Radionuclides of Concern in Support of the Fort Calhoun License Termination Plan

Technical Support Document No. 21-043 Revision 01

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August 2, 2021

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1 Calculations/Document Review and Validations

During the development of this TSD, several spreadsheets were developed to create the contained data tables. As noted in this coversheet, three reviewers are listed. The roles of each reviewer were different as described below.

- Eric Darois. Mr. Darois developed a spreadsheet to extract data from the GEL Electronic Data Delivery (EDD) file(s) for each sample ID and for each radionuclide while decay-correcting the measurement result from the analysis date to the estimated date of license termination. This spreadsheet set any negative analytical results to zero. This extraction also calculated ingrowth of Am-241 from the decay of Pu-241. Due to the size of this spreadsheet, the original spreadsheet was divided into stand-alone spreadsheets and further developed by Mr. Davis for the final data tables contained within this document. Mr. Darois did a comprehensive review of Mr. Davis' spreadsheets. Mr. Darois also did a comprehensive review of the completed TSD for grammar, format, and textual accuracy.
- Joe Davis. Mr. Davis was the primary author of this TSD. However, he performed a comprehensive review of the spreadsheet developed by Mr. Darois including validations and hand-calculations.
- Terry Sullivan. Mr. Sullivan performed a comprehensive and independent review of the document and the associated data. He was not involved in the development of this TSD.

2 Executive Summary

To assist in decommissioning planning for the Fort Calhoun Nuclear Generating Station (FCS), this Technical Support Document (TSD) identifies a comprehensive suite of radionuclides potentially present at the site. The identified radionuclides are then used in conjunction with the calculated Derived Concentration Guide Limits (DCGLs) to determine the Radionuclides of Concern (ROCs) and Insignificant Contributors (IC) to dose. Surrogate ratios are also determined for the Hard to Detect (HTD) radionuclides.

Radionuclide Selection

A systematic approach was taken including reviewing applicable nuclear industry guidance documents, relevant FCS specific historical information and representative available sample radionuclide data. The selection of the initial suite of radionuclides included identifying the potential radionuclides as well as eliminating those radionuclides which would not be present due to decay or may be present but in insignificant concentrations.

A preliminary evaluation was performed to document an initial suite of radionuclides for the decommissioning of FCS. This was contained in FC-018-002 *"Potential Radionuclides of Concern During the Decommissioning of Fort Calhoun Station".*

From November 2019 through March 2020, the staff at Fort Calhoun station implemented a comprehensive concrete characterization program. From this sample population, 37 samples were then sent to an offsite laboratory for a wide range of radionuclide analytes.

FC-20-007 *"Fort Calhoun Station Potential Radionuclides of Concern pCi/g"* used the offsite results to calculate the fractional results for each radionuclide to identify those present in the sampled plant environments. It then compared these results to the initial listing from FC-018-002 and selected the initial suite of radionuclides for Derived Concentration Guide Limit (DCGL) development.

In April 2021, twenty additional concrete samples were analyzed by GEL for Np-237 in addition to the previous suite of radionuclides. This brought the total number of concrete samples analyzed at the off-site laboratory to 57.

Soil Sampling Results

FC-18-003 *"Evaluation of Cs-137 Global Fallout in Soils at Fort Calhoun Station"* provides a review of information from published global fallout studies and Fort Calhoun Station soil sample data. It provides the technical basis for anticipated soil concentrations attributable to fallout.

As part of this study, fifteen background samples were taken in areas around Fort Calhoun. Of these background samples, eight showed positive Cs-137 activity levels detectable by gamma spectroscopy. For the three samples that did not have an identifiable Cs-137 peak, the Cs-137 activity calculated by the spectroscopy software was used. Two of the gamma spectroscopy results had an identified Cs-137 peak and were less than the minimum detectable activity (MDA). These five values were included as part of the statistical analysis. The three samples which had no identified Cs-137 were not used in the statistical analysis. The mean of the data used was 0.104 pCi/g and the standard deviation was 0.105 pCi/g. At the 95% confidence interval the activity of Cs-137 was 0.314 pCi/g.

In 2018 as part of a partial site release process, The U.S. Nuclear Regulatory Commission (NRC) requested that Oak Ridge Institute for Science and Education (ORISE) perform confirmatory survey activities of areas classified by FCS as non-impacted. The confirmatory survey included surface gamma scanning and collection of randomly selected volumetric soil samples. No elevated direct radiation was identified during surface gamma scanning. Subsequently, no judgmental samples were collected. Radionuclides that were identified in the random soil samples were attributable to natural sources and not site operations.

Cesium-137 was positively identified, above the analytical Minimum Detectable Concentration (MDC), in 16 of the 25 randomly selected confirmatory soil samples. The maximum Cs-137 concentration was 0.372 pCi/g. The average Cs-137 concentration for the confirmatory survey FCS Non-Impacted Land Areas was 0.09 pCi/g, which is less than the mean background concentration. Other radionuclides detected in the soil samples were naturally occurring and not attributable to site operations.

As part of site characterization in August 2020, 47 soil samples were sent to an offsite laboratory for a wide range of radionuclide analytes. The only positively identified radionuclides above MDA was Cs-137. The average of the positive Cs-137 results was 1.14E-01 pCi/g. The average MDA for C-14 was 3.51 pCi/g. The average Ni-63 MDA was 2.89E+00 pCi/g. The average Sr-90 MDA was 8.82E-02 pCi/g.

Radionuclide Mixture Fractions

The mixture fraction of each radionuclide in the initial suite at the projected time of license termination (October 5, 2026) has been determined using the results of the 57 concrete characterization sample analyses. Two separate sample populations were analyzed. The first population consisted solely of the Containment Building (CB) samples. The second population consisted of the Auxiliary Building, Turbine Building and Radioactive Waste Processing Building samples. The Containment Bldg. and AB/TB/RWPB sample populations were analyzed separately to recognize the potential that these may contain different radionuclide mixtures.

For each of these populations, the radionuclide fractions were determined from the decayed analytical data using three separate approaches. The three methods were chosen to represent common and conservative methods in determining activity fractions to ensure that the final selection of the radionuclide mixtures account for variability and represent conservative estimates. Each of the analysis methods use the actual reported laboratory values, whether detected or less than the reported MDC values. All negative decay corrected results were set to zero to avoid having fractional results greater than one. The results were then decay-corrected from the date of sample analysis to the anticipated date of license termination. The Am-241 decay corrected value was also adjusted to account for its in-growth from Pu-241.

The first method was to calculate the radionuclide activity fraction for each sample and each radionuclide, within each population from the reported radionuclide activity concentrations and then calculate the average activity fraction for each radionuclide, and population of samples.

The second method was to calculate the 75th percentile of the population of samples. Once the 75th percentile fraction were calculated for each radionuclide, the data set was re-normalized to determine the percentile-based activity fractions.

The third method was to calculate the individual radionuclide ratios to Cs-137 for each sample, calculate the 75th percentile for the sample group, then renormalize to determine the activity fractions.

The analyses described above remove the activity weighting and give equal statistical weight to each of the sample results. Based on the evaluation using the three statistical methods, the two methods involving the use of the 75th percentiles result in very similar results, particularly the IC dose fractions.

Using the 75th percentile provides sufficient overall conservatism in the development of the radionuclide mixtures. In addition, there is prior precedence in using the 75th percentile, particularly in the parameter selection process for dose modeling to support DCGL calculations and that this approach also results in satisfactory conservatism.

The '75th percentile of the Cs-137 fractions' has been selected to represent the overall nuclide mix for the Combined sample population, the Containment Building sample population, and the AB/TB/RWPB sample population.

The CB mix fraction contains an unusually high proportion of C-14 at 54.9%. The potential for cross contamination from this source term will be closely monitored during decommissioning.

Radionuclides of Concern and Insignificant Contributors to Dose

In accordance with NUREG-1757, radionuclides that contribute, in aggregate, less than 10% of the 25 mrem/yr dose criteria are considered to be "insignificant". The insignificant contributor radionuclides may be eliminated from further consideration in FSS and from detailed dose modeling but the aggregate dose from the insignificant contributors must be accounted for in demonstrating compliance. The remaining radionuclides, after the insignificant contributors are removed, and the associated mixture fractions, will comprise the final ROC list that will undergo evaluation in the LTP.

The Relative Dose Fraction for each nuclide is calculated using the applicable DCGL and radionuclide mixture fraction. The evaluation provided in this TSD uses the radionuclide mixture fractions of the initial suite of radionuclides and selects the radionuclides that are "insignificant dose contributors" (IC) as defined in NUREG-1757, albeit a substantially lower IC dose fraction. The radionuclides remaining after the insignificant dose contributors are eliminated are the radionuclides of concern (ROCs) that will undergo detailed analysis on Chapters 4, 5 and 6 of the FCS LTP. The insignificant contributor (IC) dose fraction will be accounted for by adjusting the final DCGLs for each ROC.

The ROCs for the CB walls and floors are C-14, Co-60, Sr-90, Cs-137 and Eu-152.

The ROCs for the CB mix fraction soil, fill material and buried pipe scenarios are C-14, Co-60, Cs-137 and Eu-152.

The ROCs for Other walls/floors are C-14, Co-60, Sr-90, Cs-137 and Eu-152.

The ROCs for AB/TB embedded pipes are C-14, Co-60, Sr-90, Cs-137 and Eu-152.

The ROCs for the AB/TB/RWPB mix fraction soil, fill material and buried pipe scenarios are C-14, Co-60, Cs-137 and Eu-152.

The remaining radionuclides are eliminated from further detailed evaluation. The ROCs were selected to ensure that sufficient margin has been attributed to the estimated dose contribution from the insignificant radionuclides. This decreases the risk of having to recalculate the adjusted DCGLS.

The IC dose fraction ranges from approximately 0.28% to 8.88% of the total dose depending on the source and the method used for determining the fractions. The highest value for the IC dose fraction is from the AB/TB/RWPB mix fraction for the Backfill Material scenario using the 75^{th} percentiles of the nuclide ratios to Cs-137 statistical method.

In addition to the analysis described above for the DCGL scenarios, five "Less Likely But Plausible" (LLBP) scenarios were also analyzed. This analysis used the same sample population mix fractions and statistical methods as was used in the DCGL scenario analyses.

The IC dose fraction for the LLBP scenarios ranges from approximately 0.01% to 0.90% of the total dose depending on the source and the method used for determining the fractions. The highest LLBP IC dose fraction is from the Steel Recycling/Disposal scenario in the Containment Building using 75th percentiles of the nuclide ratios to Cs-137.

Surrogate Ratios

From the data provided in sections 6.1, 6.2, 6.3 and 6.4, it is evident that Cs-137 is the predominant ROC gamma-emitting radionuclide. Co-60 and Eu-152 are also gamma emitting ROCs but are present at much lower fractions than Cs-137. Also, C-14, and Sr-90 are identified as ROCs while also being HTD radionuclides.

Cs-137 was selected as the most appropriate gamma emitter for the surrogate relationship for both Sr-90 and C-14. This was based on the high percentage of Cs-137 (93-98%) and the low percentage of Co-60 (2.0-2.5%). Due to the high percentage of C-14 in the mix fractions (83% in the CB and 5% in the AB/TB/RWPB) the resulting surrogate ratio to Co-60 would have been impractical to use. Due to instrument sensitivities and the high C-14/Co-60 ratios, it would not be possible to meet the required scan MDCs.

The ratio of HTDs to gamma emitters is required to develop a surrogate relationship as defined in MARSSIM. The concentration of HTDs can be inferred from the concentration of a gamma emitter in cases where samples are not subject to HTD analysis during FSS activities.

For the samples where neither nuclide was detected, the ratio of the MDC's was not used since this is merely a ratio of the detectability of the two nuclides for that specific sample and has no relationship to the activity ratio.

Of the 57 samples, 43 of the Sr-90, 55 of the C-14 and 56 of the Cs-137 results were greater than MDC. One sample was non-detectable for both Sr-90 and Cs-137 and one sample was non-detectable for both C-14 and Cs-137.

To account for the variability and level of uncertainty in the data, the 95th percentile values were selected for the final surrogate ratios. Using the 95th percentile value along with the MDC substituted will provide reasonable conservatism during the final status surveys.

The C-14/Cs-137 ratio for the CB mix fraction is 3.83E+01. The C-14/Cs-137 ratio for the AB/TB/RWPB mix fraction is 1.11E+00.

The Sr-90/Cs-137 ratio for the CB mix fraction is 1.25E-02.The Sr-90/Cs-137 ratio for the AB/TB/RWPB mix fraction is 1.97E-01.

3 Introduction

An important part of assessing and developing characterization plans, FSS plans and performing dose assessments at FCS is the identification of radionuclides that could result in a significant dose

contribution at the time of license termination. A technical evaluation was performed to document an initial suite of radionuclides for the decommissioning of FCS. A final ROC list is then developed that provides the radionuclides that will undergo detailed evaluation for FSS design and dose modeling in the License Termination Plan (LTP) (Chapters 5 and 6).

A systematic approach was taken including reviewing applicable nuclear industry guidance documents, relevant FCS specific historical information and representative available sample radionuclide data. The selection of the initial suite of radionuclides includes identifying the potential radionuclides as well as eliminating those radionuclides which would not be present due to decay or may be present but in insignificant concentrations.

The mixture fraction of each radionuclide in the initial suite at the time of license termination uses the results of concrete characterization sample analyses. The mixture fraction will be used in conjunction with the dose assessment methods developed for Chapter 6 of the FCS LTP to calculate the relative dose significance of the radionuclides in the initial suite. In accordance with NUREG-1757, Volume 2, Revision 1, Section 3.3 [1.] radionuclides that contribute, in aggregate, less than 10% of the 25 mrem/yr dose criteria are considered to be "insignificant". The insignificant contributor radionuclides may be eliminated from further consideration in FSS and from detailed dose modeling but the aggregate dose from the insignificant contributors must be accounted for in demonstrating compliance. The remaining radionuclides, after the insignificant contributors are removed, and the associated mixture fractions, will comprise the final ROC list that will undergo evaluation in the LTP.

4 Industry Document Review

For the development of the suite of potential radionuclides of concern, several nuclear industry guidance documents were reviewed, including NUREG/CR-3474 [2.] and NUREG/CR-4289 [3.]. NUREG/CR-3474 provides tables of theoretical activation products for both pressurized water reactors (PWR) and boiling water reactors (BWR) based on typical materials of construction, anticipated impurities, assumed neutron flux, etc. An initial list of radionuclides, as shown in was developed by listing those radionuclides noted in both Table 5.13 "Activity Inventory of PWR Internals at Shutdown (Total Ci)" and Table 5.15, "Inventories of PWR and BWR Vessel Walls at Shutdown (Total Ci)" from NUREG/CR-3474.

5 Initial Suite of Radionuclides

5.1 FC-18-002 *"Potential Radionuclides of Concern During the Decommissioning of Fort Calhoun Station"*

In March 2018, the Fort Calhoun RP technical staff prepared Technical Basis Document (TBD) FC-18-002, *"Potential Radionuclides of Concern During the Decommissioning of Fort Calhoun Station"* [4.]. This TBD evaluated expected radionuclides based on a review of industry guidance and site-specific FCS sample

results. This consisted of the results from 14 samples collected within various waste streams from 2016 through 2018 and analyzed by an offsite laboratory for nuclides typically required by 10 CFR 61. Based upon the review of theoretical radionuclides noted in NUREG PWR studies, and the waste/process stream sample results, an initial suite of radionuclides was generated for consideration as listed in Table 1.

Table 1: Initial List of Radionuclides from FC-18-002

Radionuclide	Half-Life, years
H-3	12.3
Fe-55	2.73
Co-60	5.27
Ni-63	100.1
Sr-90	28.74
Cs-134	2.07
Cs-137	30.04
Pu-238	87.7
Pu-239/240	24110
Pu-241	14.35
Am-241	432.2
Cm-243/244	29.1

5.2 FC-20-007 *"Fort Calhoun Station Potential Radionuclides of Concern"*

From November 2019 through March 2020, the staff at Fort Calhoun station implemented a comprehensive concrete characterization program.

Four separate sample plans were developed and implemented using the Tru-Pro concrete sampling techniques representing 744 discrete samples at multiple depths up to 6 inches. The sample plans are contained in references [8.], [9.], [10.] and [11.]. The samples were collected in the following buildings:

- containment building,
- auxiliary building,
- turbine building, and
- radwaste processing building.

Each of the 744 samples were analyzed using the onsite gamma spectroscopy system. From this sample population, 37 samples were then sent to an offsite laboratory for a wide range of radionuclide analytes. This analysis included alpha, beta and gamma emitting radionuclides typically considered during nuclear power plant decommissioning projects. The offsite analysis was performed by GEL Laboratories LLC in Charleston SC and the results are reported in references [13.], [14.], [15.] and [16.].

The list of radionuclide analyses conducted by GEL are listed in Table 2: Radionuclides Analyzed at GEL Laboratories below:

Table 2: Radionuclides Analyzed at GEL Laboratories for the Initial 37 Samples

H-3	Zn-65	Eu-152
C-14	Nb-94	Eu-154
Mn-54	Tc-99	Eu-155
Fe-55	Sr-90	Pu-238
Co-57	Ag-110m	Pu-239/ 240
Co-58	Sb-125	Pu-241
Ni-59	Cs-134	Am-241
Ni-63	Cs-137	Cm-242
Co-60	Ce-144	Cm-243/ 244

It should be noted that due to alpha energy resolution limitations, the laboratories report two radionuclide pairs; Pu-239/240, and Cm-243/244. Each of these pairs are considered a single reported nuclide in this analysis.

FC-20-007 *"Fort Calhoun Station Potential Radionuclides of Concern"* [5.] calculated the fractional results for each radionuclide to identify those present in the sampled plant environments and compared this list to the initial listing from FC-018-002 and selected the initial suite of radionuclides for Derived Concentration Guide Limit (DCGL) development.

The results of the analysis were used to evaluate whether additional radionuclides should be added or removed from the list provided in FC-018-002. This analysis identified 22 radionuclides that should be included in the initial listing of radionuclides as compared to the 12 that were initially identified in FC-018-002. No radionuclides were identified in the concrete samples that were not accounted for by the assessments described above. The initial suite of radionuclides is listed in Table 3: Initial Suite of FCS Site-Specific Radionuclides From FC-20-007 below.

Table 3: Initial Suite of FCS Site-Specific Radionuclides From FC-20-007

Radionuclide	Half Life (Years)
H-3	1.23E+01
C-14	5.70E+03
Fe-55	2.74E+00
Co-58	1.94E-01
Ni-59	1.01E+05
Co-60	5.27E+00
Ni-63	1.00E+02
Sr-90	2.88E+01
Tc-99	2.11E+05
Sb-125	2.76E+01
Cs-134	2.06E+00
Cs-137	3.02E+01
Ce-144	7.80E-01
Eu-152	1.35E+01
Eu-154	8.80E+00

Eu-155	4.76E+00
Np-237	2.14E+06
Pu-238	8.77E+01
Pu-239/240*	2.41E+04
Pu-241	1.44E+01
Am-241	4.32E+02
Cm-243/244*	2.85E+01

* For each of these radionuclide pairs the shortest half-life was selected.

5.3 Additional Analysis of Concrete Samples

In April 2021, 20 additional concrete samples were also analyzed by GEL. These analyses included Np-237 bringing the total number of concrete samples analyzed offsite to 57.

Table 4: Radionuclides Analyzed at GEL Laboratories for the 20 Additional Samples

H-3	Zn-65	Eu-152
C-14	Nb-94	Eu-154
Mn-54	Tc-99	Eu-155
Fe-55	Sr-90	Pu-238
Co-57	Ag-110m	Pu-239/ 240
Co-58	Sb-125	Pu-241
Ni-59	Cs-134	Am-241
Ni-63	Cs-137	Cm-242
Co-60	Ce-144	Cm-243/ 244
		Np-237

The concrete samples sent for offsite analysis were collected in the following locations, twenty-seven (27) from the Containment Building, twenty-six(26) from the Auxiliary Building, two (2) from the Turbine Building and two(2) from the Radwaste Processing Building. A summary of the samples is provided in Table 5.

5.4 Summary of Concrete Samples

Table 5: Sample Location Summary of the 57 Concrete Samples Sent for Offsite Analysis

Area Name	Sample ID Prefix	# Of Samples
CB 977’ Elevation – Under Vessel Area	1100	3
CB 995’/996’ Elevation G/A	1200	17
CB 1013’ Elevation G/A	1300	5
CB 1045’ Elevation G/A	1400	2
AB 971’ Elevation G/A	2100	6
AB 989’ Elevation G/A	2200	13
AB 1007’ Elevation G/A	2300	6
AB 1025’ Elevation G/A	2600	1

TB 990' Elevation G/A	3100	2
Radwaste Processing Building	4100	2
Total		57

Table 6 provides the sample identification numbers, types and general locations for all 57 concrete samples analyzed by GEL.

Table 6: Listing of Concrete Sample ID Numbers, Types and Locations

Sample ID	Elevation	Surface (floor/wall)
1100X-1-CJ-FCV1-005	CB 977' Elevation – Under Vessel	Concrete Floor
1100X-1-CJ-WCV1-003	CB 977' Elevation – Under Vessel	Concrete Wall
1100X-1-CJ-WCV1-004	CB 977' Elevation – Under Vessel	Concrete Wall
1200X-1-CJ-FCV1-001	CB 995'/996' Elevation G/A	Concrete Floor
1200X-1-CJ-FCV1-002	CB 995'/996' Elevation G/A	Concrete Floor
1200X-1-CJ-FCV1-003	CB 995'/996' Elevation G/A	Concrete Floor
1200X-1-CJ-FCV1-010	CB 995'/996' Elevation G/A	Concrete Floor
1200X-1-CJ-FCV1-018	CB 995'/996' Elevation G/A	Concrete Floor
1200X-1-CJ-FCV1-023	CB 995'/996' Elevation G/A	Concrete Floor
1200X-1-CJ-FCV1-025	CB 995'/996' Elevation G/A	Concrete Floor
1200X-1-CJ-FCV1-027	CB 995'/996' Elevation G/A	Concrete Floor
1200X-1-CJ-WCV1-005	CB 995'/996' Elevation G/A	Concrete Wall
1200X-1-CJ-WCV1-006	CB 995'/996' Elevation G/A	Concrete Wall
1200X-1-CJ-WCV1-008	CB 995'/996' Elevation G/A	Concrete Wall
1200X-1-CJ-WCV1-009	CB 995'/996' Elevation G/A	Concrete Wall
1200X-1-CJ-WCV1-011	CB 995'/996' Elevation G/A	Concrete Wall
1200X-1-CJ-WCV1-012	CB 995'/996' Elevation G/A	Concrete Wall
1200X-1-CJ-WCV1-015	CB 995'/996' Elevation G/A	Concrete Wall
1200X-1-CJ-WCV1-028	CB 995'/996' Elevation G/A	Concrete Wall
1200X-1-CJ-WCV1-029	CB 995'/996' Elevation G/A	Concrete Wall
1300X-1-CJ-FCV1-003	CB 1013' Elevation G/A	Concrete Floor
1300X-1-CJ-FCV1-005	CB 1013' Elevation G/A	Concrete Floor
1300X-1-CJ-FCV1-006	CB 1013' Elevation G/A	Concrete Floor
1300X-1-CJ-FCV1-008	CB 1013' Elevation G/A	Concrete Floor
1300X-1-CJ-WCV1-007	CB 1013' Elevation G/A	Concrete Wall
1400X-1-CJ-FCV1-002	CB 1045' Elevation G/A	Concrete Floor
1400X-1-CJ-FCV1-021	CB 1045' Elevation G/A	Concrete Floor
2100X-1-CJ-FCV1-001	AB 971' Elevation G/A	Concrete Floor
2100X-1-CJ-FCV1-003	AB 971' Elevation G/A	Concrete Floor
2100X-1-CJ-FCV1-005	AB 971' Elevation G/A	Concrete Floor
2100X-1-CJ-FCV1-006	AB 971' Elevation G/A	Concrete Floor
2100X-1-CJ-FCV1-011	AB 971' Elevation G/A	Concrete Floor
2100X-1-CJ-FCV1-014	AB 971' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-006	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-008	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-010	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-020	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-021	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-022	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-026	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-030	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-031	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-035	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-038	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-FCV1-039	AB 989' Elevation G/A	Concrete Floor
2200X-1-CJ-WCV1-009	AB 989' Elevation G/A	Concrete Wall

Sample ID	Elevation	Surface (floor/wall)
2300X-1-CJ-FCV1-001	AB 1007' Elevation G/A	Concrete Floor
2300X-1-CJ-FCV1-002	AB 1007' Elevation G/A	Concrete Floor
2300X-1-CJ-FCV1-003	AB 1007' Elevation G/A	Concrete Floor
2300X-1-CJ-FCV1-005	AB 1007' Elevation G/A	Concrete Floor
2300X-1-CJ-FCV1-007	AB 1007' Elevation G/A	Concrete Floor

Table 7 shows the average decay corrected MDCs from all 57 samples analyzed by GEL for each radionuclide. This listing demonstrates that an effective average MDC was achieved by GEL for each analysis.

Table 7: Average Decay Corrected MDCs from 57 GEL Analysis Results of Concrete Samples for Each Radionuclide

Radionuclide	Average MDC (pCi/g)
H-3	9.06E+00
C-14	2.08E+01
Mn-54	4.38E-03
Fe-55	3.70E+00
Co-57	2.41E-01
Co-58	4.82E-08
Ni-59	2.17E+00
Ni-63	1.93E+01
Co-60	1.25E+00
Zn-65	4.02E-03
Nb-94	3.02E-01
Tc-99	1.27E+00
Sr-90	2.93E-01
Ag-110m	2.57E-03
Sb-125	5.29E-01
Cs-134	1.11E-01
Cs-137	2.33E+01
Ce-144	1.83E-02
Eu-152	7.70E+00
Eu-154	1.19E+00
Eu-155	6.08E-01
Pu-238	3.79E-02
Pu-239/240	4.06E-02
Pu-241	2.32E+00
Am-241	7.35E-02
Cm-242	3.74E-05
Cm-243/244	5.15E-02
Np-237	2.37E-03

Attachment 1 provides the analytical results for all 57 concrete samples. These results include all results as reported by GEL, whether or not they were less than any screening value including the MDC. Negative decay corrected results have been reset to zero to avoid generating fractional results greater than one. The reported concrete sample concentrations were decay corrected from the sample analysis dates to the anticipated license termination date of October 5, 2026.

