Westinghouse

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Our ref: HEM-15-52
Date: May 29, 2015

Subject: Westinghouse Hematite Decommissioning Project – Submittal of Technical Report HDP-RPT-FSS-202, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02 (LSA 10-01 and LSA 10-02) in Support of Hematite Decommissioning Project License Termination (License No. SNM-00033, Docket No. 070-00036)

Reference: 1) NRC (McConnell) letter dated October 13, 2011, to Westinghouse (Hackmann) titled "U.S. Nuclear Regulatory Commission Approval of: (1) Westinghouse Hematite Decommissioning Plan, (2) Revised License Application, (3) Exemption From the Requirements of 10 CFR 70.24 and 70.22(a)(4), and Issuance of Hematite License Amendment 57"

Dear Sirs:

The purpose of this letter is for Westinghouse Electric Company LLC (Westinghouse) to provide the Technical Report, HDP-RPT-FSS-202, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02 (LSA 10-01 and LSA 10-02), to the U.S. Nuclear Regulatory Commission (NRC) for review.

In Reference 1, the NRC approved the Westinghouse Hematite Decommissioning Plan (DP). As described in Chapter 14 of the DP, submittal of Final Status Survey Area Release Records will be conducted in a phased approach by providing a survey unit area release record or a collection of survey units in an area release record for NRC review. Attachment 1 contains Technical Report, HDP-RPT-FSS-202, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02 (LSA 10-01 and LSA 10-02).

Following the completion of decommissioning activities and Final Status Survey of all survey units, Westinghouse will provide the NRC with a Final Status Survey Final Report which will be accompanied by the request for termination of NRC License SNM-33.

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

NMSS01

Sincerely,

Gay M. Fussell
Deputy Director,
Hematite Decommissioning Project

Attachments: 1) HDP-RPT-FSS-202, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02 (LSA 10-01 and LSA 10-02), with CD containing Appendices to HDP-RPT-FSS-202

cc: J. W. Smetanka, Westinghouse
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Attachment 1

HDP-RPT-FSS-202, Survey Area Release Record for Land Survey Area 10, Survey Units 01 and 02 (LSA 10-01 and LSA 10-02), with CD containing Appendices to HDP-RPT-FSS-202

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Hematite Decommissioning Project

Technical Report

NUMBER: HDP-RPT-FSS-202

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

REVISION: 0

Approvals:

Author:	Brian A. Miller	5/29/2015 Date
Reviewed By:	Andrew J. Lombardo, CHP	5/29/2015 Date
Owner/Manager:	W. Clark Evers	5/29/15 Date

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LIST OF ACRONYMS AND SYMBOLS

AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
AMSL	above mean sea level
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
FSSP	Final Status Survey Plan
FSSFR	Final Status Survey Final Report
gcpm	gross count(s) per minute
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HDP	Hematite Decommissioning Project
HP	Health Physics
HRCR	Hematite Radiological Characterization Report
I & C	Isolation and Control
IAL	Investigation Action Level
LSA	Land Survey Area
m	meter(s)
m^2	square meter(s)
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MCL	Maximum Concentration Limit
MDC	Minimum Detectable Concentration
mrem	Milliroentgen Equivalent Man
NAD	North American Datum
NaI	Sodium Iodide
ncpm	net count(s) per minute
NCS	Nuclear Criticality Safety
NRC	U.S. Nuclear Regulatory Commission
pCi/g	picocurie(s) per gram
QC	Quality Control

Ra	Radium
RASS	Remedial Action Support Survey
ROC	Radionuclides of Concern
RSO	Radiation Safety Officer
SEA	Surrogate Evaluation Area
SNM	Special Nuclear Material
SOF	Sum of Fractions
SU	Survey Unit
Tc	Technetium
TEDE	Total Effective Dose Equivalent
Th	Thorium
U	Uranium
UF_6	Uranium Hexafluoride
WRS	Wilcoxon Rank Sum
yr	year

Executive Summary

This report presents the results of the final status radiological surveys of the Hematite Decommissioning Project (HDP) Land Survey Area (LSA) 10, Survey Unit (SU) 01 (LSA 10-01) and SU 02 (LSA 10-02). In the Final Status Survey Final Report (FSSFR)[1] that will be submitted to support the request for termination of License SNM-33, the exposure results of this report will be combined with the dose attributed to groundwater and the dose attributed to reuse soil (if used to backfill the SUs) 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." This report will be incorporated as Attachment 1 of the HDP FSSFR.

As stated in the HDP DO-08-004, *Hematite Decommissioning Plan* (DP)[2] [Westinghouse 2009] (Reference 7.1), the goal of the decommissioning project is to release the facility for unrestricted use in compliance with the requirements of U.S. Nuclear Regulatory Commission (NRC) 10 Code of Federal Regulations (CFR) 20 Subpart E. The principal requirement is that the dose to future site occupants will be less than 25 millirem/year. Subpart E also requires that residual contamination be reduced to levels as low as reasonably achievable (ALARA). Applicable to Final Status Survey (FSS) of the HDP, multiple radionuclide Derived Concentration Guideline Levels (DCGLs) have been established for site soils and are presented in Attachment 4 of Westinghouse letter HEM-11-96. The principal radionuclides that may be present as residual soil contamination are Uranium (U)-234, U-235, U-238, Radium (Ra)-226, Thorium (Th)-232, and Technetium (Tc)-99. The DCGLs used for these radionuclides of concern (ROC) depend upon the Conceptual Site Model(s) (CSM) selected for evaluation of FSS results.

For LSAs, analytical results are conservatively evaluated against the Uniform Stratum CSM. This CSM assumes residual radioactivity is uniformly distributed over the entire depth profile from ground surface to 6.7 meter (m) below ground surface (bgs). However, all systematic locations are sampled according to the "Three-Layer" (multi-CSM) approach. In other words, if multiple soil strata are present at a given systematic location, samples are collected from each of the remaining strata. Collection of FSS samples using this "Three-Layer" approach allows for an alternate option for evaluating FSS results if compliance with the Uniform Stratum DCGLs is not achievable. Should evaluation of FSS data using the "Three-Layer" approach become necessary, sample results must be grouped by stratum, or CSM. Each stratum has a different set of DCGLs based on the relative risk determined through exposure pathway modeling of the Resident Farmer scenario.

Both LSA 10-01 and LSA 10-02 were initially designated Class 1 SUs as presented in Table 14-16 of the DP. The Class 1 designation for both SUs remained in effect throughout FSS. For both SUs, evaluation of analytical results against the DCGLs for the Uniform Stratum CSM was the selected approach. Application of the Uniform Stratum release criteria is the more

[1] The HDP Final Status Survey Final Report (FSSFR) comprises the report main body and several attachments. The attachments present survey results for individual buildings and open land areas. The entire FSSFR will provide the basis for requesting termination of the U.S. Nuclear Regulatory Commission (NRC) Special Nuclear Materials (SNM) License No. SNM-33 in accordance with 10 CFR 50.82 (b) (6).

[2] The DP is comprised of the Hematite Decommissioning Plan as submitted in Westinghouse letter HEM-09-94 and letters HEM-11-56, HEM-11-96, HEM-12-158, HEM-13-10, HEM-13-69 and Westinghouse letters containing responses to Requests for Additional Information.

Straight forward and conservative of the two evaluation approaches to FSS data collected within LSAs.

The primary objective of the FSS for both SUs was to obtain measurement results, analytical data, and other supporting information in order to demonstrate that the residual radioactivity levels in the LSA 10-01 and LSA 10-02 survey units are below the applicable Uniform Stratum DCGLs and that the land area formerly occupied by these SUs meets the criteria for unrestricted release. Additionally, data collected during the FSS may be used to show that residual radioactivity has been reduced to levels that are consistent with the ALARA requirement.

1.0 INTRODUCTION

The sections of this report discuss the physical, historical, and operational aspects of the LSA, and the operational and technical approaches employed to decommission the area and demonstrate acceptability for unrestricted release of SUs LSA 10-01 and LSA 10-02.

Section 2.0 provides an overview and description of the Data Quality Objectives (DQO) process utilized during the FSS of LSA 10-01 and LSA 10-02.

Section 3.0 provides a description of the LSA. This includes the location, layout, relation to other HDP buildings and facilities, design, construction, modifications, configuration for the FSS, and scope of the FSS.

Section 4.0 presents a brief history of operations pertaining to the HDP. A chronology of significant milestones is followed by history of operations with radioactive materials. Post shutdown and decommissioning activities are summarized. Results of radiological characterization surveys in support of decommissioning are presented.

Section 5.0 presents the FSS design for the LSA. This section includes applicable FSS Plan requirements, the breakdown of the survey units, and the assignment of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) classifications. The survey design approach, instrumentation, and measurement sensitivities are described.

Section 6.0 presents the FSS results. This section includes a summary of the FSS measurements performed in the survey unit, comparison to the DCGLs, tests performed and an evaluation of residual contamination levels relative to the ALARA criterion.

Section 7.0 lists the reference documents used in the preparation of this report.

Section 8.0 lists the Appendices ("A" through "M") which document supporting information pertinent to the FSS of LSA 10-01 and LSA 10-02. These files are located on the data disc (CD-ROM) companion to this report.

2.0 DATA QUALITY OBJECTIVES

The DQO process is thoroughly integrated within the DP and Hematite FSS procedures. The steps of the DQO process are most explicitly detailed in Section 9 of FSS procedure HDP-PO-FSS-700 *Final Status Survey Program* 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.

1. **State the Problem** (DP 14.4.2.1.1; HDP-PO-FSS-700 Section 9.1)
   The problem is the presence of residual radioactive material associated with previous licensed activities at HDP.

2. **Identify the Decision** (DP 14.4.2.1.2; HDP-PO-FSS-700 Section 9.2)
   For the FSS, the principal study question is "Is residual radioactive contamination in the survey unit present in quantities which exceed the established DCGLw values?" The FSS Program will be used to demonstrate that the HDP site meets the criteria for unrestricted release specified in 10 CFR 20.1402 of 25 millirem/year total effective dose equivalent (TEDE). Compliance with the release criteria will be satisfied using the guidance in MARSSIM. Section 9.2 provides a discussion on the DCGLs, Unity Rule, Area Factors, and Background Measurements needed in order to make the decision relevant to the question "Does the survey unit meet the criteria for release?"

3. **Identify Inputs to the Decision** (DP 14.4.2.1.3; HDP-PO-FSS-700 Section 9.3)
   Guidance provided in MARSSIM is the basis for this FSS Program. Inputs include sources of historical information, results of field and laboratory measurements, limitations on detectability, and the acceptable risk of a decision error. These inputs will be provided in each survey area release record. Survey Area Release Records are generated in accordance with HDP-PR-FSS-722 *Final Status Survey Reporting*.

4. **Define the Study Boundaries** (DP 14.4.2.1.4; HDP-PO-FSS-700 Section 9.4)
   For the HDP FSS, the study boundaries include the impacted buildings and systems to remain, and the impacted soil areas of the site to sample depths based on characterization data. Subsections of Section 9.4 go on to discuss the initial site designation, survey units, and their classifications. The boundaries for each individual survey unit are then identified and described in the FSS Plan for the survey unit and in the Survey Area Release Record.

5. **Develop a Decision Rule** (DP 14.4.2.1.5; HDP-PO-FSS-700 Section 9.5)
   The decision rule is the determination of whether residual radioactivity exceeds the established $DCGL_W$ values. If the SOF is less than, or equal to any applicable action limit and unity (1), then no additional investigation is required and the survey unit will be recommended for unrestricted release. If the SOF is greater than unity (1), then the Radiation Safety Officer (RSO) will be consulted to determine the appropriate action(s). Potential actions include re-classification, additional data collection, and additional remediation. To implement the decision rule, HDP-PR-FSS-721, *Final Status Survey Data Evaluation* (Reference 7.8) Section 8.4 provides the information necessary to calculate the sum-of-fractions. To ensure the DQO process has been properly implemented, a checklist is provided in HDP-PR-FSS-721, Appendix G-1, *Final Status*

Survey Data Quality Objectives Checklist. The checklists have been completed for each survey unit and are presented in Section 6.8.4. Also, Section 1.0 of HDP-PR-FSS-721 states the following: "The purpose of this procedure is to provide guidance to interpret survey results using the Data Quality Assessment (DQA) process during the assessment phase of Final Status Survey (FSS) activities in support of the Hematite Decommissioning Project (HDP)."

6. **Specify Limits on Decision Errors** (DP 14.4.2.1.6; HDP-PO-FSS-700 Section 9.6)
The probability of making decision errors is established as part of the DQO process in establishing performance goals for the data collection design and can be controlled by adopting a scientific approach through hypothesis testing. In this approach, the survey results will be used to select between the null hypothesis or the alternate condition (alternate hypothesis) as defined and shown below:

   - Null Hypothesis (H_0) – the survey unit does not meet the release criterion; or,
   - Alternate Hypothesis (H_a) – the survey unit does meet the release criterion.

   A Type 1 decision error (α) would result in the release of a survey unit containing residual radioactivity above the release criterion, or false negative. This occurs when the null hypothesis is rejected when in fact it is true. The α value will always be set at 0.05 unless prior NRC approval is granted for using a less restrictive value.

   A Type II decision error (β) would result in the failure to release a survey unit when the residual radioactivity is below the release criterion, or false positive. This occurs when the null hypothesis is accepted when it is in fact not true. The β value is nominally set at 0.10, but may be modified, as necessary, after weighing the resulting change in the number of required sampling and measurement locations against the risk of unnecessarily investigating and/or remediating survey units that are truly below the release criterion.

7. **Optimize the Design for Obtaining Data** (DP 14.4.2.1.7; HDP-PO-FSS-700 Section 9.7)
Section 9.7 states "The results of characterization and/or Remedial Action Support Surveys (RASS) will be evaluated and used to optimize the FSS design and ensure the DQOs are met. The RASS data and/or characterization data may include gamma scans, surface scanning surveys (alpha + beta), soil sampling, and surface activity measurements in impacted soil areas and SSCs. This data will be evaluated and used to refine the scope of field activities to optimize implementation of the FSS design and ensure the DQOs are met." HDP-PR-FSS-701 *Final Status Survey Plan Development* (Reference 7.5) provides the instructions to evaluate the data and refine the scope of field activities. This is accomplished in concert with HDP-PR-HP-601 *Remedial Action Support Surveys*.

3.0 HDP SITE AND LSA DESCRIPTION

A brief description of the site provides information on the LSA location and function relative to the HDP. The LSA is described, including as-built and final configuration for the FSS.

3.1 HDP Site Description

The total area of the HDP site is 228 acres and is located in Jefferson County, Missouri, approximately five miles southwest of the city of Festus, Missouri. The Central Tract, the area of the site where operational activities were historically conducted, comprises approximately 10 acres and features buildings and structures currently utilized for office space and to house equipment and materials used to support decommissioning activities. The controlled access portion of the site is bounded on the north by State Road P, on the west by the Site Creek/Pond, by the Northeast Site Creek to the east, and the Union Pacific railroad to the south. The highest elevation on the owned property is approximately 560 ft above mean sea level (AMSL) on the north side of State Road P. The site topography drops to approximately 412 ft AMSL along the banks of Joachim Creek. **Figure 3-1** below presents an aerial photograph of the initial conditions in LSA 10 prior to remediation (LSA 10 is outlined in red).

Figure 3-1
Aerial View of LSA 10 Prior to Remediation

3.2 LSA Description

The DP Chapter 14 and DP Figure 14-14 provided a conceptual approach for the configuration of LSAs and the survey units within a LSA. The DP stated that it is expected that the conceptual boundaries of these survey units may be altered based on the actual conditions at the time of survey design. This may be especially characteristic of the survey units within open land areas.

Examples of the need for this flexibility include the need to complete a portion of an excavation in advance of inclement weather, and challenges associated with water management of ground/surface water and precipitation.

The conceptual boundaries of LSA 10 have been modified (expanded) based upon remedial action visual inspections and radiological surveys. The SUs within LSA 10 have also been modified to facilitate the remediation process (benching and sloping). As such, the land area that comprises LSA 10-01 and LSA 10-02 was initially classified as a MARSSIM Class 1 survey area and remains a MARSSIM Class 1 survey area.

3.2.1 Current Configuration

LSA 10 encompasses the entire "Documented Burial Pit Area" Open Land Area footprint within the Central Tract. Although LSA 10 is located primarily within the Burial Pit Surrogate Evaluation Area (SEA), certain portions of LSA 10-01 and LSA 10-02, specifically the outer edges, extend into the adjacent "Plant Soils" SEA [see Section 5.1.1 for discussion on SEA] due to excavation safety benching leading out from the deep cuts made within the Burial Pit Open Land Area footprint proper.

LSA 10-01 is located within the northern half of the Burial Pits Open Land Area within "Area 1" – "Areas" are an internal HDP designation used for remediation work planning and task sequencing. The SU is 1,593 square meters (m^2) in planar (2-dimensional) extent, within an interior surface area of 1,970 m^2 (3-dimensional).

LSA 10-02 is also located within the northern half of the Burial Pits Open Land Area within Area 1 and is adjacent to LSA 10-01. This SU is 1,477 m^2 in planar extent, with an interior surface area of 1,937 m^2.

Figure 3-2 presents the current HDP Remediation Areas with the SUs in each area.

Figure 3-2
Current HDP Remediation Areas and Survey Units

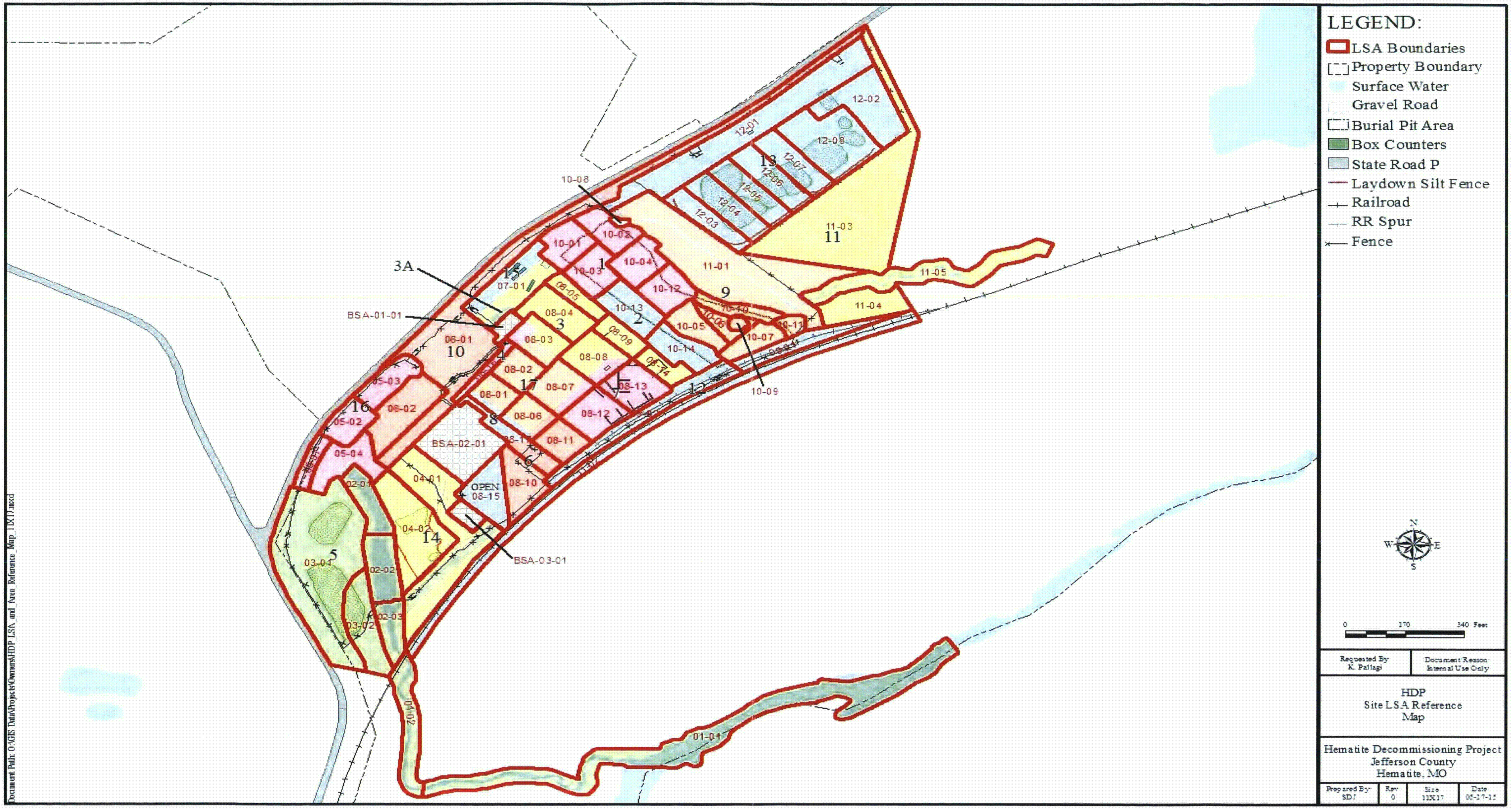


Figure 3-3 and **Figure 3-4** present inset maps showing the LSA 10-01 and LSA 10-02 boundaries within the inclusive limits of Area 1 - which comprises a total of five (5) survey units. The other neighboring survey units within Area 1 are LSA 10-03, 10-04, and 10-12.

