ZIONSOLUTIONS LLC
An EnergySolutions Company

May 1, 2020 ZS-2020-0001

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Zion Nuclear Power Station, Units 1 and 2
Facility Operating License Nos. DPR-39 and DPR-48
NRC Docket Nos. 50-295 and 50-304

Subject: Final Status Survey Final Report - Phase 4

References:

1) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "Final Status Survey Final Report - Phase 1," dated November 1, 2018
2) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "Revised Final Status Survey Report- Phase 1," dated June 21, 2019
3) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "Final Status Survey Final Report - Phase 2, Part 1," dated March 11, 2019
4) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "Revised Final Status Survey Report- Phase 2," dated September 30, 2019
5) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "Revised Final Status Survey Report- Phase 2 Part 2," dated November 25, 2019
6) Gerard van Noordennen, Zion*Solutions*, Letter to U.S. Nuclear Regulatory Commission, "Final Status Survey Report- Phase 3," dated December 30, 2019

The Zion Station Restoration Project (ZSRP) License Termination Plan (LTP) describes the process of releasing land for unrestricted use. The LTP, Section 5.11, states that the Final Status Survey (FSS) Final Report will be provided to the NRC in phases as remediation and FSS are completed with related portions of the site. The FSS Final Report and Revised FSS Final Report, for Phase 1, were submitted for NRC review as documented in References 1 and 2. The FSS Final Report and Revised FSS Final Reports for Phase 2, Parts 1 and 2, were submitted for NRC review, as documented in References 3, 4, and 5. The FSS Final Report for Phase 3 was submitted to the NRC for review as documented in Reference 6.

The purpose of this letter is to provide the ZSRP FSS Final Report for Phase 4. The report includes a compilation of all survey unit release records within the scope of Phase 4. Specifically, the Phase 4 FSS Final Report addresses sixty-seven open land survey units with a combined area of approximately 178,182 m^2. The version being submitted is Revision 1; this version incorporates changes made to the records as a result of a request for additional information received from the NRC.

NMSS01

NMSS

101 Shiloh Boulevard, Zion ▪ IL 60099
(224) 789-4016 ▪ Fax: (224) 789-4008 ▪ www.zionsolutionscompany.com

A partial site release request, to reduce the licensed area to the Independent Spent Fuel Storage Installation area, will be submitted under separate cover. The partial site release request will include an analysis of the dose from groundwater and the final compliance dose. Zion*Solutions* hereby requests the NRC review the attached FSS Final Report - Phase 4 for acceptance of this portion of the site final radiological survey by June 22, 2020.

There are no regulatory commitments made in this submittal. If you should have any questions regarding this submittal, please contact me at (860) 462-9707.

Respectfully,

Gerard van Noordennen

Gerard van Noordennen
Senior Vice President Regulatory Affairs

Attachments:

Attachment 1 - Final Status Survey Final Report - Phase 4

Attachment 2 - Preflight Report

Enclosure:

Enclosure 1 - CD containing the Final Status Survey Final Report - Phase 4 (including appendices)

cc: John Hickman, U.S. NRC Senior Project Manager
Regional Administrator, U.S. NRC, Region III
Zion Nuclear Power Station, Units 1 and 2, License Transfer Service List (w/o Attachments and Enclosure)

Zion Nuclear Power Station, Units 1 and 2, License Transfer Service List

cc:

Ken Robuck
President and CEO
Energy*Solutions*
299 South Main Street, Suite 1700
Salt Lake City, UT 84111

John Sauger
President and Chief Nuclear Officer
Reactor D&D
Energy*Solutions*
121 W. Trade Street, Suite 2700
Charlotte, NC 28202

Bruce Hinkley
Senior Vice President
D&D Operations
Energy*Solutions*
121 W. Trade Street, Suite 2700
Charlotte, NC 28202

Gerard van Noordennen
Senior Vice President
Regulatory Affairs
Energy*Solutions*
121 W. Trade Street, Suite 2700
Charlotte, NC 28202

Russ Workman
General Counsel
Energy*Solutions*
299 South Main Street, Suite 1700
Salt Lake City, UT 84111

Steven A. Reynolds
Manager, Nuclear Facility Inspection
Division of Nuclear Safety
Illinois Emergency Management Agency
245 W. Roosevelt Road, Units 55 & 56
West Chicago, Illinois 60185

Kelly F. Grahn, Senior Health Physicist
Illinois Emergency Management Agency
Division of Nuclear Safety
245 W Roosevelt Road, Building 8, Suite 55
West Chicago, IL 60185

William P. Mazzeno
Emergency Management Coordinator
Lake County Emergency Management Agency
1303 N. Milwaukee Avenue
Libertyville, IL 60048-1308

John E. Matthews
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, DC 20004

*Zion**Solutions***

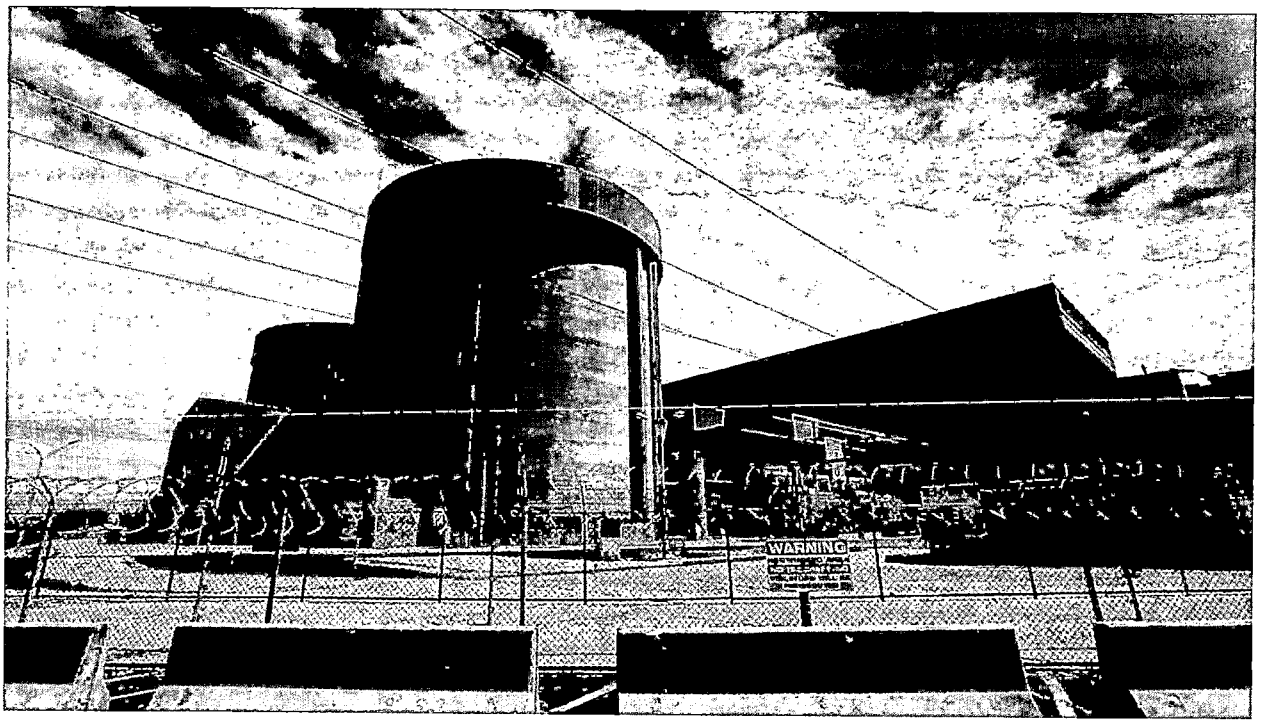
ZS-2020-0001

Attachment 1

Zion Nuclear Power Station, Units 1 and 2

Final Status Survey Final Report – Phase 4

ZIONSOLUTIONS LLC
An EnergySolutions Company



ZION STATION RESTORATION PROJECT

FINAL STATUS SURVEY

FINAL REPORT – PHASE 4

Revision 1

APRIL 2020

Summary of Changes in this Revision: Initial Revision
Revision 1: Minor revisions throughout document to incorporate changes from responses to RAIs related to Phase 2a, 2b and 3 FSS Final Reports and associated release records. Deletion of Section 7, Dose Compilation

Prepared By: R Yetter III Robert F. Yetter III Apr 29 2020 9:32 AM cosign **Date:** _____
FSS Specialist

Reviewed By: R Yetter Robert F. Yetter Robert F. Yetter Apr 29 2020 2:43 PM cosign **Date:** _____
Director, Radiological Site Closure

Approved By: S Roberts Sarah Roberts Sarah Roberts Apr 29 2020 2:57 PM cosign **Date:** _____
VP Radiological Programs

TABLE OF CONTENTS

1 Introduction 10
1.1 Executive Summary 10
1.2 Phased Submittal Approach 14
2 Final Status Survey Program Overview 16
2.1 Survey Planning 16
2.2 Survey Design 22
2.3 Survey Implementation 25
2.4 Survey Data Assessment 26
2.5 Quality Assurance and Quality Control Measures 26
3 Site Information 27
3.1 Site Description 27
3.2 Survey Unit Description 30
3.3 Summary of Historical Radiological Data 44
3.4 Conditions at the Time of Final Status Survey 50
3.5 Identification of Potential Contaminants 51
3.6 Radiological Release Criteria 52
4 Final Status Survey Protocol 53
4.1 Data Quality Objectives 53
4.2 Survey Unit Designation and Classification 58
4.3 Background Determination 58
4.4 Final Status Survey Sample Plans 58
4.5 Survey Design 59
4.5.1 Determination of Number of Data Points 59
4.5.2 Sample Locations 62
4.6 Instrumentation 62
4.6.1 Detector Efficiencies 62
4.6.2 Detector Sensitivities 63
4.6.3 Instrument Maintenance and Control 63
4.6.4 Instrument Calibration 63
4.7 Survey Methodology 64

4.7.1 Scan Surveys 64
4.7.2 Soil Sampling 64
4.8 Quality Control Surveys 65
5 Survey Findings 66
5.1 Survey Data Conversion 66
5.2 Survey Data Verification and Validation 70
5.3 Anomalous Data/Elevated Scan Results and Investigation 71
5.4 Evaluation of Number of Sample/Measurement Locations in Survey Units 85
5.5 Comparison of Findings with Derived Concentration Guideline Levels 86
5.6 Description of ALARA to Achieve Final Activity Levels 88
5.7 NRC/Independent Verification Team Findings 89
6 Summary 89
7 References 90
8 Appendices 92

LIST OF TABLES

Table 1-1, Phase 4 Survey Units 11
Table 2-1, Base Case and Operational DCGLs for Surface Soils(1) 20
Table 2-2, Base Case and Operational DCGLs for Subsurface Soils(1) 20
Table 2-3, Typical Final Status Survey Unit Areas 21
Table 2-4, Dose Significant Radionuclides and Mixture(1) 23
Table 4-1, Surrogate Ratios 55
Table 4-2, FSS Investigation Levels 55
Table 4-3, Recommended Scan Coverage 60
Table 4-4, Number of Surface Soil Samples for FSS ..... **Error! Bookmark not defined.**
Table 5-1, Basic Statistical Properties for FSS of Phase 4 Open Land Survey Units 67
Table 5-2, Mean Base Case SOF and Dose Contribution from Soil 87

LIST OF FIGURES

Figure 1-1, Phase 4 Survey Unit Locations ..... **Error! Bookmark not defined.**
Figure 2-1, Characterization/License Termination Group Organizational Chart 17
Figure 3-1, Zion Nuclear Power Station Owner Controlled Area 28
Figure 3-2, Zion Nuclear Power Station Radiologically Restricted Area 29
Figure 3-3, Fuel Handling Building (FHB) and Car Shed Excavation Survey Units 47
Figure 3-4, Demolition of Containment Domes 48
Figure 3-5, Remediation of Indigenous Soils Following Removal of Sacrificial Soil Barrier 49
Figure 3-6, Phase 4 Open Land Areas Prepared for FSS 51

LIST OF ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
AMCG	Average Member of the Critical Group
ASP	Alarm Set Point
BcDCGL	Base Case Derived Concentration Guideline Level
BcSOF	Base Case Sum of Fractions
CCDD	Clean Concrete Demolition Debris
CAD	Computer Aided Design
CAP	Corrective Action Program
C/LT	Characterization/License Termination
DCGL	Derived Concentration Guideline Level
ComEd	Commonwealth Edison Company
DSAR	Defueled Safety Analysis Report
DQA	Data Quality Assessment
DQO	Data Quality Objective
EMC	Elevated Measurement Comparison
ESCSG	Energy*Solutions* Commercial Services Group
ETD	Easy-to-Detect
FSS	Final Status Survey
FSSR	Final Status Survey Final Report
GPS	Global Positioning System
HSA	Historical Site Assessment
HTD	Hard-to-Detect
HPGe	High-Purity Germanium
IEMA	Illinois Environmental Management Agency
ISFSI	Independent Spent Fuel Storage Installation
LBGR	Lower Bound of the Gray Region
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual

MDC	Minimum Detectable Concentration
MDCR	Minimum Detectable Count Rate
NAD	North American Datum
NaI	Sodium Iodide
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
ODCM	Offsite Dose Calculation Manual
OpDCGL	Operational Derived Concentration Guideline Level
OpSOF	Operational Sum of Fractions
ORISE	Oak Ridge Institute for Science and Education
PNNL	Pacific Northwest National Laboratory
PSDAR	Post Shutdown Decommissioning Activities Report
PWST	Primary Water Storage Tank
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAI	Request for Additional Information
RCA	Radiologically Controlled Area
RE	Radiological Engineer
ROC	Radionuclides of Concern
SFP	Spent Fuel Pool
SOF	Sum of Fractions
SSC	Systems, structures and components
SST	Secondary Storage Tank
TEDE	Total Effective Dose Equivalent
TSD	Technical Support Document
UBGR	Upper Bound of the Gray Region
UCL	Upper Confidence Level
VCC	Vertical Concrete Cask

VSP	Visual Sample Plan
ZSRP	Zion Station Restoration Project
ZNPS	Zion Nuclear Power Station

1 Introduction

1.1 Executive Summary

The purpose of this Phase 4 Final Status Survey (FSS) Final Report is to provide a summary of the survey results and overall conclusions which demonstrate that the Zion Nuclear Power Station (ZNPS) facility, or portions of the site, meets the 25 mrem/year release criterion as established in Nuclear Regulatory Commission (NRC) Regulation 10CFR20.1402 *"Radiological Criteria for Unrestricted Use."* This report is the final phased submittal for the Zion Station Restoration Project (ZSRP). This Phase 4 FSS Report (FSSR) was written in accordance with Section 5.11 of Chapter 5 of the ZSRP *"License Termination Plan"* (LTP) (Reference 1).

This Phase 4 FSSR focuses on the balance of the impacted open land surface area and subsurface soils. The FSS results provided herein assess and summarize that any residual radioactivity remaining in the survey units addressed by this Phase 4 FSSR results in a Total Effective Dose Equivalent (TEDE) to an average member of the critical group (AMCG) that does not exceed 25 mrem/year and that the residual radioactivity has been reduced to levels that are As Low As Reasonably Achievable (ALARA). The release criterion is translated into site-specific Derived Concentration Guideline Levels (DCGLs) for assessment and summary.

This report documents that FSS activities were performed consistent with the guidance provided in the ZSRP LTP; NUREG-1575, *"Multi-Agency Radiation Survey and Site Investigation Manual"* (MARSSIM) (Reference 2); ZS-LT-01, *"Quality Assurance Project Plan (for Characterization and FSS)"* (QAPP) (Reference 3); ZS-LT-300-001-001, *"Final Status Survey Package Development"* (Reference 4); ZS-LT-300-001-003, *"Isolation and Control for Final Status Survey"* (Reference 5); ZS-LT-300-001-004, *"Final Status Survey Data Assessment"* (Reference 6); as well as various other station implementing procedures.

This Phase 4 FSSR has been written consistent with the guidance provided in NUREG-1757, Vol. 2, *"Consolidated Decommissioning Guidance; Characterization, Survey, and Determination of Radiological Criteria"* (Reference 7); MARSSIM; and the requirements specified in ZS-LT-300-001-005, *"Final Status Survey Data Reporting"* (Reference 8).

To facilitate the data management process, FSSRs incorporate Release Records from the FSS of multiple survey units. Release Records are complete and unambiguous records of the as-left radiological status of each specific survey unit. Each Release Record contains sufficient information necessary to perform an independent review and evaluation of both the survey activities, the analytical results and the final conclusion.

This Phase 4 FSSR specifically addresses sixty-seven (67) open land area survey units that total approximately 178,182 m^2 in area. Sixty (60) of the sixty-seven (67) open land survey units included in the Phase 4 report are classified as MARSSIM Class 1 survey units. Six (6) survey units are classified as Class 2, and one (1) survey unit is classified as Class 3. Table 1-1 provides a listing of all the survey units addressed in this report, along with their classifications and size. Figure 1-1 depicts the locations of the Phase 4 survey units in relation to the ZNPS site as well as survey unit boundaries.

Table 1-1, Phase 4 Survey Units

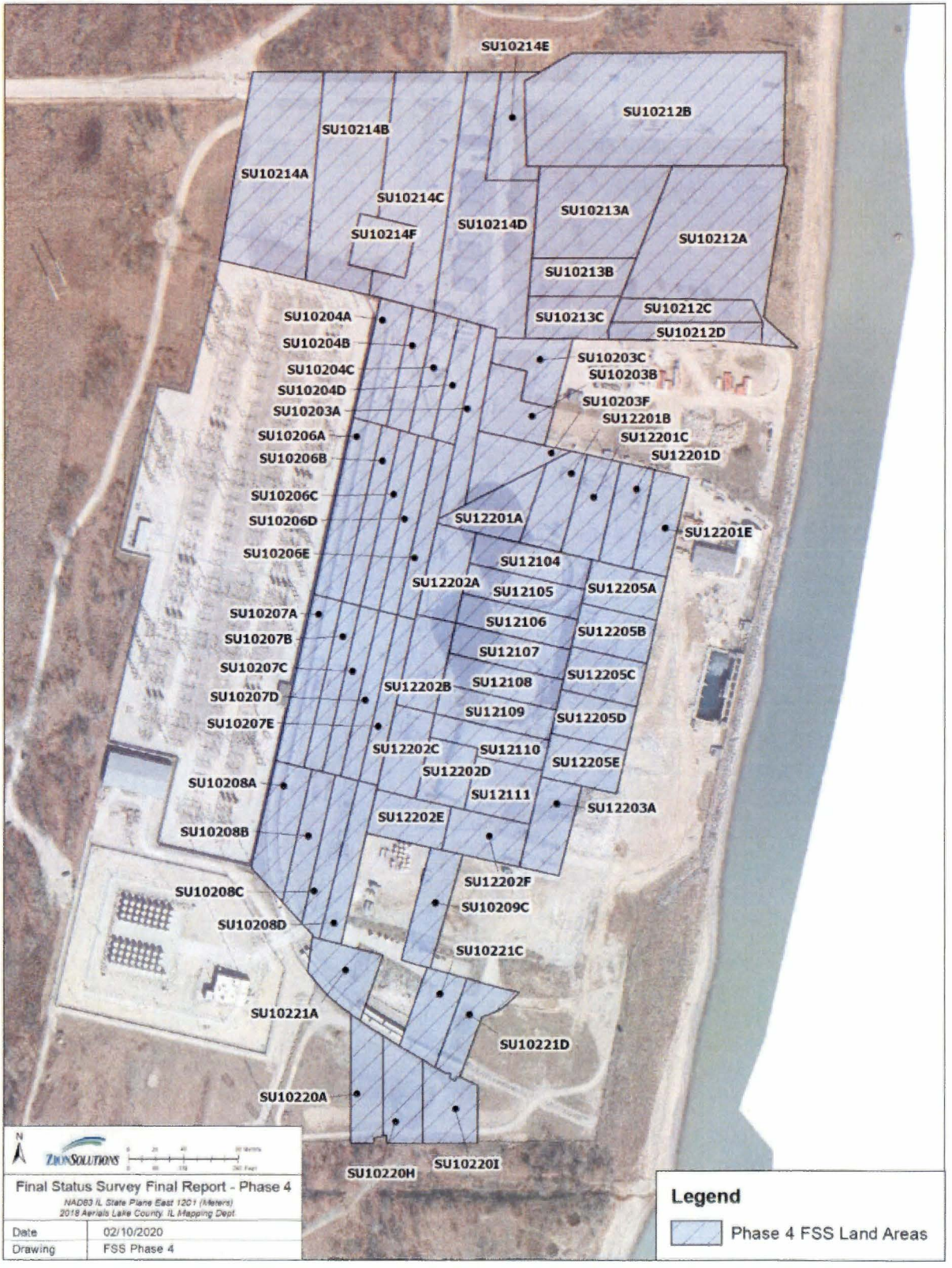
Survey Unit	Name	Class	Size (m^2)
10203A	East Training Area	1	1,999
10203B	East Training Area	1	1,977
10203C	East Training Area	1	1,871
10203F	East Training Area	1	1,888
10204A	North Gate Area	1	2,231
10204B	North Gate Area	1	1,549
10204C	North Gate Area	1	1,547
10204D	North Gate Area	1	1,545
10206A	Station Construction Area	1	2,844
10206B	Station Construction Area	1	1,837
10206C	Station Construction Area	1	1,833
10206D	Station Construction Area	1	1,829
10206E	Station Construction Area	1	1,825
10207A	North Warehouse Area	1	2,675
10207B	North Warehouse Area	1	1,736
10207C	North Warehouse Area	1	1,735
10207D	North Warehouse Area	1	1,733
10207E	North Warehouse Area	1	1,731
10208A	South Warehouse Area	1	2,460
10214E	Construction Parking Area	1	1,989
10214F	Construction Parking Area	1	1,661
10220A	SE Corner of Exclusion Area – Lakeshore	1	2,025
10220H	SE Corner of Exclusion Area – Lakeshore	1	2,088
10220I	SE Corner of Exclusion Area – Lakeshore	1	2,060
10221A	South of Protected Area - Inland	1	1,976
10221C	South of Protected Area - Inland	1	1,959
10221D	South of Protected Area - Inland	1	1,697
12104	North Half of Unit 2 Containment	1	1,940
12105	South Half of Unit 2 Containment	1	1,938
12106	North Half of Fuel & Auxiliary Buildings	1	1,936
12107	South Half of Fuel & Auxiliary Buildings	1	1,934
12108	North Half of Unit 1 Containment	1	1,933
12109	South Half of Unit 1 Containment	1	1,931
12110	Yard Between Unit 1 Containment and Turbine	1	1,740
12111	South Yard Area Northeast of Gate House	1	1,964
12201A	North Protected Area Yard	1	1,992
12201B	North Protected Area Yard	1	1,995
12201C	North Protected Area Yard	1	1,968

Table 1-1 (continued), Phase 4 Survey Units

Survey Unit	Name	Class	Size (m^2)
10208B	South Warehouse Area	1	1,835
10208C	South Warehouse Area	1	1,868
10208D	South Warehouse Area	1	1,827
10209C	Restricted Area South of Gate House	1	1,970
10212A	NE Corner of Exclusion Area - Lakeshore	2	9,550
10212B	VCC Construction Area	3	16,154
10212C	NE Corner of Exclusion Area - Lakeshore	1	1,744
10212D	NE Corner of Exclusion Area - Lakeshore	1	1,490
10213A	NE Corner of Exclusion Area	2	5,730
10213B	NE Corner of Exclusion Area	1	1,994
10213C	NE Corner of Exclusion Area	1	1,934
10214A	Construction Parking Area	2	8,542
10214B	Construction Parking Area	2	7,372
10214C	Construction Parking Area	2	7,579
10214D	Construction Parking Area	2	8,946
12201D	North Protected Area Yard	1	1,842
12201E	North Protected Area Yard	1	1,902
12202A	Gate House and Southwest Yard	1	1,998
12202B	Gate House and Southwest Yard	1	1,999
12202C	Gate House and Southwest Yard	1	1,894
12202D	Gate House and Southwest Yard	1	1,663
12202E	Gate House and Southwest Yard	1	1,845
12202F	Gate House and Southwest Yard	1	1,858
12203A	Under Service Building and Southeast Yard	1	1,988
12205A	Area Under the Turbine Building	1	1,809
12205B	Area Under the Turbine Building	1	1,814
12205C	Area Under the Turbine Building	1	1,818
12205D	Area Under the Turbine Building	1	1,821
12205E	Area Under the Turbine Building	1	1,825

All FSS activities essential to data quality have been implemented and performed under approved procedures. Trained individuals, using properly calibrated instruments and laboratory equipment, that are sensitive to the Radionuclides of Concern (ROC), performed the FSS of the Phase 4 survey units in accordance with the LTP and approved procedures. The survey data for all Phase 4 survey units demonstrate that the dose (TEDE) from residual radioactivity is less than the maximum annual dose (TEDE) which corresponds to the release criterion for license termination for unrestricted use specified in 10CFR20.1402, and support the release of these areas from the 10CFR50 license. Additionally, the ALARA requirement of 10CFR20.1402 has been satisfied.

