La Crosse Boiling Water Reactor

FINAL STATUS SURVEY FINAL REPORT – PHASE 3

January 2020

Prepared By:	R. Yetter **Director of Radiological Site Closure**	**Date:**	1/27/20
Reviewed By:	P. Hollenbeck **Radiological Engineer**	**Date:**	1/27/20
Reviewed By:	R. Yetter III **FSS Specialist**	**Date:**	1/27/20
Reviewed By:	S. Roberts R. YETTER for S. ROBERTS **VP Radiological Programs**	**Date:**	1/27/20
Approved By:	S. Zoller **FSS Manager**	**Date:**	01/27/2020

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

1.1 Executive Summary

The purpose of this Phase 3 Final Status Survey (FSS) Final Report is to provide a summary of the survey results and overall conclusions which demonstrate that the La Crosse Boiling Water Reactor (LACBWR) facility, or portions of the site, meets the 25 mrem/yr release criterion as established in Nuclear Regulatory Commission (NRC) Regulation 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use*. The FSS results provided herein demonstrate that any residual radioactivity results in a Total Effective Dose Equivalent (TEDE) to an average member of the critical group (AMCG) that does not exceed 25 mrem/yr 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 LACBWR *License Termination Plan* (LTP) (Reference 1); NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (Reference 2); LC-QA-PN-001, *Final Status Survey Quality Assurance Project Plan (QAPP)* (Reference 3); LC-FS-PR-002, *Final Status Survey Package Development* (Reference 4); LC-FS-PR-010, *Isolation and Control for Final Status Survey* (Reference 5); LC-FS-PR-008, *Final Status Survey Data Assessment* (Reference 6); as well as other various station implementing procedures.

This FSS Final Report 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 LC-FS-PR-009, *Final Status Survey Data Reporting* (Reference 8).

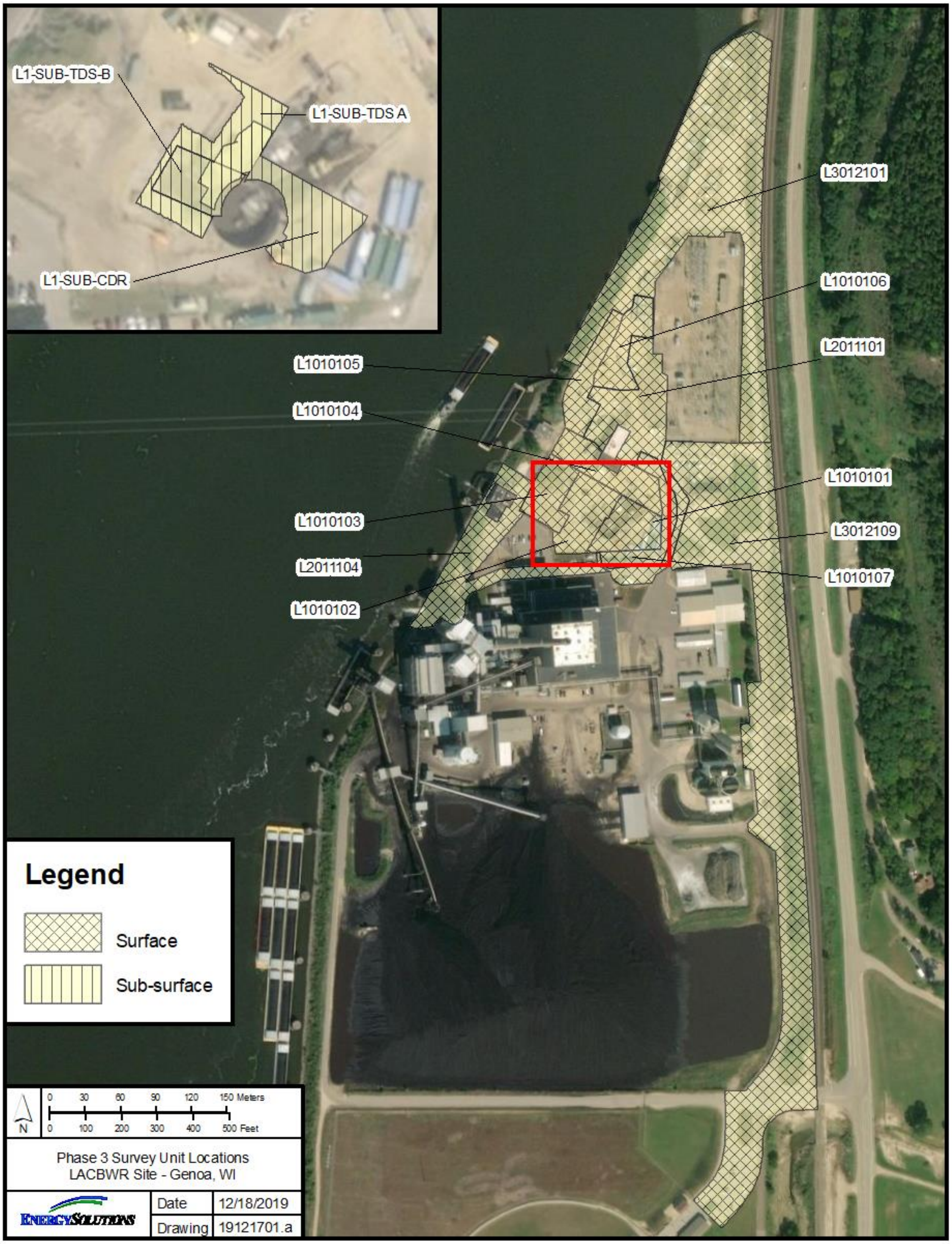
To facilitate the data management process, FSS Final Reports incorporate multiple Survey Unit Release Records. Release Records are complete and unambiguous records of the as-left radiological status of specific survey units. Sufficient data and information are provided in each Release Record to enable an independent re-creation and evaluation at some future time of both the survey activities and the derived results.

This Phase 3 Final Report specifically addresses three (3) sub-grade excavation (SGE) and eleven (11) open land area (OLA) survey units. This report contains a compilation of all fourteen (14) Release Records that are within the Phase 3 scope. 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 survey units in relation to the LACBWR site as well as survey unit boundaries.

Table 1-1 Phase 3 Survey Units

Survey Unit	Type	Survey Unit Description	Class	Size (m^2)
L1-010-101	OLA	Reactor Building, WTB, WGTV, Ventilation Stack Grounds	1	1,992
L1-010-102	OLA	Turbine Building, Turbine Office Building, 1B Diesel Generator Building Grounds	1	2,315
L1-010-103	OLA	LSA Building, Maintenance Eat Shack Grounds	1	1,749
L1-010-104	OLA	North LSE Grounds	1	2,387
L1-010-105	OLA	North Interim Debris Storage Area	1	1,974
L1-010-106	OLA	North Loading Area	1	1,936
L1-010-107	OLA	Outside East LSE Area	1	1,675
L2-011-101	OLA	Area North of LSE Fence	2	5,728
L2-011-104	OLA	G3 Crib House, Circ. Water Discharge Land	2	5,285
L3-012-101	OLA	North End of Licensed Site	3	19,885
L3-012-109	OLA	Plant Access, ISFSI Haul Road Grounds	3	28,187
L1-SUB-CDR	SGE	Stack, Pipe Tunnel, RPGPA	1	431
L1-SUB-TDS A	SGE	Eastern Portion TB, Sump, Pit, Diesel	1	476
L1-SUB-TDS B	SGE	RPGPA Area	1	259
OLA = Open Land Area SGE = Sub-Grade Excavation				

Figure 1-1 Phase 3 Survey Unit Locations



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 suspected contaminants, performed the FSS of the Phase 3 survey units. The survey data for all Phase 3 survey units demonstrate that the dose from residual radioactivity is less than the maximum annual dose which corresponds to the release criterion for license termination for unrestricted use specified in 10 CFR 20.1402 and support the release of these areas from the 10 CFR 50 license. Additionally, the ALARA requirement of 10 CFR 20.1402 has also been satisfied.

Because this is the last FSS Final Report, an overview of existing groundwater is provided in Section 6. The dose from groundwater will be calculated using the Groundwater Exposure Factors presented in Chapter 6 of the LTP. Because the industrial use scenario does not include irrigation, the only exposure pathway from groundwater is potable water from an onsite well. The results of the dose calculation for groundwater are included in this final report.

This Phase 3 Final Report represents the last of three final reports. As such, a description of how dose compliance is demonstrated through the summation of the five (5) distinct source terms for the end-state (i.e., basements, soil, buried pipe, above-grade structures, and groundwater), is provided to demonstrate that the LACBWR site, as a whole, meets the 25 mrem/yr release criterion as established in Nuclear Regulatory Commission (NRC) Regulation 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use*.

1.2 Phased Submittal Approach

To minimize the incorporation of redundant historical assessment and other FSS program information, and to facilitate potential phased releases from the current license, FSS Final Reports were prepared in a phased approach. Two FSS Final Reports have previously been submitted to the NRC. This is the third and last FSS Final Report to be be generated and submitted to the NRC during the decommissioning project.

Release of Non-Impacted Open lands

On June 27, 2016, LaCrosse*Solutions* submitted a request to release a portion of the LACBWR site from the 10 CFR 50 license (DPR-45) in accordance with 10 CFR 50.83, *Release of Part of a Power Reactor Facility or Site for Unrestricted Use*, and 10 CFR 100, *Reactor Site Criteria* (ADAMS Accession No. ML16181A068). A report was generated for the request that addressed the release of 88 of the 165 acres that comprise the LACBWR site. That report contains a summary of the final assessment performed as well as a summary of the characterization surveys performed of these non-impacted open-land survey units. LaCrosse*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 10 CFR 20, Subpart E, *Radiological Criteria for License Termination*. The five (5) survey units incorporated within the report are classified as non-impacted, and

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 April 12, 2017.

Phase 1 and 2 Final Status Survey Final Reports

The Phase 1 FSS Final Report was submitted to NRC for review on September 17, 2019, and included four (4) sub-grade excavation survey units, three (3) open land survey units, and two (2) structure basement survey units. The Phase 2 FSS Final Report was submitted to NRC for review on December 16, 2019 and included eight (8) above-grade building survey units and ten (10) buried pipe survey units. Table 1-2 provides a list of survey units within the Phase 1 and Phase 2 submittals as well as partial site release.

Table 1-2 Listing of Survey Units within the Phase 1 and Phase 2 FSS Final Report Phased Submittals as well as Partial Site Release

Survey Unit	Survey Unit Description	Class	Phase
L4-012-103	G-3 Coal Plant Grounds	Non-Impacted	-
L4-012-105	Coal Pile Grounds	Non-Impacted	-
L4-012-106	Capped Ash Impoundment Grounds	Non-Impacted	-
L4-012-107	Grounds East of Highway 35	Non-Impacted	-
L4-012-108	Hwy 35/Railroad Right of Way Grounds	Non-Impacted	-
L1-SUB-DRS	RCA North Area	1	1
L1-SUB-TDS	TB, Sump, Pit, Diesel	1	1
L1-SUB-LES	LSA, Eat Shack, Septic	1	1
L1-010-101 C	Waste Treatment Building	1	1
L2-011-102	Area South of LSE Fence	2	1
L2-011-103	LACBWR Crib House, Surrounding Area	2	1
L3-012-102	Transmission Switch Yard	3	1
B1-010-001	Reactor Building	1	1
B1-010-004	Waste Gas Tank Vault	1	1
B2-010-101	LACBWR Crib House	2	2
B2-010-102	G-3 Crib House	2	2
B2-010-103	LACBWR Administration Building	2	2
B3-012-101	Back-up Control Center	3	2
B3-012-102	Transmission Sub-Station Switch House	3	2
B3-012-103	G-1 Crib House	3	2
B3-012-104	Barge Wash Break Room	3	2
B3-012-109	Security Shack	3	2
S1-011-102	Circulating Water Discharge Pipe	1	2