The decay corrected Am-241 concentrations include the in-growth of activity from the decay of Pu-241. Equation 1 represents how this was accounted for.

Equation 1

$$(At)_2 = \left(\frac{\lambda_2 A_1^0}{\lambda_2 - \lambda_1}\right)\left(e^{-\lambda_1 t} - e^{-\lambda_2 t}\right) + A_2 e^{-\lambda_2 t}$$

These 57 sample results represent the total population used for the ROC and IC fraction analyses in this TSD. This data is used in the determination of the radionuclide mixtures and the potential dose from IC radionuclides and their associated relative contributions.

5.5 Soil Sample Analysis

FC-18-003 "*Evaluation of Cs-137 Global Fallout in Soils at Fort Calhoun Station*" [6.] provides a review of information from published global fallout studies and Fort Calhoun Station soil sample data. It provides the technical basis for anticipated soil concentrations attributable to fallout.

As part of this study, fifteen background samples were taken in areas around Fort Calhoun. Of these background samples, eight showed positive Cs-137 activity levels detectable by gamma spectroscopy. For the three samples that did not have an identifiable Cs-137 peak, the Cs-137 activity was calculated by the spectroscopy software was conservatively used. Two of the gamma spectroscopy results had an identified Cs-137 peak and were less than the minimum detectable activity (MDA). These five values were included as part of the statistical analysis. The three samples analyzed offsite which had no identified Cs-137 were not used in the statistical analysis. The mean of the data used was 0.104 pCi/g and the standard deviation (k=1) was 0.105 pCi/g. At the 95% confidence interval (k=2) the activity of Cs-137 was 0.314 pCi/g.

In 2018 as part of a partial site release process, The U.S. Nuclear Regulatory Commission (NRC) requested that Oak Ridge Institute for Science and Education (ORISE) perform confirmatory survey activities of areas classified by FCS as non-impacted [7.]. The confirmatory survey included surface gamma scanning and collection of randomly selected volumetric soil samples. No elevated direct radiation was identified during surface gamma scanning. Subsequently, no judgmental samples were collected. Radionuclides that were identified in the random soil samples were attributable to natural sources and not site operations.

Cesium-137 was positively identified, above the analytical MDC, in 16 of the 25 randomly selected confirmatory soil samples. The maximum Cs-137 concentration was 0.372 pCi/g. The average Cs-137 concentration for the confirmatory survey FCS Non-Impacted Land Areas was 0.09 pCi/g, which is less than the mean background concentration. Other radionuclides detected in the soil samples were naturally occurring and not attributable to site operations.

As part of site characterization in August 2020, 47 soil samples were sent to an offsite laboratory for a wide range of radionuclide analytes [12.]. The only positively identified radionuclides above MDA was

Cs-137. The average of the positive Cs-137 results was 1.14E-01 pCi/g. The average MDA for C-14 was 3.51 pCi/g. The average Ni-63 MDA was 2.89E+00 pCi/g. The average Sr-90 MDA was 8.82E-02 pCi/g.

6 Insignificant Dose Contributors and Radionuclide Mixture

One of the objectives of site characterization is to establish the radionuclide profiles for the various media for the purposes of ALARA analysis, dose assessment and FSS planning. The evaluation provided in this section determines the radionuclide mixture fractions of the initial suite of radionuclides and selects the radionuclides that are "insignificant dose contributors" as defined in NUREG-1757, Vol. 2, Rev 1 [1.]. The radionuclides remaining after the insignificant dose contributors are eliminated are the radionuclides of concern (ROCs) that will undergo detailed analysis on Chapters 4, 5 and 6 of the FCS LTP. The insignificant contributor (IC) dose fraction will be accounted for by adjusting the final DCGLs for each ROC. This TSD section is divided into two subsections; one for determining radionuclide mixture fractions using three methods, and a second to establish the IC dose fraction for each media's set of DCGLs.

6.1 Radionuclide Mixture Fractions

The radionuclide mixture fractions are derived from the results of the 57 concrete samples. Two separate sample populations were analyzed. The first population consisted solely of the Containment Building samples. The second population consisted of the Auxiliary Building, Turbine Building and Radioactive Waste Processing Building (AB/TB/RWPB) samples. The Containment Building and AB/TB/RWPB sample populations were analyzed separately to recognize the potential that these may contain different radionuclide mixtures.

The composition of the two sample populations was based on process knowledge and the initial evaluation of the sample results. This initial evaluation showed that the Containment Building and the Auxiliary Building formed two distinct sample populations.

For each of these two populations, *k*, the radionuclide fractions were determined from the decay corrected analytical data using three separate approaches as described below. The three methods were chosen to represent common and conservative methods in determining activity fractions to ensure that the final selection of the radionuclide mixtures account for variability and represent conservative estimates. Each of the three analysis methods use the actual reported laboratory values, whether detected or less than the reported MDC values. All negative results were reset to zero to avoid generating fractional results greater than one. The results were decay corrected from the date of sample analysis to the anticipated date of license termination. The Am-241 results also account for the in-growth from Pu-241.

An additional evaluation was performed to determine the impact of combining the 2 TB and 2 RWPB samples with the 26 AB samples into a single population. This evaluation showed that adding these 4 samples to the AB sample population did not result in a significant change to the AB mixture fraction. The results of this comparison are contained in Table 8. These fractions were calculated using the methods described above.

Table 8: Comparison of AB Only Sample Fractions with AB/TB/RWPB Sample Fractions

Radionuclide	AB Only Average Activity Fractions	AB, TB & RWPB Average Activity Fractions	AB Only 75 Perc. Norm. Frac.	AB, TB & RWPB 75 Perc. Norm. Frac.	AB Only Normalized Fractions, 75th Percentile of the Individual Sample Ratios to Cs-137	AB, TB & RWPB Normalized Fractions, 75th Percentile of the Individual Sample Ratios to Cs-137
H-3	3.00E-02	2.60E-02	2.93E-02	2.76E-02	3.22E-02	2.52E-02
C-14	4.05E-02	9.72E-02	2.97E-02	4.43E-02	3.94E-02	5.14E-02
Fe-55	1.43E-03	7.83E-03	6.61E-04	1.42E-03	5.78E-04	2.33E-03
Co-58	8.01E-11	6.94E-11	6.07E-15	4.54E-14	5.31E-15	7.00E-14
Ni-59	1.98E-03	3.11E-03	1.81E-03	1.82E-03	2.51E-03	2.48E-03
Ni-63	2.37E-01	2.25E-01	2.53E-01	2.55E-01	3.47E-01	3.43E-01
Co-60	6.89E-03	7.79E-03	6.93E-03	6.99E-03	7.96E-03	1.15E-02
Tc-99	8.18E-03	7.09E-03	5.66E-04	4.68E-04	7.30E-04	5.23E-04
Sr-90	2.70E-03	9.22E-03	1.95E-03	2.79E-03	2.13E-03	2.51E-03
Sb-125	9.18E-05	3.12E-04	8.46E-05	1.81E-04	1.34E-04	1.65E-04
Cs-134	9.58E-05	2.05E-04	9.54E-05	1.16E-04	1.59E-04	1.67E-04
Cs-137	6.67E-01	6.08E-01	6.72E-01	6.55E-01	5.62E-01	5.55E-01
Ce-144	3.82E-06	1.91E-05	1.23E-06	3.38E-06	1.83E-06	3.36E-06
Eu-152	5.41E-04	1.35E-03	4.03E-04	5.09E-04	5.00E-04	7.15E-04
Eu-154	7.08E-05	2.33E-03	4.85E-05	6.67E-05	7.22E-05	1.13E-04
Eu-155	1.85E-04	3.45E-04	1.67E-04	1.69E-04	2.75E-04	2.72E-04
Pu-238	2.48E-05	3.86E-04	2.48E-05	3.69E-05	2.62E-05	3.01E-05
Pu-239/240	2.06E-05	9.74E-05	2.50E-05	3.01E-05	2.47E-05	2.47E-05
Pu-241	3.03E-03	4.09E-03	3.16E-03	3.19E-03	4.82E-03	4.77E-03
Am-241	7.47E-05	9.73E-05	1.01E-04	1.02E-04	1.34E-04	1.32E-04
Cm-243/244	2.35E-05	8.54E-05	1.06E-05	1.07E-05	1.53E-05	1.51E-05
Np-237	7.28E-07	7.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00

1. The first was to calculate the radionuclide activity fraction, $fA_{i,j,k}$, for each sample, *j*, each radionuclide, *i*, within each population, *k*, from the reported decay corrected radionuclide activity concentrations, $C_{i,j,k}$, using Equation 2 and then calculating the average activity fraction, $fA_{i,j,k}$, for each radionuclide, *i*, and population, *k*, of N samples using Equation 3.

$$fA_{i,j,k} = \frac{C_{i,j,k}}{\sum(j)C_{i,j,k}}$$ **Equation 2**

$$fA_{i,j,k} = \frac{\sum(j)fA_{i,j,k}}{N}$$ **Equation 3**

2. The second was to calculate the 75th percentile of the population of samples from Equation 2 above. Once the 75th percentile fraction were calculated for each radionuclide, $f_{i,k,.75}$, the data set was re-normalized to determine the percentile-based activity fractions, $fA_{i,k,.75}$ using Equation 4.

$$fA_{i,k,.75} = \frac{f_{i,j,k,.75}}{\sum(j)fA_{i,j,k,.75}}$$ **Equation 4**

3. The third was to calculate the individual radionuclide ratios to Cs-137 for each sample, $R_{i,Cs\text{-}137,j}$, calculate the 75th percentile for the sample group, $R_{i,Cs\text{-}137,k,.75}$ then renormalize to determine the activity fractions, $f_R A_{i,k,.75}$ using Equation 5.

$$f_R A_{i,k,.75} = \frac{R_{i,Cs-137,k,.75}}{\sum(i)R_{i,Cs-137,k,.75}}$$ **Equation 5**

The analyses described above remove the activity weighting and give equal statistical weight to each of the sample results. The results of the three methods are provided within each of the following subsections.

6.1.1 CONTAINMENT SAMPLE POPULATION NUCLIDE FRACTIONS

Tables 9 through 11 provide the radionuclide activity fractions for all sample data that will represent the Containment Building (CB) mixture. The data is subdivided into three tables to allow for convenient inspection of all 22 radionuclides. The last three rows of these tables provide the average fraction, the 75th percentile of each fractional data set, and the normalized 75th data set as described above. Tables 12 through 14 provide the radionuclide activity ratios to Cs-137 for all sample data that will represent the CB fractions. Similar to the previous three tables, the data is subdivided into three tables to allow for convenient inspection of all 22 radionuclides. The last two rows of these tables provide the 75th percentile of each ratio data set, and the normalized 75th data set as described above.

In the following tables, NA indicates “Not Analyzed” for the 37 samples in which Np-237 was not analyzed.

Table 9: Radionuclide Activity Fractions, $fA_{i,j}$ and $fA_{i,j,.75}$, Using Sample Data for Containment Building Samples, First Set of Radionuclides

Sample ID	H-3	C-14	Fe-55	Co-58	Ni-59	Ni-63	Co-60	Tc-99
1100X-1-CJ-FCV1-005	9.13E-02	1.15E-01	5.26E-02	0.00E+00	8.27E-04	7.41E-02	3.39E-02	3.33E-06
1100X-1-CJ-WCV1-003	5.60E-02	2.01E-01	8.25E-02	0.00E+00	0.00E+00	8.04E-02	4.08E-02	7.56E-05
1100X-1-CJ-WCV1-004	1.33E-01	6.82E-02	4.86E-02	8.33E-14	2.00E-03	1.45E-01	6.05E-02	1.65E-04
1200X-1-CJ-FCV1-001	2.34E-01	6.56E-01	0.00E+00	9.56E-15	3.05E-05	5.33E-02	8.64E-03	2.94E-04
1200X-1-CJ-FCV1-002	1.27E-01	6.41E-01	2.49E-04	0.00E+00	0.00E+00	1.25E-01	8.77E-03	9.87E-05
1200X-1-CJ-FCV1-003	1.40E-01	5.46E-01	0.00E+00	3.33E-16	6.13E-04	5.33E-02	4.84E-03	1.54E-04
1200X-1-CJ-FCV1-010	5.21E-01	1.18E-01	0.00E+00	0.00E+00	0.00E+00	1.09E-01	4.31E-03	3.30E-04
1200X-1-CJ-FCV1-018	2.50E-01	6.40E-01	4.77E-04	8.84E-16	0.00E+00	2.22E-02	3.07E-04	3.45E-05
1200X-1-CJ-FCV1-023	2.98E-02	1.24E-02	0.00E+00	2.11E-15	1.68E-03	1.66E-01	5.09E-03	3.21E-05
1200X-1-CJ-FCV1-025	1.17E-01	6.54E-01	0.00E+00	0.00E+00	5.60E-05	2.76E-02	1.24E-03	5.89E-05
1200X-1-CJ-FCV1-027	6.25E-02	2.72E-01	0.00E+00	4.38E-15	1.51E-04	1.61E-02	2.25E-03	0.00E+00
1200X-1-CJ-WCV1-005	2.19E-01	6.79E-01	0.00E+00	0.00E+00	4.43E-05	1.96E-02	9.68E-04	2.09E-04
1200X-1-CJ-WCV1-006	2.36E-03	9.88E-01	0.00E+00	5.56E-13	1.27E-04	7.75E-04	1.26E-04	0.00E+00
1200X-1-CJ-WCV1-008	6.22E-02	8.83E-01	0.00E+00	5.23E-11	2.07E-03	1.89E-02	1.90E-03	4.39E-04
1200X-1-CJ-WCV1-009	5.56E-02	8.56E-01	0.00E+00	6.05E-15	1.67E-04	3.37E-03	1.29E-04	2.16E-05
1200X-1-CJ-WCV1-011	4.99E-02	8.21E-01	0.00E+00	1.04E-11	0.00E+00	2.94E-03	1.92E-04	5.68E-04
1200X-1-CJ-WCV1-012	6.48E-02	7.84E-01	0.00E+00	5.20E-11	4.90E-04	3.31E-02	6.70E-04	4.52E-03
1200X-1-CJ-WCV1-015	6.75E-02	8.71E-01	0.00E+00	0.00E+00	0.00E+00	2.49E-03	7.04E-04	4.19E-03
1200X-1-CJ-WCV1-028	6.75E-02	1.32E-01	0.00E+00	4.95E-12	8.03E-03	2.59E-02	2.47E-02	4.38E-02
1200X-1-CJ-WCV1-029	4.73E-02	8.98E-01	0.00E+00	0.00E+00	0.00E+00	5.23E-03	5.88E-04	1.20E-02
1300X-1-CJ-FCV1-003	4.40E-02	2.19E-01	0.00E+00	0.00E+00	0.00E+00	2.18E-02	1.20E-03	6.89E-05
1300X-1-CJ-FCV1-005	2.52E-02	9.33E-01	0.00E+00	2.08E-12	1.46E-04	3.99E-03	4.95E-04	0.00E+00
1300X-1-CJ-FCV1-006	1.22E-01	1.56E-01	9.08E-04	5.54E-15	0.00E+00	3.07E-02	9.48E-04	0.00E+00
1300X-1-CJ-FCV1-008	3.76E-02	2.03E-01	3.45E-04	1.20E-14	1.13E-03	2.70E-02	8.68E-04	6.78E-05
1300X-1-CJ-WCV1-007	3.71E-02	8.83E-01	0.00E+00	0.00E+00	0.00E+00	6.93E-03	2.10E-04	3.22E-03
1400X-1-CJ-FCV1-002	2.36E-02	7.59E-01	0.00E+00	5.97E-17	1.80E-04	4.12E-03	1.27E-04	1.53E-05
1400X-1-CJ-FCV1-021	1.39E-01	8.27E-01	0.00E+00	0.00E+00	7.43E-05	2.43E-03	5.83E-04	7.03E-05
Average	1.05E-01	5.49E-01	6.88E-03	4.54E-12	6.60E-04	4.00E-02	7.59E-03	2.61E-03
75 Percentile Frac.	1.30E-01	8.41E-01	1.25E-04	4.76E-14	5.51E-04	5.33E-02	4.96E-03	3.85E-04
75 Perc. Norm. Frac.	9.72E-02	6.28E-01	9.31E-05	3.56E-14	4.12E-04	3.98E-02	3.70E-03	2.87E-04

Table 10: Radionuclide Activity Fractions, $fA_{i,j}$ and $fA_{i,j,.75}$, Using Sample Data for Containment Building Samples, Second Set of Radionuclides

Sample ID	Sr-90	Sb-125	Cs-134	Cs-137	Ce-144	Eu-152	Eu-154
1100X-1-CJ-FCV1-005	3.91E-04	0.00E+00	1.05E-03	3.09E-01	0.00E+00	2.94E-01	2.69E-02
1100X-1-CJ-WCV1-003	8.31E-04	0.00E+00	1.73E-03	1.33E-01	2.21E-05	3.69E-01	3.37E-02
1100X-1-CJ-WCV1-004	5.43E-04	0.00E+00	7.65E-04	2.96E-01	0.00E+00	2.23E-01	2.12E-02
1200X-1-CJ-FCV1-001	2.58E-04	4.73E-05	5.05E-06	4.57E-02	3.77E-07	0.00E+00	1.15E-04
1200X-1-CJ-FCV1-002	4.49E-04	0.00E+00	1.14E-05	9.66E-02	0.00E+00	2.88E-05	0.00E+00
1200X-1-CJ-FCV1-003	1.01E-03	1.62E-05	3.48E-05	2.53E-01	1.79E-07	0.00E+00	8.04E-05
1200X-1-CJ-FCV1-010	3.51E-04	0.00E+00	5.70E-06	2.45E-01	1.88E-06	1.37E-03	8.22E-06
1200X-1-CJ-FCV1-018	1.55E-04	9.41E-05	7.13E-06	8.65E-02	0.00E+00	4.48E-06	0.00E+00
1200X-1-CJ-FCV1-023	2.26E-03	1.96E-04	6.40E-05	7.80E-01	1.26E-06	2.87E-05	1.26E-05
1200X-1-CJ-FCV1-025	4.30E-04	1.44E-04	1.07E-05	1.99E-01	1.18E-06	0.00E+00	0.00E+00
1200X-1-CJ-FCV1-027	1.51E-04	5.57E-05	6.62E-05	6.46E-01	0.00E+00	4.81E-05	0.00E+00
1200X-1-CJ-WCV1-005	8.64E-05	6.81E-05	3.68E-06	7.60E-02	2.44E-06	0.00E+00	1.57E-04
1200X-1-CJ-WCV1-006	7.65E-05	1.30E-07	2.87E-06	7.90E-03	1.45E-06	3.96E-04	1.62E-05
1200X-1-CJ-WCV1-008	2.10E-04	0.00E+00	4.79E-06	2.08E-02	1.74E-05	1.81E-03	1.65E-04
1200X-1-CJ-WCV1-009	2.28E-05	0.00E+00	2.06E-06	8.35E-02	0.00E+00	3.13E-04	4.68E-05
1200X-1-CJ-WCV1-011	2.21E-04	0.00E+00	2.20E-05	1.15E-01	1.64E-05	3.07E-03	1.94E-04
1200X-1-CJ-WCV1-012	5.48E-04	2.32E-04	2.35E-05	1.00E-01	8.35E-06	4.84E-03	2.32E-04
1200X-1-CJ-WCV1-015	2.85E-04	0.00E+00	3.36E-05	4.85E-02	5.27E-06	2.51E-03	5.21E-04
1200X-1-CJ-WCV1-028	0.00E+00	2.54E-04	3.15E-04	6.76E-01	0.00E+00	6.15E-03	1.58E-04
1200X-1-CJ-WCV1-029	3.65E-05	9.21E-05	6.13E-05	3.15E-02	0.00E+00	3.40E-03	7.80E-05

Sample ID	Sr-90	Sb-125	Cs-134	Cs-137	Ce-144	Eu-152	Eu-154
1300X-1-CJ-FCV1-003	6.74E-05	2.08E-05	6.72E-05	7.14E-01	0.00E+00	0.00E+00	6.70E-06
1300X-1-CJ-FCV1-005	3.15E-05	5.64E-06	1.20E-05	3.63E-02	6.68E-07	5.67E-05	2.59E-06
1300X-1-CJ-FCV1-006	1.88E-04	6.87E-05	9.00E-05	6.86E-01	2.63E-07	0.00E+00	0.00E+00
1300X-1-CJ-FCV1-008	8.19E-04	2.65E-05	4.23E-05	7.27E-01	2.53E-06	9.06E-04	1.37E-04
1300X-1-CJ-WCV1-007	2.41E-04	0.00E+00	1.94E-05	6.70E-02	0.00E+00	8.71E-04	0.00E+00
1400X-1-CJ-FCV1-002	7.78E-04	6.80E-06	2.16E-06	2.12E-01	5.61E-07	0.00E+00	1.64E-05
1400X-1-CJ-FCV1-021	0.00E+00	0.00E+00	0.00E+00	3.13E-02	0.00E+00	1.48E-04	2.31E-05
Average	3.87E-04	4.92E-05	1.65E-04	2.49E-01	3.05E-06	3.37E-02	3.10E-03
75 Percentile Frac.	4.96E-04	6.84E-05	6.51E-05	3.02E-01	2.16E-06	2.79E-03	1.62E-04
75 Perc. Norm. Frac.	3.70E-04	5.11E-05	4.86E-05	2.26E-01	1.61E-06	2.08E-03	1.21E-04

Table 11: Radionuclide Activity Fractions, $fA_{i,j}$ and $fA_{i,j,.75}$, Using Sample Data for Containment Building Samples, Third Set of Radionuclides

Sample ID	Eu-155	Pu-238	Pu-239/240	Pu-241	Am-241	Cm-243/244	Np-237
1100X-1-CJ-FCV1-005	5.19E-04	2.12E-05	9.08E-05	5.30E-04	2.97E-05	6.67E-06	NA
1100X-1-CJ-WCV1-003	5.71E-04	2.55E-05	1.08E-04	5.31E-04	3.37E-05	3.82E-06	5.05E-07
1100X-1-CJ-WCV1-004	1.78E-04	8.92E-05	1.11E-04	1.13E-03	1.74E-04	4.08E-05	NA
1200X-1-CJ-FCV1-001	3.23E-05	1.84E-05	0.00E+00	2.09E-03	4.27E-05	1.98E-06	NA
1200X-1-CJ-FCV1-002	0.00E+00	5.95E-05	2.01E-05	9.40E-04	1.28E-04	3.44E-05	NA
1200X-1-CJ-FCV1-003	0.00E+00	1.58E-05	1.35E-05	9.72E-04	3.84E-05	9.22E-06	NA
1200X-1-CJ-FCV1-010	1.47E-05	1.22E-05	0.00E+00	1.43E-03	4.62E-05	9.06E-06	NA
1200X-1-CJ-FCV1-018	0.00E+00	8.03E-06	0.00E+00	7.03E-04	1.24E-05	1.08E-06	NA
1200X-1-CJ-FCV1-023	0.00E+00	1.05E-04	6.12E-05	1.74E-03	1.65E-04	1.52E-05	NA
1200X-1-CJ-FCV1-025	0.00E+00	4.30E-07	2.45E-06	6.69E-04	1.05E-05	0.00E+00	NA
1200X-1-CJ-FCV1-027	0.00E+00	1.25E-06	1.80E-06	6.51E-04	9.37E-06	2.44E-07	NA
1200X-1-CJ-WCV1-005	7.30E-05	7.27E-06	0.00E+00	3.90E-03	6.03E-05	0.00E+00	NA
1200X-1-CJ-WCV1-006	3.09E-06	3.71E-07	1.15E-06	5.75E-04	1.42E-05	0.00E+00	0.00E+00
1200X-1-CJ-WCV1-008	0.00E+00	0.00E+00	0.00E+00	8.32E-03	1.85E-05	1.19E-05	0.00E+00
1200X-1-CJ-WCV1-009	0.00E+00	4.97E-06	0.00E+00	8.69E-04	2.05E-05	5.99E-06	NA
1200X-1-CJ-WCV1-011	5.51E-05	0.00E+00	1.18E-05	6.20E-03	9.17E-05	0.00E+00	5.97E-06
1200X-1-CJ-WCV1-012	0.00E+00	6.83E-06	3.17E-05	5.87E-03	0.00E+00	1.07E-04	0.00E+00
1200X-1-CJ-WCV1-015	0.00E+00	0.00E+00	3.40E-05	2.59E-03	4.17E-05	1.26E-05	0.00E+00
1200X-1-CJ-WCV1-028	7.52E-04	4.44E-05	0.00E+00	1.44E-02	0.00E+00	1.09E-04	0.00E+00
1200X-1-CJ-WCV1-029	3.33E-05	0.00E+00	0.00E+00	2.01E-03	2.40E-05	4.64E-05	1.59E-05
1300X-1-CJ-FCV1-003	3.95E-05	3.27E-06	1.75E-06	5.34E-04	7.11E-06	0.00E+00	NA
1300X-1-CJ-FCV1-005	1.99E-05	3.27E-06	2.49E-06	9.97E-04	3.38E-05	1.88E-05	9.56E-07
1300X-1-CJ-FCV1-006	0.00E+00	5.64E-06	5.93E-07	2.76E-03	2.96E-05	5.35E-06	NA
1300X-1-CJ-FCV1-008	2.40E-05	1.89E-05	1.55E-05	9.72E-04	4.88E-05	1.06E-06	NA
1300X-1-CJ-WCV1-007	9.23E-05	0.00E+00	8.01E-06	9.05E-04	0.00E+00	2.20E-05	0.00E+00
1400X-1-CJ-FCV1-002	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.58E-07	0.00E+00	NA
1400X-1-CJ-FCV1-021	2.05E-05	6.71E-06	1.73E-05	0.00E+00	3.37E-06	0.00E+00	NA
Average	8.99E-05	1.70E-05	1.97E-05	2.31E-03	4.02E-05	1.72E-05	2.33E-06
75 Percentile Frac.	4.73E-05	1.86E-05	1.87E-05	2.34E-03	4.44E-05	1.70E-05	8.43E-07
75 Perc. Norm. Frac.	3.53E-05	1.39E-05	1.40E-05	1.75E-03	3.32E-05	1.27E-05	6.29E-07

Table 12: Radionuclide Activity Ratios to Cs-137, $f_R A_{i,j}$, Using Combined Sample Data for Containment Building, First Set of Radionuclides