Figure 1-2, Phase 4 Survey Unit Locations



1.2 Phased Submittal Approach

To minimize the incorporation of redundant historical assessments and other FSS program information, and to facilitate potential phased releases from the current license, FSSRs were prepared in a phased approach. A total of five (5) FSSRs, including this Phase 4 submittal, were generated and submitted to the NRC during the decommissioning project.

Release of Non-Impacted Open Lands

On August 27, 2015, Zion*Solutions* submitted a request (ZS-2015-0134) to release a portion of the ZNPS site from the 10CFR50 licenses (DPR-39 and DPR-48) in accordance with 10CFR50.83, "*Release of Part of a Power Reactor Facility or Site for Unrestricted Use*," and 10CFR100, "*Reactor Site Criteria.*" Specifically, a report was generated for the request that addresses the release of eleven (11) non-impacted open land areas from the 10CFR50 licenses. The report contained a summary of the final assessment performed as well as a summary of the characterization surveys performed of these non-impacted survey units. Zion*Solutions* reviewed and assessed the subject property to ensure that the radiological condition of these land areas will have no adverse impact on the ability of the site, in aggregate, to meet the 10CFR20, Subpart E, *"Radiological Criteria for License Termination."* The submitted report was not captured as a Phased Submittal with a FSSR because the survey units incorporated within the report were classified as non-impacted. As such, no statistical tests, scan measurements, static measurements, or elevated measurement comparisons were required. The release of the non-impacted areas from the license(s) was approved by the NRC on March 31, 2016.

Phase 1 Final Status Survey Report

The Phase 1 FSSR was initially submitted to the NRC on November 1, 2018. The Phase 1 FSSR and the accompanying Release Records addressed the FSS of ten (10) Class 3 open land survey units at Zion. During the review of the Phase 1 FSSR, the NRC identified several quality mistakes which prompted Zion*Solutions* to withdraw the report until corrections were made. The required corrections were made and the Phase 1 FSSR was resubmitted to the NRC as Revision 1, minus two (2) of the original ten (10) survey units which were included in a subsequent FSSR due to the discovery of additional commodities that required removal. On October 9, 2019, the NRC stated that the FSSR was sufficient to demonstrate that the surveys performed of seven (7) of the eight (8) Class 3 open land survey units were acceptable to support release of those survey units for unrestricted release. During the review of the revised report, the NRC Staff identified that the results from survey unit 10223 should have triggered the licensee's commitment to assess subsurface residual radioactivity. By letter dated March 03, 2020, Zion*Solutions* submitted revision 2 of the release record for survey unit 10223 and the Phase 1 FSS Final Report. The submittal documented the results of the investigation that was completed in survey unit 10223, with regard to subsurface residual radioactivity.

Phase 2, Part 1 Final Status Survey Report

The Phase 2, Part 1 FSSR, submitted to the NRC in March of 2019, contained the FSS units that encompassed the basement structures including the Unit 1 and Unit 2 Containments, the Spent Fuel Pool (SFP)/Transfer Canal, the Auxiliary Building, the Crib House/Forebay, the Waste Water Treatment Facility (WWTF) and the Turbine Building. As a result of a Condition Report regarding mistakes identified by the NRC in their review of the Phase 1 FSSR, the submittal of the Phase 2, Part 1 FSSR was withdrawn. On September 30, 2019, the revised Phase 2, Part 1 FSSR was submitted to the NRC.

Phase 2, Part 2 Final Status Survey Report

The Phase 2, Part 2 FSSR and all pertinent Release Records were submitted to the NRC on November 25, 2019. The Phase 2, Part 2 FSSR contained the FSS units that encompassed buried pipe.

Phase 3 Final Status Survey Report

The Phase 3 FSSR and all pertinent Release Records were submitted to the NRC on December 30, 2019.The Phase 3 FSSR addressed forty-one (41) Class 1 open land area survey units that totaled approximately 73,546 m^2 in area.

2 Final Status Survey Program Overview

The FSS Program consists of the methods used in planning, designing, conducting, and evaluating FSS at the ZNPS site to demonstrate that the premises are suitable for release in accordance with the criteria for decommissioning in Title 10CFR20, Subpart E. Final Status Surveys serve as the key action necessary to demonstrate that the TEDE to an AMCG from residual radioactivity does not exceed 25 mrem/year, and that all residual radioactivity at the site is reduced to levels that are ALARA.

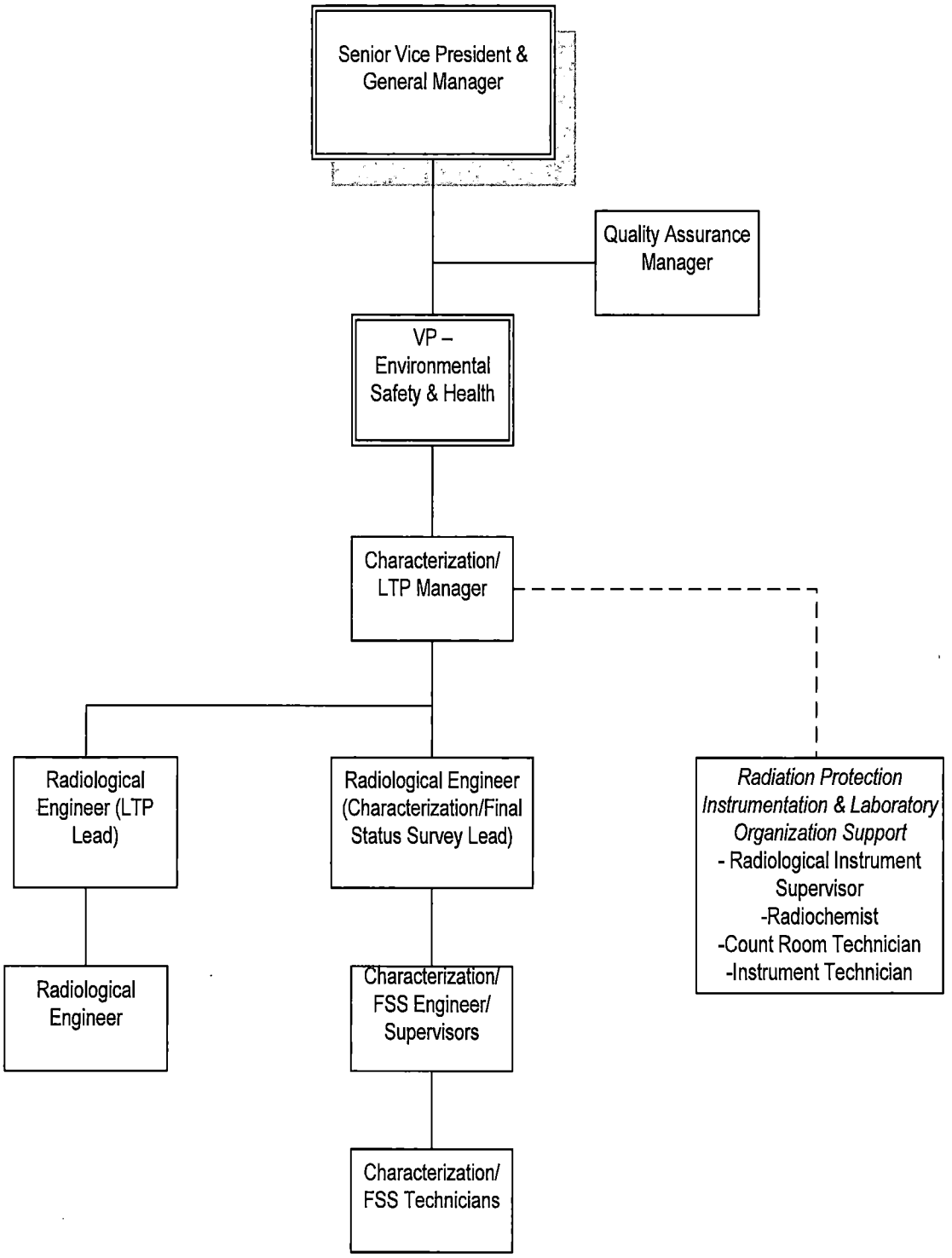
To implement the FSS Program, Zion*Solutions* established the Characterization/License Termination (C/LT) Group, within the Radiation Protection division, with sufficient management and technical resources to fulfill project objectives. The C/LT Group was responsible for the safe completion of all surveys related to characterization, FSS, and final site closure. Approved site procedures and detailed technical support documents (TSD) were written to support the FSS process to ensure consistent implementation and adherence to applicable requirements. Figure 2-1 provides an organizational chart of the C/LT Group.

2.1 Survey Planning

Following the cessation of commercial operation, the FSS planning phase was initiated in 1999 by the development of the "*Zion Station Historical Site Assessment*" (HSA) (Reference 9) and characterization process. The characterization process was iterative, and continued in some cases up to the time of completing FSS. The HSA consisted of a review of site historical records regarding plant incidents, radiological survey documents, and routine and special reports submitted by Exelon Nuclear Generation, LLC (Exelon) to various regulatory agencies. Along with these assessments, interviews with current and past site personnel, reviews of historical site photos, and extensive area inspections were performed to meet the following objectives:

- Develop the information necessary to support FSS design, including the development of Data Quality Objectives (DQO) and survey instrument performance standards,
- Develop the initial radiological information to support decommissioning planning, including building decontamination, demolition, and waste disposal,
- Identify any unique radiological or health and safety issues associated with decommissioning,
- Identify the potential and known sources of radioactive contamination in systems, surface or subsurface soils, groundwater, and on structures,
- Divide the ZNPS site into manageable areas or units for survey and classification purposes, and
- Determine the initial classification of each survey area or unit as non-impacted or impacted. Impacted survey units are classified as Class 1, 2, or 3 as defined in MARSSIM.

Figure 2-1, Characterization/License Termination Group Organizational Chart



Data Quality Objectives (DQO) are qualitative and quantitative statements derived from the DQO process. They clarify technical and quality objectives, define the appropriate type of data, and specify the tolerable levels or potential decision errors used as the basis for establishing the quality and quantity of data required to support inference and decisions. This process, described in MARSSIM and procedure ZS-LT-300-001-001, "*Final Status Survey Package Development*", is a series of graded planning steps found to be effective in establishing criteria for data quality and guiding the development of FSS Sample Plans. The DQOs developed and implemented during the initial phase of site closure planning directed data collection efforts.

The DQO approach consists of the following seven steps:

1. **State the Problem** – This step provides a clear description of the problem, identification of planning team members (especially the decision makers), a conceptual model of the hazard to be investigated, and the estimated resources required to perform the survey. The problem associated with FSS is to determine whether a given survey unit meets the radiological release criterion of 10CFR20.1402.
2. **Identify the Decision** – This step consists of developing a decision statement based on a principal study question (i.e., the stated problem) and determining alternative actions that may be taken based on the answer to the principle study question. Alternative actions identify the measures to resolve the problem. The decision statement combines the principal study question and alternative actions into an expression of choice among multiple actions. For the FSS, the principal study question is: Does residual radioactive contamination present in the survey unit exceed the established DCGL values? The alternative actions may include no action, investigation, resurvey, remediation, and reclassification.
3. **Identify Inputs to the Decision** – The information required depends on the type of media under consideration (e.g., soil, water, concrete) and whether existing data are sufficient or new data are needed to make the decision. If the decision can be based on existing data, then the source(s) will be documented and evaluated to ensure reasonable confidence that the data is acceptable. If new data is needed, then the type of measurement (e.g., scan, direct measurement, and/or sampling) is determined.
4. **Define the Study Boundaries** – This step includes identification of the target population of interest, the spatial and temporal features of that population, the time frame for collecting the data, practical constraints, and the scale of decision making. In FSS, the target population is the set of samples or direct measurements that constitute an area of interest. The medium of interest is specified during the planning process. The spatial boundaries include the entire area of interest, including soil depth, area dimensions, contained water bodies, and natural boundaries. Temporal boundaries include activities impacted by time-related events including weather conditions, season, operation of equipment under different environmental conditions, resource loading, and work schedule.

5. **Develop a Decision Rule** – This step develops the binary statement that defines a logical process for choosing among alternative actions. The decision rule is a clear statement using the "If...then..." format and includes action level conditions and the statistical parameter of interest.
6. **Specify Tolerable Limits on Decision Errors** – This step incorporates hypothesis testing and probabilistic sampling distributions to control the decision errors during data analysis. Hypothesis testing is a process based on the scientific method that compares a baseline condition (the null hypothesis) to an alternative condition (the alternative hypothesis). Hypothesis testing rests on the premise that the null hypothesis is true and that sufficient evidence must be provided to reject it.
7. **Optimize the Design for Obtaining Data** – The final step in the DQO process leads to the development of an adequate survey design. By using an on-site analytical laboratory, sampling and analysis processes are designed to provide near real-time data assessment during implementation of field activities and FSS. Gamma scans provide information on soil areas that have residual radioactivity greater than background and allow appropriate selection of biased sampling and measurement locations. 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.

As stated, the primary objective of the DQO process was to demonstrate that the level of residual radioactivity found in the soils in the land area survey units, including any areas of elevated activity, was equal to or below the site-specific DCGLs that correspond to the 25 mrem/year release criterion.

The LTP defines surface soil as in the soil layer within 0.15-m depth from the surface. The LTP defines subsurface soil as the soil layer from 0.15-m to 1-m depth of soil from the surface. Site-specific DCGLs were calculated for both the surface and subsurface soils. Based on characterization data and historical information (LTP Chapter 5, Section 5.2.3), there are no expectations of encountering a source term geometry that is comprised of a clean surface layer of soil over a contaminated subsurface soil layer. Zion*Solutions* TSD-14-011, *"Soil Area Factors"* (Reference 10) and LTP Chapter 6, Section 6.8, provide the exposure scenarios and modeling parameters that were used to calculate the site-specific DCGLs for soils (referred to as Base Case Soil DCGLs).

Each radionuclide-specific Base Case DCGL (BcDCGL) is equivalent to the level of residual radioactivity (above background levels) that could, when considered independently, result in a TEDE of 25 mrem/year to an AMCG. To ensure that the summation of dose from each source term is 25 mrem/year or less after all FSS is completed, the BcDCGLs were reduced based on an expected, or *a priori*, fraction of the 25 mrem/year dose limit from each source term. These reduced values were designated as Operational DCGLs (LTP Chapter 5, Section 5.2.4), and these Operational DCGLs (OpDCGL) were then used as the DCGL for the FSS design of the survey unit (calculation of surrogate DCGLs, investigations levels, etc.).

Details of the OpDCGLs derived for each dose component and the basis for the applied *a priori* dose fractions are provided in Zion*Solutions* TSD-17-004, *"Operational Derived Concentration Guideline Levels for Final Status Survey"* (Reference 11).

Table 2-1 and Table 2-2 presents the surface and subsurface soil BcDCGL and OpDCGL for the main ROC used for the FSS of the Phase 4 open land survey units.

Table 2-2, Base Case and Operational DCGLs for Surface Soils(1)

Radionuclide	Base Case DCGL (pCi/g)	Operational DCGL (pCi/g)
Co-60	4.26	1.091
Cs-134	6.77	1.733
Cs-137	14.18	3.630
Ni-63	3,572.10	914.458
Sr-90	12.09	3.095

(1) Compiled from Tables 5-5 and 5-7 of LTP, Chapter 5

Table 2-3, Base Case and Operational DCGLs for Subsurface Soils(1)

Radionuclide	Base Case DCGL (pCi/g)	Operational DCGL (pCi/g)
Co-60	3.44	0.881
Cs-134	4.44	1.137
Cs-137	7.75	1.984
Ni-63	763.02	195.333
Sr-90	1.66	0.425

(1) Compiled from Tables 5-6 and 5-8 of LTP, Chapter 5

The development of information to support decommissioning planning and execution was accomplished through a review of known site radiological and environmental records. This information was consolidated in the HSA, TSD-14-028, "*Radiological Characterization Report*" (Reference 12), and in files containing copies of records maintained pursuant to Title 10CFR50.75(g) (1).

An initial objective of site characterization and assessment was to correlate the impact of a radiological event to physical locations on the ZNPS site and to provide a means to correlate subsequent survey data. To satisfy these objectives, the entire 331-acre site was divided into survey areas. Survey area size determination was based upon the shape of the area and the most efficient and practical size needed to bound the lateral and vertical extent of contamination identified in the area. Survey areas that have no reasonable potential for

contamination were classified as non-impacted. These areas had no radiological impact from site operations and were identified in the HSA. Survey areas with reasonable potential for contamination were classified as impacted.

Classification, as described in MARSSIM, is the process by which an area or survey unit is ranked according to its radiological characteristics and potential for residual radioactivity. Residual radioactivity could be evenly distributed over a large area, appear as small areas of elevated activity, or a combination of both. In some cases, there may be no residual radioactivity in an area or survey unit. Therefore, the adequacy and effectiveness of the FSS process depends upon properly classified survey units to ensure that areas with the highest potential for contamination receive a higher degree of survey effort.

The impacted survey areas established by the HSA were further divided into survey units. The suggested surface area limits provided in MARSSIM were used to establish the initial set of survey units for the LTP. A survey unit is a portion of a structure, buried pipe or open land area that is surveyed and evaluated as a single entity following FSS (note that this Phase 4 FSSR only includes land areas). Survey units were delineated to physical areas with similar operational history or similar potential for residual radioactivity to the extent practical. To the extent practical, survey units were established with relatively compact shapes. Highly irregular shapes were avoided unless the unusual shape was appropriate for the site operational history or the site topography. For identification, survey units were assigned a five-digit number that could be further modified by a letter for future divisions if needed (e.g., if the classification changed, then the corresponding survey unit size limitation also would change). Physically, survey unit boundaries were determined using commercially available mapping software with coordinates consistent with the Illinois State Plane System North American Datum (NAD) 1983 East. Table 2-3 provides an outline for classification versus area size for open land survey units consistent with MARSSIM, Table 1.

Table 2-4, Typical Final Status Survey Unit Areas

Classification	Area Type	Suggested Area
Class 1	Land	Up to 2,000 m^2
Class 2	Land	2,000 to 10,000 m^2
Class 3	Land	No Limit

Prior to FSS, each survey unit's classification was reviewed and verified in accordance with the LTP and its implementing procedures. A classification change to increase the class could be implemented without notification to regulatory authorities. A classification change to decrease the class would be implemented only after accurate assessment and notification to regulatory authorities as detailed in the LTP and its implementing procedures. Typically, reclassification occurred after the evaluation of continuing characterization results or emergent data which indicated that a more restrictive classification was required. Final

classification was performed via the preparation of the FSS Sample Plan. The Sample Plan reconciled all outstanding characterization data to determine the appropriate and final survey unit classification for FSS.

2.2 Survey Design

Final Status Surveys for the ZNPS site were designed following Zion*Solutions* procedures, the LTP, and MARSSIM guidance. FSS design utilized the combination of traditional scanning surveys, systematic sampling protocols, and investigative/judgmental methodologies to evaluate survey units relative to the applicable release criteria for open land sample plans.

To aid in the development of an initial suite of potential ROC for the decommissioning of ZNPS, the analytical results of characterization samples collected at the site were reviewed. In general, the samples associated with these results were collected from within various waste/process streams and sent off site to meet the analysis criteria of 10CFR61, Subparts C and D. This initial suite of potential radionuclides was further refined by the analysis of concrete core samples taken from the concrete walls and floors of both Containment Buildings and the Auxiliary Building. This analysis determined that Co-60, Cs-134, Cs-137, Ni-63, and Sr-90 accounted for 99.5% of all dose in the contaminated concrete mixes. For activated concrete, H-3, Eu-152, and Eu-154, in addition to the five aforementioned radionuclides, accounted for 99% of the dose. Due to the assumption that all activated concrete will be removed and disposed of as waste, the final suite of ROC for all areas outside of the Containments did not include H-3, Eu-152, and Eu-154.

The results of surface and subsurface soil characterization in the impacted area surrounding ZNPS indicated that there was minimal residual radioactivity in soil. Based on the characterization survey results, ZSRP did not anticipate the presence of significant concentrations of soil contamination. In addition, based on process knowledge, minimal contamination was expected in the buried piping abandoned in place. Consequently, due to the absence of any significant source term in soil or in any buried piping, the suite of ROC and radionuclide mixture derived for the Auxiliary Building concrete was considered a reasonably conservative mixture to apply to soils for FSS planning and implementation. The final suite of potential radionuclides and the mixture to be applied to soils is provided in Table 2-4.

Table 2-5, Dose Significant Radionuclides and Mixture(1)

Radionuclide	% of Total Activity (normalized)
Co-60	0.92
Cs-134	0.01
Cs-137	75.32
Ni-63	23.71
Sr-90	0.05

(1) Compiled from Table 5-2 of the LTP

Characterization results determined that Co-60 and/or Cs-137 would be the primary gamma-emitting ROC for the majority of survey design. All the FSS results provided in this report utilized Cs-137 as the primary ROC. Cs-137 characterization data for the survey units discussed in this report were used to determine the expected variability, number of samples required, and investigation levels for FSS design.

The dose contribution from each ROC was accounted for using the Sum of Fractions (SOF) to ensure that the total dose from all ROC did not exceed the dose criterion. The SOF or "unity rule" was applied to the data used for the survey planning, data evaluation, and statistical tests for soil sample analyses since multiple radionuclide-specific measurements were performed, or concentrations were inferred based on known relationships. The application of the unity rule served to normalize the data to allow for an accurate comparison of the various data measurements to the release criteria. When the unity rule was applied, the $DCGL_W$ (used for the nonparametric statistical test) becomes one (1). The soil BcDCGLs (surface soil and subsurface soil) are directly analogous to the $DCGL_W$ as defined in MARSSIM. The use and application of the unity rule was performed in accordance with Section 4.3.3 of MARSSIM.

Survey design objectives included a verification of the survey instrument's ability to detect the radiation(s) of interest relative to the DCGL. As standard practice employed to ensure that this objective was consistently met, radiation detection instruments used in FSS were calibrated on a yearly frequency with National Institute of Standards and Technology (NIST) traceable sources in accordance with Zion*Solutions* procedures. Instruments were response checked before and after each use. Minimum Detectable Count Rates (MDCR) were established and verified prior to FSS. Control and accountability of survey instruments were maintained and documented to assure quality and prevent the loss of data.

Based upon classification, the required percentage of the surface area in the survey unit was scanned (see Table 4-3) with portable gamma radiation detection instruments. Information obtained during the survey was automatically logged by the instrument for review and analysis. For Class 3 and Class 2 survey units, sample and scan coordinates were identified

using a random sample tool in Visual Sample Plan (VSP), and a survey unit-specific required scan surface area was applied around the sample point. Sample location coordinates were programmed into a Global Positioning System (GPS), then physically located and marked. Investigational samples were collected at areas of elevated scan readings. All details and instructions were incorporated into the FSS Sample Plan for the survey unit.

Surface soil samples were collected to a depth of 0.15-meters below the topsoil surface. Leaves, rocks, roots, and other objects were excluded as much as possible from the sample. In Class 1 open land survey units, subsurface soil samples (soil from a depth of greater than 0.15-meters) were collected as part of the survey design. In accordance with Section 5.7.1.6.2 of the LTP, a subsurface soil sample was required at 10% of the systematic surface soil sample locations in a Class 1 survey unit with the location(s) selected at random. In addition, if during the performance of FSS, the analysis of a surface soil sample, or the results of a surface gamma scan indicated the potential presence of residual radioactivity at a concentration of 75% of the subsurface soil OpDCGL, then a biased subsurface soil sample(s) would be required to a depth of 1-meter within the area of concern as part of the investigation. This occurred in thirty-one (31) of the sixty-seven (67) open land area survey units in this Phase 4 FSSR (survey units 10204B, 10204D, 10206A, 10206B, 10206D, 10207A, 10207B, 10207C, 10207D, 10208C, 10208D, 10209C, 10212A, 10212B, 10213B, 10213C, 10214A, 10214B, 10214C, 10214D, 10214E, 10214F, 10220A, 10220I, 10221A, 10221C, 10221D, 12201D, 12203A, 12205A and 12205E).

Designated soil samples were sent to an off-site laboratory for Hard-to-Detect (HTD) analysis. Laboratory analysis results were summarized in Release Records and reported as actual calculated results. Sample report summaries within the Release Records included unique sample identification, analytical method, radioisotope, result, uncertainty (two standard deviations), laboratory data qualifiers, units, and required Minimum Detectable Concentration (MDC).

Another consideration of survey design was the use of surrogates. In lieu of analyzing every sample for HTD radionuclides, the development and application of Surrogate Ratio DCGLs as described in MARSSIM, Section 4.3.2 was applied to estimate the HTD radionuclide concentration in each sample and survey result. Surrogate ratios allow for expedient decision making in characterization, remediation planning, and FSS design.