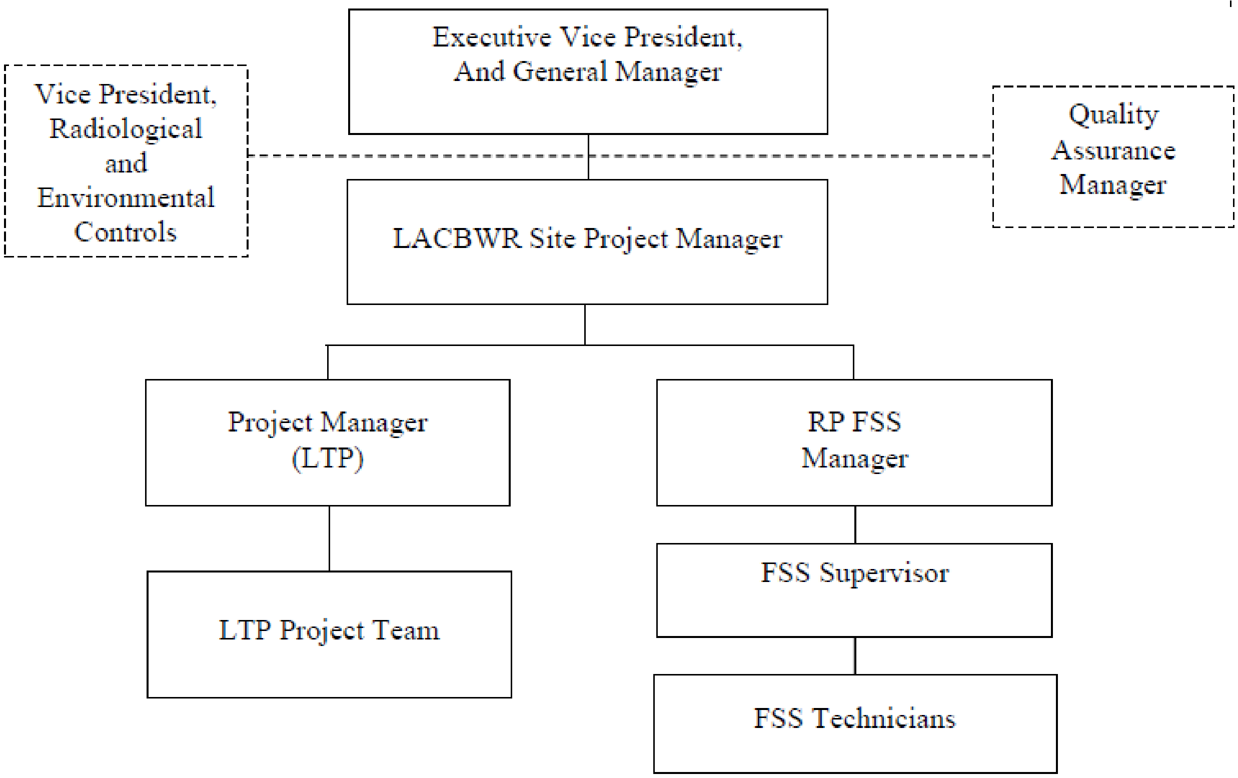
Survey Unit	Survey Unit Description	Class	Phase
S2-011-103 A	De-Icing Line	2	2
S2-011-103 B	Low Pressure Service Water	2	2
S2-011-103	Circulating Water Intake Pipe	2	2
S3-012-109 A	Storm Drain 1	3	2
S3-012-109 B	Storm Drain 2	3	2
S2-011-101 A	Storm Drain 3	3	2
S2-011-101 B	Storm Drain 6	3	2
S3-012-102 A	Storm Drain 4	3	2
S3-012-102 B	Storm Drain 5	3	2

2 Final Status Survey Program Overview

Elements of the FSS Program consist of the methods used in planning, designing, conducting, and evaluating FSS at the LACBWR site to demonstrate that the premises are suitable for unrestricted use in accordance with the criteria for decommissioning in Title 10 CFR 20, Subpart E. Final Status Surveys serve as key elements to demonstrate that the TEDE to an AMCG from residual radioactivity does not exceed 25 mrem/yr, and that all residual radioactivity at the site is reduced to levels that are ALARA.

To implement the FSS Program, LaCrosse*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 is responsible for the safe completion of all surveys related to characterization and final site closure. Approved site procedures and detailed technical support documents (TSD) direct the FSS process to ensure consistent implementation and adherence to applicable requirements. Figure 2-1 provides an organizational chart of the C/LT Group.

Figure 2-1 Characterization/License Termination Group Organizational Chart



2.1 Survey Planning

The program development and survey planning phases were initiated in 2015 by the Energy*Solutions* TSD RS-TD-313196-003, *La Crosse Boiling Water Reactor Historical Site Assessment* (HSA) (Reference 9) and the initiation of the characterization process. The HSA consisted of a review of site historical records regarding plant incidents, radiological survey documents, and routine and special reports submitted by Dairyland Power 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 (DQOs) 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 LACBWR site into manageable survey units for survey and classification purposes.
- Determine the initial classification of each survey unit as non-impacted or impacted. Impacted survey units are further designated as Class 1, 2, or 3, as defined in MARSSIM.

DQOs are qualitative and quantitative statements derived from the DQO process that 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 LC-FS-PR-002, *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. DQOs developed and implemented during the initial phase of planning directed all data collection efforts.

The DQO approach consists of the following seven steps:

- **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 10 CFR 20.1402.
- **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.
- **Identify Inputs to the Decision** – The information required depends on the type of media under consideration (e.g., soil, water, or concrete) and whether existing data are sufficient or if 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 are acceptable. If new data are needed, then the type of measurement (e.g., scan, direct measurement, or sampling) will need to be determined.
- **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 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.

- **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.
- **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.
- **Optimize the Design for Obtaining Data** – The final step in the DQO process leads to the development of an adequate survey design. Gamma scans provide information on soil surfaces that have residual radioactivity greater than background and allow appropriate selection of biased sampling and measurement locations. This data was evaluated and used to refine the scope of field activities to optimize implementation of the FSS design and ensure the DQOs are met. For soil survey units, compliance with the release criteria is shown by obtaining soil samples at randomly chosen, systematic and judgmental locations, depending on the classification.

Energy*Solutions* TSD RS-TD-313196-001, *Radionuclides of Concern During LACBWR Decommissioning* (Reference 10) evaluates the results of the concrete core analysis data from the Reactor Building, Waste Treatment Building (WTB), Piping Tunnels and Waste Gas Tank Vault (WGTV) and refines the initial suite of potential ROC by evaluating the dose significance of each radionuclide.

Insignificant dose contributors (IC) were determined consistent with the guidance contained in Section 3.3 of NUREG-1757. In all soil and concrete scenarios, Cs-137, Co-60, Sr-90, Eu-152 and Eu-154 contribute nearly 100% of the total dose. The remaining radionuclides were designated as IC and were eliminated from further detailed evaluation. Therefore, the final ROCs for LACBWR soil, basement concrete, and buried piping are Cs-137, Co-60, Sr-90, Eu-152 and Eu-154.

The results of surface and subsurface soil characterization in the impacted area surrounding LACBWR indicate that there is minimal residual radioactivity in soil.

The final suite of potential radionuclides and the mixture to be applied to soil is provided in Table 2-1.

Table 2-1 Dose Significant Radionuclides and Mixture

Radionuclide	Soil/Pipe Mixture Fraction (1)
Co-60	0.064
Sr-90	0.098
Cs-137	0.829
Eu-152	0.005
Eu-154	0.003

(1) Based on maximum percent of total activity from Table 22 of RS-TD-313196-001, normalized to one for the dose significant radionuclides.

Characterization results determined that Co-60 and/or Cs-137 would be the primary ROC for the majority of survey design. All the FSS results provided in this report utilize Cs-137 as the primary ROC. Cs-137 and Co-60 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.

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, and on structure surfaces, including any areas of elevated activity, was equal to or below the site-specific DCGLs that correspond to the 25 mrem/year release criterion.

Surface soil is defined as the first 15 cm layer of soil, and FSS for surface soil was performed on the first 15 cm. However, for conservatism, and to ensure efficient implementation of FSS, the surface soil dose assessment assumed a depth of 1 m from the surface. A standard surface soil contamination thickness of 15 cm would result in lower dose (i.e., higher DCGL). Using a 1 m thickness reduces the potential for delays or unnecessary remediation if contamination with a thickness somewhat greater than 15 cm is encountered. For the land area survey units addressed in this final report, no soil contamination was identified with a thickness greater than 1 m, with the exception of survey unit L1-SUB-TDS B, Reactor Plant Generator Plant Area (RPGPA). The following two paragraphs provide an overview of the planning activities that were taken for the FSS of L1-SUB-TDS B.

The LTP, Section 6.5.2, states that "In the unlikely event that geometries are encountered during continuing characterization or during FSS that are not bounded by the assumed 1 m soil contamination thickness, the discovered geometries will be addressed by additional modeling." The geometry of survey unit L1-SUB-TDS B is considered outside of the geometry bounded by the 1 m surface soil thickness modeled in the LTP because the excavation was unusually deep in order to remove the RPGPA Sump, resulting in portions of the excavated surface being below the water table. Therefore, additional modeling was performed as required by the LTP.

LaCrosse*Solutions* TSD LC-FS-TSD-004, *Dose Assessment of Post-Remediation Subsurface Geometry of Survey Unit L1-SUB-TDS B (including RPGPA Sump)* (Reference 11) details

the additional modeling performed for survey unit L1-SUB-TDS B. The TSD concludes that applying the LTP soil DCGLs to the L1-SUB-TDS B geometry is conservative in that the actual dose will be lower than that calculated using the LTP DCGLs. The one caveat in this analysis is that if the Sr-90/Cs-137 ratio in survey unit L1-SUB-TDS B exceeds 1.11, the dose with the L1-SUB-TDS B geometry could be higher than that calculated using the LTP soil DCGLs, depending on the concentrations of the other ROC. The 1.11 Sr-90/Cs-137 ratio was calculated using an iterative approach to determine the ratio that would result in the dose from the L1-SUB-TDS B geometry being equal to the dose calculated using the LTP Soil DCGLs (assuming that the mixture fractions for the four other ROCs are as listed in Table 2-1). Because the Sr-90/Cs-137 ratio did not exceed 1.11, the soil DCGLs provided in Table 2-2 were used in survey unit L1-SUB-TDS B.

Energy*Solutions* TSD RS-TD-313196-004, *LACBWR Soil DCGL, Basement Concrete DCGL, and Buried Pipe DCGL* (Reference 12) and LTP Section 6.20, provide the exposure scenarios and modeling parameters that were used to calculate the site-specific soil DCGLs. Each radionuclide-specific Base Case DCGL is equivalent to the level of residual radioactivity (above background levels) that could, when considered independently, result in a TEDE of 25 mrem/yr to an AMCG. To ensure that the summation of dose from each source term is 25 mrem/yr or less after all FSS is completed, the Base Case DCGLs are reduced based on an expected, or *a priori*, fraction of the 25 mrem/yr dose limit from each source term. These reduced values are designated as Operational DCGLs and are then used as the DCGL for the FSS design of the survey unit (e.g., calculation of surrogate DCGLs, investigation levels). Details of the Operational DCGLs derived for each dose component and the basis for the applied *a priori* dose fractions are provided in LaCrosse*Solutions* TSD LC-FS-TSD-002, *Operational Derived Concentration Guideline Levels for Final Status Survey* (Reference 13). The Operational and Base Case DCGLs for soil are provided in Table 2-2.

Table 2-2 Base Case and Operational DCGLs for Soil (1

Radionuclide	Base Case DCGL ($DCGL_S$) (pCi/g)	Operational DCGL ($OpDCGL_S$) (pCi/g)
Co-60	1.06E+01	3.83E+00
Sr-90	5.47E+03	1.97E+03
Cs-137	4.83E+01	1.74E+01
Eu-152	2.36E+01	8.51E+00
Eu-154	2.19E+01	7.89E+00

(1) Compiled from Tables 5-5 and 5-6 of the LTP

The development of information to support decommissioning planning and execution was accomplished through a review of all known site radiological and environmental records. Much of this information was consolidated in the HSA, and in files containing copies of records maintained pursuant to Title 10 CFR 50.75(g) (1).

An initial objective of site characterization was to correlate the impact of a radiological event to physical locations on the LACBWR site and to provide a means to correlate subsequent survey data. To satisfy these objectives, the entire 164-acre site was divided into survey units. Survey area size determination was based upon the specific area and the most efficient and practical size needed to bound the lateral and vertical extent of contamination identified in the area.

Classification, as described in MARSSIM, is the process by which an area or survey unit is described 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. 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 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 piping or open land area that is surveyed and evaluated as a single entity following FSS. Survey units were delineated to physical areas with similar operational history or similar potential for residual radioactivity. To the extent practical, survey units were established with relatively compact shapes, and 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 eight-digit number that could be further modified by a letter for future divisions if needed (i.e., if the classification changes, then the corresponding survey unit size limitation changes). Physically, land survey unit boundaries were determined using commercially available mapping software with coordinates consistent with the Wisconsin State Plane North American Datum (NAD) 1983 coordinate system. Table 2-3 provides an outline for classification versus area size for survey units consistent with MARSSIM.

Table 2-3 Typical Final Status Survey Unit Areas

Classification	Area Type	Suggested Area
Class 1	Land	Up to 2,000 m^2
	Structure	Up to 100 m^2
Class 2	Land	2,000 to 10,000 m^2
	Structure	100 to 1,000 m^2
Class 3	Land	No Limit
	Structure	No Limit

Prior to FSS, each survey unit's classification is reviewed and verified in accordance with the LTP and its implementing procedures. A classification change to increase the class (e.g., Class 2 to Class 1) may be implemented without notification to regulatory authorities. However, a classification change to decrease the class (e.g., Class 1 to Class 2) may be implemented only after accurate assessment and approval from regulatory authorities as detailed in the LTP and its implementing procedures. Typically, reclassification occurs after the evaluation of continuing characterization results or emergent data indicates a more restrictive classification is required. Final classification was performed in conjunction with the preparation of the FSS sample plans. The sample plans reconcile legacy characterization data with more recent continuing characterization data to verify that the final classification is correct.

2.2 Survey Design

Final Status Surveys for the LACBWR site are designed following LaCrosse*Solutions* procedures, the LTP, and MARSSIM guidance. FSS design utilizes the combination of traditional scanning surveys, systematic or random measurement/sampling protocols, and investigative or judgmental methodologies to evaluate survey units relative to the applicable release criteria for open land.

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 to ensure that this objective was consistently met, portable radiation detection instruments used in FSS were calibrated on a yearly frequency with a National Institute of Standards and Technology (NIST) traceable source in accordance with Energy*Solutions* procedures. Instruments were response checked before and after 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, a percentage of the surface area in the survey unit was selected and scanned with portable beta/gamma radiation detection instruments. Information obtained during the survey was automatically logged by the instrument for review and analysis. Scan and measurement coordinates were identified using a random or systematic sample tool in Visual Sample Plan (VSP). Investigational samples or measurements were collected at areas of elevated scan readings. All details and instructions were incorporated into the survey unit's FSS sample plan. The recommended survey coverage based on survey unit classification is provided below in Table 2-4.

