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Characterization of Additional Tank 18F Samples

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EXECUTIVE SUMMARY

The Savannah River National Laboratory was asked by Savannah River Remediation to characterize additional Tank 18F closure samples to provide a basis for determination of the Tank 18F residual floor inventory. These Tank 18F floor samples were taken from Tank 18F in February, 2010 and made available to SRNL in the same month.

The Tank 18F samples were analyzed for radiological, chemical and elemental constituents. Savannah River Remediation requested lower detection limits for other radioactive species (I-129, Ra-226, Ac-227 and Pa-231) and measurement of confirmatory radionuclides (Cl-36, K-40, Pd-107, Pt-193, Al-26, Zr-93, and Nb-94). SRNL developed new methodologies and completed analyses for each of these radioactive species and data reported here for Tank 18F characterizations supports the following:

- Most Tank 18F characterization detection limit requirements were met. In many cases, new methods were developed and implemented, providing lower detection limits. For the small group of radionuclides above the original detection limit targets, the results were evaluated and deemed acceptable by SRNL and SRR.

- Statistical evaluation of the entire data set was completed and documented in a separate report. Based on the statistical evaluations and a review of customer requirements, the results solely taken from these characterizations are considered sufficient to fully define the residual material in Tank 18F

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LIST OF ABBREVIATIONS

SRNL	Savannah River National Laboratory
SRNL	Savannah River National Laboratory
AD	Analytical development
SRR	Savannah River Remediation
LWO	Liquid Waste Operations
ICP-ES	Inductively Coupled Plasma – Atomic Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma – Mass Spectroscopy
AQR	Aqua Regia Digestions
PF	Sodium Peroxide/Hydroxide Fusions
TTR	Technical Task Request
SRNL	Savannah River National Laboratory
AD	Analytical development
SRR	Savannah River Remediation
LWO	Liquid Waste Operations
ICP-ES	Inductively Coupled Plasma – Atomic Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma – Mass Spectroscopy
MDA	Minimum Detectable Activity
DL	Detection limit
UL	Upper limit
PuTTA	Plutonium thenoyltrifluoro-acetone
ARG	Analytical Glass Reference

1.0 INTRODUCTION

Savannah River National Laboratory was asked by Savannah River Remediation (SRR) to provide sample characterization for additional Tank 18F samples. Sampling and characterization of residual material in Tank 18F had been previously performed as described in the approved sampling plan [1] and Technical Task Request [2]. However, additional sampling and analyses were required to reduce sampling uncertainties as described in the Savannah River National Laboratory (SRNL) reports [3]. The additional samples were taken from Tanks 18F in early January and February, 2010 and made available to SRNL in the same months. These additional floor solid samples from Tanks 18F were analyzed for the customer specified constituents in accordance with Technical Task Request number HLE-TTR-2009-120, Rev.1 and the Task Technical and Quality Assurance Plan [Task Technical and Quality Assurance Plan for the Characterization of Additional Tank 18F and 19F Floor Samples", SRNL-RP-2010-00084, Rev. 1- Jan. 27, 2010].

It was recognized that the analytes listed in Table 2 in the Technical Task Request (TTR) have target detection limits that are challenging and thus, new or modified analytical methods and/or additional sample material were required to approach these target detection limit values. SRNL had to develop new methodologies for the measurement of Cl-36, K-40, Pd-107, Pt-193 and Nb-94 at ultra trace levels (See summary of new methods in Appendix B). Special emphases were placed on achieving these target detection limits for at least one sample location. The target detection limits for analytes listed in Table 3 (See TTR) confirmatory analyses were also expected to be challenging. Only one replicate per sample was required for these Table 3 analytes. For a given analyte, where all the sample analysis results were below detection limits, only the lowest detection level obtained was required to be reported.

Prior to general analyses of these Tank 18F floor samples, aliquots of each sector solid sample were digested and submitted for analysis for a comprehensive characterization. A small initial suite of characterization data for Tank 18F had to be completed, statistically analyzed, and reviewed to determine the need for analysis of archive Tank 18F floor samples.

2.0 SAMPLING AND SAMPLE PREPARATION FOR CHARACTERIZATION

As shown in Figure 2, Tank 18F was artificially partitioned into six 60-degree sectors with an outer zone area (2 to 6 feet zone of the tank circumference) and inner zone area. The Tank 18F solids are about equally divided between the outer and inner zones. The Tank 18F samples were obtained from the inner and/or outer zones of each of six "pie-slice" shaped 60-degree sectors. One sample from the inner zone of each hemisphere (FTF-18-6 and FTF-18-7) was held as an archive for possible analysis at a later time. Approximately 70 grams of sample solids provided by SRR was required per sample location to perform the requested characterizations (See Figures 1 and 2). These additional Tank 18F sample analyses were performed on six sector floor samples. Approximate locations for the samples are shown in Figure 2 for Tank 18F.

Figure 1 shows a photo of the Tank 18F samples received from SRR for characterization. With the exception of samples FTF-18-2, FTF-18-2B, FTF-18-6, FTF-18-7 and FTF-18-7B, the other Tank 18F samples (FTF-18-3, FTF-18-8, FTF-4, FTF-4B, FTF-5, FTF-5B) were received as cake solids with about 1-2% by volume of visible free liquids. The free liquids were decanted and the remaining wet solid cake transferred into special sampling poly-bottles as shown in Figure 1. Some sample locations with multiple samples were gravimetrically combined into a single

sample. Sample FTF-18-2 and FTF-18-2B were composited into FTF-18-2 sample for processing and characterization, while sample FTF-18-7 and FTF-18-7B were composited into a sample (FTF-18-7) and archived for future use. Sample FTF-18-6 was also archived for future use. All the samples that exhibited free liquids, after decanting of the free liquids, were air dried for 120 hours inside the shielded cells by simply removing the sampling poly-bottles caps and exposing the sample container and contents to the cell air. Sample FTF-18-8-new contained more free liquids (> 7 % by volume of visible free liquids) than others and thus had the least wt % solids of all the samples. Other Tank 18F samples, notably, FTF-1, FTF-1B, FTF-6 and FTF-18-3B [FTF-18-8] contained solids which were damp and fairly loose but exhibited no free liquids. The damp samples were also similarly air dried for 120 hours. Some of the samples [FTF-18-1B, FTF-18-3B, FTF-18-4B, FTF-18-5B] were also archived for future use.

A floor scrape sample had been previously obtained at the Northeast riser of Tank 18F. This in-house floor sample (archived in the shielded cell) from Tank 18F was considered as an outer zone sample equivalent to the additional 40 grams of solid sample FTF-18-8 from SRR. This sample, FTF-18-8, was taken from the same location as a previous Tank 18F floor sample (FTF-18-8-old) as described in previous Tank 18F characterization report [4] and thus served as a complementary sample to the old Tank 18F floor sample. This old Tank 18F floor sample (FTF-18-8-old) was fairly dry and as such did not require any extra air-drying prior to processing for characterization. A partial suite of analyses for this old Tank 18F floor sample, as cited in reference 1 above, had been completed. This additional sample (FTF-18-8) was obtained to ensure that there was going to be adequate sample material for this location to complete all required analysis. If there was insufficient FTF-18-8-old sample to complete the full suite of analyses for this sample location as shown in Tables 1-4 of the TTR then sample FTF-18-8 was going to be used, otherwise sample FTF-18-8 would be archived for possible future use. There was sufficient FTF-18-8-old sample to complete the full suite of analyses for this Tank18F sector analyses.

The constituents listed in Table 3 of the TTR (Cl-36, K-40, Pd-107 and Pt-193) were not expected to be present in the tanks. Therefore, the analysis of the samples for these constituents was considered confirmatory. As a result, having multiple samples to reduce statistical sampling and analytical uncertainty was not as important for these analyses. Hence, analyses for the constituents listed in Table 3 were considered lowest priority and characterizing for them was performed to demonstrate absence. Sample materials were only used for these analyses after all Table 1, 2, and 4 analyses were completed. The specific decision logic that was followed for allocation of the available Tank 18F material for characterization is detailed in the TTR and TTQAP.

Because of the inherent risk of cross-contamination of these samples in the shielded cells environment, certain actions where taken to minimize the risks. Actions taken to control cross-contamination in the cell included wiping down the cell (cell decontaminated), covering the cell floor, and changing manipulator fingers prior to initiating work. Prior to preparing each sample for characterization, all the Tank 18F samples (both air dried and dry sample) needed to be homogenized because of the presence of chunks of solids. Homogenizing each sample involved the crushing of the samples in separate mortar and pestle and the sieving of the resulting dry material through mesh 30 (600 micron) wire sieve. Multiple aliquots were pulled from these samples and analyzed for bulk inorganic elements (Al, Fe, Mg, Mn and Si) prior to characterization to ensure adequate homogenization before proceeding with the full suite of analysis. Most of the homogenized Tank 18F solids passed through the sieve. Good sample homogeneity was demonstrated by major element determinations of better than 20 % relative standard deviation for the entire analytical process of sub-sampling the powder, shielded cell dissolutions, and elemental determinations by inductively coupled plasma-optical emission

spectroscopy. Results for this initial multiple aliquot characterizations for homogeneity of the prepared samples are summarized in Table A-1, Appendix A for all Tank 18F samples. The data shows sufficient reproducibility of the analyses results for each of the transition metals from each aliquot. The % relative standard deviations for the select transition metals were all below 10%.