A surrogate is a mathematical ratio where an Easy-to-Detect (ETD) radionuclide (i.e., Cs-137) concentration is related to a HTD radionuclide (i.e., Sr-90) concentration. From the analytical data, a ratio is developed and applied in the survey scheme for samples taken in the area. Details and applications of this method are provided in Section 5.2.11 of the LTP.

Some portion of the radioactivity found in the soil samples is typically attributed to "fallout" or background. Due to the lack of significant activity revealed during background studies, assessments and characterization, it was determined that background subtraction would not be applied during FSS.

2.3 Survey Implementation

Final Status Survey implementation of the Phase 4 survey units started on January 11, 2019. Implementation was the physical process of the FSS Sample Plan execution for a given survey unit. Each Sample Plan was assigned to a Radiological Engineer (RE) for implementation and completion in accordance with Zion*Solutions* procedures and the QAPP for Characterization and FSS. The tasks included in the implementation were:

- Verification and validation of personnel training as required by Training Department and Radiation Protection procedures,
- Monitoring instrument calibration as detailed in ZS-RP-108-000-000, "*Radiological Instrumentation Program*" (Reference 13) and ZS-RP-108-004-012, "*Calibration and Initial Set-Up of the 2350-1*" (Reference 14),
- Implementation of applicable operating and health and safety procedures,
- Implementation of isolation of control of the survey unit in accordance with ZS-LT-300-001-003, "*Isolation and Control for Final Status Survey,*"
- Determination of the amount of sampling required to meet DQOs as described in ZS-LT-300-001-001, "*Final Status Survey Package Development*,"
- Determination of sample locations and creation of survey unit maps displaying the locations in accordance with ZS-LT-300-001-001,
- Proper techniques for collecting and handling FSS samples in accordance with Job Aid LT-JA-004, "*FSS Sample Collection*" (Reference 15),
- Maintaining Quality Assurance/Quality Control requirements (i.e., replicate measurements or samples) in accordance with the QAPP for Characterization and FSS.
- Sample Chain-of-Custody maintained in accordance with ZS-LT-100-001-004, "*Sample Media Preparation*" (Reference 16),
- Sample submission to approved laboratories in accordance with ZS-WM-131, "*Chain of Custody Protocol*" (Reference 17),
- Application of the DCGLs to sample results in accordance with the Data Quality Assessment (DQA) process as detailed in ZS-LT-300-001-004, "*Final Status Survey Data Assessment*," and
- Determination of investigation methodology and corrective actions, if applicable.

The FSS implementation and completion process resulted in the generation of field data and analysis data consisting of measurements taken with handheld radiation detecting equipment, observations noted in field logs, and radionuclide specific analysis. Data were stored electronically on the Zion*Solutions* network.

2.4 Survey Data Assessment

Prior to proceeding with data evaluation and assessment, the assigned RE ensured consistency between the data quality and the data collection process and the applicable requirements.

The DQA process is an evaluation method used during review of FSS data to ensure the validity of FSS results and demonstrate compliance with the FSS Sample Plan objectives. A key step in the data assessment process converts all of the survey results to DCGL units. The individual measurements and sample concentrations are compared to the DCGL for evidence of small areas of elevated activity or results that are statistical outliers. When practical, graphical analyses of survey data were used to depict the spatial correlation of the measurements or samples.

For the Class 1 and Class 2 open land areas addressed in this final report, the survey data was evaluated using the Sign Test (as described in the LTP). The Sign Test is a one-sample statistical test that compares data directly to the release criteria. Combined with an effective sampling scheme, passing the Sign Test satisfies the release criteria. Selection of the Sign Test is prudent and conservative in the assumption that the radionuclides being considered are not present in background, or are at levels at a small fraction of the applicable release criteria. Furthermore, any background contribution (e.g., Cs-137 from global fallout) in the sample increases the likelihood of failing the survey unit, which is conservative. If the release criteria were exceeded or if results indicated the need for additional data points, appropriate further actions were implemented usually through the issue of an investigation as specified in ZS-LT-300-001-001, "*Final Status Survey Package Development*," or through an addendum or redesign of the FSS Sample Plan.

2.5 Quality Assurance and Quality Control Measures

Quality assurance and control measures were employed throughout the FSS process to ensure that all decisions were based on data of acceptable quality. Quality assurance and control measures were applied to ensure:

- The plan was correctly implemented,
- The DQA process was used to assess results,
- DQOs were properly defined and derived,
- All data and samples were collected by individuals with the proper training and in adherence to approved procedures and sample plans,
- All instruments were properly calibrated,
- All collected data was validated, recorded, and stored in accordance with approved procedures,
- All required documents were properly maintained, and
- Corrective actions were prescribed, implemented and tracked, as necessary.

Independent laboratories used for analysis of the samples collected during FSS maintained Quality Assurance Plans designed for their facility. Zion*Solutions* reviewed these plans, as required by ZS-QA-10, "*Quality Assurance Project Plan*" (Reference 18) and the QAPP for Characterization and FSS, prior to selection of a laboratory for FSS sample analysis to ensure that the standards were acceptable.

The C/LT Group has undergone surveillance by the Zion*Solutions* Quality Assurance (QA) department on a consistent basis throughout the project at ZNPS. The QA surveillances have scrutinized the LTP, C/LT procedures, Sample Plans, Release Records and other C/LT records. The responses to the QA surveillances were captured in the Corrective Action Program (CAP).

3 Site Information

3.1 Site Description

Zion Nuclear Power Station, owned by Exelon, was located in Zion, Illinois, on the west shore of Lake Michigan. The site is approximately 40 miles north of Chicago, Illinois, and 42 miles south of Milwaukee, Wisconsin.

The owner-controlled site (see Figure 3-1) consisted of approximately 331 acres, and within the owner-controlled area was an approximate 87-acre, fence-enclosed nuclear facility (see Figure 3-2). The center of the community of Zion is approximately 1.6 miles from the plant location on the site. There were no schools or hospitals within one mile of the site, and no residences within 2,000 feet of any ZNPS structures.

Westinghouse Electric Corporation, Sargent and Lundy Engineers, and the Commonwealth Edison Company (ComEd) jointly participated in the design and construction of ZNPS. The plant was comprised of two (2) pressurized water reactors with supporting facilities. The primary coolant system for each unit employed a four-loop pressurized water reactor nuclear steam supply system housed in a steel-lined, reinforced concrete containment structure. Each unit employed a pressurized water reactor nuclear steam supply system furnished by Westinghouse Electric Corporation, designed for a power output of 3,250 MWt. The equivalent warranted gross and approximate net electrical outputs of the plant were 1085 MWe and 1050 MWe, for Unit 1 and Unit 2, respectively.

ZNPS was previously operated by Commonwealth Edison until it was permanently shut down on February 13, 1998. On March 9, 1998, ComEd certified to the NRC that all fuel assemblies had been permanently removed from both reactors and placed in the Spent Fuel Pool. The NRC acknowledged the certification of permanent cessation of power operation and permanent removal of fuel from the reactor vessels in a letter dated May 4, 1998. In 2000, the license was transferred from ComEd to Exelon. In 2008, the license was transferred to Zion*Solutions* to coordinate and execute the decommissioning of the site.

Figure 3-1, Zion Nuclear Power Station Owner Controlled Area

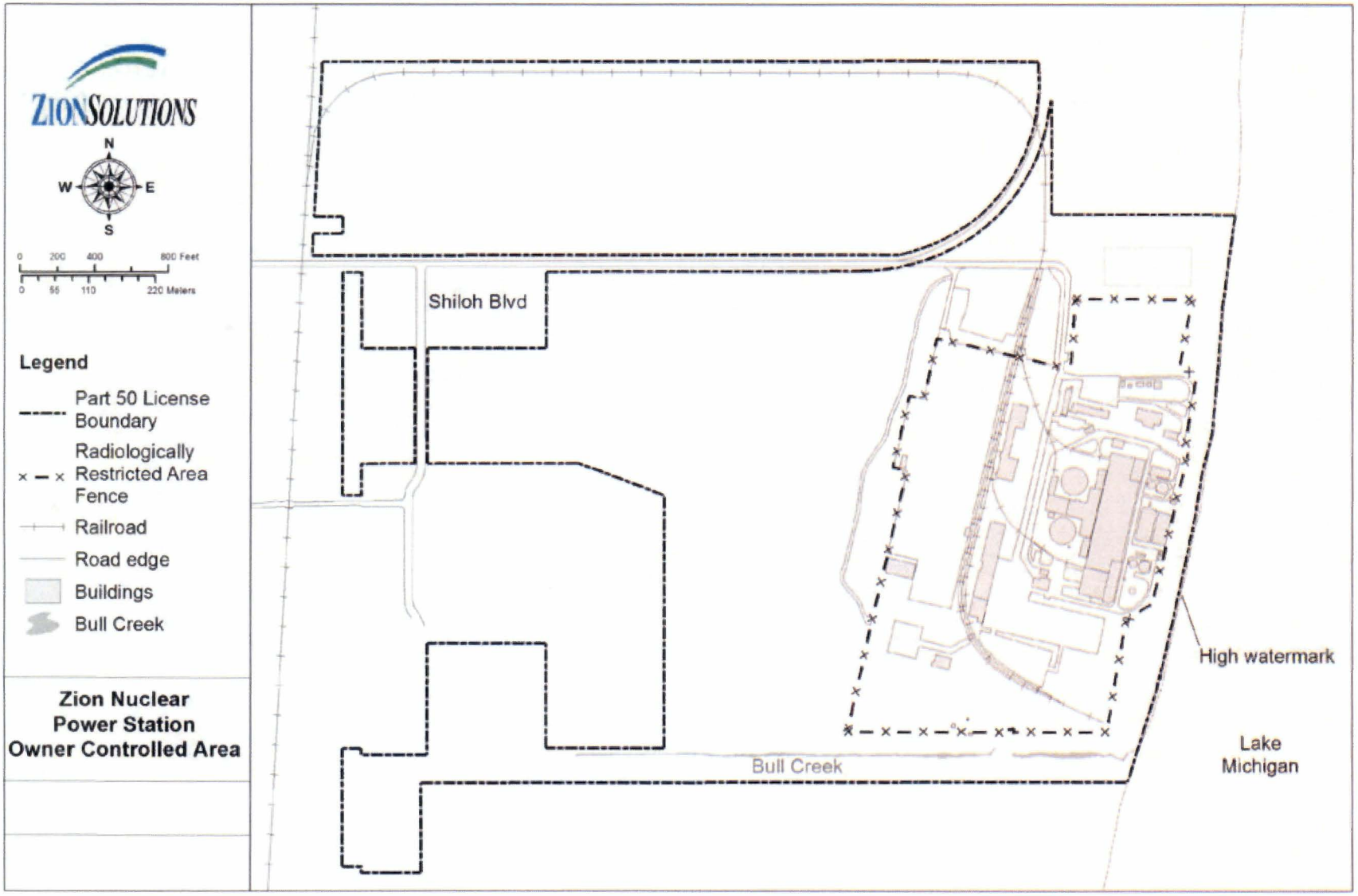
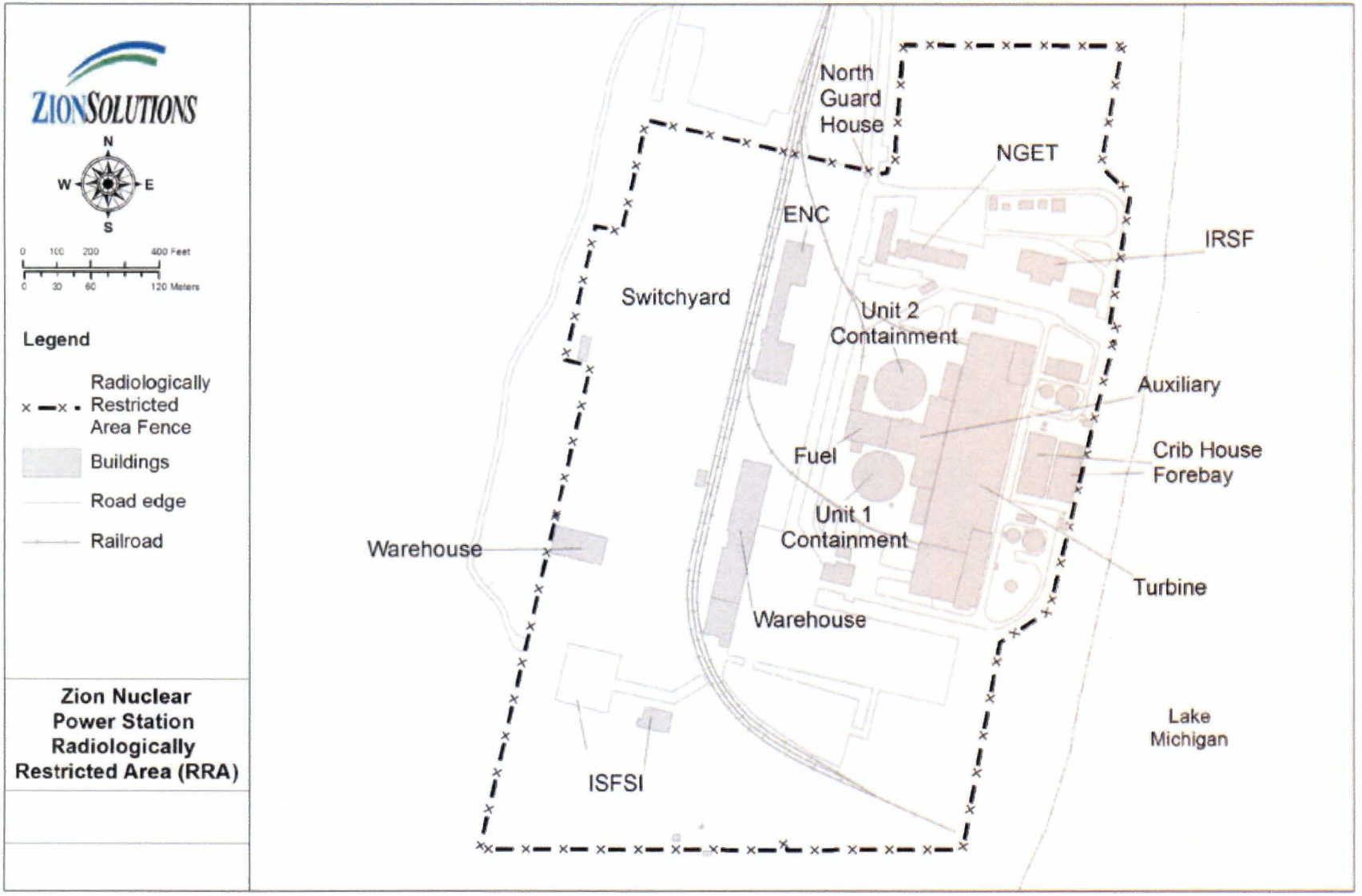


Figure 4-2, Zion Nuclear Power Station Radiologically Restricted Area



The Post Shutdown Decommissioning Activities Report (PSDAR) (Reference 19) was submitted, in accordance with 10CFR50.82(a), in February 2000 and accepted by the NRC. An amended PSDAR was submitted in March 2008 to accommodate the transfer of the 10CFR50 licenses to Zion*Solutions* and to revise cost estimates and the decommissioning schedule. The Defueled Safety Analysis Report (DSAR) (Reference 20) was updated in October 2016. An evaluation of the systems, structures, and components (SSCs) was performed to determine the function these systems would perform in a defueled condition. With the relocation of the spent fuel to the Independent Spent Fuel Storage Installation (ISFSI), the license basis for the majority of the SSCs was changed, and only minimal SSCs were needed to support the ongoing active decommissioning. The remaining SSCs needed to support active decommissioning had controls established in the QAPP and the Offsite Dose Calculation Manual (ODCM) (Reference 21).

Site characterization commenced on November 2, 2011. At the time when characterization commenced, the site-specific Zion*Solutions* characterization plans and procedures were still under development. Consequently, due to schedule restraints, Zion*Solutions* contracted the Energy*Solutions* Commercial Services Group (ESCSG) to perform characterization of the ISFSI location, the Vertical Concrete Cask (VCC) Construction Area, and the pathway for the new rail track. The results of these surveys were validated and integrated into the subsequent site-specific characterization program, which was approved in February 2012. Initial scheduled site characterization efforts concluded on November 11, 2013.

3.2 Survey Unit Description

The following information is a description of each survey unit addressed in this report at the time of FSS from January 11, 2019, until January 14, 2020. During this period, sixty-seven (67) open land area survey units that comprise an area of approximately 178,182 m^2 (44 acres), were evaluated in accordance with the FSS process specified in the LTP.

Survey Unit 10203A

Survey unit 10203A, the "East Training Area", is a Class 1 open land survey unit. It is bounded on the west by survey units 10204D and 10206E, the south by survey unit 12201A, on the east by survey units 10203B, 10203C, and 10203F, and the north by survey unit 10214D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam.

Survey Unit 10203B

Survey unit 10203B, the "East Training Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10203A, the east by survey units 10203C and 10203D, the north by survey unit 10203C, and the south by survey unit 10203F.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10203C

Survey unit 10203C, the "East Training Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10203A, the northeast by survey unit 10213C, the northwest by survey unit 10214D, the east by survey unit 10203D, and the south by survey unit 10203B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10203F

Survey unit 10203F, the "East Training Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10203A, the south by survey units 12201A and 12201B, and the north by survey units 10203B and 10203D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam.

Survey Unit 10204A

Survey unit 10204A, the "North Gate Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10205, the south by survey units 10206A and 10206B, on the east by survey unit 10204B, and the north by survey unit 10214C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam .

Survey Unit 10204B

Survey unit 10204B, the "North Gate Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10204A, the south by 10206B and 10206C, on the east by 10204C, and the north by 10214C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam .

Survey Unit 10204C

Survey unit 10204C, the "North Gate Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10204B, the south by survey units 10206C and 10206D, on the east by survey unit 10204D, and the north by survey unit 10214D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam .

Survey Unit 10204D

Survey unit 10204D, the "North Gate Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10204C, the south by survey units 10206D and 10206E, on the east by survey unit 10203A, and the north by survey unit 10214D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam .

Survey Unit 10206A

Survey unit 10206A, the "Station Construction Area", is a Class 1 open land survey unit. The survey unit is bounded on the west by survey unit 10205, the south by survey unit 10207A, on the east by survey unit 10206B, and the north by survey unit 10204A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam .

Survey Unit 10206B

Survey unit 10206B, the "Station Construction Area", is a Class 1 open land survey unit. The survey unit is bounded on the west by survey unit 10206A, the south by survey unit 10207B, on the east by survey unit 10206C, and the north by survey units 10204A and 10204B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam .

Survey Unit 10206C

Survey unit 10206C, the "Station Construction Area", is a Class 1 open land survey unit. The survey unit is bounded on the west by survey unit 10206B, the south by survey unit 10207C, on the east by survey unit 10206D, and the north by survey units 10204B and 10204C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of mostly loam .

Survey Unit 10206D

Survey unit 10206D, the "Station Construction Area", is a Class 1 open land survey unit. The survey unit is bounded on the west by survey unit 10206C, the east by survey unit 10206E, the north by survey units 10204C and 10204D; and the south by survey unit 10207D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil consists of loam .

Survey Unit 10206E

Survey unit 10206E, "Station Construction Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10206D, the northeast by survey unit 10203A, the southeast by survey unit 12202A, the north by survey unit 10204D, and the south by survey unit 10207E.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10207A

Survey unit 10207A, the "North Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10205, the south by survey unit 10208A, the east by survey unit 10207B, and the north by survey unit 10206A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. A rail spur, with a ballast made up of gravel, runs through the survey unit from the north to south.

Survey Unit 10207B

Survey unit 10207B, the "North Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10207A, the south by survey units 10208A and 10208B, the east by survey unit 10207C, and the north by survey unit 10206B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10207C

Survey unit 10207C, the "North Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10207B, the south by survey units 10208B and 10208C, the east by survey unit 10207D, and the north by survey unit 10206C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10207D

Survey unit 10207D, the "North Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10207C, the south by survey unit 10208C, the east by survey unit 10207E, and the north by survey unit 10206D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10207E

Survey unit 10207E, the "North Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10207D, the south by survey unit 10208D, the east by survey units 12202B and 12202C, and the north by survey unit 10206E.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10208A

Survey unit 10208A, "South Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10205, the east by survey unit 10208B, the north by survey units 10207A and 10207B; and the south by survey unit 10218A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. A rail spur, with a ballast made up of gravel, runs through the survey unit from the north to south.

Survey Unit 10208B

Survey unit 10208B, "South Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10208A, the east by survey unit 10208C, the north by survey units 10207B and 10207C; and the south by survey unit 10218A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10208C

Survey unit 10208C, "South Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10208B, the east by survey unit 10208D, the north by survey units 10207C and 10207D; and the south by survey units 10218A and 10221A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10208D

Survey unit 10208D, "South Warehouse Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10208C, the east by survey units 12202E and 10209A; the north by survey unit 10207E, and the south by survey unit 10221A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10209C

Survey unit 10209C, "Restricted Area South of Gate House," is a Class 1 open land survey unit. It is bounded on the west by survey unit 10209B, the east by 10209D, the north by survey units 12202E and 12202F, and the south by survey units 10221B and 10221C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10212A

Survey unit 10212A, "NE Corner of Exclusion Area - Lakeshore", is a Class 2 open land survey unit. It is bounded on the west by survey units 10213A and 10213B; the east by survey unit 10222, the north by survey unit 10212B and the south by survey units 10212C and 10201A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10212B

Survey unit 10212B, "VCC Construction Area", is a Class 3 open land survey unit. It is bounded on the west by survey unit 10214E, the east by survey unit 10222, the north by a non-impacted area and the south by survey units 10212A, 10213A and 10214E.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10212C

Survey unit 10212C, "NE Corner of Exclusion Area - Lakeshore", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10213C, the east by survey unit 10212A, the north by survey unit 10212A and the south by survey unit 10212D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10212D

Survey unit 10212D, "NE Corner of Exclusion Area - Lakeshore", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10213C, the east by survey unit 10212A, the north by survey unit 10212C and the south by survey units 10201A, 10202A and 10203E.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. A drainage ditch, which is designated a wetland, runs west to east through the survey unit.

Survey Unit 10213A

Survey unit 10213A, "NE Corner of Exclusion Area", is a Class 2 open land survey unit. It is bounded on the west by survey units 10214D and 10214E; the east by survey unit 10212A, the north by survey unit 10212B and the south by survey unit 10213B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10213B

Survey unit 10213B, "NE Corner of Exclusion Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10214D, the east by survey unit 10212A, the north by survey unit 10213A and the south by survey unit 10213C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam and the area is located within a floodplain.

Survey Unit 10213C

Survey unit 10213C, "NE Corner of Exclusion Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10214D, the east by survey units 10212C and 10212D; the north by survey unit 10213B and the south by survey units 10203C through 10203E.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam and the area is located within a floodplain.

Survey Unit 10214A

Survey unit 10214A, "Construction Parking Area", is a Class 2 open land survey unit. It is bounded on the west by a non-impacted area, the east by survey unit 10214B, the north by a non-impacted area and the south by survey unit 10205.

The topography of the survey unit is mainly flat with some small dips and depressions. Since this area was used for parking, the top surface is a mixture of gravel and soil. A paved road runs east to west in the northern part of the survey unit.

Survey Unit 10214B

Survey unit 10214B, "Construction Parking Area", is a Class 2 open land survey unit. It is bounded on the west by survey unit 10214A, the east by survey units 10214C and 10214F; the north by a non-impacted area and the south by survey unit 10205.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10214C

Survey unit 10214C, "Construction Parking Area", is a Class 2 open land survey unit. It is bounded on the west by survey units 10214B and 10214F; the east by survey unit 10214D, the north by a non-impacted area and the south by survey units 10205, 10204A, and 10204B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. Rail tracks run through the center of the survey unit in a north-south direction.

Survey Unit 10214D

Survey unit 10214D, "Construction Parking Area", is a Class 2 open land survey unit. It is bounded on the west by survey unit 10214C, the east by survey units 10213A, 10213B, 10213C and 10214E; the north by a non-impacted area and the south by survey units 10203A, 10203C, 10204B, 10204C and 10204D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10214E

Survey unit 10214E, "Construction Parking Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10214D, the east by survey units 10212B and 10213A; the north by a non-impacted area and the south by survey unit 10214D.

The topography of the survey unit is mainly flat with some small dips and depressions. The top surface is a mixture of gravel and soil.

Survey Unit 10214F

Survey unit 10214F, "Construction Parking Area", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10214B, the east by survey unit 10124C, the north by survey units 10214B and 10214C; and the south by survey units 10214B and 10214C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly gravel as it was used as a parking area. A rail spur, with a ballast made up of gravel, runs through the eastern half of the survey unit.