Table 2-4 Recommended Survey Coverage for FSS (1)

Classification	Surface Scans	Soil Samples/Static Measurements
Class 1	100%	Number of sample/measurement locations for statistical test, additional samples/measurements to investigate areas of elevated activity
Class 2	10% to 100%, Systematic and Judgmental	Number of sample/measurement locations for statistical test
Class 3	Judgmental	Number of sample/measurement locations for statistical test

(1) From Table 5-15 of the LTP

The general approach prescribed by MARSSIM for FSS requires that at least a minimum number of measurements or samples be taken within a survey unit, so that the non-parametric statistical tests used for data assessment can be applied with adequate confidence. Decisions regarding whether a given survey unit meets the applicable release criterion are made based on the results of these tests.

Designated soil samples were sent to an off-site laboratory for Hard-to-Detect (HTD) analysis (Sr-90). Laboratory DQO and 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 of 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 HTD radionuclides. Surrogate ratios allow for expedient decision making in characterization, remediation planning, or FSS design.

A surrogate is a mathematical ratio where an Easy-to-Detect (ETD) radionuclide (e.g., Cs-137) concentration is related to an HTD radionuclide (e.g., 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 5.2.9 of the LTP.

Some portion of the radioactivity found in the soil samples is certainly 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 the FSS of open land survey units.

2.3 Survey Implementation

Implementation of FSS in the Phase 3 survey units started in June, 2019, and completed in September, 2019, with the exception of L1-SUB-CDR, which completed in September, 2017. Implementation was the physical process of the FSS sample plan execution for a given survey unit. Each sample plan was assigned to an FSS Supervisor for implementation and completion, in accordance with LaCrosse*Solutions* procedures and the FSS QAPP. 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 LC-RP-PG-003, *Radiological Instrumentation Program* (Reference 14) and LC-RP-PR-060, *Calibration and Initial Set Up of the 2350-1* (Reference 15).
- Implementation of applicable operating and health and safety procedures.
- Implementation of isolation and control of the survey unit in accordance with LC-FS-PR-010, *Isolation and Control for Final Status Survey.*
- Determination of the number of samples and measurements required to meet DQOs as described in LC-FS-PR-002, *Final Status Survey Package Development*.
- Determination of sample and measurement locations and creation of survey unit maps displaying the locations in accordance with LC-FS-PR-002.
- Proper techniques for collecting and handling FSS samples in accordance with LC-FS-PR-004, *Sample Media Collection for Site Characterization and Final Status Survey* (Reference 16).
- Maintaining Quality Assurance/Quality Control requirements (i.e., replicate measurements or samples) in accordance with LC-QA-PN-001, *Final Status Survey Quality Assurance Project Plan*.
- Sample Chain-of-Custody maintained in accordance with LC-FS-PR-005, *Sample Media Preparation for Site Characterization and Final Status Survey* (Reference 17).
- Sample submission to approved laboratories in accordance with LC-FS-PR-012, *Chain of Custody Protocol* (Reference 18).
- Application of the DCGLs to sample and measurement results in accordance with the Data Quality Assessment (DQA) process as detailed in LC-FS-PR-008, *Final Status Survey Data Assessment.*
- Determination of investigation methodology and corrective actions, if applicable.

The FSS of open land areas consisted of gamma scans performed at a frequency dependent on the classification followed by the collection of surface soil samples. Sub-surface soil samples were collected at 10% of the surface soil sample locations in Class 1 survey units. Additionally, a sub-surface soil sample was required at the location of a surface soil sample if the surface soil sample result or surface gamma scan exceeded 75% of the operational DCGL.

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 analyses. Data were stored electronically on the Energy*Solutions* common network with controlled accessibility.

2.4 Survey Data Assessment

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

The DQA process is an evaluation method used during the assessment phase of FSS to ensure the validity of FSS results and demonstrate achievement with the FSS sample plan objectives. A key step in the data assessment process converts all of the survey results to DCGL units, if necessary. The individual measurements and sample concentrations are compared to the Operational DCGL for evidence of small areas of elevated activity or results that are statistical outliers. When practical, graphical analyses of survey data that depicts the spatial correlation of the measurements was used.

For soil, 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, and data evaluation and statistical tests since multiple radionuclide-specific measurements will be performed or the concentrations 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 is applied, the $DCGL_W$ (used for the nonparametric statistical test) becomes one (1).

For the soil survey units addressed by 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 addendum to 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 FSS sample plan was correctly implemented.
- DQOs were properly defined and derived.
- The DQA process was used to assess results.
- 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.
- Corrective actions were prescribed, implemented and tracked, as necessary.

Independent laboratories used for analysis of the samples collected during FSS maintain Quality Assurance Plans designed for their facility. LaCrosse*Solutions* reviewed these plans, as required by the FSS QAPP, prior to selection of a laboratory for FSS sample analysis to ensure standards are acceptable.

The Characterization/License Termination Group has undergone surveillance by the Energy*Solutions* QA department on a consistent basis throughout the project at LACBWR. 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 are captured in the Corrective Action Program (CAP).

3 Site Information

3.1 Site Description

The La Crosse Boiling Water Reactor was a 50-Megawatt Electric (MWe) BWR that is owned by Dairyland Power Cooperative (Dairyland). This unit, also known as Genoa 2, is located on the Dairyland Genoa site on the east shore of the Mississippi River about 1 mile south of the Village of Genoa, Vernon County, Wisconsin, and approximately 19 miles south of the city of La Crosse, WI. See Figure 3-1 for a map showing the site location.

The licensed site comprises a total of 163.5 acres which is owned by Dairyland, with LACBWR comprising only 1.5 acres. The site is accessed by a road on the south side of the plant, off of Highway 35. Figures 3-2 and 3-3 depict the prominent features on the site.

Figure 3-1 Site Regional Location

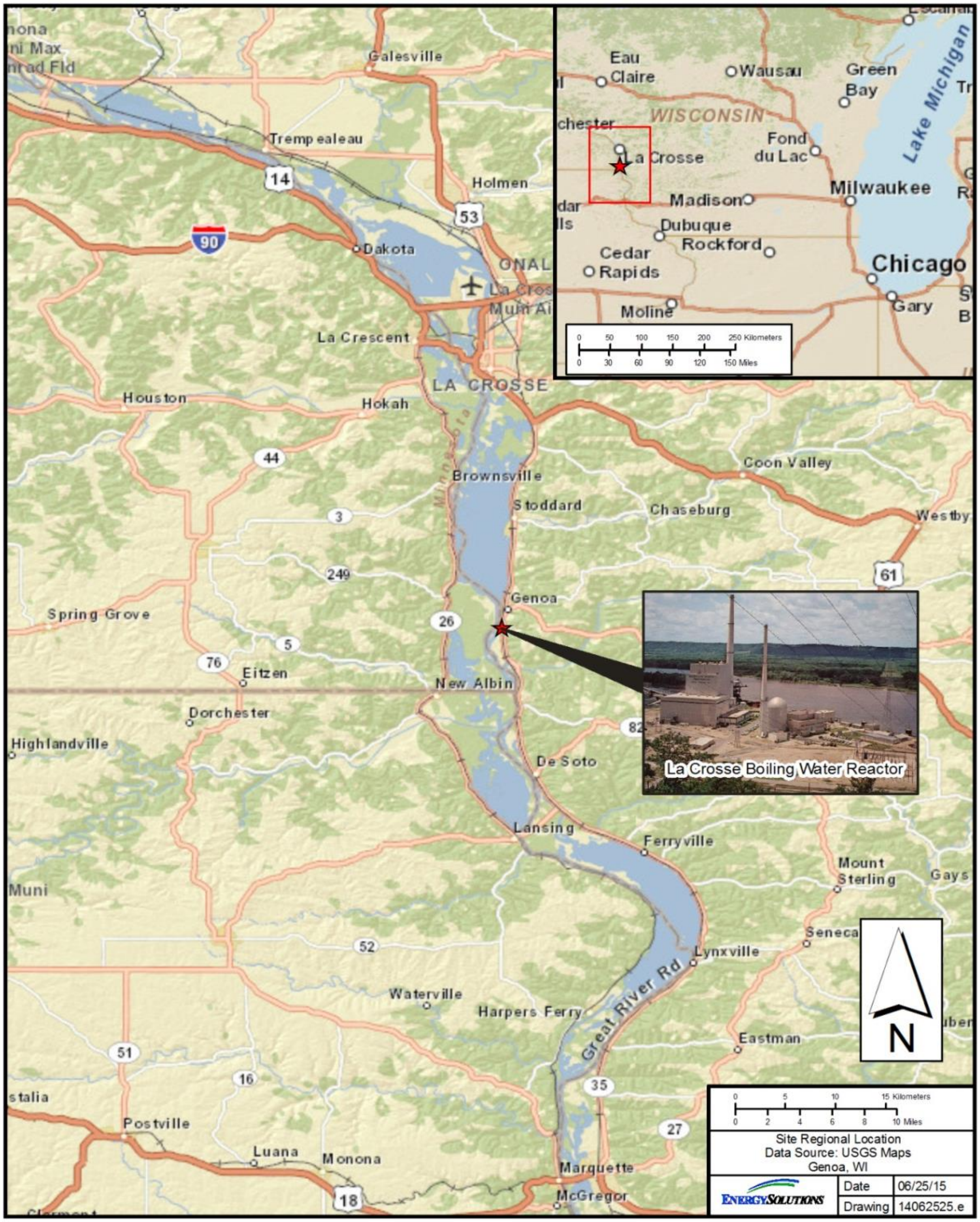


Figure 3-2 Site Overview

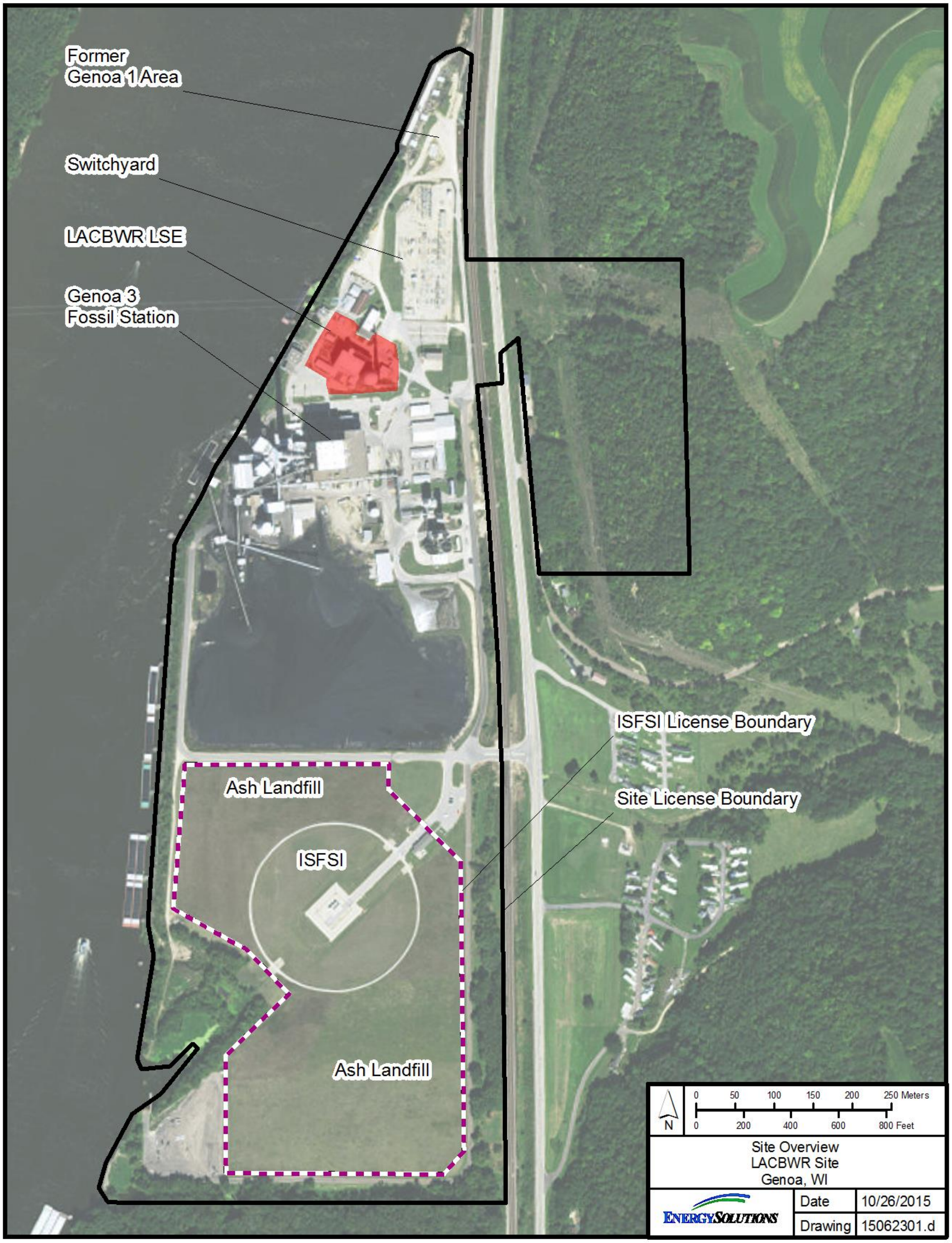
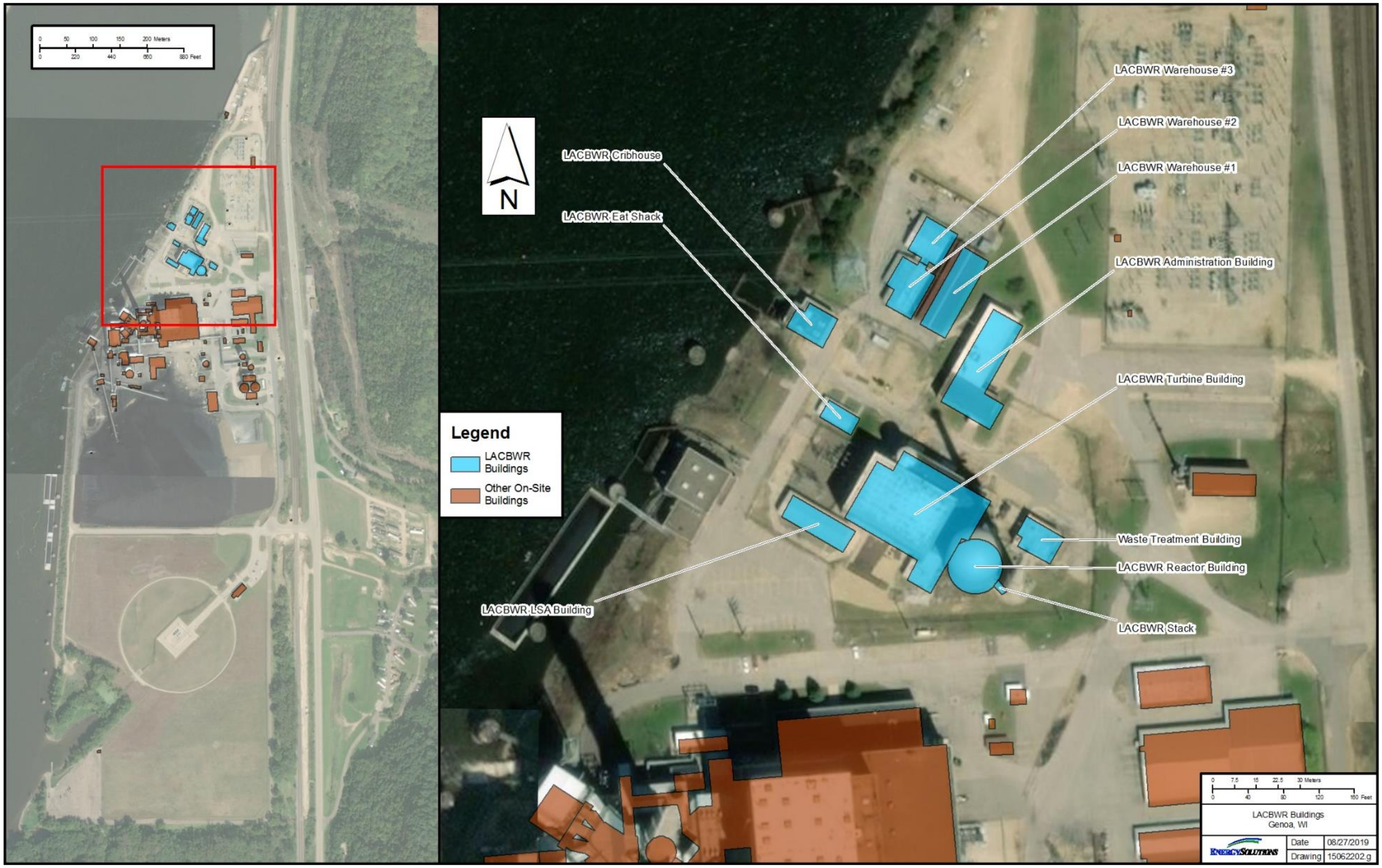