Figure 3-3
HDP Satellite View of LSA 10-01within Area 1

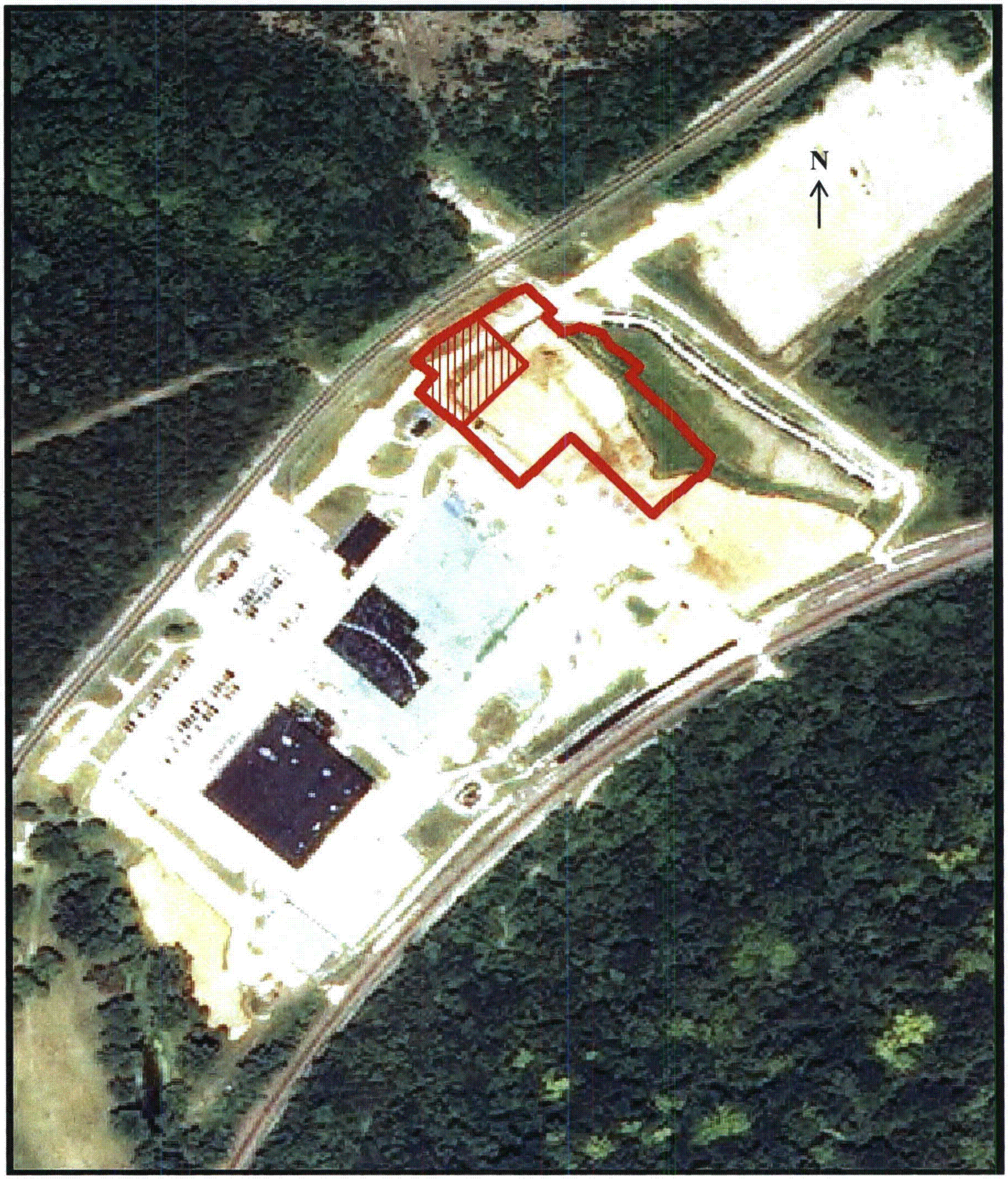
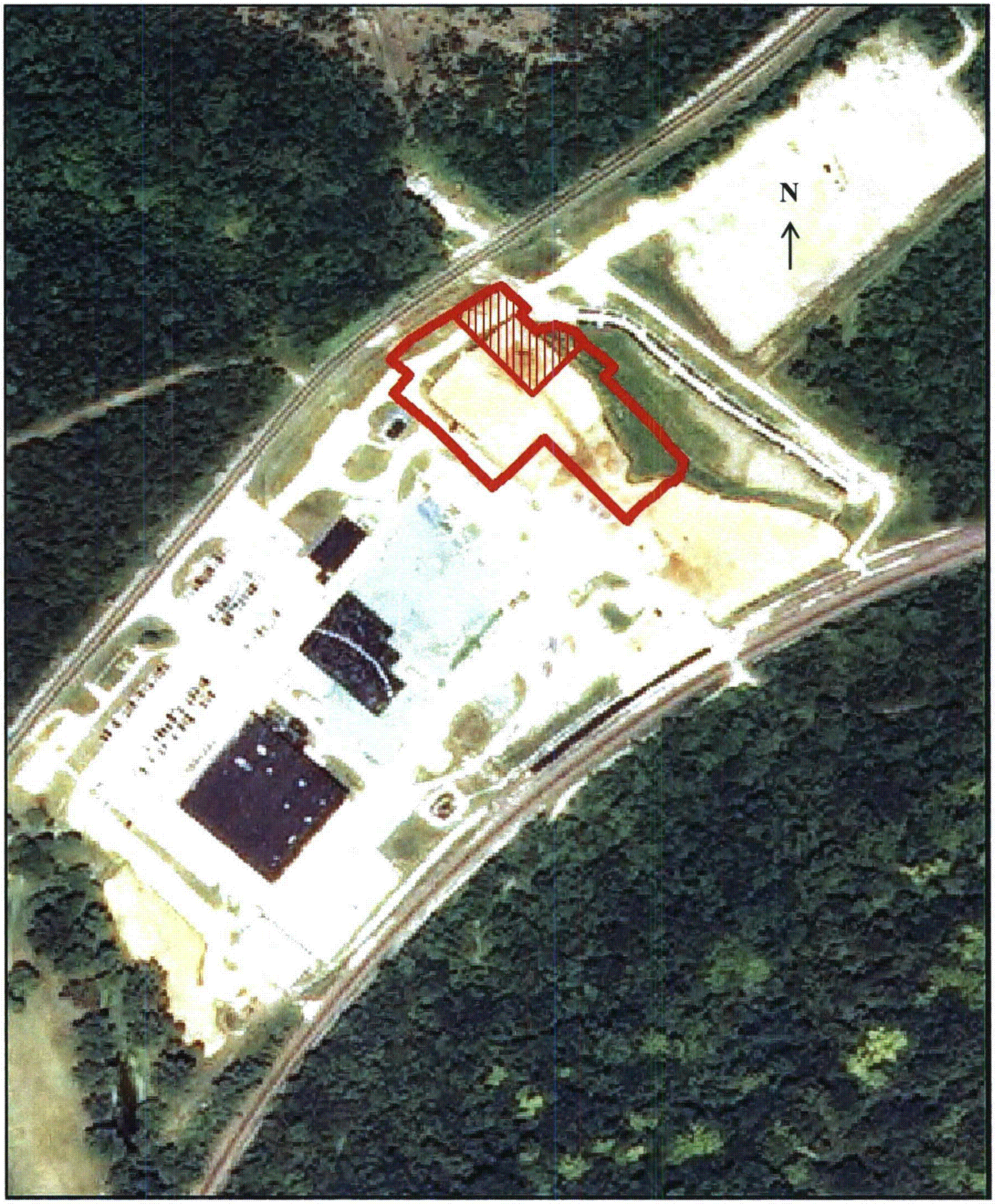


Figure 3-4
HDP Satellite View of LSA 10-02 within Area 1



3.2.2 Historic Use (Documented Burial Pits)

On-site burial was used as a disposal method for contaminated materials and wastes at the HDP from 1965 until 1970 in accordance with regulatory requirements and specific license authorizations. The detailed logbooks of waste burial described below document that the Burial Pit Area contained 40 unlined pits east of the HDP process buildings (see **Figure 3-5**). These Burial Pits were used to dispose of waste materials generated by the fuel fabrication processes. These on-site burial pits were created under the governance of Atomic Energy Commission (AEC) regulations contained in 10 CFR 20.304 (1964). These regulations described the spacing of the pits, the thickness of the cover, and the quantity of radioactive material that could be buried in each pit. The nominal dimensions of each Burial Pit are 20 ft wide by 40 ft long by 12 ft deep and the regulations provided that these were to include an approximate cover depth of 4 ft.

The owners of the facility at that time, United Nuclear Corporation (and later Gulf United Nuclear Corporation), maintained detailed logs of waste burials occurring between July, 1965, and November, 1970. Each entry contains a date, a description of the waste buried, the weight of the Uranium measured or estimated for that waste, and a cumulative total of the Uranium buried in that particular pit. The weight of the contaminated item measured or estimated was determined to the nominal value of 1 gram U-235 which likely resulted in an over-estimate of the actual amount. Some entries also list percent enrichment for the Uranium. The Burial Pit logs show a wide variety of wastes were buried in the pits; the majority of the listed waste is non-Special Nuclear Material (SNM) waste, such as contaminated trash, drums, pails, bottles, rags, etc. Additional waste materials that are listed include Uranium process metals of various enrichments, metal wastes, liquid and solid chemical wastes, and high-efficiency particulate air filters.

On-site burial of radioactive waste materials was terminated in November, 1970, as a result of an AEC violation issued to the Hematite facility for failure to adhere to revised AEC regulations concerning the quantity of material which could be buried onsite. An AEC Inspection Wrap-up Meeting memo stated that a revision of 10 CFR Part 20 was enacted in June, 1970, that reduced burial limits for enriched Uranium. The licensee at the time had continued burial based upon the limits prior to June 1970, resulting in the above AEC violation. It should be noted that Burial Pit logbook records, employee interviews, and the operational Uranium recovery process used during this time period, consistently show efforts to maximize recovery and utilization of Uranium material whenever possible. The completion of remedial activities within the Burial Pits Area has confirmed the initial conclusion drawn from the historical records - that the Burial Pits contained no significant quantities of potentially recoverable SNM.

3.2.3 Historic Use (Undocumented Burial Pits)

Interviews of former employees indicated that on-site burials (in addition to the burial practices under 10 CFR 20.304 [1964]) may have occurred as early as 1958 or 1959. Available employee interview records indicated that three or four burials may have been performed each year, prior to 1965, for disposal of general trash and items that may have been slightly contaminated relative to the radiological free release standards in effect for that period. Accordingly it was estimated that 20 – 25 burials may have been performed for which there are no records.

Burials prior to 1965 were not documented (logged) as they were not considered to contain significant quantities of SNM, and were not known to contain radioactive wastes. No information was located to indicate the specific nature of the waste material buried in these undocumented pits until visual identification occurred during site remediation. Additionally, no evidence was found during remediation to indicate that burial of known Uranium-bearing materials (i.e., above free release criteria) occurred during this time period. Discussions with the Interviewees indicated they believed these burials were in the area between the documented Burial Pits and the site buildings, and also under roadways in the eastern portion of the Central Tract.

Rather than attempting to locate and remediate individual burial pits within the Burial Pit Area, the overburden in that entire area was removed to allow for visual and radiological inspection, thus ensuring complete remediation. Therefore, regardless of the number, shape or size of a burial pit the remediation process provided for removal of both the documented and undocumented burial pits in a contiguous effort across the entirety of the Burial Pit Area. The visual and radiological inspections conducted during remediation undertaken by Westinghouse confirmed the presence of undocumented burial pits in this area, as discussed in the DP.

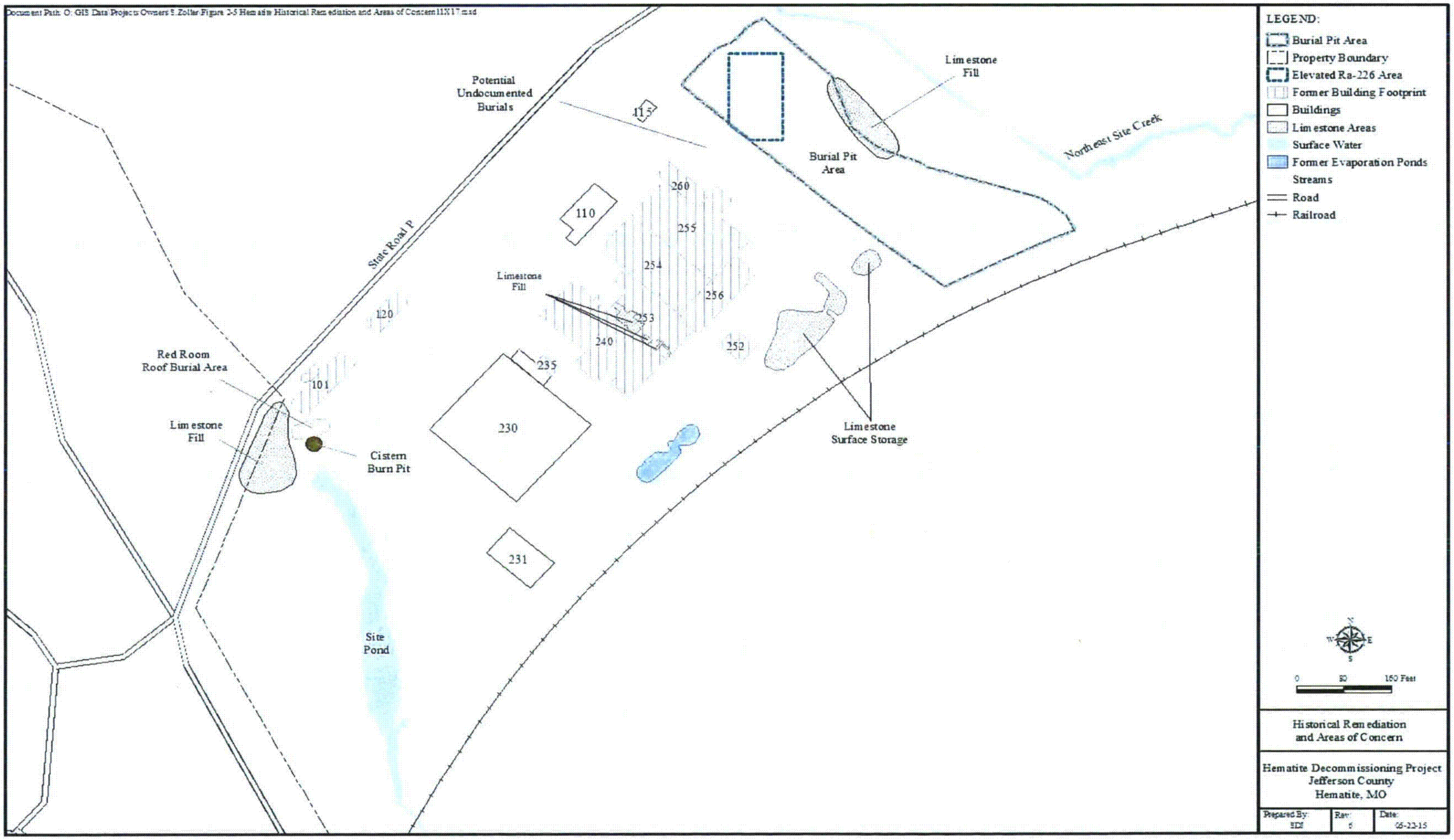
3.2.4 Historic Use of Spent Limestone

Spent Limestone was identified and removed during the remediation of Area 1. This limestone rock was used as the hydrogen fluoride off-gas scrubber media in five dry scrubber columns installed in Building 260 (Oxide Building) in 1967. The limestone media was periodically replaced, and was stored outside Building 260. This media was also utilized as onsite fill material as allowed by the facility NRC License in various locations. The general areas in which spent limestone was identified during remediation are shown in **Figure 3-5**.

The presence of Tc-99 at the site was originally discovered in the spent limestone during facility operations. The limestone scrubber media was identified as being contaminated with Tc-99. The only identified source of the Tc-99 is as a contaminant of the U.S. Department of Energy-supplied Uranium hexafluoride (UF_6) originating from reprocessed/recycled spent nuclear fuels.

Spent Limestone used as fill material was not identified in LSA 10-01 and LSA 10-02 during remediation.

Figure 3-5
Hematite Remediation Areas and Areas of Concern



4.0 HISTORY OF OPERATIONS

A chronology of major milestones is given below. This is followed by a discussion of operations, post-shutdown, and decommissioning activities. Emphasis is on operations with radioactive materials that could affect the final condition and final status survey of LSA 10.

4.1 Site Chronology

Major HDP and LSA milestones are listed below:

1956 – Mallinckrodt Chemical Works (MCW) purchases the parcel of farmland that includes the Central Tract Area.

1961 – May, ownership transferred to United Nuclear Corporation (UNC).

1971 – Gulf United Nuclear Fuels Corporation takes ownership.

1973 – UNC sells interest; now Gulf Nuclear Fuels.

1974 – January, Hematite facility transferred to General Atomic Company.

During the above time period, Hematite operations focused on Uranium fuel research and fuel production for various Government applications.

1974 – May, Hematite purchased by Combustion Engineering.

1989 – Asea Brown Boveri (ABB) acquires CE stock.

2000 – British Nuclear Fuels Limited (BNFL), parent of Westinghouse, purchases ABB's nuclear operations and merges into Westinghouse.

2001 – Westinghouse ceases operations; enters into decommissioning.

During the time period between 1974 and 2001, Hematite operations focused on fabricating fuel pellets using low-enriched (< 5% U-235 by weight) uranium. Around 1993, operations expanded to manufacturing of fuel assemblies to supply commercial nuclear power plants.

2006 – October, Westinghouse purchased by Toshiba Corporation

2009 – Hematite Decommissioning Plan submitted to NRC

2012 – 2014 Westinghouse remediation of Area 1 (North Burial Pits)

2015 – February, FSS measurements in LSA 10-01 and LSA 10-02 complete.

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

Both LSA 10-01 and LSA 10-02 are designated MARSSIM Class 1 survey units and are located in the northern half of the Burial Pits Open Land Area. Remedial actions commenced in these LSAs in April, 2012, and continued through December, 2014. These SUs along with LSA 10-03, 10-04, and 10-12 are also collectively referred to as "Area 1" for internal Hematite remediation planning and work sequencing.

During the remediation of Area 1 (see **Figure 4-1**), various types of waste materials were encountered, including drums, bags of trash, a tank, filter press plates, fuel pellets, construction

debris, small quantities of spent limestone, and contaminated soils. The filter press plates (see **Figure 4-2**) are of special interest in that they bore significant amounts of Radium-226 contamination and did not originate from historic Hematite fuel cycle operations. A small portion of the radium-226 impacted area as identified in the Hematite Radiological Characterization Report (HRCR), DO-08-003 (July 2009) was situated near the southeast corner of LSA 10-01. A somewhat larger section of the LSA 10-02 area near its southwestern corner fell inside the Radium impacted footprint.

Remedial actions within Area 1 revealed that although the underlying Burial Pits were nearly contiguous, individual burial pits were readily identifiable based on changes in soil color, soil hardness, visibly obvious items of non-native debris, and elevated gamma readings as measured by field instrumentation. **Figure 4-1** and **Figure 4-2** show that all intervening soils between individual pits were removed during the remedial excavation regardless of radioactivity concentration.

Figure 4-1
Early stage of remedial excavation in Area 1 (2012)

Figure 4-2
Removal of Buried Tank and Radium Contaminated Filter Plate during Burial Pits Remediation (2012 to 2014)

4.3 Reuse Soil Disposition and Characterization

Prior to remediation and removal of contaminated soil and other waste materials within Area 1 overburden soils which exhibited characteristics suitable for potential reuse as onsite backfill material were segregated and subjected to reuse material quality requirements. Demonstration of suitability of potential reuse soil for backfill is accomplished by data submittal and approval by the NRC prior to use. Submittals to the NRC regarding potential reuse soil are accomplished under separate correspondence.

4.4 Decommissioning (HDP Remediation and RASS Phase)

4.4.1 Remedial Actions

Remedial actions began in LSA 10-01 and LSA 10-02 in April, 2012, and continued through December, 2014. Types of waste materials encountered during the remediation were detailed in Section 3.2.

There were several indicators inherent in the remediation process of LSA 10-01 and LSA 10-02 in which a portion of the Burial Pit Area was located that provided assurance that all wastes were removed prior to the initiation of FSS. As previously discussed in Section 3.2, 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 burial pits 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 4-3** and **Figure 4-4**). 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 4-3
Example of Burial Pit Soil Discoloration

Figure 4-4
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 (see **Figures 4-5**).

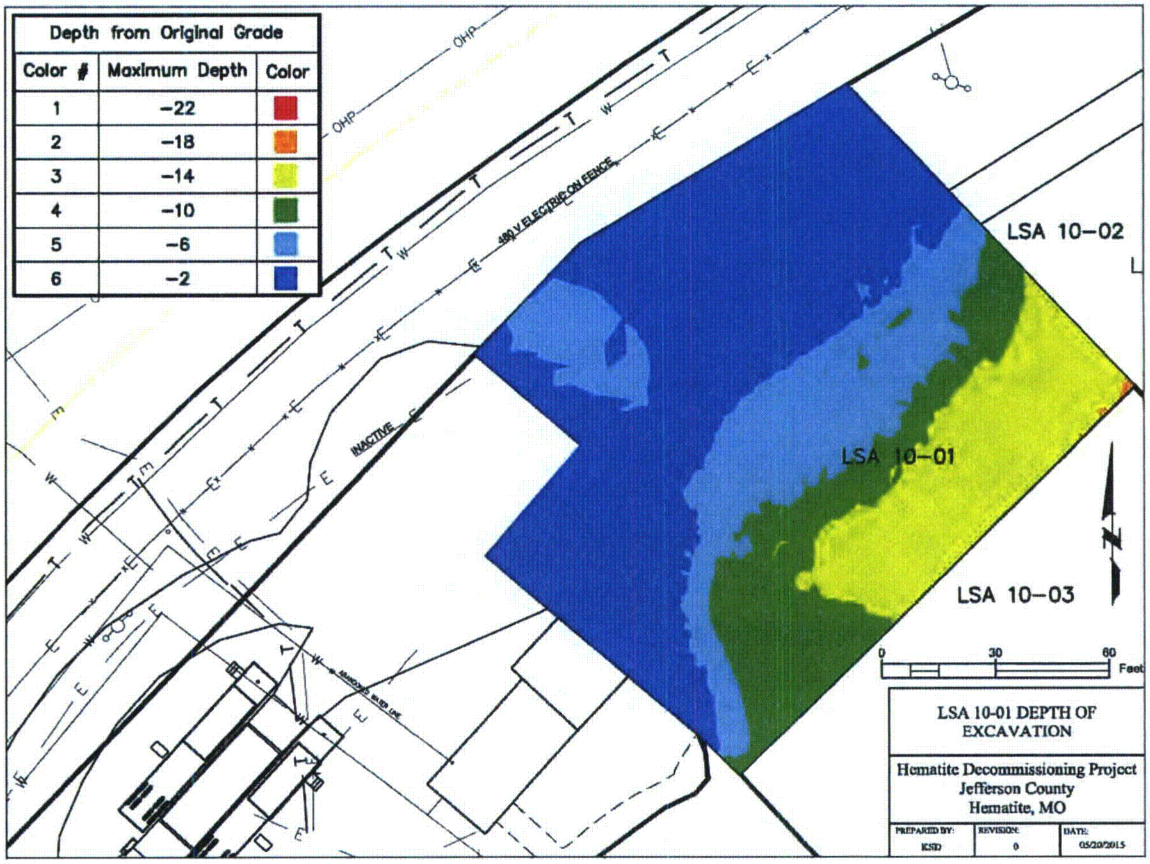
Figure 4-5
Burial Pit Area - A Large Single Excavation

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 criticality 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* (Westinghouse, 2015) (Reference 7.13) contains additional specific information related to the remediation of the Burial Pit Area and is included as a supplement to the information provided in this report as **Appendix L**.

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

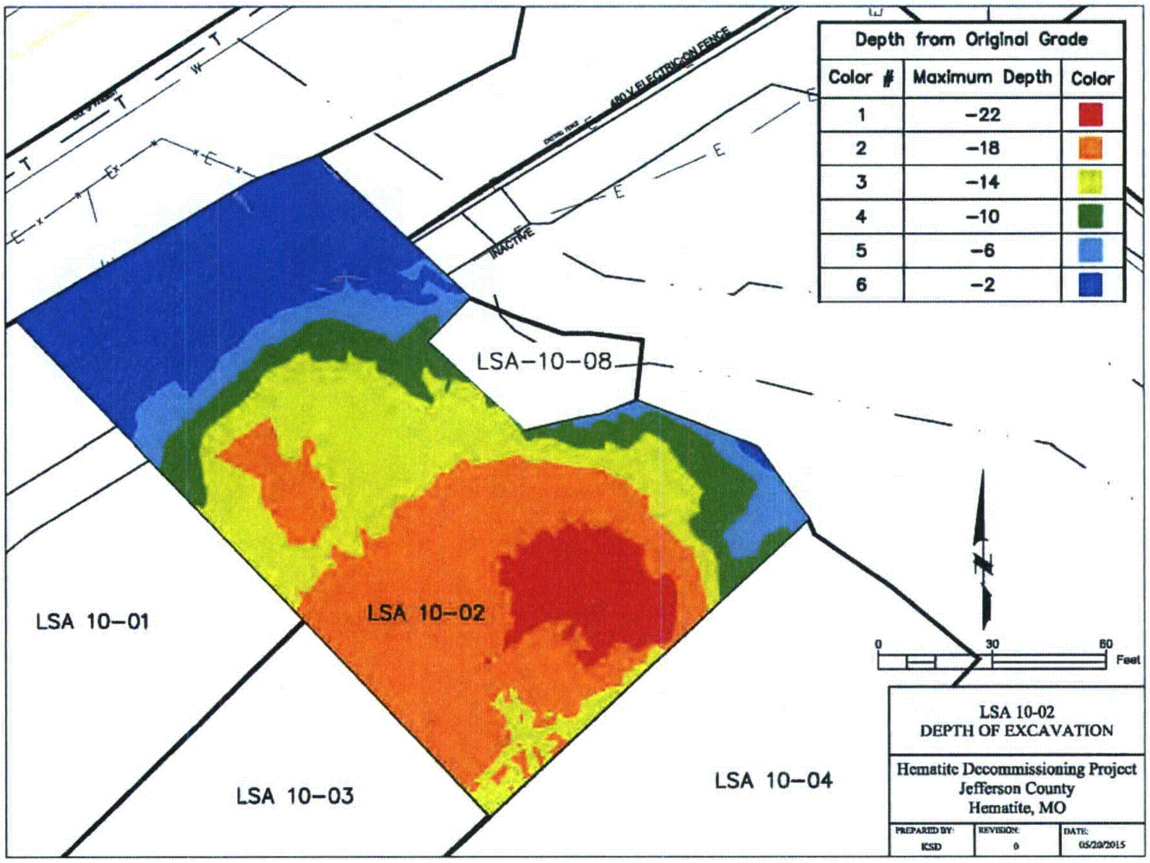
Figure 4-6
LSA 10-01 Depth of Excavation Map (Depths in Feet)*



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

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

Figure 4-7
LSA 10-02 Depth of Excavation Map (Depths in Feet)



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

4.4.2 In Process Remedial Action Support Surveys

During excavation and remediation of the Burial Pit Area remedial action support surveys were conducted in accordance with procedure HDP-PR-HP-601, *Remedial Action Support Surveys*. The radiological information obtained from the surveys served the purpose of categorizing the soil/debris into one of four categories; 1) Soil/debris potentially exceeding the NCS 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.