Prior to the processing of the Tank 18F samples, which normally involved the opening of sector samples in the shielded cell and preparation of some of the samples in the shielded cell before submitting to AD for analysis, four in-cell containers (with geometric configuration similar to the sector sample containers), each with 5-10 g of dry analytical glass reference blank standards (ARG), were placed at strategic locations in the shielded cell. The containers were opened when the Tank 18F samples were being processed and closed at the end of each day of work in the cell.

As part of the QA/QC protocol, ARG standards were retrieved, dissolved with aqua regia and peroxide fusion methods, and analyzed concurrently with each set of sector samples. The ARG analysis served as a laboratory control standard for elemental analysis and as a blank for radionuclide and ion determinations. A reagent blank which consisted of performing reference samples were digested and analyzed for each sample (one reagent blank and one ARG). ARG and reagent blanks were also used as reference blanks for all other analytical method development procedures. No other blanks or standards other than AD internal standards were used. Some of the ARG standards were taken out of the cell and made available to AD for digestion and characterization along with other Tank 18F sector samples. Thus, the ARG standards were submitted for the same analyses as the actual samples from Tank 18F. A 5% sodium chloride salt solution prepared by dissolving 5 grams of dried sodium chloride in distilled water was used as the reference standard for weight percent solids determinations. In this process, the reference salt solution was put in a different compartment of the same oven to prevent condensation on the Tank samples and the weight percent of the dissolved and recovered NaCl determined as described in Appendix B for the Tank 18F samples analytical method summary. The amount of recovered NaCl was expected be as close as possible to the original 5 g of NaCl dissolved in water.

All aqua regia and/or peroxide fusion digestions were performed inside the shielded cells. Dilute samples from these digestions were taken out of the cell and made available to AD for various characterizations as long as the activity of each dilute sample or combination of samples had a "whole body" activity less than 10 mRem. A significant number of method development procedures had to been done by AD in standard radiation hoods outside the shielded cells. For these method developments and all other analytical method not involving aqua regia and/or peroxide fusion digestions aliquots of each sector samples were taken out in "shielded cell green" bottles singly or collectively as long as the "whole body" activity was determined to be below the radiological handling limits. The description of aqua regia (AQR) and sodium peroxide/hydroxide fusions (PF) digestion procedures are described in Appendix B.

2.1 Leaching Characteristics and Density Measurements for Tank 18F Solids

Known amounts of each of the air dried Tank 18F solid samples were leached with distilled and de-ionized water in triplicate. An average of 1.22 ± 0.16 grams of the air-dried Tank 18F solid was leached with an average of 50.01 ± 0.01 grams of distilled and de-ionized water.

In this process, each solid material portion of the Tank 18F to be leached was thoroughly mixed with the given amount of distilled and de-ionized water and the mixture was hand agitated (shielded cell manipulator) for a total of about five minutes and left to stand for another 24 hours before another agitation and filtering of the mixture through 0.45 micron filter membrane for each

sample. The filtrate from the mixture was analyzed in triplicate for anions and carbon contaminants as required. Thus, only surface bound and water soluble contaminants are assumed to be accounted for in the resulting leachate analyses.

The bulk densities of the "as-received" granular Tank 18F solids were measured using a calibrated syringe tube assembly with graduation markings. With the syringe plunger removed, the syringe was loaded with Tank 18F solids with the help of a spatula to a level of about 2-mL. After sample loading in the syringe tube, the plunger was inserted into the syringe until the tip of the plunger touches the sample matrix without excessive compressing of the samples in the tube. The plunger was then slightly pulled back and tapped to ensure the granular solid was uniformly distributed around the circumference of the tube. The volume of samples in the tube was read and the weight of the whole syringe assembly, with the plunger still in place, was determined. A subtraction of the weight of the assembly without the granular samples provided the weight of the granular sample inside the syringe tube. Using the same syringe unit, the plunger was carefully removed and more granular samples were added to the syringe and the new volume and weight of the granular samples determined again. Using different syringe assemblies, this process was repeated three times for each of the Tank 18F samples from different sectors as shown in Table 1.

Figure 1. Tank 18F Additional Floor Samples after air-drying

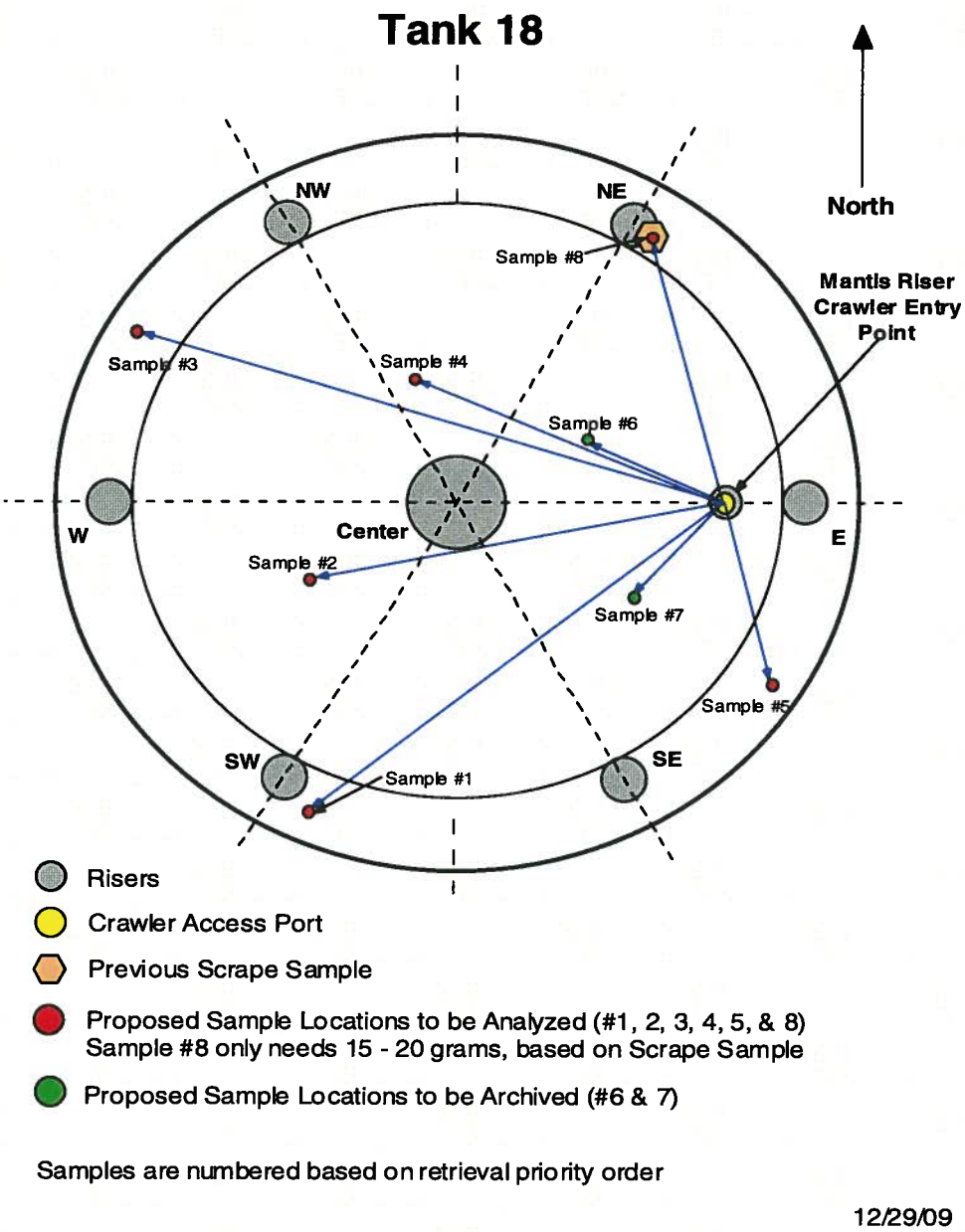

Figure 2 Tank 18F Sample Locations

3.0 RESULTS

In the result tables below, values preceded by "<" (less than sign) indicate values were below detection limits, and values proceeded by "≤" (less than or equal to sign) indicate that for replicates, at least one of the analysis values was above the instrument or method detection limit. Thus, where replicate analyses were both above and below the detection limit, the average of all replicates above and below the detection limit is given and a "≤ " sign precedes the average value. The standard deviation values were calculated only for values that were above the detection limits. The minimum detectable activity (MDA) is defined as the value above which instrument signal can be considered real and the upper limit (UL) is defined as activity observed but not

certain if the result is unbiased high due to spectral interference or blank contamination. The reporting units for all radionuclide species including PF and AQR digestion analytical results are presented per gram of Tank 18F solids after air drying and homogenization. The conversion factor, if required (original air-dried basis to dry basis), can be accomplished through the use of the dry solid weight percent (wt %) values as shown in Table 1 for each sample. For example, µCi/g dried solids = [x µCi/g of air-dried solids (100 g of air-dried solids)]/96.13 dry solids (sample FTF-18-1). The one sigma percent uncertainty for each major radionuclide, as reported in the tables, is based on the "pooled estimate" derived from the individual uncertainties for each replicate measurement for that radionuclide [SQRT(SUMSQ(x_i)/n)], where n is the number of replicates and x_i is the individual uncertainty for each run]. Here it is assumed that the radio-analytical processes, be it counting or other techniques, are of the same precision.

