LACROSSE SOLUTIONS

LACBWR Site Restoration Project

Final Radiation Survey Data Assessment

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1. PURPOSE AND SCOPE

1.1. Purpose

This procedure provides guidance to interpret survey results using the Data Quality Assessment (DQA) process during the assessment phase of Final Radiation Survey (FRS) at the La Crosse Station Restoration Project (LSRP). Because of differences in the conceptual models and required source terms, the FRS includes two different approaches depending on the media; (1) Final Status Survey (FSS) is conducted on soil, buried piping and groundwater to demonstrate that residual radionuclide concentrations are equal to or below site-specific Derived Concentration Guideline Levels (DCGL), and (2) a "Source Term Survey" (STS) is conducted to demonstrate that the inventory of residual radioactivity in building basements, embedded piping and penetrations is below a source term inventory commensurate with the dose criterion in 10 CFR 20.1402.

The term "FRS" is used in this procedure to represent both the FSS and STS surveys. When the discussion applies to only one of the survey methods, either FSS or STS is referenced.

1.2. Scope

This procedure implements the requirements of applicable U.S. Nuclear Regulatory Commission (NRC) regulations and guidance documents; specifically, NUREG-1757, Volume 2, Revision 1 "*Consolidated Decommissioning Guidance - , Survey, and Determination of Radiological Criteria"* (Reference 2.1), NUREG-1575, "*Multi-Agency Radiation Survey and Site Investigation Manual"* (MARSSIM, Reference 2.2) and Chapter 5 of the LCSRP "*License Termination Plan*" (LTP) (Reference 2.4).

This procedure applies to all persons involved with the receipt, management, storage and conversion of data collected in support of FRS. The data to be received and processed includes direct download data from instrumentation, counting instrument reports, instrument control and calibration databases, field survey records and other manual entry data. Data processing includes converting measurement data into reporting units, validating instrument applicability and sensitivity, calculating relevant statistical quantities, and verification that all Data Quality Objectives (DQO) have been met. Following data validation, processing, reduction and evaluation, a release record will be generated in accordance with procedure LC-FS-PR-009, *"Final Radiation Survey Data Reporting"* (Reference 2.5).

2. REFERENCES

2.1. NUREG-1757, "Consolidated NMSS Decommissioning Guidance - , Survey, and Determination of Radiological Criteria" Volume 2, Revision 1 – September 2002

2.2. NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) – August 2000

2.3. LC-AD-PR-004, "Corrective Action Program"

2.4. "La Crosse Station Restoration Project License Termination Plan" – December 2014

2.5. LC-FS-PR-009, "Final Radiation Survey Data Reporting"

2.6. LC-QA-PN-001, " Final Radiation Survey Quality Assurance Project Plan"

2.7. LC-FS-PR-006, "Survey Unit Classification"

2.8. LC-FS-PR-010, "Isolation and Control for Final Radiation Survey"

2.9. LC-FS-PR-002, "Final Radiation Survey Package Development"

2.10. LaCrosse*Solutions* Technical Support Document RS-TD-313196-001, "Radionuclides of Concern for Soil and Basement Fill Model Source Terms" – December 2015

3. GENERAL

3.1. Responsibilities

3.1.1 Radiation Protection (RP)/ FRS Manager – is responsible for:

- Providing overall technical support for the review, validation and interpretation of FRS results and analysis.
- Reviewing and approving the conclusions reached for the survey unit from the assessment of the survey data.
- Ensuring the conclusions from FRS are appropriately documented and technically defensible.

3.1.2 FRS Supervisor – is responsible for:

- Ensuring the survey data taken for FRS is authentic and of sufficient quality.
- Ensuring all required surveys have been performed and documented in accordance with the FRS Sample Plan for the survey unit.
- The evaluation of FRS data & results using the DQA process.

3.1.3 Graphics/GPS Specialist – is responsible for:

- Preparing survey maps, layout diagrams, composite view drawings and other graphics as necessary to support FRS data analysis.

3.1.4 Final Radiation Survey (FRS) Technician(s) – are responsible for:

- Obtaining and documenting survey measurements and samples in accordance with the FRS Sample Plans and all applicable procedures.

3.2. Definitions

3.2.1 **Basement Dose Factors** – For basements/structures below 636 foot elevation, building-specific Basement Dose Factors were calculated in units of mrem/yr per mCi. The total inventory remaining for each Radionuclide-of-Concern (ROC) will be multiplied by the Basement Dose Factors for each radionuclide to calculate the actual dose from the remaining basement source term. These Basement Dose Factors are radionuclide-specific values that are determined for each ROC.

3.2.2 **Basement Inventory Levels (BIL)** – For basements/structures below 636 foot elevation, the Basement Dose Factors were used to calculate a hypothetical maximum inventory level for each ROC in each basement. These calculated values, which are designated as Basement Inventory Levels (BIL), are used during STS design to determine a reasonable areal coverage based upon the theoretical potential of exceeding the inventory level based upon survey data. The BIL do not represent the inventory levels expected to remain at license termination.

3.2.3 **Derived Concentration Guideline Level (DCGL)** – A derived, radionuclide specific activity concentration within a survey unit corresponding to the release criterion. The $DCGL_W$ (the DCGL used for the statistical tests) is based on an average concentration over a large area. The $DCGL_{EMC}$ (the DCGL used for the elevated measurement comparison) is derived separately for small areas of elevated activity.

3.2.4 **Elevated Measurement Comparison (EMC)** – A comparison of measured values against the $DCGL_W$ modified to account for small areas where residual radioactivity levels exceed the $DCGL_W$. The modified DCGL ($DCGL_{EMC}$) is the acceptable level of residual radioactivity over a small but defined area which meets the site release criterion.

3.2.5 **Final Radiation Survey (FRS)** – Measurements and sampling to describe the radiological conditions of a site, following completion of decontamination activities (if any) in preparation for release.

3.2.6 **Final Status Survey (FSS)** – FRS conducted on soil, buried piping and groundwater to demonstrate that residual radionuclide concentrations are equal to or below site-specific DCGLs.

3.2.7 **Frequency Plot** – A bar chart of the number of data points within a certain range of values. The frequency plot may reveal any obvious departures from symmetry, such as skewness or bimodality (two peaks), in the data distributions for survey units or background reference areas.

3.2.8 **Investigation Level** – A level of radioactivity that is based on the survey unit classification and the $DCGL_W$ which, if exceeded, initiates an investigation of the survey measurement.

3.2.9 **Mean** – The average value of the data set, obtained when the sum of the individual measurements is divided by the number of measurements.

3.2.10 **Median** – The center of the data set when data points are ranked in order from smallest to largest. The median is the center data point if the data set contains an odd number of values or the average of the two center data points if the data set contains an even number of values.

3.2.11 **Minimum Detectable Concentration (MDC)** – An *a priori* radioactivity level that a specific instrument and technique can be expected to detect 95% of the time.

3.2.12 **Outlier** – A measurement that is unusually large or small relative to the rest and therefore is suspected of misrepresenting the population from which it was collected.

3.2.13 **Posting Plot** – A map of the survey unit with the data values entered at the measurement locations. The posting plot can reveal spatial non-homogeneities in the survey unit such as patches of elevated residual radioactivity or groupings of measurements that exceed the $DCGL_W$.

3.2.14 **Quantile Plot** – A plot used to diagnose asymmetry in a data set. A quantile plot is constructed by ranking the data from smallest to largest. Each data value is plotted against the percentage of the data set with that value or less.

3.2.15 **Range** – The measure of the difference between the largest and smallest values in the data set.

3.2.16 **Sign Test** – A nonparametric statistical test used to demonstrate compliance with the site release criterion when the radionuclide of interest is not present in background or constitutes a small fraction of the $DCGL_W$.

3.2.17 **Source Term Survey (STS)** – FRS conducted to demonstrate that the inventory of residual radioactivity in building basements, embedded piping and penetrations is below a source term inventory commensurate with the dose criterion in 10 CFR 20.1402.

3.2.18 **Standard Deviation** – The measure of the variability around the mean of the data set.

3.2.19 **Unity Rule** – A rule applied when more than one radionuclide is present at a concentration that is distinguishable from background and where a single concentration comparison is not applied.