Sample ID	H-3	C-14	Fe-55	Co-58	Ni-59	Ni-63	Co-60	Tc-99
1100X-1-CJ-FCV1-005	2.95E-01	3.72E-01	1.70E-01	0.00E+00	2.67E-03	2.40E-01	1.10E-01	1.08E-05
1100X-1-CJ-WCV1-003	4.20E-01	1.51E+00	6.19E-01	0.00E+00	0.00E+00	6.04E-01	3.06E-01	5.68E-04
1100X-1-CJ-WCV1-004	4.50E-01	2.31E-01	1.64E-01	2.82E-13	6.75E-03	4.91E-01	2.05E-01	5.58E-04
1200X-1-CJ-FCV1-001	5.11E+00	1.43E+01	0.00E+00	2.09E-13	6.68E-04	1.17E+00	1.89E-01	6.42E-03
1200X-1-CJ-FCV1-002	1.32E+00	6.63E+00	2.58E-03	0.00E+00	0.00E+00	1.29E+00	9.08E-02	1.02E-03
1200X-1-CJ-FCV1-003	5.54E-01	2.16E+00	0.00E+00	1.32E-15	2.42E-03	2.11E-01	1.91E-02	6.11E-04
1200X-1-CJ-FCV1-010	2.13E+00	4.80E-01	0.00E+00	0.00E+00	0.00E+00	4.46E-01	1.76E-02	1.35E-03

Sample ID	H-3	C-14	Fe-55	Co-58	Ni-59	Ni-63	Co-60	Tc-99
1200X-1-CJ-FCV1-018	2.89E+00	7.39E+00	5.52E-03	1.02E-14	0.00E+00	2.56E-01	3.55E-03	3.98E-04
1200X-1-CJ-FCV1-023	3.81E-02	1.59E-02	0.00E+00	2.71E-15	2.15E-03	2.13E-01	6.52E-03	4.12E-05
1200X-1-CJ-FCV1-025	5.86E-01	3.29E+00	0.00E+00	0.00E+00	2.81E-04	1.38E-01	6.21E-03	2.96E-04
1200X-1-CJ-FCV1-027	9.67E-02	4.21E-01	0.00E+00	6.78E-15	2.33E-04	2.49E-02	3.49E-03	0.00E+00
1200X-1-CJ-WCV1-005	2.89E+00	8.94E+00	0.00E+00	0.00E+00	5.82E-04	2.58E-01	1.27E-02	2.75E-03
1200X-1-CJ-WCV1-006	2.98E-01	1.25E+02	0.00E+00	7.04E-11	1.61E-02	9.81E-02	1.59E-02	0.00E+00
1200X-1-CJ-WCV1-008	2.99E+00	4.25E+01	0.00E+00	2.52E-09	9.98E-02	9.09E-01	9.14E-02	2.11E-02
1200X-1-CJ-WCV1-009	6.65E-01	1.03E+01	0.00E+00	7.25E-14	2.00E-03	4.04E-02	1.54E-03	2.58E-04
1200X-1-CJ-WCV1-011	4.33E-01	7.13E+00	0.00E+00	9.06E-11	0.00E+00	2.55E-02	1.66E-03	4.93E-03
1200X-1-CJ-WCV1-012	6.45E-01	7.81E+00	0.00E+00	5.18E-10	4.88E-03	3.29E-01	6.67E-03	4.50E-02
1200X-1-CJ-WCV1-015	1.39E+00	1.79E+01	0.00E+00	0.00E+00	0.00E+00	5.13E-02	1.45E-02	8.63E-02
1200X-1-CJ-WCV1-028	9.99E-02	1.96E-01	0.00E+00	7.33E-12	1.19E-02	3.84E-02	3.65E-02	6.48E-02
1200X-1-CJ-WCV1-029	1.50E+00	2.85E+01	0.00E+00	0.00E+00	0.00E+00	1.66E-01	1.87E-02	3.81E-01
1300X-1-CJ-FCV1-003	6.17E-02	3.06E-01	0.00E+00	0.00E+00	0.00E+00	3.05E-02	1.68E-03	9.65E-05
1300X-1-CJ-FCV1-005	6.92E-01	2.57E+01	0.00E+00	5.74E-11	4.02E-03	1.10E-01	1.36E-02	0.00E+00
1300X-1-CJ-FCV1-006	1.78E-01	2.27E-01	1.32E-03	8.08E-15	0.00E+00	4.48E-02	1.38E-03	0.00E+00
1300X-1-CJ-FCV1-008	5.18E-02	2.79E-01	4.75E-04	1.65E-14	1.56E-03	3.71E-02	1.19E-03	9.32E-05
1300X-1-CJ-WCV1-007	5.54E-01	1.32E+01	0.00E+00	0.00E+00	0.00E+00	1.03E-01	3.13E-03	4.81E-02
1400X-1-CJ-FCV1-002	1.11E-01	3.58E+00	0.00E+00	2.81E-16	8.50E-04	1.94E-02	5.97E-04	7.20E-05
1400X-1-CJ-FCV1-021	4.44E+00	2.64E+01	0.00E+00	0.00E+00	2.38E-03	7.77E-02	1.87E-02	2.25E-03
75th Percentile Each Sample	1.45E+00	1.38E+01	2.37E-04	2.45E-13	2.55E-03	2.94E-01	2.78E-02	5.68E-03
75th Normalized Fraction	8.70E-02	8.27E-01	1.43E-05	1.47E-14	1.53E-04	1.76E-02	1.67E-03	3.41E-04

Table 13: Radionuclide Activity Ratios to Cs-137, $f_R A_{i,j}$, Using Combined Sample Data for Containment Building, Second Set of Radionuclides

Sample ID	Sr-90	Sb-125	Cs-134	Cs-137	Ce-144	Eu-152	Eu-154
1100X-1-CJ-FCV1-005	1.26E-03	0.00E+00	3.39E-03	1.00E+00	0.00E+00	9.50E-01	8.69E-02
1100X-1-CJ-WCV1-003	6.24E-03	0.00E+00	1.30E-02	1.00E+00	1.66E-04	2.77E+00	2.53E-01
1100X-1-CJ-WCV1-004	1.84E-03	0.00E+00	2.59E-03	1.00E+00	0.00E+00	7.53E-01	7.16E-02
1200X-1-CJ-FCV1-001	5.64E-03	1.04E-03	1.10E-04	1.00E+00	8.25E-06	0.00E+00	2.51E-03
1200X-1-CJ-FCV1-002	4.65E-03	0.00E+00	1.18E-04	1.00E+00	0.00E+00	2.98E-04	0.00E+00
1200X-1-CJ-FCV1-003	3.99E-03	6.40E-05	1.38E-04	1.00E+00	7.10E-07	0.00E+00	3.18E-04
1200X-1-CJ-FCV1-010	1.43E-03	0.00E+00	2.33E-05	1.00E+00	7.68E-06	5.58E-03	3.36E-05
1200X-1-CJ-FCV1-018	1.79E-03	1.09E-03	8.24E-05	1.00E+00	0.00E+00	5.18E-05	0.00E+00
1200X-1-CJ-FCV1-023	2.89E-03	2.52E-04	8.20E-05	1.00E+00	1.61E-06	3.67E-05	1.62E-05
1200X-1-CJ-FCV1-025	2.16E-03	7.26E-04	5.37E-05	1.00E+00	5.94E-06	0.00E+00	0.00E+00
1200X-1-CJ-FCV1-027	2.33E-04	8.63E-05	1.02E-04	1.00E+00	0.00E+00	7.45E-05	0.00E+00
1200X-1-CJ-WCV1-005	1.14E-03	8.96E-04	4.84E-05	1.00E+00	3.21E-05	0.00E+00	2.06E-03
1200X-1-CJ-WCV1-006	9.69E-03	1.64E-05	3.64E-04	1.00E+00	1.84E-04	5.01E-02	2.06E-03
1200X-1-CJ-WCV1-008	1.01E-02	0.00E+00	2.31E-04	1.00E+00	8.35E-04	8.70E-02	7.95E-03
1200X-1-CJ-WCV1-009	2.73E-04	0.00E+00	2.46E-05	1.00E+00	0.00E+00	3.75E-03	5.60E-04
1200X-1-CJ-WCV1-011	1.92E-03	0.00E+00	1.91E-04	1.00E+00	1.42E-04	2.66E-02	1.69E-03
1200X-1-CJ-WCV1-012	5.45E-03	2.31E-03	2.34E-04	1.00E+00	8.32E-05	4.82E-02	2.31E-03
1200X-1-CJ-WCV1-015	5.88E-03	0.00E+00	6.92E-04	1.00E+00	1.09E-04	5.18E-02	1.07E-02
1200X-1-CJ-WCV1-028	0.00E+00	3.76E-04	4.66E-04	1.00E+00	0.00E+00	9.09E-03	2.34E-04
1200X-1-CJ-WCV1-029	1.16E-03	2.92E-03	1.95E-03	1.00E+00	0.00E+00	1.08E-01	2.48E-03
1300X-1-CJ-FCV1-003	9.45E-05	2.92E-05	9.42E-05	1.00E+00	0.00E+00	0.00E+00	9.39E-06
1300X-1-CJ-FCV1-005	8.66E-04	1.55E-04	3.30E-04	1.00E+00	1.84E-05	1.56E-03	7.12E-05
1300X-1-CJ-FCV1-006	2.73E-04	1.00E-04	1.31E-04	1.00E+00	3.83E-07	0.00E+00	0.00E+00
1300X-1-CJ-FCV1-008	1.13E-03	3.64E-05	5.82E-05	1.00E+00	3.48E-06	1.25E-03	1.89E-04
1300X-1-CJ-WCV1-007	3.60E-03	0.00E+00	2.89E-04	1.00E+00	0.00E+00	1.30E-02	0.00E+00
1400X-1-CJ-FCV1-002	3.66E-03	3.20E-05	1.02E-05	1.00E+00	2.64E-06	0.00E+00	7.74E-05
1400X-1-CJ-FCV1-021	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	4.72E-03	7.39E-04
75th Percentile Each Sample	4.32E-03	3.14E-04	3.47E-04	1.00E+00	2.53E-05	4.92E-02	2.39E-03
75th Normalized Fraction	2.59E-04	1.89E-05	2.08E-05	6.01E-02	1.52E-06	2.95E-03	1.44E-04

Table 14: Radionuclide Activity Ratios to Cs-137, $f_R A_{i,j}$, Using Combined Sample Data for Containment Building, Third Set of Radionuclides

Sample ID	Eu-155	Pu-238	Pu-239/240	Pu-241	Am-241	Cm-243/244	Np-237
1100X-1-CJ-FCV1-005	1.68E-03	6.85E-05	2.94E-04	1.71E-03	9.61E-05	2.16E-05	NA
1100X-1-CJ-WCV1-003	4.28E-03	1.91E-04	8.12E-04	3.99E-03	2.53E-04	2.87E-05	3.79E-06
1100X-1-CJ-WCV1-004	6.02E-04	3.02E-04	3.75E-04	3.84E-03	5.88E-04	1.38E-04	NA
1200X-1-CJ-FCV1-001	7.06E-04	4.02E-04	0.00E+00	4.56E-02	9.33E-04	4.34E-05	NA
1200X-1-CJ-FCV1-002	0.00E+00	6.16E-04	2.08E-04	9.73E-03	1.33E-03	3.56E-04	NA
1200X-1-CJ-FCV1-003	0.00E+00	6.23E-05	5.35E-05	3.85E-03	1.52E-04	3.65E-05	NA
1200X-1-CJ-FCV1-010	6.01E-05	4.97E-05	0.00E+00	5.86E-03	1.89E-04	3.70E-05	NA
1200X-1-CJ-FCV1-018	0.00E+00	9.28E-05	0.00E+00	8.13E-03	1.43E-04	1.24E-05	NA
1200X-1-CJ-FCV1-023	0.00E+00	1.35E-04	7.84E-05	2.22E-03	2.12E-04	1.95E-05	NA
1200X-1-CJ-FCV1-025	0.00E+00	2.16E-06	1.23E-05	3.36E-03	5.26E-05	0.00E+00	NA
1200X-1-CJ-FCV1-027	0.00E+00	1.94E-06	2.78E-06	1.01E-03	1.45E-05	3.77E-07	NA
1200X-1-CJ-WCV1-005	9.60E-04	9.57E-05	0.00E+00	5.13E-02	7.94E-04	0.00E+00	NA
1200X-1-CJ-WCV1-006	3.91E-04	4.69E-05	1.45E-04	7.29E-02	1.80E-03	0.00E+00	0.00E+00
1200X-1-CJ-WCV1-008	0.00E+00	0.00E+00	0.00E+00	4.00E-01	8.90E-04	0.00E+00	0.00E+00
1200X-1-CJ-WCV1-009	0.00E+00	5.95E-05	0.00E+00	1.04E-02	2.45E-04	7.18E-05	NA
1200X-1-CJ-WCV1-011	4.78E-04	0.00E+00	1.03E-04	5.38E-02	7.96E-04	0.00E+00	5.18E-05
1200X-1-CJ-WCV1-012	0.00E+00	6.80E-05	3.15E-04	5.84E-02	0.00E+00	1.07E-03	0.00E+00
1200X-1-CJ-WCV1-015	0.00E+00	0.00E+00	7.00E-04	5.34E-02	8.60E-04	2.60E-04	0.00E+00
1200X-1-CJ-WCV1-028	1.11E-03	6.58E-05	0.00E+00	2.13E-02	0.00E+00	1.62E-04	0.00E+00
1200X-1-CJ-WCV1-029	1.06E-03	0.00E+00	0.00E+00	6.37E-02	7.63E-04	1.47E-03	5.05E-04
1300X-1-CJ-FCV1-003	5.53E-05	4.58E-06	2.46E-06	7.48E-04	9.96E-06	0.00E+00	NA
1300X-1-CJ-FCV1-005	5.49E-04	9.00E-05	6.84E-05	2.74E-02	9.30E-04	5.17E-04	2.63E-05
1300X-1-CJ-FCV1-006	0.00E+00	8.22E-06	8.64E-07	4.03E-03	4.31E-05	7.79E-06	NA
1300X-1-CJ-FCV1-008	3.30E-05	2.60E-05	2.13E-05	1.34E-03	6.71E-05	1.46E-06	NA
1300X-1-CJ-WCV1-007	1.38E-03	0.00E+00	1.19E-04	1.35E-02	0.00E+00	3.28E-04	0.00E+00
1400X-1-CJ-FCV1-002	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-06	0.00E+00	NA
1400X-1-CJ-FCV1-021	6.54E-04	2.14E-04	5.54E-04	0.00E+00	1.08E-04	0.00E+00	NA
75th Percentile Each Sample	6.80E-04	9.42E-05	1.77E-04	4.85E-02	7.95E-04	2.11E-04	2.07E-05
75th Normalized Fraction	4.09E-05	5.66E-06	1.06E-05	2.91E-03	4.78E-05	1.27E-05	1.24E-06

Table 15 summarizes the radionuclide activity fractions using the three methods described above.

Table 15: Radionuclide Activity Fractions for Containment Building Sample Population Using Three Methods

Nuclide	Average Activity Fractions, fA_i,	75 Percentile of the Activity Average Fractions, $fA_{i,.75}$	75th Percentile of the Individual Sample Ratios to Cs-137, $f_R A_{i,.75}$
H-3	1.05E-01	9.72E-02	8.70E-02
C-14	5.49E-01	6.28E-01	8.27E-01
Fe-55	6.88E-03	9.31E-05	1.43E-05
Co-58	4.54E-12	3.56E-14	1.47E-14
Ni-59	6.60E-04	4.12E-04	1.53E-04
Ni-63	4.00E-02	3.98E-02	1.76E-02
Co-60	7.59E-03	3.70E-03	1.67E-03
Tc-99	2.61E-03	2.87E-04	3.41E-04
Sr-90	3.87E-04	3.70E-04	2.59E-04
Sb-125	4.92E-05	5.11E-05	1.89E-05
Cs-134	1.65E-04	4.86E-05	2.08E-05

Cs-137	2.49E-01	2.26E-01	6.01E-02
Ce-144	3.05E-06	1.61E-06	1.52E-06
Eu-152	3.37E-02	2.08E-03	2.95E-03
Eu-154	3.10E-03	1.21E-04	1.44E-04
Eu-155	8.99E-05	3.53E-05	4.09E-05
Pu-238	1.70E-05	1.39E-05	5.66E-06
Pu-239/240	1.97E-05	1.40E-05	1.06E-05
Pu-241	2.31E-03	1.75E-03	2.91E-03
Am-241	4.02E-05	3.32E-05	4.78E-05
Cm-243/244	1.72E-05	1.27E-05	1.27E-05
Np-237	2.33E-06	6.29E-07	1.24E-06

As can be seen from the above table, the FCS Containment Building concrete contains an unusually high average fraction of C-14 at 54.9%. The potential for cross contamination from this source term will be closely monitored throughout decommissioning.

6.1.2 AB/TB/RWPB SAMPLE POPULATION NUCLIDE FRACTIONS

Tables 16 through 18 provide the radionuclide activity fractions for all sample data that will represent the Auxiliary Building, Turbine Building and Radioactive Waste Processing Building mixture. The data is subdivided into three tables to allow for convenient inspection of all 22 radionuclides. The last three rows of these tables provide the average fraction, the 75th percentile of each fractional data set, and the normalized 75th data set as described above. Tables 19 through 21 provide the radionuclide activity ratios to Cs-137 for all sample data that will represent the AB/TB/RWPB fractions. Similar to the previous set of tables, the data is subdivided into three tables to allow for convenient inspection of all 22 radionuclides. The last two rows of these tables provide the average fraction, the 75th percentile of each ratio data set, and the normalized 75th data set as described above.

In the following tables, NA indicates “Not Analyzed” for the 37 samples in which Np-237 was not analyzed.

Table 16: Radionuclide Activity Fractions, $fA_{i,j}$ and $fA_{i,j,.75}$, Using All ores Sample Data for AB/TB/RWPB Samples, First Set of Radionuclides

Sample ID	H-3	C-14	Fe-55	Co-58	Ni-59	Ni-63	Co-60	Tc-99
2100X-1-CJ-FCV1-001	3.07E-03	4.59E-03	0.00E+00	1.70E-11	2.39E-03	4.45E-01	6.40E-04	7.18E-04
2100X-1-CJ-FCV1-003	2.68E-03	5.85E-03	1.51E-03	1.40E-13	6.51E-03	8.06E-01	4.69E-04	5.64E-06
2100X-1-CJ-FCV1-005	2.12E-02	1.83E-02	0.00E+00	0.00E+00	0.00E+00	5.13E-02	7.08E-04	2.37E-04
2100X-1-CJ-FCV1-006	1.32E-01	1.84E-02	0.00E+00	3.36E-14	0.00E+00	1.99E-01	7.22E-03	7.33E-04
2100X-1-CJ-FCV1-011	3.79E-02	2.86E-02	0.00E+00	0.00E+00	3.16E-03	4.65E-01	1.40E-02	4.35E-02
2100X-1-CJ-FCV1-014	3.96E-03	4.02E-02	0.00E+00	0.00E+00	0.00E+00	2.35E-01	2.06E-03	1.33E-01
2200X-1-CJ-FCV1-006	2.42E-03	3.29E-02	0.00E+00	7.73E-12	1.17E-03	1.11E-01	6.00E-04	1.59E-02
2200X-1-CJ-FCV1-008	5.13E-02	1.91E-02	0.00E+00	6.43E-15	0.00E+00	7.27E-02	1.56E-02	0.00E+00
2200X-1-CJ-FCV1-010	2.85E-02	2.06E-02	0.00E+00	0.00E+00	0.00E+00	2.92E-01	9.25E-03	0.00E+00
2200X-1-CJ-FCV1-020	3.36E-03	1.67E-03	5.68E-05	1.43E-15	4.13E-04	1.14E-01	8.07E-04	1.35E-04
2200X-1-CJ-FCV1-021	3.92E-03	2.63E-02	0.00E+00	0.00E+00	0.00E+00	2.31E-01	6.82E-04	0.00E+00
2200X-1-CJ-FCV1-022	6.59E-04	1.37E-03	5.18E-06	0.00E+00	3.93E-04	3.67E-02	3.17E-05	0.00E+00
2200X-1-CJ-FCV1-026	6.24E-04	7.13E-04	6.26E-06	3.28E-16	0.00E+00	9.87E-03	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-030	3.76E-02	7.80E-02	3.46E-03	0.00E+00	7.02E-03	6.07E-01	5.75E-02	0.00E+00
2200X-1-CJ-FCV1-031	2.25E-01	6.81E-03	2.11E-03	2.88E-15	3.25E-03	2.97E-01	4.05E-03	0.00E+00
2200X-1-CJ-FCV1-035	7.52E-03	1.67E-02	1.92E-03	3.21E-15	2.79E-03	3.36E-01	6.54E-03	0.00E+00
2200X-1-CJ-FCV1-038	7.24E-03	3.02E-02	0.00E+00	5.04E-11	1.83E-03	4.89E-01	8.94E-03	0.00E+00

Sample ID	H-3	C-14	Fe-55	Co-58	Ni-59	Ni-63	Co-60	Tc-99
2200X-1-CJ-FCV1-039	1.49E-02	4.00E-02	0.00E+00	0.00E+00	2.16E-03	5.00E-01	8.90E-03	0.00E+00
2200X-1-CJ-WCV1-009	6.67E-02	2.96E-01	0.00E+00	0.00E+00	1.70E-02	9.42E-02	2.90E-03	6.86E-03
2300X-1-CJ-FCV1-001	2.49E-04	1.16E-02	3.73E-04	0.00E+00	4.96E-04	4.35E-02	6.02E-05	0.00E+00
2300X-1-CJ-FCV1-002	9.74E-04	5.37E-03	2.51E-05	0.00E+00	6.69E-04	7.51E-02	3.51E-04	0.00E+00
2300X-1-CJ-FCV1-003	4.75E-04	2.21E-02	1.01E-03	0.00E+00	1.16E-03	1.47E-01	1.04E-02	2.17E-05
2300X-1-CJ-FCV1-005	1.07E-03	9.19E-03	1.19E-03	0.00E+00	1.16E-03	1.12E-01	3.26E-04	5.12E-05
2300X-1-CJ-FCV1-007	3.78E-02	6.18E-02	0.00E+00	8.28E-15	0.00E+00	6.70E-02	3.93E-03	0.00E+00
2300X-1-CJ-FCV1-010	0.00E+00	4.08E-02	2.54E-02	2.01E-09	0.00E+00	1.64E-01	1.62E-02	9.99E-03
2600X-1-CJ-FCV1-002	8.89E-02	2.15E-01	0.00E+00	0.00E+00	0.00E+00	1.62E-01	7.07E-03	1.34E-03
3100X-3-CJ-FCV1-006	0.00E+00	8.04E-01	7.09E-02	2.25E-13	0.00E+00	0.00E+00	2.55E-03	0.00E+00
3100X-3-CJ-FCV1-014	0.00E+00	4.60E-01	8.62E-03	2.02E-13	0.00E+00	4.13E-01	5.77E-03	0.00E+00
4100X-1-CJ-FCV1-004	0.00E+00	4.69E-01	2.46E-02	0.00E+00	4.18E-02	1.04E-01	6.89E-03	0.00E+00
4100X-1-CJ-FCV1-005	0.00E+00	1.30E-01	9.38E-02	6.63E-14	2.53E-05	5.86E-02	3.93E-02	0.00E+00
Average	2.60E-02	9.72E-02	7.83E-03	6.94E-11	3.11E-03	2.25E-01	7.79E-03	7.09E-03
75 Percentile Frac.	3.53E-02	5.66E-02	1.82E-03	5.81E-14	2.33E-03	3.26E-01	8.93E-03	5.98E-04
75 Perc. Norm. Frac.	2.76E-02	4.43E-02	1.42E-03	4.54E-14	1.82E-03	2.55E-01	6.99E-03	4.68E-04

Table 17: Radionuclide Activity Fractions, $fA_{i,j}$ and $fA_{i,j,.75}$, Using All Sample Data for AB/TB/RWPB Samples, Second Set of Radionuclides