Occasionally, one encounters situations where the samples prepared and analyzed in triplicate give mixed results with one or two of the triplicate analyses results being less than the minimum detection limit. In these cases, the reporting of the one sigma percent uncertainty is presented in a different format. In this situation, where it is not possible to calculate the "pooled estimate," the individual percent uncertainty associated with each run for that radionuclide is reported along with MDA or upper limit values as reported by AD. For example, under the one sigma percent uncertainty column for radionuclide in the tables a 25.5/*MDA* designation implies that the one sigma percent uncertainty for one or two of the analyses reported with values above detection limit has a one sigma percent uncertainty of 25.5 percent while one or two of the measurement which were below detection limit (no percent uncertainty values assigned) are assigned MDA, DL or upper limit. In some cases, especially with the radionuclides, the one sigma measurement uncertainty may be higher than 100%. In such a situation, the reported value is barely just above the magnitude of the minimum detection activity (MDA) for that radionuclide, which leads to a higher uncertainty in the analytical result reported.

The one sigma measurement uncertainty value for the anions and transition metals reported here is 10 percent. The analytical results for some of the non-radionuclide components (Ag, Sn and Pb), are based on the ICP-Mass spectral abundance data instead of the standard ICP-ES analyses results because of higher detection limits for these transition metals by ICP-ES. The ICP-MS abundance masses used for calculating reported values for these transition metals are masses 107 and 109 for silver, 118 for tin and 204,206,207 and 208 for lead. For tin, in particular, mass 118 is considered as 24.2 percent of the natural abundance for tin and based on that, the total amount of tin in the sample was calculated from the ICP-MS analytical result. The one sigma measurement uncertainties for these ICP-MS based analyses are 20 percent.

The analytical results for some of the "difficult" to analyze isotopes also termed "challenging analytes" (Pt-193, Pd-107, K-40, Cl-36, Zr-93, Ra-226, I-129) are presented slightly differently. For several of these radionuclides, multiple approaches were attempted on individual sector positions. In some instances, the analyses were unsuccessful and not reported for particular sector positions due to the challenging analytical separations in achieving these low detection limits (Successful methods are provided in Appendix B). The customer specified detection limits for these challenging radionuclides were met in all cases for Zr-93, Pd-107, and I-129. To meet the requested detection limits for Ra-226, the counting had to be extended for several days on selected samples (FTF-18-3, FTF-18-5 and FTF-18-8-old). Thus, two sets of results are presented in the tables for Ra-226 to reflect normal counting and enhanced counting to reduce the background as well as lower the detection limits. The activity for Pt-193 was successfully measured for only two of the Tank 18F samples (FTF-18-5 and FTF-18-8-old). Detection limit for Pt-193 was above the original requested limits for the other Tank 18F samples. The customer specified detection limits for Cl-36 were attained, as reported in Table 16 for a single sector

sample (FTF-18-2), with extra distillation and separation efforts. Analyses for K-40 in Tank 18F samples was positively detected for one sector sample (FTF-8-old) as shown in Table 11. Similarly, one of the triplicate analyses for FTF-8-old was positively measured for Nb-94. The remaining measurement for K-40 and Nb-94 were measured below detection limits, however, some of the measurements were still above the requested detection limits.

Leaching results are presented per gram of the air-dried Tank 18F solid samples. The reporting units for metals and other cations are in weight percent. The ICP-MS results are given for each atomic mass and, in most cases, each mass number represent only one isotope. An example of an exception is mass number-238, both uranium and plutonium can be represented by this mass number. Hence, Pu-238 and Pu-241 results were measured by PuTTA to distinguish the values from uranium-238 and americium-241 values, respectively (See separation methods for these radionuclides as summarized in Appendix B). In cases where ICP-MS and radiochemistry data give similar results for a species, radiochemistry is typically selected due to better sensitivity and uncertainty.

The analytical result for Cs-137, though not specifically requested by the customer, has been included because gamma scan analytical results showed that it was also present in the sample analyzed. Also, metal analyses results for archived samples FTF-18-6, not directly requested by the customer, is also provided in Table 7.

3.1 Blank Evaluations and Detection Limits

To verify the absence of sample contamination during processing, analytical blanks (reagent and AGR blanks) results were compared to select sample analytical results (mainly for uranium and Pu isotopes, Cs-137 and Cs-135, Sr-90, Hg, As, transition metals, anions and organic carbon) as presented in Appendix A (Table A-2 to Table A-6). Most of the blanks of interest, with the exception of U-238, are all below the sample analytical results. Thus, there seem to be no measurable cross contamination issues either from the environment of the shielded cell staging and operation areas or the reagents used in sample preparations. A few of the blanks results for U-238 were within the instrument detection limits although all sample analytical results for U-238 were several orders of magnitude higher than blank results for U-238. Overall, there were significantly fewer measurable constituents in the blanks than in the samples.

While many of the minimum detection limits, as specified in the Technical Task Request and Task Technical and Quality Assurance Plans were met for the species characterized for Tank 18F, some were not met. In a number of cases, the relative high levels of radioactive species of the same element or a chemically similar element precluded the ability to measure an isotope to low levels. For example, the high activities of Am-241 and Cm-244 in the sample matrix raised the alpha spectroscopy instrumental backgrounds for Cm-248, having a detrimental effect on the detection limit for that isotope. The 2.6 year half-life of Pm-147 co-extracts with the 90 year half-life Sm-151. Both have overlapping beta spectra, with slightly higher continuum beta end-point energy for Pm-147. The Sm-151 levels in these samples were relatively high, substantially raising the detection limit achievable for Pm-147. A number of gamma emitting radionuclides were analyzed using a Cs-137 removed gamma analysis; Cs-137 was expected to be the main contributor to background levels which would lower the sensitivity of the gamma analysis for other species. While that was true, the samples also contained measurable quantities of other gamma emitting isotopes (i.e. Co-60, Eu-154, Eu-155, etc…) which raised the background and thus the detection limits for gamma emitting species not observed (i.e. Nb-94, Sb-125, etc…).

Midway through the project, SRNL/SRR completed a statistical review of Tank 18F limited data sets for variability and statistical anomalies. Based on this review information, it was determined that the characterization of archived or additional samples, as was originally intended, was considered unnecessary [3, 5]. The combined 3-sigma charts [3] for select Tank 18F radionuclide data is shown in Figure 3 for both outer and inner tank zones. This figure shows the standardized data versus 3-sigma limit plots for select radionuclide species using the analyses results from all 6 Tank 18F scrape floor sample characterizations. The 3-sigma limit plot shows that most of the data fall within 3-sigma with no obvious outliers. Additional comparisons on these Tank 18F inner and outer zone sample analytical data as well as upper bounds for each radionuclide can be found in the statistical review from the SRNL statistical group [3]. The customer reviewed the results and detection limits reported and confirmed these to be adequate for use in determining Tank 18F residual inventory [6].

Table 1. Weight Percent Solids and Density of Tank 18F Sector Sample.

Sector Sample	Density g/mL	Wt% solids	Comments
FTF-18-1	1.08 ± 0.01	96.13±0.15	South hemisphere sample
FTF-18-2	1.13 ± 0.01	94.21±0.42	South hemisphere sample
FTF-18-3	1.06 ± 0.01	90.88±0.07	North hemisphere sample
FTF-18-4	1.07± 0.02	93.36±0.19	North hemisphere sample
FTF-18-5	1.12 ± 0.04	92.95±0.11	South hemisphere sample
TK 18-6	Not measured	93.71±0.74	Archived North hemisphere sample
TK 18-7	Not measured	Not measured	Archived South sample
FTF-18-8 new	1.10 ± 0.04	80.07±1.97	North hemisphere sample
FTF-18-8-old	1.14 ± 0.05	94.31±0.11	Complementary North hemisphere sample
5% Reference NaCl Salt solution	NA	98.00 ± 0.42	4.9 ± 0.02 *g* of NaCl recovered

Table 2 Elemental Constituents for Tank 18F Sample FTF-1.

Cations	Tk 18_1_D_1	Tk 18_1_D_2	Tk 18_1_D_3	Average	stdev
	Wt%	Wt%	Wt%	Wt%	
Ag	2.00E-02	1.86E-02	1.78E-02	**1.88E-02**	*1.14E-03*
Al	1.11E+01	1.10E+01	1.09E+01	**1.10E+01**	*1.00E-01*
B	<3.11E-02	<3.21E-02	<3.42E-02	**<3.25E-02**	
Ba	1.38E-02	1.34E-02	1.39E-02	**1.37E-02**	*2.65E-04*
Be	<5.80E-04	<5.99E-04	<6.38E-04	**<6.06E-04**	
Ca	2.92E+00	2.93E+00	2.94E+00	**2.93E+00**	*1.00E-02*
Cd	9.15E-01	9.13E-01	9.07E-01	**9.12E-01**	*4.16E-03*
Ce	<5.46E-02	<5.65E-02	<6.02E-02	**<5.71E-02**	
Cr	5.58E-02	5.14E-02	5.12E-02	**5.28E-02**	*2.60E-03*
Cu	<1.18E-02	<1.22E-02	<1.30E-02	**<1.23E-02**	
Fe	9.73E+00	9.59E+00	9.97E+00	**9.76E+00**	*1.92E-01*
Gd	<1.76E-02	<1.81E-02	<1.93E-02	**<1.83E-02**	
K	<2.89E-01	<2.99E-01	<3.18E-01	**<3.02E-01**	
La	<8.94E-03	<9.24E-03	<9.85E-03	**<9.34E-03**	
Li	<1.43E-02	<1.48E-02	<1.58E-02	**<1.50E-02**	
Mg	3.78E+00	3.75E+00	3.74E+00	**3.76E+00**	*2.08E-02*
Mn	1.05E+00	1.03E+00	1.04E+00	**1.04E+00**	*1.00E-02*
Mo	<3.54E-02	<3.66E-02	<3.89E-02	**<3.70E-02**	
Ni	1.35E-01	1.23E-01	1.35E-01	**1.31E-01**	*6.93E-03*
P	1.94E+00	9.36E-01	1.14E+00	**1.34E+00**	*5.31E-01*
Pb	4.04E-02	3.84E-02	3.96E-02	**3.95E-02**	*9.84E-04*
S	<1.11E+00	<1.15E+00	<1.23E+00	**<1.16E+00**	
Sb	<8.60E-02	<8.89E-02	<9.48E-02	**<8.99E-02**	
Si	2.10E+00	2.09E+00	2.29E+00	**2.16E+00**	*1.13E-01*
Sn	3.47E-03	2.64E-03	3.91E-03	**3.34E-03**	*6.43E-04*
Sr	2.38E-02	2.34E-02	2.34E-02	**2.35E-02**	*2.31E-04*
Ti	2.22E-02	2.18E-02	2.22E-02	**2.21E-02**	*2.31E-04*
U	6.23E+00	6.26E+00	6.39E+00	**6.29E+00**	*8.50E-02*
V	<4.31E-03	<4.45E-03	<4.74E-03	**<4.50E-03**	
Zn	1.95E-02	1.79E-02	2.00E-02	**1.91E-02**	*1.10E-03*
Hg	6.97E-02	6.90E-02	7.74E-02	**7.20E-02**	*4.66E-03*
As	<4.99E-04	<4.40E-04	<5.07E-04	**<4.82E-04**	
Se	<9.98E-04	<8.80E-04	<2.01E-03	**<1.30E-03**	