4.4.3 Nuclear Criticality Safety (NCS) Borings

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

As directed by the NSA-TR-09-15, *Nuclear Criticality Safety Assessment of Buried Waste Exhumation and Contaminated Soil Remediation at the Hematite Site* (Reference 7.14), 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 4-8** and **Figure 4-9**) would be performed to 3 ft below the deepest identified buried waste item in an excavation or 7 ft below ground surface (representative of 4 ft of overburden soil and an additional 3 ft into the soil that could have potential burial pit waste. In addition to performing a boring below the deepest identified waste item in an excavation, a grid with maximum spacing of 20 ft between boreholes was conducted within the entire documented burial pit area. The grid spacing chosen was based upon the nominal size of a documented burial pit. The spacing was chosen to provide a high probability that material from an unidentified burial pit would be intercepted.

In a small section of LSA10-01 and LSA 10-02 an area of very dense construction debris was encountered. In order to release this small area from NCS controls to allow for the complete removal of all construction debris, and under the guidance of the Nuclear Criticality Safety Specialist, a denser spacing grid of approximately 5 ft between boreholes was implemented prior to the removal of all construction debris. Radiological surveys were reviewed to ensure that there was no indication of significant quantities of SNM present in the area, and NCS controls were released in this isolated area to allow for the complete and adequate removal of all construction debris. Later borings were performed on the remaining areas of LSA 10-01 and LSA 10-02 with maximum spacing of 20 ft between boreholes to release the area from NCS controls.

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

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

Appendix J and Appendix K present the original NCS Borings Surveys and Maps for LSA 10-01 and LSA 10-02, respectively.

Figure 4-8
NCS Core Bore Locations in LSA 10-01

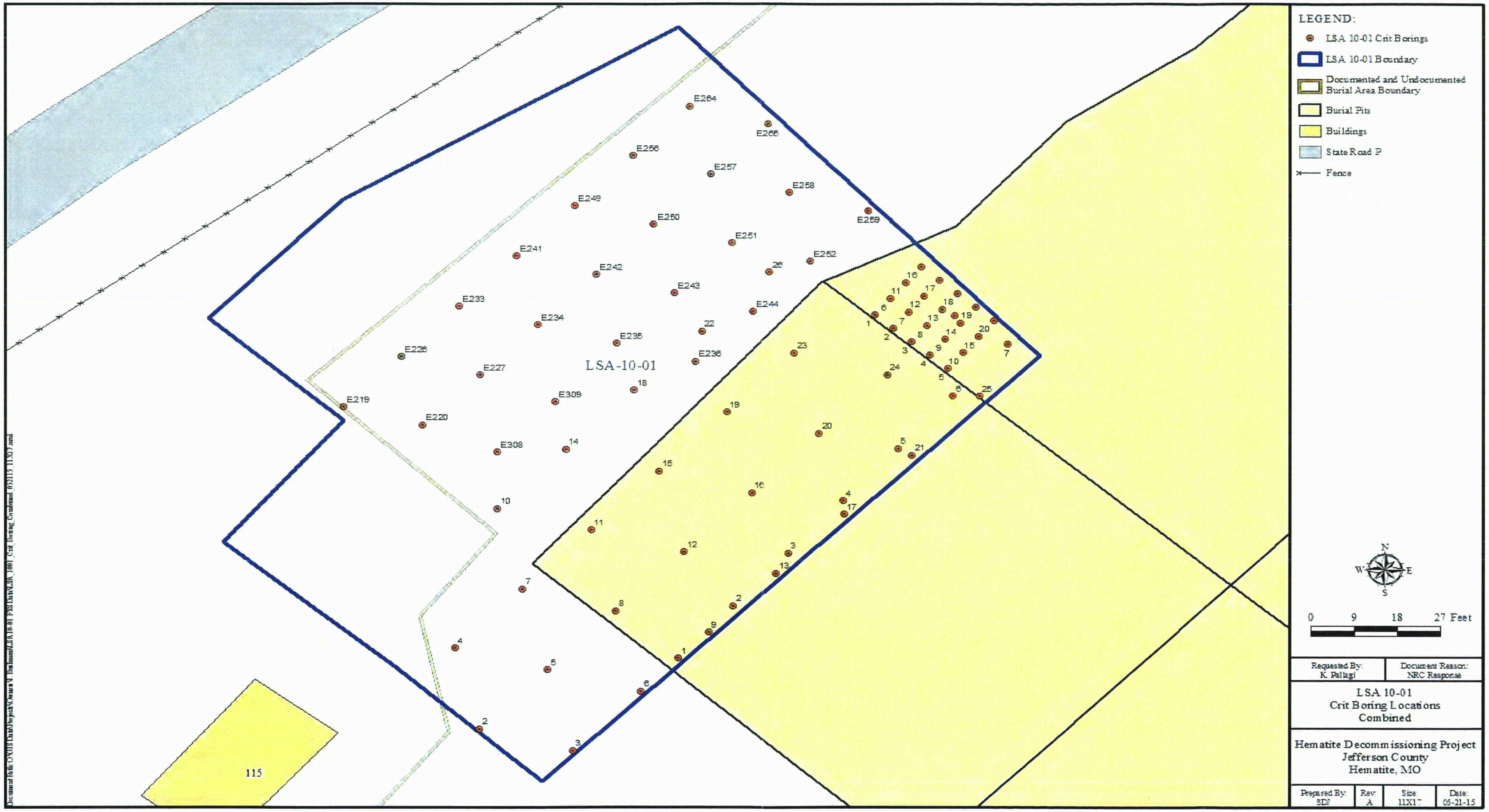
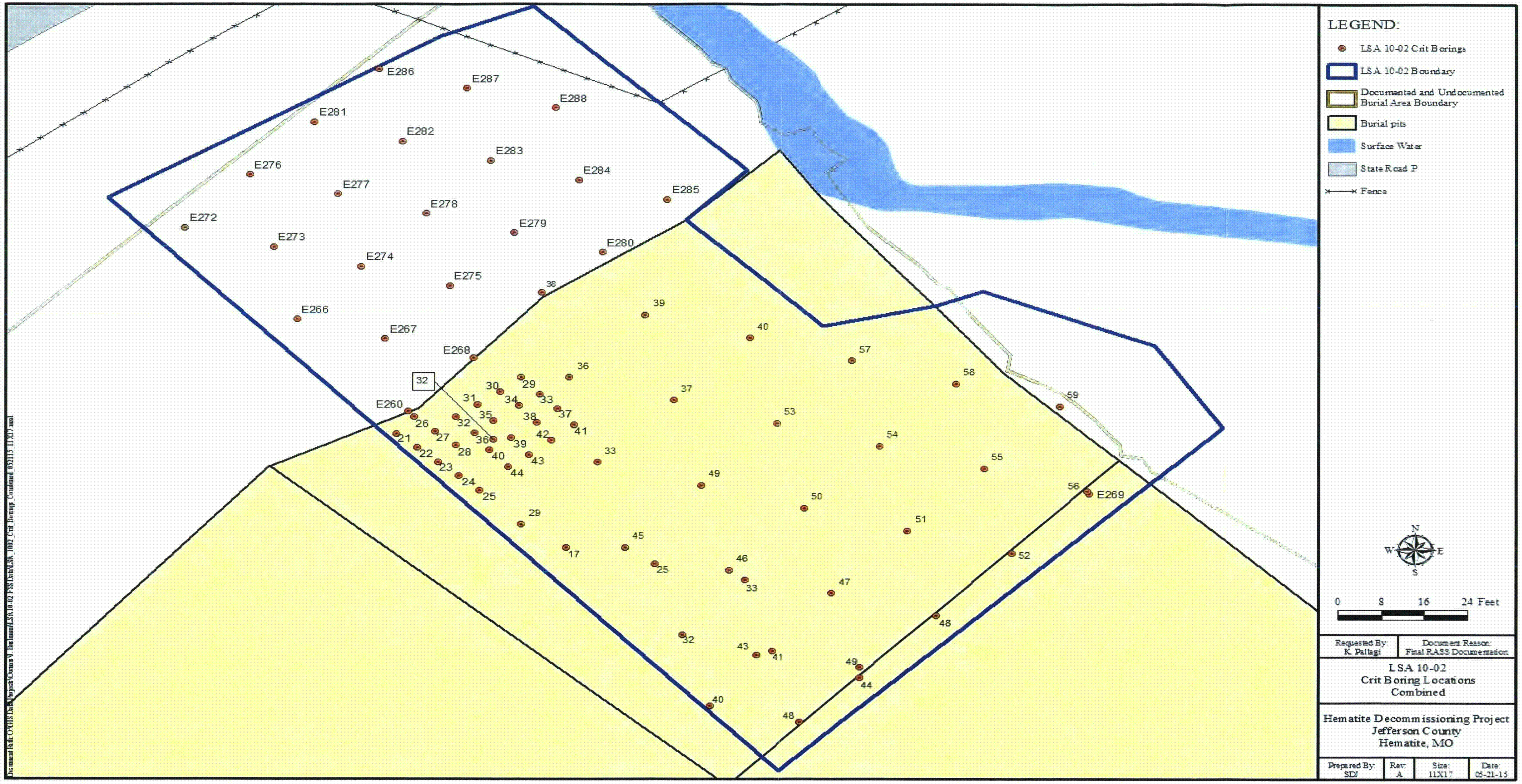


Figure 4-9
NCS Core Bore Locations in LSA 10-02



4.4.4 Monitoring Wells

Monitoring wells are designed to use a combination of stainless steel and PVC for the screen and casing materials. Five monitoring wells were installed within the boundary limits of LSA 10-01 and LSA 10-02 and all have since been abandoned in accordance with State of Missouri requirements. Monitoring wells PZ-04, and WS-22 locations are within LSA 10-01. Monitoring wells BP-015, WS-24 and WS-25 locations are within LSA 10-02.

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

"When hybrid wells are abandoned they will be over drilled using hollow stem augers of sufficient outside diameter to remove approximately two inches of surrounding soil, the well riser, well screen, and screened filter pack. The auger will continue until reaching refusal, which indicates bedrock. The soil cuttings that are removed during the boring process will be surveyed for indications of elevated radioactivity as a qualitative measure and sampled for laboratory analysis. Within each 5 foot interval, sample(s) of soil indicating elevated concentrations will be collected for laboratory analysis. In the event that an elevated count is not observed, one composite sample of the cuttings collected within each 5 foot interval will be collected for laboratory analysis."

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

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

"When completing remediation actions in the area of a hybrid well screen that extends beyond the depth of soil excavation, any water sample taken over the history of that well will be assessed for results that exceed the MDC+Error for Tc-99 or exceed the Background Threshold Value for total uranium. For such an exceedance, four borings will be made in close proximity (e.g., approximately equidistant within a 2-4 foot radius) to each monitoring well that is not excavated to the bottom of the well."

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

Appendix M presents the analytical soil and water results for Hybrid Well WS-25.

4.4.5 Subterranean Piping

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

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

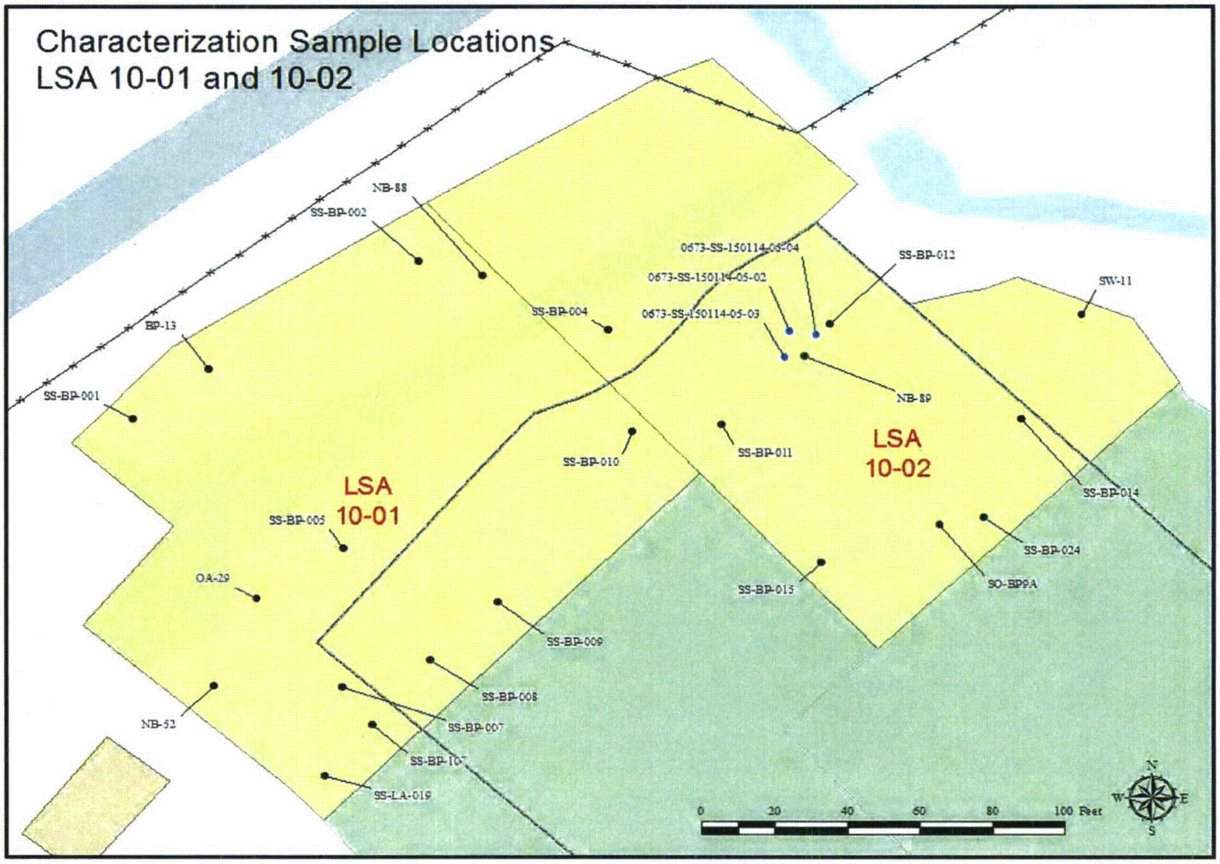
4.4.6 Characterization Core Bores

Radiological characterization surveys for the HDP were conducted in several phases by multiple contractors over several years prior to the issuance of the DP. A total of twenty-two (22) core borings to depths as deep as 35 feet bgs were performed for characterization within both LSAs 10-01 and 10-02 prior to remediation.

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

Sample NB-89-19.5-SL also had a SOF greater than 1 as compared to the Uniform Stratum criteria. The contamination depth (total Uranium ~ 650 pCi/g) at NB-89 was listed as 19.5 ft bgs in the HRCR. After completion of remedial actions and final RASS, it was determined that the excavation surface depth at the NB-89 coordinates was approximately 18 ft bgs, or 1.5 ft above the potential depth of exceedance. Because this was a sample collected between 4.5 ft and 19.5 ft with the highest gamma reading from each depth in 6-inch intervals selected for analyses, it was indeterminate as to whether the area of contamination had been remediated or not. In order to rule out the potential presence of underlying contamination, four additional soil corings were collected on January 14, 2015, using hand augers at the original NB-89 coordinates as well as three nearby locations to a depth of 20 ft. bgs. All of these supplemental investigation samples collected at and around NB-89 were well below the Uniform Stratum criteria, therefore no additional remediation was required. **Figure 4-10** below presents the characterization boring locations within LSA 10-01 and LSA 10-02, including the supplemental investigation corings (i.e., 0673-SS-150114-05-02, -03, and -04).

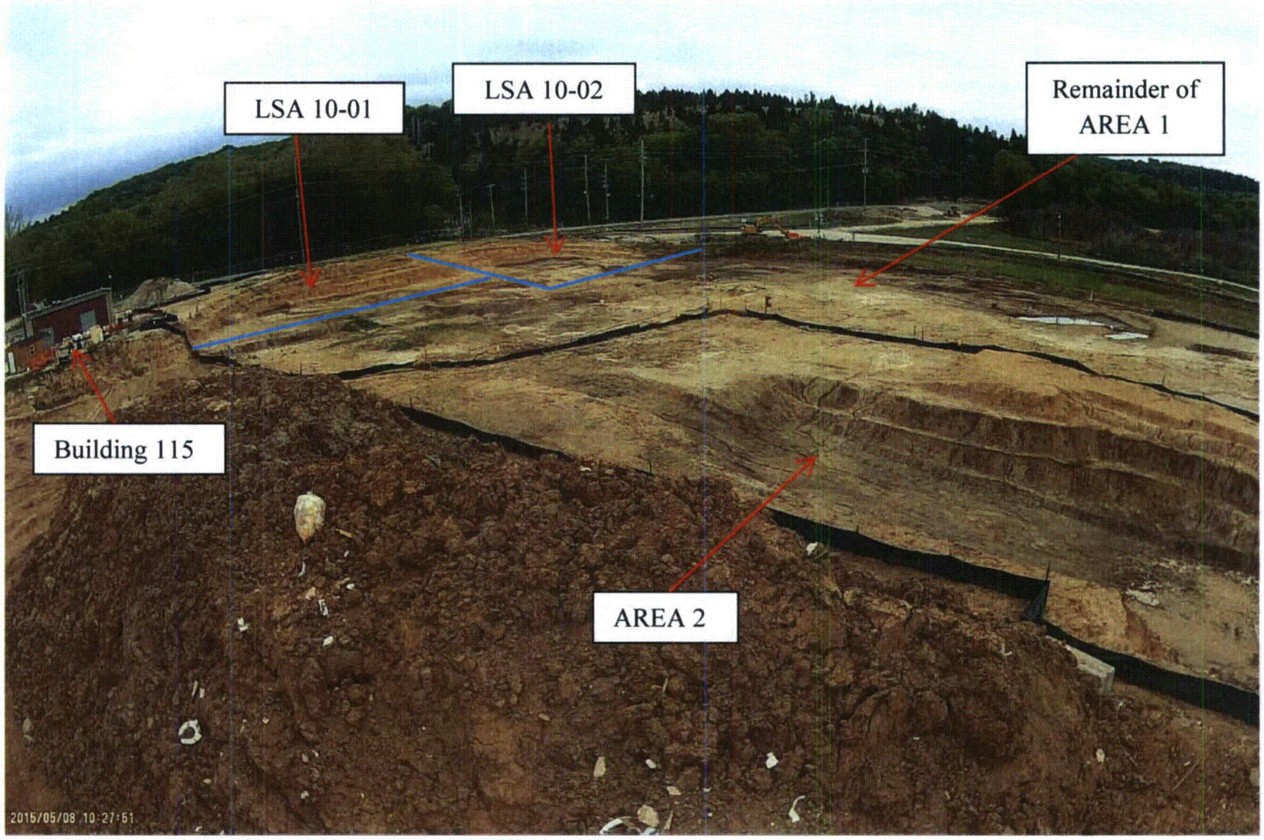
Figure 4-10
Site Characterization Borings within LSA 10-01 and LSA 10-02



4.4.7 Remedial Action Support Survey for FSS Design

The RASS was conducted to guide remediation activities, determine when an area or survey unit had been adequately prepared for FSS, and provide updated estimates of the parameters to be used for planning the FSS. Upon completion of remediation within the survey unit and prior to implementation of FSS activities, a final RASS was performed prior to the finalization of Isolation and Control (I & C) postings. The I & C postings were completed for both LSA 10-01 and LSA 10-02 on December 12, 2014. **Figure 4-11** shows LSA 10-01 and LSA 10-02 ready for the final RASS.

Figure 4-11
LSA 10-01 and LSA 10-02 for RASS FSS Design



The RASS included a 100% GWS, systematic surface sample collection based on an eight (8) - point triangular grid, and biased surface sampling. The systematic RASS results used to develop the FSS sampling grid are summarized below:

Table 4-1
Summary of Final RASS Results for LSA 10-01 and LSA 10-02

LSA	Ra-226 (net)		Tc-99		Th-232 (net)		U-234		U-235		U-238	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
10-01	0.01	0.05	0.08	0.42	0.11	0.28	2.66	5.42	0.14	0.30	1.13	1.86
10-02	0.01	0.09	0.43	1.33	0.04	0.15	3.88	10.44	0.21	0.57	1.35	2.83
DCGL[3]	1.9		25.1		2.0		195.4		51.6		168.8	

Notes:
1. All units are in picocuries per gram (pCi/g)
2. Results reflect net concentrations after subtraction of background (Ra-226 bkg = 0.9 pCi/g; Th-232 bkg = 1.0 pCi/g).
3. Uniform Stratum (From Table 5-1)

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

Appendix J and Appendix K present the final RASS surveys and maps performed for FSS design in LSA 10-01 and LSA 10-02, respectively.

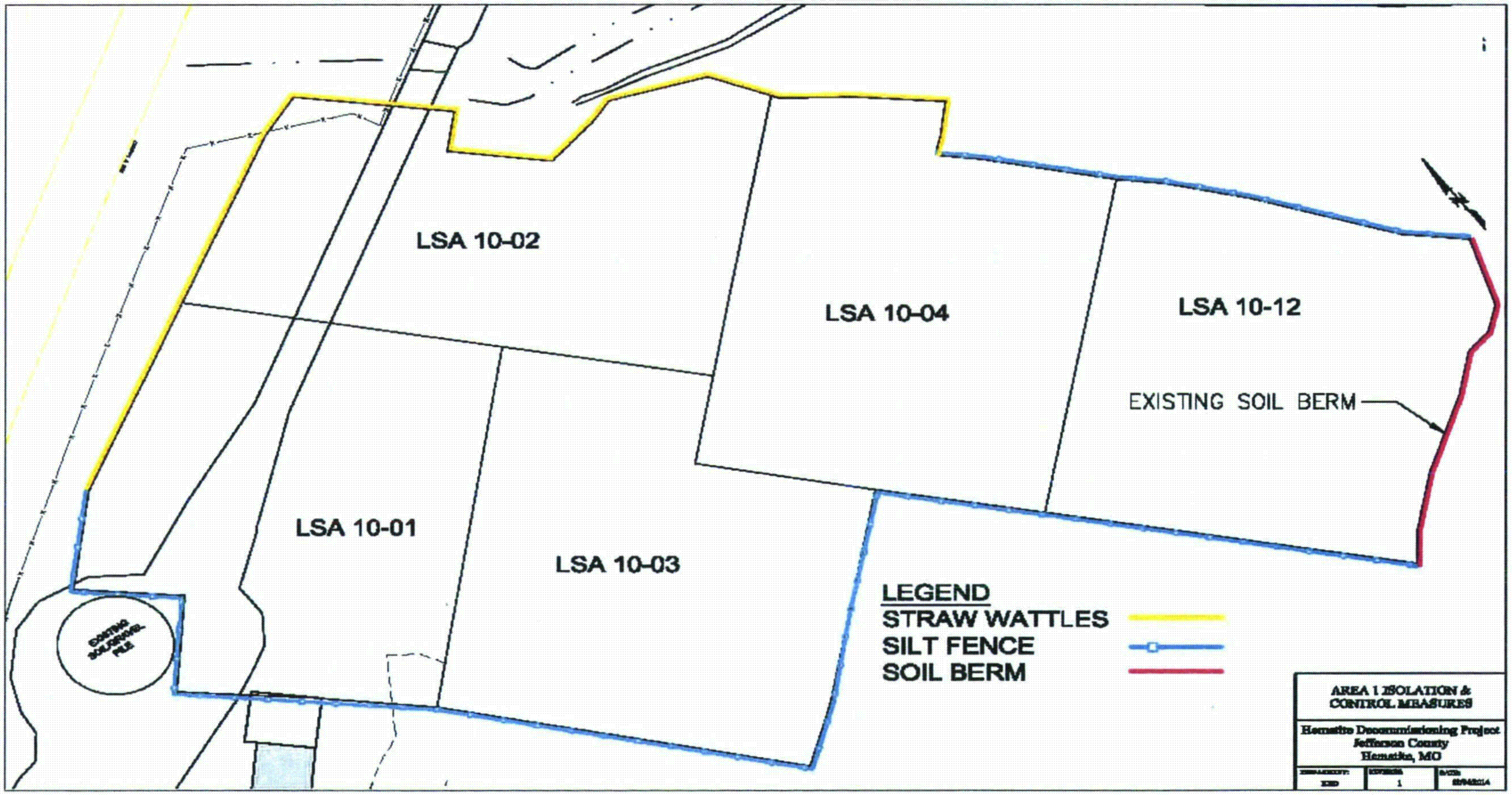
4.4.8 Isolation and Control

As directed by HDP-PR-HP-602, *Data Package Development and Isolation and Control Measures to Support Final Status Survey* (Reference 7.12), on December 12, 2014, LSA 10-04 (as well as the other four survey units included within Area 1) was isolated and controlled in accordance with Work Package HDP-WP-ENG-803, *Isolation and Control Measures,* (See **Figure 4-12**) Isolation and control measures include silt fence, straw wattle and soil berms between Area 1 (which contains LSA 10-01 and LSA 10-02) and adjacent remediation areas to ensure that cross-contamination of the LSA(s) undergoing FSS does 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 Area 1 prior to FSS field activities to prevent inadvertent entry by personnel. LSA 10-01 and LSA 10-02 are within the fenced security perimeter of the HDP Controlled Access Area to prevent access by the general public.