Survey Unit 10220A

Survey unit 10220A, the "SE Corner of Exclusion Area – Lakeshore", is a Class 1 open land survey unit. It is bounded on the west by survey units 10220E, 10220F, and 10220G, the south by survey unit 10220C, the east by survey unit 10220H, and the north by survey units 10221A and 10221B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 10220H

Survey unit 10220H, "SE Corner of Exclusion Area – Lakeshore", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10220A, the south by survey unit 10220C, the east by survey unit 10220I, and the north by survey units 10221B and 10221C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. A Wetland area runs along the southeast boundary of the survey unit.

Survey Unit 10220I

Survey unit 10220I, the "SE Corner of Exclusion Area – Lakeshore", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10220H, the south by survey unit 10220C, the east by survey unit 10220J, and the north by survey units 10221C, 10221D and 10221H.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. There is a wetland area on the west side of the survey unit.

Survey Unit 10221A

Survey unit 10221A, "South of Protected Area - Inland" is a Class 1 open land survey unit. It is bounded on the west by survey unit 10218 (ISFSI), the east by survey unit 10221B, the north by survey units 10208C, 10208D, 10209A and 10209B; and the south by survey units 10220A and 10220G.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. A rail spur, with a ballast made up of gravel, runs through the survey unit from the southeast corner to the northwest corner.

Survey Unit 10221C

Survey unit 10221C, "South of Protected Area - Inland", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10221B, the east by survey unit 10221D, the north by survey units 10209C through 10209E; and the south by survey units 10220H and 10220I.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. A rail spur, with a ballast made up of gravel, runs through the southern half of the survey unit.

Survey Unit 10221D

Survey unit 10221D, "South of Protected Area – Inland", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10221C, the south by survey unit 10220I, the east by survey units 10221E through 10221H; and the north by survey units 10209E, 10210A and 10210B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam. A rail spur, with a ballast made up of gravel, runs through the southern part of the survey unit and a drainage ditch runs north to south through the survey unit.

Survey Unit 12104

Survey unit 12104, described as the "North Half of Unit 2 Containment", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202A, the south by survey unit 12105, the east by survey unit 12205A, and the north by survey units 12201A through 12201C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12105

Survey unit 12105, "South Half of Unit 2 Containment", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202A, the south by survey unit 12106, the east by survey units 12205A and 12205B; and the north by survey unit 12104.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12106

Survey unit 12106, "North Half of Fuel & Auxiliary Buildings", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202A, the south by survey unit 12107, the east by survey units 12205B and 12205C; and the north by survey unit 12105.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12107

Survey unit 12107, the South Half of Fuel & Auxiliary Buildings, is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202B, the south by survey unit 12108, the east by survey unit 12205C, and the north by survey unit 12106.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12108

Survey unit 12108, the "North Half of Unit 1 Containment", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202B, the east by survey units 12205C and 12205D; the north by survey unit 12107 and the south by survey unit 12109.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12109

Survey unit 12109, the "South Half of Unit 1 Containment", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202B, the south by survey unit 12110, the east by survey units 12205D and 12205E, and the north by survey unit 12108.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12110

Survey unit 12110, the "Yard Between Unit 1 Containment and Turbine", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202C, the east by survey unit 12205E, the north by survey unit 12109 and the south by survey units 12202D and 12111.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12111

Survey unit 12111, the "South Yard Area Northeast of Gate House", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202D, the south by survey unit 12202F, the east by survey units 12203A and 12205E, and the north by survey unit 12110.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12201A

Survey unit 12201A, the "North Protected Area Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10206E, the south by survey units 12104 and 12202A, the east by survey unit 12201B, and the north by survey units 10203A and 10203F.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12201B

Survey unit 12201B, the "North Protected Area Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12201A, the south by survey unit 12104, the east by survey unit 12201C, and the north by survey units 10203D, 10203E, and 10203F.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12201C

Survey unit 12201C, the "North Protected Area Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12201B, the south by survey units 12104 and 12205A, the east by survey unit 12201D, and the north by survey units 10203E and 10202D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12201D

Survey unit 12201D, the "North Protected Area Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12201C, the south by survey unit 12205A, the east by survey unit 12201E, and the north by survey unit 10202D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 12201E

Survey unit 12201E, the "North Protected Area Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12201D, the south by survey unit 12205A, the east by survey units 12101, 12102, and 12103, and the north by survey unit 10202D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 12202A

Survey unit 12202A, the "Gate House and Southwest Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10206E, the south by survey unit 12202B, the east by survey units 12104 through 12106, and the north by survey unit 12201A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12202B

Survey unit 12202B, the "Gate House and Southwest Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10206E and 10207E, the south by survey unit 12202C, the east by survey units 12107, 12108, and 12109, and the north by survey unit 12202A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12202C

Survey unit 12202C, the "Gate House and Southwest Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10207E, the south by survey unit 12202E, the east by survey units 12202D and 12110, and the north by survey unit 12202B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12202D

Survey unit 12202D, the "Gate House and Southwest Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202C, the south by survey units 12202E and 12202F, the east by survey units 12110 and 12111, and the north by survey unit 12110.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12202E

Survey unit 12202E, the "Gate House and Southwest Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 10208D, the south by survey units 10209A, 10209B, and 10209C, the east by survey unit 12202F, and the north by survey units 12202C and 12202D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12202F

Survey unit 12202F, the "Gate House and Southwest Yard", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12202E, the south by survey units 10209C, 10209D, 10209E, and 10210A, the east by survey unit 12203A, and the north by survey units 12202D and 12111.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12203A

Survey unit 12203A, "Under Service Building and Southeast Yard" is a Class 1 open land survey unit. It is bounded on the west by survey units 12111 and 12202F, the south by survey units 10210A and 10210B, the east by survey unit 12203B, and the north by survey unit 12205E.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly loam.

Survey Unit 12205A

Survey unit 12205A, the "Area Under the Turbine Building", is a Class 1 open land survey unit. It is bounded on the west by survey units 12104 and 12105, the south by survey unit 12205B, the east by survey units 12103 and 12204A, and the north by survey units 12201C, 12201D, and 12201E.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12205B

Survey unit 12205B, the "Area Under the Turbine Building", is a Class 1 open land survey unit. It is bounded on the west by survey units 12105 and 12106, the south by survey unit 12205C, the east by survey units 12204A and 12204B, and the north by survey unit 12205A.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12205C

Survey unit 12205C, the "Area Under the Turbine Building", is a Class 1 open land survey unit. It is bounded on the west by survey units 12106, 12107, and 12108, the south by survey unit 12205D, the east by survey units 12204B and 12204C, and the north by survey unit 12205B.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12205D

Survey unit 12205D, the "Area Under the Turbine Building", is a Class 1 open land survey unit. It is bounded on the west by survey units 12108 and 12109, the south by survey unit 12205E, the east by survey units 12204C and 12113, and the north by survey unit 12205C.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

Survey Unit 12205E

Survey unit 12205E, the "Area Under the Turbine Building", is a Class 1 open land survey unit. It is bounded on the west by survey unit 12109, 12110, and 12111, the south by survey units 12203A and 12203B, the east by survey unit 12113, and the north by survey unit 12205D.

The topography of the survey unit is mainly flat with some small dips and depressions. The soil is mostly sand.

3.3 Summary of Historical Radiological Data

The historical site radiological data for this Phase 4 FSSR at ZNPS incorporated the results of the HSA issued in 1999 and supplemented in 2006 and included the initial characterization surveys completed in 2013.

Historical Site Assessment

The HSA was a detailed investigation to collect existing information (from the start of ZNPS activities related to radioactive materials or other contaminants) for the site and its surroundings. The HSA focused on historical events and routine operational processes that resulted in contamination of plant systems, onsite buildings, surface and subsurface soils within the Radiologically Controlled Area (RCA). It also addressed support structures, open land areas and subsurface soils outside of the RCA but within the owner-controlled area. The information compiled by the HSA was used to establish initial survey units and their MARSSIM classifications. This information was used as input into the development of site-specific DCGLs, remediation plans and the design of the FSS. The scope of the HSA included potential contamination from radioactive materials, hazardous materials, and other regulated materials.

The objectives of the HSA were to:

- Identify potential, likely, or known sources of radioactive and chemical contaminants based on existing or derived information,
- Distinguish portions of the site that may need further action from those that pose little or no threat to human health,
- Provide an assessment of the likelihood of contaminant migration,
- Provide information useful to subsequent continuing characterization surveys,
- Provide an initial classification of areas and structures as non-impacted or impacted,
- Provide a graded initial classification for impacted soils and structures in accordance with MARSSIM guidance, and
- Delineate initial survey unit boundaries based upon the initial classification.

The survey units established by the HSA were used as initial survey units for characterization. Prior to characterization, survey unit sizes were adjusted in accordance with the guidance provided in MARSSIM Section 4.6 for the suggested physical area sizes for survey units for FSS.

Of the sixty-seven (67) open land area survey units in this Phase 4 FSSR, only eight (8) survey units (survey units 12104, 12105, 12106, 12107, 12108, 12109, 12110 and 12111) were given an initial classification as Class 1, and seventeen (17) survey units (survey units 12201A, 12201B, 12201C, 12201D, 12201E, 12202A, 12202B, 12202C, 12202D, 12202E, 12202F, 12203A, 12205A, 12205B, 12205C, 12205D and 12205E) were given an initial classification as Class 2 by the HSA. Based on process knowledge and historical surveys to

date, the remaining forty-two (42) survey units were given an initial classification of Class 3. During building demolition in the Spring of 2017, discrete particles of radioactive material were identified during the performance of operational surveys and Radiological Assessments (RA) in and around the Class 2 and Class 3 survey units. As a conservative measure starting in July of 2016, the classification of a majority of the open land survey units located within the 87-acre, fence-enclosed area was increased to Class 1. This action included all survey units addressed in this report that were initially classified as Class 2 or Class 3 with the exception of survey units 10212A, 10213A, 10214A, 10214B, 10214C and 10214D, which had a final classification of Class 2 and survey unit 10212B, which retained its original classification as Class 3.

Characterization Surveys

Site characterization of the ZNPS was performed in accordance with ZS-LT-02, "*Characterization Survey Plan*" (Reference 22). It was developed to provide guidance and direction to the personnel responsible for implementing and executing characterization survey activities. The Characterization Survey Plan worked in conjunction with implementing procedures and survey unit specific survey instructions (sample plans) that were developed to safely and effectively acquire the requisite characterization data.

Characterization data acquired through the execution of the Characterization Survey Plan was used to meet three primary objectives:

- Provide radiological inputs necessary for the design of FSS,
- Develop the required inputs for the LTP,
- Support the evaluation of remediation alternatives and technologies and estimate waste volumes.

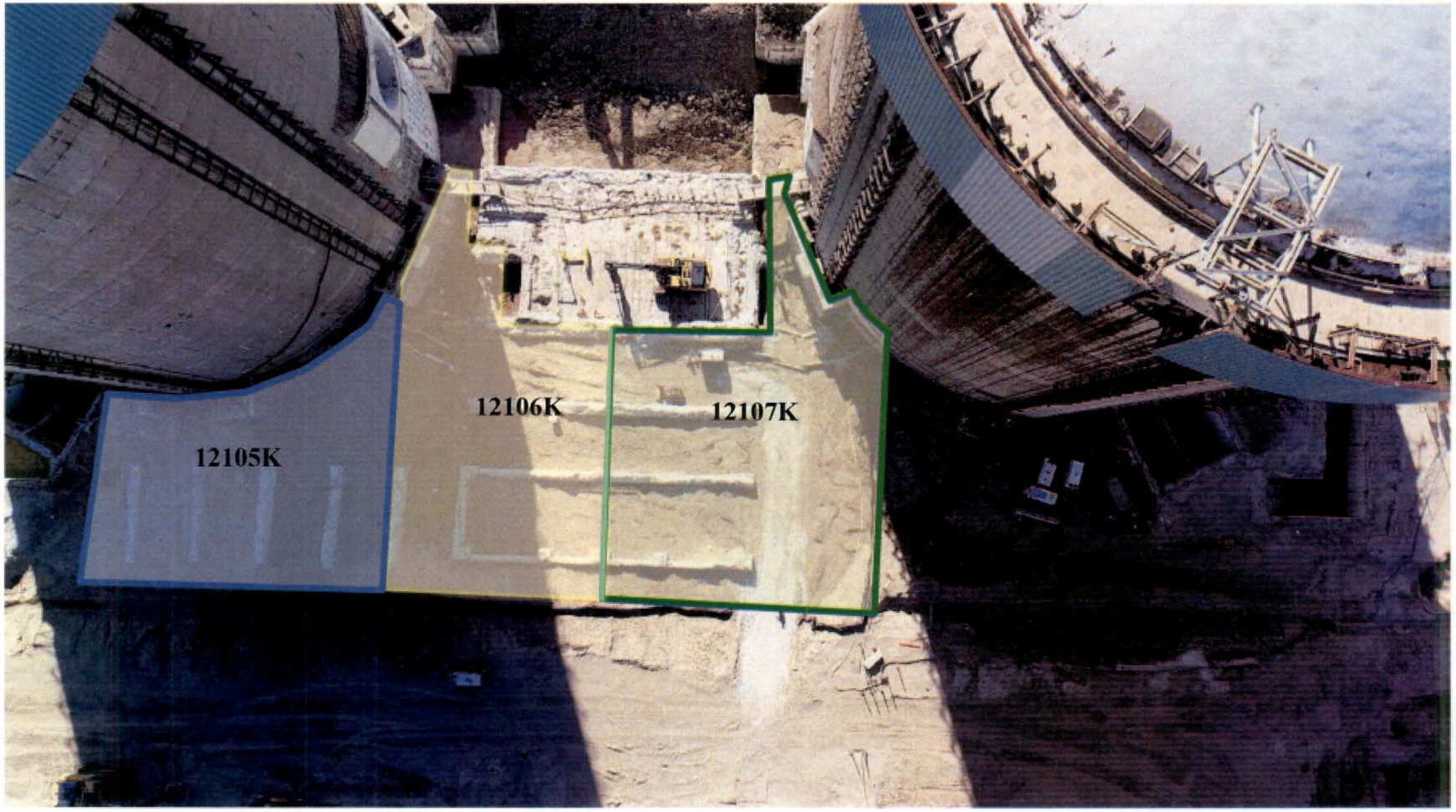
The final output of the initial site characterization was TSD-14-028, "*Radiological Characterization Report.*" The report concluded that based on the results of the characterization surveys, it was expected that residual plant-derived radioactivity was present in the sixty-seven (67) survey units addressed by this report.

FSS of Excavated Areas

In the Spring of 2018, an area was excavated to expose the remaining foundation of the Fuel Handling Building (FHB) and Car Shed (see Figure 3-3). This excavation included the west half of survey units 12105, 12106, and 12107. An FSS sample plan was written to perform an FSS on the exposed subsurface soil within the excavation prior to backfill to grade. When the FSS was performed, these survey units were designated as survey units 12105K, 12106K, and 12107K. This survey area within the excavation was assigned a MARSSIM classification of 1. A survey plan was designed based upon use of the Sign Test as the nonparametric statistical test for compliance. Both the Type I (α) and Type II (β) decision error rates were set at 0.05. Scanning was performed on 100% of the total exposed

excavation surface area. No areas of elevated activity were detected during the scans. Seventeen (17) systematic soil samples were acquired from within each survey unit. When compared to the OpDCGL for subsurface soils, the maximum observed OpSOF was 0.453 for a subsurface soil sample taken within the excavation, with survey unit 12107K exhibiting the largest mean OpSOF of 0.155. This area was subsequently backfilled with clean fill prior to the demolition of the Containment Buildings. The results of the FSS performed on survey units 12105K, 12106K, and 12107K are included as Addendums to Release Records 12105, 12106, and 12107, respectively.

Figure 5-3, Fuel Handling Building (FHB) and Car Shed Excavation Survey Units



Continuing Characterization

Chapter 5, Section 5.3.4.4 of the LTP states that the subsurface soils in the "keyways" between the Containment Buildings and the Turbine Building will be assessed for radiological contamination of subsurface soils once subsurface utilities and subsurface access-interfering structures (e.g., Waste Annex Building) had been removed. This applied to the survey unit 12109 as well as the north boundary of survey unit 12110.

During the course of the decommissioning and the remediation of the indigenous soils following the removal of the sacrificial layer, the soils in question were completely removed and disposed of as contaminated waste. The tops of the underlying structures were exposed, and post-remediation scans and samples taken from the excavation prior to backfill did not indicate the presence of the ROC at concentrations exceeding the OpDCGLs. No further action was taken.

In August of 2018, ZSRP completed the demolition and backfill of the Auxiliary Building basement and Spent Fuel Pool (SFP). The next buildings that were slated for demolition were the Unit 1 and Unit 2 Containment domes. It was the intention of ZSRP at the time to designate the exterior concrete of the Unit 1 and Unit 2 Containment domes as Clean Concrete Demolition Debris (CCDD) and to use the CCDD as fill material in basements. However, for the concrete to be considered for use as CCDD, it was important to maintain its unrestricted release pedigree. The 588-foot grade surface soils surrounding the two containments were identified as contaminated. While it was necessary to remediate the soils surrounding the Containments, the timeframe required was prohibitive at the time. Therefore, in lieu of remediating the exposed soil, a sacrificial layer of clean soil from off-site was placed over the contaminated indigenous surface soil with up to 1 ½ feet of clean fill. Once the sacrificial layer was in place, the Containment dome structures were demolished without having to wait for the remediation to be completed (see Figures 3-4).

Figure 6-4, Demolition of Containment Domes

From August 2018 through December 2018, both Unit 1 and Unit 2 Containments were demolished and the resultant CCDD was removed from the area. After removal of the CCDD, the sacrificial soil was removed and the exposed 588-foot indigenous soils were scanned. The survey was performed under an RA, which required "100% scan of the soils exposed by the removal of the sacrificial layer" with an alarm set-point set at the MDCR of the instrument plus background. Any indication of elevated activity greater than the MDCR would then prompt investigation and remediation as necessary.

From February 26, 2019, through June 18, 2019, scanning and remediation commenced south of Unit 1 and progressed to the north and west of the Containment footprints (see Figure 3-5). Large areas of elevated activity were identified by scan and verified by soil sample analysis and subsequently marked. All soil identified as exceeding the OpDCGLs for subsurface soil was excavated and disposed of as radioactive waste. Following excavation, post-remediation surveys were performed by scan and media sampling. The analysis of all post-remediation soil samples showed an OpSOF less than one (1) when sample results were directly compared against the OpDCGLs for subsurface soils. However, all excavations remained open to allow the Oak Ridge Institute for Science and Education (ORISE) to perform confirmatory surveys of the exposed remediated soil.

Figure 7-5, Remediation of Indigenous Soils Following Removal of Sacrificial Soil Barrier

ORISE performed confirmatory surveys of the exposed subsurface soils surrounding the Containments in August of 2019. Three (3) small particles of radioactive material were identified by the ORISE survey. The particles were captured and removed. Shortly thereafter, clean fill was acquired from an off-site source and used to increase the grade of all survey units surrounding any end-state basement to the 591-foot elevation. In accordance with LTP Chapter 6, Section 6.4.1, the end-state basements must be covered by at least three feet of clean soil and physically altered to a condition which would not realistically allow the remaining structures, if excavated, to be occupied.

Section 5.3.4.4 of LTP Chapter 5 states that attempts shall be made to acquire subsurface soil samples from beneath each Containment basement foundation and the Auxiliary Building basement floor slab. The objective was to assess the radiological contamination of subsurface soils adjacent to and below these basement slabs. Section 5.3.4.4 of LTP Chapter 5 also states that attempts shall be made to acquire soil samples from beneath each basement floor slab and around each foundation from grade to the floor slab depth or refusal, whichever was less.

Many attempts were made to acquire these samples following the demolition of all above-grade structures. As part of this effort, one (1) subsurface soil sample was taken in survey unit 12109 along the west side of the Auxiliary Building to a depth of 52 feet below grade, where refusal was met. Several attempts were made to acquire samples at a deeper depth and below the basement slab in survey unit 12109. However, with the exception of sample acquired under the Auxiliary Building, the "mud-mat" placed around the Containment basement exterior during construction obstructed the GeoProbe from acquiring samples at a deeper depth. For the sample acquired in survey unit 12109, the probe was able to punch through the mud-mat and acquire a sample at a sub-basement slab depth. Twelve (12) additional samples were taken adjacent to the foundations of both Unit 1 and Unit 2 Containment buildings and the Auxiliary Building to a depth of 32 feet to 48 feet. All of the deep subsurface soil samples were analyzed by the on-site gamma spectroscopy system. No ROCs were positively detected in any of these samples except for one sample taken along the foundation of Unit 2 Containment where Cs-137 was positively detected at a concentration of 0.095 pCi/g which is below the action level that would require an investigation.

3.4 Conditions at the Time of Final Status Survey

The land areas discussed in this report were open land areas. All above ground structures and commodities were removed and disposed of during decommissioning (see Figure 3-6). Portions of the open land areas specified were excavated to remove buried pipe and commodities. Excavations created to remove sub-grade commodities were assessed against the OpDCGLs for subsurface soil prior to backfill in accordance with LTP Chapter 5, Section 5.7.1.6. All subsurface soil that was identified as exceeding the subsurface soil OpDCGLs

was excavated and removed as waste. Excavations were backfilled using overburden that was verified to be less than the subsurface soil OpDCGLs or with clean fill brought in from non-radiological off-site sources. Open land survey units were then smoothed and brought to grade using heavy earth-moving machinery. Transit roads consisting of gravel and hard packed dirt were maintained for vehicular traffic.

Prior to FSS, areas ready for survey were isolated and controlled under ZS-LT-300-001-003, "*Isolation and Control for Final Status Survey.*" This included posting of the area as well as notifications to site personnel. Permission was obtained from C/LT staff to enter and work in these areas. Posting of the boundaries controlled public access, and a routine surveillance program monitored for any inadvertent public access with procedurally defined recovery and reporting protocols in the event of any impact to the final status of these survey units.

Figure 8-6, Phase 4 Open Land Areas Prepared for FSS

3.5 Identification of Potential Contaminants

Zion*Solutions* TSD-11-001, *"Technical Support Document for Potential Radionuclides of Concern During the Decommissioning of the Zion Station"* (Reference 23) was prepared and approved in October 2012. The purpose of this document was to establish the basis for an initial suite of potential ROC for the decommissioning. Industry guidance was reviewed as well as the analytical results from the sampling of various media from past plant operations. Based on the elimination of some of the theoretical neutron activation products, noble gases and radionuclides with a half-life of less than two years, an initial suite of potential ROC for the decommissioning of the ZNPS was prepared.

The site characterization showed that the radionuclide identified in most of the samples was Cs-137. For all of the characterization samples, the concentrations of Cs-137 were typical of the concentrations determined from off-site locations and fallout as documented by TSD-13-004, "*Examination of Cs-137 Global Fallout In Soils At Zion Station*" (Reference 24). Characterization results also identified Co-60 at concentrations greater than MDC at several locations.

Cs-137 deposition resulting from global fallout is thought to be the source of most of the Cs-137 encountered in samples collected in the open lands surrounding ZNPS. Geological deposition, regional concentrations and transport mechanisms are well documented and the subject of numerous publications and studies. However, as a conservative measure, Cs-137 resulting from fallout or "background" was not subtracted from analytical results for FSS at ZNPS.

In accordance with the LTP, a minimum of 10% of the non-parametric sample population or any sample with a SOF of 0.1 or greater was sent to an off-site laboratory for HTD ROC analysis. This process was done to verify that the surrogate ratios between HTD ROC and the ETD ROC as established in the LTP remained valid and conservative even with changing environmental conditions. For soil samples with positive results for both an HTD ROC and the corresponding surrogate radionuclide, the HTD to surrogate ratio would have been derived. If the derived surrogate ratio had exceeded the maximum surrogate ratios presented in LTP Chapter 5, Table 5-15, then consideration would have been given to using a survey unit specific surrogate ratio after sufficient investigation and consultation with the NRC. Analyses for HTD radionuclides positively identified Ni-63 in some samples, but the threshold described above was not encountered in any of the sixty-seven (67) survey units addressed by Phase 4. Accordingly, the maximum ratios from LTP Chapter 5, Table 5-15 were used for all surrogate calculations

During the FSS implementation, areas of interest were "scanned" with portable, hand-held radiation detection meters. Prior to scanning, background levels were determined, and investigation levels set in accordance with the Sample Plan. Areas were then scanned for elevated readings. When an elevated area was found, the area was marked, and a sample was collected at that location for gamma spectroscopy analysis and further evaluation.