Table 3 Elemental Constituents for Tank 18 Sample FTF-2.

Cations	Tk 18_2_D_1	Tk 18_2_D_2	Tk 18_2_D_3	Average	stdev
	Wt%	Wt%	Wt%	Wt%	
Ag	1.49E-02	1.38E-02	1.37E-02	**1.41E-02**	*6.25E-04*
Al	1.38E+01	1.38E+01	1.40E+01	**1.39E+01**	*1.15E-01*
B	<2.91E-02	<3.11E-02	<3.03E-02	**<3.02E-02**	
Ba	1.92E-02	1.77E-02	1.87E-02	**1.85E-02**	*7.64E-04*
Be	<5.43E-04	<5.80E-04	<5.66E-04	**<5.63E-04**	
Ca	2.19E+00	2.16E+00	2.04E+00	**2.13E+00**	*7.94E-02*
Cd	5.37E-01	5.51E-01	5.34E-01	**5.41E-01**	*9.07E-03*
Ce	<5.12E-02	<5.46E-02	<5.33E-02	**<5.30E-02**	
Cr	4.73E-02	5.24E-02	4.78E-02	**4.92E-02**	*2.81E-03*
Cu	<1.10E-02	<1.18E-02	<1.15E-02	**<1.14E-02**	
Fe	7.16E+00	6.84E+00	6.89E+00	**6.96E+00**	*1.72E-01*
Gd	<1.65E-02	<1.76E-02	<1.71E-02	**<1.71E-02**	
K	<2.71E-01	<2.89E-01	<2.82E-01	**<2.81E-01**	
La	<8.38E-03	<8.94E-03	<8.73E-03	**<8.68E-03**	
Li	<1.34E-02	<1.43E-02	<1.40E-02	**<1.39E-02**	
Mg	1.77E+00	1.82E+00	1.75E+00	**1.78E+00**	*3.61E-02*
Mn	8.16E-01	8.49E-01	8.29E-01	**8.31E-01**	*1.66E-02*
Mo	<3.31E-02	<3.54E-02	<3.45E-02	**<3.43E-02**	
Ni	8.09E-02	8.52E-02	8.30E-02	**8.30E-02**	*2.15E-03*
P	<1.04E+00	<1.11E+00	<1.08E+00	**<1.08E+00**	
Pb	2.88E-02	3.02E-02	2.90E-02	**2.93E-02**	*7.52E-03*
S	<1.04E+00	<1.11E+00	<1.09E+00	**<1.08E+00**	
Sb	<8.06E-02	<8.60E-02	<8.40E-02	**<8.35E-02**	
Si	2.97E+00	2.95E+00	2.93E+00	**2.95E+00**	*2.00E-02*
Sn	1.99E-03	3.13E-03	3.06E-03	**2.72E-03**	*6.39E-04*
Sr	1.51E-02	1.50E-02	1.49E-02	**1.50E-02**	*1.00E-04*
Ti	1.65E-02	1.63E-02	1.59E-02	**1.62E-02**	*3.06E-04*
U	3.68E+00	3.75E+00	3.54E+00	**3.66E+00**	*1.07E-01*
V	<4.04E-03	<4.31E-03	<4.20E-03	**<4.18E-03**	
Zn	1.47E-02	1.40E-02	1.31E-02	**1.39E-02**	*8.02E-04*
Hg	3.69E-02	3.84E-02	3.07E-02	**3.53E-02**	*4.08E-03*
As	<5.57E-04	<5.46E-04	<5.99E-04	**<5.67E-04**	
Se	<1.11E-03	<1.09E-03	<1.20E-03	**<1.13E-03**	

Table 4 Elemental Constituents for Tank 18 Sample FTF-3.

Cations	Tk 18_3_D_1	Tk 18_3_D_2	Tk 18_3_D_3	Average	stdev
	Wt%	Wt%	Wt%	Wt%	
Ag	1.54E-02	1.32E-02	1.21E-02	**1.36E-02**	*1.68E-03*
Al	1.68E+01	1.67E+01	1.64E+01	**1.66E+01**	*2.08E-01*
B	3.13E-02	2.75E-02	3.09E-02	**2.99E-02**	*2.09E-03*
Ba	2.36E-02	2.28E-02	2.42E-02	**2.35E-02**	*7.02E-04*
Be	< 4.51E-04	< 4.79E-04	< 5.77E-04	**< 5.02E-04**	
Ca	1.91E+00	1.95E+00	1.93E+00	**1.93E+00**	*2.00E-02*
Cd	4.91E-01	4.95E-01	4.81E-01	**4.89E-01**	*7.21E-03*
Ce	< 4.25E-02	< 4.51E-02	< 5.44E-02	**< 4.73E-02**	
Cr	4.74E-02	4.86E-02	4.63E-02	**4.74E-02**	*1.15E-03*
Cu	< 9.14E-03	< 9.71E-03	< 1.17E-02	**< 1.02E-02**	
Fe	7.14E+00	7.51E+00	7.22E+00	**7.29E+00**	*1.95E-01*
Gd	< 8.76E-03	< 9.30E-03	< 1.12E-02	**< 9.75E-03**	
K	< 2.25E-01	< 2.39E-01	< 2.88E-01	**< 2.51E-01**	
La	< 6.96E-03	< 7.39E-03	< 8.90E-03	**< 7.75E-03**	
Li	< 1.11E-02	< 1.18E-02	< 1.43E-02	**< 1.24E-02**	
Mg	2.11E+00	2.09E+00	2.07E+00	**2.09E+00**	*2.00E-02*
Mn	7.94E-01	7.85E-01	7.77E-01	**7.85E-01**	*8.50E-03*
Mo	< 2.75E-02	< 2.92E-02	< 3.52E-02	**< 3.06E-02**	
Ni	8.92E-02	9.75E-02	9.03E-02	**9.23E-02**	*4.51E-03*
P	< 5.47E-02	< 5.81E-02	< 7.00E-02	**< 6.09E-02**	
Pb	4.25E-02	4.31E-02	4.30E-02	**4.29E-02**	*3.20E-04*
S	< 8.67E-01	< 9.21E-01	< 1.11E+00	**< 9.66E-01**	
Sb	< 4.43E-02	< 4.71E-02	< 5.67E-02	**< 4.94E-02**	
Si	2.21E+00	2.21E+00	2.23E+00	**2.22E+00**	*1.15E-02*
Sn	1.33E-03	1.69E-03	1.77E-03	**1.60E-03**	*2.37E-04*
Sr	1.56E-02	1.59E-02	1.62E-02	**1.59E-02**	*3.00E-04*
Ti	1.78E-02	1.76E-02	1.79E-02	**1.78E-02**	*1.53E-04*
U	1.60E+00	1.51E+00	1.54E+00	**1.55E+00**	*4.58E-02*
V	< 3.35E-03	< 3.56E-03	< 4.28E-03	**< 3.73E-03**	
Zn	1.71E-02	1.58E-02	1.54E-02	**1.61E-02**	*8.89E-04*
Hg	2.60E-02	2.33E-02	2.48E-02	**2.47E-02**	*1.35E-03*
As	<5.48E-04	<4.28E-04	<5.38E-04	**<5.05E-04**	
Se	<1.10E-03	<8.57E-04	<1.08E-03	**<1.01E-03**	

Table 5 Elemental Constituents for Tank 18 Sample FTF-4.