Figure 3-3 LACBWR Buildings



The site is licensed under Possession Only License No. DPR-45 with Docket Numbers of 50-409 for LACBWR and 72-046 for the Independent Spent Fuel Storage Installation (ISFSI). Key milestones during the life of the plant are:

- Allis-Chalmers, under contract with the AEC, designed, fabricated, constructed and performed startup of the LACBWR from 1962 to 1967,
- Dairyland entered into a contact to purchase steam from the nuclear plant to operate a turbine-generator for production of electricity: June 1962,
- Allis-Chalmers dockets application for construction: November 5, 1962,
- Initial Criticality achieved: July 11, 1967,
- Low power testing completed: September 1967,
- Provisional Operating authorization issued (DPRA-6): October 31, 1969,
- Provisional Operating License, DPRA-45 issued: August 28, 1973,
- LACBWR permanently shut down: April 30, 1987,
- Final reactor defueling was completed on June 11, 1987, and
- Completion of fuel loading into the ISFSI was completed on September 19, 2012.

The reactor was critical for a total of 103,287.5 hours. The 50 MWe generator was on line for 96,274.6 hours. The total gross electrical energy generated was 4.047 Gigawatt-Hours (GWH). The unit availability factor was 62.9%.

The LACBWR unit consisted of major buildings and structures such as the Reactor Building, Turbine Building, 1B Diesel Generator Building, Waste Treatment Building, Underground Gas Storage Tank Vault, Ventilation Stack and Low Specific Activity (LSA) building and others which have undergone decommissioning (see Figure 3-3). Intermittent systems dismantlement and metallic radioactive equipment have been removed since 2007, including the Reactor Pressure Vessel. The Independent Spent Fuel Storage Installation (ISFSI), located south of the Genoa 3 fossil station, became operational in 2012 and holds five above-ground Dry Storage Casks with 333 spent fuel assemblies.

3.2 Survey Unit Description

The following information is a description of each survey unit at the time of FSS from September, 2017 until September, 2019. During this period, the FSS of eleven (11) open land survey units and three (3) sub-grade excavation survey units, were completed.

Survey Unit L1-010-101, Reactor Building, WTB, WGTV, Ventilation Stack Grounds

L1-010-101 is an impacted Class 1 open land survey unit. The survey unit consists of surface soil within the footprint of the former Reactor Building, including the land areas adjacent to the north, east and south of the Reactor Building footprint. The size of this survey unit is 1,992 m^2.

Survey Unit L1-010-102, Turbine Building, Turbine Office Building, 1B Diesel Generator Building Grounds

L1-010-102 is an impacted Class 1 open land survey unit. The survey unit consists of surface soil within the footprint of the former Turbine Building, east of the location of the former Reactor Building. The surface area of the survey unit is 2,315 m^2.

Survey Unit L1-010-103, LSA Building, Maintenance Eat Shack Grounds

L1-010-103 is an impacted Class 1 open land survey unit. The survey unit consists of surface soil due west of the footprint of the former Turbine Building. The surface area of the survey unit is 1,749 m^2.

Survey Unit L1-010-104, North LSE Grounds

L1-010-104 is an impacted Class 1 open land survey unit. The survey unit consists of surface soil over the entire north side of the LSE. The surface area of the survey unit is 2,387 m^2.

Survey Unit L1-010-105, North Interim Debris Storage Area

L1-010-105 is an impacted Class 1 open land survey unit. The survey unit consists of surface soil in the northwest portion of the site at the location of the former interim debris storage area. The surface area of the survey unit is 1,974 m^2.

Survey Unit L1-010-106, North Loading Area

L1-010-106 is an impacted Class 1 open land survey unit. The survey unit consists of surface soil in the northern portion of the site between L1-010-105 and the Switchyard. The surface area of the survey unit is 1,936 m^2.

Survey Unit L1-010-107, Outside East LSE Area

L1-010-107 is an impacted Class 1 open land survey unit. The survey unit consists of surface soil in the area to the east and southeast of the LSE fence. The surface area of the survey unit is 1,675 m^2.

Survey Unit L2-011-101, Area North of LSE Fence

L2-011-101 is an impacted Class 2 open land survey unit. The survey unit consists of surface soil and asphalt with a surface area of 5,728 m^2.

Survey Unit L2-011-104, G3 Crib House, Circ. Water Discharge Land

L2-011-104 is an impacted Class 2 open land survey unit. The survey unit consists of surface soil and asphalt with a surface area of 5,285 m^2. The survey unit surrounds the G3 Crib House while extending south to where the Circulating Water Discharge Pipe empties into the Mississippi River. The survey unit also serves as a buffer to the south and southwest portions of the LSE fence.

Survey Unit L3-012-101, North End of Licensed Site

L3-012-101 is an impacted Class 3 open land survey unit. The survey unit consists of surface soil and asphalt with a surface area of 19,885 m^2. The survey unit encompasses the location of the former Genoa 1 Coal Plant and surrounds the north and east boundaries of the Transmission Switchyard.

Survey Unit L3-012-109, Plant Access, ISFSI Haul Road Grounds East

L3-012-109 is an impacted Class 3 open land survey unit. The survey unit consists of surface soil and asphalt with a surface area of 28,187 m^2. The survey unit consists of the primary parking lot for LACBWR and runs south past the site entrance road and up to the ISFSI. The road was used for transporting spent fuel storage casks to the ISFSI and is still used as the sole access route for G3 and LACBWR personnel, vehicles and equipment.

Survey Unit L1-SUB-CDR, Stack, Pipe Tunnel, RPGPA Excavation

L1-SUB-CDR is an impacted Class 1 sub-grade excavation survey unit within open land survey unit L1-010-101. The survey unit consists of the underlying soil post-removal of the Stack, Pipe Tunnel and RPGPA foundations. The surface area of the survey unit is 431 m^2.

Survey Unit L1-SUB-TDS A, Eastern Portion TB, Sump, Pit

L1-SUB-TDS A is an impacted Class 1 sub-grade excavation survey unit within open land survey unit L1-010-102. The survey unit consists of the underlying soil post-removal of the Turbine Building/Turbine Building Offices and 1B Diesel Generator Building, as well as associated system lines. The surface area of the survey unit is 476 m^2.

Survey Unit L1-SUB-TDS B, RPGPA Area

L1-SUB-TDS B is an impacted Class 1 sub-grade excavation survey unit within open land survey unit L1-010-102. The survey unit consists of the underlying soil post-removal of the Turbine Building/Turbine Building Offices and 1B Diesel Generator Building, as well as associated system lines. The eastern portion of L1-SUB-TDS survey unit is designated as L1-SUB-TDS B, which includes the RPGPA Sump. Survey Unit L1-SUB-TDS B is 259 m^2 in size and consists of the sloped area boundaries of the excavation and the 39 m^2 location of the former RPGPA Sump. The maximum depth of the excavation in L1-SUB-TDS B is at 618-foot elevation, which is 21 feet below grade (639-foot elevation). At the time of FSS, the excavation was backfilled and the FSS was implemented via GeoProbe® technology.

3.3 Summary of Historical Radiological Data

The site historical radiological data for this Phase 3 FSS Final Report at LACBWR incorporates the results of the HSA issued in November 2015 and characterization surveys completed in November 2016.

3.3.1 Historical Site Assessment

The HSA was a detailed investigation to collect existing information (from the start of LACBWR 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 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 area 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 HSA did not provide information related to buried piping and therefore, initial survey unit classifications for buried piping were based on process knowledge.

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.
- Delineate initial survey unit boundaries and areas 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.

For the seven (7) land area survey units located within the LSE fence, the HSA indicated that the presence of residual radioactivity in concentrations in excess of the unrestricted release criteria was possible and therefore, these survey units were designated as Class 1. Two (2) of the open land survey units were designated as Class 2 due to decommissioning activities. For the two (2) class 3 open land survey units, although radioactive material may have traversed these areas, there is no history of spills and site characterization

verified the Class 3 designation. All three (3) sub-grade excavation survey units were designated Class 1 due the proximity in the LSE and nature of materials removed.

3.3.2 Characterization Surveys

Site characterization of the LACBWR facility was performed in accordance with Energy*Solutions* procedure LC-FS-PN-002, *Characterization Survey Plan* (Reference 19), which 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 Energy*Solutions* GG-EO-313196-RS-RP-001, *LACBWR Radiological Characterization Survey Report for October and November 2014 Field Work – November 2015* (Reference 20) and LaCrosse*Solutions* TSD LC-RS-PN-164017-001, *Characterization Survey Report*.

Additionally, the statistical quantities for Cs-137 and Co-60 from the characterization samples are provided in each of the subject release records (see Appendices A1 through A14).

3.3.3 Continuing Characterization

Previously inaccessible areas identified in LTP Section 2.4 were characterized during the continuing characterization process. Continuing characterization was performed in the following survey units within the scope of this report.

Survey Unit L1-SUB-TDS A

In 2015, as part of a broader site characterization, five (5) locations were selected for angled coring to obtain soil from beneath the Turbine Building at the location of suspected broken drain lines. GeoProbe® technology was used to obtain the samples. At each of the 5 locations, samples were collected from the 10', 15' and 20' depths, for a total of fifteen (15) soil samples. A total of two (2) surface soil samples and twenty-two (22) subsurface soil samples were collected in the survey unit prior to FSS. Additionally, one (1) continuing characterization sample was collected in L1-SUB-TDS A during FSS, due to the area being inaccessible at the time of characterization.

Survey Unit L1-SUB-TDS B

Twenty-eight (28) continuing characterization samples (four [4] subsurface soil samples from each of seven [7] locations) were collected in L1-SUB-TDS B, due to the area being inaccessible at the time of characterization.

Additionally, the statistical quantities for Cs-137 and Co-60 from the continuing characterization samples obtained in survey units L1-SUB-TDS A and L1-SUB-TDS B are provided in each of the subject release records (see Appendices A13 and A14, respectively).