3.6 Radiological Release Criteria

All FSS of the surface soil in open land survey units submitted in this Phase 4 FSSR were designed to the OpDCGL for surface soils, and all results were compared to this value. However, since the release criteria were based on the BcDCGL (25 mrem/year), surpassing the OpDCGL did not disqualify a survey unit from meeting the release criteria provided that the Elevated Measurement Comparison (EMC) was not exceeded. Discrete, elevated areas of contamination were identified in several of these survey units during FSS, however all residual radioactivity greater than the OpDCGL concentrations was remediated prior to

demonstrating compliance. The EMC was calculated during the FSS of several of these survey units (10207A, 10213B, 10220I, 10221A, 10221D and 12203A); however, as all soils identified as exceeding the OpDCGLs were remediated in these survey units, the EMC was not used to demonstrate compliance.

4 Final Status Survey Protocol

4.1 Data Quality Objectives

The DQO process as outlined in Section 2 of this report was applied for each FSS Sample Plan and contained basic elements common to all FSS Sample Plans at ZSRP. An outline of those elements that are presented in the ZSRP FSS Sample Plans are as follows:

State the Problem

The problem: To demonstrate that the level of residual radioactivity in a survey unit does not exceed the release criteria of 25 mrem/year TEDE and that the potential dose from residual radioactivity is ALARA.

Stakeholders: The primary stakeholders interested in the answer to this problem are Zion*Solutions* LLC, Exelon, the Illinois Environmental Management Agency (IEMA) and the NRC.

The Planning Team: The planning team consisted of the assigned RE with input from other C/LT personnel as well as the Safety Department. The primary decision makers were the Technical Lead/RE with input from the C/LT Manager.

Schedule: The approximate time projected to mobilize, implement, and assess an FSS unit was typically four (4) days.

Resources: The following resources were necessary to implement an FSS Sample Plan:

- RE to prepare the plan and evaluate data,
- C/LT Field Supervisor to monitor and coordinate field activities,
- Survey Mapping/computer aided design (CAD) Specialist to prepare survey maps, layout diagrams, composite view drawings, and other graphics as necessary to support design and reporting,
- C/LT Technicians to perform survey activities, collect survey measurement data, and collect media samples,
- Chemistry/Analysis laboratory Staff to analyze samples as necessary.

Identify the Decision

Principal Study Question: Are the residual radionuclide concentrations found in the soil equal to or below site-specific DCGLs for surface soils?

Alternate Actions: Alternative actions included failure of the survey unit, remediation, reclassification, and resurvey.

The Decision: If the survey unit failed to demonstrate compliance with the release criteria, then the survey unit would not be suitable for unrestricted release. The DQA process was reviewed to identify the appropriate additional action or combination of actions.

Identify Inputs to the Decision

Information Needed: The survey unit required evaluation of residual activity and its surface area. The characterization surveys and HSA were preliminary sources of information for FSS. In some cases, new measurements of sample media were needed to determine the concentration and variability for those radionuclides potentially present at the site at the time of FSS.

Historical Information: The classification as originally identified in the HSA and the verification of that classification during characterization. A summary of site processes or incidents that occurred in the survey unit.

Radiological Survey Data: The current radiological survey data from the HSA and from characterization was used to develop a sample size for FSS.

Radionuclides of Concern: The ROC for the FSS of open land areas are presented in Section 2.2, Table 2-4, of this report.

Basis for the Action Level: The action levels for the FSS of Class 1, 2 and 3 open land areas were the OpDCGL, or a percentage of the OpDCGL (100% for survey units designated as Class 1 or Class 2 and 50% for Class 3 survey units).

During FSS, concentrations for HTD ROC, Ni-63 and Sr-90, were inferred using a surrogate approach. As presented in the LTP, Cs-137 is the principle surrogate radionuclide for Sr-90 and Co-60 is the principle surrogate radionuclide for Ni-63. The mean, maximum and 95% Upper Confidence Level (UCL) of the surrogate ratios for concrete core samples taken in the Auxiliary Building basement were calculated in Zion*Solutions* TSD-14-019, *"Radionuclides of Concern for Soil and Basement Fill Model Source Terms"* (Reference 25) and are presented in Table 4-1. The maximum ratios were used in the surrogate calculations during the FSS of the Phase 4 open land survey units. No area specific ratios were determined by continuing characterization.

Table 4-1, Surrogate Ratios

Ratios	Auxiliary Building		
	Mean	Max	95% UCL
Ni-63/Co-60	44.143	180.450	154.632
Sr-90/Cs-137	0.001	0.002	0.002

For the FSS of the open land survey units in this report, the surrogate OpDCGLs for Co-60 and Cs-137 was computed based on the maximum ratios from Table 4-1.

The equation for calculating a surrogate DCGL is as follows:

Equation 1

$$Surrogate_{DCGL} = \frac{1}{\left[\left(\frac{1}{DCGL_{Sur}}\right) + \left(\frac{R_2}{DCGL_2}\right) + \left(\frac{R_3}{DCGL_3}\right) + \cdots \left(\frac{R_n}{DCGL_n}\right)\right]}$$

Where: $DCGL_{Sur}$ = Surrogate radionuclide DCGL

$DCGL_{2,3...n}$ = DCGL for radionuclides to be represented by the surrogate

R_n = Ratio of concentration (or nuclide mixture fraction) of radionuclide "n" to surrogate radionuclide

Using the OpDCGLs presented in Table 2-1 and the maximum ratios from Table 4-1, the following surrogate calculations were performed:

Equation 2

$$Surrogate_{DCGL\,(Cs-137)} = \frac{1}{\left[\left(\frac{1}{3.630_{(Cs-137)}}\right) + \left(\frac{0.002}{3.095_{(Sr-90)}}\right)\right]} = 3.622\ pCi/g$$

The surrogate OpDCGL that was used for Cs-137 in the survey units for direct comparison of sample results to demonstrate compliance was 3.622 pCi/g.

Equation 3

$$Surrogate_{DCGL\,(Co-60)} = \frac{1}{\left[\left(\frac{1}{1.091_{(Co-60)}}\right) + \left(\frac{180.45}{914.458_{(Ni-63)}}\right)\right]} = 0.898\ pCi/g$$

The surrogate OpDCGL that was used for Co-60 in the survey units for direct comparison of sample results to demonstrate compliance was 0.898 pCi/g.

The action level for investigation in a Class 1 open land survey unit was the OpDCGL. The surrogate DCGL for Co-60 while inferring Ni-63 was 0.898 pCi/g, and the surrogate DCGL for Cs-137 while inferring Sr-90 was 3.622 pCi/g.

Investigation Levels: The investigation levels used for the FSS of Phase 4 survey units were designated in accordance with Table 5-25 of the LTP, recreated below as Table 4-2.

Table 4-2 FSS Investigation Levels

Classification	Scan Investigation Levels	Direct Investigation Levels
Class 1	>Operation DCGL or >MDC_{scan} if MDC_{scan} is greater than Operational DCGL	>Operational $DCGL_W$
Class 2	>Operational DCGL or >MDC_{scan} if MDC_{scan} is greater than Operational DCGL	>Operational $DCGL_W$
Class 3	>Operational DCGL or >MDC_{scan} if MDC_{scan} is greater than Operational DCGL	>0.5 Operational $DCGL_W$

Sampling and Analysis Methods to Meet the Data Requirements: Surface soil samples were collected down to a depth of 0.15-meters (6-inches) and analyzed for gamma-emitting radionuclides by the on-site gamma spectroscopy. The media consisted of soils and sand as required to complete the FSS. Subsurface soil sampling was collected using hand-auger or GeoProbe technology, typically to a depth of 1-meter. Several samples were acquired of subsurface soils surrounding buried basement foundations to deeper depths.

The target MDC for the analysis of sample media using laboratory instruments was 10% of the applicable OpDCGL. If necessary, measurement results with associated MDC that exceeded these values were accepted as valid data after evaluation by C/LT Supervision.

In accordance with LTP Chapter 5, Section 5.1, 10% of the volumetric samples acquired for FSS or any sample with a SOF in excess of 0.1 when compared against the OpDCGL (OpSOF) were sent off-site for HTD ROC analysis. These analyses aimed to reaffirm that the radionuclide mix was not significantly different than that assumed in the LTP.

All activities were subject to the requirements of the QAPP for Characterization and FSS, which requires, among other things, the use of trained technicians, calibrated instruments, and procedures. In addition to these requirements, a minimum of 5% of the required number of samples were selected for Quality Control (QC) evaluation. At least one (1) duplicate soil sample was collected in each survey unit for QC evaluation.

Define the Boundaries of the Survey

Boundaries of the Survey: The actual physical boundaries as stated for each survey unit.

Temporal Boundaries: The times and dates the survey was performed. Scanning and sampling in a survey unit was normally performed only during daylight and dry weather.

Constraints: The most common constraints were the weather, brush or undergrowth, and standing water in a survey unit.

Develop a Decision Rule

Decision Rule: If any measurement data results exceeded the release criteria, the DQA process would be used to evaluate alternative actions.

Specify Tolerable Limits on Decision Errors

The Null Hypothesis: Residual radioactivity in the survey unit exceeds the release criteria.

Type I Error: This is also known as the "α" error. This is the error associated with incorrectly concluding the null hypothesis has been rejected. In accordance with LTP Section 5.6.4.1.1, the α error was set at 0.05 (5%).

Type II Error: This is also known as the "β" error. This is the error associated with incorrectly concluding the null hypothesis has been accepted. In accordance with LTP Section 5.6.4.1.1, the β error was set at 0.05 (5%).

The Lower Bound of the Gray Region (LBGR): The LBGR was set at 50% of the OpDCGL. In using the unity rule, the OpDCGL becomes one (1) and the LBGR is set as 0.5.

Optimize Design

Type of Statistical Test: The Sign Test was selected as the non-parametric statistical test for FSS. The Sign Test is conservative as it increases the probability of incorrectly accepting the null hypothesis (i.e., the conclusion will be that the survey unit does not meet the release criteria) and does not require the selection or use of a background reference area.

Number of Non-Parametric Samples: In the majority of the open land survey units addressed by this Phase 4 FSSR, 17 surface soil samples were required for the non-parametric statistical test (sample size N = 17). In nine (9) of the sixty-seven (67) survey units (survey units 10204A, 10206A, 10207A, 10208A, 10212A, 10212C, 10212D 10220A and 10221A), between eighteen (18) and twenty-four (24) surface soil samples were required for the non-parametric statistical test. The locations of the samples were determined using software VSP.

Number of Judgmental Samples and Locations: The selection of judgmental samples was at the discretion of the cognizant RE. Locations chosen for sampling were usually areas of interest (small piles, trenches, etc.) and any areas of elevated radiation identified by scan.

Number of Scan Areas and Locations: Scan frequencies were prescribed in accordance with LTP Chapter 5, Section 5.6.4.4 and Table 5-24. Minimum scan frequencies are presented in Table 4-3.

Table 4-1, Recommended Scan Coverage

Area Classification	Surface Scans
Class 1	100%
Class 2	10% to 100%, Systematic and Judgmental
Class 3	Judgmental

Number of Samples for Quality Control: The implementation of quality control measures as referenced by LTP Chapter 5, Section 5.9 and the QAPP included the collection of a soil sample for "split sample" analysis on 5% of the soil samples taken in a survey unit with the locations selected at random.

Power Curve: The Prospective Power Curve, developed using characterization data and VSP, showed adequate power for the survey design in each of the survey units.

4.2 Survey Unit Designation and Classification

Procedure ZS-LT-300-001-002, "*Survey Unit Classification*" (Reference 26), defines the decision process for classifying an area in accordance with the LTP and MARSSIM.

During the FSS of areas submitted for the Phase 4 FSSR, several survey units were reclassified during the performance of FSS. All changes to classification were to a more rigorous classification. All but seven (7) survey units of the sixty-seven (67) addressed by this Phase 4 FSSR were designated as Class 1.

4.3 Background Determination

During FSS area scanning, ambient backgrounds were determined. As a conservative measure, technicians established an Alarm Set Point (ASP) for the Ludlum Model 2350-1 instrument coupled to a Ludlum Model 44-10 NaI detector at the MDCR of the instrument plus the background for each scan area. The results of scans in each survey unit addressed by this Phase 4 FSSR is provided in the Release Records.

4.4 Final Status Survey Sample Plans

The level of effort associated with planning a survey is based on the complexity of the survey and nature of the hazards. Guidance for preparing FSS plans is provided in procedure ZS-LT-300-001-001 "*Final Status Survey Package Development.*" The FSS plan uses an integrated sample design that combines scanning surveys and sampling.

4.5 Survey Design

4.5.1 Determination of Number of Data Points

The number of soil samples for FSS was determined in accordance with procedure ZS-LT-300-001-001 "*Final Status Survey Package Development*" and MARSSIM. The relative shift (Δ/σ) for the survey unit data set is defined as shift (Δ), which is the Upper Boundary of the Gray Region (UBGR), or the OpDCGL (SOF of 1), minus the LBGR (SOF of 0.5), divided by sigma (σ), which is the standard deviation of the data set used for survey design (characterization). If the calculated relative shift for a survey unit was greater than 3, then a value of 3 was used as the adjusted Δ/σ.

A breakdown of the number of soil samples collected for the Phase 4 survey units is provided in Table 4-4 below.

Table 4-4, Number of Surface Soil Samples for FSS

Survey Unit	Description	Area (m^2)	Class (initial/Final)	# of Samples				Spacing (m)
				NP	Judg.	Inv.	QC	
10203A	East Training Area	1,999	3/1	17	0	0	1	11.7
10203B	East Training Area	1,977	3/1	17	6	0	2	11.6
10203C	East Training Area	1,871	3/1	17	3	0	2	11.3
10203F	East Training Area	1,888	3/1	17	0	0	1	11.3
10204A	North Gate Area	2,231	3/1	19	0	0	2	11.6
10204B	North Gate Area	1,549	3/1	17	0	2	2	10.3
10204C	North Gate Area	1,547	3/1	17	0	0	1	10.3
10204D	North Gate Area	1,545	3/1	17	0	1	2	10.2
10206A	Station Construction Area	2,844	3/1	24	0	0	2	11.7
10206B	Station Construction Area	1,837	3/1	17	0	4	3	11.2
10206C	Station Construction Area	1,833	3/1	17	0	0	1	11.2
10206D	Station Construction Area	1,829	3/1	17	0	1	2	11.1
10206E	Station Construction Area	1,825	3/1	17	0	0	1	11.1
10207A	North Warehouse Area	2,675	3/1	23	4	26	4	11.6
10207B	North Warehouse Area	1,736	3/1	17	0	10	2	10.9
10207C	North Warehouse Area	1,735	3/1	17	0	12	2	10.9
10207D	North Warehouse Area	1,733	3/1	17	1	2	2	10.8
10207E	North Warehouse Area	1,731	3/1	17	0	0	1	10.8
10208A	South Warehouse Area	2,460	3/1	21	1	0	2	11.6
10208B	South Warehouse Area	1,835	3/1	17	0	0	1	11.2
10208C	South Warehouse Area	1,868	3/1	17	0	4	2	11.3
10208D	South Warehouse Area	1,827	3/1	17	0	10	2	11.1
10209C	Restricted Area South of Gate House	1,970	3/1	17	0	15	2	11.6
10212A	NE Corner of Exclusion Area - Lakeshore	9,550	3/2	18	0	2	2	24.8
10212B	VCC Construction Area	16,154	3/3	17	0	4	2	Random
10212C	NE Corner of Exclusion Area - Lakeshore	1,744	3/1	19	0	0	2	10.3
10212D	NE Corner of Exclusion Area - Lakeshore	1,490	3/1	22	2	0	2	8.8
10213A	NE Corner of Exclusion Area	5,730	3/2	17	0	0	1	19.7
10213B	NE Corner of Exclusion Area	1,994	3/1	17	3	27	3	11.6
10213C	NE Corner of Exclusion Area	1,934	3/1	17	9	6	3	11.5
10214A	Construction Parking Area	8,542	3/2	17	0	10	2	24.1
10214B	Construction Parking Area	7,372	3/2	17	0	1	2	22.4
10214C	Construction Parking Area	7,579	3/2	17	0	6	2	22.7
10214D	Construction Parking Area	8,946	3/2	17	1	6	2	24.7
10214E	Construction Parking Area	1,989	3/1	17	0	2	2	11.6
10214F	Construction Parking Area	1,661	3/1	17	0	1	2	10.6
10220A	SE Corner of Exclusion Area – Lakeshore	2,025	3/1	23	0	13	3	10.1
10220H	SE Corner of Exclusion Area – Lakeshore	2,088	3/1	17	4	0	2	11.9
10220I	SE Corner of Exclusion Area – Lakeshore	2,060	3/1	17	5	16	2	11.8

Table 4-4 (continued), Number of Surface Soil Samples for FSS

Survey Unit	Description	Area (m^2)	Class (initial/Final)	# of Samples NP	Judg.	Inv.	QC	Spacing (m)
10221A	South of Protected Area - Inland	1,976	3/1	22	12	9	6	10.2
10221C	South of Protected Area - Inland	1,959	3/1	17	8	13	3	11.5
10221D	South of Protected Area - Inland	1,697	3/1	17	7	22	3	10.7
12104	North Half of Unit 2 Containment	1,940	1/1	17	0	0	1	11.5
12105	South Half of Unit 2 Containment	1,938	1/1	17	0	0	1	11.5
12106	North Half of Fuel & Auxiliary Buildings	1,936	1/1	17	0	0	1	11.5
12107	South Half of Fuel & Auxiliary Buildings	1,934	1/1	17	0	0	1	11.5
12108	North Half of Unit 1 Containment	1,933	1/1	17	0	0	1	11.5
12109	South Half of Unit 1 Containment	1,931	1/1	17	0	0	1	11.5
12110	Yard Between Unit 1 Containment and Turbine	1,740	1/1	17	0	0	1	10.9
12111	South Yard Area Northeast of Gate House	1,964	1/1	17	3	0	2	11.6
12201A	North Protected Area Yard	1,992	2/1	17	0	0	1	11.6
12201B	North Protected Area Yard	1,995	2/1	17	0	0	1	11.6
12201C	North Protected Area Yard	1,968	2/1	17	0	0	1	11.6
12201D	North Protected Area Yard	1,842	2/1	17	3	5	2	11.2
12201E	North Protected Area Yard	1,902	2/1	17	0	0	1	11.4
12202A	Gate House and Southwest Yard	1,998	2/1	17	0	0	1	11.6
12202B	Gate House and Southwest Yard	1,999	2/1	17	0	0	1	11.7
12202C	Gate House and Southwest Yard	1,894	2/1	17	0	0	1	11.3
12202D	Gate House and Southwest Yard	1,663	2/1	17	0	0	1	10.6
12202E	Gate House and Southwest Yard	1,845	2/1	17	2	0	2	11.2
12202F	Gate House and Southwest Yard	1,858	2/1	17	5	0	2	11.2
12203A	Under Service Building and Southeast Yard	1,988	2/1	17	0	14	4	11.6
12205A	Area Under the Turbine Building	1,809	2/1	17	0	2	2	11.1
12205B	Area Under the Turbine Building	1,814	2/1	17	0	0	1	11.1
12205C	Area Under the Turbine Building	1,818	2/1	17	0	0	1	11.1
12205D	Area Under the Turbine Building	1,821	2/1	17	0	0	1	11.1
12205E	Area Under the Turbine Building	1,825	2/1	17	0	4	2	11.1

4.5.2 Sample Locations

Locations of the samples were determined using software VSP. VSP software imports a topographical map of the selected survey area and designates the sample locations with coordinates and bearings based on the Illinois State Plane System NAD 1983 East. Pacific Northwest National Laboratory (PNNL) created VSP for the United States Department of Energy. For those locations where access was impractical or unsafe, sample locations were relocated to the closest adjacent suitable location. Sample locations were identified using GPS coordinates and are consistent with the Illinois State Plane System. Once located, sample points were physically marked as required by ZS-LT-300-001-001 and graphically plotted using drafting software.

4.6 Instrumentation

Radiation detection and measurement instrumentation for performing FSS were selected to provide both reliable operation and adequate sensitivity to detect the ROC identified at the site at levels sufficiently below the OpDCGL. Detector selection was based on detection sensitivity, operating characteristics and expected performance in the field.

The DQO process included the selection of instrumentation appropriate for the type of measurement to be performed (i.e., scan measurements and sample analysis) that were calibrated to respond to a radiation field under controlled circumstances, evaluated periodically for adequate performance to established quality standards, and sensitive enough to detect the ROC with a sufficient degree of confidence.

Electronic data logging was used to the extent practicable to automatically record measurements to minimize transcription errors.

Specific implementing procedures controlled the issuance, use, and calibration of instrumentation used for FSS. The specific DQOs for instruments were established early in the planning phase for FSS activities, implemented by standard operating procedures and executed in the FSS Sample Plan.

4.6.1 Detector Efficiencies

The Ludlum Model 2350-1 Data Logger coupled with the Ludlum Model 44-10 2-inch x 2-inch NaI Gamma Scintillation detector was selected as the primary radiation detection instrumentation for performing scanning for open land survey units for FSS at ZNPS. Instrument efficiencies (ε_i) are derived from the surface emission rate of the radioactive source(s) used during the instrument calibration. Total efficiency (ε_t) is calculated by multiplying the instrument efficiency (ε_i) by the surface efficiency (ε_s) commensurate with the radionuclide's beta energy using the guidance provided in ISO 7503-1, Part 1, "*Evaluation of Surface Contamination, Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters*" (Reference 27).

4.6.2 Detector Sensitivities

The evaluation of open land areas required a detection methodology of sufficient sensitivity for the identification of small areas of potentially elevated activity. Scanning measurements were performed by passing a hand-held detector, primarily the Ludlum Model 44-10 NaI detector, in gross count rate mode across the land surface under investigation. The centerline of the detector was maintained at the ground to detector distance detailed in the sample plan and moved from side to side in a 1-meter wide pattern at a typical scan rate of 0.25 m/sec. The audible and visuals signals were monitored for detectable increases in count rate. An observed count rate increase resulted in further investigation to verify findings and to define the level and extent of residual radioactivity.

An *a priori* determination of scanning sensitivity was performed to ensure that the measurement system (including the surveyor) was able to detect concentrations of radioactivity at levels below the regulatory release limit. The specified performance level and surveyor efficiency was expressed in terms of scan MDCR. This sensitivity is the lowest count rate that can be reliably detected at any given background by the measurement system. The specified MDCR correlates to the targeted MDC.

This approach represents the surface scanning process for land areas defined in NUREG-1507, "*Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*" (Reference 28). The gamma scan MDCR is discussed in detail in Zion*Solutions* TSD-11-004, "*Ludlum Model 44-10 Detector Sensitivity*" (Reference 29) which examines the gamma sensitivity for a 2-inch x 2-inch NaI detector to several radionuclide mixtures of Co-60 and Cs-137 at various detector distances and scan speeds. TSD-11-004 provides MDCR values for the expected ZNPS soil mixture based on detector background condition, scan speed, soil depth (0.15-meters), soil density (1.6 g/cm^3) and detector distance to the surface of interest.

4.6.3 Instrument Maintenance and Control

Control and accountability of survey instruments were maintained to assure the quality and prevent the loss of data. All personnel operating radiological instruments, analysis equipment, measurement location equipment etc., were qualified to operate any assigned equipment and recognize off-normal results and indications.

4.6.4 Instrument Calibration

Instruments and detectors were calibrated for the radiation types and energies of interest or to a conservative energy source. Instrument calibrations were documented with calibration certificates and/or forms and maintained with the instrumentation and project records. Calibration labels were also attached to all portable survey instruments. Prior to using any survey instrument, the current calibration was verified, and all operational checks were performed.

Instrumentation used for FSS were calibrated and maintained in accordance with approved Zion*Solutions* site calibration procedures. Radioactive sources used for calibration were traceable to the NIST and were obtained in standard geometries to match the type of samples being counted. When a characterized high-purity germanium (HPGe) detector was used, suitable NIST-traceable sources were used for calibration, and the software set up appropriately for the desired geometry. If vendor services were used, these were obtained in accordance with purchasing requirements for quality related services, to ensure the same level of quality.

4.7 Survey Methodology

4.7.1 Scan Surveys

The LTP specifies the minimum amount of scanning required for each class as summarized in Table 4-3. The total fraction of scanning coverage is determined during the DQO process with the amount and location(s) based on the likelihood of finding elevated activity during FSS. Sixty (60) of the sixty-seven (67) open land survey units addressed by this Report were classified as Class 1 and required 100% areal scan coverage. Of the remaining seven (7) open land survey units addressed by this Phase 4 FSSR, six (6) open land survey units were classified as Class 2 where 10% to 50% areal scan coverage were typically performed, and one open land survey unit was classified as Class 3, where 10% areal coverage was performed. Actual scan frequencies performed in each survey unit are presented in the Release Records.

For Class 1 and Class 2 survey units, the survey unit was broken down into manageable scan grids. Each scan grid was located with GPS and marked. Each scan grid was completely scanned to the extent possible. Walkover scans were conducted with a Ludlum Model 2350-1 instrument coupled to a Ludlum Model 44-10 Sodium Iodide (NaI) detector at a scanning speed of 0.5 m/sec. while observing the audible and visual indications of radioactivity. During the scanning, the technician recorded data and observations in a Field Log. This log documented field activities and other information pertaining to the survey. Where an area could not be scanned due to the presence of a physical obstruction or standing water, a notation was made in the Field Log and subsequently denoted in the Release Record. Areas with elevated readings were marked, and investigational samples were collected.