Cations	Tk 18_4_D_1	Tk 18_4_D_2	Tk 18_4_D_3	Average	stdev
	Wt%	Wt%	Wt%	Wt%	
Ag	1.84E-02	2.08E-02	2.15E-02	**2.02E-02**	*1.64E-03*
Al	1.72E+01	1.70E+01	1.68E+01	**1.70E+01**	*2.00E-01*
B	<3.15E-02	<2.96E-02	<3.09E-02	**<3.07E-02**	
Ba	2.25E-02	2.14E-02	2.08E-02	**2.16E-02**	*8.62E-04*
Be	< 5.88E-04	< 5.52E-04	< 5.77E-04	**< 5.72E-04**	
Ca	2.33E+00	2.25E+00	2.30E+00	**2.29E+00**	*4.04E-02*
Cd	5.70E-01	5.52E-01	5.35E-01	**5.52E-01**	*1.75E-02*
Ce	< 5.54E-02	< 5.20E-02	< 5.44E-02	**< 5.39E-02**	
Cr	5.38E-02	5.45E-02	4.98E-02	**5.27E-02**	*2.54E-03*
Cu	< 1.19E-02	1.26E-02	< 1.17E-02	**≤ 1.21E-02**	
Fe	7.68E+00	7.43E+00	7.23E+00	**7.45E+00**	*2.25E-01*
Gd	< 1.14E-02	< 1.07E-02	< 1.12E-02	**< 1.11E-02**	
K	< 2.93E-01	< 2.75E-01	< 2.88E-01	**< 2.85E-01**	
La	< 9.07E-03	< 8.51E-03	< 8.90E-03	**< 8.83E-03**	
Li	< 1.45E-02	< 1.36E-02	< 1.43E-02	**< 1.41E-02**	
Mg	1.52E+00	1.48E+00	1.47E+00	**1.49E+00**	*2.65E-02*
Mn	1.01E+00	9.54E-01	9.33E-01	**9.66E-01**	*3.98E-02*
Mo	< 3.59E-02	< 3.36E-02	< 3.52E-02	**< 3.49E-02**	
Ni	8.13E-02	7.99E-02	7.82E-02	**7.98E-02**	*1.55E-03*
P	1.15E-01	1.07E-01	1.24E-01	**1.15E-01**	*8.50E-03*
Pb	3.65E-02	3.47E-02	3.61E-02	**3.58E-02**	*9.50E-04*
S	< 1.13E+00	< 1.06E+00	< 1.11E+00	**< 1.10E+00**	
Sb	< 5.78E-02	< 5.42E-02	< 5.67E-02	**< 5.62E-02**	
Si	3.71E+00	3.55E+00	3.98E+00	**3.75E+00**	*2.17E-01*
Sn	3.87E-03	6.17E-04	1.69E-03	**2.06E-03**	*1.66E-03*
Sr	1.50E-02	1.50E-02	1.46E-02	**1.49E-02**	*2.31E-04*
Ti	1.68E-02	1.64E-02	1.65E-02	**1.66E-02**	*2.08E-04*
U	1.28E+00	1.29E+00	1.14E+00	**1.24E+00**	*8.39E-02*
V	< 4.37E-03	< 4.10E-03	< 4.28E-03	**< 4.25E-03**	
Zn	1.62E-02	1.51E-02	1.46E-02	**1.53E-02**	*8.19E-04*
Hg	5.65E-02	4.09E-02	5.39E-02	**5.04E-02**	*8.36E-03*
As	<5.77E-04	<4.55E-04	<5.48E-04	**<5.27E-04**	
Se	<1.15E-03	<9.11E-04	<1.10E-03	**<1.05E-03**	

Table 6 Elemental Constituents for Tank 18 Sample FTF-5.

Cations	Tk 18_5_D_1	Tk 18_5_D_2	Tk 18_5_D_3	Average	stdev
	Wt%	Wt%	Wt%	Wt%	
Ag	1.87E-02	2.19E-02	1.94E-02	**2.00E-02**	*1.68E-03*
Al	1.66E+01	1.62E+01	1.64E+01	**1.64E+01**	*2.00E-01*
B	<2.72E-02	<3.26E-02	<2.85E-02	**<2.94E-02**	
Ba	2.58E-02	2.54E-02	2.50E-02	**2.54E-02**	*4.00E-04*
Be	<5.07E-04	<6.08E-04	<5.32E-04	**<5.49E-04**	*5.26E-05*
Ca	2.76E+00	2.70E+00	2.72E+00	**2.73E+00**	*3.06E-02*
Cd	6.57E-01	6.69E-01	6.74E-01	**6.67E-01**	*8.74E-03*
Ce	<4.78E-02	<5.73E-02	<5.02E-02	**<5.18E-02**	
Cr	5.39E-02	5.29E-02	5.38E-02	**5.35E-02**	*5.51E-04*
Cu	1.11E-02	<1.23E-02	<1.09E-02	**≤1.14E-02**	
Fe	8.73E+00	8.75E+00	8.94E+00	**8.81E+00**	*1.16E-01*
Gd	<9.85E-03	<1.18E-02	<1.03E-02	**<1.07E-02**	
K	<2.53E-01	<3.03E-01	<2.65E-01	**<2.74E-01**	
La	<7.82E-03	<9.37E-03	<8.21E-03	**<8.47E-03**	
Li	<1.25E-02	<1.50E-02	<1.31E-02	**<1.35E-02**	
Mg	2.19E+00	2.20E+00	2.18E+00	**2.19E+00**	*1.00E-02*
Mn	1.10E+00	1.07E+00	1.09E+00	**1.09E+00**	*1.53E-02*
Mo	<3.09E-02	<3.71E-02	<3.25E-02	**<3.35E-02**	
Ni	9.61E-02	1.02E-01	9.84E-02	**9.88E-02**	*2.97E-03*
P	1.37E-01	1.29E-01	1.46E-01	**1.37E-01**	*8.50E-03*
Pb	3.76E-02	3.58E-02	3.69E-02	**3.68E-02**	*9.09E-04*
S	<9.75E-01	<1.17E+00	<1.02E+00	**<1.06E+00**	
Sb	<4.98E-02	<5.97E-02	<5.23E-02	**<5.39E-02**	
Si	3.55E+00	3.46E+00	3.46E+00	**3.49E+00**	*5.20E-02*
Sn	2.47E-03	1.40E-03	1.88E-03	**1.92E-03**	*5.36E-04*
Sr	1.74E-02	1.73E-02	1.74E-02	**1.74E-02**	*5.77E-05*
Ti	2.12E-02	2.00E-02	2.01E-02	**2.04E-02**	*6.66E-04*
U	8.39E-01	7.99E-01	8.62E-01	**8.33E-01**	*3.19E-02*
V	<3.76E-03	<4.51E-03	<3.95E-03	**<4.07E-03**	
Zn	1.83E-02	1.81E-02	1.88E-02	**1.84E-02**	*3.61E-04*
Hg	6.32E-02	5.36E-02	7.16E-02	**6.28E-02**	*9.01E-03*
As	<5.68E-04	<5.00E-04	<5.30E-04	**<5.33E-04**	
Se	<1.14E-03	<1.00E-03	<1.06E-03	**<1.07E-03**	

Table 7 Elemental Constituents for Tank 18 Sample FTF-6.

Cations	Tk 18_6_D_1	Tk 18_6_D_2	Tk 18_6_D_3	Average	stdev
	Wt%	Wt%	Wt%	Wt%	
Ag	1.49E-02	1.79E-02	1.57E-02	1.62E-02	1.52E-03
Al	1.10E+01	1.05E+01	1.06E+01	1.07E+01	2.65E-01
B	<2.73E-02	<3.06E-02	<2.67E-02	<2.82E-02	
Ba	2.13E-02	1.88E-02	1.97E-02	1.99E-02	1.27E-03
Be	<5.10E-04	<5.71E-04	<4.98E-04	<5.26E-04	
Ca	2.25E+00	2.22E+00	2.00E+00	2.16E+00	1.37E-01
Cd	5.34E-01	4.93E-01	4.87E-01	5.05E-01	2.56E-02
Ce	<4.80E-02	<5.39E-02	<4.70E-02	<4.96E-02	
Cr	5.04E-02	4.82E-02	4.71E-02	4.86E-02	1.68E-03
Cu	<1.03E-02	<1.16E-02	<1.01E-02	<1.07E-02	
Fe	6.32E+00	5.99E+00	6.01E+00	6.11E+00	1.85E-01
Gd	<9.90E-03	<1.11E-02	<9.68E-03	<1.02E-02	
K	<2.54E-01	<2.85E-01	<2.49E-01	<2.63E-01	
La	<7.86E-03	<8.81E-03	<7.69E-03	<8.12E-03	
Li	<1.26E-02	<1.41E-02	<1.23E-02	<1.30E-02	
Mg	1.32E+00	1.23E+00	1.22E+00	1.26E+00	5.51E-02
Mn	1.02E+00	9.62E-01	8.93E-01	9.58E-01	6.36E-02
Mo	<3.11E-02	<3.48E-02	<3.04E-02	<3.21E-02	
Ni	7.11E-02	<7.59E-02	7.16E-02	≤7.29E-02	
P	8.97E-02	9.18E-02	9.09E-02	9.08E-02	1.05E-03
Pb	4.55E-02	4.23E-02	4.22E-02	4.33E-02	1.86E-03
S	<9.80E-01	<1.10E+00	<9.58E-01	<1.01E+00	
Sb	<5.01E-02	<5.61E-02	<5.00E-02	<5.21E-02	
Si	2.95E+00	3.06E+00	3.03E+00	3.01E+00	5.69E-02
Sn	1.78E-03	1.55E-03	1.30E-03	1.54E-03	2.43E-04
Sr	1.31E-02	1.26E-02	1.23E-02	1.27E-02	4.04E-04
Ti	1.61E-02	1.41E-02	1.40E-02	1.47E-02	1.18E-03
U	2.34E+00	2.15E+00	2.07E+00	2.19E+00	1.39E-01
V	<3.79E-03	<4.24E-03	<3.70E-03	<3.91E-03	
Zn	1.28E-02	1.40E-02	1.17E-02	1.28E-02	1.15E-03
Hg	9.03E-02	6.70E-02	8.71E-02	8.15E-02	1.26E-02
As	<5.39E-04	<5.75E-04	<5.58E-04	<5.57E-04	
Se	<1.08E-03	<1.15E-03	<1.12E-03	<1.12E-03	

Table 8 Elemental Constituents for Tank 18 Sample FTF-8-old.

