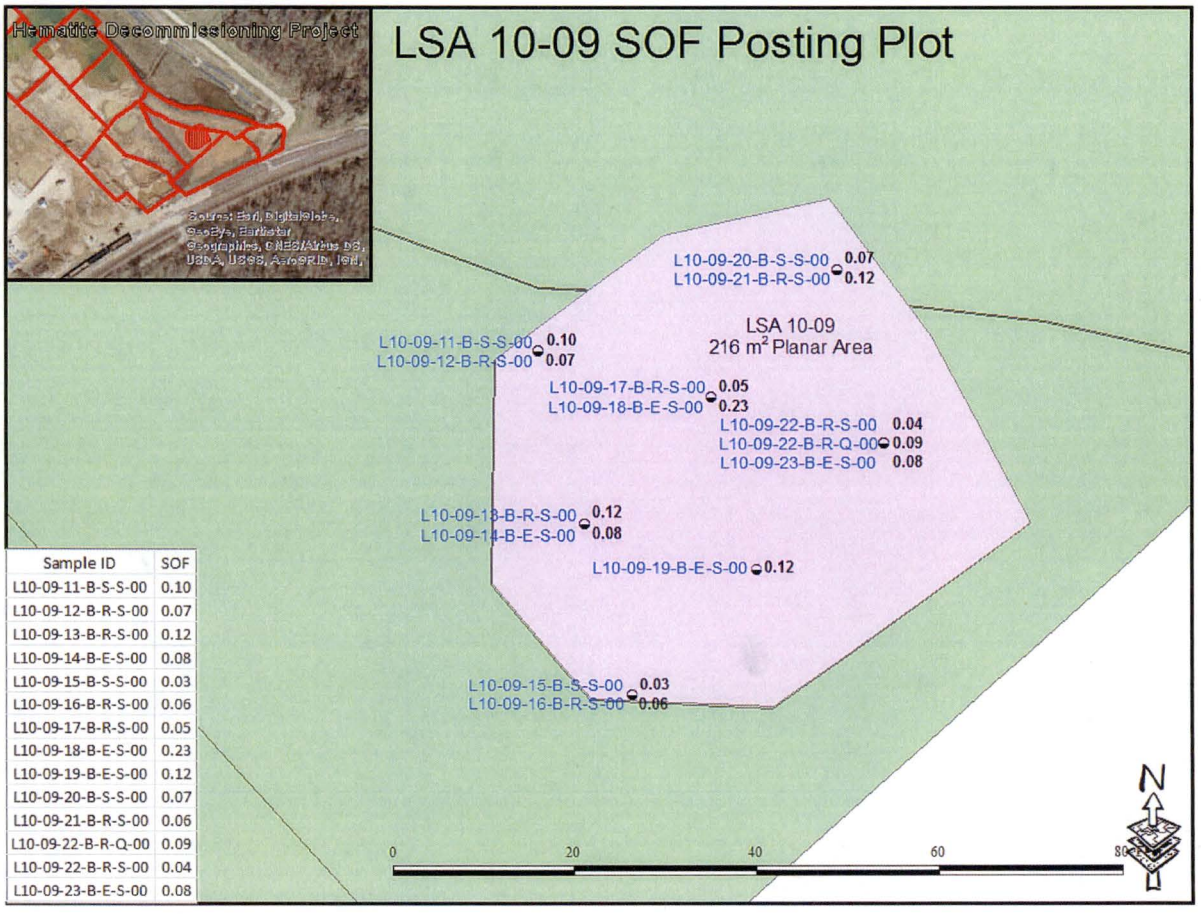
N	13

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 10-09 Sys SOF	0.09	0.05	to 0.12	0.014	0.05	0.00	2.0	5.10

	Minimum	1st quartile	Median	97.75% CI		3rd quartile	Maximum	IQR
LSA 10-09 Sys SOF	0.03	0.06	0.07	0.05	to 0.12	0.11	0.2	0.05

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 10-09 is presented below in Figure 39-4. Figure 39-4 shows no unusual patterns in the data.

Figure 39-4
Posting Plot for LSA 10-09 Systematic Measurement Locations



Sample ID	SOF
L10-09-11-B-S-S-00	0.10
L10-09-12-B-R-S-00	0.07
L10-09-13-B-R-S-00	0.12
L10-09-14-B-E-S-00	0.08
L10-09-15-B-S-S-00	0.03
L10-09-16-B-R-S-00	0.06
L10-09-17-B-R-S-00	0.05
L10-09-18-B-E-S-00	0.23
L10-09-19-B-E-S-00	0.12
L10-09-20-B-S-S-00	0.07
L10-09-21-B-R-S-00	0.06
L10-09-22-B-R-Q-00	0.09
L10-09-22-B-R-S-00	0.04
L10-09-23-B-E-S-00	0.08

Appendix E to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 39-2, Figure 39-4, and Figure 39-5 above. A summary of the analytical data is presented in Table 39-3 below. Appendix Q to this report presents the Test America Analytical Laboratory soil sample reports.

Table 39-3
Final Status Survey Analytical Data: LSA 10-09

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF
L100901BES00	7.80	S***	1.2	0.168	0.0594	N/A	0.130	0.130	0.0739	0.074	0.05	0.21	U	1.09	0.166	0.101	N/A	0.090	0.090	3.308	N/A	N/A	N/A	0.179	0.15	0.253	U	1.33	0.632	0.836	N/A	2.1	0.14
L100902BES00	12.20	S***	1.37	0.287	0.196	N/A	0.300	0.300	0.025	0.025	0.06	0.221	U	1.24	0.279	0.122	N/A	0.240	0.240	2.894	N/A	N/A	N/A	0.158	0.249	0.624	U	0.989	0.902	2.53	U	2.5	0.30
L100903BES00	8.10	S***	1.09	0.169	0.0796	N/A	0.020	0.020	0.0207	0.021	0.017	0.22	U	1.14	0.213	0.0961	N/A	0.140	0.140	2.279	N/A	N/A	N/A	0.123	0.16	0.281	U	0.952	0.445	1.19	U	2.0	0.10
L100904BEQ00	9.60	Q	1.21	0.163	0.0637	N/A	0.140	0.140	0.0159	0.016	0.009	0.22	U	1.19	0.19	0.118	N/A	0.190	0.190	3.154	N/A	N/A	N/A	0.169	0.154	0.236	U	1.44	0.64	0.819	N/A	1.8	0.20
L100904BES00	9.60	S***	1.13	0.162	0.0781	N/A	0.060	0.060	-0.008	0.000	0.035	0.227	U	1.24	0.207	0.0928	N/A	0.240	0.240	1.037	N/A	N/A	N/A	0.0456	0.153	0.265	U	1.68	0.737	0.896	N/A	0.5	0.17
L100905BES00	12.10	S***	1.57	0.21	0.0694	N/A	0.500	0.500	-0.0206	0.000	0.037	0.224	U	1.06	0.176	0.13	N/A	0.060	0.060	1.945	N/A	N/A	N/A	0.102	0.154	0.256	U	1.15	0.546	0.763	N/A	1.4	0.31
L100906BES00	12.20	S***	1.2	0.175	0.0733	N/A	0.130	0.130	0.144	0.144	0.034	0.223	U	1.08	0.189	0.144	N/A	0.080	0.080	3.178	N/A	N/A	N/A	0.172	0.147	0.18	U	1.25	0.77	0.969	N/A	2.1	0.14
L100907BES00	8.35	S***	1.15	0.165	0.0754	N/A	0.080	0.080	0.106	0.106	0.042	0.221	U	1.12	0.163	0.125	N/A	0.120	0.120	1.791	N/A	N/A	N/A	0.0888	0.145	0.25	U	1.54	0.786	0.929	N/A	0.9	0.13
L100908BUB00	7.70	B	1.13	0.155	0.06	N/A	0.060	0.060	-0.0179	0.000	0.019	0.224	U	1.13	0.171	0.11	N/A	0.130	0.130	3.372	N/A	N/A	N/A	0.0996	0.128	0.242	U	1.36	0.662	0.834	N/A	1.2	0.12
L100909BUB00	7.70	B	1.16	0.17	0.0716	N/A	0.090	0.090	-0.0236	0.000	0.008	0.229	U	1.1	0.172	0.107	N/A	0.100	0.100	2.421	N/A	N/A	N/A	0.122	0.151	0.243	U	1.02	0.345	0.912	N/A	1.9	0.12
L100910BUB00	7.70	B	1.26	0.197	0.0964	N/A	0.190	0.190	0.0259	0.026	0.094	0.24	U	1.25	0.224	0.0814	N/A	0.250	0.250	1.551	N/A	N/A	N/A	0.167	0.15	0.242	U	0.822	0.417	1.2	U	3.1	0.24
L100911BSS00	7.70	S	1.07	0.149	0.0669	N/A	0.000	0.000	0.053	0.053	0.035	0.232	U	1.14	0.165	0.0683	N/A	0.140	0.140	3.372	N/A	N/A	N/A	0.178	0.122	0.174	N/A	1.91	0.821	0.935	N/A	1.5	0.10
L100912BRS00	12.20	S	0.965	0.141	0.0695	N/A	-0.105	0.000	0.0372	0.037	0.061	0.248	U	1.08	0.167	0.0991	N/A	0.080	0.080	2.421	N/A	N/A	N/A	0.126	0.119	0.174	U	1.53	0.722	0.865	N/A	1.3	0.07
L100913BRS00	9.30	S	1.15	0.162	0.0678	N/A	0.080	0.080	0.0032	0.003	0.006	0.244	U	1.12	0.168	0.102	N/A	0.120	0.120	1.551	N/A	N/A	N/A	0.0834	0.139	0.24	U	0.689	0.322	0.83	U	1.9	0.12
L100914BES00	13.30	S	0.982	0.144	0.0702	N/A	-0.088	0.000	-0.0096	0.000	0.048	0.239	U	1.12	0.158	0.0953	N/A	0.120	0.120	2.643	N/A	N/A	N/A	0.141	0.131	0.216	U	1.34	0.624	0.787	N/A	1.7	0.08
L100915BSS00	8.60	S	1.08	0.148	0.0604	N/A	0.010	0.010	0.0187	0.019	0.05	0.231	U	0.962	0.157	0.0939	N/A	-0.038	0.000	1.980	N/A	N/A	N/A	0.101	0.117	0.171	U	1.43	0.725	0.897	N/A	1.1	0.03
L100916BRS00	13.10	S	0.921	0.13	0.085	N/A	-0.149	0.000	-0.0027	0.000	0.051	0.242	U	1.1	0.183	0.103	N/A	0.100	0.100	1.100	N/A	N/A	N/A	0.0522	0.128	0.214	U	1.32	0.618	0.775	N/A	0.7	0.06
L100917BRS00	12.70	S	1.11	0.158	0.064	N/A	0.040	0.040	0.104	0.104	0.027	0.236	U	0.976	0.189	0.11	N/A	-0.024	0.000	2.581	N/A	N/A	N/A	0.137	0.164	0.215	U	1.34	0.703	0.913	N/A	1.6	0.05
L100918BES00	13.20	S	1.4	0.21	0.0892	N/A	0.330	0.330	0.0511	0.051	0.053	0.248	U	1.06	0.188	0.176	N/A	0.060	0.060	2.566	N/A	N/A	N/A	0.138	0.17	0.275	U	1.12	0.417	1.07	N/A	1.9	0.23
L100919BES00	11.30	S	1.13	0.155	0.0548	N/A	0.060	0.060	0.0184	0.018	0.05	0.249	U	1.13	0.173	0.0791	N/A	0.130	0.130	2.174	N/A	N/A	N/A	0.114	0.137	0.235	U	1.32	0.681	0.868	N/A	1.4	0.12
L100920BSS00	9.00	S	1.16	0.16	0.0665	N/A	0.090	0.090	0.0189	0.019	0.08	0.23	U	1.02	0.155	0.124	N/A	0.020	0.020	1.109	N/A	N/A	N/A	0.055	0.147	0.245	U	1.01	0.333	0.817	N/A	0.9	0.07
L100921BRS00	12.20	S	0.964	0.137	0.0975	N/A	-0.106	0.000	0.0324	0.032	0.041	0.243	U	1.08	0.16	0.0755	N/A	0.080	0.080	2.298	N/A	N/A	N/A	0.122	0.128	0.245	U	1.18	0.685	0.855	N/A	1.6	0.06
L100922BRS00	11.40	S	1.12	0.159	0.0729	N/A	0.050	0.050	0.0078	0.008	0.021	0.242	U	0.986	0.15	0.114	N/A	-0.014	0.000	2.064	N/A	N/A	N/A	0.112	0.14	0.231	U	0.777	0.327	0.998	U	2.2	0.04
L100923BES00	11.90	S	1.14	0.187	0.0991	N/A	0.070	0.070	0.0344	0.034	0.06	0.233	U	1.05	0.211	0.144	N/A	0.050	0.050	1.362	N/A	N/A	N/A	0.0686	0.169	0.283	U	1.11	0.7	0.952	N/A	1.0	0.08
L100922BRQ00	11.40	Q	1.15	0.167	0.0775	N/A	0.080	0.080	0.0072	0.007	0.012	0.241	U	1.05	0.192	0.11	N/A	0.050	0.050	2.557	N/A	N/A	N/A	0.138	0.181	0.251	U	1.06	0.391	0.997	N/A	2.0	0.09
L100924BSS00	8.26	B	1.09	0.147	0.0554	N/A	0.020	0.020	0.0134	0.013	0.049	0.244	U	0.848	0.151	0.0837	N/A	-0.152	0.000	2.977	N/A	N/A	N/A	0.158	0.146	0.228	U	1.53	0.762	0.881	N/A	1.6	0.04
L100925BSS00	8.91	B	0.962	0.138	0.0673	N/A	-0.108	0.000	0.0106	0.011	0.089	0.235	U	1.09	0.165	0.106	N/A	0.090	0.090	1.676	N/A	N/A	N/A	0.0855	0.143	0.227	U	1.3	0.699	0.848	N/A	1.1	0.06
L100926BSS00	7.10	B	0.88	0.14	0.106	N/A	-0.190	0.000	0.0294	0.029	0.05	0.233	U	1.17	0.171	0.0926	N/A	0.170	0.170	3.571	N/A	N/A	N/A	0.197	0.111	0.191	N/A	0.833	0.318	0.825	N/A	3.6	0.11
L100927BSS00	8.00	B	1.36	0.179	0.0614	N/A	0.290	0.290	0.0142	0.014	0.007	0.24	U	1.04	0.167	0.132	N/A	0.040	0.040	3.181	N/A	N/A	N/A	0.173	0.141	0.191	U	1.19	0.59	0.811	N/A	2.3	0.20
L100928BSS00	5.30	B	1.03	0.169	0.087	N/A	-0.040	0.000	-0.0082	0.000	0.011	0.233	U	1.01	0.189	0.124	N/A	0.010	0.010	1.999	N/A	N/A	N/A	0.104	0.169	0.27	U	1.32	0.601	0.81	N/A	1.3	0.03
L100929BSS00	7.70	B	1.1	0.155	0.0664	N/A	0.030	0.030	0.0052	0.005	0.042	0.237	U	1.03	0.156	0.107	N/A	0.030	0.030	2.078	N/A	N/A	N/A	0.106	0.142	0.237	U	1.56	0.691	0.863	N/A	1.1	0.05
L100930BSS00	8.60	B	1.05	0.15	0.0681	N/A	-0.020	0.000	0.0555	0.056	0.072	0.227	U	1.21	0.205	0.102	N/A	0.210	0.210	2.995	N/A	N/A	N/A	0.159	0.133	0.173	U	1.53	0.641	0.811	N/A	1.6	0.13
Systematic Minimum			0.000						0.000					0.000						1.100				0.052				0.689				1.7	0.03
Systematic Maximum			0.330						0.104					0.140						3.372				0.178				1.910				Average Enrichment (%)	0.23
Systematic Mean			0.056						0.029					0.069						2.094				0.110				1.237					0.09
Systematic Median			0.040						0.019					0.080						2.174				0.114				1.320					0.07
Systematic Standard Deviation			0.089						0.029					0.052						0.668				0.037				0.317					0.05
			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.
*** Sample results presented for informational purposes only.
U Qualifier: Result is less than the sample detection limit.
All uncertainty values are reported at the 2-sigma confidence level.