3.3. Acronyms

AF	Area Factor
BIL	Basement Inventory Level
FRS	Final Radiation Survey
LT	License Termination
CoC	Chain-of-Custody
DCGL	Derived Concentration Guideline Level
DQA	Data Quality Assessment
DQO	Data Quality Objectives
EMC	Elevated Measurement Comparison
FOV	Field of View
FRS	Final Radiation Survey
FSS	Final Status Survey
HTD	Hard-to-Detect
ISOCS	*In-Situ* Object Counting System
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
NIST	National Institute of Standards and Technology

NRC	US Nuclear Regulatory Commission
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
ROC	Radionuclides-of-Concern
SOF	Sum-of-Fractions
STS	Source Term Survey
TSD	Technical Support Document
LCSRP	LaCrosse Station Restoration Project

3.4. Precautions, Limitations, and Prererequisites

3.4.1 Precautions

1.) Documents and databases containing FRS data are Quality Assurance (QA) records when complete. Positive control of this data shall be maintained in accordance with section 2.5.2 of LC-QA-PN-001 *" Final Radiation Survey Quality Assurance Project Plan"* (Reference 2.6).

2.) When documenting survey information, all personnel shall ensure that all QA records are of good quality and legible. Legibility is determined to be readable and reproducible.

3.) Direct access to FRS data shall be limited to personnel authorized by the RP FRS Manager.

4.) When assessing STS results, if the potential dose from the activity concentration of the identified plant-derived gamma-emitting radionuclide exceeds 10% of the dose limit (2.5 mrem/yr), then additional concrete samples shall be acquired and analyzed for the presence of Hard-to-Detect (HTD) radionuclides. If the analysis of the additional samples indicates a radionuclide distribution significantly different than the normalized mixture fractions presented in Attachment 1, then the new mixture fractions will be derived, documented and applied to the effected STS unit.

5.) If surveys indicate the presence of gamma-emitting radionuclides at concentrations greater than 50% of a DCGL in soils or buried pipe, then the samples shall be analyzed for the presence of HTD radionuclides.

6.) When assessing STS results, verify that no plant-derived gamma emitting radionuclides other than the dose-significant ROC from Table 6-3 of LTP Chapter 6 were identified at concentrations greater than MDC. If a plant-derived gamma emitting other than the ROC were identified at concentrations greater than MDC, then perform an investigation to assess the dose significance of the identified radionuclide.

7.) The total mean dose inventory in each basement, considering all STS units contained within the basement, must be below 25 mrem/yr. If a basement has multiple STS units then the sum of the mean inventory fractions (total mean dose for the survey unit divided by the dose criterion of 25 mrem/yr) for each STS unit contained within the basement must be less than one. If the sum exceeds one, then an investigation will be performed which may result in the acquisition of additional measurements, the reclassification of STS units, or additional remediation. If the sum exceeds 0.5, then an investigation will be performed to provide additional assurance that the 25 mrem/yr dose criterion is met with 95% confidence.

8.) When assessing FSS results, if the analysis of a surface soil sample, or the results of a surface gamma scan indicates the potential presence of residual radioactivity at a concentration of 75% of the surface $DCGL_w$, then additional biased subsurface soil sample(s) shall be taken to the appropriate depth within the area of concern as part of the investigation.

9.) Remediation, Reclassification, and Resurvey

A. Re-classification of a survey unit from a less restrictive classification to a more restrictive classification shall be performed in accordance with procedure LC-FS-PR-006, *"Survey Unit Classification"* (Reference 2.7).

B. A survey unit may not be reclassified to a lesser classification (e.g. from a Class 1 to a Class 2 or from a Class 2 to a Class 3) without RP FRS Manager approval.

C. The decision to separate out and reclassify a new survey unit due to the presence of elevated residual radioactivity with the remainder of the original survey unit retaining its original classification should consider the following;

i. The assumptions made as to how the original survey unit was classified.

ii. The postulated cause of the elevated residual radioactivity.

D. The possibility for other similar areas within the original survey unit having gone undetected.

E. The extent of the elevated residual radioactivity (and corresponding remediation) relative to the total area of the original survey unit.

3.4.2 Limitations

1.) Data accepted as the FRS of record shall be reviewed to verify they are authentic, appropriately documented, and technically defensible.

2.) Survey data may be accepted as FRS data provided the following requirements are met:

A. Methodology, techniques, and quality controls required for the FRS have been applied and achieved.

B. No further remediation will be performed in the survey unit or, if remediation is performed, then the remediation that occurs will be localized in nature, all resultant contamination material will be controlled, and the area impacted by the remediation activity will be re-scanned.

C. Isolation and control measures have been implemented and maintained in accordance with procedure LC-FS-PR-010*, "Isolation and Control for Final Radiation Survey"* (Reference 2.8).

3.) Use of Graphics for Data Evaluation

A. A frequency plot is useful where anomalies in the data are encountered or where the data distribution is otherwise suspected to depart from symmetry.

B. A posting plot and histogram can be useful as part of an investigation survey where one or more direct measurements or volumetric samples exceed the DCGL.

C. Other graphical data representation tools may be used, as appropriate, to examine the general shape of the data distribution or to identify spatial patterns, relationships, or potential anomalies in the data that might go unnoticed using purely numerical methods.

3.4.3 Prerequisites

1.) Programs developed to assist in calculating FRS data (i.e. Excel spreadsheets) shall be tested to verify and validate that the calculations are correct before they are used.

2.) Any field copies of data collection forms generated in support of FRS implementation shall be filed with the applicable survey package.

3.5. Records

3.5.1 Attachment 10, “Final Radiation Survey Data Quality Objectives Review Checklist”

3.5.2 Attachment 11, “FSS Preliminary Survey Data Summary”

3.5.3 Attachment 12, STS Preliminary Survey Data Summary”

3.5.4 Attachment 13, “Sign Statistical Test”

3.5.5 Attachment 14, Final Radiation Survey Investigation”

3.5.6 ATTACHMENT 14, “Corrective Actions for Final Radiation Survey Failure”

3.5.7 Attachment 16, STS Survey Plan Closeout

3.5.8 Attachment 17, FSS Survey Plan Closeout

4. PEOCEDURE

4.1. Data Validation

4.1.1 Ensure that the survey area and survey unit for which the data is relevant is clearly marked on the data report.

4.1.2 Perform a validation of the survey data to ensure the data results are authentic, realistic and valid. Assess each specific sample or measurement result individually. Data validation includes the following;

1.) Verify that the unique sample identification number for each sample or measurement is consistent between the sample analysis report, the Chain-of-Custody (CoC) form, the FRS Sample Plan and/or the survey instructions.

2.) Verify that the recorded sample date & time for each sample or measurement is consistent with the CoC form (if applicable) and the survey record.

3.) Verify that the data is complete and that there are no missing results or supporting data, including but not limited to MDC, uncertainty, background, or methods of analysis.

4.) Verify that the MDC of the instrument used for analysis was adequate to detect all ROC or gross activity at the target MDC values specified in the FRS Sample Plan for that survey unit.

5.) Verify the absence of anomalies in the sample or measurement results, or in the supporting data, including but not limited to MDC, uncertainty, deviation from established procedure or analysis flags.

6.) For data collected with a data logging instrument, verify the data has been downloaded with a unique file name.

4.1.3 For the assessment of open land or buried pipe survey units, present survey data results in units appropriate for comparison to the DCGL. As applicable, convert the units for the reported data to the DCGL units by correcting for survey instrument background, efficiency, geometry, detector area, and/or measurement size.

NOTE

The Canberra *In-Situ* Object Counting System (ISOCS) has been selected as the primary instrument that will be used to perform STS.

4.1.4 For the assessment of STS units, present the survey data in units of activity per m^2 for each gamma-emitting ROC. As applicable, convert the units for the reported data to activity by correcting for survey instrument efficiency and geometry.

4.1.5 Indicate the analysis or measurement results has been validated by signing, dating and entering the time on the cover of the analysis or survey report next to the words, "DATA VALIDATED."

4.1.6 Once analysis or measurement results have been validated, place the documentation in the survey unit package for FRS data evaluation.

4.1.7 If an analysis result, measurement or set of data cannot be validated, then highlight the sample or measurement result in question. The reviewer shall place their initials next to the measurement or sample in question and notify the RP FRS Manager.

1.) The RP FRS Manager or designee shall;

A. Consider initiating an investigation into the reason or cause in accordance with LC-AD-PR-004, "Corrective Action Program" (Reference 2.3).

B. Assess the valid data for the survey unit in order to make a determination if the remaining data is sufficient to meet the DQOs for that survey unit.

C. Direct the acquisition of additional measurements or samples as necessary if the remaining data is insufficient to continue FRS.

4.2. DQO Checklist

4.2.1 Initiate Attachment 10, "Final Radiation Survey Data Quality Objectives Review Checklist" when notified that all samples and measurements required by the FRS Sample Plan and sample instructions have been taken or acquired.

4.2.2 Using the checklist, review the FRS Sample Plan, the sample instructions, the Field Notes, survey records and/or data analyses reports to ensure that the DQOs used for the survey design are applicable and valid.