Cations	Tk 18_8-old_D_1	Tk 18_8-old_D_2	Tk 18_8-old_D_3	Average	stdev
	Wt%	Wt%	Wt%	Wt%	
Ag	2.11E-02	2.17E-02	2.32E-02	**2.20E-02**	1.07E-03
Al	1.38E+01	1.38E+01	1.41E+01	**1.39E+01**	*1.73E-01*
B	<2.84E-02	<3.29E-02	<2.93E-02	**<3.02E-02**	
Ba	2.44E-02	2.53E-02	2.58E-02	**2.52E-02**	*7.09E-04*
Be	<5.29E-04	<6.13E-04	<5.46E-04	**<5.63E-04**	
Ca	2.61E+00	2.55E+00	2.65E+00	**2.60E+00**	*5.03E-02*
Cd	6.51E-01	6.42E-01	6.43E-01	**6.45E-01**	*4.93E-03*
Ce	<4.99E-02	<5.78E-02	<5.15E-02	**<5.31E-02**	
Cr	6.20E-02	6.22E-02	6.11E-02	**6.18E-02**	*5.86E-04*
Cu	<1.07E-02	<1.24E-02	<1.11E-02	**<1.14E-02**	
Fe	8.54E+00	8.28E+00	8.59E+00	**8.47E+00**	*1.66E-01*
Gd	<1.03E-02	<1.19E-02	<1.06E-02	**<1.09E-02**	
K	<2.64E-01	<3.06E-01	<2.72E-01	**<2.81E-01**	
La	<8.16E-03	<9.46E-03	<8.42E-03	**<8.68E-03**	
Li	<1.31E-02	<1.52E-02	<1.35E-02	**<1.39E-02**	
Mg	1.85E+00	1.83E+00	1.85E+00	**1.84E+00**	*1.15E-02*
Mn	1.23E+00	1.19E+00	1.21E+00	**1.21E+00**	*2.00E-02*
Mo	<3.23E-02	<3.74E-02	<3.33E-02	**<3.43E-02**	
Ni	9.35E-02	1.02E-01	8.26E-02	**9.27E-02**	*9.72E-03*
P	1.19E-01	1.19E-01	1.28E-01	**1.22E-01**	*5.20E-03*
Pb	6.92E-02	7.16E-02	6.99E-02	**7.02E-02**	*1.22E-03*
S	<1.02E+00	<1.18E+00	<1.05E+00	**<1.08E+00**	
Sb	<5.20E-02	<6.03E-02	<5.37E-02	**<5.53E-02**	
Si	3.65E+00	3.63E+00	3.73E+00	**3.67E+00**	*5.29E-02*
Sn	4.75E-03	2.18E-03	3.93E-03	**3.62E-03**	*1.13E-03*
Sr	1.72E-02	1.70E-02	1.75E-02	**1.72E-02**	*2.52E-04*
Ti	1.89E-02	1.91E-02	1.94E-02	**1.91E-02**	*2.52E-04*
U	2.15E+00	2.15E+00	2.13E+00	**2.14E+00**	*1.15E-02*
V	<3.93E-03	<4.56E-03	<4.06E-03	**<4.18E-03**	
Zn	1.76E-02	1.94E-02	1.62E-02	**1.77E-02**	*1.60E-03*
Hg	1.20E-01	1.17E-01	7.14E-02	**1.03E-01**	*2.72E-02*
As	<5.75E-04	<5.54E-04	<5.56E-04	**<5.62E-04**	
Se	<1.16E-03	<1.11E-03	<1.11E-03	**<1.13E-03**	

Table 9 Anion Constituents for Tank 18F Sample FTF-1

	Run 1	Run 2	Run 3			
Anions	**TK 18_1_W_1**	**TK 18_1_W_2**	**TK 18_1_W_3**	**Average**	**Stdev**	**Units**
FLUORIDE	5.00E-01	5.24E-01	5.19E-01	**5.15E-01**	*1.26E-02*	*mg/g solids*
FORMATE	<3.34E-02	<4.76E-02	<4.72E-02	**<4.27E-02**		*mg/g solids*
CHLORIDE	3.34E-02	4.76E-02	4.72E-02	**4.27E-02**	*8.13E-03*	*mg/g solids*
NITRITE	2.00E-01	1.91E-01	1.89E-01	**1.93E-01**	*6.03E-03*	*mg/g solids*
NITRATE	4.33E-01	4.76E-01	4.72E-01	**4.61E-01**	*2.36E-01*	*mg/g solids*
PHOSPHATE	<1.67E-01	<2.38E-01	<2.36E-01	**<2.14E-01**		*mg/g solids*
SULFATE	3.00E-01	2.86E-01	2.83E-01	**2.90E-01**	*9.14E-03*	*mg/g solids*
OXALATE	5.77E+00	5.72E+00	5.99E+00	**5.83E+00**	*1.47E-01*	*mg/g solids*
BROMIDE	<1.67E-01	<2.38E-01	<2.36E-01	**<2.14E-01**		*mg/g solids*
TOTAL CARBON	1.64E+01	1.61E+01	1.60E+01	**1.61E+01**	*2.03E-01*	*mg C/g solids*
INORGANIC CARBON	1.35E+01	1.37E+01	1.36E+01	**1.36E+01**	*8.82E-02*	*mg C/g solids*
ORGANIC CARBON	2.87E+00	2.38E+00	2.36E+00	**2.54E+00**	*2.87E-01*	*mg C/g solids*
CARBONATE	6.75E-02	6.84E-02	6.82E-02	**6.80E-02**	*4.41E-04*	*g CO3/g solid*

Table 10 Anion Constituents for Tank 18F Sample FTF-2

	Run 1	Run 2	Run 3			
Analytes	**TK 18_2_W_1**	**TK 18_2_W_2**	**TK 18_2_W_3**	**Average**	**Stdev**	**Units**
FLUORIDE	3.97E-01	4.06E-01	3.82E-01	**3.95E-01**	*1.22E-02*	*mg/g solids*
FORMATE	<3.97E-02	<3.38E-02	<4.24E-02	**<3.86E-02**		*mg/g solids*
CHLORIDE	6.75E-01	6.76E-01	6.78E-01	**6.76E-01**	*1.72E-03*	*mg/g solids*
NITRITE	7.54E-01	7.77E-01	7.63E-01	**7.65E-01**	*1.17E-02*	*mg/g solids*
NITRATE	3.57E-01	3.72E-01	3.82E-01	**3.70E-01**	*1.22E-02*	*mg/g solids*
PHOSPHATE	<1.99E-01	<1.69E-01	<2.12E-01	**<1.93E-01**		*mg/g solids*
SULFATE	2.78E-01	6.42E-01	7.21E-01	**5.47E-01**	*2.36E-01*	*mg/g solids*
OXALATE	1.75E+00	1.86E+00	1.74E+00	**1.78E+00**	*6.74E-02*	*mg/g solids*
BROMIDE	<1.99E-01	<1.69E-01	<2.12E-01	**<1.93E-01**		*mg/g solids*
TOTAL CARBON	2.50E+01	2.37E+01	2.34E+01	**2.40E+01**	*8.29E-01*	*mg C/g solids*
INORGANIC CARBON	2.33E+01	2.26E+01	2.24E+01	**2.28E+01**	*4.53E-01*	*mg C/g solids*
ORGANIC CARBON	1.71E+00	1.12E+00	9.75E-01	**1.27E+00**	*3.89E-01*	*mg C/g solids*
CARBONATE	1.16E-01	1.13E-01	1.12E-02	**8.03E-02**	*5.98E-02*	*g CO3/g solid*

Table 11 Anion Constituents for Tank 18F Sample FTF-3

	Run 1	Run 2	Run 3			
Anions	**TK 18_3_W_1**	**TK 18_3_W_2**	**TK 18_3_W_3**	**Average**	**Stdev**	**Units**
FLUORIDE	3.21E-01	2.91E-01	2.78E-01	**2.97E-01**	*2.22E-02*	*mg/g solids*
FORMATE	<4.59E-02	<4.86E-02	<3.97E-02	**<4.47E-02**		*mg/g solids*
CHLORIDE	3.67E-01	3.40E-01	3.18E-01	**3.42E-01**	*2.48E-02*	*mg/g solids*
NITRITE	2.75E-01	2.43E-01	2.38E-01	**2.52E-01**	*2.02E-02*	*mg/g solids*
NITRATE	2.75E-01	2.91E-01	2.78E-01	**2.82E-01**	*8.62E-03*	*mg/g solids*
PHOSPHATE	<2.29E-01	<2.43E-01	<1.99E-01	**<2.24E-01**		*mg/g solids*
SULFATE	1.38E-01	9.71E-02	1.19E-01	**1.18E-01**	*2.03E-02*	*mg/g solids*
OXALATE	4.59E-01	4.37E-01	3.97E-01	**4.31E-01**	*3.14E-02*	*mg/g solids*
BROMIDE	<2.29E-01	<2.43E-01	<1.99E-01	**<2.24E-01**		*mg/g solids*
TOTAL CARBON	1.28E+01	1.17E+01	1.10E+01	**1.18E+01**	*9.10E-01*	*mg C/g solids*
INORGANIC CARBON	1.16E+01	1.12E+01	1.06E+01	**1.11E+01**	*4.67E-01*	*mg C/g solids*
ORGANIC CARBON	1.24E+00	<6.07E-02	<4.96E-02	**≤4.50E-01**		*mg C/g solids*
CARBONATE	5.78E-02	5.61E-02	5.32E-02	**5.57E-02**	*2.34E-03*	*g CO3/g solid*