39.2.5 Biased Soil Sample Result LSA 10-09

The highest biased sample collected from LSA 10-09 had a Uniform SOF result of 0.24, collected from sample location L10-09-10-B-U-B-00 and was identified by elevated GWS measurements.

39.2.6 Judgmental/Sidewall Soil Sample for Tc-99 Results LSA 10-09

Seven samples were collected from the sidewalls of LSA 10-09. Table 39-4 provides the data summary for the samples.

Table 39-4
LSA 10-09 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)
L100924BSS00	1.09	0.0134	0.848	2.977	0.158	1.53	0.04
L100925BSS00	0.962	0.0106	1.09	1.676	0.0855	1.3	0.06
L100926BSS00	0.88	0.0294	1.17	3.571	0.197	0.833	0.11
L100927BSS00	1.36	0.0142	1.04	3.181	0.173	1.19	0.20
L100928BSS00	1.03	-0.0082	1.01	1.999	0.104	1.32	0.03
L100929BSS00	1.1	0.0052	1.03	2.078	0.106	1.56	0.05
L100930BSS00	1.05	0.0555	1.21	2.995	0.159	1.53	0.13

39.2.7 Quality Control Soil Sample Result LSA 10-09

Two QC field duplicate sample points was randomly selected for LSA 10-09 which were collected at systematic locations L10-09-04 and L10-09-22.

For the 30 total "regular" samples (i.e., 20 systematic + 3 biased + 7 sidewall) collected within LSA 10-09, two field duplicate sample were collected. This frequency equates to 6.7%, (i.e. 2/30). 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 39-5 below).

Figure 39-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 10-09 (1 of 2)

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

Survey Unit No.: LSA 10-09 — Survey Unit Description: Burial Pits Open Land Area South Eastern Survey Unit in "Area 9"

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						
L100904BES00	L100904BEQ00	Ra-226	1.13	0.0781	1.21	0.0637	1.170	1.9	0.08	0.269	0.403	N
L100904BES00	L100904BEQ00	Tc-99	-0.00796	0.227	0.0159	0.22	0.004	25.1	NA	3.552	5.321	NA
L100904BES00	L100904BEQ00	Th-232	1.24	0.0928	1.19	0.118	1.215	2.0	0.050	0.283	0.424	N
L100904BES00	L100904BEQ00	U-234[1]	1.037	N/A	3.154	N/A	2.095	195.4	2.118	27.649	41.425	N
L100904BES00	L100904BEQ00	U-235	0.0456	0.265	0.169	0.236	0.107	51.6	NA	7.301	10.939	NA
L100904BES00	L100904BEQ00	U-238	1.68	0.896	1.44	0.819	1.560	168.8	0.240	23.885	35.786	N

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

Performed by: Thomas Yardy / [signature] — Reviewed by: W Clark Evans / [signature]

Date: 1-11-17 — Date: 1/11/17

Quality Record

Figure 39-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 10-09 (2 of 2)

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

Survey Unit No.: LSA 10-09 | Survey Unit Description: Burial Pits Open Land Area South Eastern Survey Unit in "Area 9"

Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{x}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L100922BRS00	L100922BRQ00	Ra-226	1.12	0.0729	1.15	0.0775	1.135	1.9	0.03	0.269	0.403	N
L100922BRS00	L100922BRQ00	Tc-99	0.00775	0.242	0.00722	0.241	0.007	25.1	NA	3.552	5.321	NA
L100922BRS00	L100922BRQ00	Th-232	0.986	0.114	1.05	0.11	1.018	2.0	0.064	0.283	0.424	N
L100922BRS00	L100922BRQ00	U-234[1]	2.064	N/A	2.557	N/A	2.311	195.4	0.493	27.649	41.425	N
L100922BRS00	L100922BRQ00	U-235	0.112	0.231	0.138	0.251	0.125	51.6	NA	7.301	10.939	NA
L100922BRS00	L100922BRQ00	U-238	0.777	0.998	1.06	0.997	0.919	168.8	NA	23.885	35.786	NA

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

Performed by: Thomas Yardley / Thomas Yardley

Date: 1-11-17

Reviewed by: W Clark Evans / W Clark Evans

Date: 1/11/17

Quality Record

39.3 Tc-99 Hot Spot Assessment LSA 10-09

During site characterization studies a total of six (6) samples were collected and analyzed for Tc-99 in LSA 10-09. Two of the six (6) samples exceeded a Uniform SOF result of 1.0 prior to remediation, however neither sample was elevated for Tc-99. No samples exceeded the Tc-99 DCGL during FSS. Within LSA 10-09, the maximum sample identified was 0.85 pCi/g, which is below the 25.1 pCi/g limit for the Uniform DCGL.

40.0 ALARA EVALUATION LSA 10-09

All samples collected within LSA 10-09 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 10-09 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.09 for LSA 10-09. The average SOF equates to residual activity contributions from the SU area 2.25 mrem/year for LSA 10-09.

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, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 10-09. Summing the dose contributions together, the total estimated dose for LSA 10-09 is 6.25 mrem/year.

Since the estimated TEDE is below the regulatory release criterion of 25 mrem/year, the conclusion of the ALARA evaluation is that the remediation of LSA 10-09 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 10-09.

41.0 FSS PLAN DEVIATIONS LSA 10-09

41.1 Remedial Actions during FSS

After FSS in LSA 10-09 had begun, and systematic samples L10-09-01 through -07 had been collected, small amounts of plastic debris was identified in the SU. This plastic was determined to be from the barrier that was placed in LSA 10-09 prior to the placement of backfill soil. All backfill soil and plastic sheeting was assumed to have be removed from LSA 10-09 prior to the start of FSS activities, however the presence of the plastic sheeting was contrary to the assumption of the removal of all backfill soil and plastic sheeting. As such, FSS was halted and the first set of systematically collected samples was discounted,

To correct this, the remediation contractor was required to perform additional excavation and civil survey to ensure that the excavation surface of LSA 10-09 was at or below the surface that received temporary backfill. This in turn ensured that all future FSS activities would be performed on native soil and that all plastic sheeting had been removed. A new set of systematically collected samples was prescribed by the revised FSS Plan.

The first set of systematic samples are still presented for informational purposes, however only the second set of systematic samples will be used for the calculation of residual radioactivity and dose for the SU.