Figure 4-12

Isolation and Control of Area 1 (Includes LSA 10-01 and LSA 10-02)



4.4.9 Surveillance Following FSS

Following the completion of a FSS, the DP requires continued surveillance to minimize the potential to re-contaminate a survey unit (e.g., surface water transport of potentially contaminated sediment or a soil pile that was not present during FSS). The surveillance includes the routine visual inspection of the integrity of the I & C measures implemented for LSA 10-01 and LSA 10-02. If a survey unit is suspected of having been re-contaminated then an investigation survey will be performed to reconfirm the FSS survey validity.

During the timeframe since the completion of FSS field activities to the date of this report LSA 10-01 and LSA 10-02 have not evidenced an event that would cause them to be suspect and thus require investigation. This requirement will remain in place until such time as the survey units are backfilled or the FSS of the adjacent survey units have been completed and no potential for cross contamination exists.

4.4.10 Backfill of Survey Units

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

DP Section 14.3.2.4 describes the methodologies for placement of backfill soil into an excavation and evaluations of dose impacts. Utilizing the unity rule approach the average value for a stockpile soil will be added to the Sum of Fractions (SOF) for the SU. The evaluation of the dose impact to a SU will be provided in the Final Status Survey Final Report submitted for License Termination.

For the purpose of this report in demonstrating SUs LSA 10-01 and LSA 10-02 are acceptable for release consistent with the requirements of the 10 CFR 20 Subpart E, "Criteria for License Termination, in Section 6.0 a bounding SOF of 0.31 will be assigned to the dose contribution of the SU from reuse soil. The bounding SOF is based upon empirical data from the sample datasets of Reuse Stockpiles 1-2, 3, 4-7, and 5-6. Reuse Stockpiles 8 and 9 were not considered as the final stockpile SOF has yet to be determined. The reuse stockpile SOFs are provided in the table below.

Table 4-2
SOF for Reuse Stockpile Soils

Reuse Stockpile	1-2	3	4-7	5-6	8	9
Stockpile SOF	0.10[1]	0.14	0.25[1]	**0.31**[1]	TBD[2]	TBD[2]
Dose (mrem)	2.5	3.5	6.3	**7.75**	TBD[2]	TBD[2]

[1]Weighted Mean SOF of combined reuse stockpiles.
[2]TBD: To be determined - stockpile reports not yet completed.

4.4.11 Groundwater Monitoring

In response to NRC RAI Chapter 3-4, during the review and approval process for the DP, Westinghouse documented in letter HEM-11-96 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 and the dose attributed to reuse soil (if used to backfill the SUs) 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." As such, for the purpose of this report, groundwater will be assigned a conservative SOF of 0.16 which equates to 4 mrem/year.

5.0 SURVEY DESIGN AND IMPLEMENTATION

This section describes the method for determining the number of samples for the FSS of LSA 10-01 and LSA 10-02. Applicable requirements of the final status survey plan (FSSP) are summarized. These include the $DCGL_W$, scan survey coverage, and investigation action levels (IAL). The radiological instrumentation used in the FSS of LSA 10-01 and LSA 10-02 and their detection sensitivities are also discussed.

5.1 FSS Plan Requirements

FSS Plan requirements for LSA 10-01 and LSA 10-02 were driven by the type (Open Land) and Class (Class 1) of the survey unit and developed in accordance with HDP procedure, HDP-PR-FSS-701, Revision 4, *Final Status Survey Plan Development*, November 2014. The land areas now identified as LSA 10-01 and LSA 10-02 were initially classified MARSSIM Class 1 in the DP Chapter 14 Table 14-16 and Figure 14-14.

5.1.1 Surrogate Evaluation Areas

The DP identifies three SEAs for the purpose of estimating quantities of hard-to-detect radionuclides, such as Tc-99, based on their radiochemical relationship with a surrogate. It is important to note, however, that surrogate relationships are not used to determine release criteria compliance. Therefore, all FSS samples are analyzed for Tc-99 and the results are then compared to the DCGLs. As noted in the Westinghouse response to the NRC Request for Additional Information (RAI) 14-3a of Attachment 10 to HEM-11-96, use of the surrogate relationship is limited to survey design for the purposes of evaluating scan sensitivity. For example, U-235 has been designated as the surrogate for Tc-99. However, the assumed activity concentration ratio between U-235 and Tc-99 in a given data set depends upon the SEA from which the data was generated.

The primary impact of SEAs for FSS planning purposes involves calculation of the $DCGL_w$ for Total Uranium. Significantly lower DCGLs for U-235 (referred to in the DP and FSS procedures as the "infer Tc-99" DCGLs) are used when calculating the $DCGL_w$ for Total Uranium in order to include the contribution of Tc-99. This results in a lower $DCGL_w$ for Total Uranium, against which the scan minimum detectable concentration (MDC) for Total Uranium is compared. If the calculated scan MDC exceeds the $DCGL_w$ for Total Uranium, then the scan MDC is compared to the $DCGL_{EMC}$ ("EMC" stands for elevated measurement comparison), which is calculated by multiplying the $DCGL_w$ by the appropriate area factor. The DP target for Scan MDCs is 50% of the applicable DCGL. For Class 1 LSAs such as LSA 10-01 and 10-02, the applicable DCGL would be the $DCGL_{EMC}$. The $DCGL_{EMC}$ is used when small areas of elevated radioactivity may exist within larger survey units. If the scan MDC exceeds the $DCGL_{EMC}$, then the sample size must be increased accordingly.

5.1.2 $DCGL_w$ Criteria

Based on the information provided in DO-08-005, *Historical Site Assessment* (Reference 7.4), and DO-08-003, *Hematite Radiological Characterization Report* (HRCR) (Reference 7.3), it has been determined that the following are the ***primary*** radionuclides of concern for the HDP:

- Uranium-234, -235, -238
- Technetium-99
- Radium-226
- Thorium-232

Based on the information provided in DO-08-008, *Derivation of Surrogates and Scaling Factors for Hard-to-Detect Radionuclides* (Reference 7.2), the following radionuclides were deemed "insignificant" in that they contributed an aggregate dose less than 10%, or 2.5 milliroentgen equivalent man (mrem) per year, of the license termination TEDE criterion:

- Americium-241
- Neptunium-237
- Plutonium 239/240
- Uranium-236

DCGLs for FSS are selected based upon which CSM is applied to the survey unit dataset of interest. Although all FSS soil samples from LSA 10-01 and LSA 10-02 were collected according to the multi-stratum CSM, the actual results of these samples were conservatively evaluated against the Uniform Stratum DCGLs, regardless of the stratum from which the sample was collected.

Table 5-1 presents the $DCGL_w$s by CSM (i.e., Uniform Stratum and ***Three-Layer*** multi-CSM) applicable to Open Land survey units undergoing FSS at HDP.

Table 5-1

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 Stratum	
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 adapted from Attachment 4 to HEM-11-96 Table 14-10.
[b] The reported DCGL$_W$s are the activities for the parent radionuclide as specified and were calculated to account for the dose contribution from insignificant radionuclides.
[c] +D indicates the DCGL$_W$ includes short-lived (half-life ≤ 6 mo.) decay products.
[d] +C indicates the DCGL$_W$ includes all radionuclides in the associated decay chain.

All FSS analytical results for samples collected within LSA 10-01 and LSA 10-02 were evaluated against the Uniform Stratum DCGLs.

The DP allows for the inference of U-234 activity based on the enrichment percentage and associated activity fractions of the U-235 and U-238 isotopes in a given FSS sample. Section 14.1.4.3.3 of the DP discusses the inference methodology for U-234. U-234 cannot be detected using conventional field instrumentation during scan survey measurements of soil, or by gamma spectroscopy. The ratio of the U-238 to U-235 concentrations obtained from gamma spectroscopy were used to infer the U-234 to U-235 ratio based on observations of the enrichment in a large number of characterization samples, assumptions regarding the consistency of the enrichment shown by the characterization data, and published values for the enrichment based on isotopic ratios. These relationships are provided in Table 14-5 of the DP. The following data quality objectives (DQOs) and equations were used to estimate the concentration of U-234 based on the results of analysis by gamma spectroscopy for U-235 and U-238.

1. When U-235 is reported as negative or zero and U-238 is reported as positive, natural Uranium is assumed and the U-234 concentration will be set equal to the U-238 concentration, as shown below:

$$C_{U\text{-}234}\ (\text{pCi/g}) = C_{U\text{-}238}$$

where: $C_{U\text{-}238}$ = Concentration of U-238 (pCi/g)

2. When U-235 is reported as positive and U-238 is reported as negative or zero, highly enriched Uranium is assumed and the U-234 concentration is determined by multiplying the U-235 concentration by 32.50, which is the U-234: U-235 ratio based on the maximum enrichment (100 percent) from DP Table 14-5, as shown below:

$$C_{U\text{-}234}\ (\text{pCi/g}) = 32.50 \times C_{U\text{-}235}$$

where: $C_{U\text{-}235}$ = Concentration of U-235 (pCi/g)

3. When both U-235 and U-238 data are reported as positive, but the U-238:U-235 ratio for the data is less than 0.0001 (indicating highly enriched Uranium), the U-234 concentration is determined using DP Equation 14-5. When both U-235 and U-238 data are reported as positive, but the U-238:U-235 ratio for the data is greater than 155.37 (indicating depleted Uranium), the U-234 concentration is determined by multiplying the U-235 concentration by the minimum U-234:U-235 ratio of 46.31 from DP Table 14-5, as shown below:

$$C_{U\text{-}234}\ (\text{pCi/g}) = 46.31 \times C_{U\text{-}235}$$

where: $C_{U\text{-}235}$ = Concentration of U-235 (pCi/g)

4. When both U-235 and U-238 data are reported as positive, the U-238:U-235 ratio for the data is used to determine the associated U-234:U-235 ratio from DP Table 14-5. The U-234 concentration is determined by multiplying the U-235 concentration by the U-234:U-235 ratio, as shown below:

$$C_{U\text{-}234}\ (\text{pCi/g}) = R_{U\text{-}234:U\text{-}235} \times C_{U\text{-}235}$$

where: $R_{U\text{-}234:U\text{-}235}$ = Estimated U-234:U-235 ratio based on U-235:U-238 ratio using Table 14-5; and, $C_{U\text{-}235}$ = Concentration of U-235 (pCi/g).

5.1.3 Scanning Surveys

5.1.3.1 Selected Instrumentation and Measurement Sensitivity

Radiological instrumentation used during the performance of GWS within LSA 10-01 and LSA 10-02 included two sets of Ludlum 44-10 2" x 2" sodium iodide (NaI) detectors, each coupled to a Ludlum 2221 scaler-ratemeter. Each NaI instrumentation set was interfaced with a Trimble Pro 6H DGPS and Nomad 800XL handheld data logger. Prior to the first field use of the GWS instrumentation, initial set-ups were performed. Also, daily pre- and post-use source checks were performed for each day that GWS was performed within the SU. Initial set-ups, daily source checks and control charting were performed according to the requirements of HDP procedure, HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey* (Reference 7.11).

Appendix H presents the daily source check logs and control charts used for GWS surveys within LSA 10-01 and LSA 10-02.

Since background levels were approximately 10,000 counts per minute (cpm) within both LSA 10-01 and LSA 10-02, the scan minimal detection concentration (MDC) calculation for total uranium given in HDP-PR-FSS-701, *Final Status Survey Plan Development*, Step 8.2.6.d, was applied:

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

In order to calculate the Scan MDC for total uranium using the above equation, an average enrichment for the SU must be known which in turn will provide relative isotopic fractions for U-234, U-235, and U-238 as given in Appendix G of HDP-PR-FSS-701, Revision 4, *Final Status*

Survey Plan Development. Based on the systematically collected RASS samples in LSA 10-01 and LSA 10-02, the average enrichments for the SUs were 2.0% and 2.4%, respectively.

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 5-2**. Prospectively calculated scan MDCs for 2" x 2" NaI detectors that were to be used in LSA 10-01 and LSA 10-02 are shown below:

Table 5-2
Scan MDCs for 2" x 2" NaI detector, 10,000 cpm background: LSA 10-01, 10-02

	Scan MDC (Total U)	DCGLw (Total U)	Scan MDC (Ra-226)	DCGLw* (Ra-226)	Scan MDC (Th-232)	DCGLw* (Th-232)
LSA 10-01	82.6	87.7	2.8	2.8	1.8	3.0
LSA 10-02	83.6	84.5	2.8	2.8	1.8	3.0

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

5.1.3.2 GWS Technical Requirements

As Class 1 SUs, LSA 10-01 and LSA 10-02 were required to undergo a 100% GWS. A small fraction of the excavation surface area was comprised of sidewalls, benching, steep slopes, and small pits. These surfaces were also required to undergo 100% GWS and are subject to biased sampling if scanning measurements exceeded the investigation action level (IAL).

The selected instrumentation was a 2" x 2" NaI detector in combination with a Ludlum 2221, rate meter and a Global Positioning System (GPS) antenna with data logging capability. The GWS technical 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 is required to slowly advance, causing the detector to trace out a serpentine path over the excavation surface.

The IAL used during the GWS of LSA 10-01 and LSA 10-02 was 4,000 ncpm. The basis of the IAL is detailed in HDP memorandum, HEM-15-MEMO-021 "Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site". FSS technicians performing GWS in the SU 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), FSS technicians are required to pause momentarily and observe count rates. If sustained count rates are approaching the IAL, further focused investigation is conducted within the locally elevated area. But, in order to use the IAL effectively, FSS technicians must first determine a local background count rate before starting the GWS. Although the ambient gamma level can vary across the SU due to excavation geometry and relative distance from contaminated materials in nearby remedial excavations, the average background rate (measured at waist level) within the LSA ranged between 10,000 and 11,000 gross counts per minute (gcpm). Therefore, at locations where the 2" x 2" NaI detector measurements exceeded 14,000 to 15,000 gross counts per minute (gcpm), FSS technicians slow

or pause the GWS for more careful investigation of small areas of elevated activity before deciding if "flagging" a point for potential biased sampling was warranted.

All GWS measurements on the excavation floor and sidewalls collected with the NaI detector(s) were connected to a Trimble Differential Global Positioning System (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. Post-processed GPS coordinate data is accurate to within ± 0.1 m for the DGPS models used during the GWS. The GWS maps are plotted and presented in 2-D. For a given point during the walkover, the most elevated radiological measurements are plotted "on top". Therefore, if any sidewalls featured more elevated readings than the floor directly below, the sidewall radiological measurements would overlie the lower floor readings.

5.1.4 Soil Sampling

Based on statistical evaluations of the respective RASS data sets, eight (8) point systematic grids were designed for both LSA 10-01 and LSA 10-02. Determination of the required sample sizes for each SU was performed according to the requirements in Step 8.2.5 of HDP-PR-FSS-701, Revision 4 (effective version at time of FSS plan design), and is documented in Step 8 of Appendix P-1. Preparation of Appendix P-1, along with Appendix P-3, electronic spreadsheets, and Survey Unit figure(s) comprise the FSS Plan components for each LSA. FSS Plans for LSA 10-01 and LSA 10-02 are presented in Appendix C and Appendix D, respectively.

Within both LSAs, there were areas where remedial excavation was not necessary (e.g. approaching the shared boundary with adjacent Class 2 or Class 3 LSAs). The number and type of samples required to be collected at each systematic sampling locations are specified in the DP and FSS procedures and are driven by the depth of the sampling point relative to final grade.

Because multiple radionuclides are present, the unity rule is applied when comparing soil sample results to the DCGLs using the following equation for the SOF:

$$SOF = \frac{Conc_{U\text{-}234}}{DCGL_{w,U\text{-}234}} + \frac{Conc_{U\text{-}235}}{DCGL_{w,U\text{-}235}} + \frac{Conc_{U\text{-}238}}{DCGL_{w,U\text{-}238}} + \frac{Conc_{Tc-99}}{DCGL_{w,Tc-99}} \frac{Conc_{Th-232}}{DCGL_{w,Th-232}} + \frac{Conc_{Ra-226}}{DCGL_{w,Ra-226}}$$

Background values for Ra-226 and Th-232 are subtracted from sample results in calculating the SOFs. The background value, in pCi/g, for Ra-226 is 1.07 pCi/g with ingrowth, and 1.0 pCi/g for Th-232. Negative values are treated as zero for calculating the SOF.

The Ra-226 background value of 1.07 pCi/g has been reduced from the background value of 1.47 previously reported in the HRCR (Reference 7.3). This reduction in the Ra-226 background value was an administrative decision made by HDP after a review of the data set for the LSAs associated with Area 1 (10-01, 10-02, 10-03, 10-04, and 10-12) showed that the mean Ra-226 concentration of the data set of 1.21 pCi/g was less than background, and only 8 of the 72 samples taken had values above 1.47 pCi/g. Based on data results discussed in HDP-RPT-FSS-301, *Off Site Borrow Soil Analysis, 2112 Horine Road, Festus, Missouri*, (Reference 7.15), it was determined that the value of 1.07 pCi/g is a better representation than 1.47 pCi/g for background, and it would be appropriate to reduce the Ra-226 background value. It was not necessary to

adjust the Th-232 background value of 1.0 pCi/g. The report contains the data collected by HDP consisting of soil samples from sites used to establish background soil concentrations for the HRCR. HDP collected new soil samples at 8 sample points at each of the two locations previously specified in the HRCR. Each sample location was sampled in 3 foot intervals to a depth of at least 6 feet, or until refusal was met. A total of 32 samples were taken from the two reference areas. The mean Ra-226 concentration of these 32 samples was 1.07 pCi/g, and will be used as the Ra-226 background value for FSS samples moving forward as a conservative measure. The updated background reference area data with ingrowth for Ra-226 was utilized for the WRS Test Evaluation.

5.1.4.1 Systematic Soil Sampling

The number and type of samples required to be collected at each systematic sampling location are specified in the DP and incorporated into FSS procedures which are driven by the depth of the sampling point relative to final grade. The requirements are restated below.

1. If the systematic sample location falls on a point in the SU where the soil surface is within six inches of the planned backfill grade (the surface stratum), then the remaining soil within the surface stratum (0 – 0.15 m) location will be sampled. In addition to the surface stratum sample, the entire root stratum (0.15 – 1.5 m) will be composited and sampled at that location. Sampling of the underlying deep (or "excavation") stratum is not required, unless the root stratum composite sample exceeds a SOF of 0.5.
2. If the systematic sample location falls on a point in the SU where that is greater than six inches from final grade but less than 4.9 ft (root stratum) on the excavation surface, then the remaining soil within the root stratum (0.15 – 1.5 m) soil will be composited and sampled. In addition to the root stratum sample, the top six inches of the underlying deep stratum will be sampled at that location.
3. If the systematic sample location falls on a point on the excavation surface at a depth of 1.5 m or deeper relative to the backfill grade (deep stratum), then a six-inch grab sample is required.

Table 5-3 presents the systematic sampling requirements based on relative depth of the sample point.

Table 5-3
Systematic Sampling Requirements Based on Relative Depth of Sample Point

(Stratum)	Start (Top) Depth of FSS Sample Point Relative to Final Grade	Surface Sample Required?	Root Stratum Required?	Deep Stratum Required?
Surface	0 – 0.5 ft (0 – 0.15 m)	Yes	Yes	No*
Root	0.5 – 4.9 ft (0.15 – 1.5 m)	N/A	Yes	Yes
Deep	4.9 – 22.0 ft (1.5 – 6.7 m)	N/A	N/A	Yes (6-inch grab)

*In the unlikely event that the overlying root stratum composite sample exceeds an SOF of 0.5, then a Deep Stratum sample shall be collected at that location. Otherwise, an excavation stratum sample is not necessary at locations where both surface and root strata samples have been taken.

5.1.4.2 Biased Soil Sampling

The number of biased samples is not pre-determined during the FSS Planning phase, but rather after the GWS is completed and a statistical review (e.g., greater than 3 standard deviations (σ) above the mean) of the GWS data is performed. Typically, at least one biased sample is collected within a SU at the point of maximum GWS measurement. In addition, locations flagged as IAL exceedance by FSS technicians during the GWS are subject to evaluation and potential biased sampling.

5.1.4.3 QC Sampling

Duplicate samples are to be collected at a 5% frequency in accordance with HDP-PR-FSS-703 *Final Status Survey Quality Control* (Reference 7.6. Duplicate samples are evaluated per Subsection 7.4.1.1 of the Multi-Agency Radiological Laboratory Analytical Protocols, NUREG-1576, using the following equations:

If < DCGL:

Statistic: $|x_1 - x_2|$

Warning limit: 0.1415 (DCGL)
Control limit: 0.2120 (DCGL)

If ≥ DCGL:

Statistic: $RPD(\%) = \frac{|x_1 - x_2|}{\bar{x}}(100\%)$

Warning limit: 14.15%
Control limit: 21.20%

Where:
x_1 = activity of sample
x_2 = activity of field duplicate sample
$\bar{x}$ = average activity
RPD = Relative Percent Difference

5.1.4.4 Sidewall Sampling for Tc-99
To address the possibility of undetected lateral migration of Tc-99 in sidewalls of excavations the NRC requested that Westinghouse perform sidewall sampling. Based on discussions with the NRC, Westinghouse developed the following process for determining when sidewall samples would be collected:

- If any systematic or biased soil sample Tc-99 result from the survey unit exceeded 10% of the applicable $DCGL_W$, and
- If vertical or near vertical sidewalls exist within the survey unit, and
- If those sidewalls exceed 12 inches in height vertically, and
- If those sidewalls exceed (in aggregate) 5 % of the total survey unit surface area (e.g., greater than 100 m^2 of sidewall in a 2,000 m^2 survey unit), then sidewall sampling is necessary.

The review of soil sample data for LSA 10-01 and LSA 10-02 indicated that no samples exceeded 10% of the $DCGL_W$ for Tc-99 (2.5 pCi/g) with a maximum Tc-99 result of 0.530 pCi/g in LSA 10-01, and 0.453 pCi/g in LSA 10-02. Therefore, sidewall sampling was not required for LSA 10-01 and LSA 10-02.

Although the NRC request to address sidewall sampling was not included in the DP and RAI review and approval process, Westinghouse chose to conduct sidewall sampling in LSA 10-01 and LSA 10-02 to validate the technical adequacy of the approach as described above. Two discretionary (biased) samples were collected in the sidewall of LSA 10-01. Three discretionary samples were collected in the sidewall of LSA 10-02 due to a greater percentage of sidewall area. The sidewall sample results indicated that the 10% threshold is appropriate. See sidewall sample results in Section 6.5.

5.1.4.5 LSA 10-01 and LSA 10-02 Sampling
Table 4-4 provides a summary of systematic sampling by stratum for LSA 10-01 and LSA 10-02.