4.2.3 If the review identifies discrepancies, then document any corrective actions that were taken to resolve the discrepancy.

4.2.4 If discrepancies remain that are unresolved, then forward the documentation to the RP FRS Manager for completion.

1.) The RP FRS Manager or designee shall;

A. Assess the data that has been impacted by the discrepancy to determine if the data remains valid.

B. Assess the remaining data that has not been impacted by the discrepancy to make a determination if the remaining data is sufficient to meet the DQOs for that survey unit.

C. Consider initiating an investigation into the reason or cause in accordance with LC-AD-PR-004, "Corrective Action Program" (Reference 2.3).

D. Direct the acquisition of additional measurements or samples as necessary if the remaining data is insufficient to continue FRS.

4.3. Preliminary Data Review for FSS

NOTE

Attachment 11, "FSS Preliminary Survey Data Summary" is designed for the assessment of volumetric media for FSS. If FSS is performed on a buried pipe system using gross measurements to demonstrate compliance, then an equivalent format using gross measurements may be used. Preliminary data review can also be processed using alternate formats, pre-programmed computer databases, computer spreadsheets, electronic calculators and hand calculations provided that all requisite data is included.

4.3.1 Using Attachment 11, "FSS Preliminary Survey Data Summary" or an equivalent form, prepare a summary of the survey data that will be used for FSS for the survey unit, including scan survey results, any biased samples that were taken and any investigation measurements or samples that were taken as a result of elevated scan measurements.

4.3.2 Ensure all valid measured numerical values are recorded, including values below the MDC and values that are negative.

NOTE

For FSS, only samples or measurements taken as part of the systematic sample population for the survey unit are used to derive statistical data. Biased, judgmental and/or investigation samples are compared directly against the respective DCGL.

4.3.3 Derive and list the basic statistical data for each analyzed radionuclide or direct measurement in the systematic sample population to be used to demonstrate compliance for the survey unit. At a minimum, the statistics will include;

1.) Minimum value.

2.) Maximum value.

3.) Mean value of the data set.

4.) Median value of the data set.

5.) Standard deviation.

4.3.4 Calculate the Sum-of-Fractions.

NOTE

Attachment 2 presents the site-specific DCGLs for surface soils reproduced from Table 5-4 of LTP Chapter 5. Attachment 2 also presents the site-specific DCGLs for buried pipe reproduced from Table 5.5 of LTP Chapter 5.

For multiple radionuclides, the DCGL is "1" and the unity rule applies.

NOTE

If a surrogate DCGL was calculated as part of the survey design for the FSS (section 5.4.4 of LC-FS-PR-002, "Final Radiation Survey Package Development" [Reference 2.9]), then the surrogate DCGL calculated will be used for the selected surrogate radionuclide.

1.) Denote the appropriate DCGL(s) value for each ROC.

2.) Calculate a Fraction of the DCGL for each sample or measurement by dividing the reported concentration by the DCGL. If a sample has multiple ROCs, then the Fraction of the DCGL for each ROC will be summed to provide a Sum-of-Fractions (SOF) for the sample.

NOTE

For soil survey units, if both surface (grade to 1 meter below grade) and subsurface (greater than 1 meter below grade) soil samples are taken, then an average SOF is determined as part of the statistical sample population.

3.) Calculate an average SOF for the systematic sample population for the survey unit.

A. The average SOF is calculated using the following equation;

$$SOF_{avg} = \sum_{i=1}^{n} (SOF_i)$$

where: n = Number of measurements or samples;

SOF_i = SOF for the ith measurement or sample.

B. If the average SOF is less than or equal to unity (1), then proceed to the next step. If an average SOF is greater than unity (1), then stop data assessment and notify the RP FRS Manager.

4.3.5 Denote the results of any biased or judgmental samples and/or measurements taken in the survey unit.

4.3.6 Assess the scan survey results for the survey unit.

1.) Compare the reported scan results to the appropriate scan investigation level for the survey unit. Scan investigation levels are presented in Attachment 8.

2.) If a scan measurement exceeds an investigation level, then ensure that a biased sample or measurement was taken at the flagged location.

4.3.7 Prepare a map for the survey unit that includes the following information;

1.) The survey unit boundaries.

2.) The locations corresponding to the coordinates for each systematic measurement or sample.

3.) The locations corresponding to the coordinates where any elevated scan measurements were detected.

4.) The locations corresponding to the coordinates for each biased or investigation measurement or sample.

NOTE

Refer to section 8.2.2.2 of MARSSIM (Reference 2.2) for examples and methods for the graphical representation of data.

4.3.8 Display the data using graphical representation by creating a "posting plot" and a "frequency plot".

4.4. Preliminary Data Review for STS

NOTE

Attachment 3 reproduces Table 5-3 from LTP Chapter 5, which presents the Basement Dose Factors in units of mrem/yr per mCi. Attachment 4 presents the Basement Inventory Levels (BIL) from Table 5.7 from LTP Chapter 5 in units of pCi for each ROC. Attachment 5 presents the BIL values in Attachment 4 divided by the area of each basement survey unit.

NOTE

In accordance with section 5.2 of LTP Chapter 5, it was determined that Co-60, Sr-90, and Cs-137 accounted for 100% of all dose in contaminated concrete. Attachment 1 reproduces Table 5-2 from LTP Chapter 5, which presents the final suite of ROC for the decommissioning of LCNPS and the normalized mixture fractions based on the radionuclide distribution for the Waste Treatment Building and soils.

NOTE

Attachment 12, "STS Preliminary Survey Data Summary" is designed for the assessment of direct measurements using the ISOCS for STS. If STS is performed on an embedded pipe system or penetration using gross measurements to demonstrate compliance, then an equivalent format using gross measurements may be used. Preliminary data review can also be processed using alternate formats, pre-programmed computer databases, computer spreadsheets, electronic calculators and hand calculations provided that all requisite data is included.

4.4.1 Using Attachment 12, "STS Preliminary Survey Data Summary" or an equivalent form, prepare a summary of the survey data that will be used for STS for the survey unit, including any investigation measurements or samples that were taken as a consequence of higher than expected direct measurement results.

4.4.2 List the measured activity for each gamma-emitting ROC.

4.4.3 Using the radionuclide mixture fractions applicable to the survey unit, derive inferred activity for any HTD ROC.

4.4.4 Calculate a fraction for each ROC by dividing the reported concentration by the BIL per area levels in Attachment 5. If a sample has multiple ROCs, then the fractions for each ROC are summed to provide a SOF for the measurement.

4.4.5 Derive and list the data for each measurement that will be used to demonstrate compliance for the STS unit. At a minimum, the statistics will include;

1.) The Total Mean Activity per ROC.

2.) The Total Mean Dose for each ROC.

3.) The Total Mean Dose for the STS unit.

4.) The Mean Inventory Fraction for the STS unit.

4.4.6 If the SOF for an individual measurement exceeds the STS Investigation Levels presented in Attachment 7 or, if the Total Mean Dose exceeds 25 mrem/yr or, if the sum of the Mean Inventory Fractions for all STS units in a basement exceeds one, then;

1.) Notify the RP FRS Manager.

2.) Perform an investigation as to the cause of the higher than expected activity. This may include the acquisition of additional measurements to bound the area of elevated activity.

3.) Perform an assessment to determine if the basis for the current classification of the survey unit is still valid. If it is determined that the classification basis is no longer valid, then proceed to step 4.6.1.

4.4.7 Prepare a map for the survey unit that includes the following information:

1.) The survey unit boundaries.

2.) The locations corresponding to the coordinates for each direct measurement.

3.) The locations corresponding to the coordinates for each biased or investigation measurement or sample.

4.5. Selection and Performance of Statistical Tests

NOTE

Statistical tests will only be applied to the systematic sampling and/or measurement populations. For soil survey units, the statistical test will be performed on the systematic sample population that represents the as-left grade of the surface soil.

4.5.1 If every measurement in the systematic sample population;

- is less than or equal to the $DCGL_w$, or
- where a background reference area is used, the difference between the maximum survey data set measurement and the minimum background reference area measurement is less than or equal to the DCGLw, or
- has a SOF less than "one,"

then a statistical test is not required and proceed to step 4.6.3.

NOTE

For STS, the Sign Test will be used to evaluate the remaining residual radioactivity in each survey unit against the BIL presented in Attachment 5. The Sign Test is expected to be the most appropriate test for LSRP FSS results because background is expected to constitute a small fraction of the DCGL.

4.5.2 Perform the Sign test as follows;

NOTE

Attachment 14, "Sign Statistical Test", or an equivalent form can be used to document the performance of the Sign test. Data can also be processed using one or more of the following methods: the use of pre-programmed computer databases, computer spreadsheets, electronic calculators and hand calculations.