Sample ID	Sr-90	Sb-125	Cs-134	Cs-137	Ce-144	Eu-152	Eu-154
2100X-1-CJ-FCV1-001	4.29E-03	4.25E-05	1.40E-05	5.34E-01	0.00E+00	0.00E+00	7.50E-05
2100X-1-CJ-FCV1-003	5.10E-04	0.00E+00	1.06E-06	1.72E-01	0.00E+00	1.67E-04	5.39E-05
2100X-1-CJ-FCV1-005	2.01E-03	2.57E-04	3.29E-04	9.01E-01	3.50E-05	1.50E-03	0.00E+00
2100X-1-CJ-FCV1-006	2.42E-03	0.00E+00	8.38E-05	6.28E-01	2.79E-06	1.93E-03	3.24E-04
2100X-1-CJ-FCV1-011	1.33E-03	0.00E+00	1.18E-04	4.05E-01	0.00E+00	0.00E+00	1.92E-05
2100X-1-CJ-FCV1-014	1.08E-03	1.11E-04	4.59E-05	5.84E-01	1.30E-05	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-006	6.84E-05	0.00E+00	4.35E-05	8.29E-01	0.00E+00	6.03E-04	6.13E-05
2200X-1-CJ-FCV1-008	1.18E-03	2.53E-04	1.20E-04	8.40E-01	1.87E-07	0.00E+00	8.86E-05
2200X-1-CJ-FCV1-010	2.54E-03	5.77E-04	0.00E+00	6.46E-01	0.00E+00	5.33E-04	0.00E+00
2200X-1-CJ-FCV1-020	5.50E-04	5.54E-05	2.27E-04	8.79E-01	1.69E-07	1.88E-04	2.91E-06
2200X-1-CJ-FCV1-021	1.55E-03	0.00E+00	0.00E+00	7.32E-01	4.82E-06	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-022	9.07E-04	0.00E+00	1.61E-06	9.60E-01	0.00E+00	6.82E-05	0.00E+00
2200X-1-CJ-FCV1-026	1.04E-03	0.00E+00	1.26E-06	9.88E-01	6.01E-07	9.27E-05	0.00E+00
2200X-1-CJ-FCV1-030	9.07E-03	3.91E-04	1.24E-04	1.97E-01	0.00E+00	2.75E-04	0.00E+00
2200X-1-CJ-FCV1-031	1.37E-03	0.00E+00	3.04E-05	4.61E-01	1.91E-06	0.00E+00	6.28E-05
2200X-1-CJ-FCV1-035	1.30E-03	8.03E-05	1.66E-05	6.27E-01	3.49E-07	8.58E-05	3.41E-05
2200X-1-CJ-FCV1-038	9.27E-03	1.68E-04	1.90E-04	4.28E-01	3.24E-05	1.70E-04	0.00E+00
2200X-1-CJ-FCV1-039	1.52E-02	1.04E-04	4.58E-05	4.07E-01	0.00E+00	1.46E-03	3.13E-04
2200X-1-CJ-WCV1-009	0.00E+00	0.00E+00	1.57E-04	5.16E-01	0.00E+00	0.00E+00	0.00E+00
2300X-1-CJ-FCV1-001	2.23E-03	0.00E+00	0.00E+00	9.41E-01	1.45E-07	0.00E+00	5.71E-06
2300X-1-CJ-FCV1-002	2.05E-03	1.35E-05	2.18E-06	9.15E-01	0.00E+00	1.27E-04	4.32E-06
2300X-1-CJ-FCV1-003	1.67E-03	4.97E-05	0.00E+00	8.15E-01	0.00E+00	0.00E+00	3.76E-05
2300X-1-CJ-FCV1-005	1.55E-03	0.00E+00	2.36E-06	8.74E-01	2.81E-07	0.00E+00	0.00E+00
2300X-1-CJ-FCV1-007	3.88E-03	2.65E-04	2.97E-04	8.23E-01	7.76E-06	4.78E-04	1.84E-04
2300X-1-CJ-FCV1-010	2.66E-03	0.00E+00	5.34E-04	7.32E-01	0.00E+00	6.67E-04	0.00E+00
2600X-1-CJ-FCV1-002	4.14E-04	2.17E-05	1.06E-04	5.16E-01	0.00E+00	5.74E-03	5.75E-04
3100X-3-CJ-FCV1-006	2.22E-02	2.19E-03	0.00E+00	7.48E-02	9.23E-05	1.42E-02	0.00E+00
3100X-3-CJ-FCV1-014	1.37E-02	5.84E-04	3.11E-03	3.33E-02	3.33E-04	0.00E+00	5.16E-02
4100X-1-CJ-FCV1-004	0.00E+00	0.00E+00	5.36E-04	3.42E-01	0.00E+00	2.89E-03	7.32E-03
4100X-1-CJ-FCV1-005	1.70E-01	4.21E-03	0.00E+00	4.41E-01	4.95E-05	9.44E-03	9.25E-03
Average	9.22E-03	3.12E-04	2.05E-04	6.08E-01	1.91E-05	1.35E-03	2.33E-03
75 Percentile Frac.	3.57E-03	2.32E-04	1.48E-04	8.37E-01	4.32E-06	6.51E-04	8.52E-05
75 Perc. Norm. Frac.	2.79E-03	1.81E-04	1.16E-04	6.55E-01	3.38E-06	5.09E-04	6.67E-05

Table 18: Radionuclide Activity Fractions, $fA_{i,j}$ and $fA_{i,j,.75}$, Using All Sample Data for AB/TB/RWPB Samples, Third Set of Radionuclides

Sample ID	Eu-155	Pu-238	Pu-239/240	Pu-241	Am-241	Cm-243/244	Np-237
2100X-1-CJ-FCV1-001	0.00E+00	1.08E-05	4.36E-06	4.84E-03	6.79E-05	1.65E-04	0.00E+00
2100X-1-CJ-FCV1-003	1.01E-04	1.22E-04	5.16E-05	3.04E-03	1.34E-04	7.64E-05	0.00E+00
2100X-1-CJ-FCV1-005	5.04E-04	1.84E-05	4.02E-05	2.59E-03	0.00E+00	0.00E+00	0.00E+00
2100X-1-CJ-FCV1-006	2.23E-03	9.70E-05	0.00E+00	8.03E-03	1.69E-04	0.00E+00	NA
2100X-1-CJ-FCV1-011	0.00E+00	0.00E+00	0.00E+00	5.66E-04	0.00E+00	0.00E+00	NA
2100X-1-CJ-FCV1-014	2.28E-04	1.16E-04	0.00E+00	0.00E+00	0.00E+00	2.92E-06	NA
2200X-1-CJ-FCV1-006	4.34E-04	0.00E+00	0.00E+00	5.96E-03	0.00E+00	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-008	0.00E+00	1.37E-06	1.09E-05	0.00E+00	1.14E-05	0.00E+00	NA
2200X-1-CJ-FCV1-010	4.10E-04	0.00E+00	2.81E-05	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-020	0.00E+00	7.09E-07	1.18E-06	0.00E+00	1.44E-06	0.00E+00	NA
2200X-1-CJ-FCV1-021	0.00E+00	1.13E-05	7.15E-05	4.42E-03	0.00E+00	0.00E+00	5.60E-06
2200X-1-CJ-FCV1-022	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-026	0.00E+00	2.15E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-030	0.00E+00	9.29E-05	4.51E-05	2.68E-03	2.24E-04	1.62E-05	1.68E-06
2200X-1-CJ-FCV1-031	0.00E+00	0.00E+00	1.85E-05	0.00E+00	5.28E-06	1.51E-05	NA
2200X-1-CJ-FCV1-035	0.00E+00	3.38E-05	2.77E-05	0.00E+00	2.24E-05	3.61E-06	NA
2200X-1-CJ-FCV1-038	2.93E-04	1.81E-05	1.86E-05	2.46E-02	2.46E-04	2.43E-04	0.00E+00
2200X-1-CJ-FCV1-039	1.36E-05	6.50E-06	0.00E+00	1.06E-02	3.40E-06	0.00E+00	0.00E+00
2200X-1-CJ-WCV1-009	1.78E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2300X-1-CJ-FCV1-001	9.04E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2300X-1-CJ-FCV1-002	0.00E+00	4.98E-05	3.35E-05	2.99E-04	9.43E-05	9.50E-06	NA
2300X-1-CJ-FCV1-003	1.40E-05	3.92E-05	1.76E-05	9.38E-04	1.19E-04	3.44E-05	0.00E+00
2300X-1-CJ-FCV1-005	0.00E+00	1.08E-06	0.00E+00	0.00E+00	1.32E-05	0.00E+00	NA
2300X-1-CJ-FCV1-007	0.00E+00	2.62E-05	3.99E-07	1.01E-03	3.15E-04	0.00E+00	NA
2300X-1-CJ-FCV1-010	0.00E+00	0.00E+00	4.37E-05	7.67E-03	2.93E-04	9.91E-11	0.00E+00
2600X-1-CJ-FCV1-002	3.09E-04	0.00E+00	1.24E-04	1.61E-03	2.25E-04	4.51E-05	NA
3100X-3-CJ-FCV1-006	0.00E+00	5.13E-03	1.71E-03	0.00E+00	0.00E+00	1.95E-03	NA
3100X-3-CJ-FCV1-014	5.54E-03	5.18E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
4100X-1-CJ-FCV1-004	0.00E+00	6.36E-04	6.71E-04	0.00E+00	0.00E+00	0.00E+00	NA
4100X-1-CJ-FCV1-005	0.00E+00	0.00E+00	0.00E+00	4.37E-02	9.76E-04	0.00E+00	NA
Average	3.45E-04	3.86E-04	9.74E-05	4.09E-03	9.73E-05	8.54E-05	7.28E-07
75 Percentile Frac.	2.16E-04	4.71E-05	3.85E-05	4.07E-03	1.30E-04	1.37E-05	0.00E+00
75 Perc. Norm. Frac.	1.69E-04	3.69E-05	3.01E-05	3.19E-03	1.02E-04	1.07E-05	0.00E+00

Table 19: Radionuclide Activity Ratios to Cs-137, $f_R A_{i,j}$, Using Combined Sample Data for AB/TB/RWPB Samples, First Set of Radionuclides

Radionuclide	H-3	C-14	Fe-55	Co-58	Ni-59	Ni-63	Co-60	Tc-99
2100X-1-CJ-FCV1-001	5.74E-03	8.59E-03	0.00E+00	3.19E-11	4.46E-03	8.32E-01	1.20E-03	1.34E-03
2100X-1-CJ-FCV1-003	1.56E-02	3.40E-02	8.79E-03	8.12E-13	3.78E-02	4.68E+00	2.72E-03	3.27E-05
2100X-1-CJ-FCV1-005	2.35E-02	2.03E-02	0.00E+00	0.00E+00	0.00E+00	5.69E-02	7.86E-04	2.63E-04
2100X-1-CJ-FCV1-006	2.09E-01	2.94E-02	0.00E+00	5.35E-14	0.00E+00	3.17E-01	1.15E-02	1.17E-03
2100X-1-CJ-FCV1-011	9.35E-02	7.06E-02	0.00E+00	0.00E+00	7.80E-03	1.15E+00	3.45E-02	1.07E-01
2100X-1-CJ-FCV1-014	6.78E-03	6.89E-02	0.00E+00	0.00E+00	0.00E+00	4.03E-01	3.52E-03	2.28E-01
2200X-1-CJ-FCV1-006	2.92E-03	3.97E-02	0.00E+00	9.32E-12	1.41E-03	1.34E-01	7.24E-04	1.92E-02
2200X-1-CJ-FCV1-008	6.11E-02	2.28E-02	0.00E+00	7.66E-15	0.00E+00	8.66E-02	1.86E-02	0.00E+00
2200X-1-CJ-FCV1-010	4.41E-02	3.19E-02	0.00E+00	0.00E+00	0.00E+00	4.52E-01	1.43E-02	0.00E+00
2200X-1-CJ-FCV1-020	3.82E-03	1.90E-03	6.46E-05	1.63E-15	4.70E-04	1.30E-01	9.19E-04	1.54E-04
2200X-1-CJ-FCV1-021	5.35E-03	3.60E-02	0.00E+00	0.00E+00	0.00E+00	3.16E-01	9.32E-04	0.00E+00
2200X-1-CJ-FCV1-022	6.87E-04	1.42E-03	5.39E-06	0.00E+00	4.10E-04	3.83E-02	3.30E-05	0.00E+00
2200X-1-CJ-FCV1-026	6.32E-04	7.22E-04	6.34E-06	3.32E-16	0.00E+00	9.99E-03	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-030	1.91E-01	3.96E-01	1.76E-02	0.00E+00	3.56E-02	3.08E+00	2.92E-01	0.00E+00
2200X-1-CJ-FCV1-031	4.87E-01	1.48E-02	4.58E-03	6.25E-15	7.05E-03	6.44E-01	8.79E-03	0.00E+00
2200X-1-CJ-FCV1-035	1.20E-02	2.67E-02	3.06E-03	5.12E-15	4.44E-03	5.36E-01	1.04E-02	0.00E+00
2200X-1-CJ-FCV1-038	1.69E-02	7.06E-02	0.00E+00	1.18E-10	4.28E-03	1.14E+00	2.09E-02	0.00E+00

2200X-1-CJ-FCV1-039	3.66E-02	9.83E-02	0.00E+00	0.00E+00	5.30E-03	1.23E+00	2.19E-02	0.00E+00
2200X-1-CJ-WCV1-009	1.29E-01	5.74E-01	0.00E+00	0.00E+00	3.30E-02	1.83E-01	5.62E-03	1.33E-02
2300X-1-CJ-FCV1-001	2.65E-04	1.23E-02	3.96E-04	0.00E+00	5.26E-04	4.63E-02	6.39E-05	0.00E+00
2300X-1-CJ-FCV1-002	1.06E-03	5.87E-03	2.74E-05	0.00E+00	7.31E-04	8.21E-02	3.84E-04	0.00E+00
2300X-1-CJ-FCV1-003	5.82E-04	2.71E-02	1.24E-03	0.00E+00	1.43E-03	1.80E-01	1.28E-02	2.67E-05
2300X-1-CJ-FCV1-005	1.22E-03	1.05E-02	1.37E-03	0.00E+00	1.33E-03	1.28E-01	3.73E-04	5.86E-05
2300X-1-CJ-FCV1-007	4.59E-02	7.51E-02	0.00E+00	1.01E-14	0.00E+00	8.14E-02	4.78E-03	0.00E+00
2300X-1-CJ-FCV1-010	0.00E+00	5.58E-02	3.47E-02	2.74E-09	0.00E+00	2.24E-01	2.21E-02	1.36E-02
2600X-1-CJ-FCV1-002	1.72E-01	4.17E-01	0.00E+00	0.00E+00	0.00E+00	3.14E-01	1.37E-02	2.61E-03
3100X-3-CJ-FCV1-006	0.00E+00	1.08E+01	9.48E-01	3.01E-12	0.00E+00	0.00E+00	3.41E-02	0.00E+00
3100X-3-CJ-FCV1-014	0.00E+00	1.38E+01	2.59E-01	6.06E-12	0.00E+00	1.24E+01	1.73E-01	0.00E+00
4100X-1-CJ-FCV1-004	0.00E+00	1.37E+00	7.19E-02	0.00E+00	1.22E-01	3.03E-01	2.01E-02	0.00E+00
4100X-1-CJ-FCV1-005	0.00E+00	2.94E-01	2.13E-01	1.50E-13	5.74E-05	1.33E-01	8.92E-02	0.00E+00
75th Percentile Each Sample	4.54E-02	9.25E-02	4.20E-03	1.26E-13	4.46E-03	6.17E-01	2.07E-02	9.42E-04
75th Normalized Fraction	2.52E-02	5.14E-02	2.33E-03	7.00E-14	2.48E-03	3.43E-01	1.15E-02	5.23E-04

Table 20: Radionuclide Activity Ratios to Cs-137, $f_R A_{i,j}$, Using Combined Sample Data for AB/TB/RWPB Samples, Second Set of Radionuclides

Radionuclide	Sr-90	Sb-125	Cs-134	Cs-137	Ce-144	Eu-152	Eu-154
2100X-1-CJ-FCV1-001	8.04E-03	7.96E-05	2.61E-05	1.00E+00	0.00E+00	0.00E+00	1.40E-04
2100X-1-CJ-FCV1-003	2.96E-03	0.00E+00	6.18E-06	1.00E+00	0.00E+00	9.70E-04	3.13E-04
2100X-1-CJ-FCV1-005	2.23E-03	2.85E-04	3.65E-04	1.00E+00	3.88E-05	1.66E-03	0.00E+00
2100X-1-CJ-FCV1-006	3.85E-03	0.00E+00	1.34E-04	1.00E+00	4.45E-06	3.07E-03	5.16E-04
2100X-1-CJ-FCV1-011	3.28E-03	0.00E+00	2.91E-04	1.00E+00	0.00E+00	0.00E+00	4.73E-05
2100X-1-CJ-FCV1-014	1.84E-03	1.90E-04	7.87E-05	1.00E+00	2.23E-05	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-006	8.25E-05	0.00E+00	5.24E-05	1.00E+00	0.00E+00	7.27E-04	7.40E-05
2200X-1-CJ-FCV1-008	1.41E-03	3.01E-04	1.43E-04	1.00E+00	2.23E-07	0.00E+00	1.06E-04
2200X-1-CJ-FCV1-010	3.94E-03	8.93E-04	0.00E+00	1.00E+00	0.00E+00	8.26E-04	0.00E+00
2200X-1-CJ-FCV1-020	6.26E-04	6.31E-05	2.58E-04	1.00E+00	1.92E-07	2.14E-04	3.32E-06
2200X-1-CJ-FCV1-021	2.12E-03	0.00E+00	0.00E+00	1.00E+00	6.59E-06	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-022	9.45E-04	0.00E+00	1.67E-06	1.00E+00	0.00E+00	7.11E-05	0.00E+00
2200X-1-CJ-FCV1-026	1.05E-03	0.00E+00	1.27E-06	1.00E+00	6.09E-07	9.39E-05	0.00E+00
2200X-1-CJ-FCV1-030	4.61E-02	1.99E-03	6.28E-04	1.00E+00	0.00E+00	1.39E-03	0.00E+00
2200X-1-CJ-FCV1-031	2.98E-03	0.00E+00	6.59E-05	1.00E+00	4.15E-06	0.00E+00	1.36E-04
2200X-1-CJ-FCV1-035	2.08E-03	1.28E-04	2.64E-05	1.00E+00	5.58E-07	1.37E-04	5.44E-05
2200X-1-CJ-FCV1-038	2.17E-02	3.93E-04	4.45E-04	1.00E+00	7.57E-05	3.98E-04	0.00E+00
2200X-1-CJ-FCV1-039	3.74E-02	2.55E-04	1.13E-04	1.00E+00	0.00E+00	3.58E-03	7.69E-04
2200X-1-CJ-WCV1-009	0.00E+00	0.00E+00	3.04E-04	1.00E+00	0.00E+00	0.00E+00	0.00E+00
2300X-1-CJ-FCV1-001	2.37E-03	0.00E+00	0.00E+00	1.00E+00	1.54E-07	0.00E+00	6.06E-06
2300X-1-CJ-FCV1-002	2.24E-03	1.47E-05	2.38E-06	1.00E+00	0.00E+00	1.38E-04	4.72E-06
2300X-1-CJ-FCV1-003	2.05E-03	6.09E-05	0.00E+00	1.00E+00	0.00E+00	0.00E+00	4.61E-05
2300X-1-CJ-FCV1-005	1.78E-03	0.00E+00	2.70E-06	1.00E+00	3.22E-07	0.00E+00	0.00E+00
2300X-1-CJ-FCV1-007	4.71E-03	3.21E-04	3.61E-04	1.00E+00	9.43E-06	5.81E-04	2.23E-04
2300X-1-CJ-FCV1-010	3.64E-03	0.00E+00	7.30E-04	1.00E+00	0.00E+00	9.11E-04	0.00E+00
2600X-1-CJ-FCV1-002	8.02E-04	4.20E-05	2.05E-04	1.00E+00	0.00E+00	1.11E-02	1.11E-03
3100X-3-CJ-FCV1-006	2.97E-01	2.92E-02	0.00E+00	1.00E+00	1.23E-03	1.90E-01	0.00E+00
3100X-3-CJ-FCV1-014	4.11E-01	1.75E-02	9.34E-02	1.00E+00	9.99E-03	0.00E+00	1.55E+00
4100X-1-CJ-FCV1-004	0.00E+00	0.00E+00	1.57E-03	1.00E+00	0.00E+00	8.45E-03	2.14E-02
4100X-1-CJ-FCV1-005	3.87E-01	9.55E-03	0.00E+00	1.00E+00	1.12E-04	2.14E-02	2.10E-02
75th Percentile Each Sample	4.52E-03	2.97E-04	3.01E-04	1.00E+00	6.06E-06	1.29E-03	2.03E-04
75th Normalized Fraction	2.51E-03	1.65E-04	1.67E-04	5.55E-01	3.36E-06	7.15E-04	1.13E-04

Table 21: Radionuclide Activity Ratios to Cs-137, $f_R A_{i,j}$, Using Combined Sample Data for AB/TB/RWPB Samples, Third Set of Radionuclides

Radionuclide	Eu-155	Pu-238	Pu-239/240	Pu-241	Am-241	Cm-243/244	Np-237
2100X-1-CJ-FCV1-001	0.00E+00	2.01E-05	8.16E-06	9.05E-03	1.27E-04	3.09E-04	0.00E+00
2100X-1-CJ-FCV1-003	5.87E-04	7.10E-04	2.99E-04	1.76E-02	7.75E-04	4.43E-04	0.00E+00
2100X-1-CJ-FCV1-005	5.59E-04	2.04E-05	4.46E-05	2.88E-03	0.00E+00	0.00E+00	0.00E+00
2100X-1-CJ-FCV1-006	3.56E-03	1.54E-04	0.00E+00	1.28E-02	2.68E-04	0.00E+00	NA
2100X-1-CJ-FCV1-011	0.00E+00	0.00E+00	0.00E+00	1.40E-03	0.00E+00	0.00E+00	NA
2100X-1-CJ-FCV1-014	3.91E-04	1.99E-04	0.00E+00	0.00E+00	0.00E+00	5.00E-06	NA
2200X-1-CJ-FCV1-006	5.24E-04	0.00E+00	0.00E+00	7.19E-03	0.00E+00	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-008	0.00E+00	1.63E-06	1.29E-05	0.00E+00	1.36E-05	0.00E+00	NA
2200X-1-CJ-FCV1-010	6.35E-04	0.00E+00	4.36E-05	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-020	0.00E+00	8.07E-07	1.34E-06	0.00E+00	1.64E-06	0.00E+00	NA
2200X-1-CJ-FCV1-021	0.00E+00	1.55E-05	9.77E-05	6.04E-03	0.00E+00	0.00E+00	7.66E-06
2200X-1-CJ-FCV1-022	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-026	0.00E+00	2.17E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-030	0.00E+00	4.72E-04	2.29E-04	1.36E-02	1.14E-03	8.22E-05	8.53E-06
2200X-1-CJ-FCV1-031	0.00E+00	0.00E+00	4.01E-05	0.00E+00	1.15E-05	3.28E-05	NA
2200X-1-CJ-FCV1-035	0.00E+00	5.39E-05	4.42E-05	0.00E+00	3.58E-05	5.75E-06	NA
2200X-1-CJ-FCV1-038	6.84E-04	4.22E-05	4.36E-05	5.75E-02	5.75E-04	5.67E-04	0.00E+00
2200X-1-CJ-FCV1-039	3.35E-05	1.60E-05	0.00E+00	2.61E-02	8.36E-06	0.00E+00	0.00E+00
2200X-1-CJ-WCV1-009	3.45E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2300X-1-CJ-FCV1-001	9.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2300X-1-CJ-FCV1-002	0.00E+00	5.44E-05	3.66E-05	3.27E-04	1.03E-04	1.04E-05	NA
2300X-1-CJ-FCV1-003	1.72E-05	4.81E-05	2.16E-05	1.15E-03	1.46E-04	4.22E-05	0.00E+00
2300X-1-CJ-FCV1-005	0.00E+00	1.23E-06	0.00E+00	0.00E+00	1.51E-05	0.00E+00	NA
2300X-1-CJ-FCV1-007	0.00E+00	3.18E-05	4.85E-07	1.22E-03	3.83E-04	0.00E+00	NA
2300X-1-CJ-FCV1-010	0.00E+00	0.00E+00	5.97E-05	1.05E-02	4.00E-04	1.35E-10	0.00E+00
2600X-1-CJ-FCV1-002	5.99E-04	0.00E+00	2.40E-04	3.12E-03	4.36E-04	8.74E-05	NA
3100X-3-CJ-FCV1-006	0.00E+00	6.85E-02	2.29E-02	0.00E+00	0.00E+00	2.61E-02	0.00E+00
3100X-3-CJ-FCV1-014	1.66E-01	1.55E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
4100X-1-CJ-FCV1-004	0.00E+00	1.86E-03	1.96E-03	0.00E+00	0.00E+00	0.00E+00	NA
4100X-1-CJ-FCV1-005	0.00E+00	0.00E+00	0.00E+00	9.93E-02	2.22E-03	0.00E+00	0.00E+00
75th Percentile Each Sample	4.90E-04	5.43E-05	4.45E-05	8.59E-03	2.38E-04	2.72E-05	0.00E+00
75th Normalized Fraction	2.72E-04	3.01E-05	2.47E-05	4.77E-03	1.32E-04	1.51E-05	0.00E+00

Table 22 summarizes the radionuclide activity fractions using the three methods described above. The Np-237 values for the 75th Percentile of the Activity Average Fractions and the 75th Percentile of the Individual Sample Ratios to Cs-137 are zero due to the very small number of positive activity concentrations for this nuclide.

Table 22: Radionuclide Activity Fractions for AB/TB/RWPB Sample Population Using Three Methods

Nuclide	Average Activity Fractions, fA_i,	75 Percentile of the Activity Average Fractions, $fA_{i,.75}$	75th Percentile of the Individual Sample Ratios to Cs-137, $f_R A_{i,.75}$
H-3	2.60E-02	2.76E-02	2.52E-02
C-14	9.72E-02	4.43E-02	5.14E-02
Fe-55	7.83E-03	1.42E-03	2.33E-03
Co-58	6.94E-11	4.54E-14	7.00E-14
Ni-59	3.11E-03	1.82E-03	2.48E-03
Ni-63	2.25E-01	2.55E-01	3.43E-01

Nuclide	Average Activity Fractions, $fA_{i,}$	75 Percentile of the Activity Average Fractions, $fA_{i,,.75}$	75th Percentile of the Individual Sample Ratios to Cs-137, $f_RA_{i,.75}$
Co-60	7.79E-03	6.99E-03	1.15E-02
Tc-99	7.09E-03	4.68E-04	5.23E-04
Sr-90	9.22E-03	2.79E-03	2.51E-03
Sb-125	3.12E-04	1.81E-04	1.65E-04
Cs-134	2.05E-04	1.16E-04	1.67E-04
Cs-137	6.08E-01	6.55E-01	5.55E-01
Ce-144	1.91E-05	3.38E-06	3.36E-06
Eu-152	1.35E-03	5.09E-04	7.15E-04
Eu-154	2.33E-03	6.67E-05	1.13E-04
Eu-155	3.45E-04	1.69E-04	2.72E-04
Pu-238	3.86E-04	3.69E-05	3.01E-05
Pu-239/240	9.74E-05	3.01E-05	2.47E-05
Pu-241	4.09E-03	3.19E-03	4.77E-03
Am-241	9.73E-05	1.02E-04	1.32E-04
Cm-243/244	8.54E-05	1.07E-05	1.51E-05
Np-237	7.28E-07	0.00E+00	0.00E+00

6.2 Insignificant Dose Contributors and Radionuclides of Concern

NUREG-1757, Vol. 2, Rev. 1 [1] defines radionuclides as "insignificant dose contributors" if the sum of the dose from the group of insignificant contributors is less than 10% of the total dose from all radionuclides combined. The insignificant contributors can be eliminated from further detailed consideration in the LTP and FSS. However, the dose contribution from the insignificant contributors must be accounted for in the final DCGLs. The radionuclides remaining after the insignificant contributors are removed are the ROC for FCS.

The ROCs were selected to ensure that sufficient margin has been attributed to the estimated dose contribution from the insignificant radionuclides. This decreases the risk of having to recalculate the adjusted DCGLS.

The Relative Dose Fraction, $RDF_{i,k}$, for nuclide *i* and population *k* is calculated using the applicable DCGLs from Attachment 2 , and the nuclide activity fraction from Section 5.1 and Equation 6.

$$RDF_{i,k} = \frac{fA_{i,k}}{DCGL_{i,k}} \left[\frac{1}{\sum(i) \frac{fA_{i,k}}{DCGL_{i,k}}} \right] \qquad \text{Equation 6}$$

The values of $DCGL_{i,k}$ are listed in Attachment 2. A list of the 12 DCGLs evaluated in this TSD is summarized in Table 23.