3.3.4 Radiological Assessments

Radiological Assessments (RA) are a form of continuing characterization that are performed in previously inaccessible areas that are not listed in LTP Section 2.4, and in other areas to verify that radiological conditions in a survey unit are suitable for FSS or to obtain data for the design of FSS. A RA was performed in the following survey units within the scope of this report.

Survey Unit L1-010-101

A RA was performed in survey unit L1-010-101 in April of 2019. Thirty-five (35) soil samples were collected and analyzed by the on-site gamma spectroscopy system. The average SOF of the sample set was 0.04, with a standard deviation 0.02.

Survey Unit L1-010-104

A RA was performed in survey unit L1-010-104 in May of 2019. Twenty-two (22) soil samples were collected and analyzed by the on-site gamma spectroscopy system. The average SOF of the sample set was 0.022, with a standard deviation 0.0103.

Survey Unit L1-010-105

A RA was performed in survey unit L1-010-105 in May of 2019. Nine (9) soil samples were collected and analyzed by the on-site gamma spectroscopy system. The average SOF of the sample set was 0.03, with a standard deviation 0.013.

Survey Unit L1-010-106

A RA was performed in survey unit L1-010-106 in June of 2019. Seven (7) soil samples were collected and analyzed by the on-site gamma spectroscopy system. The average SOF of the sample set was 0.025, with a standard deviation 0.016.

Survey Unit L1-010-107

A RA was performed in survey unit L1-010-107 in June of 2019. Seven (7) soil samples were collected and analyzed by the on-site gamma spectroscopy system. The average SOF of the sample set was 0.04, with a standard deviation 0.014.

Survey Unit L2-011-101

A RA was performed in survey unit L2-011-101 in June of 2019. Thirty-nine (39) soil samples were collected and analyzed by the on-site gamma spectroscopy system. The average SOF of the sample set was 0.023, with a standard deviation 0.008.

Survey Unit L2-011-104

A RA was performed in survey unit L2-011-104 in June of 2019. Twenty-seven (27) soil samples were collected and analyzed by the on-site gamma spectroscopy system. The average SOF of the sample set was 0.014, with a standard deviation 0.006.

3.3.5 Remedial Action Support Surveys

None of the fourteen (14) survey units within the scope of this report required remediation and therefore, Remedial Action Support Surveys were not required.

3.4 Conditions at the Time of Final Status Survey

The open land survey units in this report had many instances of disturbance occurring since the shut-down of LACBWR. Within the LSE, a large amount of excavation took place during decommissioning to remove buildings and their foundations, buried piping and other utilities. These excavations were subject to continuing characterizations, RAs and/or FSS prior to backfill. The conditions at the time that these radiological surveys were performed varied depending on the depth and slope of the excavations, as well as weather. In the case of L1-SUB-TDS B, the RPGPA excavation had to be backfilled prior to FSS which had to be performed using GeoProbe® technology. In other excavations, steep slopes and increased depth required the use of an articulated boom lift to safely access 100% of the excavation surfaces. Once the radiological surveys were completed (including verification surveys performed by the Nuclear Regulatory Commission (NRC) or their contractor) the excavations were backfilled with either overburden soil from the excavation process or with clean fill material imported from an off-site source using the processes described in LTP Section 5.7.1.6. After backfill, all open land survey units within the LSE underwent FSS. The topside soil was fairly smoothed out with minimal indentions and no debris. Land areas outside the LSE were primarily soil with sparse vegetation, as well as asphalt. In instances where miscellaneous materials, equipment or structures were present at the time of FSS (e.g., abandoned well casings), the items were surveyed during the FSS in accordance with LC-FS-PR-017, *Unconditional Release of M&E and Secondary Structures* (Reference 21).

Prior to FSS, areas ready for survey were isolated and controlled under LC-FS-PR-010, *Isolation and Control for Final Status Survey.* This included posting of the area as well as notifications to site personnel. Permission was then obtained from C/LT staff to enter and work in these areas. A routine surveillance program monitored for any inadvertent personnel access or anomalies with procedurally defined recovery and reporting protocols in the event of any impact to these survey unit's as-left radiological conditions or final configuration.

3.5 Identification of Potential Contaminants

Energy*Solutions* TSD RS-TD-313196-001, *Radionuclides of Concern During LACBWR Decommissioning* established the basis for an initial suite of potential ROC for 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 LACBWR was prepared (see Table 5-1 in the LTP).

LTP Chapter 2 provides detailed characterization data that describes current contamination levels in the basements and soils from the characterization campaign conducted from September 2014 through August 2015. The initial survey data for basements was based on core samples obtained from the walls and floors of the Reactor Building, WTB and the balance of the basement structures (primarily the Piping Tunnels) at biased locations with elevated contact dose rates, contamination levels, and/or evidence of leaks/spills. During subsequent characterizations, additional cores were obtained from the Reactor Building and the WGTV. Surface and subsurface soil samples were taken in each impacted open land survey unit (including soil beneath and adjacent to basements) and analyzed for the presence of plant-derived radionuclides. TSD RS-TD-313196-001 evaluates the results of the concrete core analysis data from the Reactor Building, WTB, Piping Tunnels and WGTV and refines the initial suite of potential ROC by evaluating the dose significance of each radionuclide.

IC were determined consistent with the guidance contained in Section 3.3 of NUREG-1757. In all soil and concrete scenarios, Cs-137, Co-60, Sr-90, Eu-152 and Eu-154 contribute nearly 100% of the total dose. The remaining radionuclides were designated as IC and were eliminated from further detailed evaluation. Therefore, the final ROCs for LACBWR soil, basement concrete and buried piping are Cs-137, Co-60, Sr-90, Eu-152 and Eu-154.

3.6 Radiological Release Criteria

All FSSs for the survey units detailed in this report were conservatively designed to the Operational DCGLs for soil, and all results were compared to these values. However, since the release criteria were based on the Base Case DCGL, surpassing the Operational DCGL did not disqualify a survey unit from meeting the release criteria provided that the data passed the Sign Test and the Base Case DCGL was not exceeded. The Base Case DCGLs and Operational DCGLs for soil are provided in Table 2-2.

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 contains basic elements common to all FSS sample plans at LACBWR. An outline of those elements presented in the 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/yr TEDE and that the potential dose from residual radioactivity is ALARA.

Stakeholders: The primary stakeholders interested in the answer to this problem are LaCrosse*Solutions* LLC, Dairyland Power Generation LLC, the Wisconsin Department of Health Services and the NRC.

The Planning Team: The planning team consisted of the assigned Radiological Engineer or FSS Supervisor with input from other C/LT personnel as well as the Safety Department. The primary decision maker was the FSS Supervisor with input from the C/LT Manager.

Schedule: The approximate time projected to mobilize, implement, and asses an FSS unit was between four (4) and ten (10) days.

Resources: The following resources were necessary to implement an FSS sample plan:

- Radiological Engineer or FSS Supervisor to prepare the plan and evaluate data.
- FSS Supervisor to monitor and coordinate field activities.
- Graphics/GPS Specialist to prepare survey maps, layout diagrams, composite view drawings, and other graphics as necessary to support survey design and reporting.
- FSS 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 buried pipe and above-grade buildings equal to or below site-specific DCGLs?

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

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

Identify Inputs to the Decision

Information Needed: The survey unit requires an evaluation of residual activity and its surface area. The HSA and characterization surveys were preliminary sources of information for FSS; however, the results were not sufficient to provide the current as-left radiological conditions. New measurements of sample media are needed to determine the concentration and variability for those radionuclides potentially present at the site at the time of FSS. For the open land and sub-grade excavation survey units, gamma scans are needed to identify areas of elevated activity and volumetric sampling of bulk materials (e.g., soil, sediment, asphalt) are needed as compliance measurements. In instance where scan surveys could not be performed (L1-SUB-TDS B) additional compliance samples were obtained as required by MARSSIM.

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 characterization, RA, or turnover surveys. This information is used to develop a sample size for FSS.

Radionuclides of Concern: The ROC are presented in Table 2-1 of this final report.

Basis for the Action Level: The investigation and action levels for FSS were selected in accordance with Table 5-16 of the LTP, recreated below as Table 4-1.

Table 4-1 FSS Investigation Levels

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

During the data analysis of the FSS results, concentrations for the HTD ROC Sr-90 are inferred using a surrogate approach. The 95% Upper Confidence Limit (UCL) of the Cs-137 fractions was chosen to represent the overall nuclide mix for soils/buried pipe, the Reactor Building, and the WGTV. The surrogate ratio for soil/buried pipe is given in Table 4-2.

Table 4-2 Soil/Buried Pipe Surrogate Ratio

Radionuclides	Ratio
Sr-90/Cs-137	0.502

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

$DCGL_{2,3\ldots n}$ = 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 Operational DCGLs presented in Table 2-2 and the ratio for soil from Table 4-2, the following surrogate calculation was performed:

Equation 2

$$Soil\ Surrogate_{DCGL\ (Cs-137)} = \frac{1}{\left[\left(\frac{1}{1.74E+01_{(Cs-137)}}\right) + \left(\frac{5.02E-01}{1.97E+03_{(Sr-90)}}\right)\right]}$$
$$= 1.73E+01\ pCi/g$$

The surrogate Operational DCGL that was used for Cs-137 in open land survey units, for direct comparison of sample results to demonstrate compliance, was 1.73E+01 pCi/g.

Investigation Levels: Table 4-1 provides the investigation levels for the Phase 3 survey units.

Define the Boundaries of the Survey

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

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

Constraints: The most common constraints were the weather, temperature, and water intrusion and steep slopes in sub-grade excavation survey units.

Develop a Decision Rule

Decision Rule: If any measurement data exceeded the action levels specified in the survey plans, alternative actions would be taken.

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): Typically, the LBGR was set at 50% of the Operational DCGL. In using the unity rule, the Operational DCGL becomes one (1) and the LBGR is set as 0.5. In some cases, the LBGR was set at the mean SOF from continuing characterization or RA data.

<u>Optimize Design</u>

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 Measurements/Samples Required for the Sign Test: All open land and sub-grade excavation survey units had a relative shift of three (3), which corresponds to fourteen (14) systematic or randomly located measurements for use with the Sign Test. The locations of the samples and measurements were determined using the software VSP.

Because a large portion of survey unit L1-SUB-TDS B was backfilled prior to FSS, performing gamma scans over 100% of the surface area was not possible. The lack of scan data was augmented by adding an additional fourteen (14) sample locations to the originally prescribed fourteen (14) sample locations. At each of the twenty-eight (28) sample locations, four (4) soil samples were collected for a total of one hundred and twelve (112) systematic samples. One (1) sample from each of the twenty-eight (28) sample locations that exhibited the highest Cs-137 concentration was selected for the Sign Test.

Number of Judgmental Measurements/Samples and Locations: Typically, a minimum of one (1) judgmental sample or measurement was required in each Phase 3 survey unit. The selection of additional judgmental samples or measurements was at the discretion of the FSS Supervisor. Locations chosen for judgmental investigation were usually areas of interest (e.g., low points, drain covers, cracks, pipe elbows).

Number of Scan Areas and Locations: For Class 3 survey units, a minimum of 5% of the accessible surface area was scanned. For Class 2 survey units, 25% to 50% of the accessible surface area was scanned. For Class 1 survey units, 100% of the accessible surface area was scanned with the exception of L1-SUB-TDS B (see discussion above). For Class 3 open land survey units, scan locations were biased to areas with more contamination potential (e.g., low points, culverts, outfall piping). In the absence of any areas with more contamination potential, a scan area was developed around each randomly selected static measurement

location that, when totaled, equated to the required scan frequency percentage of the total surface area. Additional scans were performed at the locations of judgmental measurements. For the Class 1 and Class 2 open land and sub-grade excavation survey units detailed in this report, scan areas were established based on the systematic grid.

Number of Measurements/Samples for Quality Control: The implementation of quality control measures as referenced by the LTP in Section 5.9.3 and the QAPP included the collection of split samples, duplicate samples and/or replicate measurements, as appropriate, at a frequency of 5% of the measurement/sample set. The locations for replicate measurements/samples were selected randomly using a random number generator.

Power Curve: The Prospective Power Curve, developed using characterization data and MARSSIM Power 2000 or COMPASS software, showed adequate power for the survey design in each of the survey units.

4.2 Survey Unit Designation and Classification

Procedure LC-FS-PR-006, *Survey Unit Classification* (Reference 22), defines the decision process for classifying an area in accordance with the LTP and MARSSIM. During the FSS of areas submitted for this Phase 3 Final Report, no survey units were reclassified.

4.3 Background Determination

During the gamma scanning, ambient background was determined by taking the average of five (5) background readings and establishing the alarm set point based on the background value for each scan area.

Each survey unit release record (enclosed as appendices to this report) discusses background determination in further detail.

4.4 Final Status Survey Sample Plans

The level of effort associated with planning a survey is based on the complexity of the survey unit and nature of the hazards. Guidance for preparing FSS plans of open land and sub-grade excavation survey units is provided in procedure LC-FS-PR-002, *Final Status Survey Package Development*. The FSS sample plans for all Phase 3 survey units use an integrated sample design that combines scanning surveys and media samples.