1.) List the survey unit measurements, 1, 2, 3…, *n*; where *n* = the number of measurements.

NOTE

Gross activity measurements taken on structural surfaces will be corrected for material specific gross background activity.

2.) For volumetric media, list the fraction of DCGL (measured concentration divided by the $DCGL_w$) for each ROC. For direct measurements, divide the gross direct measurement by the Adjusted Gross DCGL. For STS, list the SOF for each STS measurement.

3.) For volumetric media, sum the individual fractions for each ROC to derive a weighted sum (W_s). For direct measurements, use the fraction of the Adjusted Gross DCGL as the weighted sum for the measurement (W_s). For STS, use the SOF as the weighted sum for the measurement (W_s).

4.) Subtract the weighted sum (W_s) from unity (one) to obtain the difference.

5.) Discard differences where the value is exactly zero and reduce *n* by the number of such zero measurements.

6.) Count the number of positive differences. The result is the test statistic S^+, or critical value.

NOTE

In accordance with section 5.5.2.2 of LTP Chapter 5, the Type I decision error that was used for STS design was set at 0.05

7.) Compare the value of S^+ to the critical values in Table I.3 of MARSSIM (Reference 2.2).

A. If S+ is greater than or equal to the critical value for the Type 1 Error (α), 'then the null hypothesis can be rejected and the survey data set passes the Sign test.

B. If S+ is less than the critical value, then the survey data set fails the Sign test.

4.5.3 If the survey unit passes the statistical test, then proceed to step 4.6.3. If the survey unit fails the statistical test, then inform the RP FRS Manager and further analyze the data to determine why the statistical test failed.

1.) If it appears that the failure is caused by the presence of radioactivity concentrations that will require further remediation, then proceed to step 5.7.

2.) If it appears that the failure is due to statistical fluctuations, then the survey unit may be resurveyed and another set of discrete measurements or samples collected for statistical analysis. A larger number of measurements may increase the probability of passing the statistical test if the survey unit actually meets the site release criterion.

3.) If it appears the power of the test is insufficient due to the number of measurements, then a retrospective power analysis for the test may be performed as described in Appendices I.9 and I.10 of MARSSIM (Reference 2.2) to determine if additional data may be collected and included in the data set.

4.6. Investigations

4.6.1 For STS, if the survey unit fails the statistical test or, if it was determined in step 4.4.6 that the SOF for an individual measurement exceeds the STS Investigation Levels presented in Attachment 7 or, if the Total Mean Dose exceeds 25 mrem/yr or, if the sum of the Mean Inventory Fractions for all STS units in a basement exceeds one, then proceed to step 4.6.4.

4.6.2 For FSS, if any location identified by volumetric sample, scan or static measurements exceeds the investigation levels as presented in Attachment 7 that are applicable to the survey unit, then proceed to step 4.6.4.

4.6.3 If the survey unit (FSS and STS) has passed the statistical test, and does not have any volumetric sample, scan or static measurements in excess of the investigation levels, then close out the survey package per section 5.8 and commence the generation of the FRS Release Record for this survey unit in accordance with procedure LC-FS-PR-009, *"Final Radiation Survey Data Reporting"* (Reference 2.5).

NOTE

At LCSRP, Elevated Measurement Comparison (EMC) only applies to Class 1 open land survey units.

NOTE

Investigation(s) can also be processed using alternate formats, pre-programmed computer databases, computer spreadsheets, electronic calculators and hand calculations provided that all requisite data is included.

4.6.4 If the results of the FRS require an investigation, then initiate ATTACHMENT 14, "Final Radiation Survey Investigation" or equivalent.

4.6.5 Document the reason for the investigation.

4.6.6 List the locations and sample or measurement results that exceed the investigation levels.

4.6.7 Using the sample or measurement coordinates, assess if the elevated area has been adequately bounded. If the elevated area has not been adequately bounded, then take additional samples or measurements as necessary to establish the boundaries of the elevated area.

NOTE

Use of location plots on a map of the survey unit is an effective tool to determine bounding and area size.

4.6.8 List the bounding samples or measurements for each elevated area.

4.6.9 If the survey unit is a STS unit, then proceed to step 4.6.10. If the survey unit is a FSS survey unit and is classified as Class 2, then proceed to step 4.6.12. If the survey unit is a FSS survey unit and is classified as Class 3, then proceed to step 4.6.13. If the survey unit is classified as a FSS Class 1 open land area, then perform an EMC as follows;

1.) In each elevated area, denote the $DCGL_w$(s) for each ROC pertinent to the elevated sample(s) or the applicable Adjusted Gross DCGL.

NOTE

Attachment 6 reproduces Tables 5-6 from LTP Chapter 5, which presents the Area Factors (AF) for surface soils.

2.) Calculate an area in square meters for the identified elevated area(s) and select the appropriate AF from Attachment 6 that corresponds to the area with the elevated activity.

3.) Calculate a $DCGL_{EMC}$ for each applicable radionuclide or for gross activity by multiplying the $DCGL_w$ for the elevated measurement(s) or sample(s) by the AF.

NOTE

The Average Radioactivity Fraction is calculated using only sample results from the systematic sample population that are located outside of any identified elevated area.

4.) For volumetric media, sum the products of the average concentration for each individual radionuclide divided by its respective $DCGL_w$. For gross measurements, the Average Radioactivity Fraction (δ_j) is calculated by dividing the average gross activity concentration by the Adjusted Gross DCGL.

5.) Calculate an Elevated Radioactivity Fraction (f_{EMC}) for each identified elevated area as follows;

A. Determine the average concentration (τj) for gross activity for gross measurements or for each radionuclide for volumetric media in each identified elevated area.

B. For gross measurements, subtract the Average Gross Activity (δj) from the Average Gross Activity Concentration (τj) in the elevated area and divide this value by the DCGLEMC to derive an Elevated Radioactivity Fraction (fEMC) for the elevated area.

C. For volumetric media, subtract the Average Concentration of Radionuclide (δj) for each radionuclide from the average radionuclide concentration (τj) in the elevated area and divide this value by the DCGLEMC to derive a Fraction of DCGLEMC (fEMC) for each radionuclide.

6.) Sum the Elevated Radioactivity Fractions (f_{EMC}) for each elevated area.

7.) Add the Average Radioactivity Fraction (f_{avg}) to the summed Elevated Radioactivity Fractions (f_{EMC}). This value represents the EMC SOF for this survey unit.

4.6.10 If the survey unit is STS, proceed to step 5.7.

4.6.11 If the survey unit is classified as FSS Class 1, and the measured gross activity or, the concentration for any radionuclide reported for any systematic, biased or investigative sample or measurement taken in the survey unit is equal to or greater than its respective $DCGL_w$, and, the EMC SOF for the survey unit is greater than unity (1), then proceed to step 4.7. If the EMC SOF is less than or equal to unity (1), then the survey unit will pass the EMC, the investigation is complete and the FRS Release Record for this survey unit may be generated in accordance with procedure LC-FS-PR-009, *"Final Radiation Survey Data Reporting"* (Reference 2.5).

4.6.12 If the survey unit is classified as a FSS Class 2 survey unit, and the measured gross activity or the concentration for any radionuclide reported for any systematic, biased or investigative sample or measurement taken in the survey unit is equal to or greater than its respective $DCGL_w$, then proceed to step 5.7. If the action level has not been exceeded, then the investigation is complete and the FRS Release Record for this survey unit may be generated in accordance with procedure LC-FS-PR-009, *"Final Radiation Survey Data Reporting"* (Reference 2.5).

4.6.13 If the survey unit is classified as a FSS Class 3 survey unit and, the measured gross activity or, the concentration for any radionuclide reported for any systematic, biased or investigative sample or measurement taken in the survey unit is equal to or greater than 50% of its respective $DCGL_w$, then proceed to step 4.7. If the action level has not been exceeded, then the investigation is complete and the FRS Release Record for this survey unit may be generated in accordance with procedure LC-FS-PR-009, *"Final Radiation Survey Data Reporting"* (Reference 2.5).

4.7. Corrective Actions for Final Radiation Survey Failure

4.7.1 If the survey unit did not pass FRS, then initiate Attachment 16, "Corrective Actions for Final Radiation Survey Failure" or equivalent. Attachment 9 provides potential corrective actions that may be taken as corrective actions for the FSS failure of a survey unit. These corrective actions may require remediation, reclassification, and/or resurvey.

4.7.2 Submit completed form to the RP FRS Manager for approval.

4.7.3 When the RP FRS Manager has approved the corrective action, then prepare a revision (addendum), as appropriate, to the FRS Sample Plan in accordance with LC-FS-PR-009, ***"****Final Radiation Survey Package Development"* (Reference 2.9). If any new survey units were created from existing survey units, then prepare a new survey design in accordance with LC-FS-PR-002, ***"****Final Radiation Survey Package Development"* (Reference 2.9).