4.7.2 Soil Sampling

In accordance with the FSS Sample Plan and applicable job aids, FSS technicians collected surface and subsurface soil samples at locations specified by the survey design. Each sample location was documented, along with soil conditions and observations, and a chain of custody was developed to maintain sample integrity.

4.8 Quality Control Surveys

The method used for evaluating QC split samples collected in support of the FSS program is specified in the QAPP for Characterization and FSS. QC split data was assessed using criteria taken from the NRC Inspection Manual, Inspection Procedure 84750, *"Radioactive Waste Treatment, and Effluent and Environmental Monitoring"* (Reference 30).

A minimum of 5% of the sample locations used in the FSS design were selected randomly and submitted as "splits." Split samples taken for FSS were obtained from one location, homogenized, divided into separate containers, and treated as separate samples. These samples were then used to assess errors associated with sample heterogeneity, sample methodology, and analytical procedures. It was desirable that when analyzed, there is agreement between the splits resulting in data acceptance. If there was no agreement between the samples, the RE evaluated the magnitude and impact on survey design, the implementation and evaluation of results as well as the need to perform confirmatory sampling. If the RE had determined that the discrepancy affected quality or was detrimental to the implementation of FSS, then a Condition Report would have been issued. This threshold was not encountered during the FSS of Phase 4 open land survey units.

To maintain the quality of the FSS, isolation and control measures were implemented prior to and during survey activities upon completion of FSS until there was no risk of recontamination or upon license termination. Following FSS, and until the area is released, a semi-annual surveillance will be performed on completed FSS survey units. This includes an inspection of area postings, inspection of the area for signs of dumping or disturbance and biased sampling. In the event that isolation and control measures were compromised, a follow-up survey may be performed after evaluation.

5 Survey Findings

Procedure ZS-LT-300-001-004, *"Final Status Survey Data Assessment,"* provided guidance to C/LT personnel to interpret survey results using the DQA process during the assessment phase of FSS activities.

The DQA process was the primary evaluation tool to determine that data is of the right type, quality and quantity to support the objectives of the FSS Sample Plan. The five steps of the DQA process are:

1. Review the Sample Plan DQOs and the survey design,
2. Conduct a preliminary data assessment,
3. Select the statistical test,
4. Verify the assumptions of the statistical test,
5. Draw conclusions from the data.

Data validation descriptors described in MARSSIM Table 9.3 were used during the DQA process to verify and validate collected data as required by the QAPP for Characterization and FSS.

5.1 Survey Data Conversion

During the data conversion, the RE evaluated raw data for problems or anomalies encountered during Sample Plan activities (sample collection and analysis, handling and control, etc.) including the following:

- Recorded data,
- Missing values,
- Deviation from established procedure, and
- Analysis flags.

Once resolved, initial data conversion, which is part of preliminary data assessment, was performed and consisted of converting the data into units relative to the release criteria (e.g., pCi/g) and calculating basic statistical quantities (e.g., mean, median, standard deviation). Table 5-1 provides a summary of the basic statistical properties for the FSS of the sixty-seven (67) Phase 4 open land survey units.

Table 5-1, Basic Statistical Properties for FSS of Phase 4 Open Land Survey Units

Survey Unit	Description	Mean OpSOF	Max OpSOF	# OpSOF >1	Radionuclide Statistical Summary					
					Co-60 Max (pCi/g)	Co-60 Mean (pCi/g)	Co-60 St. Dev. (pCi/g)	Cs-137 Max (pCi/g)	Cs-137 Mean (pCi/g)	Cs-137 St. Dev. (pCi/g)
10203A	East Training Area	0.038	0.092	0	6.95E-02	1.78E-02	1.90E-02	9.90E-02	4.41E-02	3.00E-02
10203B	East Training Area	0.050	0.127	0	6.48E-02	2.21E-02	2.30E-02	2.18E-01	5.17E-02	5.70E-02
10203C	East Training Area	0.037	0.090	0	5.00E-02	1.79E-02	1.60E-02	8.18E-02	3.20E-02	2.20E-02
10203F	East Training Area	0.028	0.078	0	4.89E-02	1.55E-02	1.40E-02	3.56E-02	1.02E-02	1.10E-02
10204A	North Gate Area	0.044	0.085	0	5.57E-02	2.29E-02	1.40E-02	6.17E-02	2.45E-02	1.90E-02
10204B	North Gate Area	0.037	0.095	0	6.02E-02	1.77E-02	1.90E-02	6.17E-02	2.94E-02	2.10E-02
10204C	North Gate Area	0.056	0.102	0	6.50E-02	3.52E-02	1.90E-02	1.14E-01	3.73E-02	2.40E-02
10204D	North Gate Area	0.044	0.084	0	6.36E-02	2.37E-02	1.70E-02	5.68E-02	2.48E-02	1.90E-02
10206A	Station Construction Area	0.061	0.422	0	5.18E-02	2.11E-02	1.70E-02	1.52E+00	9.90E-02	3.04E-01
10206B	Station Construction Area	0.048	0.117	0	6.61E-02	2.64E-02	2.30E-02	7.91E-02	3.97E-02	2.20E-02
10206C	Station Construction Area	0.058	0.106	0	5.18E-02	2.70E-02	1.60E-02	9.11E-02	5.55E-02	2.40E-02
10206D	Station Construction Area	0.069	0.198	0	1.56E-01	3.99E-02	3.40E-02	1.26E-01	6.45E-02	3.10E-02
10206E	Station Construction Area	0.028	0.104	0	8.29E-02	1.73E-02	2.20E-02	5.37E-02	1.70E-02	1.70E-02
10207A	North Warehouse Area	0.136	1.345	1 (1)	1.51E-01	3.31E-02	3.20E-02	4.26E+00	3.14E-01	8.88E-01
10207B	North Warehouse Area	0.038	0.085	0	6.19E-02	2.05E-02	2.10E-02	1.03E-01	3.65E-02	2.50E-02
10207C	North Warehouse Area	0.069	0.150	0	1.04E-01	3.87E-02	3.00E-02	1.78E-01	6.00E-02	3.80E-02
10207D	North Warehouse Area	0.052	0.110	0	5.88E-02	2.59E-02	1.90E-02	8.72E-02	4.06E-02	2.80E-02
10207E	North Warehouse Area	0.044	0.096	0	6.78E-02	2.65E-02	2.10E-02	6.34E-02	3.34E-02	1.60E-02
10208A	South Warehouse Area	0.046	0.089	0	6.13E-02	2.71E-02	1.70E-02	8.74E-02	3.43E-02	2.30E-02
10208B	South Warehouse Area	0.047	0.095	0	6.05E-02	2.67E-02	2.20E-02	9.88E-02	3.76E-02	3.60E-02
10208C	South Warehouse Area	0.045	0.083	0	6.33E-02	2.58E-02	2.00E-02	5.92E-02	2.27E-02	2.10E-02
10208D	South Warehouse Area	0.042	0.086	0	5.35E-02	2.44E-02	1.70E-02	5.54E-02	2.37E-02	1.50E-02
10209C	Restricted Area South of Gate House	0.060	0.117	0	7.23E-02	3.19E-02	2.20E-02	1.48E-01	6.04E-02	3.40E-02
10212A	NE Corner of Exclusion Area - Lakeshore	0.048	0.092	0	3.87E-02	2.01E-02	1.50E-02	1.44E-01	5.54E-02	3.70E-02
10212B	VCC Construction Area	0.039	0.097	0	6.92E-02	2.19E-02	1.90E-02	5.25E-02	2.35E-02	1.60E-02
10212C	NE Corner of Exclusion Area - Lakeshore	0.060	0.202	0	5.97E-02	2.00E-02	1.60E-02	4.90E-01	9.46E-02	1.06E-01

Table 5-1 (continued), Basic Statistical Properties for FSS of Phase 4 Open Land Survey Units

Survey Unit	Description	Mean OpSOF	Max OpSOF	# OpSOF >1	Radionuclide Statistical Summary					
					Co-60 Max (pCi/g)	Co-60 Mean (pCi/g)	Co-60 St. Dev. (pCi/g)	Cs-137 Max (pCi/g)	Cs-137 Mean (pCi/g)	Cs-137 St. Dev. (pCi/g)
10212D	NE Corner of Exclusion Area - Lakeshore	0.082	0.150	0	8.32E-02	2.53E-02	1.90E-02	4.00E-01	1.60E-01	1.20E-01
10213A	NE Corner of Exclusion Area	0.081	0.188	0	7.02E-02	2.76E-02	1.90E-02	4.54E-01	1.55E-01	1.36E-01
10213B	NE Corner of Exclusion Area	0.151	1.014	1 (1)	5.00E-02	2.27E-02	1.80E-02	3.47E+00	4.31E-01	8.05E-01
10213C	NE Corner of Exclusion Area	0.096	0.187	0	6.23E-02	2.93E-02	2.20E-02	5.85E-01	1.90E-01	1.37E-01
10214A	Construction Parking Area	0.036	0.059	0	5.05E-02	1.84E-02	1.40E-02	8.22E-02	2.41E-02	2.20E-02
10214B	Construction Parking Area	0.038	0.085	0	4.62E-02	2.00E-02	1.60E-02	8.78E-02	2.65E-02	2.90E-02
10214C	Construction Parking Area	0.035	0.067	0	3.98E-02	1.78E-02	1.20E-02	9.50E-02	1.96E-02	2.60E-02
10214D	Construction Parking Area	0.036	0.101	0	6.20E-02	1.59E-02	1.60E-02	1.45E-01	3.44E-02	4.10E-02
10214E	Construction Parking Area	0.030	0.090	0	5.60E-02	1.50E-02	1.50E-02	5.87E-02	2.05E-02	1.80E-02
10214F	Construction Parking Area	0.043	0.086	0	5.87E-02	2.05E-02	1.90E-02	5.44E-02	2.16E-02	1.60E-02
10220A	SE Corner of Exclusion Area – Lakeshore	0.058	0.298	0	2.34E-01	3.36E-02	4.70E-02	6.63E-02	3.40E-02	2.10E-02
10220H	SE Corner of Exclusion Area – Lakeshore	0.048	0.100	0	4.87E-02	2.47E-02	1.70E-02	1.22E-01	4.83E-02	3.10E-02
10220I	SE Corner of Exclusion Area – Lakeshore	0.038	0.117	0	7.76E-02	2.00E-02	1.70E-02	9.76E-02	3.30E-02	2.70E-02
10221A	South of Protected Area - Inland	0.059	0.189	1 (1)	8.32E-02	3.15E-02	2.00E-02	3.81E-01	5.48E-02	7.90E-02
10221C	South of Protected Area - Inland	0.067	0.262	0	1.05E-01	3.19E-02	2.90E-02	4.32E-01	7.78E-02	1.20E-01
10221D	South of Protected Area - Inland	0.045	0.110	0	4.45E-02	2.35E-02	1.30E-02	2.28E-01	4.36E-02	5.40E-02
12104	North Half of Unit 2 Containment	0.034	0.068	0	5.14E-02	1.89E-02	1.80E-02	4.36E-02	1.55E-02	1.60E-02
12105	South Half of Unit 2 Containment	0.034	0.080	0	4.85E-02	1.91E-02	1.70E-02	5.74E-02	1.03E-02	1.70E-02
12106	North Half of Fuel & Auxiliary Buildings	0.031	0.053	0	4.35E-02	1.83E-02	1.50E-02	4.08E-02	1.28E-02	1.50E-02
12107	South Half of Fuel & Auxiliary Buildings	0.038	0.076	0	6.09E-02	2.54E-02	1.90E-02	4.07E-02	1.16E-02	1.30E-02
12108	North Half of Unit 1 Containment	0.027	0.046	0	3.33E-02	1.59E-02	1.20E-02	1.35E-02	3.53E-03	5.00E-03
12109	South Half of Unit 1 Containment	0.037	0.131	0	9.77E-02	2.43E-02	2.50E-02	3.78E-02	1.01E-02	1.30E-02
12110	Yard Between Unit 1 Containment and Turbine	0.053	0.114	0	7.99E-02	3.78E-02	2.30E-02	2.84E-02	7.66E-03	9.00E-03
12111	South Yard Area Northeast of Gate House	0.031	0.061	0	4.82E-02	1.76E-02	1.60E-02	2.82E-02	7.52E-03	1.00E-02
12201A	North Protected Area Yard	0.035	0.077	0	4.61E-02	2.12E-02	1.50E-02	4.45E-02	1.25E-02	1.40E-02
12201B	North Protected Area Yard	0.030	0.068	0	5.15E-02	1.61E-02	1.70E-02	3.61E-02	1.12E-02	1.40E-02

Table 5-1 (continued), Basic Statistical Properties for FSS of Phase 4 Open Land Survey Units

Survey Unit	Description	Mean OpSOF	Max OpSOF	# OpSOF >1	Radionuclide Statistical Summary Co-60 Max (pCi/g)	Co-60 Mean (pCi/g)	Co-60 St. Dev. (pCi/g)	Cs-137 Max (pCi/g)	Cs-137 Mean (pCi/g)	Cs-137 St. Dev. (pCi/g)
12201C	North Protected Area Yard	0.042	0.093	0	7.03E-02	2.79E-02	2.10E-02	2.42E-02	1.05E-02	1.00E-02
12201D	North Protected Area Yard	0.061	0.351	0	3.02E-01	3.69E-02	7.10E-02	1.43E-01	3.98E-02	3.80E-02
12201E	North Protected Area Yard	0.041	0.086	0	5.84E-02	2.28E-02	1.70E-02	7.72E-02	3.15E-02	2.30E-02
12202A	Gate House and Southwest Yard	0.032	0.094	0	8.10E-02	2.09E-02	2.40E-02	4.75E-02	7.12E-03	1.30E-02
12202B	Gate House and Southwest Yard	0.032	0.072	0	4.86E-02	2.04E-02	1.50E-02	4.24E-02	7.50E-03	1.20E-02
12202C	Gate House and Southwest Yard	0.039	0.091	0	4.79E-02	2.47E-02	1.60E-02	5.65E-02	1.14E-02	1.40E-02
12202D	Gate House and Southwest Yard	0.039	0.092	0	7.43E-02	2.50E-02	2.10E-02	4.37E-02	1.65E-02	1.50E-02
12202E	Gate House and Southwest Yard	0.024	0.046	0	3.23E-02	1.28E-02	1.10E-02	4.05E-02	1.32E-02	1.40E-02
12202F	Gate House and Southwest Yard	0.039	0.074	0	5.52E-02	2.11E-02	1.60E-02	6.61E-02	2.31E-02	2.10E-02
12203A	Under Service Building and Southeast Yard	0.155	1.096	1 (1)	5.32E-01	7.47E-02	1.44E-01	1.78E+00	2.01E-01	4.78E-01
12205A	Area Under the Turbine Building	0.021	0.056	0	3.77E-02	1.30E-02	1.50E-02	2.99E-02	6.26E-03	9.00E-03
12205B	Area Under the Turbine Building	0.023	0.055	0	3.90E-02	1.32E-02	1.30E-02	3.56E-02	5.50E-03	1.10E-02
12205C	Area Under the Turbine Building	0.034	0.092	0	6.51E-02	2.12E-02	1.90E-02	4.53E-02	1.35E-02	1.40E-02
12205D	Area Under the Turbine Building	0.031	0.075	0	6.71E-02	2.01E-02	1.70E-02	2.09E-02	4.67E-03	7.00E-03
12205E	Area Under the Turbine Building	0.033	0.083	0	5.87E-02	1.88E-02	1.60E-02	3.59E-02	4.09E-03	1.00E-02

(1) Although the survey unit passed EMC, as a conservative measure, the soils in the identified elevated area were completely excavated and removed and replaced with clean fill imported from off-site.

5.2 Survey Data Verification and Validation

Items supporting DQO sample design and data were reviewed for completeness and consistency. These included:

- Classification history and related documents,
- Site description,
- Survey design and measurement locations,
- Analytic method and detection limits and that the required analytical method(s) were adequate for the radionuclides of concern,
- Sampling variability provided for the radionuclides of interest,
- QC measurements have been specified,
- Survey and sampling result accuracy have been specified,
- MDC limits,
- Field conditions for media and environment, and
- Field records.

Documentation, as listed, was reviewed to verify completeness and that it was legible:

- Field and analytical results,
- Chain-of-custody,
- Field Logs,
- Instrument issue, return and source check records,
- Instrument downloads, and
- Measurement results relative to measurement location.

After completion of these previously mentioned tasks, a Preliminary Data Assessment record was initiated. This record served to verify that all data was reported in standard units in relation to the DCGLs and that the calculation of the statistical parameters needed to complete data evaluation were completed which, at a minimum, included the following:

- The number of observations (i.e. samples or measurements),
- The range of observations (i.e. minimum and maximum values),
- Mean,
- Median, and
- Standard deviation.

In order to adequately evaluate the data set, consideration as additional options included the coefficient of variation, measurements of relative standing (such as percentile), and other statistical applications as necessary (frequency distribution, histograms, skew, etc.). Finalization of the data review consisted of graphically displaying the data in distributions and percentiles plots.

5.3 Anomalous Data/Elevated Scan Results and Investigation

The following are summaries of anomalous data, elevated scan results and investigations performed during the FSS of the Phase 4 open land survey units. Details and specifics are provided in the individual Release Records.

Survey Unit 10203B

During the gamma scan, one (1) location was identified with suspected higher than normal background readings. A separate scan was performed in this area and a surface soil sample was obtained at the location with the highest scan reading. The gamma spectroscopy results revealed no activity levels above MDC for Cs-137, Co-60 or Cs-134.

Survey Unit 10203C

During the gamma scan, three (3) locations were identified with suspected higher than normal background readings. A separate scan was performed in these areas, and a surface soil sample was obtained at the location with the highest scan reading in each area. The gamma spectroscopy results for the judgmental samples revealed two (2) samples with activity levels above MDC for Cs-137 and no samples with activity levels above MDC for Co-60 or Cs-134. None of the judgmental sample results identified an OpSOF exceeding 0.1.

Survey Unit 10204B

During the FSS of Class 1 open land survey unit 10204B, an investigation was performed following the observation of two (2) scan alarms. The source of the elevated activity was determined to be a layer of clay that retained elevated levels of Naturally Occurring Radioactive Material (NORM). Two (2) surface soil samples and one (1) QC soil sample were taken for the investigation. Gamma spectroscopy results revealed none of the investigative samples had activity levels above MDC for the ROC.

Survey Unit 10204D

During the FSS of Class 1 open land survey unit 10204D, an investigation was performed following the observation of a scan alarm. A small elevated area was observed toward the western edge of a scan row. The activity was found to be from a small radioactive particle, located approximately 2 inches below the surface, reading 20,000 cpm. One (1) surface soil sample, one (1) surface soil QC sample and one (1) subsurface soil sample were taken following the removal of the particle. Gamma spectroscopy results of the investigative samples revealed one sample with detectable Cs-137 and less than MDC for all other ROC.

Survey Unit 10206A

During the FSS of Class 1 open land survey unit 10206A, the survey design identified a sample variability of 0.30, and N=17 for the number of systematic samples to be collected. However, since the survey unit had a surface area of 2,844 m^2, seven (7) additional samples were added to maintain the grid spacing of 11.7 m.

Survey Unit 10206B

Several investigations occurred throughout this survey unit. Several scan alarms were observed. The second scan alarm could not be reproduced on subsequent scans. Four (4) investigational surface samples were taken as a result of these elevated scans. In addition to the surface samples, four (4) investigational subsurface samples were also collected at the areas with elevated scans. Gamma spectroscopy results of the investigative samples revealed one sample with detectable Cs-137 (but less than OpDCGL) and less than MDC for all other ROC. No additional investigations were conducted in this survey unit.

Survey Unit 10206D

One (1) investigation occurred within this survey unit. A scan alarm was detected. An elevated area was identified as a 1 ft^2 area. It was determined that the cause of the elevated scan result was due to a small particle of radioactive material approximately 3 inches below the surface. The particle was removed, and a surface investigative sample and subsurface investigative sample were collected at the location of the remediation. The gamma spectroscopy results for the two (2) investigative samples identified no activity above MDC for the ROC.

Survey Unit 10207A

An investigation was performed based on a scan alarm. The activity was identified as a small radioactive particle located 3 inches below the surface. The particle was captured and removed. A surface soil sample was taken at the location of the particle, along with a QC split sample and a subsurface soil sample. The gamma spectroscopy results of these samples revealed a positive activity for Cs-137 in the QC split sample, with no activity above MDC for Co-60 and Cs-134.

A second investigation was performed based on another scan alarm. An elevated area of 1 ft^2 was identified. A surface soil sample was taken at the location, along with a QC split sample and a subsurface soil sample. The gamma spectroscopy results for these samples indicated a positive activity for Cs-137 in the surface sample, with no activity above MDC for Cs-137, Co-60 and Cs-134 in the other samples.

A third investigation was performed based on the analytical results of a surface soil sample that exceeded an OpSOF of one. An additional fourteen (14) investigation surface soil samples were taken to bound the area of elevated activity. When analyzed by the on-site gamma spectroscopy system, three (3) of these samples also had activity above an OpSOF

of one. The area was calculated to be 6 m^2 based on the GPS coordinates of the samples. The average OpSOF in the bounded area was 1.383. The average activity for all ROC was below the $DCGL_{EMC}$ values. The conclusion of the investigation was that the survey unit would have passed the EMC, with a final dose for the survey unit of 2.50 mrem/year.

One (1) judgmental sample was taken in an area of higher background readings on the west end of the survey unit. In addition, three (3) judgmental samples were taken in the northern end of the survey unit. These samples were taken at the same distance from the railroad tracks as the identified elevated area in order to verify that there was no activity near the rail spur ballast in the north end of the survey unit. The gamma spectroscopy results for the judgmental samples showed two samples with low levels of Cs-137 activity, with the OpSOF below one for all four samples.

As a conservative measure, it was decided to remediate the activity identified in the elevated area. Six (6) to twelve (12) inches of soil was removed from a 14 m^2 area surrounding the elevated area. Post-remediation scans showed no areas above the scan MDCR of the instruments. Ten (10) soil samples were taken in the remediated area. The results of these samples were compared to the surface OpDCGLs. None of these samples exceeded an OpSOF of one. As the source term that was prompting the application of the EMC process was removed, the additional dose to the mean of the survey unit BcSOF was not added.

Fifteen (15) systematic samples were relocated to the closest adjacent suitable location due to the original locations falling on the railroad spur which is made up of gravel and not soil. In addition, one of the sample locations randomly selected for a subsurface sample was not accessible to the Geoprobe, so a sample was collected at an adjacent location.

Survey Unit 10207B

During the FSS of Class 1 open land survey unit 10207B, an investigation was performed following the identification of two areas of elevated activity during scanning. Scanning performed during the investigation identified a small radioactive particle (16,000 cpm) 4 inches below the surface. The particle was captured. An investigation sample was taken at the location of the particle, with four (4) bounding samples taken 0.5 meter from the location of the particle. A QC split sample and a subsurface sample were also obtained as part of the investigation. Gamma spectroscopy results revealed that Cs-137 activity was present at low levels in three samples, and the activity level for Co-60 and Cs-134 was less than MDC in all five samples. The highest OpSOF for these samples was 0.098.

A second elevated area was also bounded by scan. An investigation sample was taken at the location of the highest scan reading, with four (4) bounding samples taken 0.5 meter from the initial sample. A subsurface sample was also obtained at the location of elevated scan. Gamma spectroscopy results revealed that Cs-137 activity was present at low levels in one sample, and the activity level for Co-60 and Cs-134 was less than MDC in all five samples. The highest OpSOF for these samples was 0.064.

Survey Unit 10207C

During the FSS of Class 1 open land survey unit 10207C, investigations were performed in three (3) locations following scan alarms. In the first two identified elevated areas, small radioactive particles were identified and captured. In both areas, a surface sample was obtained at the location of the particle, with four (4) bounding samples taken at a distance of 0.5 meters. One (1) subsurface sample was taken at the location of the highest scan reading in the area covered by the two investigations. Gamma spectroscopy results revealed that there were positively detected Cs-137 concentrations in nine (9) of the twelve (12) investigation samples. The highest OpSOF for these samples was 0.095.

A third elevated area was also identified in this survey unit during FSS. On a rescan of this area, the alarm was not verified. A surface sample was obtained at the scan location. Gamma spectroscopy results revealed no activity above MDC for the ROC in this sample.

Survey Unit 10207D

During the FSS of Class 1 open land survey unit 10207D, an investigation was performed following the identification of two (2) areas of elevated activity. A surface and subsurface investigation sample was taken at each point along with a QC split sample. Gamma spectroscopy results revealed that three (3) of the samples had positive activity for Cs-137 with the highest OpSOF of 0.132. No further action was taken.