4.5 Survey Design

4.5.1 Determination of Number of Data Points

The number of soil samples for the FSS of open land and sub-grade excavation survey units was determined in accordance with procedures LC-FS-PR-002, *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 DCGL, minus the LBGR, divided by sigma (σ), which is the standard deviation of the data set used for survey design. As the calculated relative shift for all open land and subgrade excavation survey units was greater than three (3), a value of 3 was used. The sample size from Table 5.5 in MARSSIM that equates to α and β errors of 0.05 and a relative shift of three (3) is fourteen (14). As a conservative measure, and to address the inability to collect gamma scan measurements, a total of twenty-eight (28) sample locations with four (4) samples obtained at each location (one-hundred and twelve (112) total samples) were collected in survey unit L1-SUB-TDS B. A breakdown of the samples collected for the Phase 3 survey units is provided in Table 4-3.

Table 4-3 Number of Measurements for FSS

Survey Unit	Random/Systematic Samples	Judgmental Samples	Investigational Samples
L1-010-101	14	3	0
L1-010-102	14	2	2
L1-010-103	14	2	1
L1-010-104	14	4	1
L1-010-105	14	2	2
L1-010-106	14	2	6
L1-010-107	14	4	5
L2-011-101	14	3	0
L2-011-104	14	8	2
L3-012-101	14	2	0
L3-012-109	14	4	24
L1-SUB-CDR	14	0 (1)	6
L1-SUB-TDS A	14	4	4
L1-SUB-TDS B	28 (2)	32	0

(1) FSS was implemented prior to the current LTP Rev. 1 commitment to obtain a minimum of one judgmental sample from each survey unit. The six investigation samples serve as the judgmental samples.
(2) The sample with the highest concentration of Cs-137 from each of the twenty-eight (28) sample locations was used in the Sign Test.

4.5.2 Sample Locations

Locations of the samples and measurements were determined using the VSP software. For open land areas, VSP software imports a topographical map of the selected survey area and designates the sample locations with coordinates and bearings based on the Wisconsin State Plane System. The VSP software designated the measurement locations with coordinates based on a local origin established on the drawing (an x, y system in meters). Pacific Northwest National Laboratory created VSP for the United States

Department of Energy. For those locations where access was impractical or unsafe, alternate sample locations were generated and documented. Sample locations were identified using GPS coordinates and are consistent with the Wisconsin State Plane System. Once located, sample points were physically marked and graphically plotted using drafting software.

4.6 Instrumentation

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

The DQO process includes the selection of instrumentation appropriate for the type of measurement to be performed and that are calibrated to respond to a radiation field under controlled circumstances. Instruments are also evaluated periodically for adequate performance to established quality standards and ensure that they are sensitive enough to detect the ROC with a sufficient degree of confidence. For example, when determining instrument MDCR, an index of sensitivity (*d'*) of 1.38 was used to provide a detection rate of 95% and a false positive rate of 60%.

The field instrumentation will, to the extent practicable, use data logging to automatically record measurements to minimize transcription errors.

Specific implementing procedures control the issuance, use, and calibration of instrumentation used for FSS. The specific DQOs for instruments are 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 NaI detector were selected as the primary radiation detection instrumentation for performing scanning in open land and sub-grade survey units. 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 23).

4.6.2 Detector Sensitivities

The evaluation of open land areas requires a detection methodology of sufficient sensitivity for the identification of small areas of potentially elevated activity. Scanning

measurements are 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 rate of 0.5 m/sec. The audible and visual 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 24). The gamma scan MDCR is discussed in detail in Energy*Solutions* TSD RS-TD-313196-006, *Ludlum Model 44-10 Detector Sensitivity* (Reference 25) which examines the gamma sensitivity for a 5.08 by 5.08 cm (2" x 2") NaI detector to several radionuclide mixtures of Co-60 and Cs-137 using sand (SiO_2) as the soil base. TSD RS-TD-313196-006 derives the MDCR for the radionuclide mixtures at various detector distances and scan speeds. The model in TSD RS-TD-313196-006 uses the same geometry configuration as the model used in MARSSIM. TSD RS-TD-313196-006 provides MDCR values for the expected LACBWR 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 irregular 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 was calibrated and maintained in accordance with approved LaCrosse*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 was set up appropriately for the desired geometry. If vendor services were used for instrument calibration or repair, these services 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 survey unit classification as summarized in Table 2-4. 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.

The following pertains to survey unit L3-012-101 and L3-012-109 only, as they are the only Class 3 open land survey unit in this Phase 3 Final Report. The LTP Section 5.6.4.4 states that for Class 3 survey units, judgmental surface scans will typically be performed on areas with the greatest potential of contamination and that for open land areas, this will include surface drainage areas and collection points. For the two Class 3 survey units, scan locations were biased to high traffic areas such as roadways and pathways. Additionally, scanning was performed around each sampling location. This allowed for the scanned areas to be evenly distributed throughout the survey unit.

For the Class 1 and Class 2 open land survey units detailed in this report, scan areas were established based on the systematic grid. Each established scan area was located with GPS, marked, and completely scanned. Areas with elevated readings were marked and investigational samples were collected. The probe was positioned as close to the ground as possible and was moved at a scan speed not to exceed 0.5 meters per second. Table 4-4 provides a summary of the area scanned during FSS.

During the scanning, the technician recorded data and observations in a Field Log. This log documented field activities, anomalies and other information pertaining to the survey.

Table 4-4 Summary of Total Area Scanned for Phase 3 Survey Units

Survey Unit	Survey Unit Classification	Area (m^2)	Area Scanned (m^2)	% Scan
L1-010-101	1	1,992	1,992	100%
L1-010-102	1	2,315	2,315	100%
L1-010-103	1	1,749	1,749	100%
L1-010-104	1	2,387	2,387	100%
L1-010-105	1	1,974	1,974	100%
L1-010-106	1	1,936	1,936	100%
L1-010-107	1	1,675	1,675	100%
L2-011-101	2	5,728	1,509	26%
L2-011-104	2	5,285	1,344	25%
L3-012-101	3	19,885	2,007	10%
L3-012-109	3	28,187	2,897	10%
L1-SUB-CDR	1	431	431	100%
L1-SUB-TDS A	1	476	476	100%
L1-SUB-TDS B	1	259	NA[1]	NA[1]

1) Scan surveys were not performed in L1-SUB-TDS B because the survey unit was backfilled prior to FSS.

4.7.2 Soil

In accordance with the FSS Sample Plan and applicable procedures, FSS technicians collected surface 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.

4.7.3 Soil Sampling Via GeoProbe®

Soil sampling in survey unit L1-SUB-TDS B was performed by a sub-contractor using GeoProbe® technology. A direct push machine "pushes" tools into the ground without the use of drilling to remove soil to make a path for the tool. Direct push machines rely on a relatively small amount of static (vehicle) weight combined with percussion as the energy for advancing a tool string. Unlike rotary, the drill cuttings are not removed from the hole, rather the soil is collected in tubes in one-meter increments.

4.8 Quality Control Surveys

The method used for evaluating Quality Control (QC) split samples and replicate measurements collected in support of the FSS program is specified in the FSS QAPP. QC

split and replicate data was assessed using criteria taken from the USNRC Inspection Manual, Inspection Procedure 84750, Radioactive Waste Treatment and Effluent and Environmental Monitoring (Reference 26). A minimum of 5% of the sample and measurement locations used in the FSS design were selected randomly for QC evaluation using a random number generator.

Most soil split samples taken for FSS were field duplicates; that is, samples obtained from one location, homogenized, divided into separate containers, and treated as separate samples. QC split samples and replicate measurements were used to assess errors associated with sample/measurement heterogeneity, sample/measurement methodology, and analytical procedures. It is desirable that when analyzed, there is agreement between the split samples and replicate measurements to their respective standard sample or measurement, resulting in data acceptance. If there was no agreement, the FSS Supervisor or FSS Manager 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 FSS Supervisor or FSS Manager had determined that the discrepancy affected quality or was detrimental to the implementation of FSS, then a Condition Report (CR) would have been issued.

No CRs were issued as there was either an acceptable agreement between standard and replicate measurements in every Phase 3 survey unit or, if not, no further action was deemed necessary (i.e., replicate measurements were far below Operational DCGL). Results of QC replicate measurements are provided as attachments in each of the survey unit release records which are attached as appendices to this final report.

To maintain the quality of the FSS, isolation and control measures were implemented prior to, during, and upon completion of FSS until there was no risk of recontamination. Periodic surveillances were performed which consisted of an inspection of area postings, and an inspection of the area for signs of excavation, dumping, or disturbance. In the event that isolation and control measures were compromised, a follow-up survey may be performed after evaluation.

5 Survey Findings

Procedure LC-FS-PR-008, *Final Status Survey Data Assessment,* provides guidance to C/LT personnel to interpret survey results using the DQA process during the assessment phase of FSS activities. The DQA process is 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:

- Review the sample plan DQOs and the survey design.
- Conduct a preliminary data assessment.
- Select the statistical test.
- Verify the assumptions of the statistical test.
- 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 FSS QAPP.

5.1 Survey Data Conversion

During the data conversion, the FSS Supervisor or FSS Manager 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., dpm/100 cm^2) and calculating basic statistical quantities (e.g., mean, median, standard deviation). Table 5-1 provides a summary of the basic statistical properties in the Phase 3 systematic or random sample populations.

Table 5-1 Basic Statistical Properties of Phase 3 Systematic/Random Sample Populations

Survey Unit	Class	Samples	Radionuclide Statistical Summary (pCi/g)					
			Cs-137			Co-60		
			Max	Mean	Std. Dev.	Max	Mean	Std. Dev.
L1-010-101	1	14	1.02E-01	5.84E-02	3.14E-02	8.80E-02	3.50E-02	2.65E-02
L1-010-102	1	14	1.10E-01	4.74E-02	3.40E-02	7.11E-02	3.94E-02	2.21E-02
L1-010-103	1	14	1.77E-01	7.96E-02	4.20E-02	1.48E-01	6.68E-02	3.11E-02
L1-010-104	1	14	3.79E-01	8.50E-02	9.01E-02	7.52E-02	2.78E-02	2.54E-02
L1-010-105	1	14	1.25E-01	6.15E-02	3.24E-02	7.48E-02	4.06E-02	2.03E-02
L1-010-106	1	14	8.24E-02	5.00E-02	2.57E-02	5.85E-02	2.90E-02	2.14E-02
L1-010-107	1	14	1.53E-01	6.31E-02	3.77E-02	9.81E-02	5.04E-02	2.84E-02
L2-011-101	2	14	1.53E-01	6.39E-02	4.10E-02	8.98E-02	3.78E-02	2.58E-02
L2-011-104	2	14	9.98E-02	6.64E-02	2.25E-02	9.27E-02	4.40E-02	2.52E-02
L3-012-101	3	14	1.66E-01	7.42E-02	4.17E-02	1.40E-01	5.75E-02	3.39E-02
L3-012-109	3	14	1.99E-01	9.01E-02	4.69E-02	9.24E-02	3.68E-02	3.38E-02
L1-SUB-CDR	1	14	6.25E+00	1.24E+00	1.67E+00	3.42E-01	1.03E-01	7.88E-02
L1-SUB-TDS A	1	14	4.02E-01	1.35E-01	1.09E-01	1.41E-01	5.04E-02	4.12E-02
L1-SUB-TDS B	1	28	2.44E+01	1.32E+00	4.60E+00	1.49E-01	4.70E-02	3.77E-02

Table 5-2 provides a summary of the basic statistical properties for the Phase 3 judgmental and investigational sample populations.

Table 5-2 Basic Statistical Properties of Phase 3 Judgmental and Investigational Sample Populations

Survey Unit	Class	Samples	Radionuclide Statistical Summary (pCi/g)					
			Cs-137			Co-60		
			Max	Mean	Std. Dev.	Max	Mean	Std. Dev.
L1-010-101	1	3	8.15E-02	5.16E-02	2.59E-02	3.69E-02	2.19E-02	1.75E-02
L1-010-102	1	4	3.33E-01	1.38E-01	1.31E-01	7.95E-02	4.87E-02	2.39E-02
L1-010-103	1	3	6.18E-02	4.28E-02	1.88E-02	6.79E-02	4.20E-02	2.36E-02
L1-010-104	1	5	2.79E-01	1.24E-01	1.07E-01	9.41E-02	6.40E-02	2.40E-02
L1-010-105	1	4	7.42E-02	5.17E-02	1.88E-02	6.44E-02	4.41E-02	1.56E-02
L1-010-106	1	8	1.22E-01	5.78E-02	4.57E-02	1.44E-01	7.58E-02	4.10E-02
L1-010-107	1	9	1.17E-01	6.93E-02	3.82E-02	7.19E-02	2.69E-02	3.07E-02
L2-011-101	2	3	5.86E-02	5.13E-02	7.25E-03	8.65E-02	4.91E-02	4.39E-02
L2-011-104	2	10	5.76E-02	3.29E-02	2.26E-02	8.97E-02	3.98E-02	2.54E-02
L3-012-101	3	2	6.53E-02	5.67E-02	1.22E-02	6.99E-02	5.97E-02	1.44E-02
L3-012-109	3	28	2.76E-01	8.27E-02	7.39E-02	4.00E+02	1.43E+01	7.56E+01
L1-SUB-CDR	1	6	1.57E+00	7.89E-01	6.50E-01	8.11E-02	4.82E-02	3.53E-02
L1-SUB-TDS A	1	8	2.86E+00	8.20E-01	1.01E+00	1.55E-01	8.25E-02	4.13E-02
L1-SUB-TDS B	1	8	1.11E+01	2.73E+00	3.90E+00	1.51E-01	6.40E-02	4.72E-02

5.2 Survey Data Verification and Validation

Items supporting DQO sample design and data are reviewed for completeness and consistency. This includes:

- Classification history and related documents,
- Site description,
- Survey design and measurement locations,
- Analytic method and detection limits and that the required analytical method(s) are 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, is reviewed to verify completeness and that it is 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 are in standard units in relation to the DCGLs and requires the calculation of the statistical parameters needed to complete data evaluation 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 of 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

In all Phase 3 survey units combined, with the exception of L1-SUB-TDS B in which scan surveys were not performed, ninety-one (91) elevated scan readings resulted in the collection of fifty-three (53) investigation samples. This process was documented in accordance with LC-FS-PR-008, *Final Status Survey Data Assessment*. All investigational samples had a SOF of less than 1.0 when compared to the Operational DCGLs, and therefore, use of the area-weighted approach was not necessary. No investigational samples or measurements resulted in the remediation and/or reclassification of a survey unit.