Table 12 Anion Constituents for Tank 18F Sample FTF-4

	Run 1	Run 2	Run 3			
Anions	**TK 18_4_W_1**	**TK 18_4_W_2**	**TK 18_4_W_3**	**Average**	**Stdev**	**Units**
FLUORIDE	2.68E-01	2.31E-01	2.38E-01	**2.46E-01**	*1.97E-02*	*mg/g solids*
FORMATE	<4.47E-02	<3.85E-02	<4.76E-02	**<4.36E-02**		*mg/g solids*
CHLORIDE	2.68E-01	2.69E-01	2.86E-01	**2.74E-01**	*9.94E-03*	*mg/g solids*
NITRITE	1.34E-01	1.54E-01	1.43E-01	**1.44E-01**	*9.98E-03*	*mg/g solids*
NITRATE	2.23E-01	2.31E-01	2.38E-01	**2.31E-01**	*7.44E-03*	*mg/g solids*
PHOSPHATE	<2.23E-01	<1.92E-01	<2.38E-01	**<2.18E-01**		*mg/g solids*
SULFATE	8.93E-02	7.70E-02	9.53E-02	**8.72E-02**	*9.35E-03*	*mg/g solids*
OXALATE	2.68E-01	3.08E-01	2.86E-01	**2.87E-01**	*2.00E-02*	*mg/g solids*
BROMIDE	<2.23E-01	<1.92E-01	<2.38E-01	**<2.18E-01**		*mg/g solids*
TOTAL CARBON	8.80E+00	8.12E+00	8.62E+00	**8.51E+00**	*3.53E-01*	*mg C/g solids*
INORGANIC CARBON	7.91E+00	7.70E+00	8.20E+00	**7.93E+00**	*2.50E-01*	*mg C/g solids*
ORGANIC CARBON	8.93E-01	<4.81E-02	<5.96E-02	**≤3.34E-01**		*mg C/g solids*
CARBONATE	3.95E-02	3.85E-02	4.10E-02	**3.97E-02**	*1.25E-03*	*g CO3/g solid*

Table 13 Anion Constituents for Tank 18F Sample FTF-5

	Run 1	Run 2	Run 3			
Analytes	**TK 19_5_W_1**	**TK 19_5_W_2**	**TK 19_5_W_3**	**Average**	**Stdev**	**Units**
FLUORIDE	2.45E-01	2.36E-01	2.48E-01	2.43E-01	*6.44E-03*	*mg/g solids*
FORMATE	<4.90E-02	<4.72E-02	<3.55E-02	<4.39E-02		*mg/g solids*
CHLORIDE	9.81E-02	9.44E-02	1.06E-01	9.96E-02	*6.17E-03*	*mg/g solids*
NITRITE	1.47E-01	1.42E-01	1.42E-01	1.44E-01	*3.11E-03*	*mg/g solids*
NITRATE	4.41E-01	4.25E-01	3.55E-01	4.07E-01	*4.60E-02*	*mg/g solids*
PHOSPHATE	<2.45E-01	<2.36E-01	<1.77E-01	<2.20E-01		*mg/g solids*
SULFATE	9.81E-02	9.44E-02	7.10E-02	8.78E-02	*1.47E-02*	*mg/g solids*
OXALATE	2.94E-01	3.30E-01	3.19E-01	3.15E-01	*1.85E-02*	*mg/g solids*
BROMIDE	<2.45E-01	<2.36E-01	<1.77E-01	<2.20E-01		*mg/g solids*
TOTAL CARBON	5.20E+00	4.86E+00	4.44E+00	**4.83E+00**	*3.83E-01*	*mg C/g solids*
INORGANIC CARBON	4.32E+00	4.48E+00	4.15E+00	**4.32E+00**	*1.66E-01*	*mg C/g solids*
ORGANIC CARBON	8.34E-01	<5.90E-02	<4.44E-02	**≤3.12E-01**		*mg C/g solids*
CARBONATE	2.16E-02	2.24E-02	2.08E-02	**2.16E-02**	*8.31E-04*	*g CO3/g solid*

Table 14 Anion Constituents for Tank 18F Sample FTF-8-old

	Run 1	Run 2	Run 3			
Analytes	**TK 18_8-old_W_1**	**TK 18_8-old_W_2**	**TK 18_8-old_W_3**	**Average**	**Stdev**	**Units**
FLUORIDE	2.88E-01	2.84E-01	2.58E-01	**2.76E-01**	*1.65E-02*	*mg/g solids*
FORMATE	<3.60E-02	<3.55E-02	<3.68E-02	**<3.61E-02**		*mg/g solids*
CHLORIDE	4.68E-01	4.61E-01	4.41E-01	**4.57E-01**	*1.38E-02*	*mg/g solids*
NITRITE	2.52E-01	2.13E-01	2.21E-01	**2.29E-01**	*2.07E-02*	*mg/g solids*
NITRATE	2.16E-01	1.77E-01	1.84E-01	**1.92E-01**	*2.06E-02*	*mg/g solids*
PHOSPHATE	<1.80E-01	<1.77E-01	<1.84E-01	**<1.80E-01**		*mg/g solids*
SULFATE	1.08E-01	1.06E-01	1.10E-01	**1.08E-01**	*1.97E-03*	*mg/g solids*
OXALATE	3.96E-01	3.90E-01	3.68E-01	**3.85E-01**	*1.48E-02*	*mg/g solids*
BROMIDE	<1.80E-01	<1.77E-01	<1.84E-01	**<1.80E-01**		*mg/g solids*
TOTAL CARBON	1.19E+01	1.18E+01	1.38E+01	**1.25E+01**	*1.14E+00*	*mg C/g solids*
INORGANIC CARBON	1.10E+01	1.14E+01	1.34E+01	**1.19E+01**	*1.26E+00*	*mg C/g solids*
ORGANIC CARBON	9.00E-01	4.97E-01	4.78E-01	**6.25E-01**	*2.38E-01*	*mg C/g solids*
CARBONATE	5.51E-02	5.68E-02	6.68E-02	**5.95E-02**	*6.32E-03*	*g CO3/g solid*

Table 15 Challenging Radiological Constituents for Tank 18F Sample FTF-1: South Hemisphere.

Units in µCi/g

Constituents	Run 1 TK 18-1-1	Run 2 TK 18-1-2	Run 3 TK 18-1-3	Average	stdev	Target detection limit	1 Sigma %Uncertainty
Zr-93	1.74E-03	2.20E-03	No yield	**1.97E-03**	*3.25E-04*	5.0E-5	
Nb-94	<2.57E-04	<1.52E-04	<1.94E-04	**<2.01E-04**		5.0E-5	MDA
I-129	1.02E-05	1.14E-05	1.07E-05	**1.08E-05**	5.86E-07	5.0E-5	6.65
Ra-226	<1.63E-03	<1.09E-03	<2.18E-03	**<1.63E-03**		1.0E-4	MDA
Cl-36	<2.19E-03	Not measured	<7.68E-03	**<4.94E-03**		5.0E-5	Upper limit
K-40	<8.47E-04	1.23E-03	<6.89E-04	**≤9.23E-04**		5.0E-5	*MDA*/17.20
Pd-107	2.96E-03	3.36E-03	1.67E-03	**2.66E-03**	*8.83E-04*	5.0E-5	20

Table 16 Challenging Radiological Constituents for Tank 18F Sample FTF-2: South Hemisphere.

Units in µCi/g

Constituents	Run 1 TK 18-2-1	Run 2 TK 18-2-2	Run 3 TK 18-2-3	Average	stdev	Target detection limit	1 Sigma %Uncertainty
Zr-93	5.59E-04	1.50E-03	5.82E-04	**8.80E-04**	*5.37E-04*	5.0E-5	
Nb-94	<2.77E-05	<1.83E-04	<1.82E-04	**<1.31E-04**		5.0E-5	MDA
I-129	6.31E-06	1.15E-05	1.17E-05	**9.85E-06**	*3.07E-06*	5.0E-5	14.2
Ra-226	<9.61E-04	<5.55E-02	<2.48E-03	**<1.96E-02**		1.0E-4	MDA
Cl-36	<3.20E-03	<3.36E-02	<1.59E-02	**<1.76E-02**		5.0E-5	Upper limit
Cl-36@	< 1.04E-05	Not measured	Not measured			5.0E-5	upper limit
K-40	1.16E-03	<6.71E-04	<7.52E-04	**≤8.60E-04**		5.0E-5	5/*MDA*
Pd-107	5.81E-03	4.59E-03	4.78E-03	**5.06E-03**	*6.56E-04*	5.0E-5	20

@ Method required extra separation steps

Table 17 Challenging Radiological Constituents for Tank 18F Sample FTF-3: North Hemisphere.