41.2 Adjustments to Scan MDC Calculations

As previously stated in Section 37.1.5, adjustments were made to the Scan MDC calculations for instrumentation used for the GWS in LSA 10-09. The Scan MDCs presented in the FSS Plan shown in Table 37-1 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 10-09, 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 10-09 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 41-1 below:

Table 41-1

Revised Scan MDCs for 2" x 2" NaI detector: LSA 10-09

	Scan MDC (Total U)	**$DCGL_W$ (Total U)**	**Scan MDC (Ra-226)**	**$DCGL_W$ (Ra-226)**	**Scan MDC (Th-232)**	**$DCGL_W$ (Th-232)**
LSA 10-09	44.9	93.5	1.32	1.9	0.95	2.0

42.0 DATA QUALITY ASSESSMENT

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

42.1 Data Quality Assessment for LSA 10-09

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 10-09 (see Figure 42-1) provides the following:

- The field and laboratory instruments utilized were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be

operable prior to and after use in accordance with HDP-PR-HP-416 (*Operation of the Ludlum 2221 for Final Status Survey*).

- The calibration of all instruments that were used to measure or analyze data was current at the time of use and the calibrations of the instruments were performed using a NIST traceable source. The instruments used were successfully source checked prior to and after use.
- The systematic samples that were collected (on a random-start triangular grid) and the gamma scan surveys that were conducted were performed in accordance with procedure HDP-PR-FSS-711, *Final Status Surveys and Sampling of Soil and Sediment*.
- All samples sent for analysis at the approved offsite laboratory (TestAmerica) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody*.
- Quality Control sample results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.
- LSA 10-09 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 10-09, 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 10-09, however the WRS Test was still performed for illustrative purposes. Since the test statistic, WR (944) exceeded the critical value (802), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix E.
- A biased soil sample was collected from the location of the highest gamma count rate within the SU, and the result was a 0.24 Uniform SOF.
- The maximum SOF result for all surface samples within LSA 10-09 was 0.24. The maximum SOF result for all subsurface samples within LSA 10-09 was 0.23. The average SOF result for all systematically collected samples within LSA 10-09 was 0.09, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.12.
- No FSS sample result in LSA 10-09 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an EMC or supplemental investigations was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (7) of systematic sample locations actually collected within LSA 10-09. The result of the retrospective power evaluation presented in Table 42-1 for LSA 10-09 indicates that the minimum number of sample locations required (7) for the

WRS Test were equal to the number of sampling locations actually collected within LSA 10-09, however the "optimal" number of sample locations including the + 20% allowance indicates 8 sample locations. Given that 32 samples in total were collected within the LSA, and that the additional 20% allowance is considered optional to ensure adequate power for the test, the results of the retrospective power evaluation are still considered acceptable. Additionally the retrospective power evaluation is only procedurally required when the WRS Test fails, in the case of LSA 10-09 the WRS was not required. 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.

- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures for LSA 10-09 was completed prior to the commencement of backfill operations.

Table 42-1
Retrospective Sample Size Verification for LSA 10-09

Uniform DCGL Criteria Evaluation	
N/2 Value Verification	
Isotope(s)	**SOF (Ra/Tc/Th/Iso U)**
St. Dev.	0.05
$DCGL_{SOF}$	1
LBGR (Mean)	0.09
Shift	0.91
Relative Shift (Δ/σ)	18.02
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS N/2	7
Verification Check	**ADDITIONAL DATA REVIEW REQUIRED**
"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 42-1
Data Evaluation Checklists prepared for LSA 10-09 (page 1 of 2)

Revision: 2 Page G-1 of 2

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

Survey Area: 10 **Description:** Burial Pits Open Land Area
Survey Unit: 09 **Description:** VOC Pit in LSA10-06

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 step 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 ☐
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 (Reference 5.11)	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;

Biased samples included collection of sidewall samples within the confines of the pit. R.N

See page G-2 of this checklist for detail on a field discrepancy that was resolved prior to completion of FSS surveys. R.N

Figure 42-1
Data Evaluation Checklists prepared for LSA 10-09 (page 2 of 2)

Revision: 2 Page G-2 of 2

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

Survey Area: No. 10 **Description:** Burial Pits Open Land Area
Survey Unit: No. 09 **Description:** VOC Pit in LSA 10-06

Discrepancy; Plastic sheeting was discovered on Sept. 24, 2013. A section of plastic approx. 2-3 ft wide was exposed from recent rainfall and erosion. on the west wall of pit. It was determined that this plastic was placed in Fall of 2013 to designate the extent of VOC test pit excavations. This plastic/test pit was missed. FSS was halted and maps (with elevations + depth of excavation) were developed to guide subsequent excavations, (see maps in "5.0 Figures" section of HDP-INST-FSS-LSA10-09, rev.1) Excavations commenced to remove all soils to elevations beyond those documented when the VOC Test Pits were dug.

Corrective Actions Taken; Map "LSA-10-09 VOC Excavation Pit" was used to guide excavations (10-07-13). Excavations were completed and verified to be beyond the elevations of previously dug test pits (see map "VOC Test Pits, LSA-10-09, dated 10-09-2013. FSS isolation was re-established and surveys commenced on 10-18-2013.
END

11. Have the corrective actions resolved the discrepancy with the data? Yes ☒ No ☐
    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 ~~13~~ 11 was "No", then is the affected data still valid? WCC 1/31/17 Yes ☐ No ☐ N/A
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐ N/A WCC 1/31/17
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

Prepared by (HP Staff): Rock Nevenan (Print Name) _____ (Signature) 12-10-13 (Date)

Approved by (RSO): Joseph Guido (Print Name) _____ (Signature) 1/9/14 (Date)

43.0 SURVEILLENCE FOLLOWING FSS

Due to the need to ensure a safe work area the deep excavation of LSA 10-09 was immediately backfilled upon successful completion of FSS. As such, surveillance following FSS was not necessary for LSA 10-09.

44.0 CONCLUSION LSA 10-09

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 10-09 does not to exceed the dose criterion for unrestricted release in accordance with 10 CFR 20.1402 of 25 mrem/year.

Table 44-1
LSA 10-09 SOF and Dose Summation

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

45.0 FINAL STATUS SURVEY DESIGN LSA 10-10

This section describes the method for determining the number of samples required for the FSS of LSA 10-10 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 10-10 and their detection sensitivities are also discussed.

45.1 FSS Plan Design Requirements

FSS Plan requirements for LSA 10-10 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 2, *Final Status Survey Plan Development*, February 2013.

45.1.1 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.*

45.1.2 $DCGL_W$

During the FSS design process a review was performed of the historic characterization data for LSA 10-10. The review identified no areas that were previously found to exceed a Uniform SOF of 1.0 (discussed in Section 3.3.8). Next the remediation history was reviewed 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.

45.1.3 GWS Coverage

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

45.1.4 Instrumentation

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

45.1.5 Scan Minimum Detectable Concentration

As background levels were approximately 10,000 cpm within both LSA 10-10, 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 45-1

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 10-10, the average enrichment for the SU was 86.26%. Note that this estimate of enrichment is conservatively high as the RASS samples used to determine the enrichment were analyzed in the onsite counting laboratory. These low activity samples did not identify U-238 above the MDC of the onsite counting equipment in several of the samples, so a conservatively high U-235 enrichment was assumed. It should also be noted that the average enrichment of the FSS samples when analyzed at the offsite counting laboratory was 1.8%.

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 45-1. Prospectively calculated Scan MDCs for 2" x 2" NaI detectors that were used in LSA 10-10 are shown below:

Table 45-1
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 10-10

	Scan MDC (Total U)	**$DCGL_W$ (Total U)**	**Scan MDC (Ra-226)**	**$DCGL_W$* (Ra-226)**	**Scan MDC (Th-232)**	**$DCGL_W$* (Th-232)**
LSA 10-10	148.8	95.6	2.8	2.8	1.8	3.0

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

The values in Table 46-1 reflect those presented in the FSS Plan prepared for the SU prior to FSS.

45.1.6 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 FSS in LSA 10-10 was performed prior to the development of HDP memorandum, HEM-15-MEMO-021 "*Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*" which established a standard Scan IAL for all Class 1 SU's at the Hematite Site. The IAL used during the GWS of LSA 10-10 was established at 3,357 net counts per minute (ncpm) which was a calculated value equivalent to the expected scan rate for a potential hot spot representing the $DCGL_{EMC}$ for Total Uranium of 330 pCi/g (using a U-235 enrichment of 86%). Given that this Scan IAL is conservative compared to the value of 4,000 ncpm prescribed by the revised HDP FSS program, and that all FSS data is post processed and evaluated as described in FSSFR Volume 3, Chapter 1, Section 6.1.3, the Scan IAL for LSA 10-10 of 3,357 is acceptable.

45.1.7 LSA 10-10 FSS Design Summary

The FSS Plan for LSA 10-10 can be found in Appendix L. Table 45-2 presents an overall FSS design and implementation summary for LSA 10-10.

Table 45-2
FSS Design Summary for LSA 10-10

Gamma Walkover Survey (GWS):		
Scan Coverage	100% accessible excavation floors and walls	
Scan MDC	148.8 pCi/g total Uranium (1,512 ncpm)	
Investigation Action Level (IAL)	3,357 net cpm	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	3	These samples were collected on a systematic grid.
15 cm – 1.5 m (Root)	7	
> 1.5m (Excavation)	5	
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.	Used for GWS and to obtain static count rates at biased measurement locations.	

46.0 FINAL STATUS SURVEY IMPLEMENTATION LSA 10-10

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

46.1 Gamma Walkover Survey

46.1.1 Instrumentation

The selected instrumentation to perform the GWS in LSA 10-10 was a 2" x 2" NaI detector in combination with a Ludlum 2221 rate meter. Each NaI instrumentation set was interfaced with a Trimble DGPS and handheld data logger.

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

46.1.2 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 one (1) GWS measurement per second. Each gross gamma measurement is correlated to a set of coordinates based on the Missouri East State Plane, NAD 1983.

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

HP Technicians performing GWS in LSA 10-10 used the 3,357 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 12,000 gcpm. Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 13,357 to 15,357 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 SU that required biased sample investigation. Areas that were flagged by the HP Technician were considered, as well as a statistical evaluation of the GWS data set. The statistical evaluation determined the mean count rate and standard deviation associated with the GWS and then could be used to identify any areas that exceeded 3 standard deviations above the mean. The number of biased samples to be collected and the locations are based on flagged locations exceeding the IAL, the statistical evaluation of the GWS data set, and the professional judgment of Radiological Engineering.

46.2 Soil Sampling

46.2.1 Systematic Soil Sampling Summary

Table 46-1 provides a summary of systematic sampling by stratum for LSA 10-10.