It should be noted that for the nuclide pairs Pu-239/240 and Cm-243/244 that the most limiting DCGL for each pair was selected for use in Equation 6.

Table 23: List of DCGLs Evaluated in this TSD

Soil 0.15 m DCGL (pCi/g)
Soil 1.0 m DCGL (pCi/g)
Buried Pipe Excavation Scenario DCGL (dpm/100 cm2)
BFM[1] Wall/Floor DCGL (Auxiliary, Turbine, Circulating Water Tunnels, Intake Structure) LTP Chapter 6 Equation 6-18 (pCi/m2)
BFM Wall/Floor DCGL (Containment Building LTP Chapter 6 Equation 6-18 (pCi/m2)
Embedded Pipe Auxiliary Floor 971' elevation LTP Chapter 6 Equation 6-14 (pCi/m2)
Embedded Pipe Auxiliary Floor 989' elevation LTP Chapter 6 Equation 6-14 (pCi/m2)
Embedded Pipe Turbine Floor 990' elevation LTP Chapter 6 Equation 6-14 (pCi/m2)
BFM fill material (pCi/g)

The results of these calculations are provided in Tables 25 through 38. The tables show the dose fractions for each sample population. For each sample population the normalized 75th percentile mix fraction and the 75th percentile off the normalized Cs-137 ratios are evaluated.

In addition to the DCGLs evaluated using Equation 6, five "Less Likely But Plausible Scenarios"(LLBP) were also evaluated. Each scenario was evaluated using the same set of radionuclide mix fractions and mathematical methods that were used in the DCGL evaluations.

Table 24 List of LLBP Scenarios Evaluated in this TSD

Embedded Pipe LLBP Drilling Spoils Concentration AB EP 4.03 in ID (pCi/m2 per 25 mrem/yr)
Embedded Pipe LLBP Drilling Spoils Concentration AB EP 18.81 in ID (pCi/m2 per 25 mrem/yr)
Embedded Pipe LLBP Drilling Spoils Concentration TB EP 9.4 in ID (pCi/m2 per 25 mrem/yr)
Recycle/Disposal LLBP Scenario Concrete (pCi/m2 per 25 mrem/yr)
Recycle/Disposal LLBP Scenario Steel (pCi/m2 per 25 mrem/yr)

Table 25: Relative Dose Fractions, $RDF_{i,k}$, Containment Mix Fraction, Using 75th Percentiles of the Averages, CB BFM Wall/Floor DCGL Scenario

Nuclide	ROC?	CB Mix Fraction	Containment Wall/Floor Dose Fraction
H-3		9.72E-02	2.66E-03
C-14	Y	6.28E-01	4.53E-01
Fe-55		9.31E-05	9.11E-08
Co-58		3.56E-14	2.72E-14
Ni-59		4.12E-04	2.26E-06
Ni-63		3.98E-02	5.99E-04
Co-60	Y	3.70E-03	2.65E-02
Tc-99		2.87E-04	2.91E-04
Sr-90	Y	3.70E-04	2.57E-03
Sb-125		5.11E-05	5.54E-05
Cs-134		4.86E-05	2.23E-04
Cs-137	Y	2.26E-01	5.07E-01
Ce-144		1.61E-06	1.68E-07
Eu-152	Y	2.08E-03	6.48E-03

[1] BFM represents "Basement Fill Model"

Nuclide	ROC?	CB Mix Fraction	Containment Wall/Floor Dose Fraction
Eu-154		1.21E-04	4.05E-04
Eu-155		3.53E-05	3.21E-06
Pu-238		1.39E-05	2.92E-05
Pu-239/240		1.40E-05	3.26E-05
Pu-241		1.75E-03	8.30E-05
Am-241		3.32E-05	5.06E-05
Cm-243/244		1.27E-05	1.11E-05
Np-237		6.29E-07	4.96E-05
		Sum	1.00E+00
		ROC	9.96E-01
		IC Dose	4.50E-03

Table 26: Relative Dose Fractions, $RDF_{i,k}$, Containment Mix Fraction, Using 75th Percentiles of the Nuclide Ratios to Cs-137, BFM Wall/Floor of CB DCGL Scenario

Nuclide	ROC?	CB Mix Fraction	Containment Wall/Floor Dose Fraction
H-3		8.70E-02	3.14E-03
C-14	Y	8.27E-01	7.87E-01
Fe-55		1.43E-05	1.84E-08
Co-58		1.47E-14	1.49E-14
Ni-59		1.53E-04	1.11E-06
Ni-63		1.76E-02	3.51E-04
Co-60	Y	1.67E-03	1.58E-02
Tc-99		3.41E-04	4.57E-04
Sr-90	Y	2.59E-04	2.37E-03
Sb-125		1.89E-05	2.70E-05
Cs-134		2.08E-05	1.26E-04
Cs-137	Y	6.01E-02	1.78E-01
Ce-144		1.52E-06	2.09E-07
Eu-152	Y	2.95E-03	1.21E-02
Eu-154		1.44E-04	6.36E-04
Eu-155		4.09E-05	4.90E-06
Pu-238		5.66E-06	1.57E-05
Pu-239/240		1.06E-05	3.26E-05
Pu-241		2.91E-03	1.83E-04
Am-241		4.78E-05	9.61E-05
Cm-243/244		1.27E-05	1.46E-05
Np-237		1.24E-06	1.29E-04
		Sum	1.00E+00
		ROC	9.95E-01
		IC Dose	5.22E-03

Table 27: Relative Dose Fractions, $RDF_{i,k}$, Containment Mix Fraction, Using 75th Percentiles of the Averages, CB Soil, BP & Fill Material DCGL Scenarios

Nuclide	ROC?	CB Mix Fraction	0.15 m Soil Dose Fraction	1.0 m Soil Dose Fraction	Buried Pipe Dose Fraction	Fill Material Dose Fraction
H-3		9.72E-02	2.89E-04	1.21E-03	5.82E-04	9.32E-03
C-14	Y	6.28E-01	3.72E-01	6.63E-01	5.66E-02	7.28E-01
Fe-55		9.31E-05	9.04E-08	4.72E-08	2.25E-08	9.01E-08
Co-58		3.56E-14	3.48E-14	1.22E-14	6.07E-14	1.29E-15
Ni-59		4.12E-04	1.30E-06	1.92E-06	5.56E-07	5.74E-06
Ni-63		3.98E-02	3.43E-04	5.08E-04	1.47E-04	1.52E-03

Nuclide	ROC?	CB Mix Fraction	0.15 m Soil Dose Fraction	1.0 m Soil Dose Fraction	Buried Pipe Dose Fraction	Fill Material Dose Fraction
Co-60	Y	3.70E-03	3.31E-02	1.29E-02	5.71E-02	3.48E-03
Tc-99		2.87E-04	7.52E-05	2.00E-04	1.57E-04	8.84E-04
Sr-90		3.70E-04	1.18E-03	2.30E-03	1.48E-03	6.94E-03
Sb-125		5.11E-05	6.82E-05	2.34E-05	1.20E-04	1.04E-05
Cs-134		4.86E-05	2.69E-04	1.23E-04	4.29E-04	6.74E-05
Cs-137	Y	2.26E-01	5.84E-01	3.17E-01	8.68E-01	2.49E-01
Ce-144		1.61E-06	2.09E-07	7.48E-08	3.66E-07	2.62E-08
Eu-152	Y	2.08E-03	8.35E-03	2.89E-03	1.46E-02	5.66E-05
Eu-154		1.21E-04	5.21E-04	1.81E-04	9.13E-04	4.77E-06
Eu-155		3.53E-05	4.07E-06	1.25E-06	7.10E-06	2.17E-07
Pu-238		1.39E-05	2.82E-06	4.23E-06	4.71E-06	1.08E-04
Pu-239/240		1.40E-05	3.15E-06	4.72E-06	5.25E-06	1.21E-04
Pu-241		1.75E-03	1.09E-05	1.80E-05	1.87E-05	2.92E-04
Am-241		3.32E-05	8.41E-06	1.17E-05	1.44E-05	1.77E-04
Cm-243/244		1.27E-05	6.68E-06	4.46E-06	1.17E-05	2.36E-05
Np-237		6.29E-07	4.73E-06	8.88E-06	5.16E-06	1.85E-04
		Sum	1.00E+00	1.00E+00	1.00E+00	1.00E+00
		ROC	9.97E-01	9.95E-01	9.96E-01	9.80E-01
		IC Dose	2.79E-03	4.60E-03	3.90E-03	1.97E-02

Table 28: Relative Dose Fractions, $RDF_{i,k}$, Containment Mix Fraction, Using 75th Percentiles of the Nuclide Ratios to Cs-137, CB Soil, BP & Fill Material DCGL Scenarios

Nuclide	ROC?	CB Mix Fraction	0.15 m Soil Dose Fraction	1.0 m Soil Dose Fraction	Buried Pipe Dose Fraction	Fill Material Dose Fraction
H-3		8.70E-02	3.84E-04	1.11E-03	1.47E-03	8.00E-03
C-14	Y	8.27E-01	7.27E-01	8.99E-01	2.10E-01	9.19E-01
Fe-55		1.43E-05	2.05E-08	7.45E-09	9.71E-09	1.33E-08
Co-58		1.47E-14	2.14E-14	5.22E-15	7.09E-14	5.14E-16
Ni-59		1.53E-04	7.16E-07	7.36E-07	5.82E-07	2.05E-06
Ni-63		1.76E-02	2.26E-04	2.32E-04	1.84E-04	6.47E-04
Co-60	Y	1.67E-03	2.22E-02	6.00E-03	7.25E-02	1.51E-03
Tc-99		3.41E-04	1.33E-04	2.45E-04	5.24E-04	1.01E-03
Sr-90		2.59E-04	1.23E-03	1.66E-03	2.92E-03	4.67E-03
Sb-125		1.89E-05	3.73E-05	8.91E-06	1.25E-04	3.68E-06
Cs-134		2.08E-05	1.71E-04	5.45E-05	5.18E-04	2.77E-05
Cs-137	Y	6.01E-02	2.30E-01	8.70E-02	6.50E-01	6.35E-02
Ce-144		1.52E-06	2.91E-07	7.25E-08	9.68E-07	2.36E-08
Eu-152	Y	2.95E-03	1.76E-02	4.22E-03	5.85E-02	7.71E-05
Eu-154		1.44E-04	9.21E-04	2.22E-04	3.06E-03	5.45E-06
Eu-155		4.09E-05	6.99E-06	1.50E-06	2.31E-05	2.41E-07
Pu-238		5.66E-06	1.70E-06	1.77E-06	5.39E-06	4.23E-05
Pu-239/240		1.06E-05	3.54E-06	3.69E-06	1.12E-05	8.81E-05
Pu-241		2.91E-03	2.71E-05	3.10E-05	8.81E-05	4.68E-04
Am-241		4.78E-05	1.80E-05	1.73E-05	5.86E-05	2.44E-04
Cm-243/244		1.27E-05	9.90E-06	4.59E-06	3.30E-05	2.26E-05
Np-237		1.24E-06	1.39E-05	1.81E-05	2.86E-05	3.50E-04
		Sum	1.00E+00	1.00E+00	1.00E+00	1.00E+00
		ROC	9.97E-01	9.96E-01	9.91E-01	9.84E-01
		IC Dose	3.18E-03	3.62E-03	9.05E-03	1.56E-02

Table 29: Relative Dose Fractions, $RDF_{i,k}$, AB/TB/RWPB Mix Fraction, Using 75th Percentiles of the Averages, BFM Other Walls/Floors DCGL Scenario

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	Other Wall/Floor Dose Fraction
H-3		2.76E-02	1.23E-03
C-14	Y	4.43E-02	5.06E-02
Fe-55		1.42E-03	1.01E-06
Co-58		4.54E-14	1.14E-14
Ni-59		1.82E-03	1.47E-05
Ni-63		2.55E-01	5.66E-03
Co-60	Y	6.99E-03	1.93E-02
Tc-99		4.68E-04	7.82E-04
Sr-90	Y	2.79E-03	3.18E-02
Sb-125		1.81E-04	7.23E-05
Cs-134		1.16E-04	2.61E-04
Cs-137	Y	6.55E-01	8.89E-01
Ce-144		3.38E-06	1.30E-07
Eu-152	Y	5.09E-04	4.96E-04
Eu-154		6.67E-05	7.04E-05
Eu-155		1.69E-04	4.60E-06
Pu-238		3.69E-05	1.22E-04
Pu-239/240		3.01E-05	1.11E-04
Pu-241		3.19E-03	2.40E-04
Am-241		1.02E-04	2.41E-04
Cm-243/244		1.07E-05	1.05E-05
Np-237		0.00E+00	0.00E+00
		Sum	1.00E+00
		ROC	9.91E-01
		IC Dose	8.82E-03

Table 30: Relative Dose Fractions, $RDF_{i,k}$, AB/TB/RWPB Mix Fraction, Using 75th Percentiles of the Nuclide Ratios to Cs-137, BFM Other Walls/Floors DCGL Scenario

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	Other Wall/Floor Dose Fraction
H-3		2.52E-02	1.27E-03
C-14	Y	5.14E-02	6.64E-02
Fe-55		2.33E-03	1.88E-06
Co-58		7.00E-14	1.99E-14
Ni-59		2.48E-03	2.27E-05
Ni-63		3.43E-01	8.58E-03
Co-60	Y	1.15E-02	3.58E-02
Tc-99		5.23E-04	9.88E-04
Sr-90	Y	2.51E-03	3.23E-02
Sb-125		1.65E-04	7.44E-05
Cs-134		1.67E-04	4.24E-04
Cs-137	Y	5.55E-01	8.52E-01
Ce-144		3.36E-06	1.47E-07
Eu-152	Y	7.15E-04	7.88E-04
Eu-154		1.13E-04	1.34E-04
Eu-155		2.72E-04	8.39E-06
Pu-238		3.01E-05	1.13E-04
Pu-239/240		2.47E-05	1.03E-04
Pu-241		4.77E-03	4.06E-04
Am-241		1.32E-04	3.53E-04
Cm-243/244		1.51E-05	1.68E-05
Np-237		0.00E+00	0.00E+00

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	Other Wall/Floor Dose Fraction
		Sum	1.00E+00
		ROC	9.87E-01
		IC Dose	1.25E-02

Table 31: Relative Dose Fractions, $RDF_{i,k}$, AB/TB/RWPB Mix Fraction, Using 75th Percentiles of the Averages, Embedded Pipe DCGL Scenarios*

Nuclide	ROC?		AB/TB/RWPB Mix Fraction	971' Embedded Pipe Dose Fraction	989' Embedded Pipe Dose Fraction	990' Embedded Pipe Dose Fraction
H-3			2.76E-02	9.06E-03	9.06E-03	9.06E-03
C-14	Y		4.43E-02	2.26E-01	2.26E-01	2.26E-01
Fe-55			1.42E-03	4.11E-06	4.11E-06	4.11E-06
Co-58			4.54E-14	2.62E-15	2.62E-15	2.62E-15
Ni-59			1.82E-03	7.02E-05	7.02E-05	7.02E-05
Ni-63			2.55E-01	1.96E-02	1.96E-02	1.96E-02
Co-60	Y		6.99E-03	1.04E-02	1.04E-02	1.04E-02
Tc-99			4.68E-04	4.75E-03	4.75E-03	4.75E-03
Sr-90	Y		2.79E-03	9.88E-02	9.88E-02	9.88E-02
Sb-125			1.81E-04	1.09E-04	1.09E-04	1.09E-04
Cs-134			1.16E-04	1.40E-04	1.40E-04	1.40E-04
Cs-137	Y		6.55E-01	6.26E-01	6.26E-01	6.26E-01
Ce-144			3.38E-06	1.43E-07	1.43E-07	1.43E-07
Eu-152	Y		5.09E-04	4.30E-05	4.30E-05	4.30E-05
Eu-154			6.67E-05	8.18E-06	8.18E-06	8.18E-06
Eu-155			1.69E-04	3.22E-06	3.22E-06	3.22E-06
Pu-238			3.69E-05	9.09E-04	9.09E-04	9.09E-04
Pu-239/240			3.01E-05	1.09E-03	1.09E-03	1.09E-03
Pu-241			3.19E-03	1.71E-03	1.71E-03	1.71E-03
Am-241			1.02E-04	1.66E-03	1.66E-03	1.66E-03
Cm-243/244			1.07E-05	5.61E-05	5.61E-05	5.61E-05
Np-237			0.00E+00	0.00E+00	0.00E+00	0.00E+00
			Sum	1.00E+00	1.00E+00	1.00E+00
			ROC	9.61E-01	9.61E-01	9.61E-01
			IC Dose	3.91E-02	3.91E-02	3.91E-02

* The dose fractions for the Embedded Pipe scenarios differ slightly but round to the same number.

Table 32: Relative Dose Fractions, $RDF_{i,k}$, AB/TB/RWPB Mix Fraction, Using 75th Percentiles of the Nuclide Ratios to Cs-137, Embedded Pipe DCGL Scenarios*

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	971' Embedded Pipe Dose Fraction	989' Embedded Pipe Dose Fraction	990' Embedded Pipe Dose Fraction
H-3		2.52E-02	8.76E-03	8.76E-03	8.76E-03
C-14	Y	5.14E-02	2.77E-01	2.77E-01	2.77E-01
Fe-55		2.33E-03	7.14E-06	7.14E-06	7.14E-06
Co-58		7.00E-14	4.26E-15	4.26E-15	4.26E-15
Ni-59		2.48E-03	1.01E-04	1.01E-04	1.01E-04
Ni-63		3.43E-01	2.78E-02	2.78E-02	2.78E-02
Co-60	Y	1.15E-02	1.81E-02	1.81E-02	1.81E-02
Tc-99		5.23E-04	5.61E-03	5.61E-03	5.61E-03
Sr-90	Y	2.51E-03	9.38E-02	9.38E-02	9.38E-02
Sb-125		1.65E-04	1.05E-04	1.05E-04	1.05E-04
Cs-134		1.67E-04	2.13E-04	2.13E-04	2.13E-04
Cs-137	Y	5.55E-01	5.61E-01	5.61E-01	5.61E-01
Ce-144		3.36E-06	1.51E-07	1.51E-07	1.51E-07
Eu-152	Y	7.15E-04	6.38E-05	6.38E-05	6.38E-05
Eu-154		1.13E-04	1.46E-05	1.46E-05	1.46E-05

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	971' Embedded Pipe Dose Fraction	989' Embedded Pipe Dose Fraction	990' Embedded Pipe Dose Fraction
Eu-155		2.72E-04	5.50E-06	5.50E-06	5.50E-06
Pu-238		3.01E-05	7.86E-04	7.86E-04	7.86E-04
Pu-239/240		2.47E-05	9.42E-04	9.42E-04	9.42E-04
Pu-241		4.77E-03	2.70E-03	2.70E-03	2.70E-03
Am-241		1.32E-04	2.28E-03	2.28E-03	2.28E-03
Cm-243/244		1.51E-05	8.36E-05	8.36E-05	8.36E-05
Np-237		0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Sum	1.00E+00	1.00E+00	1.00E+00
		ROC	9.51E-01	9.51E-01	9.51E-01
		IC Dose	4.94E-02	4.94E-02	4.94E-02

* The dose fractions for the Embedded Pipe scenarios differ slightly but round to the same number.

Table 33: Relative Dose Fractions, $RDF_{i,k}$, AB/TB/RWPB Mix Fraction, Using 75th Percentiles of the Averages, Soil, Buried Pipe, & Fill Material DCGL Scenarios

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	Soil 0.15 m Dose Fraction	Soil 1.0 m Dose Fraction	Buried Pipe Dose Fraction	Fill Material Dose Fraction
H-3		2.76E-02	4.57E-05	3.38E-04	1.09E-04	3.12E-03
C-14	Y	4.43E-02	1.46E-02	4.61E-02	2.00E-03	6.05E-02
Fe-55		1.42E-03	7.67E-07	7.10E-07	1.53E-07	1.62E-06
Co-58		4.54E-14	2.47E-14	1.54E-14	2.78E-14	1.95E-15
Ni-59		1.82E-03	3.19E-06	8.38E-06	1.63E-06	3.00E-05
Ni-63		2.55E-01	1.23E-03	3.22E-03	6.25E-04	1.15E-02
Co-60	Y	6.99E-03	3.48E-02	2.40E-02	3.89E-02	7.75E-03
Tc-99		4.68E-04	6.82E-05	3.22E-04	1.28E-04	1.70E-03
Sr-90		2.79E-03	4.97E-03	1.71E-02	7.91E-03	6.18E-02
Sb-125		1.81E-04	1.35E-04	8.19E-05	1.53E-04	4.35E-05
Cs-134		1.16E-04	3.58E-04	2.91E-04	3.78E-04	1.90E-04
Cs-137	Y	6.55E-01	9.42E-01	9.08E-01	9.48E-01	8.51E-01
Ce-144		3.38E-06	2.43E-07	1.55E-07	2.77E-07	6.47E-08
Eu-152	Y	5.09E-04	1.14E-03	6.97E-04	1.28E-03	1.63E-05
Eu-154		6.67E-05	1.60E-04	9.87E-05	1.80E-04	3.11E-06
Eu-155		1.69E-04	1.08E-05	5.91E-06	1.21E-05	1.22E-06
Pu-238		3.69E-05	4.16E-06	1.11E-05	1.03E-05	3.39E-04
Pu-239/240		3.01E-05	3.78E-06	1.00E-05	9.32E-06	3.08E-04
Pu-241		3.19E-03	1.11E-05	3.25E-05	2.56E-05	6.30E-04
Am-241		1.02E-04	1.43E-05	3.53E-05	3.07E-05	6.40E-04
Cm-243/244		1.07E-05	3.14E-06	3.72E-06	4.43E-06	2.35E-05
Np-237		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Sum	1.00E+00	1.00E+00	1.00E+00	1.00E+00
		ROC	9.93E-01	9.78E-01	9.90E-01	9.20E-01
		IC Dose	7.02E-03	2.16E-02	9.58E-03	8.04E-02

Table 34: Relative Dose Fractions, $RDF_{i,k}$, AB/TB/RWPB Mix Fraction, Using 75th Percentiles of the Nuclide Ratios to Cs-137, Soil, Buried Pipe & Fill Material DCGL Scenarios

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	Soil 0.15 m Dose Fraction	Soil 1.0 m Dose Fraction	Buried Pipe Dose Fraction	Fill Material Dose Fraction
H-3		2.52E-02	4.73E-05	3.50E-04	1.13E-04	3.23E-03
C-14	Y	5.14E-02	1.92E-02	6.05E-02	2.64E-03	7.96E-02
Fe-55		2.33E-03	1.43E-06	1.32E-06	2.86E-07	3.01E-06
Co-58		7.00E-14	4.32E-14	2.69E-14	4.87E-14	3.40E-15
Ni-59		2.48E-03	4.92E-06	1.29E-05	2.51E-06	4.62E-05
Ni-63		3.43E-01	1.86E-03	4.88E-03	9.52E-04	1.75E-02
Co-60	Y	1.15E-02	6.49E-02	4.47E-02	7.27E-02	1.44E-02
Tc-99		5.23E-04	8.64E-05	4.07E-04	1.62E-04	2.15E-03
Sr-90		2.51E-03	5.06E-03	1.74E-02	8.05E-03	6.28E-02

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	Soil 0.15 m Dose Fraction	Soil 1.0 m Dose Fraction	Buried Pipe Dose Fraction	Fill Material Dose Fraction
Sb-125		1.65E-04	1.39E-04	8.43E-05	1.58E-04	4.49E-05
Cs-134		1.67E-04	5.83E-04	4.73E-04	6.16E-04	3.10E-04
Cs-137	Y	5.55E-01	9.06E-01	8.70E-01	9.12E-01	8.17E-01
Ce-144		3.36E-06	2.75E-07	1.74E-07	3.13E-07	7.30E-08
Eu-152	Y	7.15E-04	1.81E-03	1.11E-03	2.04E-03	2.60E-05
Eu-154		1.13E-04	3.07E-04	1.88E-04	3.45E-04	5.95E-06
Eu-155		2.72E-04	1.98E-05	1.08E-05	2.22E-05	2.24E-06
Pu-238		3.01E-05	3.86E-06	1.02E-05	9.52E-06	3.14E-04
Pu-239/240		2.47E-05	3.51E-06	9.31E-06	8.67E-06	2.86E-04
Pu-241		4.77E-03	1.89E-05	5.50E-05	4.34E-05	1.07E-03
Am-241		1.32E-04	2.11E-05	5.19E-05	4.53E-05	9.41E-04
Cm-243/244		1.51E-05	5.01E-06	5.91E-06	7.08E-06	3.75E-05
Np-237		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Sum	1.00E+00	1.00E+00	1.00E+00	1.00E+00
		ROC	9.92E-01	9.76E-01	9.89E-01	9.11E-01
		IC Dose	8.17E-03	2.39E-02	1.05E-02	8.88E-02

Table 35: Relative Dose Fractions, $RDF_{i,k}$, Containment Mix Fraction, Using 75th Percentiles of the Averages, LLBP Scenarios

Nuclide	ROC?	CB Mix Fraction	R/D Concrete Dose Fraction	R/D Steel Dose Fraction
H-3		9.72E-02	1.71E-04	1.86E-04
C-14	Y	6.28E-01	1.01E-02	1.07E-02
Fe-55		8.86E-05	1.26E-11	1.04E-11
Co-58		3.56E-14	3.15E-60	2.65E-60
Ni-59		4.12E-04	1.23E-07	1.02E-07
Ni-63		3.98E-02	9.34E-06	8.17E-06
Co-60	Y	3.70E-03	2.83E-03	1.95E-03
Tc-99		2.87E-04	2.49E-04	2.49E-04
Sr-90	Y	3.70E-04	3.72E-05	5.90E-05
Sb-125		5.11E-05	1.66E-07	1.07E-07
Cs-134		4.86E-05	4.64E-08	4.74E-08
Cs-137	Y	2.26E-01	9.79E-01	9.80E-01
Ce-144		1.61E-06	3.04E-18	2.20E-18
Eu-152	Y	2.09E-03	7.59E-03	5.11E-03
Eu-154		1.21E-04	2.19E-04	1.33E-04
Eu-155		3.54E-05	2.31E-07	1.28E-07
Pu-238		1.39E-05	4.33E-05	1.82E-04
Pu-239/240		1.40E-05	6.05E-05	2.50E-04
Pu-241		1.75E-03	3.57E-05	1.23E-04
Am-241		3.32E-05	2.74E-06	8.06E-04
Cm-243/244		1.27E-05	2.65E-05	1.10E-04
Np-237		6.29E-07	9.42E-05	1.06E-04
		Sum	1.00E+00	1.00E+00
		ROC	9.99E-01	9.98E-01
		IC Dose	9.12E-04	2.15E-03