Table 5-4
Systematic Sampling Summary by Stratum for LSA 10-01 and LSA 10-02

LSA	SU Area, planar (m^2)	Systematic			QC
		Surface	Root	Deep	
10-01	1,593	3	6	8	1
10-02	1,477	2	2	8	1

LSA 10-01

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

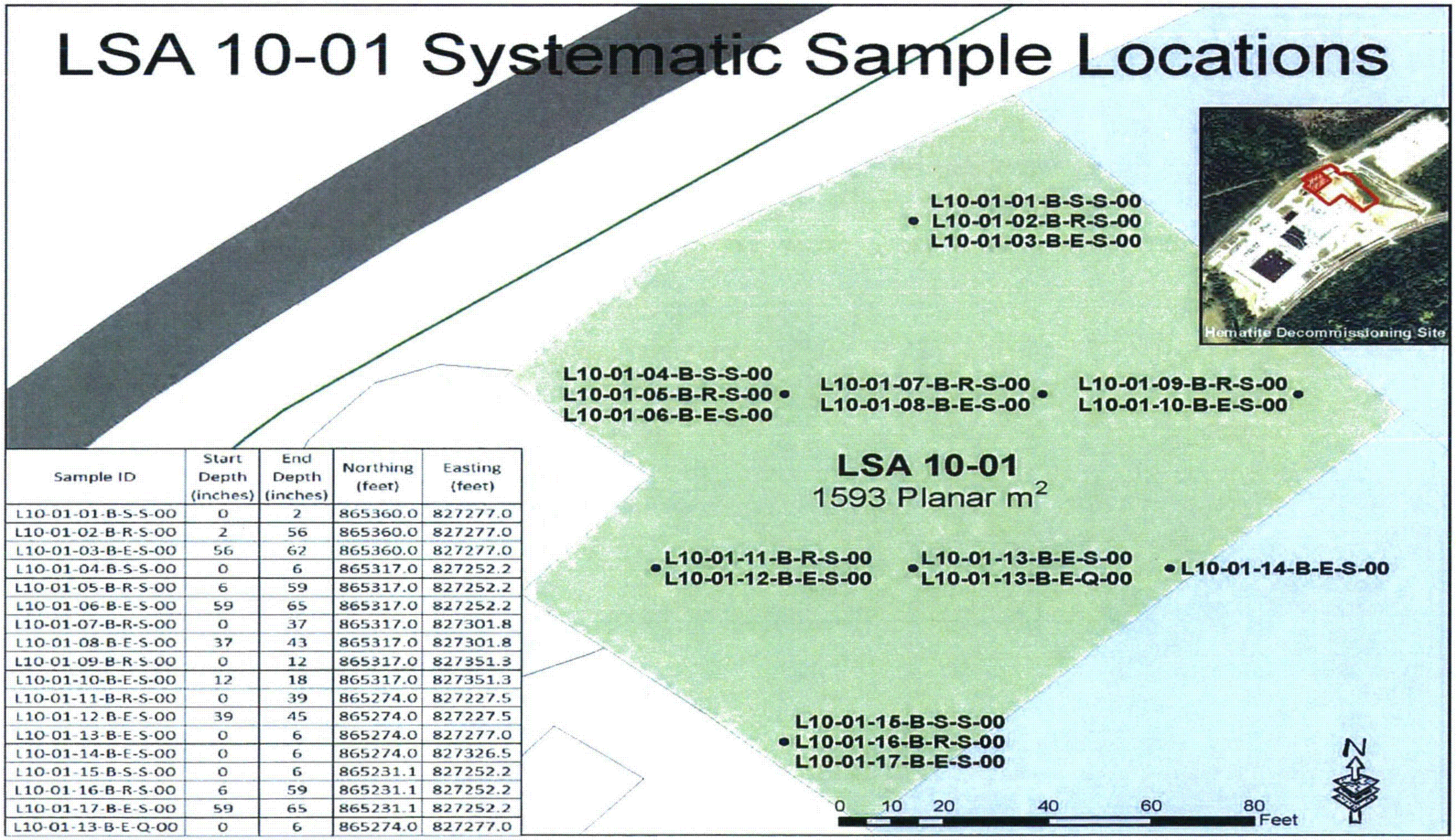
Given a planar area of 1,593 m^2 for LSA 10-01 and an eight - point systematic triangular grid, the point-to-point distance within each row was 14.3 m with spacing of 12.4 m between each of the parallel grid rows within the SU.

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

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

Figure 5-1 presents the map of the eight systematic sample locations which were sampled within LSA 10-01. The inset table notes the location coordinates (Missouri East, North American Datum (NAD) 1983) and collection intervals for each systematic location.

Figure 5-1
LSA 10-01 Systematic Sample Locations



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

Figure 5-2 below presents a tabular listing of all FSS samples collected within LSA 10-01 with associated IDs, sample types, collection intervals, coordinates, and notes.

Figure 5-2
FSS Sample Locations and Coordinates for LSA 10-01

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

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

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

Measurement or Sample ID	Surface or CSM	Type	Start Elevation	End Elevation	Northing (Y Axis) *	Easting (X Axis) *	Remarks / Notes
L10-01-01-B-S-S-00	Surface	S	437.0	436.8	865360.0	827277.0	Surface 2-inch grab
L10-01-02-B-R-S-00	Root	S	436.8	432.3	865360.0	827277.0	Root 4.4-foot composite
L10-01-03-B-E-S-00	Excavation	S	432.3	431.8	865360.0	827277.0	Excavation 6-inch grab
L10-01-04-B-S-S-00	Surface	S	436.9	436.5	865317.0	827252.2	Surface 6-inch grab
L10-01-05-B-R-S-00	Root	S	436.5	432.0	865317.0	827252.2	Root 4.4-foot composite
L10-01-06-B-E-S-00	Excavation	S	432.0	431.5	865317.0	827252.2	Excavation 6-inch grab
L10-01-07-B-R-S-00	Root	S	433.2	430.1	865317.0	827301.8	Root 3.1-foot composite
L10-01-08-B-E-S-00	Excavation	S	430.1	429.7	865317.0	827301.8	Excavation 6-inch grab
L10-01-09-B-R-S-00	Root	S	427.6	426.6	865317.0	827351.3	Root 1-foot composite
L10-01-10-B-E-S-00	Excavation	S	426.6	426.2	865317.0	827351.3	Excavation 6-inch grab
L10-01-11-B-R-S-00	Root	S	436.3	433.1	865274.0	827227.5	Root 3.3-foot composite
L10-01-12-B-E-S-00	Excavation	S	433.1	432.6	865274.0	827227.5	Excavation 6-inch grab
L10-01-13-B-E-S-00	Excavation	S	429.1	428.6	865274.0	827277.0	Excavation 6-inch grab
L10-01-14-B-E-S-00	Excavation	S	425.1	424.7	865274.0	827326.5	Excavation 6-inch grab
L10-01-15-B-S-S-00	Surface	S	436.9	436.5	865231.1	827252.2	Surface 6-inch grab
L10-01-16-B-R-S-00	Root	S	436.5	432.0	865231.1	827252.2	Root 4.4-foot composite
L10-01-17-B-E-S-00	Excavation	S	432.0	431.5	865231.1	827252.2	Excavation 6-inch grab
L10-01-13-B-E-Q-00	Excavation	Q	429.1	428.6	865274.0	827277.0	Excavation 6-inch grab
L10-01-18-B-E-B-00	Excavation	B	435.5	422.2	865276.8	827272.7	Excavation 6-inch grab

Samples highlighted in red will be collected and archived; radiological analyses required only if overlying root sample has a SOF >0.5.

* Missouri - East State Plane Coordinates [North American Datum (NAD) 1983]
Surface: Floor = F; Wall = W; Ceiling = C; Roof = R
CSM: Three-Layer (Surface-Root-Excavation) with conservative use of Uniform DCGLs
Type: Systematic = S, Biased = B; QC =Q; Investigation = I

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

Quality Record

Table 5-5 presents an overall FSS design and implementation summary table for LSA 10-01.

Table 5-5
FSS Design and Implementation Summary Table: LSA 10-01

Gamma Walkover Survey (GWS):		
Scan Coverage		100% accessible excavation floors, benches, pits, and sidewalls
Scan MDC		82.6 pCi/g total Uranium (based on a 10,000 cpm background)
Investigation Action Level (IAL)		4,000 net cpm*
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	3	These samples were collected on a systematic grid.**Analysis of excavation stratum samples is not required if there was surface stratum collected at sample grid location and the overlying root stratum SOF result was less than 0.5.
15 cm – 1.5 m (Root)	6	
> 1.5m (Excavation)	8**	
Biased Survey/Sampling Locations:		
Biased samples may be collected during GWS at the discretion of the HP Technician, after statistical analysis of the survey data, or at the direction of the FSS Supervisor.		
Instrumentation		
Ludlum 2221 with 44-10 (2" x 2" NaI) detector; with collimation for investigations.		Used for GWS and to obtain static count rates at biased measurement locations.
*IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum $DCGL_w$ derived from the technical bases presented in HEM-MEMO-15-021 and HDP-TBD-FSS-003 "*Modeling and Calculation of Investigative Action Levels for Final Status Soil Survey Units*", Westinghouse, March 2015.		

LSA 10-02

Within LSA 10-02, there were two systematic locations in which portions of the surface stratum [0 – 15 centimeters (cm)] remained in the SU after remediation. At these locations, the remaining surface stratum interval was collected using a hand trowel. Portions of the root stratum (15 cm – 150 cm) remained at two of the eight systematic locations. At these locations the remaining root stratum interval was collected using a hand auger and composited. Excavation stratum samples were collected at all eight locations using either hand trowels for six-inch grabs below the existing excavation surface or hand augers where necessary. However, since both surface and root samples were collected at two locations and no root stratum composite samples exceeded a SOF of 0.5, it was not necessary to analyze excavation stratum samples collected at those two locations which had successful surface and root stratum results.

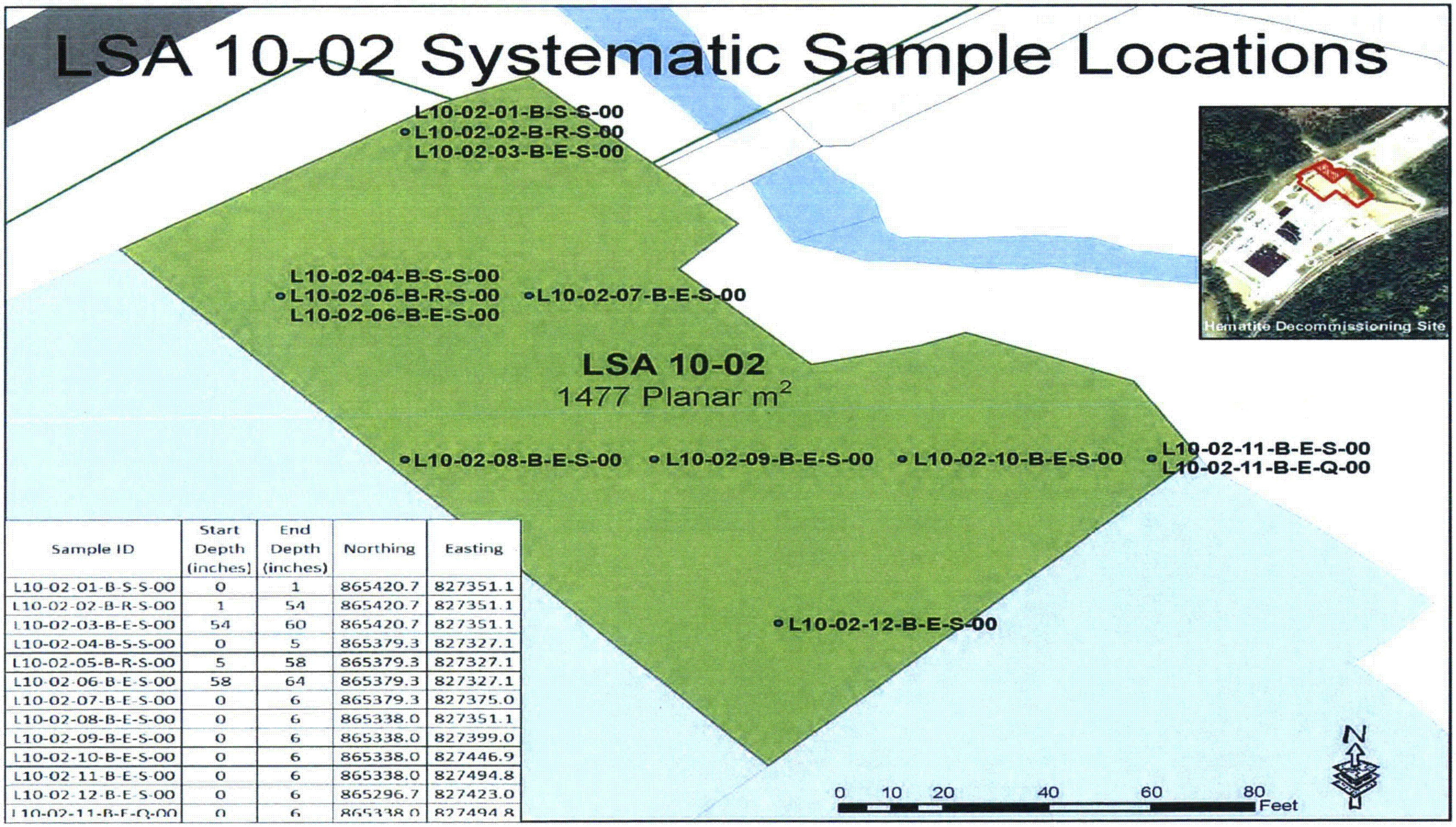
Given a planar area of 1,477 m^2 for LSA 10-02 and an eight - point systematic triangular grid, the point-to-point distance within each row was 14.6 m with spacing of 12.6 m between each of the parallel grid rows within the SU.

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

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

Figure 5-3 below presents the map of the eight systematic sample locations which were collected within LSA 10-02. The inset table notes the location coordinates (Missouri East, NAD 1983) and collection intervals for each systematic location.

Figure 5-3
LSA 10-02 Systematic Sample Locations



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

Figure 5-4 below presents a tabular listing of all FSS samples collected within LSA 10-02 with associated IDs, sample types, collection intervals, coordinates, and notes.

Figure 5-4
FSS Sample Locations and Coordinates for LSA 10-02

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

APPENDIX P-4
FSS SAMPLE & MEASUREMENT LOCATIONS & COORDINATES

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

Measurement or Sample ID	Surface or CSM	Type	Start Elevation	End Elevation	Northing (Y Axis) *	Easting (X Axis) *	Remarks / Notes
L10-02-01-B-S-S-00	Surface	S	432.6	432.5	865420.7	827351.1	Surface 1-inch grab
L10-02-02-B-R-S-00	Root	S	432.5	428.1	865420.7	827351.1	Root 4.4-foot composite
L10-02-03-B-E-S-00	Excavation	S	428.1	427.6	865420.7	827351.1	Excavation 6-inch grab
L10-02-04-B-S-S-00	Surface	S	436.2	435.8	865379.3	827327.1	Surface 5-inch grab
L10-02-05-B-R-S-00	Root	S	435.8	431.3	865379.3	827327.1	Root 4.4-foot composite
L10-02-06-B-E-S-00	Excavation	S	431.3	430.8	865379.3	827327.1	Excavation 6-inch grab
L10-02-07-B-E-S-00	Excavation	S	424.7	424.2	865379.3	827375.0	Excavation 6-inch grab
L10-02-08-B-E-S-00	Excavation	S	426.9	426.4	865338.0	827351.1	Excavation 6-inch grab
L10-02-09-B-E-S-00	Excavation	S	423.5	423.0	865338.0	827399.0	Excavation 6-inch grab
L10-02-10-B-E-S-00	Excavation	S	418.9	418.4	865338.0	827446.9	Excavation 6-inch grab
L10-02-11-B-E-S-00	Excavation	S	422.3	421.8	865338.0	827494.8	Excavation 6-inch grab
L10-02-12-B-E-S-00	Excavation	S	422.3	421.8	865296.7	827423.0	Excavation 6-inch grab
L10-02-11-B-E-Q-00	Excavation	Q	422.3	421.8	865338.0	827494.8	Excavation 6-inch grab
L10-02-13-B-E-B-00	Excavation	B	429.5	419.6	865341.1	827408.1	Excavation 6-inch grab

Samples highlighted in red will be collected and archived; radiological analyses required only if overlying root sample has a SOF >0.5.

* Missouri - East State Plane Coordinates [North American Datum (NAD) 1983]
Surface: Floor = F; Wall = W; Ceiling = C; Roof = R
CSM: Three-Layer (Surface-Root-Excavation) with conservative use of Uniform DCGLs
Type: Systematic = S, Biased = B; QC =Q; Investigation = I

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

Quality Record

Table 5-6 presents an overall FSS design and implementation summary table for LSA 10-02.

Table 5-6
FSS Design and Implementation Summary Table: LSA 10-02

Gamma Walkover Survey (GWS):		
Scan Coverage	100% accessible excavation floors, benches, pits, and sidewalls	
Scan MDC	83.6 pCi/g total Uranium (based on a 10,000 cpm background)	
Investigation Action Level (IAL)	4,000 net cpm*	
Systematic Sampling Locations:		
Depth	Number of Samples	Comments
0 – 15 cm (Surface)	2	These samples were collected on a systematic grid.**Analysis of excavation stratum samples is/was not required if there was surface stratum collected at sample grid location and the overlying root stratum SOF result was less than 0.5.
15 cm – 1.5 m (Root)	2	
> 1.5m (Excavation)	8**	
Biased Survey/Sampling Locations:		
Biased samples may be collected during GWS at the discretion of the HP Technician, after statistical analysis of the survey data, or at the direction of the FSS Supervisor.		
Instrumentation		
Ludlum 2221 with 44-10 (2" x 2" NaI) detector; with collimation for investigations.	Used for GWS and to obtain static count rates at biased measurement locations.	
*IAL is the net count per minute (ncpm) equivalent of an activity concentration less than the Uniform Stratum $DCGL_w$ derived from the technical bases presented in HEM-MEMO-15-021 and HDP-TBD-FSS-003 "*Modeling and Calculation of Investigative Action Levels for Final Status Soil Survey Units*", Westinghouse, March 2015.		

6.0 SURVEY RESULTS

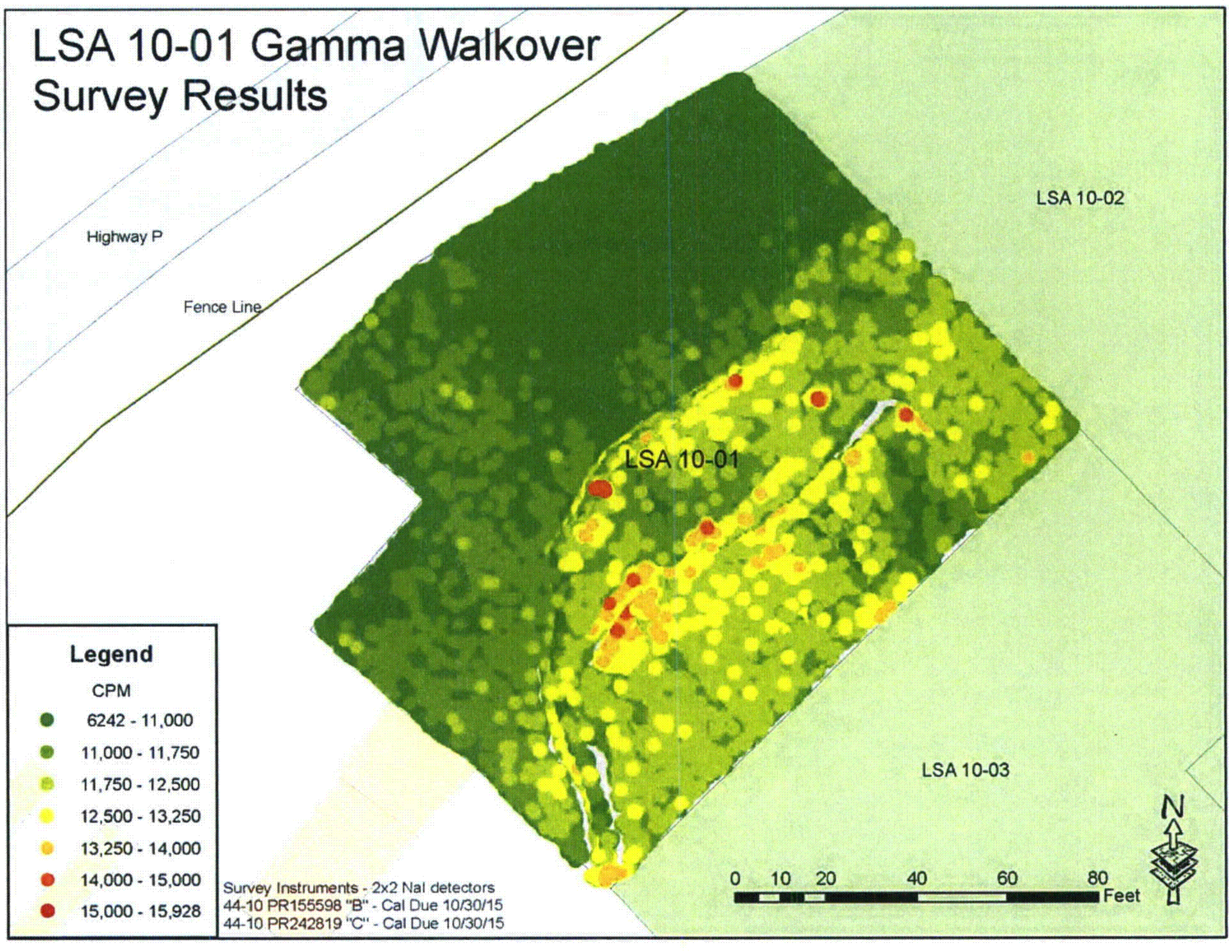
6.1 Gamma Walkover Survey (GWS) Results

GWS measurements were collected in LSA 10-01 and LSA 10-02 between January 22, 2015 and February 2, 2015.

6.1.1 GWS Results LSA 10-01

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

Figure 6-1
Colorimetric GWS Plot for LSA 10-01

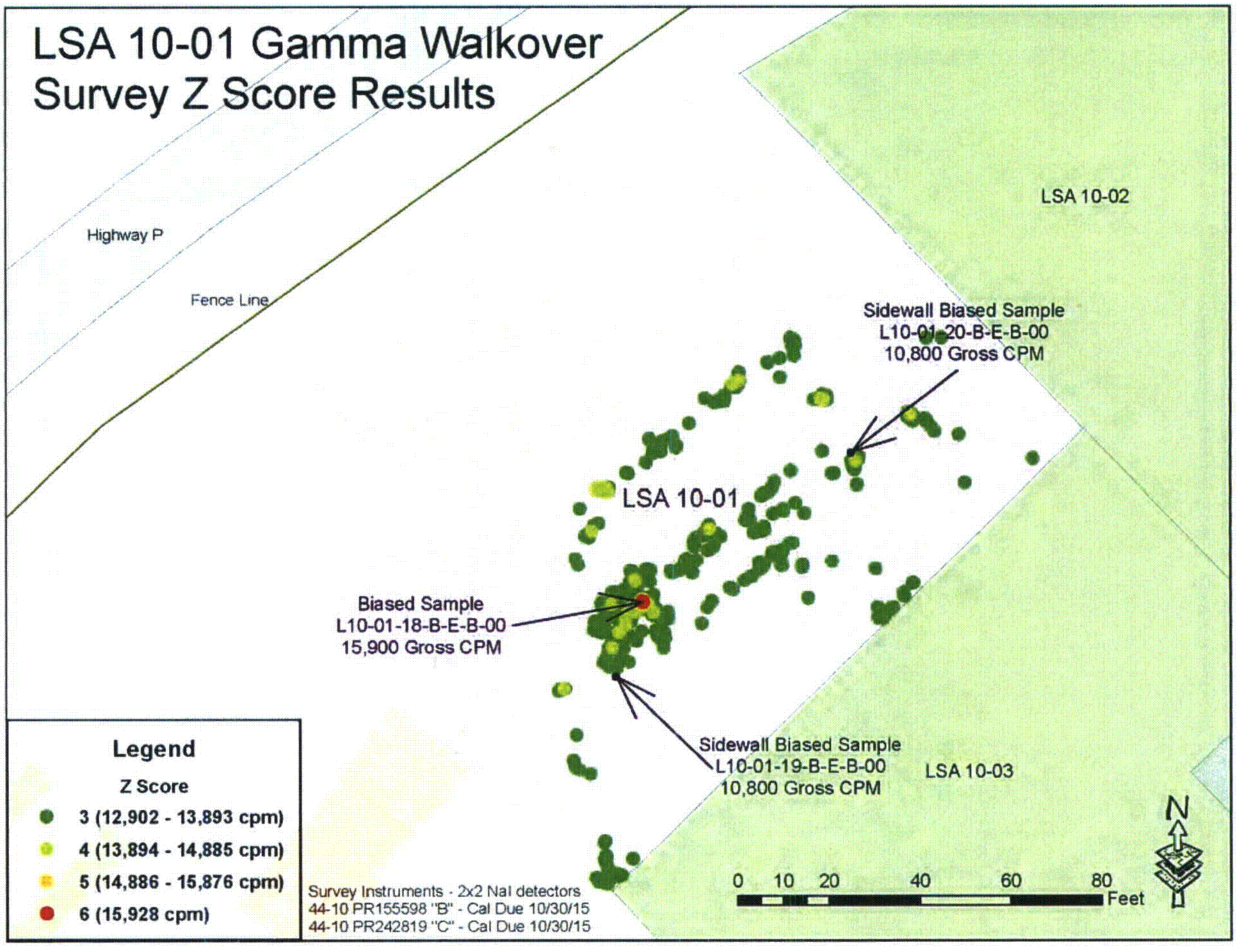


An evaluation of the entire GWS data set was performed to evaluate those small areas of elevated activity which exceeded three (3) standard deviations above the GWS mean measurement, (i.e., "+3 Z-score"). One location, L10-01-18, was selected for biased sample collection. This biased location represented the maximum GWS measurement encountered within the survey unit. Also, this single biased location was the only point which exceeded both

the IAL based on the local background readings and a Z-score of 3. Therefore, no additional biased locations were selected for sampling.