Table 46-1
Systematic Sampling Summary by Stratum for LSA 10-10

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep (Excavation)	
10-10	1,030	3	7	5	1

46.2.2 Systematic Sampling LSA 10-10

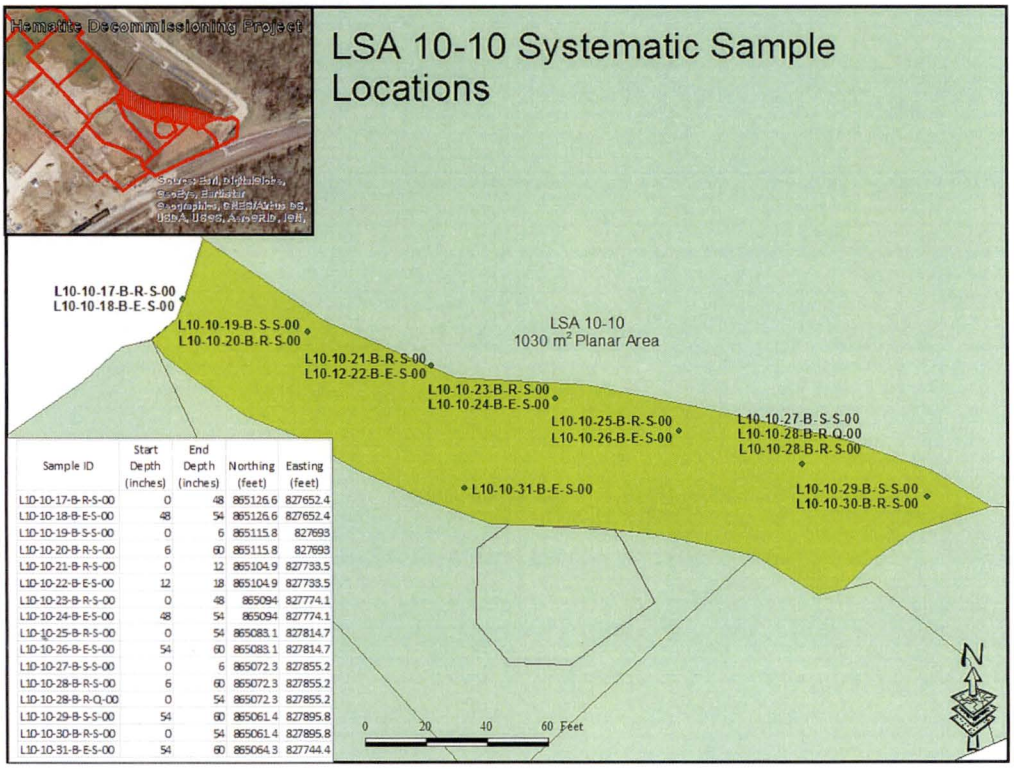
Within LSA 10-10, there were three (3) locations in which portions of the surface stratum (0 – 15 cm) remained in the SU after remediation. Portions of the root stratum (15 cm – 150 cm) remained at seven (7) of the eight systematic locations. At these locations the remaining root stratum interval was collected using a hand auger and composited. Excavation stratum samples were collected at five (5) locations using either hand trowels for six-inch grabs below the existing excavation surface or hand augers where necessary. Given a planar area of 1,030 m^2 for LSA 10-10 and an eight - point systematic triangular grid, the point-to-point distance within each row was 13.23 m.

While there were eight systematic locations on the LSA 10-10 sampling grid, a total of sixteen (16) samples were collected at these locations, including:

- Three (3) samples collected within the remaining surface stratum
- Seven (7) sample collected within the remaining root stratum
- Five (5) samples collected within the excavation, or "deep" stratum
- One (1) QC field replicate

Figure 46-1 presents the map of the nine systematic sample locations which were sampled within LSA 10-10. The inset table in Figure 46-1 notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 46-1
LSA 10-10 Systematic Soil Sample Locations



Sample ID	Start Depth (inches)	End Depth (inches)	Northing (feet)	Easting (feet)
L10-10-17-B-R-S-00	0	48	865126.6	827652.4
L10-10-18-B-E-S-00	48	54	865126.6	827652.4
L10-10-19-B-S-S-00	0	6	865115.8	827693
L10-10-20-B-R-S-00	6	60	865115.8	827693
L10-10-21-B-R-S-00	0	12	865104.9	827733.5
L10-10-22-B-E-S-00	12	18	865104.9	827733.5
L10-10-23-B-R-S-00	0	48	865094	827774.1
L10-10-24-B-E-S-00	48	54	865094	827774.1
L10-10-25-B-R-S-00	0	54	865083.1	827814.7
L10-10-26-B-E-S-00	54	60	865083.1	827814.7
L10-10-27-B-S-S-00	0	6	865072.3	827855.2
L10-10-28-B-R-S-00	6	60	865072.3	827855.2
L10-10-28-B-R-Q-00	0	54	865072.3	827855.2
L10-10-29-B-S-S-00	54	60	865061.4	827895.8
L10-10-30-B-R-S-00	0	54	865061.4	827895.8
L10-10-31-B-E-S-00	54	60	865064.3	827744.4

Table 46-2 below presents a tabular listing of all FSS samples collected within LSA 10-10 with associated IDs, sample types, collection intervals, coordinates, and notes.

Table 46-2
FSS Sample Locations and Coordinates for LSA 10-10

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

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

Survey Area:	LSA 10	**Description:**	Burial Pits Open Land Area
Survey Unit:	10	**Description:**	South Eastern Survey Unit in "Area 9"
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
L101001BRS00	Uniform	S***	423.9	419.9	865127.3	827679.2	Root zone composite
L101002BES00	Uniform	S***	419.9	419.4	865127.3	827679.2	Excavation 6 inch grab
L101003BRS00	Uniform	S***	422	420.5	865114.3	827720.6	Root zone composite
L101005BRS00	Uniform	S***	422.1	421.6	865101.3	827762.0	Root zone composite
L101006BES00	Uniform	S***	421.6	421.1	865101.3	827762.0	Excavation 6 inch grab
L101007BRS00	Uniform	S***	423.8	419.3	865088.2	827803.4	Root zone composite
L101008BES00	Uniform	S***	419.3	418.8	865088.2	827803.4	Excavation 6 inch grab
L101009BSS00	Uniform	S***	424.1	423.6	865075.2	827844.8	Surface 6 inch grab
L101010BRS00	Uniform	S***	423.6	419.1	865075.2	827844.8	Root zone composite
L101011BSS00	Uniform	S***	423.7	423.2	865062.1	827886.2	Surface 6 inch grab
L101011BSQ00	Uniform	Q	423.7	423.2	865062.1	827886.2	Surface 6 inch grab
L101012BRS00	Uniform	S***	423.2	418.7	865062.1	827886.2	Root zone composite
L101013BSS00	Uniform	S***	-	-	865049.1	827927.6	Surface 6 inch grab
L101014BRS00	Uniform	S***	-	-	865049.1	827927.6	Root zone composite
L101015BES00	Uniform	S***	421.5	421.0	865071.9	827730.0	Excavation 6 inch grab
L101016BUB00	Uniform	B	-	-	865077.8	827854.9	Biased 6 inch grab
L101016BUI01	Uniform	I	-	-	865065.7	827897.9	Investigation 6 inch grab
L101016BUI02	Uniform	I	-	-	865082.4	827852.6	Investigation 6 inch grab
L101016BUI03	Uniform	I	-	-	865091.6	827798.3	Investigation 6 inch grab
L101016BUI04	Uniform	I	-	-	865100.6	827721.0	Investigation 6 inch grab
L101017BRS00	Uniform	S	426.0	422.0	865126.6	827652.4	Root zone composite
L101018BES00	Uniform	S	422.0	421.5	865126.6	827652.4	Excavation 6 inch grab
L101019BSS00	Uniform	S	426.3	425.8	865115.8	827693.0	Surface 6 inch grab
L101020BRS00	Uniform	S	425.8	421.3	865115.8	827693.0	Root zone composite
L101021BRS00	Uniform	S	422.9	421.9	865104.9	827733.5	Root zone composite
L101023BRS00	Uniform	S	423.9	419.9	865094.0	827774.1	Root zone composite
L101025BRS00	Uniform	S	424.2	419.7	865083.1	827814.7	Root zone composite
L101026BES00	Uniform	S	419.7	419.2	865083.1	827814.7	Excavation 6 inch grab
L101027BSS00	Uniform	S	424.1	423.6	865072.3	827855.2	Surface 6 inch grab
L101028BRS00	Uniform	S	423.6	419.1	865072.3	827855.2	Root zone composite
L101028BRQ00	Uniform	Q	423.6	419.1	865072.3	827855.2	Root zone composite
L101029BSS00	Uniform	S	423.4	422.9	865061.4	827895.8	Surface 6 inch grab
L101030BRS00	Uniform	S	422.9	418.4	865061.4	827895.8	Root zone composite
L101031BES00	Uniform	S	421.6	421.1	865064.3	827744.4	Excavation 6 inch grab
L101032BUB00	Uniform	B	422.9	418.4	865063.3	827807.6	Biased 6 inch grab
L101033BUB00	Uniform	B	422.9	418.4	865086.1	827809.0	Biased 6 inch grab

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

*Elevations are in feet above mean sea level.
** Missouri - East State Plane Coordinates [North American Datum (NAD) 1983]
*** First round of samples presented for information only
CSM: Three-Layer (Surface-Root-Excavation) or Uniform DCGLs used
Type: Systematic = S, Biased = B; QC =Q; Investigation = I
Quality Record

Note that in Table 46-2 above, some information was errantly not recorded such as sample coordinates and elevations. These sample results are still reported as part of the FSS data set for informational purposes.

Also note that the first set of systematic samples collected prior to halting the initial FSS (see section 3.3.1.1) are being reported for informational purposes, but only the final FSS set of systematic samples will be used to determine the SU residual radioactivity and calculate dose.

46.3 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 10-10 one sample locations was selected within the SU based on the evaluation of the GWS survey data.

Biased location L10-10-16-10-B-U-B-00 represents the maximum GWS measurement encountered within LSA 10-10 and has a Uniform SOF value of 0.34. This is the location where a fuel pellet was discovered during the first performance of FSS field activities. The soil sample results report only the soil sample activity as the fuel pellet was removed from the soil and disposed of as waste. During record retrieval to generate this report the coordinates of this sample location could not be located. However, as required by procedure, it is known that four (4) investigation follow up samples were performed in the immediate vicinity of the biased sample location to bound the area where the fuel pellet was identified. It is therefore presumed that the location of biased sample L10-10-16-10-B-U-B-00 was within the area of soil bounded by the 4 investigation samples. As previously stated, no additional discrete sources of radioactive material were identified, and none of the biased investigation samples exceeded a Uniform SOF of 1.0.

46.4 Judgmental/Sidewall Sampling for Tc-99

During the FSS planning for LSA 10-10, in accordance with procedure HDP-PR-FSS-701, *Final Status Survey Plan Development*, it was determined that sidewall sampling was not necessary for LSA 10-10.

As previously discussed in Section 6.4, Westinghouse and the NRC agreed upon protocol for sidewall sampling for Tc-99 predated the performance of FSS in LSA 10-10. A retrospective review is provided utilizing the criteria of HEM-15-MEMO-039 that demonstrates that Tc-99 sidewall sampling was not required for LSA 10-10 had the agreed upon protocol been in effect at the time of FSS of LSA 10-10.

Figure 3-26, *LSA 10-06, LSA 10-07 and LSA 10-10 Isolated and Prepared for FSS Design*, provides evidence of the results of the inspection for the presence of sidewall areas in LSA 10-10 at the time of FSS. As can be seen by review of Figure 3-9, *LSA 10-10 Depth of Excavation Map*, the SU does not present any sidewalls. Although Figure 3-9 does present a small number of areas in the intervals between 8 and 12 feet, the GPS data of these areas indicate that the actual height of the possible sidewall is 0.82 feet, which is less than the sidewall criteria of 1 foot. As such, had the agreed upon protocol been in effect at the time of FSS of LSA 10-10 sidewall sampling would not have been required.

46.5 Quality Control Soil Sampling

Two QC field duplicate sample points were randomly selected and collected at systematic locations L10-10-11 and L10-10-28 for LSA 10-10.