Table 36: Relative Dose Fractions, $RDF_{i,k}$, Containment Mix Fraction, Using 75th Percentiles of the Nuclide Ratios to Cs-137, LLBP Scenarios

Nuclide	ROC?	CB Mix Fraction	R/D Concrete Dose Fraction	R/D Steel Dose Fraction
H-3		8.70E-02	5.32E-04	5.83E-04
C-14	Y	8.27E-01	4.64E-02	4.93E-02

Nuclide	ROC?	CB Mix Fraction	R/D Concrete Dose Fraction	R/D Steel Dose Fraction
Fe-55		1.43E-05	6.74E-12	5.58E-12
Co-58		1.47E-14	4.55E-60	3.85E-60
Ni-59		1.53E-04	1.60E-07	1.32E-07
Ni-63		1.76E-02	1.44E-05	1.27E-05
Co-60	Y	1.67E-03	4.45E-03	3.07E-03
Tc-99		3.41E-04	1.03E-03	1.04E-03
Sr-90		2.59E-04	9.07E-05	1.45E-04
Sb-125		1.89E-05	2.14E-07	1.38E-07
Cs-134		2.08E-05	6.94E-08	7.12E-08
Cs-137	Y	6.01E-02	9.08E-01	9.13E-01
Ce-144		1.52E-06	9.96E-18	7.25E-18
Eu-152	Y	2.95E-03	3.75E-02	2.54E-02
Eu-154		1.44E-04	9.11E-04	5.53E-04
Eu-155		4.09E-05	9.34E-07	5.17E-07
Pu-238		5.66E-06	6.13E-05	2.59E-04
Pu-239/240		1.06E-05	1.60E-04	6.65E-04
Pu-241		2.91E-03	2.08E-04	7.18E-04
Am-241		4.78E-05	1.38E-05	4.06E-03
Cm-243/244		1.27E-05	9.24E-05	3.83E-04
Np-237		1.24E-06	6.48E-04	7.31E-04
		Sum	1.00E+00	1.00E+00
		ROC	9.96E-01	9.91E-01
		IC Dose	3.67E-03	9.01E-03

Table 37: Relative Dose Fractions, $RDF_{i,k}$, AB/TB/RWPB Mix Fraction, Using 75th Percentiles of the Averages, LLBP Scenarios*

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	AB EP 4.03 in ID Dose Fraction	AB EP 18.81 in ID Dose Fraction	TB EP 9.4 in ID Dose Fraction	R/D Concrete Dose Fraction	R/D Steel Dose Fraction
H-3		2.76E-02	2.33E-07	2.33E-07	2.33E-07	1.70E-05	1.85E-05
C-14	Y	4.43E-02	3.08E-06	3.08E-06	3.08E-06	2.50E-04	2.64E-04
Fe-55		1.42E-03	1.33E-12	1.33E-12	1.33E-12	6.76E-11	5.56E-11
Co-58		4.54E-14	5.45E-61	5.45E-61	5.45E-61	1.41E-60	1.19E-60
Ni-59		1.82E-03	2.72E-08	2.72E-08	2.72E-08	1.92E-07	1.58E-07
Ni-63		2.55E-01	8.40E-06	8.40E-06	8.40E-06	2.11E-05	1.84E-05
Co-60	Y	6.99E-03	1.69E-03	1.69E-03	1.69E-03	1.87E-03	1.29E-03
Tc-99		4.68E-04	2.86E-06	2.86E-06	2.86E-06	1.42E-04	1.42E-04
Sr-90	Y	2.79E-03	1.05E-04	1.05E-04	1.05E-04	9.85E-05	1.56E-04
Sb-125		1.81E-04	2.00E-07	2.00E-07	2.00E-07	2.07E-07	1.33E-07
Cs-134		1.16E-04	3.51E-08	3.51E-08	3.51E-08	3.90E-08	3.97E-08
Cs-137	Y	6.55E-01	9.98E-01	9.98E-01	9.98E-01	9.97E-01	9.96E-01
Ce-144		3.38E-06	1.63E-18	1.63E-18	1.63E-18	2.23E-18	1.62E-18
Eu-152	Y	5.09E-04	6.30E-04	6.30E-04	6.30E-04	6.52E-04	4.38E-04
Eu-154		6.67E-05	3.94E-05	3.94E-05	3.94E-05	4.26E-05	2.57E-05
Eu-155		1.69E-04	5.20E-07	5.20E-07	5.20E-07	3.88E-07	2.13E-07
Pu-238		3.69E-05	6.56E-07	6.56E-07	6.56E-07	4.03E-05	1.69E-04
Pu-239/240		3.01E-05	7.49E-07	7.49E-07	7.49E-07	4.58E-05	1.89E-04
Pu-241		3.19E-03	1.59E-06	1.59E-06	1.59E-06	2.29E-05	7.87E-05
Am-241		1.02E-04	7.81E-06	7.81E-06	7.81E-06	2.95E-06	8.66E-04
Cm-243/244		1.07E-05	3.28E-06	3.28E-06	3.28E-06	7.87E-06	3.24E-05
Np-237		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Sum	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
		ROC	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.98E-01
		IC Dose	6.57E-05	6.57E-05	6.57E-05	3.44E-04	1.54E-03

* The dose fractions for the Embedded Pipe scenarios differ slightly but round to the same number.

Table 38: Relative Dose Fractions, $RDF_{i,k}$, AB/TB/RWPB Mix Fraction, Using 75th Percentiles of the Nuclide Ratios to Cs-137, LLBP Scenarios*

Nuclide	ROC?	AB/TB/RWPB Mix Fraction	AB EP 4.03 in ID Dose Fraction	AB EP 18.81 in ID Dose Fraction	TB EP 9.4 in ID Dose Fraction	R/D Concrete Fraction	R/D Steel Dose Fraction
H-3		2.52E-02	2.51E-07	2.51E-07	2.51E-07	1.83E-05	1.99E-05
C-14	Y	5.14E-02	4.21E-06	4.21E-06	4.21E-06	3.42E-04	3.61E-04
Fe-55		2.33E-03	2.57E-12	2.57E-12	2.57E-12	1.31E-10	1.07E-10
Co-58		7.00E-14	9.89E-61	9.89E-61	9.89E-61	2.56E-60	2.15E-60
Ni-59		2.48E-03	4.35E-08	4.35E-08	4.35E-08	3.06E-07	2.52E-07
Ni-63		3.43E-01	1.33E-05	1.33E-05	1.33E-05	3.32E-05	2.90E-05
Co-60	Y	1.15E-02	3.28E-03	3.28E-03	3.28E-03	3.63E-03	2.49E-03
Tc-99		5.23E-04	3.77E-06	3.77E-06	3.77E-06	1.87E-04	1.87E-04
Sr-90	Y	2.51E-03	1.11E-04	1.11E-04	1.11E-04	1.04E-04	1.65E-04
Sb-125		1.65E-04	2.14E-07	2.14E-07	2.14E-07	2.22E-07	1.42E-07
Cs-134		1.67E-04	5.93E-08	5.93E-08	5.93E-08	6.59E-08	6.72E-08
Cs-137	Y	5.55E-01	9.95E-01	9.95E-01	9.95E-01	9.94E-01	9.94E-01
Ce-144		3.36E-06	1.91E-18	1.91E-18	1.91E-18	2.62E-18	1.89E-18
Eu-152	Y	7.15E-04	1.04E-03	1.04E-03	1.04E-03	1.08E-03	7.23E-04
Eu-154		1.13E-04	7.82E-05	7.82E-05	7.82E-05	8.46E-05	5.10E-05
Eu-155		2.72E-04	9.88E-07	9.88E-07	9.88E-07	7.37E-07	4.05E-07
Pu-238		3.01E-05	6.31E-07	6.31E-07	6.31E-07	3.87E-05	1.62E-04
Pu-239/240		2.47E-05	7.23E-07	7.23E-07	7.23E-07	4.42E-05	1.82E-04
Pu-241		4.77E-03	2.79E-06	2.79E-06	2.79E-06	4.03E-05	1.39E-04
Am-241		1.32E-04	1.19E-05	1.19E-05	1.19E-05	4.51E-06	1.32E-03
Cm-243/244		1.51E-05	5.44E-06	5.44E-06	5.44E-06	1.30E-05	5.37E-05
Np-237		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
		Sum	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
		ROC	1.00E+00	1.00E+00	1.00E+00	1.00E+00	9.98E-01
		IC Dose	1.18E-04	1.18E-04	1.18E-04	4.65E-04	2.15E-03

* The dose fractions for the Embedded Pipe scenarios differ slightly but round to the same number.

In addition to the RDFs for each nuclide and population,

Table 25 through Table 38 show the relative doses for the ROC and IC nuclides as ROC Fractional Dose and IC Fractional Dose, respectively. A summary of each location/scenario ROCs are provided in Table 39.

Table 39: Summary of ROC Lists

Location/Scenario	ROC List
CB Walls and Floors	C-14, Co-60, Sr-90, Cs-137, Eu-152
Soil (CB Mix), Backfill Material, Buried Pipe	C-14, Co-60, Cs-137, Eu-152
Other Floors/Walls	C-14, Co-60, Sr-90, Cs-137, Eu-152
AB/TB Embedded Pipes	C-14, Co-60, Sr-90, Cs-137, Eu-152
AB/TB, RWPB Soil, Backfill Material, Buried Pipe	C-14, Co-60, Cs-137, Eu-152

The evaluation shows that the IC dose fraction ranges from approximately 0.28% to 8.88% of the total dose depending on the source and the method used for determining the fractions. The highest value for

the IC dose fraction is from the AB/TB/RWPB mix fraction for the Backfill Material scenario using the 75th percentiles of the nuclide ratios to Cs-137 statistical method.

The evaluations of the LLBP Scenarios shows that the relative doses for these scenarios for the IC nuclides are very small. The highest LLBP IC dose fraction being 0.90%. The highest value for the IC dose fraction is from the Steel Recycling/Disposal scenario in the CB using 75th percentiles of the nuclide ratios to Cs-137.

6.3 Selection of Overall Nuclide Fraction

To support FSS activities, a single radionuclide mix is desired for each potential source-term rather than a set of values as has been used in Sections 5.1 and 6.2 representing three statistical/mathematical methods. Evaluation of the three statistical methods, shows that the two methods involving the use of the 75th percentiles result in very similar results, particularly the IC dose fractions.

Using the 75th percentile provides sufficient overall conservatism in the development of the radionuclide mixtures. We do recognize that a higher percentile value will provide a different mixture profile, but such an approach would give undo weight to outliers of the sample populations. In addition, there is prior precedence in using the 75th percentile, particularly in the parameter selection process for dose modeling to support DCGL calculations and that this approach also results in satisfactory conservatism. This approach was previously used in the development of the La Crosse Boiling Water Reactor (LACBWR) radionuclide mixtures as documented in Energy Solutions Technical Support Document RS-TD-313196-001 "*Radionuclides of Concern During LACBWR Decommissioning"* [17.].

For consistency and simplicity, we have chosen the '75th percentile of the Cs-137 fractions' to represent the overall nuclide mix for the Containment Building sample population and the AB/TB/RWPB sample population as reproduced in Section 5.2. Table 40 shows the final radionuclide mixture fractions which have been selected for each mixture evaluated. These were the radionuclide mix fractions for the nuclides used to calculate the DCGLS and for the determination of ROCs and IC to dose.

Table 40: Final Radionuclide Mixtures for FCS

Nuclide	CB Mix	AB/TB/RWPB Mix
H-3	8.70E-02	2.52E-02
C-14	8.27E-01	5.14E-02
Fe-55	1.43E-05	2.33E-03
Co-58	1.47E-14	7.00E-14
Ni-59	1.53E-04	2.48E-03
Ni-63	1.76E-02	3.43E-01
Co-60	1.67E-03	1.15E-02
Tc-99	3.41E-04	5.23E-04
Sr-90	2.59E-04	2.51E-03
Sb-125	1.89E-05	1.65E-04
Cs-134	2.08E-05	1.67E-04
Cs-137	6.01E-02	5.55E-01
Ce-144	1.52E-06	3.36E-06
Eu-152	2.95E-03	7.15E-04
Eu-154	1.44E-04	1.13E-04
Eu-155	4.09E-05	2.72E-04

Nuclide	CB Mix	AB/TB/RWPB Mix
Pu-238	5.66E-06	3.01E-05
Pu-239/240	1.06E-05	2.47E-05
Pu-241	2.91E-03	4.77E-03
Am-241	4.78E-05	1.32E-04
Cm-243/244	1.27E-05	1.51E-05
Np-237	1.24E-06	0.00E+00

6.4 ROC Mixture Fractions

In order to support gross gamma measurements during characterization and final status surveys, an ROC mixture for gamma emitting radionuclides can be used to calculate the sensitivity of gross gamma detectors for a specific mixture. This determination begins with the re-normalized ROC fractions listed in Table 40 for the ROC's identified in Section 5.2. These fractions are provided in, Table 41 including the HTD radionuclides.

Table 41: ROC Mixture Fraction

Nuclide	CB Wall/Floor Mix Fraction	CB Soil & BP Mix Fraction	CB Fill Material Mix Fraction	AB/TB/RWPB Wall/Floor & Embedded Pipe Mix Fraction	AB/TB/RWPB Soils & Buried Pipe Mix Fraction	AB/TB/RWPB Fill Material Mix Fraction
C-14	9.27E-01	9.27E-01	9.27E-01	8.27E-02	8.30E-02	8.30E-02
Co-60	1.87E-03	1.87E-03	1.87E-03	1.85E-02	1.86E-02	1.86E-02
Sr-90	2.91E-04	0.00E+00	0.00E+00	4.04E-03	0.00E+00	0.00E+00
Cs-137	6.74E-02	6.74E-02	6.74E-02	8.94E-01	8.97E-01	8.97E-01
Eu-152	3.31E-03	3.31E-03	3.31E-03	1.15E-03	1.16E-03	1.16E-03

Using the data in Table 41, the ROC mixture fraction for only the gamma emitters is re-normalized against the total gamma ROC activity and shown in Table 42.

Table 42: Gamma ROC Mixture Fractions

Nuclide	CB Wall/Floor Mix Fraction	CB Soil & BP Mix Fraction	CB Fill Material Mix Fraction	AB/TB/RWPB Wall/Floor & Embedded Pipe Mix Fraction	AB/TB/RWPB Soils & Buried Pipe Mix Fraction	AB/TB/RWPB Fill Material Mix Fraction
Co-60	2.58E-02	2.58E-02	2.58E-02	2.03E-02	2.03E-02	2.03E-02
Cs-137	9.29E-01	9.29E-01	9.29E-01	9.78E-01	9.78E-01	9.78E-01
Eu-152	4.56E-02	4.56E-02	4.56E-02	1.26E-03	1.26E-03	1.26E-03

6.5 Surrogate Ratios

From the data provided in sections 6.1, 6.2, 6.3 and 6.4, it is evident that Cs-137 is the predominant ROC gamma-emitting radionuclide. Co-60 and Eu-152 are also gamma emitting ROCs are present, but at much lower fractions than Cs-137. Also, C-14, and Sr-90 are identified as ROCs while also being HTD radionuclides.

Cs-137 was selected as the most appropriate gamma emitter for the surrogate relationship for both Sr-90 and C-14. This was based on the high percentage of Cs-137 (93-98%) and the low percentage of Co-60 (2.0-2.5%). Due to the high abundance of C-14 in the mix fractions (83% in the CB and 5% in the AB/TB/RWPB) the resulting surrogate ratio to Co-60 would have been impractical to use during additional characterization, remediation, and final status surveys. Due to instrument sensitivities and the high C-14/Co-60 ratios, it would not be possible to meet the required scan MDCs.

The ratio of HTDs to gamma emitters is required to develop a surrogate relationship as defined in MARSSIM. The concentration of HTDs can be inferred from the concentration of a gamma emitter in cases where samples are not subject to HTD analysis during FSS activities. Tables 42 and 43 show the decayed concentrations, MDCs and the Cs-137 ratios for each HTD ROC in each mixture fraction. As shown by an "ND" notation, there are some instances where HTDs and/or gamma emitters were not detected. These tables show the decayed reported activity if detected, and if not detected, the decayed MDC is used.

For the samples where neither nuclide was detected, the ratio of the MDC's was not used since this is merely a ratio of the detectability of the two nuclides for that specific sample and has no relationship to the activity ratio.

Of the 57 samples, 43 of the Sr-90, 55 of the C-14 and 56 of the Cs-137 results were greater than MDC. One sample was non-detectable for both Sr-90 and Cs-137 and one sample was non-detectable for both C-14 and Cs-137.

Table 43: Sr-90 and Cs-137 Decayed Reported Concentrations, MDCs and Ratios

Sample ID	Building	Sr-90 Decayed Reported Concentrations (pCi/g)	Sr-90 Decayed MDCs (pCi/g)	Cs-137 Decayed Reported Concentrations (pCi/g)	Cs-137 Decayed MDCs (pCi/g)	Sr-90 Concentration Using Reported or MDC Values (pCi/g)	Cs-137 Concentration Using Reported or MDC Values (pCi/g)	Sr-90/Cs-137 Ratio Using Reported or MDC Values
1100X-1-CJ-FCV1-005	CB	5.29E+00	2.32E-01	4.19E+03	1.78E+01	5.29E+00	4.19E+03	1.26E-03
1100X-1-CJ-WCV1-003	CB	8.53E+00	1.62E+00	1.37E+03	1.64E+02	8.53E+00	1.37E+03	6.24E-03
1100X-1-CJ-WCV1-004	CB	8.43E+00	5.30E-01	4.59E+03	1.44E+01	8.43E+00	4.59E+03	1.84E-03
1200X-1-CJ-FCV1-001	CB	6.02E-01	7.70E-02	1.07E+02	1.95E+00	6.02E-01	1.07E+02	5.64E-03
1200X-1-CJ-FCV1-002	CB	1.87E+00	1.38E-01	4.02E+02	5.19E+00	1.87E+00	4.02E+02	4.65E-03
1200X-1-CJ-FCV1-003	CB	3.67E+00	1.84E-01	9.20E+02	5.49E+00	3.67E+00	9.20E+02	3.99E-03
1200X-1-CJ-FCV1-010	CB	4.33E-01	6.33E-02	3.02E+02	3.47E+00	4.33E-01	3.02E+02	1.43E-03
1200X-1-CJ-FCV1-018	CB	3.85E-01	6.19E-02	2.15E+02	2.94E+00	3.85E-01	2.15E+02	1.79E-03
1200X-1-CJ-FCV1-023	CB	1.47E+01	3.53E-01	5.07E+03	1.36E+01	1.47E+01	5.07E+03	2.89E-03
1200X-1-CJ-FCV1-025	CB	1.78E+00	1.21E-01	8.21E+02	5.36E+00	1.78E+00	8.21E+02	2.16E-03
1200X-1-CJ-FCV1-027	CB	8.96E-01	9.30E-02	3.84E+03	1.20E+01	8.96E-01	3.84E+03	2.33E-04
1200X-1-CJ-WCV1-005	CB	9.13E-02	5.41E-02	8.04E+01	1.81E+00	9.13E-02	8.04E+01	1.14E-03
1200X-1-CJ-WCV1-006	CB	3.46E-01	2.29E-01	3.57E+01	4.34E+00	3.46E-01	3.57E+01	9.69E-03

Sample ID	Building	Sr-90 Decayed Reported Concentrations (pCi/g)	Sr-90 Decayed MDCs (pCi/g)	Cs-137 Decayed Reported Concentrations (pCi/g)	Cs-137 Decayed MDCs (pCi/g)	Sr-90 Concentration Using Reported or MDC Values (pCi/g)	Cs-137 Concentration Using Reported or MDC Values (pCi/g)	Sr-90/Cs-137 Ratio Using Reported or MDC Values
1200X-1-CJ-WCV1-008	CB	1.11E-01	1.49E-01	1.10E+01	1.08E+00	1.49E-01	1.10E+01	1.35E-02
1200X-1-CJ-WCV1-009	CB	6.97E-02	7.22E-02	2.55E+02	3.38E+00	7.22E-02	2.55E+02	2.83E-04
1200X-1-CJ-WCV1-011	CB	1.52E-01	1.40E-01	7.89E+01	7.42E+00	1.52E-01	7.89E+01	1.92E-03
1200X-1-CJ-WCV1-012	CB	2.47E-01	2.05E-01	4.53E+01	4.36E+00	2.47E-01	4.53E+01	5.45E-03
1200X-1-CJ-WCV1-015	CB	1.19E-01	2.04E-01	2.03E+01	2.23E+00	2.04E-01	2.03E+01	1.01E-02
1200X-1-CJ-WCV1-028	CB	-7.76E-02	1.34E-01	1.29E+02	1.11E+01	1.34E-01	1.29E+02	1.04E-03
1200X-1-CJ-WCV1-029	CB	1.41E-02	1.85E-01	1.22E+01	1.45E+00	1.85E-01	1.22E+01	1.52E-02
1300X-1-CJ-FCV1-003	CB	4.34E-01	7.36E-02	4.60E+03	1.25E+01	4.34E-01	4.60E+03	9.45E-05
1300X-1-CJ-FCV1-005	CB	7.05E-02	1.53E-01	8.14E+01	8.70E+00	1.53E-01	8.14E+01	1.88E-03
1300X-1-CJ-FCV1-006	CB	2.07E-01	5.19E-02	7.56E+02	5.50E+00	2.07E-01	7.56E+02	2.73E-04
1300X-1-CJ-FCV1-008	CB	1.22E+00	1.08E-01	1.08E+03	6.89E+00	1.22E+00	1.08E+03	1.13E-03
1300X-1-CJ-WCV1-007	CB	1.89E-01	2.09E-01	5.26E+01	4.60E+00	2.09E-01	5.26E+01	3.96E-03
1400X-1-CJ-FCV1-002	CB	8.75E+00	3.41E-01	2.39E+03	9.59E+00	8.75E+00	2.39E+03	3.66E-03
1400X-1-CJ-FCV1-021	CB	-2.04E-02	9.18E-02	7.83E+01	1.39E+00	9.18E-02	7.83E+01	1.17E-03
2100X-1-CJ-FCV1-001	AB	3.37E+00	7.15E-01	4.19E+02	4.68E+01	3.37E+00	4.19E+02	8.04E-03
2100X-1-CJ-FCV1-003	AB	7.31E-01	2.47E-01	2.47E+02	2.80E+01	7.31E-01	2.47E+02	2.96E-03
2100X-1-CJ-FCV1-005	AB	1.34E+00	3.77E-01	6.00E+02	4.94E+01	1.34E+00	6.00E+02	2.23E-03
2100X-1-CJ-FCV1-006	AB	3.76E-01	6.63E-02	9.76E+01	2.31E+00	3.76E-01	9.76E+01	3.85E-03
2100X-1-CJ-FCV1-011	AB	1.69E-01	5.33E-02	5.15E+01	1.33E+00	1.69E-01	5.15E+01	3.28E-03
2100X-1-CJ-FCV1-014	AB	2.10E-01	5.75E-02	1.14E+02	2.53E+00	2.10E-01	1.14E+02	1.84E-03
2200X-1-CJ-FCV1-006	AB	4.68E-02	1.94E-01	5.67E+02	4.94E+01	1.94E-01	5.67E+02	3.42E-04
2200X-1-CJ-FCV1-008	AB	1.47E+00	1.21E-01	1.04E+03	5.11E+00	1.47E+00	1.04E+03	1.41E-03
2200X-1-CJ-FCV1-010	AB	1.13E+00	9.77E-02	2.87E+02	3.78E+00	1.13E+00	2.87E+02	3.94E-03
2200X-1-CJ-FCV1-020	AB	6.53E+00	2.46E-01	1.04E+04	1.49E+01	6.53E+00	1.04E+04	6.26E-04
2200X-1-CJ-FCV1-021	AB	7.96E-01	2.93E-01	3.75E+02	3.95E+01	7.96E-01	3.75E+02	2.12E-03
2200X-1-CJ-FCV1-022	AB	1.51E+01	3.37E-01	1.60E+04	1.96E+01	1.51E+01	1.60E+04	9.45E-04
2200X-1-CJ-FCV1-026	AB	1.91E+01	3.92E-01	1.81E+04	2.52E+01	1.91E+01	1.81E+04	1.05E-03
2200X-1-CJ-FCV1-030	AB	1.11E+01	2.08E+00	2.42E+02	2.80E+01	1.11E+01	2.42E+02	4.61E-02
2200X-1-CJ-FCV1-031	AB	1.00E+00	9.09E-02	3.36E+02	2.68E+00	1.00E+00	3.36E+02	2.98E-03
2200X-1-CJ-FCV1-035	AB	1.50E+00	1.10E-01	7.22E+02	4.08E+00	1.50E+00	7.22E+02	2.08E-03
2200X-1-CJ-FCV1-038	AB	2.43E+00	5.73E-01	1.12E+02	1.10E+01	2.43E+00	1.12E+02	2.17E-02
2200X-1-CJ-FCV1-039	AB	4.49E+00	9.29E-01	1.20E+02	1.08E+01	4.49E+00	1.20E+02	3.74E-02
2200X-1-CJ-WCV1-009	AB	-3.37E-02	4.17E-02	3.27E+01	1.12E+00	4.17E-02	3.27E+01	1.28E-03
2300X-1-CJ-FCV1-001	AB	1.54E+01	3.54E-01	6.48E+03	1.21E+01	1.54E+01	6.48E+03	2.37E-03
2300X-1-CJ-FCV1-002	AB	2.01E+01	4.12E-01	8.99E+03	1.40E+01	2.01E+01	8.99E+03	2.24E-03
2300X-1-CJ-FCV1-003	AB	1.04E+01	1.98E+00	5.10E+03	6.03E+02	1.04E+01	5.10E+03	2.05E-03