4.8. Survey Package Closeout

4.8.1 For STS Survey packages, complete Attachment 17, "STS Survey Plan Closeout" and file the completed form in the appropriate survey package.

4.8.2 For FRS Survey packages, complete Attachment 18, "FSS Survey Plan Closeout" and file the completed form in the appropriate survey package.

5. ATTACHMENTS

5.1. Attachment 1, Dose Significant Radionuclides and Mixtures

5.2. Attachment 2, DCGLs for Soils and Buried Pipe

5.3. Attachment 3, Basement Dose Factors

5.4. Attachment 4, Basement Inventory Levels (BIL)

5.5. Attachment 5, STS Investigation Levels

5.6. Attachment 6, Area Factors for Surface Soils

5.7. Attachment 7, STS Investigation Levels

5.8. Attachment 8, FSS Investigation Levels

5.9. Attachment 9, Remediation, Reclassification and Resurvey Actions

5.10. Attachment 10, "Final Radiation Survey Data Quality Objectives Review Checklist"

5.11. Attachment 11, "FSS Preliminary Survey Data Summary"

5.12. Attachment 12, "STS Preliminary Survey Data Summary"

5.13. Attachment 13, "Sign Statistical Test"

5.14. Attachment 14, "Final Radiation Survey Investigation"

5.15. ATTACHMENT 14, "Corrective Actions for Final Radiation Survey Failure"

5.16. Attachment 16, STS Survey Plan Closeout

5.17. Attachment 17, FSS Survey Plan Closeout

ATTACHMENT 1

Table 5-1 Dose Significant Radionuclides and Mixture

Radionuclide(2)	Distribution Fraction
Co-60	0.014
Sr-90	0.010
Cs-137	0.976

1.) Based on maximum percent of total activity from Table 22 of La Crosse*Solutions* RS-TD-313196-001, *"Radionuclides of Concern for Soil and Basement Fill Model Source Terms"* (Reference 2.10), normalized to one for the dose significant radionuclides.

2.) Does not include dose significant radionuclides for activated concrete (H-3, Eu-152, Eu-154) under the assumption that all activated concrete will be removed and disposed of as waste.

ATTACHMENT 2

DCGLs FOR SOILS AND BURIED PIPE

Table 5-2 DCGLs for Soils (pCi/g)

Radionuclide	Surface Soil DCGL (pCi/g)
Co-60	1.28E+01
Sr-90	6.55E+03
Cs-137	5.79E+01

DCGLs for Buried Pipe

Table 5-3 DCGLs for Buried Piping (dpm/100cm^2)

Radionuclide	Pipe DCGL (dpm/100cm^2)					
	2 in	3 in	4 in	6 in	8 in	48 in
Co-60	6.27E+03	1.41E+04	2.51E+04	5.64E+04	1.00E+05	3.61E+06
Sr-90	2.85E+04	6.40E+04	1.14E+05	2.56E+05	4.55E+05	1.64E+07
Cs-137	3.22E+06	7.25E+06	1.29E+07	2.90E+07	5.15E+07	1.85E+09

ATTACHMENT 3

BASEMENT DOSE FACTORS

Table 5-4 Basement Dose Factors (mrem/yr per mCi)

	Reactor Building			Waste Treatment Building		
	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario
	mrem/yr per mCi			mrem/yr per mCi		
Co-60	4.86E-01	1.16E-01	1.55E+00	6.80E-02	1.14E+00	2.05E+01
Sr-90	5.03E+00	2.06E-04	3.01E-03	2.99E+00	2.03E-03	3.99E-02
Cs-137	1.75E-01	2.84E-02	3.41E-01	4.25E-02	2.79E-01	4.52E+00

	Waste Gas Tank Vault			Remaining Basements		
	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario	Groundwater Scenario	Drilling Spoils Scenario	Excavation Scenario
	mrem/yr per mCi			mrem/yr per mCi		
Co-60	1.19E-01	5.93E-01	6.84E+00	1.49E-02	1.31E-01	3.43E+00
Sr-90	1.09E+00	1.04E-03	1.34E-02	1.27E+00	2.31E-04	6.69E-03
Cs-137	4.76E-02	1.45E-01	1.51E+00	5.62E-03	3.18E-02	7.57E-01

ATTACHMENT 4

Basement Inventory Levels (BIL) Used for STS Design

Table 5-5 Basement Inventory Levels (BIL) Used for STS Design (mCi Total Inventory)

	Reactor Building (mCi)	WTB (mCi)	WGTV (mCi)	Remaining Basements (mCi)
Co-60	1.16E+01	1.15E+00	3.31E+00	6.98E+00
Sr-90	4.97E+00	8.25E+00	2.26E+01	1.96E+01
Cs-137	4.59E+01	5.16E+00	1.47E+01	3.15E+01

ATTACHMENT 5

BIL Divided by Basement Survey Unit Area

	Reactor Building (mCi)	WTB (mCi)	WGTV (mCi)	Remaining Basements (mCi)
Co-60	2.26E-03	1.12E-02	7.20E-04	1.05E-03
Sr-90	9.7E-04	8.09E-02	4.91E-03	2.94E-03
Cs-137	8.9E-03	5.06E-02	3.19E-03	4.72E-0

Note: Attachment 5 presents the Basement Inventory Level values in attachment 4 divided by the area of each basement survey unit. (obtained from LTP Chapter 5, on page 5-26 from table 5-8.)

ATTACHMENT 6

Area Factors for Surface Soils

Table 5-6 Area Factors for Soils

Radionuclide	Area Factor				
	1 m^2	2 m^2	5 m^2	10 m^2	100 m^2
Co-60	9.44	5.56	3.07	2.04	1.19
Sr-90	11.22	6.66	3.69	2.45	1.41
Cs-137	9.11	5.42	3.01	2.00	1.18

ATTACHMENT 7

STS INVESTIGATION LEVELS

STS Unit Classification	Direct Measurement Investigation Levels:
Class 1	None
Class 2	> SOF of 0.5
Class 3	> SOF of 0.1

Note 1 Exceeding the investigation levels for STS could incur the acquisition of additional measurements to increase the areal coverage of the survey. Consequently, as the areal coverage for a Class 1 STS unit is 100%, there is no applicable investigation level for a Class 1 STS unit.

Note 2 These STS units will be subjected to an areal coverage commensurate with the guidance pertaining scan coverage as presented in the MARSSIM. As the areal coverage is commensurate with the lower range of the scan coverage guidance, the investigation levels for STS have been conservatively adjusted to 50% of the limit.

ATTACHMENT 8

FSS INVESTIGATION LEVELS

Table 5-7 Investigation Levels

Survey Unit Classification	Scan Investigation Levels:	Direct Measurement Investigation Levels:
Class 1	> $DCGL_{EMC}$	> $DCGL_{EMC}$
Class 2	> $DCGL_W$ or > MDC_{scan} if MDC_{scan} is greater than $DCGL_W$	> $DCGL_w$
Class 3	> $DCGL_W$ or > MDC_{scan} if MDC_{scan} is greater than $DCGL_W$	> 50 percent of $DCGL_w$

ATTACHMENT 9

REMEDIATION, RECLASSIFICATION AND RESURVEY ACTIONS

Page 1 of 2

REMEDIATION			
Remediation Criteria			Proposed Remediation
Class 1 FSS Survey Unit	1) The EMC SOF for survey unit is less than or equal to unity (1)		None
	2) The Elevated Radioactivity Fraction (f_{EMC}) exceeds unity in 5% or less of the survey unit area.		Spot Remediation & Resurvey
	3) The Elevated Radioactivity Fraction (f_{EMC}) exceeds unity in greater than 5% of the survey unit area.		General Remediation and Restart FSS
Class 1 STS Unit	1) The mean inventory fraction (total mean dose for the survey unit divided by the dose criterion of 25 mrem/yr) is greater than or equal to one.		General Remediation and Restart STS
	2) The sum of the mean inventory fractions for each STS unit contained within a building basement is greater than or equal to one.		
RECLASSIFICATION			
Reclassification Criteria			Proposed Action
Class 2 Survey Unit	One or several survey measurements (scan, sample or direct measurement) exceed 50% of the dose criterion or a $DCGL_w$ or a portion of the survey unit is remediated.	The extent of the elevated area relative to the total area of the survey unit is minimal and the source of the residual radioactivity is known	Reclassify only the bounded discrete area of elevated activity to Class 1.
		The extent of the elevated area relative to the total area of the survey unit is minimal and the source of the residual radioactivity is unknown	Reclassify 2,000 m^2 for soils or 100 m^2 for structures around the area of elevated activity as Class 1.
		The extent of the elevated area relative to the total area of the survey unit is significant.	Reclassify the entire survey unit as Class 1.
Class 3 Survey Unit	One or several survey measurements (scan, sample or direct measurement) exceed 50% of the dose criterion or a $DCGL_w$ or a portion of the survey unit is remediated.	The extent of the elevated area relative to the total area of the survey unit is minimal	Reclassify the area of elevated activity to Class 1 and create a Class 2 buffer zone of appropriate size around the area.
		The extent of the elevated area relative to the total area of the survey unit is significant.	Reclassify the area of elevated activity to Class 1 and create a Class 2 buffer zone of appropriate size around the area.
	One or several survey measurements (scan, sample or direct measurement) exceed 1% of the dose criterion or 50% of a $DCGL_w$	The extent of the elevated area relative to the total area of the survey unit is minimal	Reclassify the area of elevated activity to Class 2.
		The extent of the elevated area relative to the total area of the survey unit is significant.	For soils, reclassify 10,000 m^2 around the area of elevated activity to Class 2. For structures, reclassify 1,000 m^2 around the area of elevated activity to Class 2.