47.0 FINAL STATUS SURVEY RESULTS LSA 10-10

47.1 Gamma Walkover Survey

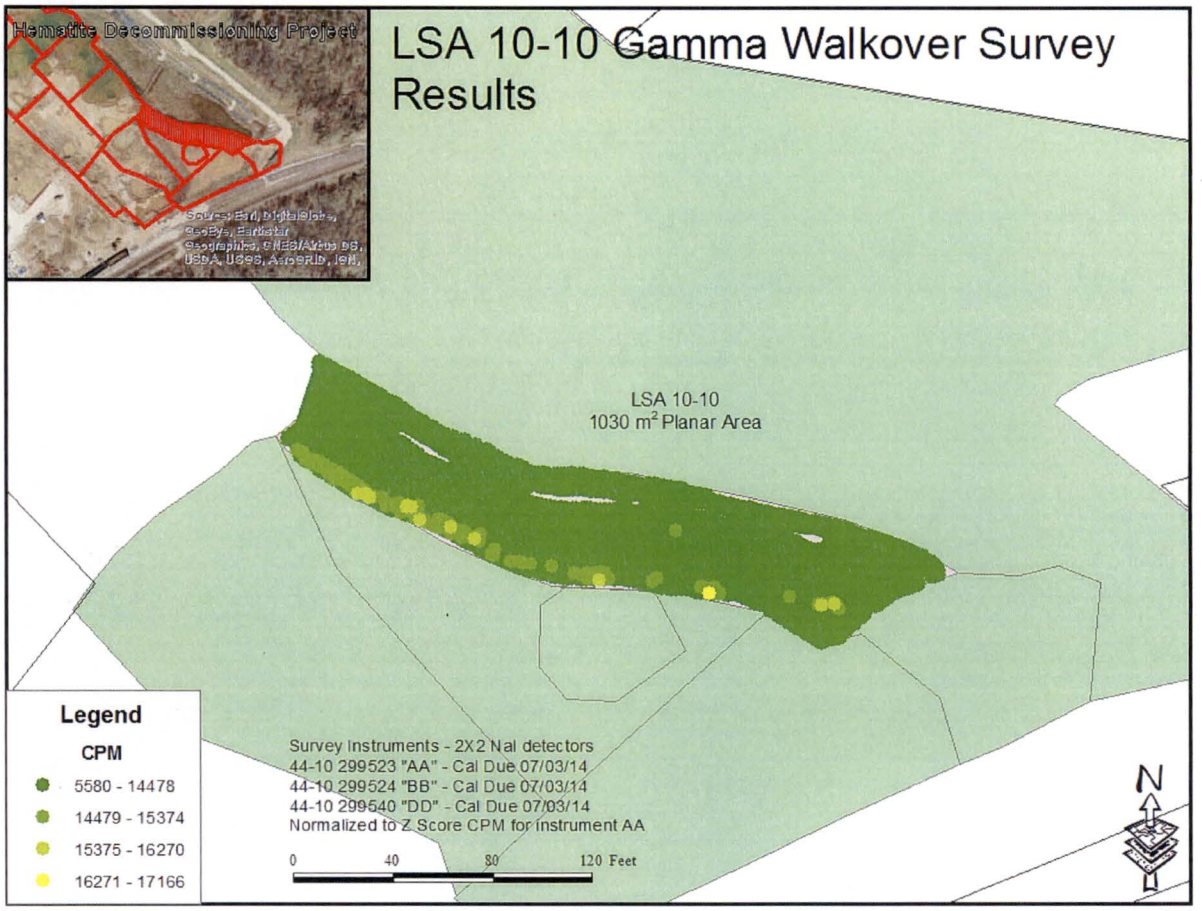
Post-processed GPS coordinate data is accurate to within ± 0.1 m for the handheld GPS models used during the GWS. The GWS maps are plotted and presented in a 2-D format. When multiple data points are collected at the same GPS location during the walkover, the most elevated radiological measurements are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

GWS measurements were collected in LSA 10-10 from December 3, 2013 to January 25, 2014.

47.1.1 GWS Results for LSA 10-10

For LSA 10-10, GWS count rates ranged between 5,580 gcpm and 16,316 gcpm, with a mean count rate of 11,611 gcpm. The median count rate was 11,659 gcpm with a standard deviation of 1160 cpm. Figure 47-1 below presents a map of the complete GWS data set.

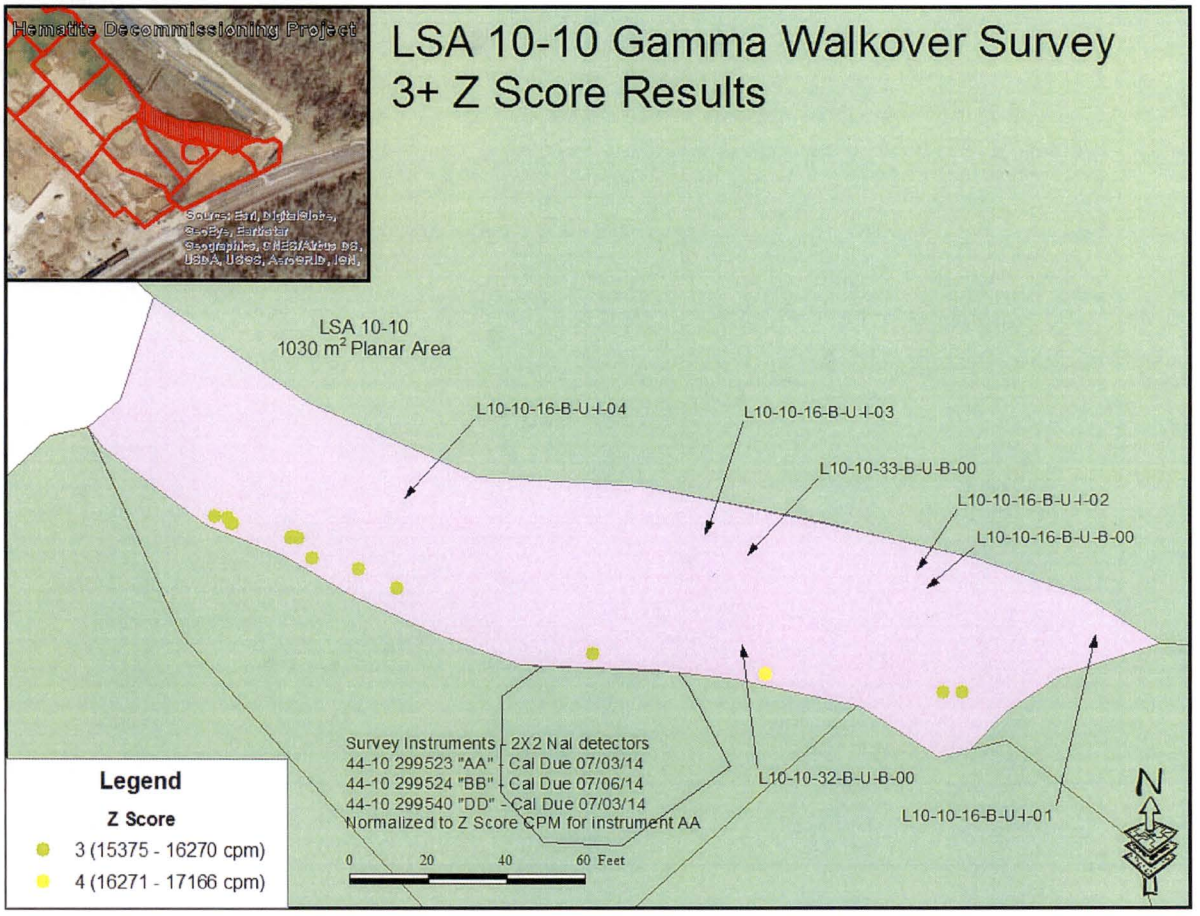
Figure 47-1
Colorimetric GWS Plot for LSA 10-10



An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded both the IAL (> 4000 ncpm) and three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location (L10-10-16) was selected for biased sample collection as described in Section 41.3 above.

Figure 47-2 presents a map of the +3 Z-score GWS measurements within LSA 10-10.

Figure 47-2
Colorimetric GWS Plot for LSA 10-10 (Measurements > Z-score of 3)



Since all GWS data collected in LSA 10-10 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 and a general area background of 12,000 gcpm, a new Scan MDC of approximately 44.9 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 10-10, 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:

$$\text{Scan MDC}_{Total\ Uranium} = \quad 1 \Big/ \left(\left(\frac{0.7928}{4008}\right) + \left(\frac{0.0438}{2.54}\right) + \left(\frac{0.1634}{33.5}\right) \right) = 44.9 \frac{pCi}{g}$$

Equation 47-1

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 1.32 pCi/g and 0.95 pCi/g, respectively using a two inch air gap. A two inch (2") 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.

47.1.2 GWS Coverage Results LSA 10-10

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, very small areas of the LSA 10-10 interior were not accessed by GPS primarily due to limitations in the GPS technology. These areas appear as small pink blanks or "slivers" in the Figure 47-1 above.

The post survey processing of the GPS data indicated that the GWS was 96.03% of the SU (see Table 47-1). 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 47-1
GWS Gap Analysis LSA 10-10

	Total SU Pixels	GWS Gap Pixels	Gap Percentage	GWS Coverage	MARSSIM Class
LSA 10-10	69,091	2,743	3.97%	96.03%	1

47.2 Soil Sample Results LSA 10-10

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

47.2.1 Surface Soil Sample Results LSA 10-10

There were three (3) samples collected within the surface stratum (0 – 15 cm) of LSA 10-10. However, there were a total of fourteen (14) soil samples collected within the topmost soil layer of the excavation surface including eight systematic samples, five biased samples (including four investigation samples), and one QC field duplicate sample. The maximum SOF result for "topmost" samples in LSA 10-10 was 0.34 corresponding to the biased sample L10-10-16-B-U-B-00. The maximum systematic sample SOF result was 0.23 at L10-10-17-B-R-S-00.

47.2.2 Subsurface Soil Sample Results LSA 10-10

There were five (5) systematic locations within LSA 10-10 where subsurface sampling was performed. The root stratum and excavation stratum samples where there was overlying stratum remaining are considered a "subsurface" sample. The maximum SOF result of the subsurface sample collected in LSA 10-10 was 0.39. This sample (L10-10-18) was the excavation stratum sample collected directly underneath the root stratum sample L10-10-17.

47.2.3 WRS Test Evaluation LSA 10-10

Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the WRS statistical test was required for LSA 10-10 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 13 systematically collected samples in LSA 10-10 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, (943) was greater than the critical value (802) 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 F.

47.2.4 Graphical Data Review LSA 10-10

Table 48-2 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 10-10, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.14.

Table 47-2
LSA 10-10 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	0.103	0.147	0.118	2.789	0.141	1.522	**0.14**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	1.353	0.064	0.817	0.03
Maximum	0.410	0.320	0.300	4.312	0.231	2.530	0.39

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.