No anomalies were identified in Phase 3 survey units during the FSS.

5.4 Evaluation of Number of Measurement Locations in Survey Units

An effective tool utilized to evaluate the number of samples collected in the sampling scheme is the Retrospective Power Curve generated by MARSSIM Power 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 sampling design had adequate power to pass the FSS release criteria (i.e., an adequate number of samples was collected).

5.5 Comparison of Findings with Derived Concentration Guideline Levels

As previously described in Section 2.4, the SOF or "unity rule" was applied to FSS data obtained in open land and sub-grade excavation survey units 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 Operational DCGL for each measurement by dividing the reported concentration by the Operational DCGL. Surrogate Operational DCGLs for Cs-137, which take into account the HTD radionuclide Sr-90, were calculated as part of the survey design for the FSS, but were only used to develop action levels. During data assessment, activities for Sr-90 were inferred based on the HTD ratio in Table 4-2 and compared to their respective DCGLs.

A Base Case SOF was calculated for each ROC by dividing the reported concentration by the Base Case DCGL. A Base Case SOF of one (1) is equivalent to the decision rule, meaning any measurement with a SOF of one (1) or greater, would not meet the 25 mrem/yr release criteria. The mean Base Case SOF was multiplied by 25 to establish the dose attributed to a survey unit.

The dose from elevated judgmental or investigational measurements (measurements exceeding SOF of 1 when compared to the Operational DCGL) is accounted for using an area-weighted approach. An area-weighted SOF is calculated and added to the average systematic measurement SOF. The product of this summation is then used to calculate the overall dose assigned to the survey unit. During the FSS of all Phase 3 survey units, no judgmental or investigational measurements exceeded the SOF of 1 when compared to the Operational DCGL.

The Elevated Measurement Comparison (EMC) was not required for the survey units addressed by this report.

A summary of the Mean Base Case SOF and dose contribution for each Phase 3 survey unit is provided in Table 5-3.

Table 5-3 Mean Base Case SOF and Dose Contribution

Survey Unit	Mean Base Case SOF	Dose (mrem/yr)
L1-010-101	0.0110	0.2751
L1-010-102	0.0095	0.2363
L1-010-103	0.0140	0.3393
L1-010-104	0.0110	0.2624
L1-010-105	0.0104	0.2609
L1-010-106	0.0104	0.2603
L1-010-107	0.0135	0.3377
L2-011-101	0.0124	0.3103

Survey Unit	Mean Base Case SOF	Dose (mrem/yr)
L2-011-104	0.0102	0.2557
L3-012-101	0.0148	0.3699
L3-012-109	0.0176	0.4389
L1-SUB-CDR	0.0408	1.0190
L1-SUB-TDS A	0.0141	0.3526
L1-SUB-TDS B	0.0385	0.9613

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 the LTP 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 FSS. Good housekeeping practices and properly executed isolation and control 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

According to NRC IR Nos. 05000409/2019001 (NNMS) (Reference 27), on October 21, 2019, the NRC completed inspection activities at LACBWR, which included the observation of FSS and confirmatory surveys of multiple survey units. The survey units included subsurface units L1-SUB-TDS A and L1-SUB-TDS B, open land units L1-010-101 through L1-010-107, L2-011-101 through L2-011-104, L3-012-101, and L3-012-109. No findings were identified during the inspections.

6 Overview of Existing Groundwater

LaCrosse*Solutions* has collected groundwater samples semiannually from 2014 through June 2018, then monthly from October 2018, through July 2019, from monitoring and supply wells. The analytical results are provided in LaCrosse*Solutions* letter, LC-2019-0042, *Request for No Further Action* (Reference 28) submitted to the Wisconsin Department of Natural

Resources (WDNR) on September 24, 2019. All monitoring and supply wells on site were abandoned with concurrence of the NRC via letter dated October 1, 2019, La Crosse Boiling Water Reactor – Acknowledgment of Discontinuation of Facility Groundwater Monitoring (Reference 29).

Section 6.21 of the LTP discusses the approach to calculating groundwater dose. Groundwater exposure factors were calculated for the ROCs and H-3 directly using the Federal Guidance Report (FGR) No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* (Reference 30) ingestion dose conversion factors and the assumed industrial worker AMCG drinking water intake rate of 327 L/year. The groundwater exposure factors are shown in Table 6-1.

Table 6-1 Exposure Factors for Groundwater Contamination

ROC	GW Exposure Factor (mrem/yr per pCi/L)
Co-60	8.8E-03
Cs-137	1.64E-02
Sr-90	4.64E-02
H-3	2.09E-05
Eu-152	2.12E-03
Eu-154	3.12E-03

The groundwater exposure factors will be multiplied by the maximum concentration (in units of pCi/L) from all groundwater sampling wells collectively for each positively identified ROC (including H-3) within the most recent two years of sampling. Additionally, per the NRC Safety Evaluation Report (SER) for the LTP dated May 21, 2019 (Reference 31), the potential dose from the radionuclides previously delegated as insignificant contributors must also be accounted for in demonstrating overall compliance.

During the June 2014 sampling campaign, H-3 and Sr-90 were detected; Carbon-14, Technecium-99, Europium-152, Plutonium-239 and 240, and Americium-241 were also positively detected at low concentrations in several wells. The results for the June 2014 sampling event are shown in Table 2-19 of the LTP and Table 1 of LC-2019-0042. The maximum dose rate calculated, using the FGR-11 ingestion dose conversion factors, from the identified positive detections in the June 2014 groundwater sampling event was 0.471 mrem/yr. The assigned total dose from groundwater of 3.25 mrem in TSD LC-FS-TSD-002, *Operational DCGLs for FSS*, corresponding to a total dose from groundwater of 3.25 mrem/yr. Although the June 2014 groundwater sampling event is outside the two-year window for inclusion in the dose summation for compliance, LaCrosse*Solutions* has conservatively reduced the 3.25 mrem/yr by 0.471 mrem/yr thus yielding a remaining allowable dose rate for groundwater of 2.779 mrem/yr.

On March 12, 2018, LaCrosse*Solutions* notified the NRC regarding the detection of tritium above background levels in site groundwater wells. The tritium in the groundwater is believed to be associated with exhaust from ventilation systems, employed during decontamination and demolition activities with the Reactor Building. The exhaust impacted ice/snow melt on frozen ground existing approximately four feet below the exhaust point. During rain events, the impacted ice/snow flowed from its location below the ventilation discharge point at the southeast side of the Reactor Building, across the ground surface into the former RPGPA sump, located southwest of the Reactor Building. The lowest point of the excavation at the RPGPA sump is below the water table and the excavation had been kept open by the placement of a trench box. The bottom of the former RPGPA sump area is therefore in direct communication with the shallow aquifer and is likely the point source for the resulting groundwater plume. The RPGPA sump is located upgradient from the MW-203A and MW-203B monitoring well pair.

The maximum groundwater tritium level identified during this event was 24,200 pCi/L obtained in Monitoring Well MW-203A associated with the detection of H-3. This equates to a dose rate of 0.506 mrem/yr using the exposure factors for groundwater in Table 6-1. However, as stated in Section 3.7.8.2 of the SER, based on the NRC staff's judgment and experience, for the purpose of estimating a maximum H-3 concentration, a dilution factor of two is considered bounding for the contaminated surface water (at a concentration of 237,000 pCi/L of H-3) mixing with the groundwater in the highly permeable sediments of the site with the observed groundwater gradients. As previously stated, the LTP allotted a remaining radiological dose of 2.779 mrem/yr (of the 3.25 mrem/yr total dose rate for groundwater) for the hypothetical maximum allowable H-3 concentration in groundwater, which corresponds to 110,000 pCi/L of H-3. The NRC staff considered 110,000 pCi/L of H-3 sufficiently close to half the source concentration and as such, the NRC concluded that the use of an estimated value of H-3 concentration of 110,000 pCi/L is sufficient to demonstrate compliance. This equates to a dose rate of 2.299 mrem/yr using the exposure factors for groundwater in Table 6-1. The total dose rate for existing groundwater is 2.779 mrem/yr.

On May 9, 2018 the NRC provided request for additional information (RAI) ENVIRO-26, related to groundwater. Additional details related to this event are provided in LaCrosse*Solutions* letter, LC-2018-0075 which is the LaCrosse*Solutions* response to RAI ENVIRO-26 that was submitted to NRC on November 15, 2018 (Reference 32).

7 Dose Summation for Compliance

Each radionuclide-specific Base Case DCGL is equivalent to the level of residual radioactivity (above background levels) that could, when considered independently, result in a TEDE of 25 mrem per year to the AMCG. Compliance is demonstrated through the summation of the dose from each of the ROCs in each of the five media (basement concrete, soil, buried pipe, above grade buildings and existing groundwater). Dose summation for compliance is discussed in further detail in Sections 6.5.6 and 6.22 of the LTP.

7.1 Demonstrating Compliance with Dose Criterion

The compliance dose will be calculated using Equation 6-11 in the LTP after FSS has been completed in all survey units. The equation is replicated below as Equation 3 to this report.

Equation 3

Compliance Dose = (Max $BcSOF_{BASEMENT}$ + Max $BcSOF_{SOIL}$ + Max $BcSOF_{BURIED\ PIPE}$ + $BcSOF_{AG\ BUILDING}$ + GW $BcSOF_{BS\ OB}$ + GW $BcSOF_{BPS\ OBP}$ + Max SOF_{EGW}) x 25 mrem/yr

where:

Compliance Dose = must be less than or equal to 25 mrem/yr,

Max $BcSOF_{BASEMENT}$ = Maximum BcSOF (mean of FSS systematic results plus the dose from any identified elevated areas) for backfilled Basements,

Max $BcSOF_{SOIL}$ = Maximum BcSOF (mean of FSS systematic results plus the dose from any identified elevated areas) for open land survey units,

Max $BcSOF_{BURIED\ PIPE}$ = Maximum BcSOF (mean of FSS systematic results plus the dose from any identified elevated areas) from buried piping survey units,

Max $BcSOF_{AG\ BUILDING}$ = Maximum BcSOF (mean of FSS systematic results plus the dose from any identified elevated areas) from above grade standing building survey units,

GW $BcSOF_{BS\ OB}$ = Groundwater scenario dose from the “Other Basement” (OB) which is defined as the basement not used to generate the Max $BcSOF_{BASEMENT}$ term in Equation 3

GW $BcSOF_{BPS\ OBP}$ = Groundwater scenario dose from the “Other Buried Pipe” (OBP) which is defined as the buried pipe survey unit not used to generate the Max $BcSOF_{BURIED\ PIPE}$ term in Equation 3

Max SOF_{EGW} = Maximum SOF from existing groundwater (EGW)

The release records for all survey units have been reviewed to determine the maximum mean dose from each of the five source terms. The compliance dose must be less than or equal to 25 mrem/yr. Tables 7-1 through 7-5 list the survey units in each source term along with their respective Base Case SOF and dose. The highest Base Case SOF and Dose in each source term is highlighted.

Table 7-1 Mean Base Case SOF and Dose Contribution for Basements

Survey Unit	Mean Base Case SOF	Dose (mrem/yr)
B1-010-004	**0.0233**	**0.5813**
B1-010-001	0.0006	0.015

Table 7-2 Mean Base Case SOF and Dose Contribution for Soil

Survey Unit	Mean Base Case SOF	Dose (mrem/yr)
L1-010-101	0.0110	0.2751
L1-010-101C	0.0144	0.3597
L1-010-102	0.0095	0.2363
L1-010-103	0.0140	0.3393
L1-010-104	0.0110	0.2624
L1-010-105	0.0104	0.2609
L1-010-106	0.0104	0.2603
L1-010-107	0.0135	0.3377
L2-011-101	0.0124	0.3103
L2-011-102	0.0095	0.2368
L2-011-103	0.0097	0.2416
L2-011-104	0.0102	0.2557
L3-012-101	0.0148	0.3699
L3-012-102	0.009	0.2247
L3-012-109	0.0176	0.4389
L1-SUB-CDR	**0.0408**	**1.0190**
L1-SUB-TDS A	0.0141	0.3526
L1-SUB-TDS B	0.0385	0.9613
L1-SUB-DRS	0.0105	0.262
L1-SUB-TDS	0.0125	0.3115
L1-SUB-LES	0.01	0.2495

Table 7-3 Mean Base Case SOF and Dose Contribution for Buried Pipe

Survey Unit	Mean Base Case SOF	Dose (mrem/yr)
S1-011-102	0.0012	0.0299
S2-011-103 A	0.0126	0.3144
S2-011-103 B	0.0120	0.3006
S2-011-103	0.0240	0.6010
S3-012-109 A	**0.1204**	**3.0112**
S3-012-109 B	0.0213	0.5317
S2-011-101 A	0.0696	1.7407
S2-011-101 B	0.0586	1.4645
S3-012-102 A	0.0028	0.0712
S3-012-102 B	0.0645	1.6121

Table 7-4 Mean Base Case SOF and Dose Contribution for Above Grade Buildings

Survey Unit	Mean Base Case SOF	Dose (mrem/yr)
B2-010-101	**0.0202**	**0.5055**
B2-010-102	0.0128	0.3197
B2-010-103	0.0057	0.1426
B3-012-101	0.0122	0.3038
B3-012-102	0.0028	0.0711
B3-012-103	0.0136	0.3409
B3-012-104	0.0010	0.0239
B3-012-109	0.0022	0.0541

Table 7-5 Maximum SOF and Dose Contribution for Existing Groundwater

Survey Unit	Maximum SOF	Dose (mrem/yr)
2014	0.0188	0.4710
2018/2019	0.0920	2.299
Total EGW	**0.1108**	**2.779**

Demonstrating compliance with the dose criterion requires the summation of dose from the five media as shown in Equation 3. Note that there are five media but seven dose terms in Equation 1. The GW $BcSOF_{BS\ OB}$ term is calculated using the FSS results from the basement media. The GW $BcSOF_{BPS\ OBP}$ term is calculated using the FSS results from the buried pipe media.