ATTACHMENT 9

REMEDIATION, RECLASSIFICATION AND RESURVEY ACTIONS

RESURVEY			
Resurvey Criteria			Proposed Action
Class 1 Survey Unit	The survey unit has been remediated.	The extent of the elevated area relative to the total area of the survey unit is minimal.	Re-scan remediated area; collect replacement systematic population samples/measurements within the remediated area using random selection.
		The extent of the elevated area relative to the total area of the survey unit is significant.	Resurvey entire survey unit using a new survey design.
	Survey unit has been reclassified from a Class 2 survey unit.	No remediation was performed.	Increase scan or areal coverage to 100%. Additional statistical samples are not required.
Class 2 Survey Unit	Survey unit has been divided to accommodate a new Class 1 survey unit.	The area of the new Class 1 survey unit relative to the area of the initial Class 2 survey unit is minimal and no statistical samples were affected.	Increase scan or areal coverage in Class 2 survey unit.
		Statistical sample population was affected by the reclassification.	Increase scan or areal coverage in Class 2 survey unit and resurvey entire survey unit using a new survey design.
Class 3 Survey Unit	Survey unit has been divided to accommodate a new Class 2 survey unit.	The area of the new Class 2 survey unit relative to the area of the initial Class 3 survey unit is minimal.	Increase scan or areal coverage in Class 3 survey unit, collect replacement systematic population samples/measurements within the remediated area using random selection.
		The area of the new Class 2 survey unit relative to the area of the initial Class 3 survey unit is significant.	Resurvey entire survey unit using a new survey design.

ATTACHMENT 10

FINAL RADIATION SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: No. _____ **Description:** _____
Survey Unit: No. _____ **Description:** _____
Classification: _____

Reviewer: _____ **Date:** _____ **Time:** _____

1.	Have all measurements and/or analysis results that will be subjected to data analysis for FRS been individually reviewed and validated in accordance with step 5.1 of this procedure?	Yes ☐	No ☐ (explain)
2.	Have all systematic measurements and/or samples been taken or acquired at the locations specified in the FRS Sample Plan and the FRS Sample Instructions?	Yes ☐	No ☐ (explain)
3.	Have all scans surveys been performed of the areas specified as required in the FRS Sample Plan and the FRS Sample Instructions? (applicable to FSS only)	Yes ☐	No ☐ (explain)
4.	Was a meter circumference scanned around each systematic sample or measurement location? (applicable to FSS only)	Yes ☐	No ☐ (explain)
5.	Have all biased measurements and/or samples been taken or acquired at the locations specified in the FRS Sample Plan & the FRS Sample Instructions? (applicable to FSS only)	Yes ☐	No ☐ (explain)
6.	Have duplicate and/or split samples or measurements been taken or acquired at each location designated as a QC sample?	Yes ☐	No ☐ (explain)
7.	Were the instruments used to measure or analyze the survey data capable of detecting the ROCs or gross activity at a MDC less than the specified target MDC?	Yes ☐	No ☐ (explain)
8.	Are the MDCs and the assumptions used to develop the MDCs appropriate for the instruments and methods used to analyze the data?	Yes ☐	No ☐ (explain)
9.	Was the calibration of all instruments that were used to measure or analyze data, current at the time of use and were those calibrations performed using a NIST traceable source?	Yes ☐	No ☐ (explain)
10.	Were the instruments successfully response-checked before use and, where required, after use on the day the data was measured?	Yes ☐	No ☐ (explain)
11.	Was the custody of samples collected for laboratory analysis tracked from the point of collection until final results were obtained?	Yes ☐	No ☐ (explain)
12.	Do the QC sample results meet the acceptance criteria as specified in LC-QA-PN-001, *"Final Radiation Survey Quality Assurance Project Plan(QAPP)"* (Reference 6.5)	Yes ☐	No ☐ (explain)

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

ATTACHMENT 10

FINAL RADIATION SURVEY DATA QUALITY OBJECTIVES REVIEW CHECKLIST

Survey Area: No. _____ **Description:** _____

Survey Unit: No. _____ **Description:** _____

Discrepancy; _____

Corrective Actions Taken; _____

13. Have the corrective actions resolved the discrepancies with the data? ---------- Yes ☐ No ☐
    a. If "No", then forward this form to the RP FRS Manager.
14. The following questions will be answered by the RP FRS Manager.
    a. If the answer to question 13 was "No", then is the affected data still valid? ---------- Yes ☐ No ☐
    b. If "No", then are the existing valid measurements or samples sufficient to demonstrate compliance for the survey unit? ---------- Yes ☐ No ☐
    c. If "No", then direct the acquisition of additional measurements or samples as necessary to demonstrate compliance for the survey unit.

Prepared by (FRS Supervisor): _____ (Print Name) _____ (Signature) _____ (Date)

Approved by: _____ (RP FRS Manager) _____ (Signature) _____ (Date)

ATTACHMENT 11

FSS PRELIMINARY SURVEY DATA SUMMARY

Page 1 of 3

Survey Area: No. __________ **Description:** ______________________________ **Classification:** ________

Survey Unit: No. __________ **Description:** ______________________________

Sample ID	Location			Radionuclides of Concern						SOF
	Northing	Easting		Cs-137	______	______	______	______	______	
			Result							
			DCGL							
			Fraction of DCGL							
			Result							
			DCGL							
			Fraction of DCGL							
			Result							
			DCGL							
			Fraction of DCGL							
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			Fraction of DCGL							
			Result							
			DCGL							
			Fraction of DCGL							

ATTACHMENT 11

FSS PRELIMINARY SURVEY DATA SUMMARY

Page 2 of 3

Sample ID	Location			Radionuclides of Concern						SOF
	Northing	Easting		Cs-137	________	________	________	________	________	
			Result							
			DCGL							
			Fraction of DCGL							
			Result							
			DCGL							
			Fraction of DCGL							
			Result							
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			Fraction of DCGL							
			Result							
			DCGL							
			Fraction of DCGL							

ATTACHMENT 11

FSS PRELIMINARY SURVEY DATA SUMMARY

Page 3 of 3

Statistical Quantities	**Radionuclides of Concern** Cs-137	_____	_____	_____	_____	_____
Number of Measurements =						
# of Measurements > MDC =						
# of Measurements > DCGL =						
# of Samples with SOF >1 =						
Mean Concentration =	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Median Concentration =	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Minimum Concentration =	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Maximum Concentration =	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Standard Deviation =						
Average Fraction of DCGL =						

Average Sum-of-Fractions for Survey Unit = _____ **Average Dose for Survey Unit =** _____ mrem

Prepared by (FRS Supervisor): _____ (Print Name) _____ (Signature) _____ (Date)

ATTACHMENT 12

STS PRELIMINARY SURVEY DATA SUMMARY

Page 1 of 3

STS Unit: ____________________ **Description:** ____ **Classification:** __________

Sample ID	Location		FOV (m^2)	ROC	Ratio to Cs-137	Measured Activity (pCi/m^2)	Inferred Activity (pCi/m^2)	Activity per ROC (pCi/m^2)	BIL [1] (pCi/m^2)	Fraction of BIL [2]	SOF [3]	Total Activity [4] (pCi/m^2)
	X Coordinate	Y Coordinate										
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								

Notes
1 From Attachment 5
2 "Activity per ROC" divided by the "BIL/Area"
3 Sum of the "Fraction of BIL"
4 Sum of "Activity per ROC"