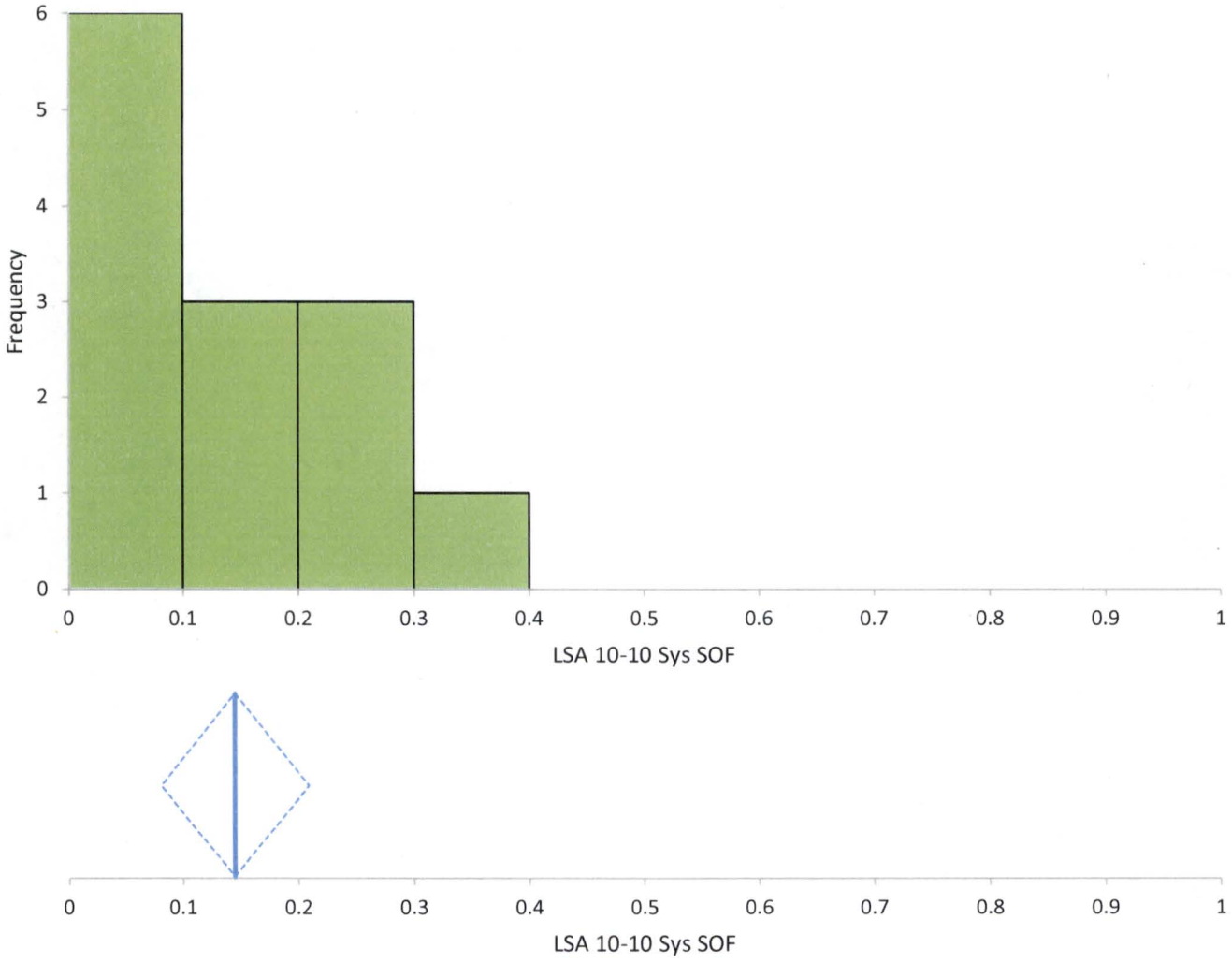
Section 8.2.2.2 of MARSSIM recommends a graphical review of FSS analytical data, to include at a minimum, a posting plot and a histogram. A frequency plot, or histogram, is a useful tool for examining the general shape of a data distribution. This plot is a bar chart of the number of data points within 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 47-3 presents the overall statistical metrics for the SOF parameter for the 13 systematically collected samples from LSA 10-10. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-10. The middle graph presents the mean SOF (0.14) 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 0.08 to 0.21. The 97.75% confidence interval based on the median (0.11) of the sample results is 0.07 to 0.24. The bottom two charts present the various statistical metrics of the LSA 10-10 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 47-3 exhibits no unusual symmetry or bimodality concerns for the LSA 10-10 data associated with the systematically collected measurement locations.

Figure 47-3
Graphic Statistical Summary for LSA 10-10 (SOF parameter)



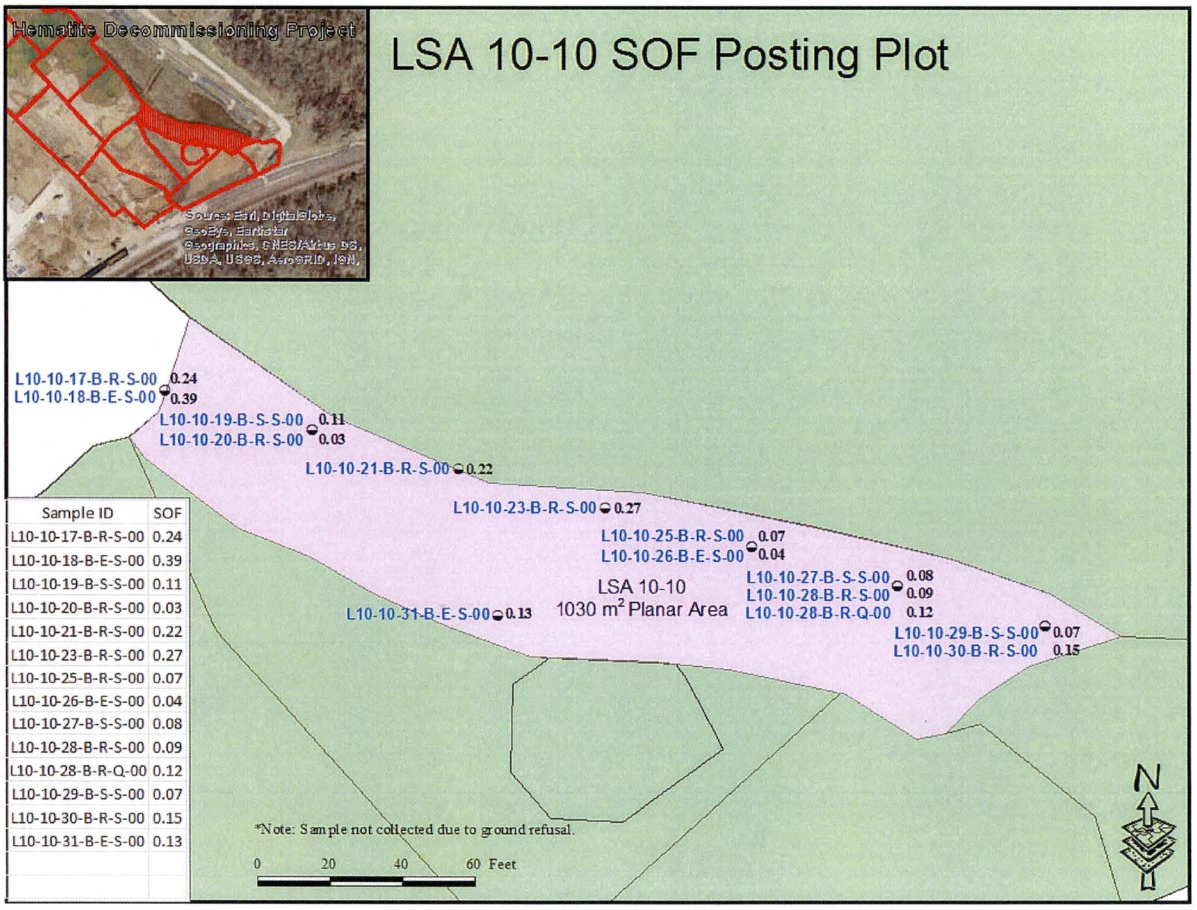
N	13

	Mean	95% CI		Mean SE	SD	Variance	Skewness	Kurtosis
LSA 10-10 Sys SOF	0.14	0.08	to 0.21	0.029	0.11	0.01	1.1	0.80

	Minimum	1st quartile	Median	97.75% CI		3rd quartile	Maximum	IQR
LSA 10-10 Sys SOF	0.03	0.07	0.11	0.07	to 0.24	0.23	0.4	0.16

A posting plot is simply a map of the SU with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 10-10 is presented below in Figure 47-4. Figure 47-4 shows no unusual patterns in the data.

Figure 47-4
Posting Plot for LSA 10-10 Systematic Measurement Locations



Appendix F to this report presents the complete analytical data set (in Microsoft Excel format) used to derive the summary statistics presented in Table 47-2, Figure 47-3, and Figure 47-4 above. A summary of the analytical data is presented in Table 47-3 below. Appendix R to this report presents the Test America Analytical Laboratory soil sample reports.