Figure 6-2 below presents a map of the +3 Z-score GWS measurements within LSA 10-01, including the selected biased sampling location (ID: L10-01-18-B-E-B-00).

Figure 6-2
Colorimetric GWS Plot for LSA 10-01 (Measurements > Z-score of 3)



A total of 39,381 individual GWS measurements were collected in LSA 10-01. Using a conservative side-to-side movement distance of 1 foot, and given the internal SU surface area of LSA 10-01 of approximately 21,000 square feet, the average estimated surveyor speed during GWS of LSA 10-01 was approximately 0.5 ft/sec. Since this retrospectively estimated scanning speed was less than the 1.0 ft/second FSS Plan requirement and the fact that the NaI probe was maintained as close as possible to the surface, actual scan MDCs based on real field conditions would have been considerably less than the 82.6 pCi/g total Uranium Scan MDC estimate determined during the FSS planning phase for this SU. It should also be noted that the 82.6 pCi/g Scan MDC prospectively estimated for LSA 10-01 assumed a surveyor efficiency of 0.5. Since all GWS data collected in LSA 10-01 was datalogged and post-processed in GIS software, the surveyor efficiency can effectively be set to 1.0 as discussed in Section 14.4.4.2.9 of the DP.

Using these parameters, a more realistic scan MDC of approximately 35.5 pCi/g is determined. The technical basis document, HDP-TBD-FSS-002, prepared after the completion of field FSS activities in LSA 10-01, presents the modeling assumptions and evaluation of scan MDCs for FSS reflecting actual technical implementation of the GWS, rather than using default parameters such as presented in NUREG-1507. The equation used to derive the revised Total Uranium Scan MDC (with a conservative estimate of 4% enrichment) from Section 1.1.5 of HDP-TBD-FSS-002 is as follows:

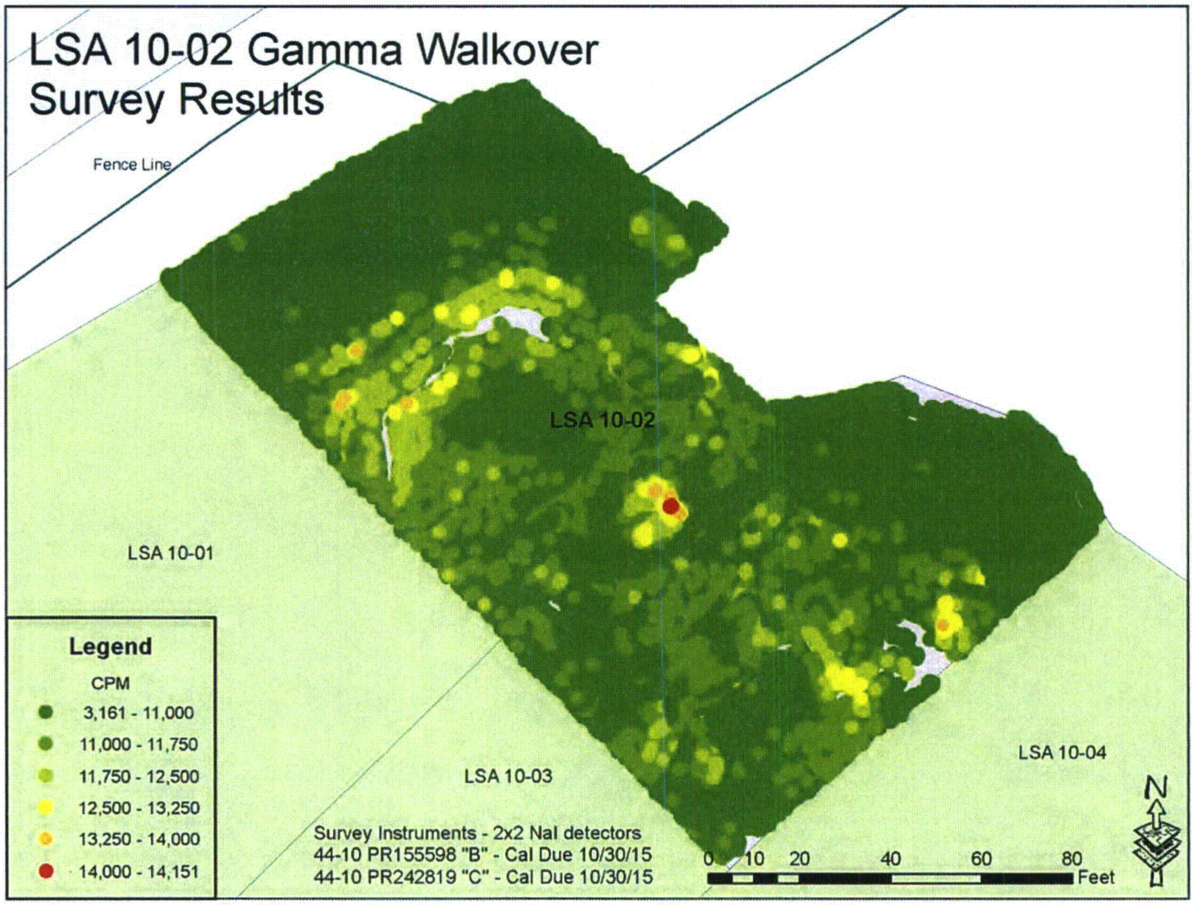
$$\text{Scan MDC}_{Total\ Uranium} = 1 \Big/ \left(\left(\frac{0.7928}{3169}\right) + \left(\frac{0.0438}{2.01}\right) + \left(\frac{0.1634}{26.5}\right) \right) = 35.5 \frac{pCi}{g}$$

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 1.04 pCi/g and 0.75 pCi/g, respectively using a two inch air gap. A two inch air gap is utilized as a conservative measure considering NUREG-1507 states that the position relates to the average height of the detector. The FSS 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.

6.1.2 GWS Results LSA 10-02

For LSA 10-02, GWS count rates ranged between 3,161 gcpm and 14,151 gcpm, with a mean count rate of 9,781 gcpm. The median count rate was 10,184 gcpm with a standard deviation of 1,284 cpm. **Figure 6-3** below presents a map of the complete GWS data set.

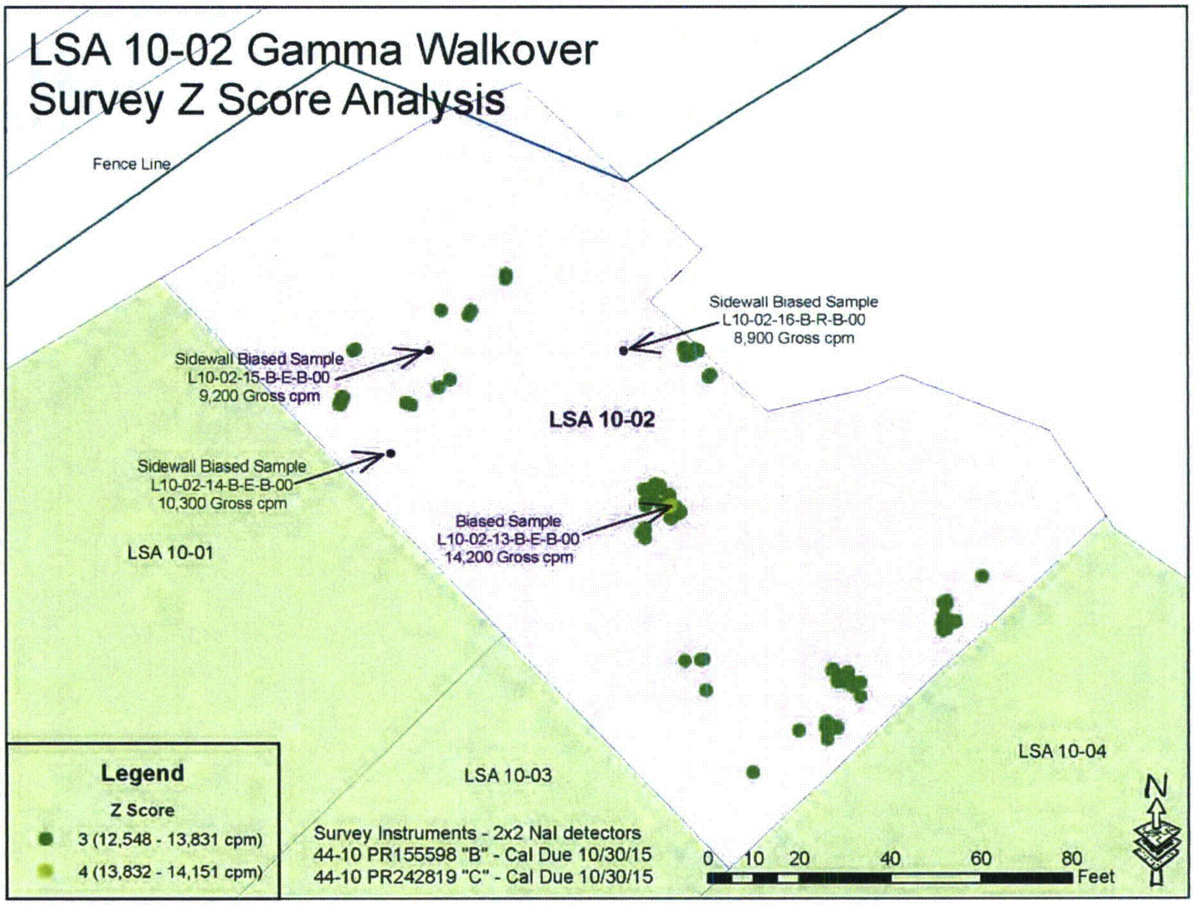
Figure 6-3
Colorimetric GWS Plot for LSA 10-02



Although 100% of accessible areas underwent GWS, certain small areas of the LSA 10-02 interior could not be accessed for GWS due to overly steep side slopes or especially tall interior pit sidewalls. These areas appear as pink blanks in the **Figure 6-3** above. Given the overall uniformity of the GWS measurements and scarcity of measurements exceeding the IAL, it can be reasonably assumed that radioactivity in the blank areas can be interpolated from neighboring measurements. 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, L10-02-13, was selected for biased sample collection.

Figure 6-4 below presents a map of the +3 Z-score GWS measurements within LSA 10-02, including the selected biased sampling location (ID: L10-02-13-B-E-B-00).

Figure 6-4
Colorimetric GWS Plot for LSA 10-02 (Measurements > Z-score of 3)



A total of 37,199 GWS measurements were collected in LSA 10-02. Using a conservative side-to-side movement distance of 1 foot, and given the internal SU surface areas of LSA 10-02 of approximately 21,000 square feet, the average estimated surveyor speed during GWS of LSA 10-02 was approximately 0.5 ft/sec. Since this retrospectively estimated scanning speed was less than the 1.0 ft/second FSS Plan requirement and the fact that the NaI probe was maintained as close as possible to the surface, actual scan MDCs based on real field conditions would have been considerably less than the 83.6 pCi/g total Uranium Scan MDC estimate determined during the FSS planning phase for this SU. It should also be noted that the 83.6 pCi/g Scan MDC prospectively estimated for LSA 10-02 assumed a surveyor efficiency of 0.5. Since all GWS data collected in LSA 10-02 was datalogged and post-processed in GIS software, the surveyor efficiency can effectively be set to 1.0 as discussed in Section 14.4.4.2.9 of the DP. Using these parameters, a more realistic scan MDC of approximately 35.5 pCi/g is determined. The technical basis document, HDP-TBD-FSS-002, *Evaluation and Documentation of the Scanning Minimum Detectable Concentration (MDC) for Final Status Survey (FSS)* prepared after the completion of field FSS activities in LSA 10-02, presents the modeling assumptions and

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

$$\text{Scan MDC}_{\text{Total Uranium}} = 1 \Big/ \left(\left(\frac{0.7928}{3169}\right) + \left(\frac{0.0438}{2.01}\right) + \left(\frac{0.1634}{26.5}\right) \right) = 35.5 \frac{pCi}{g}$$

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 1.04 pCi/g and 0.75 pCi/g, respectively using a two inch air gap. A two inch air gap is utilized as a conservative measure considering NUREG-1507 states that the position relates to the average height of the detector. The FSS 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.

6.2 Surface Soil Sample Results

6.2.1 LSA 10-01

There were three (3) samples collected within the surface stratum (0 – 15 cm) of LSA 10-01. However, there were a total of ten (10) soil samples collected within the topmost soil layer of the excavation surface including eight systematic samples, one biased sample, and one QC field duplicate sample. Per Step 7.8.3 of HDP-PR-FSS-721 *Final Status Survey Data Evaluation*, the Wilcoxon Rank Sum (WRS) statistical test was performed for LSA 10-01 since the difference between the maximum survey unit data set gross SOF and the minimum background area adjusted SOF was greater than one. The WRS evaluation is included in Appendix A. QC and biased sample results are not utilized in the WRS test. The eight systematic samples collected in the "topmost" excavation surface layer were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The survey unit passed the WRS test since the ranked sum of the reference area ranks was greater than the critical value for the test. As such, the null hypothesis that the survey unit average concentration is greater than the $DCGL_W$ was rejected. The maximum SOF result for the "topmost" samples was 0.40 corresponding to the QC field replicate sample L10-01-13-B-E-Q-00, with the biased sample (L10-01-18-B-E-B-00) resulting in a 0.28 SOF.

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

6.2.2 LSA 10-02

There were two (2) samples collected within the surface stratum (0 – 15 cm) of LSA 10-02. However, there were a total of ten (10) soil samples collected within the topmost soil layer of the excavation surface including eight systematic samples, one biased sample, and one QC field duplicate sample. Per Step 7.8.3 of HDP-PR-FSS-721, *Final Status Survey Data Evaluation*, the WRS statistical test was not necessary for LSA 10-02, since the difference between the maximum survey unit data set gross SOF and the minimum background area adjusted SOF was

less than one. However, for illustrative purposes, the WRS evaluation was performed for LSA 10-02 and is included in Appendix B. QC and biased sample results are not utilized in the WRS test. The eight systematic samples collected in the "topmost" excavation surface layer were ranked against the adjusted activity concentrations of the 32 samples collected within the Background Reference Area. The survey unit passed the WRS test since the ranked sum of the reference area ranks was greater than the critical value for the test. As such, the null hypothesis that the survey unit average concentration is greater than the $DCGL_W$ was rejected. The maximum SOF result for "topmost" samples in LSA 10-02 was 0.10 corresponding to the systematic sample L10-02-08-B-E-B-00, with the biased sample (L10-02-13-B-E-B-00) resulting in a 0.08 SOF.

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

6.3 Subsurface Soil Sample Results

6.3.1 LSA 10-01

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

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

6.3.2 LSA 10-02

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

The LSA 10-02 subsurface samples are presented in **Appendix B**.

6.4 Graphical Data Review LSA 10-01

6.4.1 LSA 10-01

Table 6-1 below presents summary results for the all systematically collected samples (includes surface, root, and excavation stratum samples, but not biased or QC samples) collected within LSA 10-01, and the associated SOF when compared to the Uniform Stratum $DCGL_W$s. The arithmetic average concentration resulted in a SOF of 0.19.

Table 6-1
LSA 10-01 FSS Sample Data Summary and Calculated SOF Values (Systematic)

Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Uniform DCGL)
Average	0.14	0.09	0.17	2.64	0.14	1.27	**0.19**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.74	0.03	0.69	0.02
Maximum	0.40	0.53	0.37	4.33	0.24	1.68	0.40*

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

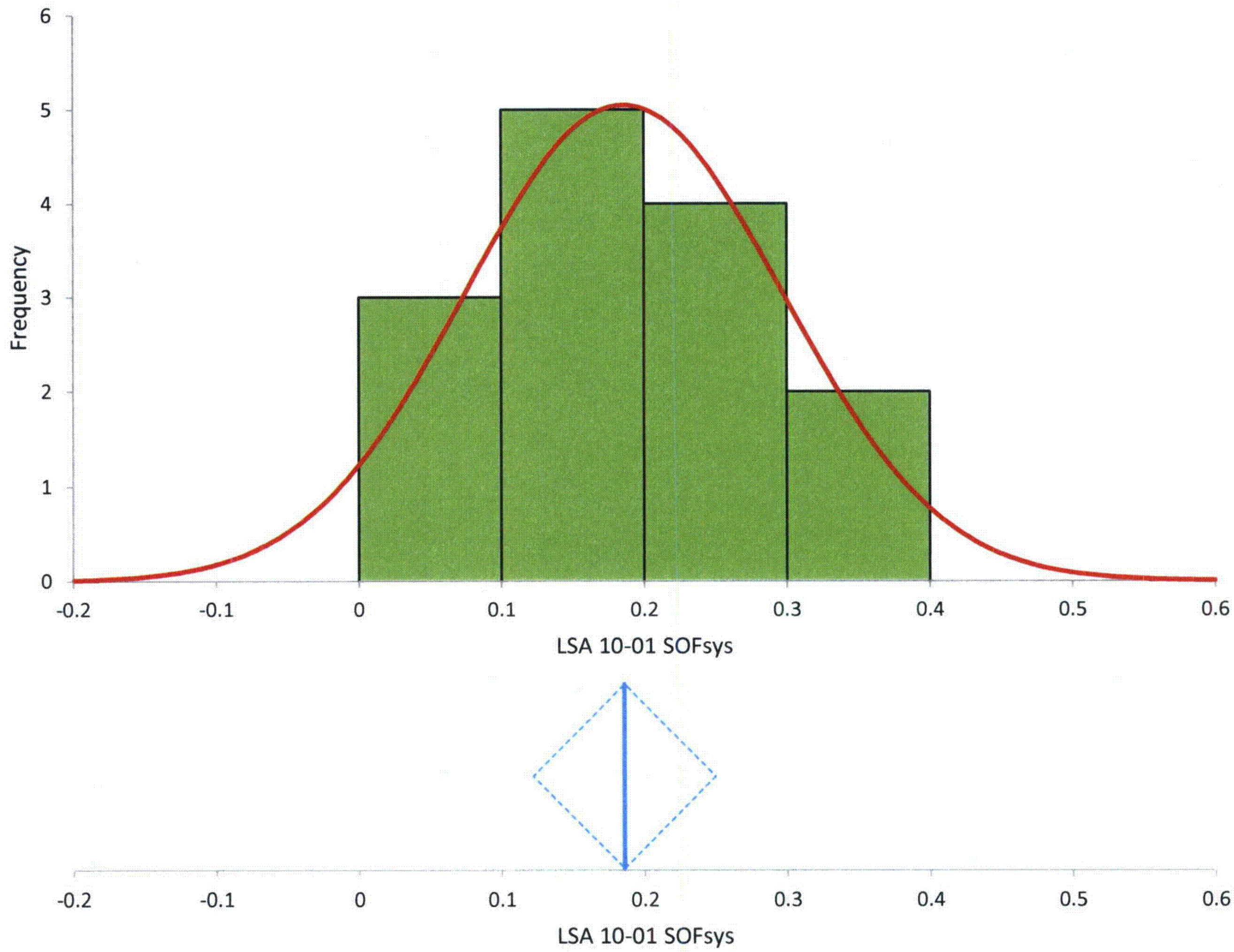
Notes:
1. All units are pCi/g.
2. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
3. Average SOF for data set calculated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

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

Figure 6-5 presents the overall statistical metrics for the SOF parameter for the 14 systematically collected samples from LSA 10-01. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-01. The middle graph presents the mean SOF (0.19 as indicated by the blue vertical line) of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.12 to 0.25. The 99% confidence interval based on the median (0.17) of the sample results is 0.07 to 0.25. The bottom two charts present the various statistical metrics of the LSA 10-01 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 6-5 exhibits no unusual symmetry or bimodality concerns for the LSA 10-01 data associated with the systematically collected measurement locations.

Figure 6-5
Graphic Statistical Summary for LSA 10-01 (SOF parameter)



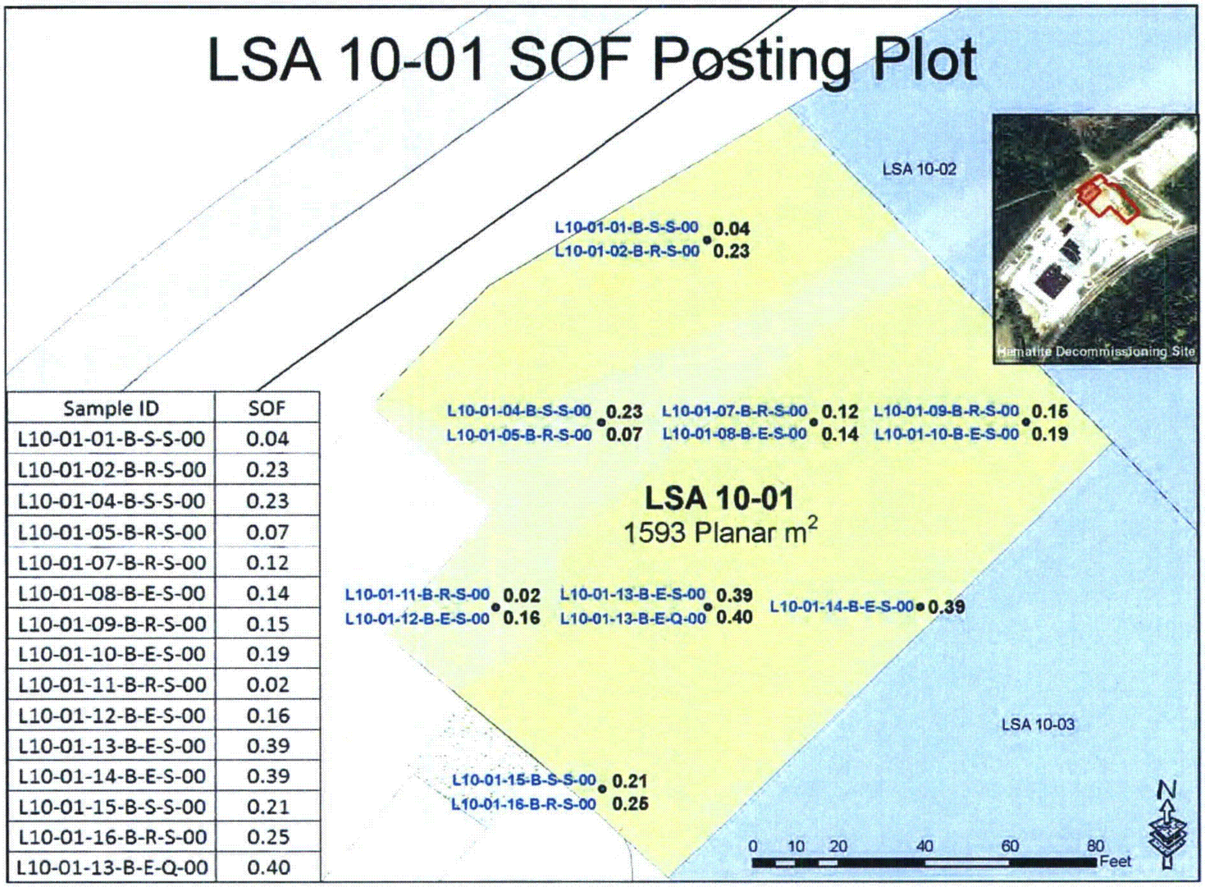
N	14

	Mean	95% Confidence Interval		Standard Error	Standard Deviation	Variance	Skewness	Kurtosis
LSA 10-01 SOFsys	0.19	0.12	to 0.25	0.03	0.11	0.01	0.6	0.03

	Minimum	1st quartile	Median	98.71% Confidence Interval		3rd quartile	Maximum	IQR
LSA 10-01 SOFsys	0.02	0.11	0.17	0.07	to 0.25	0.23	0.39	0.12

A posting plot is simply a map of the survey unit with the data values (in this case the SOF values for each systematically collected sample) entered at the measurement locations. This potentially reveals heterogeneities in the data – especially possible patches of elevated residual radioactivity. The posting plot for LSA 10-01 is presented below in **Figure 6-6**. **Figure 6-6** shows no unusual patterns in the data.