Sample ID	Building	Sr-90 Decayed Reported Concentrations (pCi/g)	Sr-90 Decayed MDCs (pCi/g)	Cs-137 Decayed Reported Concentrations (pCi/g)	Cs-137 Decayed MDCs (pCi/g)	Sr-90 Concentration Using Reported or MDC Values (pCi/g)	Cs-137 Concentration Using Reported or MDC Values (pCi/g)	Sr-90/Cs-137 Ratio Using Reported or MDC Values
2300X-1-CJ-FCV1-005	AB	5.50E+00	2.17E-01	3.09E+03	7.85E+00	5.50E+00	3.09E+03	1.78E-03
2300X-1-CJ-FCV1-007	AB	3.15E+00	3.20E-01	6.68E+02	5.04E+00	3.15E+00	6.68E+02	4.71E-03
2300X-1-CJ-FCV1-010	AB	1.67E-01	2.06E-01	4.60E+01	6.10E+00	2.06E-01	4.60E+01	4.47E-03
2600X-1-CJ-FCV1-002	AB	4.65E-02	4.66E-02	5.80E+01	1.53E+00	4.66E-02	5.80E+01	8.03E-04
3100X-3-CJ-FCV1-006	TB	9.00E-02	7.25E-02	3.03E-01	1.02E-01	9.00E-02	3.03E-01	2.97E-01
3100X-3-CJ-FCV1-014	TB	5.42E-02	5.85E-02	1.32E-01	1.81E-01	ND	ND	Not Used
4100X-1-CJ-FCV1-004	RWPB	-2.87E-02	5.55E-02	5.86E+00	3.99E-01	5.55E-02	5.86E+00	9.46E-03
4100X-1-CJ-FCV1-005	RWPB	1.11E+00	9.09E-02	2.88E+00	3.11E-01	1.11E+00	2.88E+00	3.87E-01

Table 44: C-14 and Cs-137 Decayed Reported Concentrations, MDCs and Ratios

Sample ID	Building	C-14 Decayed Reported Concentrations (pCi/g)	C-14 Decayed MDCs (pCi/g)	Cs-137 Decayed Reported Concentrations (pCi/g)	Cs-137 Decayed MDCs (pCi/g)	C-14 Concentration Using Reported or MDC Values (pCi/g)	Cs-137 Concentration Using Reported or MDC Values (pCi/g)	C-14/Cs-137 Ratio Using Reported Concentrations or MDC Values (pCi/g)
1100X-1-CJ-FCV1-005	CB	1.56E+03	1.26E+01	4.19E+03	1.78E+01	1.56E+03	4.19E+03	3.72E-01
1100X-1-CJ-WCV1-003	CB	2.06E+03	1.60E+02	1.37E+03	1.64E+02	2.06E+03	1.37E+03	1.51E+00
1100X-1-CJ-WCV1-004	CB	1.06E+03	1.06E+01	4.59E+03	1.44E+01	1.06E+03	4.59E+03	2.31E-01
1200X-1-CJ-FCV1-001	CB	1.53E+03	1.26E+01	1.07E+02	1.95E+00	1.53E+03	1.07E+02	1.43E+01
1200X-1-CJ-FCV1-002	CB	2.67E+03	1.64E+01	4.02E+02	5.19E+00	2.67E+03	4.02E+02	6.63E+00
1200X-1-CJ-FCV1-003	CB	1.99E+03	1.45E+01	9.20E+02	5.49E+00	1.99E+03	9.20E+02	2.16E+00
1200X-1-CJ-FCV1-010	CB	1.45E+02	4.29E+00	3.02E+02	3.47E+00	1.45E+02	3.02E+02	4.80E-01
1200X-1-CJ-FCV1-018	CB	1.59E+03	1.28E+01	2.15E+02	2.94E+00	1.59E+03	2.15E+02	7.39E+00
1200X-1-CJ-FCV1-023	CB	8.08E+01	3.21E+00	5.07E+03	1.36E+01	8.08E+01	5.07E+03	1.59E-02
1200X-1-CJ-FCV1-025	CB	2.70E+03	1.63E+01	8.21E+02	5.36E+00	2.70E+03	8.21E+02	3.29E+00
1200X-1-CJ-FCV1-027	CB	1.62E+03	1.23E+01	3.84E+03	1.20E+01	1.62E+03	3.84E+03	4.21E-01
1200X-1-CJ-WCV1-005	CB	7.18E+02	8.48E+00	8.04E+01	1.81E+00	7.18E+02	8.04E+01	8.94E+00
1200X-1-CJ-WCV1-006	CB	4.47E+03	3.46E+02	3.57E+01	4.34E+00	4.47E+03	3.57E+01	1.25E+02
1200X-1-CJ-WCV1-008	CB	4.69E+02	3.65E+01	1.10E+01	1.08E+00	4.69E+02	1.10E+01	4.25E+01
1200X-1-CJ-WCV1-009	CB	2.62E+03	1.58E+01	2.55E+02	3.38E+00	2.62E+03	2.55E+02	1.03E+01
1200X-1-CJ-WCV1-011	CB	5.63E+02	4.36E+01	7.89E+01	7.42E+00	5.63E+02	7.89E+01	7.13E+00

Sample ID	Building	C-14 Decayed Reported Concentrations (pCi/g)	C-14 Decayed MDCs (pCi/g)	Cs-137 Decayed Reported Concentrations (pCi/g)	Cs-137 Decayed MDCs (pCi/g)	C-14 Concentration Using Reported or MDC Values (pCi/g)	Cs-137 Concentration Using Reported or MDC Values (pCi/g)	C-14/Cs-137 Ratio Using Reported Concentrations or MDC Values (pCi/g)
1200X-1-CJ-WCV1-012	CB	3.54E+02	2.75E+01	4.53E+01	4.36E+00	3.54E+02	4.53E+01	7.81E+00
1200X-1-CJ-WCV1-015	CB	3.64E+02	2.83E+01	2.03E+01	2.23E+00	3.64E+02	2.03E+01	1.79E+01
1200X-1-CJ-WCV1-028	CB	2.52E+01	2.88E+00	1.29E+02	1.11E+01	2.52E+01	1.29E+02	1.96E-01
1200X-1-CJ-WCV1-029	CB	3.47E+02	2.70E+01	1.22E+01	1.45E+00	3.47E+02	1.22E+01	2.85E+01
1300X-1-CJ-FCV1-003	CB	1.41E+03	1.21E+01	4.60E+03	1.25E+01	1.41E+03	4.60E+03	3.06E-01
1300X-1-CJ-FCV1-005	CB	2.09E+03	1.62E+02	8.14E+01	8.70E+00	2.09E+03	8.14E+01	2.57E+01
1300X-1-CJ-FCV1-006	CB	1.72E+02	4.37E+00	7.56E+02	5.50E+00	1.72E+02	7.56E+02	2.27E-01
1300X-1-CJ-FCV1-008	CB	3.03E+02	5.74E+00	1.08E+03	6.89E+00	3.03E+02	1.08E+03	2.79E-01
1300X-1-CJ-WCV1-007	CB	6.94E+02	5.38E+01	5.26E+01	4.60E+00	6.94E+02	5.26E+01	1.32E+01
1400X-1-CJ-FCV1-002	CB	8.54E+03	3.19E+01	2.39E+03	9.59E+00	8.54E+03	2.39E+03	3.58E+00
1400X-1-CJ-FCV1-021	CB	2.07E+03	1.63E+01	7.83E+01	1.39E+00	2.07E+03	7.83E+01	2.64E+01
2100X-1-CJ-FCV1-001	AB	3.60E+00	1.96E+00	4.19E+02	4.68E+01	3.60E+00	4.19E+02	8.59E-03
2100X-1-CJ-FCV1-003	AB	8.38E+00	2.10E+00	2.47E+02	2.80E+01	8.38E+00	2.47E+02	3.40E-02
2100X-1-CJ-FCV1-005	AB	1.22E+01	2.27E+00	6.00E+02	4.94E+01	1.22E+01	6.00E+02	2.03E-02
2100X-1-CJ-FCV1-006	AB	2.87E+00	2.14E+00	9.76E+01	2.31E+00	2.87E+00	9.76E+01	2.94E-02
2100X-1-CJ-FCV1-011	AB	3.64E+00	2.26E+00	5.15E+01	1.33E+00	3.64E+00	5.15E+01	7.06E-02
2100X-1-CJ-FCV1-014	AB	7.84E+00	2.42E+00	1.14E+02	2.53E+00	7.84E+00	1.14E+02	6.89E-02
2200X-1-CJ-FCV1-006	AB	2.25E+01	2.73E+00	5.67E+02	4.94E+01	2.25E+01	5.67E+02	3.97E-02
2200X-1-CJ-FCV1-008	AB	2.38E+01	2.69E+00	1.04E+03	5.11E+00	2.38E+01	1.04E+03	2.28E-02
2200X-1-CJ-FCV1-010	AB	9.14E+00	2.36E+00	2.87E+02	3.78E+00	9.14E+00	2.87E+02	3.19E-02
2200X-1-CJ-FCV1-020	AB	1.99E+01	2.56E+00	1.04E+04	1.49E+01	1.99E+01	1.04E+04	1.90E-03
2200X-1-CJ-FCV1-021	AB	1.35E+01	2.29E+00	3.75E+02	3.95E+01	1.35E+01	3.75E+02	3.60E-02
2200X-1-CJ-FCV1-022	AB	2.28E+01	2.60E+00	1.60E+04	1.96E+01	2.28E+01	1.60E+04	1.42E-03
2200X-1-CJ-FCV1-026	AB	1.31E+01	2.44E+00	1.81E+04	2.52E+01	1.31E+01	1.81E+04	7.22E-04
2200X-1-CJ-FCV1-030	AB	9.57E+01	7.81E+00	2.42E+02	2.80E+01	9.57E+01	2.42E+02	3.96E-01
2200X-1-CJ-FCV1-031	AB	4.97E+00	2.17E+00	3.36E+02	2.68E+00	4.97E+00	3.36E+02	1.48E-02
2200X-1-CJ-FCV1-035	AB	1.93E+01	2.57E+00	7.22E+02	4.08E+00	1.93E+01	7.22E+02	2.67E-02
2200X-1-CJ-FCV1-038	AB	7.90E+00	2.08E+00	1.12E+02	1.10E+01	7.90E+00	1.12E+02	7.06E-02
2200X-1-CJ-FCV1-039	AB	1.18E+01	2.12E+00	1.20E+02	1.08E+01	1.18E+01	1.20E+02	9.83E-02
2200X-1-CJ-WCV1-009	AB	1.88E+01	2.43E+00	3.27E+01	1.12E+00	1.88E+01	3.27E+01	5.74E-01
2300X-1-CJ-FCV1-001	AB	7.98E+01	3.69E+00	6.48E+03	1.21E+01	7.98E+01	6.48E+03	1.23E-02
2300X-1-CJ-FCV1-002	AB	5.28E+01	3.28E+00	8.99E+03	1.40E+01	5.28E+01	8.99E+03	5.87E-03
2300X-1-CJ-FCV1-003	AB	1.38E+02	1.09E+01	5.10E+03	6.03E+02	1.38E+02	5.10E+03	2.71E-02
2300X-1-CJ-FCV1-005	AB	3.25E+01	2.83E+00	3.09E+03	7.85E+00	3.25E+01	3.09E+03	1.05E-02
2300X-1-CJ-FCV1-007	AB	5.02E+01	3.37E+00	6.68E+02	5.04E+00	5.02E+01	6.68E+02	7.51E-02
2300X-1-CJ-FCV1-010	AB	2.57E+00	1.92E+00	4.60E+01	6.10E+00	2.57E+00	4.60E+01	5.58E-02

Sample ID	Building	C-14 Decayed Reported Concentrations (pCi/g)	C-14 Decayed MDCs (pCi/g)	Cs-137 Decayed Reported Concentrations (pCi/g)	Cs-137 Decayed MDCs (pCi/g)	C-14 Concentration Using Reported or MDC Values (pCi/g)	Cs-137 Concentration Using Reported or MDC Values (pCi/g)	C-14/Cs-137 Ratio Using Reported Concentrations or MDC Values (pCi/g)
2600X-1-CJ-FCV1-002	AB	2.42E+01	2.66E+00	5.80E+01	1.53E+00	2.42E+01	5.80E+01	4.17E-01
3100X-3-CJ-FCV1-006	TB	3.26E+00	2.32E+00	3.03E-01	1.02E-01	3.26E+00	3.03E-01	1.08E+01
3100X-3-CJ-FCV1-014	TB	1.82E+00	2.15E+00	1.32E-01	1.81E-01	ND	ND	Not Used
4100X-1-CJ-FCV1-004	RWPB	8.04E+00	2.25E+00	5.86E+00	3.99E-01	8.04E+00	5.86E+00	1.37E+00
4100X-1-CJ-FCV1-005	RWPB	8.46E-01	2.09E+00	2.88E+00	3.11E-01	2.09E+00	2.88E+00	7.26E-01

For each set of ratios, the average, minimum, maximum, standard deviation, % coefficient of variation, 75th and 95th percentile of the ratios is shown for each sample population in Table 45 and Table 46.

To account for the variability and level of uncertainty in the data, the 95th percentile values were selected for the final surrogate ratios. Using the 95th percentile value along with the MDC substituted will provide reasonable conservatism during the final status surveys.

Table 45: Sr-90/Cs-137 Ratio

Sr-90/Cs-137 Based on Reported or MDC Concentrations		
Parameter	**CB Sample Population**	**AB/TB/RWPB Sample Population**
Average	3.80E-03	2.95E-02
Minimum	9.45E-05	3.42E-04
Maximum	1.52E-02	3.87E-01
Standard Deviation	4.03E-03	8.96E-02
% Coefficient of Variation	1.06E+00	303.37%
75th Percentile	5.05E-03	4.71E-03
95th Percentile	1.25E-02	1.97E-01

Table 46: C-14/Cs-137 Ratio

C-14/Cs-137 Based on Reported or MDC Concentrations		
Parameter	**CB Sample Population**	**AB/TB/RWPB Sample Population**
Average	1.31E+01	5.17E-01
Minimum	1.59E-02	7.22E-04
Maximum	1.25E+02	1.08E+01
Standard Deviation	2.49E+01	2.03E+00
% Coefficient of Variation	189.27%	391.43%
75th Percentile	1.38E+01	7.51E-02
95th Percentile	3.83E+01	1.11E+00

Cs-137 was selected as the most appropriate surrogate for Sr-90 and C-14.

Table 47: Cs-137 Surrogate Ratios

Mix Fraction	Nuclide Ratioed to Cs-137	Value
CB	C-14	38.3
AB/TB/RWPB	C-14	1.11
CB	Sr-90	0.0125
AB/TB/RWPB	Sr-90	0.197

7 References:

[1.] U.S. Nuclear Regulatory Commission, "*Consolidated Decommissioning Guidance: Decommissioning Process for Material Licensees*", NUREG-1757 Volume 2, Revision 2, 2006.

[2.] U.S. Nuclear Regulatory Commission, "*Long-Lived Activation Products in Reactor Materials*", Pacific Northwest Laboratory, NUREG/CR-3474,1984.

[3.] U.S. Nuclear Regulatory Commission, "*Residual Radionuclide Concentration Within and Around Commercial Nuclear Power Plants; Origin, Distribution, Inventory, and Decommissioning Assessment*", Pacific Northwest Laboratory, NUREG/CR-4289, 1985.

[4.] FC-18-002, *"Potential Radionuclides of Concern During the Decommissioning of Fort Calhoun Station",* Fort Calhoun Station Technical Basis Document, 2018.

[5.] FC-20-007 "Fort Calhoun Station Potential Radionuclides of Concern", Fort Calhoun Station Technical Basis Document, 2020.

[6.] FC-18-003 "*Evaluation of Cs-137 Global Fallout in Soils at Fort Calhoun Station*", 2018.

[7.] Oak Ride Institute of Science and Education, "Confirmatory Survey Summary and Results for the Non-Impacted Land Areas Associated with the Fort Calhoun Nuclear Generating Station, Blair, Nebraska", 2019.

[8.] *Fort Calhoun Characterization Sample Plan*, Survey Area 1000, 2019.

[9.] *Fort Calhoun Characterization Sample Plan*, Survey Area 2000, 2019.

[10.] *Fort Calhoun Characterization Sample Plan*, Survey Area 3000, 2019.

[11.] *Fort Calhoun Characterization Sample Plan*, Survey Area 4000, 2019.

[12.] ENRG078, WO No. 518752, Charleston, SC,: GEL Laboratories LLC, 2020

[13.] ENRG078, WO No. 499910, Charleston, SC,: GEL Laboratories LLC, 2020.

[14.] ENRG078, WO No. 499244, Charleston, SC: GEL Laboratories LLC, 2020.

[15.] ENRG078, WO No. 505229, Charleston, SC: GEL Laboratories LLC, 2020.

[16.] ENRG078, WO No. 539900, Charleston, SC: GEL Laboratories LLC, 2020.

[17.] RS-TD-313196-001 “Radionuclides of Concern During LACBWR Decommissioning”, Energy Solutions Technical Support Document, 2018.

8 Attachments:

8.1 Attachment 1: Decay Corrected Analytical Results for Concrete Samples, With Negative Value Reset to Zero

Table 48: Sample Analytical Results, First Set of Radionuclides (pCi/g)

Sample ID	H-3	C-14	Fe-55	Co-58	Ni-59	Ni-63	Co-60	Tc-99
1100X-1-CJ-FCV1-005	1.24E+03	1.56E+03	7.13E+02	0.00E+00	1.12E+01	1.00E+03	4.59E+02	4.51E-02
1100X-1-CJ-WCV1-003	5.75E+02	2.06E+03	8.46E+02	0.00E+00	0.00E+00	8.25E+02	4.18E+02	7.76E-01
1100X-1-CJ-WCV1-004	2.07E+03	1.06E+03	7.55E+02	1.29E-09	3.10E+01	2.25E+03	9.39E+02	2.56E+00
1200X-1-CJ-FCV1-001	5.45E+02	1.53E+03	0.00E+00	2.23E-11	7.12E-02	1.24E+02	2.01E+01	6.85E-01
1200X-1-CJ-FCV1-002	5.31E+02	2.67E+03	1.04E+00	0.00E+00	0.00E+00	5.19E+02	3.65E+01	4.11E-01
1200X-1-CJ-FCV1-003	5.10E+02	1.99E+03	0.00E+00	1.21E-12	2.23E+00	1.94E+02	1.76E+01	5.62E-01
1200X-1-CJ-FCV1-010	6.42E+02	1.45E+02	0.00E+00	0.00E+00	0.00E+00	1.35E+02	5.31E+00	4.07E-01
1200X-1-CJ-FCV1-018	6.21E+02	1.59E+03	1.19E+00	2.20E-12	0.00E+00	5.50E+01	7.62E-01	8.56E-02
1200X-1-CJ-FCV1-023	1.93E+02	8.08E+01	0.00E+00	1.37E-11	1.09E+01	1.08E+03	3.31E+01	2.09E-01
1200X-1-CJ-FCV1-025	4.81E+02	2.70E+03	0.00E+00	0.00E+00	2.31E-01	1.14E+02	5.10E+00	2.43E-01
1200X-1-CJ-FCV1-027	3.72E+02	1.62E+03	0.00E+00	2.61E-11	8.96E-01	9.55E+01	1.34E+01	0.00E+00
1200X-1-CJ-WCV1-005	2.32E+02	7.18E+02	0.00E+00	0.00E+00	4.68E-02	2.07E+01	1.02E+00	2.21E-01
1200X-1-CJ-WCV1-006	1.07E+01	4.47E+03	0.00E+00	2.51E-09	5.76E-01	3.50E+00	5.69E-01	0.00E+00
1200X-1-CJ-WCV1-008	3.30E+01	4.69E+02	0.00E+00	2.77E-08	1.10E+00	1.00E+01	1.01E+00	2.33E-01
1200X-1-CJ-WCV1-009	1.70E+02	2.62E+03	0.00E+00	1.85E-11	5.12E-01	1.03E+01	3.94E-01	6.60E-02
1200X-1-CJ-WCV1-011	3.42E+01	5.63E+02	0.00E+00	7.15E-09	0.00E+00	2.01E+00	1.31E-01	3.89E-01
1200X-1-CJ-WCV1-012	2.92E+01	3.54E+02	0.00E+00	2.35E-08	2.21E-01	1.49E+01	3.02E-01	2.04E+00
1200X-1-CJ-WCV1-015	2.82E+01	3.64E+02	0.00E+00	0.00E+00	0.00E+00	1.04E+00	2.94E-01	1.75E+00
1200X-1-CJ-WCV1-028	1.29E+01	2.52E+01	0.00E+00	9.43E-10	1.53E+00	4.94E+00	4.70E+00	8.34E+00
1200X-1-CJ-WCV1-029	1.83E+01	3.47E+02	0.00E+00	0.00E+00	0.00E+00	2.02E+00	2.27E-01	4.63E+00
1300X-1-CJ-FCV1-003	2.84E+02	1.41E+03	0.00E+00	0.00E+00	0.00E+00	1.40E+02	7.75E+00	4.44E-01
1300X-1-CJ-FCV1-005	5.63E+01	2.09E+03	0.00E+00	4.67E-09	3.27E-01	8.92E+00	1.11E+00	0.00E+00
1300X-1-CJ-FCV1-006	1.35E+02	1.72E+02	1.00E+00	6.11E-12	0.00E+00	3.38E+01	1.04E+00	0.00E+00
1300X-1-CJ-FCV1-008	5.61E+01	3.03E+02	5.15E-01	1.79E-11	1.69E+00	4.02E+01	1.29E+00	1.01E-01
1300X-1-CJ-WCV1-007	2.92E+01	6.94E+02	0.00E+00	0.00E+00	0.00E+00	5.44E+00	1.65E-01	2.53E+00
1400X-1-CJ-FCV1-002	2.65E+02	8.54E+03	0.00E+00	6.72E-13	2.03E+00	4.64E+01	1.43E+00	1.72E-01
1400X-1-CJ-FCV1-021	3.47E+02	2.07E+03	0.00E+00	0.00E+00	1.86E-01	6.08E+00	1.46E+00	1.76E-01
2100X-1-CJ-FCV1-001	2.40E+00	3.60E+00	0.00E+00	1.34E-08	1.87E+00	3.49E+02	5.01E-01	5.63E-01
2100X-1-CJ-FCV1-003	3.84E+00	8.38E+00	2.17E+00	2.01E-10	9.32E+00	1.16E+03	6.71E-01	8.08E-03
2100X-1-CJ-FCV1-005	1.41E+01	1.22E+01	0.00E+00	0.00E+00	0.00E+00	3.42E+01	4.72E-01	1.58E-01
2100X-1-CJ-FCV1-006	2.04E+01	2.87E+00	0.00E+00	5.22E-12	0.00E+00	3.09E+01	1.12E+00	1.14E-01
2100X-1-CJ-FCV1-011	4.82E+00	3.64E+00	0.00E+00	0.00E+00	4.02E-01	5.92E+01	1.78E+00	5.53E+00
2100X-1-CJ-FCV1-014	7.73E-01	7.84E+00	0.00E+00	0.00E+00	0.00E+00	4.59E+01	4.01E-01	2.60E+01
2200X-1-CJ-FCV1-006	1.65E+00	2.25E+01	0.00E+00	5.28E-09	8.01E-01	7.59E+01	4.10E-01	1.09E+01
2200X-1-CJ-FCV1-008	6.38E+01	2.38E+01	0.00E+00	7.99E-12	0.00E+00	9.04E+01	1.94E+01	0.00E+00
2200X-1-CJ-FCV1-010	1.26E+01	9.14E+00	0.00E+00	0.00E+00	0.00E+00	1.30E+02	4.11E+00	0.00E+00
2200X-1-CJ-FCV1-020	3.99E+01	1.99E+01	6.75E-01	1.70E-11	4.91E+00	1.35E+03	9.59E+00	1.61E+00
2200X-1-CJ-FCV1-021	2.01E+00	1.35E+01	0.00E+00	0.00E+00	0.00E+00	1.18E+02	3.49E-01	0.00E+00
2200X-1-CJ-FCV1-022	1.10E+01	2.28E+01	8.63E-02	0.00E+00	6.56E+00	6.13E+02	5.29E-01	0.00E+00
2200X-1-CJ-FCV1-026	1.15E+01	1.31E+01	1.15E-01	6.02E-12	0.00E+00	1.81E+02	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-030	4.61E+01	9.57E+01	4.25E+00	0.00E+00	8.61E+00	7.44E+02	7.06E+01	0.00E+00
2200X-1-CJ-FCV1-031	1.64E+02	4.97E+00	1.54E+00	2.10E-12	2.37E+00	2.17E+02	2.95E+00	0.00E+00
2200X-1-CJ-FCV1-035	8.67E+00	1.93E+01	2.21E+00	3.70E-12	3.21E+00	3.87E+02	7.54E+00	0.00E+00
2200X-1-CJ-FCV1-038	1.90E+00	7.90E+00	0.00E+00	1.32E-08	4.79E-01	1.28E+02	2.34E+00	0.00E+00
2200X-1-CJ-FCV1-039	4.39E+00	1.18E+01	0.00E+00	0.00E+00	6.36E-01	1.47E+02	2.62E+00	0.00E+00
2200X-1-CJ-WCV1-009	4.23E+00	1.88E+01	0.00E+00	0.00E+00	1.08E+00	5.97E+00	1.84E-01	4.35E-01
2300X-1-CJ-FCV1-001	1.71E+00	7.98E+01	2.57E+00	0.00E+00	3.41E+00	3.00E+02	4.14E-01	0.00E+00
2300X-1-CJ-FCV1-002	9.56E+00	5.28E+01	2.46E-01	0.00E+00	6.57E+00	7.38E+02	3.45E+00	0.00E+00
2300X-1-CJ-FCV1-003	2.97E+00	1.38E+02	6.32E+00	0.00E+00	7.27E+00	9.18E+02	6.52E+01	1.36E-01
2300X-1-CJ-FCV1-005	3.77E+00	3.25E+01	4.22E+00	0.00E+00	4.10E+00	3.95E+02	1.15E+00	1.81E-01
2300X-1-CJ-FCV1-007	3.06E+01	5.02E+01	0.00E+00	6.72E-12	0.00E+00	5.44E+01	3.19E+00	0.00E+00
2300X-1-CJ-FCV1-010	0.00E+00	2.57E+00	1.60E+00	1.26E-07	0.00E+00	1.03E+01	1.02E+00	6.28E-01