Table 47-3
Final Status Survey Analytical Data: LSA 10-10

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	TestAmerica Analytical Results																										Enr.	SOF
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238					
			Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF
L101001BRS00	7.12	S*	1.07	0.147	0.0614	N/A	0.000	0.000	0.239	0.239	0.077	0.226	N/A	1.15	0.171	0.117	N/A	0.150	0.150	2.450	N/A	N/A	N/A	0.134	0.168	0.235	U	0.812	0.319	1.04	U	2.6	0.10
L101002BES00	7.62	S*	1.14	0.163	0.0709	N/A	0.070	0.070	0.0714	0.071	0.043	0.224	U	0.991	0.153	0.125	N/A	-0.009	0.000	1.293	N/A	N/A	N/A	0.0667	0.129	0.223	U	0.87	0.333	0.863	N/A	1.2	0.05
L101003BRS00	6.05	S*	1.04	0.168	0.085	N/A	-0.030	0.000	0.381	0.381	0.072	0.226	N/A	1	0.187	0.0949	N/A	0.000	0.000	3.240	N/A	N/A	N/A	0.172	0.133	0.185	U	1.65	0.822	0.95	N/A	1.6	0.04
L101005BRS00	4.20	S*	0.874	0.124	0.0539	N/A	-0.196	0.000	0.444	0.444	0.106	0.227	N/A	0.808	0.123	0.0922	N/A	-0.192	0.000	2.893	N/A	N/A	N/A	0.155	0.0885	0.141	N/A	1.34	0.568	0.71	N/A	1.8	0.04
L101006BES00	4.70	S*	0.693	0.101	0.046	N/A	-0.377	0.000	0.886	0.886	0.193	0.226	N/A	0.704	0.142	0.0786	N/A	-0.296	0.000	0.986	N/A	N/A	N/A	0.0513	0.102	0.171	U	0.638	0.233	0.644	U	1.3	0.05
L101007BRS00	6.23	S*	1.11	0.154	0.0649	N/A	0.040	0.040	0.103	0.103	0.069	0.213	U	1	0.182	0.121	N/A	0.000	0.000	3.098	N/A	N/A	N/A	0.166	0.103	0.159	N/A	1.48	0.711	0.874	N/A	1.8	0.05
L101008BES00	6.73	S*	1.17	0.163	0.0619	N/A	0.100	0.100	-0.0778	0.000	0.042	0.227	U	1.14	0.168	0.0886	N/A	0.140	0.140	1.303	N/A	N/A	N/A	0.0672	0.146	0.245	U	0.906	0.319	0.816	N/A	1.2	0.14
L101009BSS00	1.20	S*	1.04	0.167	0.0848	N/A	-0.030	0.000	0.124	0.124	0.035	0.219	U	1.05	0.175	0.161	N/A	0.050	0.050	2.968	N/A	N/A	N/A	0.159	0.107	0.188	U	1.38	0.796	0.997	N/A	1.8	0.06
L101010BRS00	5.70	S*	1.09	0.162	0.0806	N/A	0.020	0.020	0.0419	0.042	0.071	0.221	U	1.17	0.187	0.106	N/A	0.170	0.170	2.899	N/A	N/A	N/A	0.153	0.132	0.237	U	1.61	0.664	0.848	N/A	1.5	0.12
L101011BSS00	1.49	S*	1.13	0.162	0.073	N/A	0.060	0.060	0.502	0.502	0.094	0.218	N/A	0.938	0.162	0.104	N/A	-0.062	0.000	2.975	N/A	N/A	N/A	0.157	0.123	0.173	U	1.71	0.802	0.962	N/A	1.5	0.08
L101011BSQ00	1.49	Q	1.26	0.194	0.0784	N/A	0.190	0.190	0.381	0.381	0.064	0.221	N/A	1.28	0.223	0.128	N/A	0.280	0.280	2.606	N/A	N/A	N/A	0.139	0.182	0.3	U	1.26	0.438	1.09	N/A	1.7	0.28
L101012BRS00	5.99	S*	1.18	0.163	0.0658	N/A	0.110	0.110	0.0606	0.061	0.088	0.228	U	1.05	0.177	0.0957	N/A	0.050	0.050	1.225	N/A	N/A	N/A	0.0617	0.151	0.251	U	1.02	0.32	0.795	N/A	1.0	0.10
L101013BSS00	-	S*	1.16	0.176	0.0836	N/A	0.090	0.090	0.223	0.223	0.043	0.225	U	1.16	0.177	0.121	N/A	0.160	0.160	3.051	N/A	N/A	N/A	0.16	0.139	0.187	U	1.78	0.632	0.814	N/A	1.4	0.17
L101014BRS00	-	S*	1.12	0.172	0.0809	N/A	0.050	0.050	0.0082	0.008	0.034	0.228	U	1.03	0.175	0.143	N/A	0.030	0.030	1.484	N/A	N/A	N/A	0.0722	0.158	0.281	U	1.51	0.802	0.953	N/A	0.8	0.06
L101015BES00	7.34	S*	1.06	0.144	0.0662	N/A	-0.010	0.000	-0.0083	0.000	0.035	0.238	U	1.23	0.176	0.0881	N/A	0.230	0.230	1.369	N/A	N/A	N/A	0.0629	0.142	0.237	U	1.79	0.74	0.879	N/A	0.6	0.13
L101016BUB00	-	B	1.16	0.175	0.0869	N/A	0.090	0.090	0.379	0.379	0.163	0.237	N/A	1.36	0.202	0.138	N/A	0.360	0.360	11.342	N/A	N/A	N/A	0.612	0.212	0.257	N/A	4.82	1.11	1.15	N/A	2.0	0.34
L101016BUI01	-	I	1.19	0.19	0.0903	N/A	0.120	0.120	0.332	0.332	0.132	0.232	N/A	1.07	0.222	0.165	N/A	0.070	0.070	2.450	N/A	N/A	N/A	0.125	0.11	0.306	U	1.82	0.86	1.05	N/A	1.1	0.14
L101016BUI02	-	I	1.24	0.179	0.0678	N/A	0.170	0.170	0.365	0.365	0.064	0.23	N/A	1.04	0.168	0.0941	N/A	0.040	0.040	3.828	N/A	N/A	N/A	0.209	0.177	0.231	U	1.32	0.415	0.987	N/A	2.5	0.16
L101016BUI03	-	I	1.26	0.204	0.104	N/A	0.190	0.190	0.234	0.234	0.093	0.223	N/A	1.2	0.195	0.171	N/A	0.200	0.200	20.109	N/A	N/A	N/A	1.09	0.286	0.347	N/A	1.8	0.521	1.16	N/A	8.7	0.34
L101016BUI04	-	I	1.25	0.175	0.079	N/A	0.180	0.180	0.292	0.292	0.063	0.231	N/A	1.28	0.187	0.138	N/A	0.280	0.280	4.040	N/A	N/A	N/A	0.222	0.153	0.226	U	1.15	0.362	0.873	N/A	3.0	0.28
L101017BRS00	5.95	S	1.25	0.19	0.0895	N/A	0.180	0.180	0.283	0.283	0.111	0.249	N/A	1.21	0.211	0.118	N/A	0.210	0.210	3.543	N/A	N/A	N/A	0.189	0.178	0.296	U	1.71	0.876	1.06	N/A	1.7	0.24
L101018BES00	6.45	S	1.48	0.201	0.0756	N/A	0.410	0.410	0.0375	0.038	0.034	0.261	U	1.3	0.182	0.137	N/A	0.300	0.300	2.769	N/A	N/A	N/A	0.152	0.162	0.269	U	0.817	0.353	0.936	U	2.9	0.39
L101019BSS00	1.06	S	1.17	0.18	0.0804	N/A	0.100	0.100	0.207	0.207	0.088	0.221	U	1.05	0.184	0.122	N/A	0.050	0.050	3.031	N/A	N/A	N/A	0.16	0.19	0.269	U	1.7	0.936	1.12	N/A	1.5	0.11
L101020BRS00	5.56	S	1.07	0.148	0.0603	N/A	0.000	0.000	0.124	0.124	0.075	0.22	U	1	0.164	0.106	N/A	0.000	0.000	2.558	N/A	N/A	N/A	0.135	0.124	0.208	U	1.42	0.645	0.81	N/A	1.5	0.03
L101021BRS00	4.93	S	1.14	0.26	0.206	N/A	0.070	0.070	0.0495	0.050	0.006	0.229	U	1.3	0.257	0.161	N/A	0.300	0.300	3.479	N/A	N/A	N/A	0.191	0.313	0.504	U	1.03	0.721	2.59	U	2.9	0.22
L101023BRS00	6.13	S	1.32	0.363	0.201	N/A	0.250	0.250	0.32	0.320	0.044	0.225	N/A	1.21	0.505	0.693	N/A	0.210	0.210	1.931	N/A	N/A	N/A	0.0985	0.153	0.892	U	1.39	2.49	4.3	U	1.1	0.27
L101025BRS00	5.90	S	1.16	0.189	0.102	N/A	0.090	0.090	0.0428	0.043	0.039	0.207	U	0.927	0.195	0.14	N/A	-0.073	0.000	1.353	N/A	N/A	N/A	0.0642	0.112	0.286	U	1.6	0.801	1.01	N/A	0.7	0.07
L101026BES00	6.40	S	0.959	0.143	0.0764	N/A	-0.111	0.000	0.0499	0.050	0.067	0.224	U	1.03	0.164	0.0875	N/A	0.030	0.030	2.274	N/A	N/A	N/A	0.116	0.137	0.224	U	1.66	0.707	0.837	N/A	1.1	0.04
L101027BSS00	1.20	S	1.11	0.158	0.0684	N/A	0.040	0.040	0.303	0.303	0.091	0.217	N/A	1.05	0.175	0.133	N/A	0.050	0.050	2.402	N/A	N/A	N/A	0.121	0.14	0.249	U	1.92	0.77	0.887	N/A	1.0	0.08
L101028BRS00	5.70	S	1.09	0.183	0.105	N/A	0.020	0.020	0.283	0.283	0.15	0.217	N/A	1.06	0.221	0.17	N/A	0.060	0.060	3.097	N/A	N/A	N/A	0.156	0.192	0.281	U	2.53	0.96	1.07	N/A	1.0	0.09
L101029BSS00	1.79	S	1.11	0.176	0.0757	N/A	0.040	0.040	0.193	0.193	0.106	0.22	U	0.955	0.164	0.166	N/A	-0.045	0.000	4.312	N/A	N/A	N/A	0.231	0.137	0.235	U	2.07	0.803	1	N/A	1.8	0.07
L101030BRS00	6.29	S	1.2	0.167	0.07	N/A	0.130	0.130	-0.0119	0.000	0.033	0.213	U	1.12	0.172	0.123	N/A	0.120	0.120	2.372	N/A	N/A	N/A	0.0938	0.13	0.224	U	1.06	0.724	0.894	N/A	1.4	0.15
L101031BES00	7.38	S	1.08	0.15	0.0619	N/A	0.010	0.010	0.0173	0.017	0.017	0.228	U	1.2	0.185	0.102	N/A	0.200	0.200	3.133	N/A	N/A	N/A	0.129	0.163	0.258	U	0.883	0.679	1.1	U	2.3	0.13
L101032BUB00	6.29	B	1.19	0.172	0.0695	N/A	0.120	0.120	0.0157	0.016	0.012	0.218	U	1.28	0.21	0.137	N/A	0.280	0.280	4.836	N/A	N/A	N/A	0.17	0.167	0.261	U	1.18	0.576	0.808	N/A	2.2	0.24
L101033BUB00	6.29	B	1.08	0.163	0.0734	N/A	0.010	0.010	0.222	0.222	0.046	0.22	N/A	0.985	0.186	0.133	N/A	-0.015	0.000	1.789	N/A	N/A	N/A	0.263	0.141	0.216	N/A	1.77	0.922	1.07	N/A	2.3	0.04
L101028BRQ00	5.70	Q	1.18	0.174	0.082	N/A	0.110	0.110	0.16	0.160	0.068	0.219	U	1.07	0.181	0.0968	N/A	0.070	0.070	2.254	N/A	N/A	N/A	0.115	0.151	0.253	U	1.73	0.766	0.931	N/A	1.1	0.12
Systematic Minimum			0.000						0.000					0.000						1.353				0.064				0.817				**1.8**	0.03
Systematic Maximum			0.410						0.320					0.300						4.312				0.231				2.530				Average Enrichment (%)	0.39
Systematic Mean			0.103						0.147					0.118						2.789				0.141				1.522					0.14
Systematic Median			0.070						0.124					0.060						2.769				0.135				1.600					0.11
Systematic Standard Deviation			0.118						0.122					0.113						0.768				0.045				0.496					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.

47.2.5 Biased Soil Sample Result LSA 10-10

As described in Section 41.3 above, One biased and four investigation samples were collected within the SU, and had a maximum result of 0.34 Uniform SOF from sample L10-10-16-B-U-B-00 which was identified by GWS and represented the highest gamma measurement identified within the SU.

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

No sidewall sampling was necessary for LSA 10-10.

47.2.7 Quality Control Soil Sample Result LSA 10-10

Two QC field duplicate sample point was randomly selected for LSA 10-10 which were collected at systematic locations L10-10-11 and L10-10-28.

For the 34 samples (i.e., 9 systematic + 3 biased + 2 sidewall) collected within LSA 10-10, two field duplicate samples were collected. This frequency equates to 5.9%, (i.e. 2/34). Form HDP-PR-FSS-703-1 documents that the duplicate sample result comparison with the partner's sample results that all comparison criteria were less than the calculated Warning Limits with one exception (see Figure 47-5 below).

The statistical assessment of the Laboratory QC sample results indicated that one field duplicate sample (L10-10-11-B-S-Q-00) exceeded the calculated Warning Limit for Th-232. In accordance with procedure HDP-PR-FSS-703, when an exceedance occurs an investigation is performed to determine if corrective actions were necessary. The investigation determined that for Th-232 the calculated statistic (0.342) only slightly exceeded the Warning Limit (0.283). Also, considering the low activity and the errors associated with the sample results, the Th-232 activity of both samples were relatively close. Based upon the investigation of the exceedance and the results of previous Quality Assurance audits of the overall performance of the laboratory, no corrective actions were determined to be necessary.