Figure 6-6
Posting Plot for LSA 10-01 Systematic Measurement Locations



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

Appendix A to this report presents the complete analytical data set used to derive the summary statistics presented in **Table 6-1, Figure 6-5**, and **Figure 6-6** above.

Table 6-2 presents the *primary* data evaluation worksheet table used to derive the statistical summary results presented in **Table 6-1, Figure 6-5**, and **Figure 6-6**.

Table 6-2
Final Status Survey Analytical Data: LSA 10-01

TestAmerica Analytical Results

Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	Ra-226 Result	Ra-226 Uncertainty	Ra-226 MDC	Ra-226 Qualifier	Ra-226 Net Result*	Ra-226 Corrected Result	Tc-99 Result	Tc-99 Corrected Result	Tc-99 Uncertainty	Tc-99 MDC	Tc-99 Qualifier
L10-01-01-B-S-S-00	0.29	S	1.010	0.170	0.087	N/A	-0.060	0.000	0.363	0.363	0.094	0.249	N/A
L10-01-02-B-R-S-00	0.49	S	1.270	0.179	0.078	N/A	0.200	0.200	0.019	0.019	0.069	0.227	U
L10-01-04-B-S-S-00	0.01	S	1.160	0.170	0.075	N/A	0.090	0.090	0.530	0.530	0.054	0.220	N/A
L10-01-05-B-R-S-00	0.49	S	1.080	0.164	0.068	N/A	0.010	0.010	0.016	0.016	0.016	0.220	U
L10-01-07-B-R-S-00	1.86	S	1.200	0.167	0.070	N/A	0.130	0.130	0.010	0.010	0.052	0.212	U
L10-01-08-B-E-S-00	4.92	S	1.140	0.161	0.071	N/A	0.070	0.070	0.001	0.001	0.028	0.220	U
L10-01-09-B-R-S-00	3.93	S	1.240	0.179	0.079	N/A	0.170	0.170	0.047	0.047	0.052	0.219	U
L10-01-10-B-E-S-00	4.92	S	1.210	0.197	0.103	N/A	0.140	0.140	0.033	0.033	0.075	0.224	U
L10-01-11-B-R-S-00	1.67	S	1.030	0.155	0.081	N/A	-0.040	0.000	0.132	0.132	0.020	0.215	U
L10-01-12-B-E-S-00	4.92	S	0.763	0.140	0.148	N/A	-0.307	0.000	-0.015	0.000	0.039	0.210	U
L10-01-13-B-E-S-00	6.14	S	1.470	0.200	0.069	N/A	0.400	0.400	-0.004	0.000	0.028	0.230	U
L10-01-14-B-E-S-00	7.95	S	1.400	0.183	0.074	N/A	0.330	0.330	0.021	0.021	0.030	0.252	U
L10-01-15-B-S-S-00	0.01	S	1.210	0.178	0.090	N/A	0.140	0.140	0.023	0.023	0.026	0.224	U
L10-01-16-B-R-S-00	0.49	S	1.300	0.181	0.067	N/A	0.230	0.230	0.017	0.017	0.052	0.228	U
L10-01-13-B-E-Q-00	6.14	Q	1.400	0.219	0.121	N/A	0.330	0.330	0.038	0.038	0.014	0.225	U
L10-01-18-B-E-B-00	13.25	B	1.270	0.199	0.099	N/A	0.200	0.200	-0.010	0.000	0.011	0.235	U
Systematic Mean			0.136						0.087				
Systematic Median			0.135						0.020				
Systematic Minimum			0.000						0.000				
Systematic Maximum			0.400						0.530				
Systematic Standard Deviation			0.124						0.159				
			With ingrowth, use Ra226 bkg =					1.07					

Sample ID	Th-232 Result	Th-232 Uncertainty	Th-232 MDC	Th-232 Qualifier	Th-232 Net Result**	Th-232 Corrected Result	Inferred U-234 Result	Inferred U-234 Uncertainty	Inferred U-234 MDC	Inferred U-234 Qualifier
L10-01-01-B-S-S-00	0.673	0.150	0.175	N/A	-0.327	0.000	3.521	NA	NA	NA
L10-01-02-B-R-S-00	1.200	0.185	0.112	N/A	0.200	0.200	3.150	NA	NA	NA
L10-01-04-B-S-S-00	1.250	0.216	0.079	N/A	0.250	0.250	4.331	NA	NA	NA
L10-01-05-B-R-S-00	1.090	0.190	0.109	N/A	0.090	0.090	2.587	NA	NA	NA
L10-01-07-B-R-S-00	1.040	0.187	0.134	N/A	0.040	0.040	2.882	NA	NA	NA
L10-01-08-B-E-S-00	1.160	0.172	0.102	N/A	0.160	0.160	3.009	NA	NA	NA
L10-01-09-B-R-S-00	1.060	0.169	0.097	N/A	0.060	0.060	3.806	NA	NA	NA
L10-01-10-B-E-S-00	1.190	0.206	0.115	N/A	0.190	0.190	1.603	NA	NA	NA
L10-01-11-B-R-S-00	1.000	0.160	0.099	N/A	0.000	0.000	2.072	NA	NA	NA
L10-01-12-B-E-S-00	1.270	0.201	0.106	N/A	0.270	0.270	3.621	NA	NA	NA
L10-01-13-B-E-S-00	1.340	0.203	0.132	N/A	0.340	0.340	0.738	NA	NA	NA
L10-01-14-B-E-S-00	1.370	0.200	0.136	N/A	0.370	0.370	2.928	NA	NA	NA
L10-01-15-B-S-S-00	1.240	0.189	0.093	N/A	0.240	0.240	1.084	NA	NA	NA
L10-01-16-B-R-S-00	1.220	0.188	0.128	N/A	0.220	0.220	1.571	NA	NA	NA
L10-01-13-B-E-Q-00	1.400	0.227	0.130	N/A	0.400	0.400	3.370	NA	NA	NA
L10-01-18-B-E-B-00	1.310	0.221	0.166	N/A	0.310	0.310	2.922	NA	NA	NA
Systematic Mean	0.174						2.636			
Systematic Median	0.195						2.905			
Systematic Minimum	0.000						0.738			
Systematic Maximum	0.370						4.331			
Systematic Standard Deviation	0.120						1.077			
	Th232 bkg =	1.0								

Sample ID	U-235 Result	U-235 Uncertainty	U-235 MDC	U-235 Qualifier	U-238 Result	U-238 Uncertainty	U-238 MDC	U-238 Qualifier	Enr. Enrichment (%)	SOF_N
L10-01-01-B-S-S-00	0.190	0.148	0.214	U	1.450	0.675	1.030	N/A	2.0	0.04
L10-01-02-B-R-S-00	0.172	0.140	0.245	U	1.070	0.572	0.904	N/A	2.5	0.23
L10-01-04-B-S-S-00	0.235	0.151	0.252	U	1.680	0.544	0.771	N/A	2.2	0.23
L10-01-05-B-R-S-00	0.140	0.190	0.319	U	1.020	0.559	0.878	N/A	2.1	0.07
L10-01-07-B-R-S-00	0.153	0.161	0.253	U	1.500	0.735	0.933	N/A	1.6	0.12
L10-01-08-B-E-S-00	0.165	0.138	0.188	U	0.905	0.385	1.110	U	2.8	0.14
L10-01-09-B-R-S-00	0.207	0.181	0.232	U	1.380	0.561	0.841	N/A	2.3	0.15
L10-01-10-B-E-S-00	0.082	0.151	0.334	U	1.210	0.672	1.060	N/A	1.1	0.19
L10-01-11-B-R-S-00	0.110	0.137	0.242	U	1.100	0.673	0.873	N/A	1.6	0.02
L10-01-12-B-E-S-00	0.200	0.116	0.178	N/A	0.689	0.341	0.943	U	4.4	0.16
L10-01-13-B-E-S-00	0.028	0.083	0.266	U	1.440	0.609	0.926	N/A	0.3	0.39
L10-01-14-B-E-S-00	0.158	0.164	0.272	U	1.260	0.600	0.935	N/A	2.0	0.39
L10-01-15-B-S-S-00	0.050	0.162	0.286	U	1.540	0.898	1.070	N/A	0.6	0.21
L10-01-16-B-R-S-00	0.078	0.152	0.270	U	1.500	0.573	0.852	N/A	0.9	0.25
L10-01-13-B-E-Q-00	0.185	0.185	0.300	U	0.997	0.638	1.020	U	2.9	0.40
L10-01-18-B-E-B-00	0.160	0.196	0.333	U	0.912	0.515	1.390	U	2.7	0.28
Systematic Mean	0.141				1.267				1.9	0.19
Systematic Median	0.156				1.320				Average Enrichment (%)	0.17
Systematic Minimum	0.028				0.689					0.02
Systematic Maximum	0.235				1.680					0.39
Systematic Standard Deviation	0.062				0.281					0.11

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 results are reported at the 2-σ confidence level.

6.4.2 LSA 10-02

Table 6-3 below presents summary results for the all systematically collected samples (includes surface, root, and excavation stratum samples, but not biased or QC samples) collected within LSA 10-02, and the associated SOF when compared to the ***Uniform*** $DCGL_W$. The arithmetic average concentration resulted in a SOF of 0.07.

Table 6-3
LSA 10-02 FSS Sample Data Summary and Calculated SOF Values (Systematic)

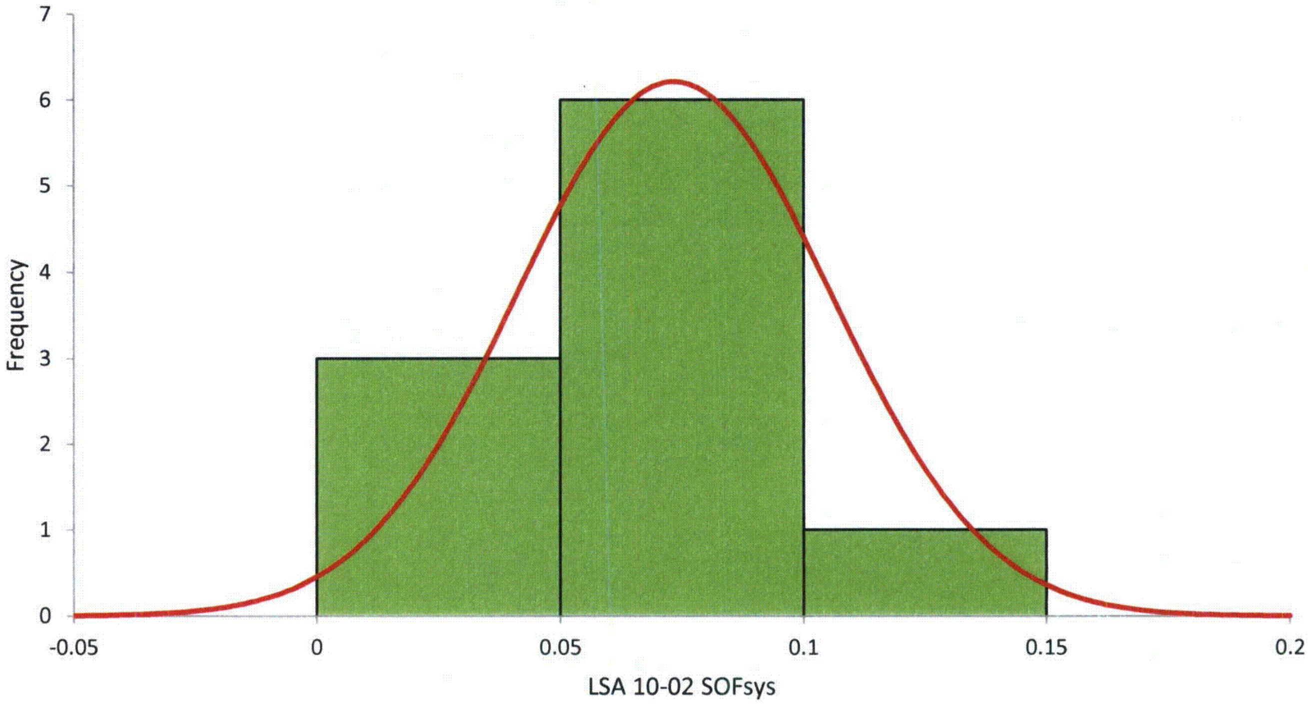
Statistic	Ra-226 DCGL = 1.9 BKG = 1.07 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Uniform DCGL)
Average	0.05	0.27	0.03	2.65	0.14	1.09	**0.07**
Minimum	0.00 (<BKG)	0.00 (NEG)	0.00 (<BKG)	0.89	0.04	0.52	0.03
Maximum	0.14	0.87	0.11	5.94	0.33	1.71	0.14

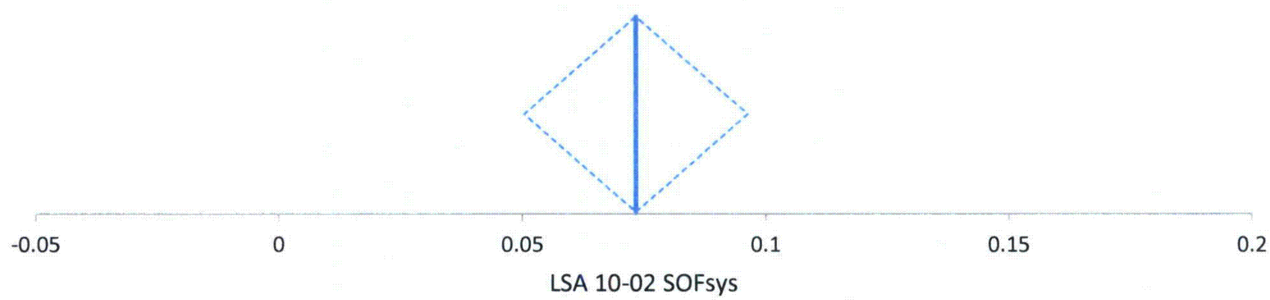
Notes:
1. All units are pCi/g.
2. Ra-226 and Th-232 background activities subtracted prior to calculating SOF value. Ra-226 background without ingrowth = 0.9 pCi/g; Ra-226 background with ingrowth = 1.07 pCi/g. Negative SOF components are set to zero in SOF calculation.
3. Average SOF for data set calculated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

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

Figure 6-7 below presents the overall statistical metrics (based on the SOF parameter) for the ten systematically samples collected within LSA 10-02. The top graph is a histogram and line plot of the SOF for the systematic data population for LSA 10-02. The middle graph presents the mean SOF (0.07 as indicated by the blue vertical line) of the sample population and the 95% confidence interval of the mean SOF represented by the blue diamond which is 0.05 to 0.10. The 98% confidence interval based on the median (0.07) of the sample results is 0.04 to 0.10. The bottom two charts present the various statistical metrics of the LSA 10-02 SOF data set, including the mean, median, standard deviation, minimum, maximum, confidence intervals, etc.

Figure 6-7
Graphic Statistical Summary for LSA 10-02 (SOF parameter)





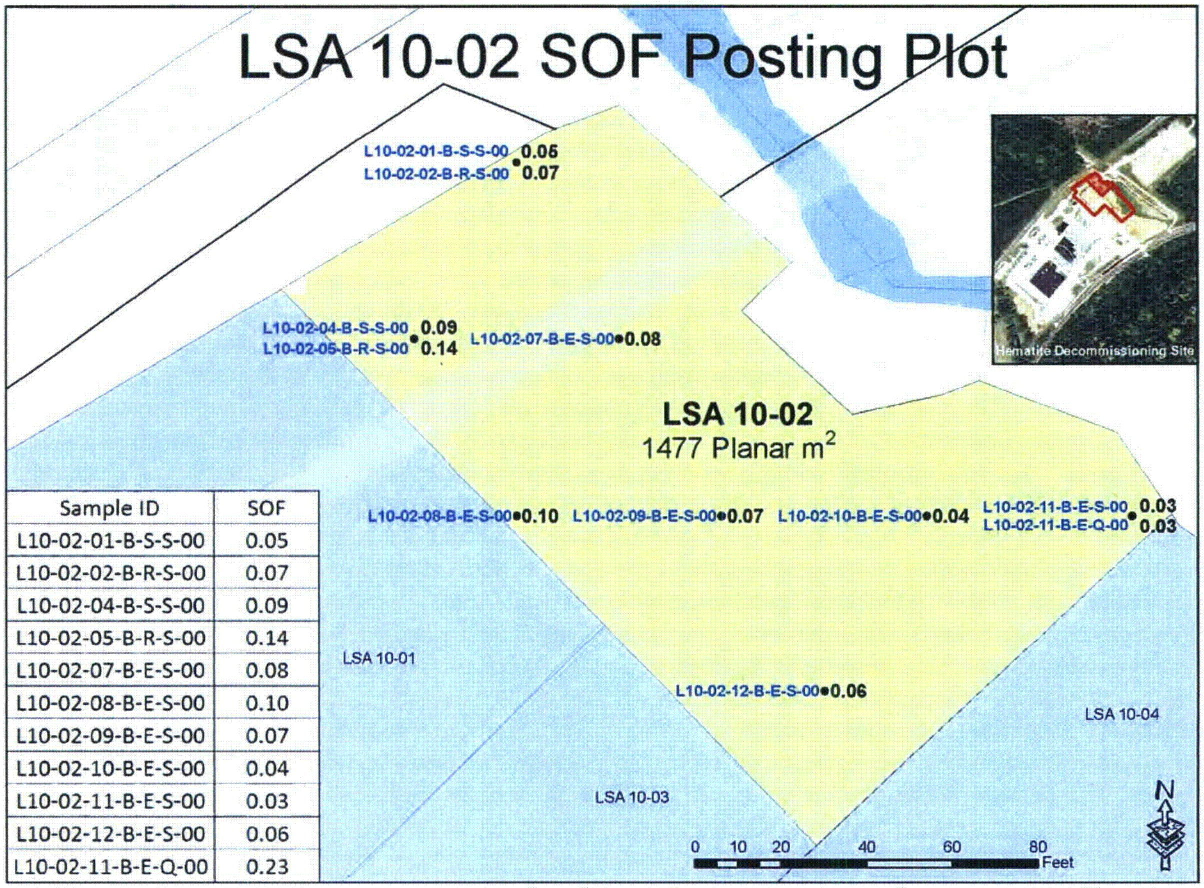
N	10

	Mean	95% Confidence Interval		Standard Error	Standard Deviation	Variance	Skewness	Kurtosis
LSA 10-02 SOFsys	0.07	0.05	to 0.10	0.01	0.03	0.001	0.8	0.91

	Minimum	1st quartile	Median	97.85% Confidence Interval		3rd quartile	Maximum	IQR
LSA 10-02 SOFsys	0.03	0.05	0.07	0.04	to 0.10	0.09	0.14	0.04

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 10-02 is presented below in **Figure 6-8** and shows no unusual patterns in the data.

Figure 6-8
Posting Plot for LSA 10-02 Systematic Measurement Locations



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

Appendix B to this report presents the complete analytical data set used to derive the summary statistics presented in **Table 6-3, Figure 6-7**, and **Figure 6-8** above.

Table 6-4 below presents the *primary* data evaluation worksheet table used to derive the statistical summary results presented in **Table 6-3, Figure 6-7**, and **Figure 6-8**.

Table 6-4
Final Status Survey Analytical Data: LSA 10-02

			TestAmerica Analytical Results																														
			Ra-226						Tc-99					Th-232						Inferred U-234				U-235				U-238				Enr.	SOF_N
Sample ID	Sample Depth (ft)	Type (Systematic, Bias, QC)	Result	Uncertainty	MDC	Qualifier	Net Result*	Corrected Result	Result	Corrected Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Net Result**	Corrected Result	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Result	Uncertainty	MDC	Qualifier	Enrichment (%)	SOF_N
L10-02-01-B-S-S-00	0.39	S	0.998	0.146	0.067	N/A	-0.072	0.000	0.443	0.443	0.079	0.243	N/A	0.987	0.161	0.108	N/A	-0.013	0.000	4.381	NA	NA	NA	0.242	0.115	0.159	N/A	0.858	0.308	0.826	N/A	4.3	0.05
L10-02-02-B-R-S-00	0.49	S	1.110	0.172	0.083	N/A	0.040	0.040	0.130	0.130	0.095	0.231	U	1.050	0.191	0.127	N/A	0.050	0.050	1.905	NA	NA	NA	0.099	0.161	0.286	U	1.190	0.355	0.929	N/A	1.3	0.07
L10-02-04-B-S-S-00	0.06	S	1.160	0.181	0.055	N/A	0.090	0.090	0.303	0.303	0.041	0.232	N/A	0.936	0.222	0.133	N/A	-0.064	0.000	3.433	NA	NA	NA	0.188	0.195	0.310	U	1.080	0.699	1.120	U	2.7	0.09
L10-02-05-B-R-S-00	0.49	S	1.210	0.165	0.067	N/A	0.140	0.140	0.019	0.019	0.090	0.240	U	1.110	0.172	0.137	N/A	0.110	0.110	0.889	NA	NA	NA	0.042	0.159	0.268	U	0.911	0.316	0.900	N/A	0.7	0.14
L10-02-07-B-E-S-00	6.09	S	1.170	0.211	0.134	N/A	0.100	0.100	0.042	0.042	0.129	0.256	U	1.040	0.192	0.161	N/A	0.040	0.040	1.125	NA	NA	NA	0.059	0.183	0.320	U	0.626	0.440	1.310	U	1.5	0.08
L10-02-08-B-E-S-00	5.17	S	1.160	0.159	0.066	N/A	0.090	0.090	-0.008	0.000	0.059	0.239	U	1.060	0.170	0.119	N/A	0.060	0.060	2.268	NA	NA	NA	0.118	0.153	0.261	U	1.410	0.534	0.800	N/A	1.3	0.10
L10-02-09-B-E-S-00	6.32	S	1.030	0.167	0.083	N/A	-0.040	0.000	0.871	0.871	0.119	0.237	N/A	1.050	0.207	0.084	N/A	0.050	0.050	1.760	NA	NA	NA	0.097	0.167	0.256	U	0.515	0.670	1.110	U	2.9	0.07
L10-02-10-B-E-S-00	9.53	S	0.941	0.151	0.086	N/A	-0.129	0.000	0.353	0.353	0.119	0.290	N/A	0.939	0.170	0.127	N/A	-0.061	0.000	2.274	NA	NA	NA	0.116	0.135	0.246	U	1.680	0.636	0.807	N/A	1.1	0.04
L10-02-11-B-E-S-00	4.93	S	0.956	0.154	0.074	N/A	-0.114	0.000	0.274	0.274	0.038	0.249	N/A	0.843	0.160	0.084	N/A	-0.157	0.000	2.477	NA	NA	NA	0.135	0.117	0.163	U	0.875	0.498	0.785	N/A	2.4	0.03
L10-02-12-B-E-S-00	7.88	S	0.734	0.107	0.041	N/A	-0.336	0.000	0.301	0.301	0.086	0.214	N/A	0.336	0.068	0.042	N/A	-0.664	0.000	5.938	NA	NA	NA	0.326	0.109	0.119	N/A	1.710	0.441	0.582	N/A	2.9	0.06
L10-02-11-B-E-Q-00	4.93	Q	0.812	0.125	0.059	N/A	-0.258	0.000	0.453	0.453	0.210	0.243	N/A	0.577	0.127	0.065	N/A	-0.423	0.000	1.840	NA	NA	NA	0.101	0.119	0.195	U	0.536	0.244	0.712	U	2.9	0.03
L10-02-13-B-E-B-00	9.86	B	0.953	0.173	0.101	N/A	-0.117	0.000	0.265	0.265	0.024	0.287	U	1.080	0.220	0.115	N/A	0.080	0.080	4.085	NA	NA	NA	0.224	0.184	0.320	U	1.240	0.700	1.100	N/A	2.8	0.08
Systematic Mean			0.046						0.274					0.031						2.645				0.142				1.086				2.1	0.07
Systematic Median			0.020						0.288					0.020						2.271				0.117				0.996				Average Enrichment (%)	0.07
Systematic Minimum			0.000						0.000					0.000						0.889				0.042				0.515					0.03
Systematic Maximum			0.140						0.871					0.110						5.938				0.326				1.710					0.14
Systematic Standard Deviation			0.054						0.260					0.038						1.546				0.087				0.411					0.03
			With ingrowth, use Ra-226 bkg =					1.07						Th-232 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.