ATTACHMENT 12

STS PRELIMINARY SURVEY DATA SUMMARY

Page 2 of 3

Sample ID	Location		FOV (m^2)	ROC	Ratio to Cs-137	Measured Activity (pCi/m^2)	Inferred Activity (pCi/m^2)	Activity per ROC (pCi/m^2)	BIL [1] (pCi/m^2)	Fraction of BIL [2]	SOF [3]	Total Activity [4] (pCi/m^2)
	X Coordinate	Y Coordinate										
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								
				Co-60								
				Cs-137								
				Ni-63								
				Sr-90								

Notes 1 From Attachment 5
2 "Activity per ROC" divided by the "BIL/Area"
3 Sum of the "Fraction of BIL"
4 Sum of "Activity per ROC"

ATTACHMENT 12

STS PRELIMINARY SURVEY DATA SUMMARY

Page 3 of 3

STS Unit: _____ **Description:** _____ **Classification:** _____

Number of Measurements Taken in STS Unit--- _____ **Corresponding Areal Coverage based on FOV** (1)---------- _____ %

Maximum SOF Observed (5)---------- _____ **Mean of Total Activity Results** (6)---------- _____ **pCi/m^2**

Calculation of Mean Activity and Dose						
ROC	**Mean Activity per ROC** (7) **(pCi/m^2)**	**Total Mean Activity per ROC** (8) **(mCi)**	**Basement Dose Factors** (9) **(mrem/yr per mCi)**	**Mean Dose per ROC** (10) **(mrem/yr)**	**Total Mean Dose for STS Unit** (11) **(mrem/yr)**	**Mean Inventory Fraction for STS Unit** (12)
Co-60						
Cs-137						
Ni-63						
Sr-90						

(1) The Maximum SOF value observed in the SOF column from the Preliminary Data Summary.

(2) The average of the "Total Activity" column from the Preliminary Data Summary.

(3) The average of the "Activity per ROC" column from the Preliminary Data Summary.

(4) The "Mean Activity per ROC" converted to units of mCi/m^2 multiplied by the area of the STS unit.

(5) From Attachment 3.

(6) The "Total Mean Activity per ROC" multiplied by the "Basement Dose Factors".

(7) The sum of the "Mean Dose per ROC".

(8) The "Total Mean Dose for STS unit" divided by 25 mrem/yr. See section 4.1.7.

Prepared by (FRS Supervisor): _____ _____ _____
(Print Name) (Signature) (Date)

ATTACHMENT 13

SIGN STATISTICAL TEST

Survey Area: No. _____ **Description:** _____

Survey Unit: No. _____ **Description:** _____

Classification: _____ **Type I (α)Error:** _____ **Number of Samples (n):** _____

#	Fraction of the Release Criterion							Weighted Sum (W_s)	1-W_s	Sign
	Radionuclides of Concern						Activity or SOF (as applicable)			
	Cs-137	_____	_____	_____	_____	_____				
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Critical Value (Table I.3 of MARSSIM) = _____ Number of Positive Differences (S+) = _____

The survey unit ☐ (meets) ☐ (does not meet) the acceptance criteria

Prepared by (FRS Supervisor): _____ (Print Name) _____ (Signature) _____ (Date)

Reviewed by RP FRS Manager: _____ (Print Name) _____ (Signature) _____ (Date)

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FINAL RADIATION SURVEY INVESTIGATION

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Survey Area: No. _____ **Description:** _____ **Classification:** _____

Survey Unit: No. _____ **Description:** _____

Performed by: _____ **Date:** _____ **Time:** _____

1. Reason for Investigation

☐ FSS Sample(s) with Result(s) > Investigation Levels ☐ Scan Measurement(s) > Investigation Levels

☐ STS Measurement(s) with Results(s) > Investigation Levels ☐ Failure of Statistical Test

☐ Other _____

2. Identified Elevated Sample(s)

Sample ID	Location		Radionuclides-of-Concern											
			Cs-137		_____		_____		_____		_____		_____	
	Northing	Easting	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction

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FINAL RADIATION SURVEY INVESTIGATION

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3. Bounding of Identified Elevated Area(s)
   a. Is the elevated area(s) adequately verified and bounded by the existing samples? Yes ☐ No ☐
      1) If "Yes", then proceed to step 4
      2) If "No", then prepare an addendum to the FRS Sample Plan for this survey unit to take additional samples as necessary to adequately verify and bound the identified area(s) of suspected elevated activity.

   b. Bounding Sample(s)

Sample ID	Location		Radionuclides-of-Concern											
			Cs-137		_____		_____		_____		_____		_____	
	Northing	Easting	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction	_____	Fraction

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4. Elevated Measurement Comparison
   a. If the survey unit is an STS unit or classified as FSS Class 2 or Class 3, then proceed to step 5.
   b. In each elevated area, denote the $DCGL_w$ pertinent to the location where the elevated sample is located.
   c. Calculate an area in square meters for the identified elevated area(s) and select the appropriate Area Factor from Attachment 6 that corresponds to the area and to the radionuclide with the elevated activity.

Elevated Area #1 Area Size: _____ m^2

	Cs-137	_____	_____	_____	_____	_____
$DCGL_w$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Area Factor						

Elevated Area #2 Area Size: _____ m^2

	Cs-137	_____	_____	_____	_____	_____
$DCGL_w$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Area Factor						

Elevated Area #3 Area Size: _____ m^2

	Cs-137	_____	_____	_____	_____	_____
$DCGL_w$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Area Factor						

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d. Calculate a $DCGL_{EMC}$ for each applicable radionuclide by multiplying the $DCGL_w$ for the elevated measurement(s) or sample(s) by the Area Factor.

Elevated Area #1

	Cs-137	_____	_____	_____	_____	_____
$DCGL_{EMC}$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g

Elevated Area #2

	Cs-137	_____	_____	_____	_____	_____
$DCGL_{EMC}$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g

Elevated Area #3

	Cs-137	_____	_____	_____	_____	_____
$DCGL_{EMC}$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g

e. Calculate the Average Radioactivity Fraction for the survey unit as follows;

Note: The Average Radioactivity Fraction is calculated using only sample results from the systematic sample population that are located outside of any identified elevated area.

	Cs-137	_____	_____	_____	_____	_____
Avg. Concentration of Radionuclide (δ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$DCGL_w$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Average Fraction of DCGL (f_j)						

1) Sum the "Fraction of DCGL (f_j)" values for each pertinent radionuclide to derive the Average Radioactivity Fraction (f_{avg}) = _____

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f. Calculate an Elevated Radioactivity Fraction (f_{EMC}) for each identified elevated area as follows;
   1) Determine the average concentration (τ_j) for each radionuclide in each identified elevated area.
   2) Subtract the Average Concentration of Radionuclide (δ_j) for each radionuclide from step 4e from the average radionuclide concentration (τ_j) in the elevated area and divide this value by the $DCGL_{EMC}$ from step 4d to derive a Fraction of $DCGL_{EMC}$ (f_{elev}) for each radionuclide.
   3) Sum the Fraction of $DCGL_{EMC}$ (f_{elev}) values for each pertinent radionuclide to derive the Elevated Radioactivity Fraction (f_{EMC}) for the elevated area.

Elevated Area #1

	Cs-137	_____	_____	_____	_____	_____
Avg. Concentration of Elevated Area (τ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Avg. Concentration of Radionuclide (δ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$(\tau_j - \delta_j) =$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$DCGL_{EMC}$						
Fraction of $DCGL_{EMC}$ (f_{elev})						

Elevated Radioactivity Fraction (f_{EMC}) for Elevated Area #1 _____

Elevated Area #2

	Cs-137	_____	_____	_____	_____	_____
Avg. Concentration of Elevated Area (τ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Average Concentration of Survey Unit (δ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$(\tau_j - \delta_j) =$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$DCGL_{EMC}$						
Fraction of $DCGL_{EMC}$ (f_{elev})						

Elevated Radioactivity Fraction (f_{EMC}) for Elevated Area #2 _____

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Elevated Area #3

	Cs-137	_____	_____	_____	_____	_____
Avg. Concentration of Elevated Area (τ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
Average Concentration of Survey Unit (δ_j)	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$(\tau_j - \delta_j) =$	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g	ρCi/g
$DCGL_{EMC}$						
Fraction of $DCGL_{EMC}$ (f_{elev})						

Elevated Radioactivity Fraction (f_{EMC}) for Elevated Area #3 _____

g. Sum the Elevated Radioactivity Fractions (f_{EMC}) for each elevated area. _____

h. Add the Average Radioactivity Fraction (f_{avg}) from step 4e to the summed Elevated Radioactivity Fractions (f_{EMC}). This value represents the EMC SOF for this survey unit. _____

i. If the SOF is less than or equal to unity (1), then the survey unit will pass the EMC. If the SOF is greater than unity (1), then the need for additional remediation is likely.