Figure 47-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 10-10 (1 of 2)

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

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

Survey Unit No.: LSA 10-10 — Survey Unit Description: Burial Pits Open Land Area South Eastern Survey Unit in "Area 9"

Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) Activity (x_i)	Sample (pCi/g) MDC	Field Duplicate Sample (pCi/g) Activity (x_i)	Field Duplicate Sample (pCi/g) MDC	Average Activity ($\bar{X}$) (pCi/g)	Nuclide DCGL (pCi/g)	Statistic[2]	Warning Limit	Control Limit	Statistic Exceeds Limit? (Y/N)
L101011BSS00	L101011BSQ00	Ra-226	1.13	0.073	1.26	0.0784	1.195	1.9	0.13	0.269	0.403	N
L101011BSS00	L101011BSQ00	Tc-99	0.502	0.218	0.381	0.221	0.442	25.1	0.121	3.552	5.321	N
L101011BSS00	L101011BSQ00	Th-232	0.938	0.104	1.28	0.128	1.109	2.0	0.342	0.283	0.424	Y
L101011BSS00	L101011BSQ00	U-234[1]	2.975	NA	2.606	NA	2.790	195.4	0.369	27.649	41.425	N
L101011BSS00	L101011BSQ00	U-235	0.157	0.173	0.139	0.3	0.148	51.6	NA	7.301	10.939	NA
L101011BSS00	L101011BSQ00	U-238	1.71	0.962	1.26	1.09	1.485	168.8	0.450	23.885	35.786	N

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

Performed by: Thomas Yardy / [signature] Date: 1-11-17

Reviewed by: W. Clark Ervin / [signature] Date: 1/11/17

Quality Record

Figure 47-5
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment LSA 10-10 (2 of 2)

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

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

Survey Unit No.:	LSA 10-10				Survey Unit Description:		Burial Pits Open Land Area South Eastern Survey Unit in "Area 9"					
			Sample (pCi/g)		Field Duplicate Sample (pCi/g)		Average Activity ($\bar{X}$)	Nuclide DCGL				Statistic Exceeds Limit?
Sample ID	Field Duplicate Sample ID	Radionuclide	Activity (x_i)	MDC	Activity (x_i)	MDC	(pCi/g)	(pCi/g)	Statistic[2]	Warning Limit	Control Limit	(Y/N)
L101028BRS00	L101028BRQ00	Ra-226	1.11	0.0757	1.2	0.07	1.155	1.9	0.09	0.269	0.403	N
L101028BRS00	L101028BRQ00	Tc-99	0.193	0.22	-0.0119	0.213	0.091	25.1	NA	3.552	5.321	NA
L101028BRS00	L101028BRQ00	Th-232	0.955	0.166	1.12	0.123	1.038	2.0	0.165	0.283	0.424	N
L101028BRS00	L101028BRQ00	U-234[1]	4.312	NA	1.789	NA	3.050	195.4	2.523	27.649	41.425	N
L101028BRS00	L101028BRQ00	U-235	0.231	0.235	0.0938	0.224	0.162	51.6	NA	7.301	10.939	NA
L101028BRS00	L101028BRQ00	U-238	2.07	1	1.06	0.894	1.565	168.8	1.010	23.885	35.786	N

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

Performed by: Thomas Yardy / Thomas Yardy

Date: 1-11-17

Reviewed by: W. Clark Cross / W. Clark Cross

Date: 1/11/17

Quality Record

47.3 Tc-99 Hot Spot Assessment LSA 10-10

During site characterization studies a total of 10 samples were collected and analyzed for Tc-99 in LSA 10-10. None of the ten characterization sample results exceeded the Uniform DCGL of 25.1 pCi/g for Tc-99 or a Uniform SOF of 1.0 prior to remediation. No samples exceeded the Tc-99 DCGL during FSS. Within LSA 10-10, the maximum sample identified was 0.32 pCi/g, which is below the 25.1 pCi/g limit for the Uniform DCGL.

48.0 ALARA EVALUATION LSA 10-10

All samples collected within LSA 10-10 were evaluated against the Uniform Stratum $DCGL_W$. For LSA 10-10 no sample result exceeded a SOF of 1.0. The average SOF result, based on all systematically collected samples, was 0.14 for LSA 10-10. The average SOF equates to residual activity contributions from the SU area of 3.5 mrem/year for LSA 10-10.

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, a maximum groundwater contribution assumption of 4.0 mrem/year based upon the EPA MCLs will be added to the total estimated dose for LSA 10-10. Summing the dose contributions together, the total estimated dose for LSA 10-10 is 7.5 mrem/year.

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

49.0 FSS PLAN DEVIATIONS LSA 10-10

49.1 Remedial Actions during FSS

As discussed in section 3.3.1.1, after the initial FSS was halted and the remediation contractor was directed to recommence remediation in LSA 10-10. Upon completion of remediation and revision of the FSS Plan for LSA 10-10 FSS was implemented. There for no remedial actions generated during the final FSS.

49.2 Adjustments to Scan MDC Calculations

As previously stated in Section 45.1.5, adjustments were made to the Scan MDC calculations for instrumentation used for the GWS in LSA 10-10. The Scan MDCs presented in the FSS Plan shown in Table 45-1 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 10-10, 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 10-10 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 49-1 below.

Table 49-1

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

	Scan MDC (Total U)	**$DCGL_W$ (Total U)**	**Scan MDC (Ra-226)**	**$DCGL_W$ (Ra-226)**	**Scan MDC (Th-232)**	**$DCGL_W$ (Th-232)**
LSA 10-10	44.9	95.6	1.32	1.9	0.95	2.0

50.0 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.

50.1 Data Quality Assessment for LSA 10-10

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 10-10 (see Figure 50-1) 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 10-10 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 10-10, 1 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 required for LSA 10-10. Since the test statistic, WR (802) exceeded the critical value (943), the FSS data set passed the WRS Test and the null hypothesis was rejected. The WRS Test worksheet is presented in Appendix F.
- The maximum SOF result for all surface samples within LSA 10-10 was 0.34. The maximum SOF result for all subsurface samples within LSA 10-10 was 0.39. The average SOF result for all systematically collected samples within LSA 10-10 was 0.14, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.20.
- No FSS sample result in LSA 10-10 exceeded a SOF of 1.0 as compared to the Uniform Stratum criteria, therefore an EMC or supplemental investigations was not required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.
- A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (8) of systematic sample locations actually collected within LSA 10-10. The successful result of the retrospective power evaluation presented in Table 50-1 for LSA 10-10 indicates that the minimum number of sample locations required (8) for the WRS Test was equal the number of sampling locations actually collected within LSA 10-10. 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.
- HDP staff ensured that a visual inspection of the SU configuration and of the Isolation & Control measures for LSA 10-10 was completed prior to the commencement of backfill operations.

Table 50-1
Retrospective Sample Size Verification for LSA 10-10

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)	0.14
Shift	0.86
Relative Shift (Δ/σ)	8.07
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
N/2	8
FSS N/2	8
Verification Check	**SUFFICIENT MEASUREMENTS**
"N/2" Corresponds to the number of survey unit measurement locations required for the WRS Test	

MARSSIM Table 5.1

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

MARSSIM Table 5.2, α = 0.05, β = 0.10

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

Figure 50-1
Data Evaluation Checklists prepared for LSA 10-10 (page 1 of 2)

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

Survey Area: 10 **Description:** Burial Pit Open Land Area
Survey Unit: 10 **Description:** Eastern Extent of Excavation-South Burial Pit

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 step 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 ☐
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 (Reference 5.11)	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.

Ludlum 2221 meters AA (299523), DD (299540), EE (299553) and G (234985) were used to conduct the FSS scanning in LSA-10-10. Ludlum 2360 O (297733) was used for non-soil survey. All QC measurements were within specification. While within specification, all pre and post QC checks measure above the mean for meters AA and DD. The QC charts were reviewed for all meters and no indication of the meters drifting out of the acceptable range was identified.
***The data used for the QC sample analysis was preliminary onsite gamma spec results. The QC sample analysis will be performed using the offsite gamma spec data after it is received.**
* Warning Limit Exceeded for Th-232, but results still acceptable per review by RSO WEE 1/4/17

Figure 50-1
Data Evaluation Checklists prepared for LSA 10-10 (page 2 of 2)

Revision: 2 Page G-2 of 2

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

Survey Area: No. 10 **Description:** Burial Pit Open Land Area
Survey Unit: No. 10 **Description:** Eastern Extent of Excavation-South Burial pit

Discrepancy; None

Corrective Actions Taken; None

11. Have the corrective actions resolved the discrepancy with the data? Yes ☐ No ☐
    a. If "No", then forward this form to the RSO. N/A
12. The following questions will be answered by the RSO.
    a. If the answer to question 13 was "No", then is the affected data still valid? Yes ☐ No ☐
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? Yes ☐ No ☐
    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):	Scott Jenkins		2/18/14
Approved by (RSO):	Joseph Guido		2/18/14

51.0 SURVIELLENCE FOLLOWING FSS

FSS of SU LSA 10-10 was completed on January 25, 2014 as well as FSS of adjacent SUs LSA 10-05 (January 19, 2014), LSA 10-06 (November 18, 2013) LSA 10-07 (November 25, 2013) and LSA 10-10 (January 25, 2013). Adjacent SU LSA 11-01 is a Class 2 survey area and does not present radioactive materials (waste) that could have possibly transported into LSA 10-10. As such, the radiological status of all of the SUs adjacent to LSA 10-10 did not present a possibility of recontamination of LSA 10-10 as a consequence of a storm event.

52.0 CONCLUSION LSA 10-10

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

Table 52-1
LSA 10-10 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.14	N/A	0.16	N/A	N/A	**0.30**
DOSE	3.5 mrem/year	N/A	4.0 mrem/year	N/A	N/A	**7.5 mrem/year**

53.0 REFERENCES

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

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

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

53.4 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}

53.5 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)

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

54.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A: Analytical Data Evaluation Spreadsheets for LSA 10-05

APPENDIX B: Analytical Data Evaluation Spreadsheets for LSA 10-06

APPENDIX C: Analytical Data Evaluation Spreadsheets for LSA 10-07

APPENDIX D: Analytical Data Evaluation Spreadsheets for LSA 10-08

APPENDIX E: Analytical Data Evaluation Spreadsheets for LSA 10-09

APPENDIX F: Analytical Data Evaluation Spreadsheets for LSA 10-10

APPENDIX G: FSS Plan Development for LSA 10-05

APPENDIX H: FSS Plan Development for LSA 10-06

APPENDIX I: FSS Plan Development for LSA 10-07

APPENDIX J: FSS Plan Development for LSA 10-08

APPENDIX K: FSS Plan Development for LSA 10-09

APPENDIX L: FSS Plan Development for LSA 10-10

APPENDIX M: TestAmerica Laboratory Analytical Data Reports for LSA 10-05

APPENDIX N: TestAmerica Laboratory Analytical Data Reports for LSA 10-06

APPENDIX O: TestAmerica Laboratory Analytical Data Reports for LSA 10-07

APPENDIX P: TestAmerica Laboratory Analytical Data Reports for LSA 10-08

APPENDIX Q: TestAmerica Laboratory Analytical Data Reports for LSA 10-09

APPENDIX R: TestAmerica Laboratory Analytical Data Reports for LSA 10-10

APPENDIX S:	Completed Field Logs (Appendix P-6 from HDP-PR-FSS-701)
APPENDIX T:	HDP-RPT-FSS-303, Summary Report for Burial Pit Area Remediation
APPENDIX U:	Manual GWS Surveys of LSA 10-05 Sidewalls
APPENDIX V:	LSA 10-05 Surveillance Following FSS
APPENDIX W:	Manual GWS Surveys of LSA 10-07 Sidewalls
APPENDIX X:	Manual GWS Surveys of LSA 10-09 Sidewalls