Sample ID	H-3	C-14	Fe-55	Co-58	Ni-59	Ni-63	Co-60	Tc-99
2600X-1-CJ-FCV1-002	9.98E+00	2.42E+01	0.00E+00	0.00E+00	0.00E+00	1.82E+01	7.94E-01	1.51E-01
3100X-3-CJ-FCV1-006	0.00E+00	3.26E+00	2.87E-01	9.13E-13	0.00E+00	0.00E+00	1.03E-02	0.00E+00
3100X-3-CJ-FCV1-014	0.00E+00	1.82E+00	3.41E-02	7.99E-13	0.00E+00	1.63E+00	2.28E-02	0.00E+00
4100X-1-CJ-FCV1-004	0.00E+00	8.04E+00	4.22E-01	0.00E+00	7.16E-01	1.77E+00	1.18E-01	0.00E+00
4100X-1-CJ-FCV1-005	0.00E+00	8.46E-01	6.12E-01	4.32E-13	1.65E-04	3.83E-01	2.57E-01	0.00E+00

Table 49: Sample Analytical Results, Second Set of Radionuclides (pCi/g)

Sample ID	Sr-90	Sb-125	Cs-134	Cs-137	Ce-144	Eu-152	Eu-154
1100X-1-CJ-FCV1-005	5.29E+00	0.00E+00	1.42E+01	4.19E+03	0.00E+00	3.98E+03	3.64E+02
1100X-1-CJ-WCV1-003	8.53E+00	0.00E+00	1.78E+01	1.37E+03	2.26E-01	3.78E+03	3.46E+02
1100X-1-CJ-WCV1-004	8.43E+00	0.00E+00	1.19E+01	4.59E+03	0.00E+00	3.46E+03	3.29E+02
1200X-1-CJ-FCV1-001	6.02E-01	1.10E-01	1.18E-02	1.07E+02	8.79E-04	0.00E+00	2.68E-01
1200X-1-CJ-FCV1-002	1.87E+00	0.00E+00	4.73E-02	4.02E+02	0.00E+00	1.20E-01	0.00E+00
1200X-1-CJ-FCV1-003	3.67E+00	5.88E-02	1.27E-01	9.20E+02	6.53E-04	0.00E+00	2.93E-01
1200X-1-CJ-FCV1-010	4.33E-01	0.00E+00	7.03E-03	3.02E+02	2.32E-03	1.69E+00	1.01E-02
1200X-1-CJ-FCV1-018	3.85E-01	2.34E-01	1.77E-02	2.15E+02	0.00E+00	1.11E-02	0.00E+00
1200X-1-CJ-FCV1-023	1.47E+01	1.28E+00	4.16E-01	5.07E+03	8.18E-03	1.86E-01	8.22E-02
1200X-1-CJ-FCV1-025	1.78E+00	5.96E-01	4.41E-02	8.21E+02	4.87E-03	0.00E+00	0.00E+00
1200X-1-CJ-FCV1-027	8.96E-01	3.32E-01	3.94E-01	3.84E+03	0.00E+00	2.86E-01	0.00E+00
1200X-1-CJ-WCV1-005	9.13E-02	7.21E-02	3.89E-03	8.04E+01	2.58E-03	0.00E+00	1.66E-01
1200X-1-CJ-WCV1-006	3.46E-01	5.86E-04	1.30E-02	3.57E+01	6.56E-03	1.79E+00	7.34E-02
1200X-1-CJ-WCV1-008	1.11E-01	0.00E+00	2.54E-03	1.10E+01	9.21E-03	9.59E-01	8.77E-02
1200X-1-CJ-WCV1-009	6.97E-02	0.00E+00	6.29E-03	2.55E+02	0.00E+00	9.57E-01	1.43E-01
1200X-1-CJ-WCV1-011	1.52E-01	0.00E+00	1.51E-02	7.89E+01	1.12E-02	2.10E+00	1.33E-01
1200X-1-CJ-WCV1-012	2.47E-01	1.05E-01	1.06E-02	4.53E+01	3.77E-03	2.18E+00	1.05E-01
1200X-1-CJ-WCV1-015	1.19E-01	0.00E+00	1.40E-02	2.03E+01	2.20E-03	1.05E+00	2.18E-01
1200X-1-CJ-WCV1-028	0.00E+00	4.84E-02	6.00E-02	1.29E+02	0.00E+00	1.17E+00	3.01E-02
1200X-1-CJ-WCV1-029	1.41E-02	3.56E-02	2.37E-02	1.22E+01	0.00E+00	1.31E+00	3.01E-02
1300X-1-CJ-FCV1-003	4.34E-01	1.34E-01	4.33E-01	4.60E+03	0.00E+00	0.00E+00	4.32E-02
1300X-1-CJ-FCV1-005	7.05E-02	1.26E-02	2.68E-02	8.14E+01	1.50E-03	1.27E-01	5.79E-03
1300X-1-CJ-FCV1-006	2.07E-01	7.57E-02	9.91E-02	7.56E+02	2.89E-04	0.00E+00	0.00E+00
1300X-1-CJ-FCV1-008	1.22E+00	3.95E-02	6.30E-02	1.08E+03	3.77E-03	1.35E+00	2.04E-01
1300X-1-CJ-WCV1-007	1.89E-01	0.00E+00	1.52E-02	5.26E+01	0.00E+00	6.84E-01	0.00E+00
1400X-1-CJ-FCV1-002	8.75E+00	7.65E-02	2.43E-02	2.39E+03	6.31E-03	0.00E+00	1.85E-01
1400X-1-CJ-FCV1-021	0.00E+00	0.00E+00	0.00E+00	7.83E+01	0.00E+00	3.69E-01	5.78E-02
2100X-1-CJ-FCV1-001	3.37E+00	3.33E-02	1.09E-02	4.19E+02	0.00E+00	0.00E+00	5.88E-02
2100X-1-CJ-FCV1-003	7.31E-01	0.00E+00	1.52E-03	2.47E+02	0.00E+00	2.39E-01	7.73E-02
2100X-1-CJ-FCV1-005	1.34E+00	1.71E-01	2.19E-01	6.00E+02	2.33E-02	9.97E-01	0.00E+00
2100X-1-CJ-FCV1-006	3.76E-01	0.00E+00	1.30E-02	9.76E+01	4.34E-04	2.99E-01	5.03E-02
2100X-1-CJ-FCV1-011	1.69E-01	0.00E+00	1.50E-02	5.15E+01	0.00E+00	0.00E+00	2.44E-03
2100X-1-CJ-FCV1-014	2.10E-01	2.16E-02	8.96E-03	1.14E+02	2.54E-03	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-006	4.68E-02	0.00E+00	2.97E-02	5.67E+02	0.00E+00	4.12E-01	4.20E-02
2200X-1-CJ-FCV1-008	1.47E+00	3.15E-01	1.50E-01	1.04E+03	2.32E-04	0.00E+00	1.10E-01
2200X-1-CJ-FCV1-010	1.13E+00	2.56E-01	0.00E+00	2.87E+02	0.00E+00	2.37E-01	0.00E+00
2200X-1-CJ-FCV1-020	6.53E+00	6.58E-01	2.70E+00	1.04E+04	2.01E-03	2.23E+00	3.46E-02
2200X-1-CJ-FCV1-021	7.96E-01	0.00E+00	0.00E+00	3.75E+02	2.47E-03	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-022	1.51E+01	0.00E+00	2.68E-02	1.60E+04	0.00E+00	1.14E+00	0.00E+00
2200X-1-CJ-FCV1-026	1.91E+01	0.00E+00	2.31E-02	1.81E+04	1.10E-02	1.70E+00	0.00E+00
2200X-1-CJ-FCV1-030	1.11E+01	4.80E-01	1.52E-01	2.42E+02	0.00E+00	3.37E-01	0.00E+00
2200X-1-CJ-FCV1-031	1.00E+00	0.00E+00	2.22E-02	3.36E+02	1.40E-03	0.00E+00	4.58E-02
2200X-1-CJ-FCV1-035	1.50E+00	9.26E-02	1.91E-02	7.22E+02	4.03E-04	9.89E-02	3.93E-02
2200X-1-CJ-FCV1-038	2.43E+00	4.40E-02	4.98E-02	1.12E+02	8.48E-03	4.46E-02	0.00E+00
2200X-1-CJ-FCV1-039	4.49E+00	3.06E-02	1.35E-02	1.20E+02	0.00E+00	4.29E-01	9.23E-02
2200X-1-CJ-WCV1-009	0.00E+00	0.00E+00	9.94E-03	3.27E+01	0.00E+00	0.00E+00	0.00E+00
2300X-1-CJ-FCV1-001	1.54E+01	0.00E+00	0.00E+00	6.48E+03	1.00E-03	0.00E+00	3.93E-02
2300X-1-CJ-FCV1-002	2.01E+01	1.32E-01	2.14E-02	8.99E+03	0.00E+00	1.24E+00	4.24E-02
2300X-1-CJ-FCV1-003	1.04E+01	3.11E-01	0.00E+00	5.10E+03	0.00E+00	0.00E+00	2.35E-01
2300X-1-CJ-FCV1-005	5.50E+00	0.00E+00	8.34E-03	3.09E+03	9.93E-04	0.00E+00	0.00E+00

Sample ID	Sr-90	Sb-125	Cs-134	Cs-137	Ce-144	Eu-152	Eu-154
2300X-1-CJ-FCV1-007	3.15E+00	2.15E-01	2.41E-01	6.68E+02	6.30E-03	3.88E-01	1.49E-01
2300X-1-CJ-FCV1-010	1.67E-01	0.00E+00	3.36E-02	4.60E+01	0.00E+00	4.19E-02	0.00E+00
2600X-1-CJ-FCV1-002	4.65E-02	2.43E-03	1.19E-02	5.80E+01	0.00E+00	6.45E-01	6.46E-02
3100X-3-CJ-FCV1-006	9.00E-02	8.86E-03	0.00E+00	3.03E-01	3.74E-04	5.75E-02	0.00E+00
3100X-3-CJ-FCV1-014	5.42E-02	2.31E-03	1.23E-02	1.32E-01	1.32E-03	0.00E+00	2.04E-01
4100X-1-CJ-FCV1-004	0.00E+00	0.00E+00	9.18E-03	5.86E+00	0.00E+00	4.95E-02	1.25E-01
4100X-1-CJ-FCV1-005	1.11E+00	2.75E-02	0.00E+00	2.88E+00	3.23E-04	6.16E-02	6.04E-02

Table 50: Sample Analytical Results, Third Set of Radionuclides (pCi/g)

Sample ID	Eu-155	Pu-238	Pu-239/240	Pu-241	Am-241	Cm-243/244	Np-237
1100X-1-CJ-FCV1-005	7.03E+00	2.87E-01	1.23E+00	7.18E+00	4.02E-01	9.03E-02	NA
1100X-1-CJ-WCV1-003	5.85E+00	2.61E-01	1.11E+00	5.45E+00	3.46E-01	3.92E-02	5.18E-03
1100X-1-CJ-WCV1-004	2.76E+00	1.39E+00	1.72E+00	1.76E+01	2.70E+00	6.33E-01	NA
1200X-1-CJ-FCV1-001	7.53E-02	4.28E-02	0.00E+00	4.86E+00	9.95E-02	4.63E-03	NA
1200X-1-CJ-FCV1-002	0.00E+00	2.48E-01	8.37E-02	3.92E+00	5.33E-01	1.43E-01	NA
1200X-1-CJ-FCV1-003	0.00E+00	5.73E-02	4.92E-02	3.54E+00	1.40E-01	3.36E-02	NA
1200X-1-CJ-FCV1-010	1.81E-02	1.50E-02	0.00E+00	1.77E+00	5.70E-02	1.12E-02	NA
1200X-1-CJ-FCV1-018	0.00E+00	1.99E-02	0.00E+00	1.75E+00	3.07E-02	2.68E-03	NA
1200X-1-CJ-FCV1-023	0.00E+00	6.85E-01	3.98E-01	1.13E+01	1.08E+00	9.89E-02	NA
1200X-1-CJ-FCV1-025	0.00E+00	1.78E-03	1.01E-02	2.76E+00	4.32E-02	0.00E+00	NA
1200X-1-CJ-FCV1-027	0.00E+00	7.46E-03	1.07E-02	3.87E+00	5.58E-02	1.45E-03	NA
1200X-1-CJ-WCV1-005	7.72E-02	7.69E-03	0.00E+00	4.13E+00	6.38E-02	0.00E+00	NA
1200X-1-CJ-WCV1-006	1.40E-02	1.68E-03	5.19E-03	2.60E+00	6.43E-02	0.00E+00	0.00E+00
1200X-1-CJ-WCV1-008	0.00E+00	0.00E+00	0.00E+00	4.41E+00	9.80E-03	6.29E-03	0.00E+00
1200X-1-CJ-WCV1-009	0.00E+00	1.52E-02	0.00E+00	2.66E+00	6.27E-02	1.83E-02	NA
1200X-1-CJ-WCV1-011	3.77E-02	0.00E+00	8.11E-03	4.24E+00	6.28E-02	0.00E+00	4.09E-03
1200X-1-CJ-WCV1-012	0.00E+00	3.08E-03	1.43E-02	2.65E+00	0.00E+00	4.85E-02	0.00E+00
1200X-1-CJ-WCV1-015	0.00E+00	0.00E+00	1.42E-02	1.08E+00	1.74E-02	5.28E-03	0.00E+00
1200X-1-CJ-WCV1-028	1.43E-01	8.47E-03	0.00E+00	2.74E+00	0.00E+00	2.08E-02	0.00E+00
1200X-1-CJ-WCV1-029	1.29E-02	0.00E+00	0.00E+00	7.75E-01	9.28E-03	1.79E-02	6.14E-03
1300X-1-CJ-FCV1-003	2.55E-01	2.11E-02	1.13E-02	3.44E+00	4.58E-02	0.00E+00	NA
1300X-1-CJ-FCV1-005	4.47E-02	7.33E-03	5.57E-03	2.23E+00	7.57E-02	4.21E-02	2.14E-03
1300X-1-CJ-FCV1-006	0.00E+00	6.21E-03	6.53E-04	3.04E+00	3.26E-02	5.89E-03	NA
1300X-1-CJ-FCV1-008	3.57E-02	2.82E-02	2.31E-02	1.45E+00	7.27E-02	1.59E-03	NA
1300X-1-CJ-WCV1-007	7.25E-02	0.00E+00	6.29E-03	7.11E-01	0.00E+00	1.72E-02	0.00E+00
1400X-1-CJ-FCV1-002	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.40E-03	0.00E+00	NA
1400X-1-CJ-FCV1-021	5.12E-02	1.68E-02	4.34E-02	0.00E+00	8.43E-03	0.00E+00	NA
2100X-1-CJ-FCV1-001	0.00E+00	8.44E-03	3.42E-03	3.79E+00	5.32E-02	1.30E-01	0.00E+00
2100X-1-CJ-FCV1-003	1.45E-01	1.75E-01	7.39E-02	4.35E+00	1.91E-01	1.09E-01	0.00E+00
2100X-1-CJ-FCV1-005	3.36E-01	1.23E-02	2.68E-02	1.73E+00	0.00E+00	0.00E+00	0.00E+00
2100X-1-CJ-FCV1-006	3.47E-01	1.51E-02	0.00E+00	1.25E+00	2.62E-02	0.00E+00	NA
2100X-1-CJ-FCV1-011	0.00E+00	0.00E+00	0.00E+00	7.20E-02	0.00E+00	0.00E+00	NA
2100X-1-CJ-FCV1-014	4.45E-02	2.27E-02	0.00E+00	0.00E+00	0.00E+00	5.69E-04	NA
2200X-1-CJ-FCV1-006	2.97E-01	0.00E+00	0.00E+00	4.08E+00	0.00E+00	0.00E+00	0.00E+00
2200X-1-CJ-FCV1-008	0.00E+00	1.71E-03	1.35E-02	0.00E+00	1.42E-02	0.00E+00	NA
2200X-1-CJ-FCV1-010	1.82E-01	0.00E+00	1.25E-02	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-020	0.00E+00	8.43E-03	1.40E-02	0.00E+00	1.71E-02	0.00E+00	NA
2200X-1-CJ-FCV1-021	0.00E+00	5.79E-03	3.66E-02	2.26E+00	0.00E+00	0.00E+00	2.87E-03
2200X-1-CJ-FCV1-022	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-026	0.00E+00	3.94E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2200X-1-CJ-FCV1-030	0.00E+00	1.14E-01	5.54E-02	3.29E+00	2.75E-01	1.99E-02	2.06E-03
2200X-1-CJ-FCV1-031	0.00E+00	0.00E+00	1.35E-02	0.00E+00	3.85E-03	1.10E-02	NA
2200X-1-CJ-FCV1-035	0.00E+00	3.90E-02	3.19E-02	0.00E+00	2.59E-02	4.15E-03	NA
2200X-1-CJ-FCV1-038	7.66E-02	4.73E-03	4.88E-03	6.44E+00	6.44E-02	6.35E-02	0.00E+00
2200X-1-CJ-FCV1-039	4.02E-03	1.92E-03	0.00E+00	3.13E+00	1.00E-03	0.00E+00	0.00E+00
2200X-1-CJ-WCV1-009	1.13E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
2300X-1-CJ-FCV1-001	6.22E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA

Sample ID	Eu-155	Pu-238	Pu-239/240	Pu-241	Am-241	Cm-243/244	Np-237
2300X-1-CJ-FCV1-002	0.00E+00	4.89E-01	3.29E-01	2.94E+00	9.26E-01	9.33E-02	NA
2300X-1-CJ-FCV1-003	8.78E-02	2.45E-01	1.10E-01	5.86E+00	7.45E-01	2.15E-01	0.00E+00
2300X-1-CJ-FCV1-005	0.00E+00	3.81E-03	0.00E+00	0.00E+00	4.66E-02	0.00E+00	NA
2300X-1-CJ-FCV1-007	0.00E+00	2.12E-02	3.24E-04	8.16E-01	2.56E-01	0.00E+00	NA
2300X-1-CJ-FCV1-010	0.00E+00	0.00E+00	2.75E-03	4.82E-01	1.84E-02	6.23E-09	0.00E+00
2600X-1-CJ-FCV1-002	3.47E-02	0.00E+00	1.39E-02	1.81E-01	2.53E-02	5.07E-03	NA
3100X-3-CJ-FCV1-006	0.00E+00	2.08E-02	6.94E-03	0.00E+00	0.00E+00	7.90E-03	NA
3100X-3-CJ-FCV1-014	2.19E-02	2.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA
4100X-1-CJ-FCV1-004	0.00E+00	1.09E-02	1.15E-02	0.00E+00	0.00E+00	0.00E+00	NA
4100X-1-CJ-FCV1-005	0.00E+00	0.00E+00	0.00E+00	2.85E-01	6.37E-03	0.00E+00	NA

8.2 Attachment 2: Derived Concentration Guide Limits

Table 51: DCGLs

Radionuclide	Soil 0.15 m DCGL, pCi/g	Soil 1.0 m DCGL, pCi/g	Fill Material DCGL, pCi/g	Buried Pipe Excavation Scenario DCGL, dpm/100cm²	BFM Wall/Floor DCGL (No IC Dose Correction)		Embedded Pipe DCGL Calculation		
					Auxiliary, Turbine, Circulating Water Tunnels, Intake Structure, pCi/m²	Contain-ment Building, pCi/m²	Auxiliary Floor 971' elevation LTP Chapter 6 Equation 6-14, pCi/m²	Auxiliary Floor 989' elevation LTP Chapter 6 Equation 6-14, pCi/m²	Turbine Floor 990' elevation LTP Chapter 6 Equation 6-14, pCi/m²
Am-241	1.402E+02	3.053E+01	3.115E+00	7.442E+05	4.168E+06	4.046E+06	4.90E+08	3.83E+08	2.63E+08
C-14	5.996E+01	1.019E+01	1.433E+01	3.596E+06	8.629E+06	8.559E+06	1.568E+09	1.224E+09	8.406E+08
Ce-144	2.746E+02	2.319E+02	1.023E+03	1.430E+06	2.553E+08	5.922E+07	1.886E+11	1.473E+11	1.011E+11
Cm-243	6.747E+01	3.060E+01	8.928E+00	3.511E+05	1.003E+07	7.082E+06	1.528E+09	1.193E+09	8.192E+08
Cm-244	2.944E+02	5.766E+01	8.928E+00	1.548E+06	1.369E+07	1.330E+07	1.528E+09	1.193E+09	8.192E+08
Co-58	3.631E+01	3.128E+01	1.117E+01	1.898E+05	3.916E+07	8.058E+06	1.912E+09	1.493E+09	1.025E+09
Co-60	3.970E+00	3.086E+00	4.575E+02	2.103E+04	3.578E+06	8.640E+05	1.390E+11	1.085E+11	7.452E+10
Cs-134	6.424E+00	4.237E+00	1.767E+01	3.670E+04	4.396E+06	1.345E+06	5.366E+09	4.190E+09	2.877E+09
Cs-137	1.374E+01	7.656E+00	1.197E+01	8.432E+04	7.265E+06	2.749E+06	6.648E+09	5.191E+09	3.564E+09
Eu-152	8.857E+00	7.748E+00	1.508E+01	4.610E+04	1.013E+07	1.983E+06	8.371E+09	6.537E+09	4.487E+09
Eu-154	8.220E+00	7.168E+00	6.108E+02	4.282E+04	9.336E+06	1.839E+06	9.484E+10	7.406E+10	5.084E+10
Eu-155	3.081E+02	3.027E+02	4.200E+02	1.611E+06	3.619E+08	6.791E+07	6.519E+10	5.090E+10	3.495E+10
Fe-55	3.660E+04	2.122E+04	2.703E+03	1.341E+09	1.384E+10	6.308E+09	4.193E+11	3.274E+11	2.248E+11
H-3	1.195E+04	8.655E+02	1.716E+04	5.409E+07	2.208E+08	2.254E+08	2.764E+12	2.158E+12	1.482E+12
Ni-59	1.128E+04	2.307E+03	1.733E+02	2.400E+08	1.219E+09	1.122E+09	2.436E+10	1.902E+10	1.306E+10
Ni-63	4.120E+03	8.424E+02	1.190E+03	8.763E+07	4.451E+08	4.098E+08	2.075E+11	1.620E+11	1.112E+11
Np-237	4.723E+00	7.619E-01	4.345E+02	3.955E+04	7.808E+04	7.831E+04	1.043E+11	8.146E+10	5.593E+10
Pu-238	1.752E+02	3.536E+01	5.655E-02	9.576E+05	2.976E+06	2.939E+06	6.148E+06	4.801E+06	3.296E+06
Pu-239	1.578E+02	3.184E+01	2.131E+00	8.624E+05	2.681E+06	2.647E+06	3.246E+08	2.534E+08	1.740E+08
Pu-240	1.578E+02	3.185E+01	1.919E+00	8.630E+05	2.681E+06	2.647E+06	2.221E+08	1.734E+08	1.190E+08
Pu-241	5.666E+03	1.040E+03	1.919E+00	3.018E+07	1.310E+08	1.298E+08	2.221E+08	1.734E+08	1.190E+08
Sb-125	2.662E+01	2.348E+01	1.919E+00	1.382E+05	2.475E+07	5.694E+06	2.399E+08	1.874E+08	1.286E+08
Sr-90	1.111E+01	1.731E+00	9.916E+01	8.093E+04	8.666E+05	8.903E+05	1.493E+10	1.166E+10	8.002E+09
Tc-99	1.356E+02	1.542E+01	8.165E+01	5.938E+05	5.900E+06	6.084E+06	1.328E+10	1.037E+10	7.119E+09

8.3 Attachment 3: LLBP Scenario Concentrations that Result in 25 mrem

Table 52: LLBP Scenario Concentrations that Result in 25 mrem

	Embedded Pipe LLBP Drilling Spoils Concentration Scenario			Recycle/Disposal LLBP Scenario	
Radionuclide	**AB EP 4.03 in ID**	**AB EP 18.81 in ID**	**TB EP 9.4 in ID**	**Concrete**	**Steel**
	(pCi/m² per 25 mrem/yr)	**(pCi/m² per 25 mrem/yr)**	**(pCi/m² per 25 mrem/yr)**	**(pCi/m² per 25 mrem/yr)**	**(pCi/m² per 25 mrem/yr)**
Am-241	4.065E+10	8.191E+10	1.743E+10	3.223E+10	7.542E+06
C-14	4.492E+13	9.051E+13	1.926E+13	1.654E+11	1.076E+10
Ce-144	6.468E+21	1.303E+22	2.773E+21	1.414E+21	1.343E+20
Cm-243	1.020E+10	2.055E+10	4.372E+09	1.274E+09	2.123E+07
Cm-244	6.993E+11	1.409E+12	2.998E+11	3.328E+09	4.095E+07
Co-58	2.603E+56	5.246E+56	1.116E+56	3.007E+55	2.460E+54
Co-60	1.289E+10	2.598E+10	5.528E+09	3.489E+09	3.489E+08
Cs-134	1.035E+13	2.085E+13	4.437E+12	2.787E+12	1.879E+11
Cs-137	2.051E+09	4.133E+09	8.793E+08	6.142E+08	4.222E+07
Eu-152	2.526E+09	5.091E+09	1.083E+09	7.305E+08	7.475E+07
Eu-154	5.292E+09	1.066E+10	2.269E+09	1.464E+09	1.668E+08
Eu-155	1.013E+12	2.042E+12	4.344E+11	4.062E+11	5.077E+10
Fe-55	3.334E+18	6.718E+18	1.429E+18	1.963E+16	1.640E+15
H-3	3.698E+14	7.452E+14	1.585E+14	1.516E+12	9.573E+10
Ni-59	2.091E+14	4.214E+14	8.965E+13	8.893E+12	7.427E+11
Ni-63	9.493E+13	1.913E+14	4.070E+13	1.134E+13	8.926E+11
Np-237	2.540E+09	5.118E+09	1.089E+09	1.778E+07	1.090E+06
Pu-238	1.757E+11	3.541E+11	7.535E+10	8.563E+08	1.404E+07
Pu-239	1.257E+11	2.532E+11	5.388E+10	6.148E+08	1.025E+07
Pu-240	1.266E+11	2.550E+11	5.426E+10	6.162E+08	1.027E+07
Pu-241	6.277E+12	1.265E+13	2.691E+12	1.301E+11	2.602E+09
Sb-125	2.834E+12	5.710E+12	1.215E+12	8.189E+11	8.773E+10
Sr-90	8.303E+10	1.673E+11	3.560E+10	2.653E+10	1.150E+09
Tc-99	5.104E+11	1.028E+12	2.188E+11	3.072E+09	2.112E+08