5. Investigation Conclusions

a. STS Unit

1) Did the survey unit fail the statistical test or, was determined in step 5.4.6 that the SOF for an individual measurement exceeds the STS Investigation Levels (Attachment 7) or, the Total Mean Dose exceeds 25 mrem/yr or, the sum of the Mean Inventory Fractions for all STS units in a basement exceeds one? Yes ☐ No ☐

(If "Yes", then initiate Attachment 16, "Corrective Actions for Final Radiation Survey Failure". If "No", then the investigation is complete and no further action is required.)

b. FSS Class 3 Survey Unit

1) Is the concentration for any radionuclide reported in any systematic, biased or investigative sample taken in the survey unit equal to or greater than 50% of its respective $DCGL_w$? Yes ☐ No ☐

ATTACHMENT 14
FINAL RADIATION SURVEY INVESTIGATION

(If "Yes", then initiate Attachment 16, "Corrective Actions for Final Radiation Survey Failure". If "No", then the investigation is complete and no further action is required.)

c. FSS Class 2 Survey Unit

1) Is the concentration for any radionuclide reported in any systematic, biased or investigative sample taken in the survey unit equal to or greater than its respective $DCGL_w$? ☐ Yes ☐ No

(If "Yes", then initiate Attachment 16, "Corrective Actions for Final Radiation Survey Failure". If "No", then the investigation is complete and no further action is required.)

d. FSS Class 1 Survey Unit

1) Is the concentration for any radionuclide reported in any systematic, biased or investigative sample taken in the survey unit equal to or greater than its respective $DCGL_w$? ☐ Yes ☐ No

(If "Yes", then proceed to next step. If "No", then the investigation is complete and no further action is required.)

2) Is the EMC SOF for this survey unit greater than unity (1)? ☐ Yes ☐ No

(If "Yes", then initiate Attachment 16, "Corrective Actions for Final Radiation Survey Failure". If "No", then the investigation is complete and no further action is required.)

6. Comments;

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6. Comments (continued);

7. Approval

Prepared by (FRS Supervisor): _____ (Print Name) _____ (Signature) _____ (Date)

Reviewed by RP FRS Manager: _____ (Print Name) _____ (Signature) _____ (Date)

ATTACHMENT 15

CORRECTIVE ACTIONS FOR FINAL RADIATION SURVEY FAILURE

Survey Area: No. _____ **Description:** _____

Survey Unit: No. _____ **Description:** _____

Classification: _____

Performed by: _____ **Date:** _____ **Time:** _____

Resurvey, Reclassification or Remediation

Based upon the failure of the statistical test or the results of an investigation, the following action(s) are required.

Note: Use the guidance provided in Attachment 9 for determination of appropriate action(s).

☐ Resurvey Action(s) Required _____

☐ Reclassify Action(s) Required _____

☐ Remediate Action(s) Required _____

Approval

Prepared by (FRS Supervisor): _____ (Print Name) _____ (Signature) _____ (Date)

Approved by: _____ (RP/FRS Manager) _____ (Signature) _____ (Date)

ATTACHMENT 16

STS SURVEY PLAN CLOSEOUT

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STS Sample Plan #:	Survey Unit #:	
Survey Unit Location/Description:		

The following documentation is included in the STS Sample Plan

	DESCRIPTION	TOTAL	COMMENTS
☐	LC-FS-PR-002 Attachment 10, "FRS Sample Plan Cover Sheet"		
☐	LC-FS-PR-010 Attachment 1, "Area Turnover and Control Checklist"		
☐	LC-FS-PR-010 Attachment 2, "Pre-Turnover Walk-Down"		
☐	LC-FS-PR-006 Attachment 1, "Survey Unit Classification Basis Summary"		
☐	LC-FS-PR-006 Attachment 2, "Survey Unit Classification Worksheet"		
☐	LC-FS-PR-002 Attachment 11, "FRS Data Quality Objectives and Survey Design		
☐	LC-FS-PR-002 Attachment 12, "FRS Survey Instructions"		
☐	LC-FS-PR-002 Attachment 13, "Field Log."		
☐	LC-FS-PR-002 ATTACHMENT 14, "Sample/Measurement Identification and Coordinates."		
☐	LC-FS-PR-002 Attachment 15, "Scan Area Identification and Coordinates."		
☐	Photographs, maps, and/or drawings of the survey unit.		
☐	FRS field measurement and analytical results.		
☐	LC-FS-PR-008 Attachment 10, "Final Radiation Survey Data Quality Objective Review Checklist"		
☐	LC-FS-PR-008 Attachment 12, "STS Preliminary Survey Data Summary"		
☐	LC-FS-PR-008 Attachment 13, "Sign Statistical Test"		
☐	Other : _____		

ATTACHMENT 16

STS SURVEY PLAN CLOSEOUT

Sign Test/ – STATISTICAL VALUES	
☐ The Survey Unit data results are Accepted	☐ The Survey Unit data results are Rejected
	Reason:_____
SURVEY UNIT REMEDIATION	
☐ No remediation required.	
☐ Perform additional investigation surveys.	
☐ For survey units containing residual radioactivity above the DCGL, recommend remediation.	
☐ If a Class 2 survey unit has a verified individual survey measurement (scan or direct) that exceeds the DCGL, consider reclassification of the survey unit or a portion of the survey unit.	
☐ If a Class 3 survey unit has an individual survey measurement (scan or direct) that exceeds 0.5 DCGL, recommend reclassification of the survey unit or a portion of the survey unit as a Class 2.	
☐ Other (Specify):	
Surveys have been completed and data has been evaluated. All forms are legible and complete. The survey unit has been properly classified and survey unit remediation prescribed.	

Prepared by: _____ Date: _____

(Print/Sign) FRS Supervisor

Reviewed and Approved by: _____ Date: _____

(Print/Sign) RP FRS Manager

ATTACHMENT 17

FSS SURVEY PLAN CLOSEOUT

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FRS Sample Plan #:	Survey Unit #:	
Survey Unit Location/Description:		

The following documentation is included in the FRS Sample Plan

	DESCRIPTION	TOTAL	COMMENTS
☐	LC-FS-PR-002 Attachment 11, "FRS Sample Plan Cover Sheet"		
☐	LC-FS-PR-002 Attachment 1, "Area Turnover and Control Checklist"		
☐	LC-FS-PR-010 Attachment 2, "Pre-Turnover Walk-Down"		
☐	LC-FS-PR-006 Attachment 1, "Survey Unit Classification Basis Summary"		
☐	LC-FS-PR-006 Attachment 2, "Survey Unit Classification Worksheet"		
☐	LC-FS-PR-002 Attachment 11, "FRS Data Quality Objectives and Survey Design		
☐	LC-FS-PR-002 Attachment 12, "FRS FRS Survey Instructions"		
☐	LC-FS-PR-002 Attachment 13, "Field Log."		
☐	LC-FS-PR-002 ATTACHMENT 14, "Sample/Measurement Identification and Coordinates."		
☐	LC-FS-PR-002 Attachment 15, "Scan Area Identification and Coordinates."		
☐	Photographs, maps, and/or drawings of the survey unit.		
☐	FRS field measurement and analytical results.		
☐	LC-FS-PR-008 Attachment 10, "Final Radiation Survey Data Quality Objective Review Checklist"		
☐	LC-FS-PR-008 Attachment 11, "FSS Preliminary Survey Data Summary"		
☐	LC-FS-PR-008 Attachment 13, "Sign Statistical Test"		
☐	Other : _____		

ATTACHMENT 17

FSS SURVEY PLAN CLOSEOUT

Sign Test – STATISTICAL VALUES	
☐	The Survey Unit data results are Accepted ☐ The Survey Unit data results are Rejected
	Reason:_____
SURVEY UNIT REMEDIATION	
☐	No remediation required.
☐	Perform additional investigation surveys.
☐	For survey units containing residual radioactivity above the DCGL, recommend remediation.
☐	If a Class 2 survey unit has a verified individual survey measurement (scan or direct) that exceeds the DCGL, consider reclassification of the survey unit or a portion of the survey unit.
☐	If a Class 3 survey unit has an individual survey measurement (scan or direct) that exceeds 0.5 DCGL, recommend reclassification of the survey unit or a portion of the survey unit as a Class 2.
☐	Other (Specify):
Surveys have been completed and data has been evaluated. All forms are legible and complete. The survey unit has been properly classified and survey unit remediation prescribed.	

Prepared by: _____ Date: _____

(Print/Sign) FRS Supervisor

Reviewed and Approved by: _____ Date: _____

(Print/Sign) RP FRS Manager