6.5 Tc-99

6.5.1 Sidewall Sample Results for Tc-99

Westinghouse chose to conduct sidewall sampling in LSA 10-01 and LSA 10-02 to validate the technical adequacy of the approach as described in Section 5.1.4.4. Two discretionary samples were collected from the sidewalls of LSA 10-01. Due to a proportionately larger sidewall surface area, three samples were collected from the sidewalls of LSA 10-02. Although the collection of the sidewall samples was not driven by elevated gamma measurements, these samples will be treated as biased samples for the purposes of FSS data evaluation.

Table 6-5 below presents summary results for the discretionary sidewall samples collected within LSA 10-01 and LSA 10-02, and the associated SOF when compared to the ***Uniform*** $DCGL_W$.

Table 6-5
LSA 10-01 and LSA 10-02 Sidewall Sample Data Summary and Calculated SOF Values

Sample ID	Ra-226 DCGL = 1.9 BKG = 0.9 (pCi/g)	Tc-99 DCGL = 25.1 (pCi/g)	Th-232 DCGL = 2.0 BKG = 1.0 (pCi/g)	U-234 DCGL=195.4 (pCi/g)	U-235 DCGL=51.6 (pCi/g)	U-238 DCGL=168.8 (pCi/g)	Sample SOF (Uniform DCGL)
L10-01-19-B-E-B-00	1.149	0.360	1.023	7.587	0.233	< 4.911	0.20
L10-01-20-B-E-B-00	1.217	0.005	1.022	0.000	< 0.276	< 5.524	0.18
L10-02-14-B-E-B-00	1.361	-0.003	1.259	0.000	< 0.300	< 6.065	0.37
L10-02-15-B-E-B-00	1.415	-0.009	1.101	0.000	< 0.307	< 5.214	0.32
L10-02-16-B-R-B-00	1.334	-0.019	1.296	5.507	0.169	< 5.291	0.41

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

All sidewall samples collected in LSA 10-01 and LSA 10-02 had results well below a SOF value of 1 as evaluated against the Uniform Stratum DCGLs. The sidewall sample results indicated that the 10% threshold (i.e., 2.5 pCi/g Tc-99) is appropriate.

6.5.2 Tc-99 Hot Spot Assessment

During site characterization studies a total of 62 samples were collected and analyzed for Tc-99 in LSA-10-01 and LSA-10-02. The maximum sample identified was 31.1 pCi/g, with an overall mean and median concentration of 1.38 pCi/g and 0.32 pCi/g respectively. The 31.1 pCi/g result was the only sample result that exceeded the Uniform DCGL of 25.1 pCi/g for Tc-99

during site characterization and no samples exceeded the Tc-99 DCGL during RASS and FSS. It is also noted that the overall average of the entire sample column within the Uniform conceptual site model layer was below the Uniform DCGL for Tc-99.

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

6.6 QC Sample Results

One Quality Control (QC) field duplicate sample point was randomly selected for each SU and collected at systematic locations L10-01-13 and L10-02-11 for LSA 10-01 and LSA 10-02, respectively. Refer to Section 5.1.4.3 for a more detailed discussion of the QC sampling requirements.

For the 15 "regular" (i.e., 14 systematic + 1 biased) samples collected within LSA 10-01, one field duplicate sample was collected. This frequency equates to 6.7%, (i.e. 1/15). The results were documented on form HDP-PR-FSS-703-1 (see **Figure 6-9** below). Form HDP-PR-FSS-703-1 documents that the duplicate sample result compare wells with its partner's results – all comparison criteria were less than the calculated warning limits.

For the 11 "regular" (i.e., 10 systematic + 1 biased) samples collected within LSA 10-02, one field duplicate sample was collected. This frequency equates to 9.0%, (i.e. 1/11). The results were documented on form HDP-PR-FSS-703-1 (see **Figure 6-10** below). Form HDP-PR-FSS-703-1 documents that the duplicate sample result compares well with its partner's results – all comparison criteria less than the calculated warning limits.

Note that the duplicate sample quality assessment is not required when the activity value for a given nuclide is less than the MDC for either sample - duplicate or regular.

Figure 6-9
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment: LSA 10-01

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

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

Survey Unit No.:	LSA 10-01				Survey Unit Description:	North West Corner Survey Unit (North Burial Pit Area)						
Sample ID	Field Duplicate Sample ID	Radionuclide	Sample (pCi/g) 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)
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Ra-226	1.47	0.0692	1.4	0.121	1.435	1.9	0.07	0.269	0.403	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Tc-99	-0.00436	0.23	0.0376	0.225	0.01662	25.1	NA	3.552	5.321	NA
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	Th-232	1.34	0.132	1.4	0.13	1.370	2.0	0.060	0.283	0.424	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-234[1]	0.738	NA	3.370	NA	2.054	195.4	2.632	27.649	41.425	N
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-235	0.0277	0.266	0.185	0.3	0.106	51.6	NA	7.301	10.939	NA
L10-01-13-B-E-S-00	L10-01-13-B-E-Q-00	U-238	1.44	0.926	0.997	1.02	1.2185	168.8	NA	23.885	35.786	NA

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

Performed by: [signature] 2-27-15

Date: 2-27-15

Reviewed by: [signature]

Date: 3/16/15

Quality Record

Figure 6-10
Form HDP-PR-FSS-703-1 Field Duplicate Sample Assessment: LSA 10-02

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

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

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

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

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

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

Quality Record

6.7 ALARA Evaluation

All FSS samples collected within LSA 10-01 and LSA 10-02 were evaluated against the Uniform Stratum $DCGL_{WS}$ which features the most conservative set of DCGLs of the available CSMs. All FSS samples collected within LSA 10-01 and LSA 10-02, including biased samples, were less than the Uniform Stratum $DCGL_{WS}$ for each of the six ROCs. Also, no individual sample result exceeded a SOF of 1, with 0.40 and 0.14 being the maximum SOF values from the entire analytical data sets of LSA 10-01 and LSA 10-02, respectively.

The average SOF results based on all systematically collected samples were 0.19 and 0.07 for LSA 10-01 and 10-02, respectively. These average SOFs equate to residual activity contributions from the general survey unit areas of 4.75 and 1.75 mrem/year (mrem/yr) for LSA 10-01 and 10-02, respectively. Assuming a maximum groundwater contribution of 4.0 mrem/yr based on a very conservative assignment of groundwater concentrations in HDP monitoring wells equal to the U.S. Environmental Protection Agency (EPA) maximum concentration limits (MCLs), and that onsite reuse material will be used as backfill with a maximum contribution of 7.75 mrem/yr based on the most conservative reuse dose from Stockpile 5-6, the total estimated doses for LSA 10-01 and LSA 10-02 are 16.55 and 13.50 mrem/yr, respectively. Since these estimated TEDEs are well below the license release criterion of 25 mrem/yr, the conclusion is that the remediation of LSA 10-01 and LSA 10-02 achieved HDP ALARA goals.

6.8 Data Quality Assessment

6.8.1 Selection and Training of Personnel

Health Physics (HP) personnel who performed FSS tasks within LSA 10-01 and LSA 10-02 met the qualifications listed in HDP-PR-HP-102, *Health Physics Technician Training* and have received training and instruction commensurate with their duties. The RSO has approved all FSS personnel to perform work associated with their individual roles and responsibilities. Training records are documented in accordance with HDP-PR-GM-020, *Training Material Development and Documentation of Training.*

6.8.2 Instrumentation Operation and Daily Quality Control

The instruments used for FSS were operated in accordance with procedure HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey.* Prior to field use, all FSS instrumentation underwent a receipt inspection by HDP Quality Assurance personnel. All instrumentation used for FSS within LSA 10-01 and LSA 10-02 was verified to be within the current calibration period. Prior to and after FSS use, daily source checks were performed to verify instrument responses were within ±20% of the calculated mean based on the initial set-up of the instrument per HDP-PR-HP-411, *Radiological Instrumentation.* All QC check logs were reviewed for the appropriate dates and verified to have been both pre- and post-checked in accordance with the procedure with no discrepancies noted. Prior to collection of FSS data, HP technicians confirmed that environmental conditions (e.g. manufacturer's operating temperature range, minimal standing water) were acceptable for use. **Appendix H**, Instrumentation Quality Control, presents all initial set-ups, daily pre- and post-use source checks, and control charts for FSS instrumentation used within LSA 10-01 and LSA 10-02.

6.8.3 Survey Records and Documentation

Appendix A presents the analytical results from LSA 10-01 FSS soil sampling. **Appendix B** presents the analytical results from LSA 10-02 FSS soil sampling. All sample results were independently reviewed, recorded, and stored in accordance with procedure HDP-PR-FSS-721, *Final Status Survey Data Evaluation.* All results from samples associated with LSA 10-01 and LSA 10-02 were loaded into the Hematite FSS database and verified to be in units of picocuries per gram (pCi/g) consistent with the units used for the site DCGL values to which they were compared.

6.8.4 Analytical Data Review and Validation

Prior to review and evaluation of FSS data, all analytical results were confirmed to be reported in units of pCi/g, and in agreement with the DCGLs units applied to release of Land Survey Areas.

Within each LSA (10-01, 10-02), eight systematic samples were collected at the excavation surface layer. For LSA 10-01, two individual gross SOF results in the FSS data set exceeded the $DCGL_w$ (SOF of 1.0) by more than the adjusted SOF of the minimum background reference area result using the Uniform Stratum criteria. Therefore, the WRS test was required for LSA 10-01. Since the test statistic, W_R (782) exceeded the critical value (705), the FSS data set passed the WRS Test and the null hypothesis was rejected.

For LSA 10-02, no individual gross SOF result in the FSS data set exceeded the $DCGL_w$ (SOF of 1.0) by more than the adjusted SOF of the minimum background reference area result using the Uniform Stratum criteria. Therefore, the WRS test was not required for LSA 10-02. The WRS Test worksheets are presented in Appendix A and Appendix B for LSA 10-01 and LSA 10-02, respectively.

The maximum SOF result for all surface samples within LSA 10-01 was 0.40; for LSA 10-02 the maximum subsurface SOF result was 0.10. The maximum SOF result for all subsurface samples within LSA 10-01 was 0.25; for LSA 10-02 the maximum subsurface SOF result was 0.14. The average SOF result for all systematically collected samples within LSA 10-01 was 0.19; for LSA 10-02 the average SOF result for all systematically collected samples was 0.07.

Since no FSS sample result in either LSA (10-01 or 10-02) exceeded a SOF of 1 as compared to the Uniform Stratum criteria, no elevated measurement comparisons (EMC) or supplemental investigations were required. For the same reason, no comparisons to the alternate "Three-Layer" multi-CSM (i.e. Surface, Root and Excavation) DCGLs were necessary.

A retrospective sampling frequency evaluation was performed to determine if sufficient statistical power exists to reject the null hypothesis based on the total number (8) of systematic samples actually collected within each SU. The successful result of the retrospective power evaluations presented in **Table 6-6** and **Table 6-7** for LSA 10-01 and LSA 10-02, respectively, indicate that the minimum number of samples required (8) for the WRS Test were equal to the number of sampling locations actually collected within each LSA. The methodology used for the retrospective sampling frequency evaluation is similar to the prospective sample size determination performed during FSS Plan Development except that actual FSS sample results

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

Table 6-6
Retrospective Sample Size Verification for LSA 10-01

Uniform DCGL Criteria Evaluation	
Retrospective N/2 Value Verification	
Isotope(s)	SOF (Ra/Tc/Th/Iso U)
St. Dev.*	0.14
$DCGL_{SOF}$	1
LBGR (Mean)*	0.19
Shift	0.81
Relative Shift (Δ/σ)	5.76
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
Min Required N/2	8
FSS N/2	8
Verification Check	SUFFICIENT MEASUREMENTS

* Statistics derived from the eight "topmost", or excavation surface layer samples only

"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

Table 6-7
Retrospective Sample Size Verification for LSA 10-02

Uniform DCGL Criteria Evaluation	
Retrospective N/2 Verification	
Isotope(s)	SOF (Ra/Tc/Th/Iso U)
St. Dev.*	0.02
$DCGL_{SOF}$	1
LBGR (Mean)*	0.07
Shift	0.93
Relative Shift (Δ/σ)	37.77
MARSSIM Table 5.1 (P_r)	1.000000
N	12
N + 20%	14.4
Required N/2	8
FSS N/2	8
Verification Check	SUFFICIENT MEASUREMENTS

* Statistics derived from the eight "topmost", or excavation surface layer samples only

"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

Sample results were independently reviewed and validated in accordance with HDP-PR-FSS-721, *Final Status Survey Data Evaluation*, and are provided in **Appendix A** and **Appendix B** for LSA 10-01 and LSA 10-02, respectively. The calculated average SOF value for LSA 10-01 when compared to the Uniform Stratum DCGLs is 0.19, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.25. The calculated average SOF value for LSA 10-02 when compared to the Uniform Stratum DCGLs is 0.07, with an upper 95% confidence level (UCL_{mean} 0.95) of 0.10. Biased and QC samples were not included in the calculation of the average SOF value.

All samples sent for analysis at the approved offsite laboratory (TestAmerica, Earth City, MO) were tracked on a chain of custody form in accordance with HDP-PR-QA-006, *Chain of Custody* (Reference 7.9).

Systematic samples were collected on a random-start triangular grid, biased samples were collected at two locations exceeding the IAL (one from each LSA), and gamma scan surveys were performed in accordance with procedures HDP-PR-FSS-701, *Final Status Survey Plan Development*; HDP-PR-FSS-711, *Soil and Sediment Sampling for Final Status Survey* (Reference 7.7); and HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Surveys*.

Duplicate FSS samples were collected in accordance with HDP-PR-FSS-703, *Final Status Survey Quality Control*. QC Sample Results were verified to meet the acceptance criteria as specified in HDP-PR-FSS-703, *Final Status Survey Quality Control*.

Field and laboratory instruments were capable of detecting activity at an MDC less than the appropriate investigation level, and were verified to be within acceptable operating ranges prior to and after FSS use in accordance with HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey*.

The following four figures document the completed Data Evaluation Checklists prepared for LSA 10-01 and LSA 10-02.

Figure 6-11A
Data Evaluation Checklists prepared for LSA 10-01 (page 1 of 2)

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

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

Survey Unit: 01 **Description:** Northern Pits; northwest SU in Area 1

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

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

Comments:

Quality Record

Figure 6-11B
Data Evaluation Checklists prepared for LSA 10-01 (page 2 of 2)

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

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

Survey Area: No. LSA 10 **Description:** Burial Pits Open Land Area

Survey Unit: No. 01 **Description:** Northern Pits; northwest SU in Area 1

Discrepancy: N / A

Corrective Actions Taken: N / A

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

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

Quality Record

Figure 6-12A
Data Evaluation Checklists prepared for LSA 10-02 (page 1 of 2)

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

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

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

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

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

Comments:

Figure 6-12B
Data Evaluation Checklists prepared for LSA 10-02 (page 2 of 2)

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

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

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

Discrepancy: N / A

Corrective Actions Taken: N / A

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

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

Quality Record

6.9 Conclusions

6.9.1 LSA 10-01

The complete data set for FSS of LSA 10-01 includes a total of 16 soil samples and a 100% GWS coverage with post-processed statistical evaluation. After a statistical evaluation of the GWS measurements, one biased location corresponding to the maximum GWS measurement within the SU was selected for sampling.

The sampling breakdown is as follows:

- (14) Systematic samples: 8 locations; (3 surface, 6 root, 5 excavation)
- (1) Biased sample: 1 location based on a statistical evaluation of GWS measurements exceeding both the IAL and a Z-score of 3 (i.e., greater than 3 standard deviations above the mean GWS measurement).
- (1) QC duplicate sample: 1 location representing a frequency of 6.7% of the total FSS sample population for LSA 10-01.

DP 14.4.5.6.1 states "*The average radioactivity within the survey unit will be determined from the systematic sampling and measurement results, excluding all biased measurements and any measurements within an elevated area. This is to ensure the proper statistical testing of the survey data without skewing the results of the evaluation. Any samples taken within an elevated area, including systematic and biased samples used to evaluate the average radioactivity within the elevated area, will be excluded from the survey unit average. Additionally, biased sampling results less than the* $DCGL_W$ *will typically be excluded as these were not randomly selected; however, these measurements may be included, with caution.*" The calculated average SOF value for all systematically collected samples in the survey unit was **0.19** when compared to the ***Uniform Stratum*** criteria. Background activity concentrations for Ra-226 and Th-232 (1.07 pCi/g with ingrowth and 1.0 pCi/g, respectively) were subtracted prior to calculation of the average SOF. Negative radionuclide activity results (either due to background subtraction or actual lab data) were corrected to zero before SOF calculations.

The one biased sample result produced a SOF value of 0.18 when compared to the ***Uniform Stratum*** criteria; therefore no EMC investigation was necessary and the biased sample result will be excluded from the calculated average SOF for the survey unit as it was not randomly selected.

Reuse soil dose contribution is tentatively assigned the bounding SOF value of **0.31** (see Section 4.4.10).

DP 14.5, Post-Remediation Groundwater Sampling and Analysis, describes groundwater sampling that will be conducted during, and following the completion of soil remediation. As remediation activities are ongoing in other areas of the Hematite Site post-remediation groundwater sampling is not complete. Therefore, the groundwater dose contribution is tentatively assigned a value of 4 mrem/yr based on a conservative approach that sets the

radionuclide concentrations in HDP groundwater equal to the EPA MCLs. The SOF for the groundwater pathway is tentatively assigned a value **0.16**.

No buried piping remains under the footprints of LSA 10-01; therefore there is no dose contribution from this pathway.

A summation of the three dose contribution inputs from residual soil activity within the SU, groundwater, and onsite reuse material results in a combined SOF of **0.66**, or **16.55 mrem/yr**.

Table 6-8
LSA 10-01 SOF and Dose Summation

	AVE. SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.19	N/A	0.16	N/A	0.31	**0.66**
DOSE	4.75 mrem	N/A	4.0 mrem	N/A	7.75 mrem	**16.55 mrem**

Based on the above findings, Westinghouse has demonstrated that the unrestricted release of LSA 10-01 is consistent with Title 10 CFR Part 20.1403 "Criteria for License Termination." Thus, LSA 10-01 is suitable for backfill and unrestricted release. Westinghouse will maintain control of the area until the survey area has been released from the license.

6.9.2 LSA 10-02

The complete data set for LSA 10-02 includes a total of 12 soil samples and a 100% GWS coverage with post-processed statistical evaluation. After a statistical evaluation of the GWS measurements, one biased location corresponding to the maximum GWS measurement within the SU was selected for sampling.

The sampling breakdown is as follows:

- (10) Systematic samples: 8 locations; (2 surface, 2 root, 6 excavation).
- (1) Biased sample: 1 location based on a statistical evaluation of GWS measurements exceeding both the IAL and a Z-score of 3 (i.e., greater than 3 standard deviations above the mean GWS measurement).
- (1) QC duplicate sample: 1 location representing a frequency of 9.0% of the total FSS sample population for LSA 10-01.

DP 14.4.5.6.1 states "*The average radioactivity within the survey unit will be determined from the systematic sampling and measurement results, excluding all biased measurements and any measurements within an elevated area. This is to ensure the proper statistical testing of the survey data without skewing the results of the evaluation. Any samples taken within an elevated area, including systematic and biased samples used to evaluate the average radioactivity within the elevated area, will be excluded from the survey unit average. Additionally, biased sampling results less than the DCGLW will typically be excluded as these were not randomly selected; however, these measurements may be included, with caution.*" The calculated average SOF value for all systematically collected samples in the survey unit was **0.07** when compared to the ***Uniform Stratum*** criteria. Background activity concentrations for Ra-226 and Th-232 (1.07 and 1.0 pCi/g, respectively) were subtracted prior to calculation of the average SOF. Negative radionuclide activity results (either due to background subtraction or actual lab data) were corrected to zero before SOF calculations.

The one biased sample result produced a SOF value of 0.08 when compared to the ***Uniform Stratum*** criteria; therefore no EMC investigation was necessary and the biased sample result will be excluded from the calculated average SOF for the survey unit as it was not randomly selected.

Reuse soil dose contribution is tentatively assigned the bounding SOF value of **0.31** (see Section 4.4.10).

DP 14.5, Post-Remediation Groundwater Sampling and Analysis, describes groundwater sampling that will be conducted during, and following the completion of soil remediation. As remediation activities are ongoing in other areas of the Hematite Site post-remediation groundwater sampling is not complete. Therefore, he groundwater dose contribution is tentatively assigned a value of 4 mrem/yr based on a conservative approach that sets the radionuclide concentrations in HDP groundwater equal to the EPA MCLs. The SOF for the groundwater pathway is tentatively assigned a value **0.16**.

No buried piping remains under the footprint of LSA 10-02; therefore there is no dose contribution from this pathway.

A summation of the three dose contribution inputs from residual soil activity within the SU, groundwater, and onsite reuse material results in a combined SOF of **0.54**, or **13.50 mrem/yr**.

Table 6-9
LSA 10-02 SOF and Dose Summation

	AVERAGE SU SOIL RADIOACTIVITY	ELEVATED AREA CONTRIBUTION	GROUND WATER	BURIED PIPING	REUSE SOIL	**TOTAL**
SOF	0.07	N/A	0.16	N/A	0.31	**0.54**
DOSE	1.75 mrem	N/A	4.0 mrem	N/A	7.75 mrem	**13.50 mrem**

Based on the above findings, Westinghouse has demonstrated that the unrestricted release of LSA 10-02 is consistent with Title 10 CFR Part 20.1403 "Criteria for License Termination." Thus, LSA 10-02 is suitable for backfill and unrestricted release. Westinghouse will maintain control of the area until the survey area has been released from the license.

7.0 REFERENCES

7.1 DO-08-004, *Hematite Decommissioning Plan*

7.2 DO-08-008, *Derivations of Scaling Factors and Surrogates for Hematite Radionuclides*

7.3 DO-08-003, *Hematite Radiological Characterization Report*

7.4 DO-08-005, *Hematite Historical Site Assessment*

7.5 HDP-PR-FSS-701, *Final Status Survey Plan Development*

7.6 HDP-PR-FSS-703, *Final Status Survey Quality Control*

7.7 HDP-PR-FSS-711, *Soil and Sediment Sampling*

7.8 HDP-PR-FSS-721, *Final Status Survey Data Evaluation*

7.9 HDP-PR-QA-006, *Chain of Custody*

7.10 HDP-PR-HP-411, *Radiological Instrumentation*

7.11 HDP-PR-HP-416, *Operation of the Ludlum 2221 for Final Status Survey*

7.12 HDP-PR-HP-602, *Data Package Development and Isolation and Control Measures to Support Final Status Survey*

7.13 HDP-RPT-FSS-303, *Summary Report for Burial Pit Area Remediation*

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

7.15 HDP-RPT-FSS-301, *Off-Site Borrow Soil Analysis 2112 Horine Road, Festus, Missouri*

7.16 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*

7.17 Westinghouse Internal Memorandum HEM-15-MEMO-021, *Evaluation of the Scan IAL for Class 1 areas at the Westinghouse Hematite Site*

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

7.19 HDP-TBD-FSS-002, *Evaluation and Documentation of the Scanning Minimum Detectable Concentration (MDC) for Final Status Survey (FSS)*

8.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A	Analytical Data Evaluation Spreadsheets for LSA 10-01
APPENDIX B	Analytical Data Evaluation Spreadsheets for LSA 10-02
APPENDIX C	FSS Plan Development for LSA 10-01
APPENDIX D	FSS Plan Development for LSA 10-02
APPENDIX E	GIS Maps for LSA 10-01 and LSA 10-02
APPENDIX F	TestAmerica Laboratory Analytical Data Reports for LSA 10-01
APPENDIX G	TestAmerica Laboratory Analytical Data Reports for LSA 10-02
APPENDIX H	Instrumentation Quality Control (Source Check Logs and Control Charts)
APPENDIX I	Completed Field Logs (Appendix P-6 from HDP-PR-FSS-701)
APPENDIX J	Remedial Action Support Survey (RASS) Data for LSA 10-01
APPENDIX K	Remedial Action Support Survey (RASS) Data for LSA 10-02
APPENDIX L	HDP-RPT-FSS-303, *Summary Report for Burial Pit Area Remediation*
APPENDIX M	Hybrid Well Analytical Data