In addition, a judgmental sample was taken in an area that exhibited a higher background reading. This sample had positive activity for Cs-137 with an OpSOF of 0.063. No further action was taken.

Survey Unit 10208A

The area of Class 1 survey unit 10208A is 2,460 m^2, which is above the suggested size limitation of 2,000 m^2 for Class 1 Open Land areas. Subsequently, additional samples were collected to maintain the grid spacing at approximately 11.6 m, which is the calculated result based on a survey unit size of 2,000 m^2.

Of the twenty-one (21) systematic surface soil sample locations provided by VSP, eleven (11) samples were relocated to the closest adjacent suitable location because they fell on the rail spur, which consists of gravel and not soil.

In addition, one (1) judgmental surface sample was collected in the southwest corner of the survey unit.

Survey Unit 10208B

During the FSS of Class 1 open land survey unit 10208B, one (1) systematic sample was relocated to the closest adjacent suitable location due to the original location falling on the railroad spur which is made up of gravel and not soil.

Survey Unit 10208C

During the FSS of Class 1 open land survey unit 10208C, an investigation was performed following a scan alarm. A 2 ft. x 6 ft. area was identified with a maximum count rate of 5,081 cpm. Four (4) surface soil samples were taken in this area. Gamma spectroscopy results revealed only one (1) sample with an activity level above MDC for Cs-137 and no samples with activity levels above MDC for Co-60 or Cs-134. Since the OpSOF for the investigation samples were all less than 1.0, with a maximum OpSOF of 0.086, no further action was deemed necessary.

Survey Unit 10208D

During the FSS of Class 1 open land survey unit 10208D, investigations were performed following scan alarms. Four (4) small areas (each less than 1 ft^2) were identified. One (1) surface and one (1) subsurface soil sample were taken in each area. Gamma spectroscopy results revealed all samples to be less than MDC for Cs-137, Co-60 and Cs-134. No further action was necessary.

Surface and subsurface investigation soil samples were also taken in six other locations where scan alarms occurred during the FSS readiness survey performed under an RA. These scan alarms were not reproduced during the FSS. Gamma spectroscopy results revealed only two (2) samples with activity levels above MDC for Cs-137 and no samples with activity levels above MDC for Co-60 or Cs-134. Since the OpSOF for the samples were all less than 1.0, with a maximum OpSOF of 0.108, no further action was deemed necessary.

Survey Unit 10209C

An investigation was performed based on a scan alarm. The activity was identified as a small radioactive particle. The particle was captured and removed. An investigation sample was taken at the location of the particle, along with four (4) bounding samples taken approximately 1 m from the initial sample. A QC split sample and a subsurface sample were also obtained. Gamma spectroscopy results revealed that the activity for the ROC in the samples was below the OpDCGLs, therefore no further action was taken.

Another investigation was performed based on another scan alarm observed during a QC scan. The activity was identified as a small metallic object (nail) which was captured and removed. A surface soil sample was obtained at the location of the metallic object. The gamma spectroscopy results revealed positive Cs-137 activity, with an OpSOF less than one. No further action was taken

A third investigation was performed following additional scan alarms during the QC scan. An area approximately 3 m by 7 m was identified on the east end of the survey unit and an area approximately 1 m by 1 m was identified on the west end of the survey unit. Four (4) investigation samples were taken in the areas. Positive Cs-137 activity was detected in all four of the surface samples, with Co-60 activity detected above MDC in one sample. No sample exceeded an OpSOF of one. In addition, subsurface samples were taken at each location. The gamma spectroscopy results for the subsurface samples were less than MDC for the ROC. No further action was taken.

Survey Unit 10212A

No remediation was performed in Class 2 open land survey unit 10212A. Investigations were performed following scan alarms. Two (2) small areas (each less than 100 cm^2) were identified. One (1) surface and one (1) subsurface soil sample were taken at each location. Gamma spectroscopy results revealed only one (1) sample with an activity level above MDC for Cs-137 and no samples with activity levels above MDC for Co-60 or Cs-134. Since the OpSOF for the investigation samples were all less than 1.0, with a maximum OpSOF of 0.089, no further action was deemed necessary.

In addition to the scan alarms addressed above, a technician documented two (2) scan alarms; however, the exact locations were not marked. The two locations were immediately re-scanned by the technician but the alarms could not be reproduced. Two other technicians scanned the row one week later and were not able to reproduce the alarms. Therefore, no further action was deemed necessary.

Finally, due to some areas in the survey unit being inaccessible for scan due to standing water and low-lying trees, two (2) additional scan rows were added. This enabled the survey to achieve the areal scan coverage requirement of 50%.

Survey Unit 10212B

No remediation was performed in Class 3 open land survey unit 10212B. An investigation was performed following scan alarms. Two (2) areas with elevated activity were identified. A 1-meter by 1-meter area, with a maximum count rate of 1,845 cpm, and a 1-meter by 8-meter area, with a maximum count rate of 1,802 cpm, were investigated. One (1) surface soil sample was taken in the smaller area and three (3) surface samples were taken in the larger area. A subsurface soil sample was also obtained in each area. Gamma spectroscopy results revealed only one (1) surface soil sample with an activity level above MDC for Cs-137. None of the samples had activity levels above MDC for Co-60 or Cs-134. Since the OpSOF for the investigation samples were all less than 0.5, with a maximum OpSOF of 0.059, no further action was deemed necessary.

Finally, due to some areas in the survey unit being inaccessible for scan due to standing water, two (2) additional scan areas were added. This enabled the survey to achieve the areal scan coverage requirement of 10%.

Survey Unit 10212D

One of the randomly selected locations for a subsurface sample, selected per the sample plan, was not available at the time of FSS. The Geoprobe machine could not access the area; therefore, a sample was collected at an adjacent location.

When the FSS of Class 1 open land survey unit 10212D was performed, the inlet pipe on the west end of the drainage ditch and the outlet pipe on the east end were both dammed. Two (2) pumps were removing water while the survey was in progress. However, due to the influx of ground water, it was not possible to remove all of the water from the drainage ditch. Approximately 377 m^2 was inaccessible for scanning due to standing water in the drainage ditch.

The standing water in the drainage ditch also precluded scanning a 1-meter radius around 10 systematic soil samples, one judgmental soil sample, and one judgmental sediment sample. The quality of the data that was collected during FSS was determined to be acceptable and sufficient for determining that the survey unit was suitable for unrestricted release.

Survey Unit 10213B

An investigation was performed based on several scan alarms. Two small areas of elevated activity were identified, each 1 ft^2 in size. One (1) surface soil sample was taken in each area. Gamma spectroscopy results revealed both samples with concentrations above MDC for Cs-137, and neither sample with concentrations above MDC for Co-60 or Cs-134. Since the OpSOF for both investigation samples were less than one, no further action was necessary.

An additional investigation was performed based on the results of a systematic surface soil sample with an OpSOF exceeding one. An additional 17 investigation samples were taken to bound the area of elevated activity. During the investigation process it was discovered that the rope boundary separating survey unit 10213B with the Class 2 survey unit 10213A, was positioned approximately 2 feet south of the actual boundary defined using GPS. This was discovered during the performance of a surveillance survey in survey unit 10213A. The GPS locations of three (3) of the samples collected during the surveillance survey showed them to be within the boundaries of survey unit 10213B and these samples are included in the FSS. Three (3) of the investigation samples also had activity above an OpSOF of one. The bounded area was calculated to be approximately 5 m^2 based on the GPS coordinates of the bounding samples. The average OpSOF in the bounded area was 1.052.

The average activities for all ROC were below the $DCGL_{EMC}$ values. The conclusion of the investigation was that the survey unit would have passed the EMC, with a final dose for the survey unit of 1.922 mrem/year TEDE.

As a conservative measure, it was decided to remediate the elevated area. Six (6) inches to one (1) foot of soil was removed from the area encompassed by the bounding samples. The

area remediated was approximately 10 m^2. Post-remediation scans showed no areas above the scan MDCR of the instrument. Eight (8) soil samples were taken in the remediated area. The results of these samples were compared to the subsurface OpDCGLs. No sample result exceeded an OpSOF of one. The remediated excavation was subsequently backfilled using clean fill imported from off-site. As the source term that was prompting the application of the EMC process was removed, the additional dose to the mean of the survey unit BcSOF was not added.

Approximately 42 m^2 of open land surface area was inaccessible for scanning due to low lying trees. This area was not in the vicinity of the previously discussed elevated area.

Survey Unit 10213C

Investigations were performed based on several scan alarms. Three small areas were identified, each less than 2 ft^2 in size. One (1) surface soil sample was taken in each area. Gamma spectroscopy results revealed all of the samples with concentrations above MDC for Cs-137 and no samples with concentrations above MDC for Co-60 or Cs-134. The OpSOF for the investigation samples were all less than one. No further action was deemed necessary.

Additional surface soil samples were taken where technicians observed elevated count rates near but below the action level. Gamma spectroscopy results revealed all of the samples with concentrations above MDC for Cs-137 and no samples with concentrations above MDC for Co-60 or Cs-134. The OpSOF for these samples were all less than one. No further action was deemed necessary.

An additional investigation was performed when two (2) technicians logged count rates above the alarm set points of their instruments in two (2) locations. The technicians were unaware that this occurred until the downloaded data from the instrument was reviewed. The two (2) locations were re-scanned and the alarms could not be reproduced. No further action was deemed necessary.

One of the sample points randomly selected in the sample plan for a subsurface sample was relocated to the closest adjacent suitable location, which was approximately 3-meters directly south of the original location. The original location was not accessible for the Geoprobe machine to obtain a sample due to the presence of standing water.

Approximately 123 m^2 of open land surface area was inaccessible for scanning due to low lying trees and approximately 86 m^2 was inaccessible due to standing water and ice.

The standing water and low-lying trees also precluded scanning a 1-meter radius around several sample locations. This did not adversely affect the quality of the data collected during the FSS of this survey unit, which was deemed acceptable.

Survey Unit 10214A

Investigations were performed following scan alarms. Four (4) areas were identified. One (1) surface and one (1) subsurface soil sample were taken in each elevated area. Two (2) surface and two (2) subsurface soil samples were taken in the elevated area located in row 10. Gamma spectroscopy results revealed three (3) samples with activity levels above MDC for Cs-137 and no samples with activity levels above MDC for Co-60 or Cs-134.

Survey Unit 10214B

An investigation was performed following a scan alarm. One (1) area was identified. The surface at this location was broken asphalt and soil. One (1) surface and one (1) subsurface soil sample were taken in the elevated area, along with a QC split sample of the surface sample. Gamma spectroscopy results revealed no activity levels above MDC for the ROC in these samples. No further action was taken.

Survey Unit 10214C

Investigations were performed following several scan alarms. An area approximately 6 m by 7 m was marked on the west end of the survey unit, in the roadway that consisted of a mix of broken asphalt and soil surfaces. A surface and subsurface soil sample pair were obtained from six (6) locations. Gamma spectroscopy results revealed one (1) sample with activity levels above MDC for Cs-137, one (1) sample with activity levels above MDC for Cs-134, and no samples with activity levels above MDC for Co-60. The OpSOF for all the investigation samples were all less than one. No further action was taken.

Survey Unit 10214D

Investigations were performed following several scan alarms. Four (4) areas were identified. Six (6) surface and six (6) subsurface soil samples were taken in the elevated areas. Gamma spectroscopy results for the investigation samples revealed low levels of Cs-137 activity, and no activity above the MDC for Co-60 or Cs-134. The highest OpSOF for these samples was 0.115. No further action was taken.

A judgmental sample was taken in an area where the instrument recorded the alarm setpoint of the instrument. The instrument did not alarm because the value was incorrectly stored in the instrument. The gamma analysis results for the sample revealed no activity above the MDC for the ROC.

Survey Unit 10214E

Investigations were performed following observed scan alarms. Two (2) areas were identified. One (1) surface and one (1) subsurface soil sample were taken in each elevated area. Gamma spectroscopy results revealed one (1) sample with an activity level above MDC for Cs-137 and no samples with activity levels above MDC for Co-60 or Cs-134. The OpSOF for the investigation samples were all less than one. No further action was necessary.

Survey Unit 10214F

During the FSS of Class 1 open land survey unit 10214F, an investigation was performed following a scan alarm. An elevated area of 1 m^2 was identified. One (1) surface soil sample and one (1) subsurface soil sample were taken in the location. Gamma spectroscopy results revealed both of the samples to be less than MDC for Cs-137, Co-60 and Cs-134. No further action was deemed necessary.

Six (6) systematic soil samples were relocated to the closest adjacent suitable location due to the original locations falling on the railroad ballast which is made up of gravel and not soil.

Survey Unit 10220A

During the FSS of Class 1 open land survey unit 10220A, two (2) investigations were performed. An investigation was performed following a scan alarm. A small radioactive particle was discovered and captured. Five (5) surface soil samples and a subsurface soil sample were taken following the removal of the particle. Gamma spectroscopy results revealed that activity level for the ROC was less than MDC in all of the investigation samples.

In addition, a second investigation was performed for activity identified at one of the systematic sample locations. This sample had a positive result for Co-60 at 2.16 pCi/g. Bounding samples were taken to the west, southwest, northwest and directly adjacent to the location of the elevated systematic sample. Gamma spectroscopy results revealed that activity level for the ROC was less than MDC in all of the samples. It was suspected that the activity in the sample was a small radioactive particle. The sample was split and sent to Eberline for HTD analysis. The Eberline results positively indicated Co-60 at a concentration of 5.75 pCi/g, while the on-site lab results showed Co-60 to be less than MDC, which supports the conclusion that the activity was a particle and it was embedded in the soil matrix of the aliquot sent to Eberline. Because the particle was not captured, a conservative estimate of the size of the area was set at 1 m^2. The conclusion of the investigation using these parameters was that the survey unit would have passed the EMC, with a final dose for the survey unit of 1.3 mrem/year TEDE. However, use of the EMC was not necessary as the FSS failed due to excessive variability and was performed again with a new set of samples.

Addendum 2 was added to the sample plan for the FSS of survey unit 10220A, which directed that a second set of twenty-three (23) systematic samples be collected to replace the initial sample population of seventeen (17) surface soil samples. This was done because the initial set of seventeen (17) systematic samples had a greater variability, than the value used to calculate the number of samples used in the original survey design.

Survey Unit 10220H

During the FSS of Class 1 open land survey unit 10220H, an area of elevated activity above an OpSOF of 1.0 was found in adjacent survey unit 10221D. This activity was found at the

discharge point of a drain-pipe that runs under the rail line. This water drains to the wetland area in survey units 10220I and 10220H. An additional area was found in the wetland in 10220I that was also above an OpSOF of 1.0. To determine if the activity had spread to the wetlands in 10220H, four (4) judgmental samples were taken in the wetland starting at the boundary with 10220I. Positive Cs-137 was identified in all of the samples, with Co-60 present above the MDC in one (1) of the samples. These samples were all below an OpSOF of 1.0, with the highest at 0.371. No further action was taken.

Survey Unit 10220I

During the FSS of Class 1 open land survey unit 10220I, two (2) investigations were performed.

An area of elevated activity was identified by gamma scans. The area of the elevated area was estimated to be approximately 1 ft^2. Due to the fact that the area in question was covered with an asphalt like material, a surface soil sample could not be readily obtained. The asphalt like material was removed to a depth of approximately 3 feet. A sample of the asphalt substance was sent to the on-site lab for gamma spectroscopy analysis for a qualitative analysis. This analysis showed that the sample contained concentrations of NORM, but no plant-derived ROC at detectable concentrations. A subsurface soil sample was obtained to a 3-foot depth at the elevated location, along with two (2) additional samples of the asphalt media. Again, the analysis of these samples showed concentrations of NORM, but no plant-derived ROC at detectable concentrations. No further action was deemed necessary.

A second investigation occurred prompted by an area of elevated activity identified in the adjacent survey unit 10221D. This activity was found at the discharge point of a drain pipe that runs under the rail line. This water drains to the wetland area in survey units 10220I and 10220H. To determine if the activity had spread to the wetlands in 10220I, five (5) judgmental samples were taken in the wetland starting at the boundary with 10221D.

Positive concentrations of Cs-137 were identified in all of the samples, and Co-60 was present in positively detected concentrations in two (2) of the judgmental samples. The result of the analysis of one of the judgmental surface soil samples resulted in an OpSOF for the sample of 1.04. Six (6) additional investigation samples were taken to bound the area of elevated activity at an area of 2 m^2. The conclusion of the investigation was that the survey unit would have passed the EMC, with a final dose to the survey unit of 1.00 mrem/year. However, as a conservative measure, the elevated area in this survey unit was remediated, along with an adjoining elevated area in survey unit 10221D. An area of approximately 25 m^2 was remediated in the two survey units to a depth of approximately 1 foot. The void was backfilled using clean fill imported from off-site.

Post-remediation scans and sampling showed that the remediation was successful and that the activity was removed. Post-remediation investigation samples were taken at the same locations as the original judgmental samples.

Also, a discrete area in the wetland was not accessible for surface soil scanning due to the presence of standing water.

Survey Unit 10221A

During the first attempt at performing FSS in Class 1 open land survey unit 10221A, an investigation was performed based on the analysis of one of the systematic surface soil sample with results exceeding an OpSOF of one. Nine (9) investigation samples were taken to bound the area of elevated activity. Three (3) of the investigation samples also had activity above an OpSOF of one. The elevated area was bounded on all sides except the southwest side which abuts the railroad ballast which consists of gravel and not soil. Therefore, twelve (12) judgmental surface soil samples were taken adjacent to the railroad ballast.

The area of the bounded elevated activity was calculated to be approximately 10 m^2 based on the GPS coordinates of the bounding samples. The conclusion of the investigation was that the survey unit would have passed the EMC, with a final dose for the survey unit of 5.795 mrem/year TEDE.

Even though the survey unit passed the sign test and the EMC, and the mean OpSOF did not exceed unity, the initial set of systematic samples had an actual variability which was significantly higher than the variability used for survey design. Consequently, a decision was made to fail the survey unit and, as corrective actions, to remediate the elevated area and obtain a second set of systematic samples under a revised FSS Plan. These samples were collected using a higher estimated variability to increase the sample population density. One foot of soil was removed from the area encompassed by the bounding samples up to the railroad ballast on the southwest side. Post-remediation scans showed no areas above the scan MDCR of the instrument. Five (5) soil samples were taken of the exposed soil in the excavation created by the remediation. The results of these samples were compared to the subsurface OpDCGLs. The maximum OpSOF was 0.672. The remediated excavation was subsequently backfilled using clean fill imported from off-site.

Eight (8) systematic samples were relocated to the closest adjacent suitable location due to the original locations falling on the railroad ballast which is made up of gravel and not soil.

Survey Unit 10221C

During the FSS of Class 1 open land survey unit 10221C, an investigation was performed based on the results of gamma scans performed under an RA on the railroad ballast located in survey unit 10221C and the soil areas extending 1-meter beyond the ballast gravel. The RA identified two (2) small areas of elevated activity. A small radioactive particle was identified and captured in the second area. A surface soil sample was taken at the location of each elevated scan and bounding samples were taken in the immediate vicinity (within 1 meter). Gamma spectroscopy results revealed five (5) samples with activity levels above MDC for Cs-137 and no samples with activity levels above MDC for Co-60 and Cs-134.

Since the OpSOF for the investigation samples were all less than one, with a maximum observed OpSOF of 0.300, no further action was deemed necessary.

Three (3) systematic samples were relocated to the closest adjacent suitable location due to the original locations falling on the railroad ballast which is made up of gravel and not soil.

Survey Unit 10221D

During the FSS of Class 1 open land survey unit 10221D, an area of elevated activity above an OpSOF of one was discovered after collecting a judgmental surface soil sample in the drainage ditch on the south side of the railroad ballast at the discharge point of a steel culvert running under the ballast. Seventeen (17) investigation surface samples were taken to bound the area of elevated activity. Five (5) of the seventeen (17) investigation samples also showed activity above an OpSOF of one. In addition, the elevated area extended into adjacent survey unit 10220I, where a separate investigation was performed. The area of the bounded elevated area was calculated to be approximately 10 m^2 based on the GPS coordinates of the bounding samples. The average OpSOF in the bounded area was 2.628. The conclusion of the investigation was that the survey unit could have passed the EMC, with a final dose for the survey unit of 5.738 mrem/year TEDE. However, as a conservative measure, the decision was made to remediate the area of elevated activity, including the portion located in survey unit 10220I.

Post-remediation scans showed no areas above the scan MDCR of the instrument. Also, the ballast was scanned and no areas above the scan MDCR of the instrument were detected. Five (5) additional soil samples were taken in the remediated area. The maximum OpSOF of the post-remediation investigation surface soil samples was 0.743.

Two (2) systematic samples were relocated to the closest adjacent suitable location due to the original locations falling on the railroad ballast which is made up of gravel and not soil. In addition, a small 1.6 m^2 area was not accessible for survey due to standing water.

Survey Unit 12111

During the FSS of Class 1 open land survey unit 12111, three (3) judgmental samples were taken for the FSS. The first sample was taken to investigate an area exhibiting a higher background. This sample was taken at the location in this area which scanning exhibited the highest count rate. Two (2) additional judgmental surface soil samples were taken along the south 20-meter section of the survey unit, which was inaccessible for scans due to standing water. The sample results for all judgmental samples showed activity for the ROC was less than the MDC of the instrument.

Survey Unit 12201D

During the FSS of Class 1 open land survey unit 12201D, an investigation was performed following a scan alarm. The activity was found to be a small radioactive particle, which was captured. One (1) surface soil sample was taken at the location where the particle was found

and four (4) bounding surface soil samples were taken at a distance of approximately 0.5 meters. In addition, a subsurface soil sample was taken to a depth of 1 meter at the location of the particle. Gamma spectroscopy results revealed that activity level for the Cs-137 was greater than MDC in three (3) of the samples, with a maximum observed concentration of 0.101 pCi/g. No further actions were deemed necessary.

Survey Unit 12202E

During the FSS of Class 1 open land survey unit 12202E, two (2) judgmental surface soil samples were taken to investigate an area exhibiting a higher background. The results of these samples showed no activity above MDC for the ROC. No further action was taken.

Survey Unit 12202F

During the FSS of Class 1 open land survey unit 12202F, five (5) judgmental surface soil samples and two (2) judgmental subsurface soil samples were taken to investigate two areas exhibiting higher background. In the first area, two (2) surface soil samples were taken, along with a QC split soil sample and two (2) subsurface soil samples. The results of the analysis of these samples indicated no activity above MDC for the ROC.

In the second area, three (3) surface soil samples were taken. Sample analysis indicated positive activity for Cs-137 in one (1) of the samples at a concentration of 0.208 pCi/g. The analysis of remaining samples indicated no activity above MDC for the ROC. No further action was taken.

Survey Unit 12203A

An investigation was performed in survey unit 12203A based on the analytical results of one systematic surface soil sample which exhibited an OpSOF of 1.096. An additional thirteen (13) investigation samples were taken to bound the area of elevated activity. When analyzed by the on-site gamma spectroscopy system, two (2) of these bounding samples also had activity above an OpSOF of one. The elevated area was bounded by the remaining investigation samples, which all had an OpSOF less than one. The area that was elevated was calculated to be 8.5 m^2 based on the GPS coordinates of the samples. The average OpSOF in the bounded area was 1.122. The conclusion of the investigation was that the survey unit would have passed the EMC, with a final dose for the survey unit calculated at 2.61 mrem/year TEDE.

As a conservative measure, it was decided to remediate the activity identified in the elevated area described in the previous section. The corners of a rectangular area surrounding the elevated area were marked using their GPS coordinates. Two feet of soil was removed from this area. The area remediated was measured to be 5-meters x 5-meters in size. Post-remediation scans showed no areas above the scan MDCR of the instruments. Four soil samples were taken in the remediated area. The results of these samples were compared to the subsurface OpDCGLs, with a maximum observed OpSOF of 0.101. The excavation in

survey unit 12203A that was created by this remediation was backfilled with clean fill. As the source term that was prompting the application of the EMC process was removed, the additional dose to the mean of the survey unit Base Case SOF (BcSOF) due to the EMC calculation was not added. However, the elevated concentration of the systematic sample that exceeded the OpSOF was conservatively used to calculate the mean BcSOF and the resultant assigned dose for the survey unit.

Additionally, it was concluded during Data Assessment that the variability of the sample data observed during the FSS was less than the estimated variability used during survey design. The retrospective power curve showed that a sufficient number of samples were collected to achieve the desired power.

Survey Unit 12205A

During the FSS of Class 1 open land survey unit 12205A, an investigation was performed following the identification of an area of elevated activity by scan. This area was resurveyed, and the activity was verified. Two (2) surface soil samples were taken along with a QC split soil sample and a subsurface soil sample for the investigation. Gamma spectroscopy results revealed that activity level for the ROC was less than MDC in all of the samples. No further action was deemed necessary.