7.1.1 GW $BcSOF_{BS\ OB}$

The GW $BcSOF_{BS\ OB}$ is the Groundwater Basement Scenario dose from the "Other Basement" which is defined as the basement that is not used to calculate the MAX $BcSOF_{BASEMENT}$ in Equation 3. Because the mean of the FSS data from the WGTV is higher than the mean of the FSS data from the Reactor Building, the WGTV mean was used to calculate the MAX $BcSOF_{BASEMENT}$ in Equation 3. The Reactor Building therefore has been designated as the "Other Basement."

The dose modeling for the basements includes three scenarios; groundwater, drilling spoils, and excavation. DCGLs are calculated for each scenario separately ($DCGL_{BS}$) and for the summation of dose from all scenarios ($DCGL_B$). The $DCGL_{BS}$ for the drilling spoils and the excavation scenarios are equal for the Reactor Building and WGTV. The MAX $BcSOF_{BASEMENT}$ term therefore maximizes the drilling spoils and excavation pathways for both basements.

The GW $DCGL_{BS}$ for the Reactor Building and WGTV are not equal due to geometry considerations. Each basement was modeled as a separate source term. Conceptually, the modeled groundwater concentrations from the two basements could mix at a location downstream of both basements in such a way as to increase the concentration that would result from each basement separately. To conservatively account for this conceptual possibility, the groundwater pathway dose from the "Other Basement" will be added to the Compliance Dose (Equation 3) through the GW $BcSOF_{BS\ OB}$ term.

GW $BcSOF_{BS\ OB}$ will be calculated for the basement wall and floor surface survey unit of the "Other Basement" in accordance with Equation 4.

Equation 4

$$GW\ BcSOF_{BS\ OB} = \sum_{i=1}^{n} \frac{Mean\ Conc_{OB\ ROC_i}}{Base\ Case\ Basement\ Scenario\ GW\ DCGL_{BS\ OB\ ROC_i}}$$

where:

$GW\ BcSOF_{BS\ OB}$ = SOF for the groundwater pathway only from the structural surface survey unit in the "Other Basement" using Base Case DCGLs applicable to the groundwater scenario only

$Mean\ Conc_{OB\ ROC_i}$ = Mean concentration for the systematic measurements taken in the "Other Basement" during the FSS of the structural surface in survey unit for ROC_i

$GW\ DCGL_{BS\ OB\ ROC_i}$ = Base Case DCGL for Basement Scenario Groundwater in the "Other Basement" for ROC_i

The Groundwater Basement Scenario dose from the "Other Basement" (Reactor Building) is presented in Table 7-6.

Table 7-6 Groundwater Scenario Dose from the "Other Basement"

Survey Unit	GW $BcSOF_{BS\ OB}$	Dose (mrem/yr)
B1-010-001	0.0001	0.0025

7.1.2 GW $BcSOF_{BPS\ OBP}$

Each buried pipe was modeled as a separate source term. Conceptually, the modeled groundwater concentrations from the two buried pipe survey units could mix at a location downstream of both survey units in such a way as to increase the concentration, and corresponding dose, that would result from each basement separately. To conservatively account for this conceptual possibility, the groundwater pathway dose from the "Other Buried Pipe" was added to the Compliance Dose calculation (Equation 3) through the GW $BcSOF_{BPS\ OBP}$ term.

The GW $B_CSOF_{BPS\ OBP}$ is the dose from the Groundwater Buried Pipe Scenario (designated as "Insitu" in LTP Table 6-37) from the "Other Buried Pipe" (OBP) which is defined as the buried pipe survey unit that is not used to calculate the MAX $_{BC}SOF_{BURIED\ PIPE}$ term in Equation 3. For example, if the mean of the FSS data from the buried pipe "Group" survey unit is higher than the mean of the FSS data from the buried pipe "Circulating Water Discharge Pipe" survey unit, then the "Group" survey unit FSS mean will be used to calculate the Max $BcSOF_{BURIED\ PIPE}$ term in Equation 3. The "Circulating Water Discharge Pipe" would therefore be assigned as the "Other Buried Pipe." However, the buried pipe "Group" original survey unit was broken into nine separate survey units, and a survey unit within the buried pipe "Group" had the highest Max SOF_{EGW} of the FSS data for all buried pipe (survey unit S3-012-109A). To alleviate any confusion, the GW $B_CSOF_{BPS\ OBP}$ will be calculated using both the mean of FSS data for the survey unit within the buried pipe "Group" that has the next highest Max SOF_{EGW} (S2-011-101 A), and the FSS data from the "Circulating Water Discharge Pipe." As a conservative measure, the higher dose of the two (survey unit S2-011-101A) will be used as the GW $B_CSOF_{BPS\ OBP}$ in Equation 3.

The dose modeling for the buried pipe includes two scenarios, Insitu (i.e., groundwater) and Excavation. Buried Pipe DCGLs are calculated for each scenario separately ($DCGL_{BPS}$) and for the summation of dose from both scenarios ($DCGL_{BP}$).

GW $BcSOF_{BPS\ OBP}$ will be derived for the "Other Buried Pipe" survey unit in accordance with Equation 5.

Equation 5

$$GW\ BcSOF_{BPS\ OBP} = \sum_{i=1}^{n} \frac{Mean\ Conc_{OBP\ ROC_i}}{Base\ Case\ Buried\ Pipe\ Scenario\ GW\ DCGL_{BPS\ OBP\ ROC_i}}$$

where:

$GW\ BcSOF_{BPS\ OBP}$ = SOF for the groundwater pathway only from the survey unit in the "Other Buried Pipe" using Base Case $DCGL_{BS}$ applicable to the groundwater scenario only (i.e., Insitu).

$Mean\ Conc_{OBP\ ROCi}$ = Mean concentration for the systematic measurements taken in the "Other Buried Pipe" during the FSS of the survey unit for ROC_i

$GW\ DCGL_{BPS\ OBP\ ROCi}$ = Base Case $DCGL_{BPS}$ for groundwater scenario ("Insitu" in LTP Table 6-37) in the "Other Buried Pipe" for ROC_i

The Groundwater Buried Pipe Scenario dose from the "Other Buried Pipe" is presented in Table 7-7.

Table 7-7 Groundwater Scenario Dose from the "Other Buried Pipe"

Survey Unit	GW $BcSOF_{BPS\ OBP}$	Dose (mrem/yr)
S1-011-102 (CWD)	0.0002	0.0050
S2-011-101A	0.0138	0.345

7.2 Final Dose Summation for Compliance

The results of the final compliance dose have been calculated using Equation 3 using the maximum SOF for the five media and the two groundwater scenarios and are presented in Tables 7-1 through 7-7. The final dose summation is presented in Table 7-8.

Table 7-8 Final Dose Summation

Source	Base Case SOF	Dose (mrem/yr)
Max $BcSOF_{BASEMENT}$	0.0233	0.5813
Max $BcSOF_{SOIL}$	0.0408	1.0190
Max $BcSOF_{BURIED\ PIPE}$	0.1204	3.0112
Max $BcSOF_{AG\ BUILDING}$	0.0202	0.5055
Max SOF_{EGW}	0.1108	2.770
GW $BcSOF_{BS\ OB}$	0.0001	0.0025
GW $BcSOF_{BPS\ OBP}$	0.0138	0.345
TOTAL	**0.3294**	**8.2345**

8 Summary

FSS is the process used to demonstrate that the LACBWR open land and sub-grade excavation soils comply with the radiological criteria for unrestricted use specified in 10 CFR 20.1402. 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 10 CFR 20.1402 are: 1) the residual radioactivity that is distinguishable from background radiation results in a TEDE to an AMCG that does not exceed 25 mrem/yr, including that from groundwater sources of drinking water, and 2) the residual radioactivity has been reduced to levels that are ALARA.

The survey units 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, and a Retrospective Power Curve showed that adequate power was achieved. Each of the survey units were properly classified. In accordance with the LTP Section 5.10, all the Phase 3 survey units meet the release criterion.

Additionally, the dose summation for compliance was determined in accordance with Sections 6.5.6 and 6.22 of the LTP and LC-FS-TSD-002. The dose applied to the LACBWR site is 8.2345 mrem/yr which meets the release criterion as established in 10 CFR 20.1402. The FSS results provided in the Phase 1, Phase 2 and Phase 3 Final Reports demonstrate that any residual radioactivity within the LACBWR site results in a TEDE to an AMCG that does not exceed 25 mrem/yr and that the residual radioactivity has been reduced to levels that are ALARA.

9 References

1. *La Crosse Boiling Water Reactor License Termination Plan*
2. NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM)
3. LC-QA-PN-001, *Final Status Survey Quality Assurance Project Plan*
4. LC-FS-PR-002, *Final Status Survey Package Development*
5. LC-FS-PR-010, *Isolation and Control for Final Status Survey*
6. LC-FS-PR-008, *Final Status Survey Data Assessment*
7. NUREG-1757, Vol. 2, *Consolidated Decommissioning Guidance - Characterization, Survey, and Determination of Radiological Criteria*
8. LC-FS-PR-009, *Final Status Survey Data Reporting*
9. RS-TD-313196-003, *La Crosse Boiling Water Reactor Historical Site Assessment*
10. RS-TD-313196-001, *Radionuclides of Concern During LACBWR Decommissioning*
11. LC-FS-TSD-004, *Dose Assessment of Post-Remediation Subsurface Geometry of Survey Unit L1-SUB-TDS B (including RPGPA Sump)*
12. RS-TD-313196-004, *LACBWR Soil DCGL, Basement Concrete DCGL, and Buried Pipe DCGL*
13. LC-FS-TSD-002, *Operational Derived Concentration Guideline Levels for Final Status Survey*
14. LC-RP-PG-003, *Radiological Instrumentation Program*
15. LC-RP-PR-060, *Calibration and Initial Set Up of the 2350-1*
16. LC-FS-PR-004, *Sample Media Collection for Site Characterization and Final Status Survey*
17. LC-FS-PR-005, *Sample Media Preparation for Site Characterization and Final Status Survey*
18. LC-FS-PR-012, *Chain of Custody Protocol*
19. LC-FS-PN-002, *Characterization Survey Plan*
20. GG-EO-313196-RS-RP-001, *LACBWR Radiological Characterization Survey Report for October and November 2014 Field Work – November 2015*
21. LC-FS-PR-017, *Unconditional Release of M&E and Secondary Structures*
22. LC-FS-PR-006, *Survey Unit Classification*

23. ISO 7503-1, Part 1, *Evaluation of Surface Contamination, Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters*
24. NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*
25. RS-TD-313196-006, *Ludlum Model 44-10 Detector Sensitivity*
26. Inspection Manual, Inspection Procedure 84750, *Radioactive Waste Treatment and Effluent and Environmental Monitoring*
27. NRC Inspection Report 05000409/2019001 (DNMS)
28. LC-2019-0042, Request for No Further Action, letter to WDNR dated September 24, 2019
29. NRC letter to John Sauger, La Crosse Boiling Water Reactor – Acknowledgment of Discontinuation of Facility Groundwater Monitoring, October 1, 2019
30. Federal Guidance Report No. 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*
31. NRC Safety Evaluation Report, *Approval of the License Termination Plan, La Crosse Boiling Water Reactor,* May 21, 2019
32. LC-2018-0075, Response to RAI ENVIRO-26, letter to NRC dated November 15, 2018

10 Appendices

A1 FSS Release Record, Survey Unit L1-010-101

A2 FSS Release Record, Survey Unit L1-010-102

A3 FSS Release Record, Survey Unit L1-010-103

A4 FSS Release Record, Survey Unit L1-010-104

A5 FSS Release Record, Survey Unit L1-010-105

A6 FSS Release Record, Survey Unit L1-010-106

A7 FSS Release Record, Survey Unit L1-010-107

A8 FSS Release Record, Survey Unit L2-011-101

A9 FSS Release Record, Survey Unit L2-011-104

A10 FSS Release Record, Survey Unit L3-012-101

A11 FSS Release Record, Survey Unit L3-012-109

A12 FSS Release Record, Survey Unit L1-SUB-CDR

A13 FSS Release Record, Survey Unit L1-SUB-TDS A

A14 FSS Release Record, Survey Unit L1-SUB-TDS B