Survey Unit 12205E

During the FSS of Class 1 open land survey unit 12205E, an investigation was performed following scan alarms in the south end of the survey unit. The area was bounded by scans as being approximately 0.3 m in width by 5 m in length. Four (4) surface soil samples were taken in the bounded area, as well as a split QC soil sample and a subsurface soil sample for the investigation. Gamma spectroscopy results revealed that activity level for the ROC was less than MDC in all of the samples. It was suspected that the higher readings in this area was due to the presence of clay approximately 6-inches below the surface of the sand used to backfill the area. No further action was deemed necessary.

5.4 Evaluation of Number of Sample/Measurement Locations in Survey Units

An effective tool utilized to evaluate the number of samples collected in the sampling design is the Retrospective Power Curve generated by VSP, MARSSIM 2000 or COMPASS. The Retrospective Power Curve shows how well the survey design achieved the DQOs. For reporting purposes, all Release Records include a Retrospective Power Curve analysis indicating that the survey design had adequate power to pass the FSS release criteria (i.e., an adequate number of samples were collected).

The Sign Test was selected as the statistical test for all Release Records submitted in this report. This test, performed in accordance with ZS-LT-300-001-004, along with the Retrospective Power Curve demonstrates survey design adequacy. If the data passed the Sign Test and Retrospective Power Curve, the null hypothesis was rejected, and the survey

unit was released with no further actions required. For reporting purposes, all survey unit Release Records passed the Sign Test, indicating that the survey design was adequate (i.e., an adequate number of samples were collected).

The EMC was not implemented during the FSS of the survey units addressed by this report; however, it was calculated in several survey units (survey units 10207A, 10213B, 10220I, 10221A, 10221D and 12203A). Discrete, elevated areas of contamination were identified in several survey units during FSS. As a conservative measure, it was decided to remediate all activity identified by the surveys as exceeding the OpDCGLs prior to demonstrating compliance. In all cases, post-remediation scans showed no areas above the scan MDCR of the instruments and the analysis of all post-remediation samples that were taken indicated OpSOF less than one. In the survey units where the EMC was calculated, as the elevated activity was removed by the remediation, the additional dose to the mean of the survey unit due to the elevated activity was not added. However, the elevated concentration of the systematic sample that exceeded the OpSOF was conservatively used to calculate the mean BcSOF and the resultant assigned dose for the survey unit.

5.5 Comparison of Findings with Derived Concentration Guideline Levels

The SOF or "unity rule" was applied to FSS data in accordance with the guidance provided in Section 2.7 of NUREG-1757, Vol. 2, and the LTP. This was accomplished by calculating a fraction of the OpDCGL for each sample or measurement by dividing the reported concentration by the OpDCGL. If a sample had multiple ROC, then the fraction of the OpDCGL for each ROC was summed to provide an OpSOF for the sample.

Unity rule equivalents were calculated for each measurement result using the inferred concentration for the HTD ROC calculated using the maximum ratios from LTP Chapter 5, Table 5-15. The inferred concentrations were then compared against the applicable OpDCGL to derive an OpSOF for each ROC. The individual OpSOF for each ROC were then summed to derive an OpSOF for the sample. This was the value used to perform the Sign Test. The mean and maximum OpSOF for each open land survey unit addressed in this Phase 4 FSSR is presented in Table 5-1 of this report.

A mean BcSOF was calculated for each ROC by dividing the reported mean concentration for each ROC by the BcDCGL. A BcSOF of one is equivalent to the decision rule, meaning any measurement with a BcSOF of one or greater, would not meet the 25 mrem/year release criteria. The mean BcSOF was multiplied by 25 to establish the dose attributed to soil in a survey unit. A summary of the mean BcSOF and dose contribution for each Phase 4 survey unit is provided in Table 5-2 below.

Table 5-2, Mean Base Case SOF and Dose Contribution from Soil

Survey Unit	Description	Mean BcSOF	Dose (mrem/yr)
10203A	East Training Area	0.010	0.244
10203B	East Training Area	0.013	0.321
10203C	East Training Area	0.010	0.238
10203F	East Training Area	0.007	0.181
10204A	North Gate Area	0.011	0.283
10204B	North Gate Area	0.009	0.235
10204C	North Gate Area	0.014	0.361
10204D	North Gate Area	0.011	0.279
10206A	Station Construction Area	0.016	0.392
10206B	Station Construction Area	0.012	0.309
10206C	Station Construction Area	0.015	0.370
10206D	Station Construction Area	0.018	0.440
10206E	Station Construction Area	0.007	0.180
10207A	North Warehouse Area	0.035	0.869
10207B	North Warehouse Area	0.010	0.243
10207C	North Warehouse Area	0.018	0.441
10207D	North Warehouse Area	0.013	0.333
10207E	North Warehouse Area	0.011	0.282
10208A	South Warehouse Area	0.012	0.297
10208B	South Warehouse Area	0.012	0.300
10208C	South Warehouse Area	0.012	0.291
10208D	South Warehouse Area	0.011	0.272
10209C	Restricted Area South of Gate House	0.015	0.382
10214E	Construction Parking Area	0.008	0.195
10214F	Construction Parking Area	0.011	0.278
10220A	SE Corner of Exclusion Area – Lakeshore	0.014	0.348
10220H	SE Corner of Exclusion Area – Lakeshore	0.012	0.307
10220I	SE Corner of Exclusion Area – Lakeshore	0.010	0.244
10221A	South of Protected Area - Inland	0.015	0.379
10221C	South of Protected Area - Inland	0.017	0.427
10221D	South of Protected Area - Inland	0.011	0.286
12104	North Half of Unit 2 Containment	0.009	0.215
12105	South Half of Unit 2 Containment	0.009	0.216
12106	North Half of Fuel & Auxiliary Buildings	0.008	0.198
12107	South Half of Fuel & Auxiliary Buildings	0.010	0.246
12108	North Half of Unit 1 Containment	0.007	0.170
12109	South Half of Unit 1 Containment	0.009	0.236
12110	Yard Between Unit 1 Containment and Turbine	0.014	0.340
12111	South Yard Area Northeast of Gate House	0.008	0.197
12201A	North Protected Area Yard	0.009	0.223
12201B	North Protected Area Yard	0.008	0.190
12201C	North Protected Area Yard	0.011	0.268
12201D	North Protected Area Yard	0.016	0.392
12201E	North Protected Area Yard	0.011	0.264
12202A	Gate House and Southwest Yard	0.008	0.206
12202B	Gate House and Southwest Yard	0.008	0.202

Table 5-2 (continued), Mean Base Case SOF and Dose Contribution from Soil

Survey Unit	Description	Mean BcSOF	Dose (mrem/yr)
10212A	NE Corner of Exclusion Area - Lakeshore	0.012	0.304
10212B	VCC Construction Area	0.010	0.250
10212C	NE Corner of Exclusion Area - Lakeshore	0.015	0.382
10212D	NE Corner of Exclusion Area - Lakeshore	0.021	0.526
10213A	NE Corner of Exclusion Area	0.021	0.519
10213B	NE Corner of Exclusion Area	0.039	0.968
10213C	NE Corner of Exclusion Area	0.025	0.616
10214A	Construction Parking Area	0.009	0.230
10214B	Construction Parking Area	0.010	0.243
10214C	Construction Parking Area	0.009	0.227
10214D	Construction Parking Area	0.009	0.232

Survey Unit	Description	Mean BcSOF	Dose (mrem/yr)
12202C	Gate House and Southwest Yard	0.010	0.248
12202D	Gate House and Southwest Yard	0.010	0.252
12202E	Gate House and Southwest Yard	0.006	0.156
12202F	Gate House and Southwest Yard	0.010	0.248
12203A	Under Service Building and Southeast Yard	0.040	0.994
12205A	Area Under the Turbine Building	0.005	0.135
12205B	Area Under the Turbine Building	0.006	0.150
12205C	Area Under the Turbine Building	0.009	0.220
12205D	Area Under the Turbine Building	0.008	0.199
12205E	Area Under the Turbine Building	0.008	0.211

5.6 Description of ALARA to Achieve Final Activity Levels

Section N.1.5 of NUREG-1757, Vol. 2, states that "For residual radioactivity in soil at sites that may have unrestricted release, generic analyses show that shipping soil to a low-level waste disposal facility is unlikely to be cost effective for unrestricted release, largely because of the high costs of waste disposal. Therefore, shipping soil to a low-level waste disposal facility generally does not have to be evaluated for unrestricted release." Section 4.4.1 of LTP Chapter 4 presents a simple ALARA analysis for the excavation and disposal of soils as low-level radioactive waste that confirms the statement in Section N.1.5 of NUREG-1757, Vol. 2 that the cost of disposing excavated soil as low-level radioactive waste is clearly greater than the benefit of removing and disposing of soil with residual radioactivity concentrations less than the dose criterion. Since the cost is greater than the benefit, it is not ALARA to excavate and dispose of soils with residual radioactivity concentrations below the DCGL.

"Housekeeping" and cleanup of survey units was completed prior to turnovers for FSS, and good housekeeping practices were employed during the execution of the FSS. Good housekeeping practices and proper implementation of isolation and control measures in survey units mitigated any potential cross-contamination and ensured that the reported residual activity levels were accurate and final.

5.7 NRC/Independent Verification Team Findings

As of the date of this report, ORISE has performed confirmatory surveys in the sixty-seven (67) survey units addressed by this Phase 4 FSSR. While no official report detailing the findings of the confirmatory surveys has yet been issued, no indications have been received that any conclusion of the survey would question the adequacy of the FSS performed in the Phase 4 open land survey units.

6 Summary

Final Status Survey is the process used to demonstrate that the ZNPS structures and soils comply with the radiological criteria for unrestricted use specified in 10CFR20.1402. The purpose of the FSS Sample Plan is to describe the methods to be used in planning, designing, conducting, and evaluating the FSS.

The two radiological criteria for unrestricted use specified in 10CFR20.1402 are: 1) the residual radioactivity that is distinguishable from background radiation results in a TEDE to an AMCG that does not exceed 25 mrem/year, including that from groundwater sources of drinking water, and 2) the residual radioactivity has been reduced to levels that are ALARA.

The sixty (60) Class 1 open land survey units, six (6) Class 2 open land survey units and one (1) Class 3 open land survey unit addressed in this Final Report have met the DQOs of the FSS Sample Plans developed and implemented for each. In each survey unit, all identified ROC were used for statistical testing to determine the adequacy of the survey unit for FSS, the sample data passed the Sign Test, the null hypothesis was rejected, and a Retrospective Power Curve showed that adequate power was achieved. Each of the sixty-seven (67) survey units were properly classified. Evaluation of the data for each survey unit shows that none of the ROC concentration values exceeded the OpDCGL or any investigational levels and therefore, in accordance with the LTP Section 5.10, each of the survey units addressed in this Phase 4 FSSR meets the release criterion.

7 References

1. Zion Station Restoration Project "License Termination Plan"
2. NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual"
3. ZS-LT-01, "Quality Assurance Project Plan (for Characterization and FSS)"
4. ZS-LT-300-001-001, "Final Status Survey Package Development"
5. ZS-LT-300-001-003, "Isolation and Control for Final Status Survey"
6. ZS-LT-300-001-004, "Final Status Survey Data Assessment"
7. NUREG-1757, Vol. 2, "Consolidated Decommissioning Guidance Characterization, Survey, and Determination of Radiological Criteria"
8. ZS-LT-300-001-005, "Final Status Survey Data Reporting"
9. "Zion Station Historical Site Assessment"
10. TSD-14-011, "Soil Area Factors"
11. TSD-17-004, "Operational Derived Concentration Guideline Levels for Final Status Survey"
12. TSD-14-028, "Radiological Characterization Report"
13. ZS-RP-108-000-000, "Radiological Instrumentation Program"
14. ZS-RP-108-004-012, "Calibration and Initial Set-Up of the 2350-1"
15. LT-JA-004, "FSS Sample Collection"
16. ZS-LT-100-001-004, "Sample Media Preparation"
17. ZS-WM-131, "Chain of Custody Protocol"
18. ZS-QA-10, "Quality Assurance Project Plan"
19. [Amended] Post-Shutdown Decommissioning Activities Report
20. Defueled Safety Analysis Report
21. Offsite Dose Calculation Manual
22. ZS-LT-02, "Characterization Survey Plan"
23. TSD-11-001, "Technical Support Document for Potential Radionuclides of Concern During the Decommissioning of the Zion Station"
24. TSD-13-004, "Examination of Cs-137 Global Fallout In Soils At Zion Station"

25. TSD-14-019, "Radionuclides of Concern for Soil and Basement Fill Model Source Terms"

26. ZS-LT-300-001-002, "Survey Unit Classification"

27. ISO 7503-1, Part 1, "Evaluation of Surface Contamination, Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters"

28. NUREG-1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions"

29. TSD-11-004, "Ludlum Model 44-10 Detector Sensitivity"

30. NRC Inspection Manual, Inspection Procedure 84750, "Radioactive Waste Treatment, and Effluent and Environmental Monitoring"

8 Appendices

A1 FSS Release Record, Survey Unit 10203A
A2 FSS Release Record, Survey Unit 10203B
A3 FSS Release Record, Survey Unit 10203C
A4 FSS Release Record, Survey Unit 10203F
A5 FSS Release Record, Survey Unit 10204A
A6 FSS Release Record, Survey Unit 10204B
A7 FSS Release Record, Survey Unit 10204C
A8 FSS Release Record, Survey Unit 10204D
A9 FSS Release Record, Survey Unit 10206A
A10 FSS Release Record, Survey Unit 10206B
A11 FSS Release Record, Survey Unit 10206C
A12 FSS Release Record, Survey Unit 10206D
A13 FSS Release Record, Survey Unit 10206E
A14 FSS Release Record, Survey Unit 10207A
A15 FSS Release Record, Survey Unit 10207B
A16 FSS Release Record, Survey Unit 10207C
A17 FSS Release Record, Survey Unit 10207D
A18 FSS Release Record, Survey Unit 10207E
A19 FSS Release Record, Survey Unit 10208A
A20 FSS Release Record, Survey Unit 10208B
A21 FSS Release Record, Survey Unit 10208C
A22 FSS Release Record, Survey Unit 10208D
A23 FSS Release Record, Survey Unit 10209C
A24 FSS Release Record, Survey Unit 10212A
A25 FSS Release Record, Survey Unit 10212B
A26 FSS Release Record, Survey Unit 10212C
A27 FSS Release Record, Survey Unit 10212D
A28 FSS Release Record, Survey Unit 10213A
A29 FSS Release Record, Survey Unit 10213B
A30 FSS Release Record, Survey Unit 10213C
A31 FSS Release Record, Survey Unit 10214A
A32 FSS Release Record, Survey Unit 10214B
A33 FSS Release Record, Survey Unit 10214C
A34 FSS Release Record, Survey Unit 10214D
A35 FSS Release Record, Survey Unit 10214E
A36 FSS Release Record, Survey Unit 10214F
A37 FSS Release Record, Survey Unit 10220A

A38 FSS Release Record, Survey Unit 10220H
A39 FSS Release Record, Survey Unit 10220I
A40 FSS Release Record, Survey Unit 10221A
A41 FSS Release Record, Survey Unit 10221C
A42 FSS Release Record, Survey Unit 10221D
A43 FSS Release Record, Survey Unit 12104
A44 FSS Release Record, Survey Unit 12105
A45 FSS Release Record, Survey Unit 12106
A46 FSS Release Record, Survey Unit 12107
A47 FSS Release Record, Survey Unit 12108
A48 FSS Release Record, Survey Unit 12109
A49 FSS Release Record, Survey Unit 12110
A50 FSS Release Record, Survey Unit 12111
A51 FSS Release Record, Survey Unit 12201A
A52 FSS Release Record, Survey Unit 12201B
A53 FSS Release Record, Survey Unit 12201C
A54 FSS Release Record, Survey Unit 12201D
A55 FSS Release Record, Survey Unit 12201E
A56 FSS Release Record, Survey Unit 12202A
A57 FSS Release Record, Survey Unit 12202B
A58 FSS Release Record, Survey Unit 12202C
A59 FSS Release Record, Survey Unit 12202D
A60 FSS Release Record, Survey Unit 12202E
A61 FSS Release Record, Survey Unit 12202F
A62 FSS Release Record, Survey Unit 12203A
A63 FSS Release Record, Survey Unit 12205A
A64 FSS Release Record, Survey Unit 12205B
A65 FSS Release Record, Survey Unit 12205C
A66 FSS Release Record, Survey Unit 12205D
A67 FSS Release Record, Survey Unit 12205E

*Zion**Solutions***

ZS-2020-0001

Attachment 2

Zion Nuclear Power Station, Units 1 and 2

Preflight Report

This document serves as the preflight report for Enclosure 1 to ZionSolutions letter ZS-2020-0001. The following files do not pass pre-flight criteria or do not meet NRC criteria; however, the text is word searchable and legible.

File Name	Preflight Status	Reason
Final Status Survey Final Report - Phase 4 April 2020	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
Appendices to the Final Status Survey Final Report - Phase 4		
A1 FSS Release Record - Survey Unit 10203A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A2 FSS Release Record - Survey Unit 10203B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A3 FSS Release Record - Survey Unit 10203C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A4 FSS Release Record - Survey Unit 10203F	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A5 FSS Release Record - Survey Unit 10204A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A6 FSS Release Record - Survey Unit 10204B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A7 FSS Release Record - Survey Unit 10204C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A8 FSS Release Record - Survey Unit 10204D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A9 FSS Release Record - Survey Unit 10206A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible

File Name	Preflight Status	Reason
A10 FSS Release Record - Survey Unit 10206B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A11 FSS Release Record - Survey Unit 10206C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A12 FSS Release Record - Survey Unit 10206D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A13 FSS Release Record - Survey Unit 10206E	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A14 FSS Release Record - Survey Unit 10207A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A15 FSS Release Record - Survey Unit 10207B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A16 FSS Release Record - Survey Unit 10207C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A17 FSS Release Record - Survey Unit 10207D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A18 FSS Release Record - Survey Unit 10207E	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A19 FSS Release Record - Survey Unit 10208A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A20 FSS Release Record - Survey Unit 10208B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A21 FSS Release Record - Survey Unit 10208C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible

File Name	Preflight Status	Reason
A22 FSS Release Record - Survey Unit 10208D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A23 FSS Release Record - Survey Unit 10209C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A24 FSS Release Record - Survey Unit 10212A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A25 FSS Release Record - Survey Unit 10212B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A26 FSS Release Record - Survey Unit 10212C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A27 FSS Release Record - Survey Unit 10212D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A28 FSS Release Record - Survey Unit 10213A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A29 FSS Release Record - Survey Unit 10213B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A30 FSS Release Record - Survey Unit 10213C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A31 FSS Release Record - Survey Unit 10214A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A32 FSS Release Record - Survey Unit 10214B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A33 FSS Release Record - Survey Unit 10214C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible

File Name	Preflight Status	Reason
A34 FSS Release Record - Survey Unit 10214D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A35 FSS Release Record - Survey Unit 10214E	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A36 FSS Release Record - Survey Unit 10214F	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A37 FSS Release Record - Survey Unit 10220A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A38 FSS Release Record - Survey Unit 10220H	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A39 FSS Release Record - Survey Unit 10220I	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A40 FSS Release Record - Survey Unit 10221A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A41 FSS Release Record - Survey Unit 10221C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A42 FSS Release Record - Survey Unit 10221D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A43 FSS Release Record - Survey Unit 12104	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A44 FSS Release Record - Survey Unit 12105	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A45 FSS Release Record - Survey Unit 12106	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible

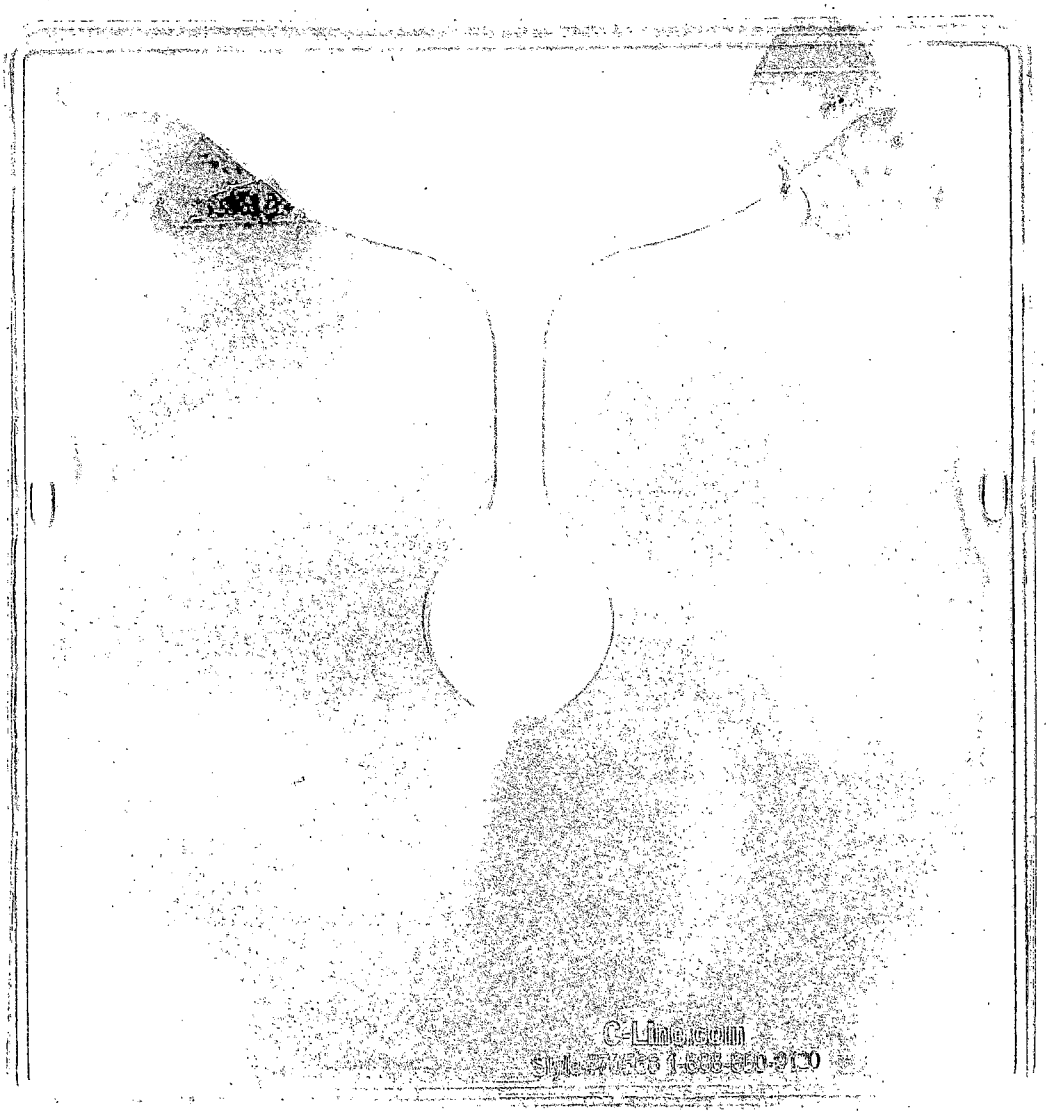
File Name	Preflight Status	Reason
A46 FSS Release Record - Survey Unit 12107	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A47 FSS Release Record - Survey Unit 12108	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A48 FSS Release Record - Survey Unit 12109	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A49 FSS Release Record - Survey Unit 12110	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A50 FSS Release Record - Survey Unit 12111	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A51 FSS Release Record - Survey Unit 12201A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A52 FSS Release Record - Survey Unit 12201B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A53 FSS Release Record - Survey Unit 12201C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A54 FSS Release Record - Survey Unit 12201D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A55 FSS Release Record - Survey Unit 12201E	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A56 FSS Release Record - Survey Unit 12202A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A57 FSS Release Record - Survey Unit 12202B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible

File Name	Preflight Status	Reason
A58 FSS Release Record - Survey Unit 12202C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A59 FSS Release Record - Survey Unit 12202D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A60 FSS Release Record - Survey Unit 12202E	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A61 FSS Release Record - Survey Unit 12202F	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A62 FSS Release Record - Survey Unit 12203A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A63 FSS Release Record - Survey Unit 12205A	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A64 FSS Release Record - Survey Unit 12205B	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A65 FSS Release Record - Survey Unit 12205C	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A66 FSS Release Record - Survey Unit 12205D	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible
A67 FSS Release Record - Survey Unit 12205E	Error / Failed	Document contains logos, color maps, signatures, digital photos, and scanned pages < 300 ppi, clear and legible

*Zion**Solutions***

ZS-2020-0001

Enclosure

CD

Final Status Survey Final Report – Phase 4 (including appendices)