Units in µCi/g

Constituents	Run 1 TK 18-3-1	Run 2 TK 18-3-2	Run 3 TK 18-3-3	Average	stdev	Target detection limit	1 Sigma %Uncertainty
Zr-93	3.91E-03	4.99E-03	6.86E-03	**5.25E-03**	*1.49E-03*	5.0E-5	30
Nb-94	<2.09E-04	<2.00E-04	<2.12E-04	**<2.07E-04**		5.0E-5	MDA
I-129	1.09E-05	7.57E-06	<4.77E-06	**≤7.73E-06**		5.0E-5	6.30/*MDA*
Ra-226	<2.00E-03	<1.93E-03	<2.41E-03	**<2.11E-03**		1.0E-4	MDA
Ra-226*	< 4.11E-04	Not measured	Not measured	Not measured		1.0E-4	MDA
K-40	<7.70E-04	<7.66E-04	<6.17E-04	**<7.18E-04**		5.0E-5	MDA
Pd-107	3.25E-03	2.33E-03	1.73E-03	**2.44E-03**	*7.66E-04*	5.0E-5	20

* Enhanced detection limit with longer count.

Table 18 Challenging Radiological Constituents for Tank 18F Sample FTF-4: North Hemisphere.

Units in µCi/g

Constituents	Run 1 TK 18-4-1	Run 2 TK 18-4-2	Run 3 TK 18-4-3	Average	stdev	Target detection limit	1 Sigma %Uncertainty
Zr-93	1.47E-03	9.41E-04	2.39E-03	**1.60E-03**	*7.33E-04*	5.0E-5	30
Nb-94	<1.73E-04	<1.05E-04	<6.49E-05	**<1.15E-04**		5.0E-5	MDA
I-129	1.28E-05	1.37E-05	1.58E-05	**1.41E-05**	1.54E-05	5.0E-5	6.05
Ra-226	<3.08E-03	<3.20E-03	<5.16E-03	**<3.81E-03**		1.0E-4	MDA
K-40	<6.53E-04	<3.58E-04	<4.12E-04	**<4.74E-04**		5.0E-5	MDA
Pd-107	6.80E-03	5.94E-03	7.22E-03	**6.65E-03**	*6.52E-04*	5.0E-5	20

Table 19 Challenging Radiological Constituents for Tank 18F Sample FTF-5: South Hemisphere.

Units in µCi/g

Constituents	Run 1 TK 18-5-1	Run 2 TK 18-5-2	Run 3 TK 18-5-3	Average	stdev	Target detection limit	1 Sigma %Uncertainty
Zr-93	2.04E-03	2.54E-03	1.30E-03	**1.96E-03**	*6.24E-04*	5.0E-5	
Nb-94	<5.95E-05	<1.82E-04	<2.36E-04	**<1.59E-04**		5.0E-5	MDA
I-129	<1.03E-05	1.45E-05	1.24E-05	**≤1.24E-05**		5.0E-5	9.0/*MDA*
Ra-226	<1.86E-03	<2.01E-03	<1.02E-03	**<1.63E-03**		1.0E-4	MDA
Ra-226*	NA	NA	< 4.03E-04	NA		1.0E-4	MDA
Cl-36	<7.33E-04	<1.36E-02	<5.77E-02	**2.40E-02**		5.0E-5	Upper limit
K-40	1.06E-03	<7.39E-04	<9.50E-04	**≤9.17E-04**		5.0E-5	11/*MDA*
Pd-107	6.58E-03	4.21E-03	5.50E-03	**5.43E-03**	*1.18E-03*	5.0E-5	20
Pt-193	<2.09E-04	<2.91E-03	Not measured	**<1.56E-03**		5.0E-5	Upper limit

* Enhanced detection limit with longer count

Table 20 Challenging Radiological Constituents for Tank 18F Sample FTF-8-old: North Hemisphere.

Units in µCi/g

Constituents	Run 1 TK 18-old-1	Run 2 TK 18-old-2	Run 3 TK 18-old-3	Average	stdev	Target detection limit	1 Sigma %Uncertainty
Zr-93	1.98E-03	1.64E-03	2.24E-03	**1.95E-03**	3.01E-04	5.0E-5	30
Nb-94	<1.75E-04	1.23E-04	<1.01E-04	**≤1.33E-04**		5.0E-5	MDA
I-129	<5.72E-06	1.26E-05	1.41E-05	**≤1.08E-05**		5.0E-5	*MDA*/8.30
Ra-226	<1.67E-03	<1.70E-03	<1.73E-03	**<1.70E-03**		1.0E-4	MDA
Ra-226*	< 1.70E-04	Not measured	Not measured	Not measured		1.0E-4	MDA
K-40	6.40E-04	1.62E-03	<3.65E-04	**≤8.76E-04**		5.0E-5	20.64/*MDA*
Pd-107	3.62E-03	4.03E-03	5.48E-03	**4.38E-03**	*9.77E-04*	5.0E-5	20
Pt-193	<2.85E-04	<1.28E-03	Not measured	**<7.83E-04**		5.0E-5	Upper limit

* Enhanced detection limit with longer count

Table 21 Radiological Constituents for Tank 18F Sample FTF-1.

Analytes	Run 1 TK18-1-D-1	Run 2 TK18-1-D-2	Run 3 TK18-1-D-3	Average	Stdev.	1 Sigma %Uncertainty
	µCi/g	µCi/g	µCi/g	µCi/g		
H-3	<1.39E-03	<1.72E-03	<2.23E-03	**<1.78E-03**		MDA
C-14	7.88E-02	6.98E-02	7.93E-02	**7.60E-02**	*5.34E-03*	9.59
Ni-59	2.38E-02	1.07E-02	1.02E-02	**1.49E-02**	*7.70E-03*	18.51
Ni-63	1.09E+00	9.91E-01	1.07E+00	**1.05E+00**	*5.19E-02*	10
Co-60	3.29E-02	2.67E-02	3.09E-02	**3.02E-02**	*3.15E-03*	5
Se-79	<2.55E-05	<2.96E-05	<2.40E-05	**<2.64E-05**		MDA
Sr-90	6.08E+01	6.53E+01	5.68E+01	**6.10E+01**	*4.28E+00*	7.46
Y-90	6.08E+01	6.53E+01	5.68E+01	**6.10E+01**	*4.28E+00*	7.46
Tc-99	2.92E-02	2.47E-02	2.67E-02	**2.69E-02**	*2.23E-03*	5.75
Sb-126	7.48E-04	5.90E-04	5.41E-04	**6.26E-04**	*1.08E-04*	6.03
Sb-126m	7.48E-04	5.90E-04	5.41E-04	**6.26E-04**	*1.08E-04*	6.03
Sn-126	7.48E-04	5.90E-04	5.41E-04	**6.26E-04**	*1.08E-04*	6.03
Cs-135	8.21E-04	9.36E-04	9.58E-04	**9.05E-04**	*7.36E-05*	8.63
Cs-137	2.34E+02	2.30E+02	2.34E+02	**2.32E+02**	*2.34E+00*	5
Ba-137m	2.21E+02	2.17E+02	2.21E+02	**2.20E+02**	*4.22E+00*	5
Sm-151	1.82E+00	1.64E+00	1.67E+00	**1.71E+00**	*9.53E-02*	16.8
Eu-152	8.74E-04	<4.40E-04	8.24E-04	**≤7.13E-04**		10.9/*MDA*
Eu-154	2.48E-02	2.00E-02	2.27E-02	**2.25E-02**	*2.37E-03*	5
Eu-155	<1.15E-02	7.03E-03	6.53E-03	**≤8.35E-03**		*Upper limit*/5
Th-229	1.82E-05	2.50E-05	1.42E-05	1.91E-05	5.44E-06	65.06
Th-230	1.06E-04	1.27E-04	1.86E-04	1.40E-04	4.18E-05	9.43
U-232	Not available	2.88E-05	5.68E-05	**4.28E-05**	*1.98E-05*	78.36
U-233	1.15E-03	1.17E-03	1.20E-03	**1.17E-03**	*2.52E-05*	20
U-234	2.04E-02	2.03E-02	2.05E-02	**2.04E-02**	*1.00E-04*	20
U-235	7.88E-04	8.11E-04	8.13E-04	**8.04E-04**	*1.39E-05*	20
U-236	6.52E-04	6.55E-04	6.65E-04	**6.57E-04**	*6.81E-06*	20
U-238	1.99E-02	2.00E-02	2.02E-02	**2.00E-02**	*1.53E-04*	20
Np-237	8.80E-03	8.94E-03	9.62E-03	**9.12E-03**	*4.39E-04*	20
Pu-238	5.77E+00	5.72E+00	5.68E+00	**5.72E+00**	*4.50E-02*	5.79
Pu-239	1.57E+01	1.70E+01	1.57E+01	**1.61E+01**	*7.51E-01*	20
Pu-240	3.54E+00	3.86E+00	3.45E+00	**3.62E+00**	*2.15E-01*	20
Pu-239/240	1.92E+01	2.09E+01	1.91E+01	**1.98E+01**	*9.89E-01*	5.74
Pu-241	1.29E+01	1.72E+01	1.73E+01	**1.58E+01**	*2.50E+00*	14.87
Pu-242	<2.36E-02	<2.97E-02	<1.59E-03	**<1.83E-02**		DL
Pu-244	<1.10E-04	<1.38E-04	<7.41E-06	**<8.51E-05**		DL
Am-241	8.06E+00	6.62E+00	7.84E+00	**7.51E+00**	*7.75E-01*	5
Am-242m	<2.05E-04	<1.65E-04	<6.53E-04	**<3.41E-04**		MDA
Cm-242	<1.69E-04	<1.36E-04	<5.41E-04	**<2.82E-04**		MDA
Am-243	<2.94E-03	<2.80E-03	<8.47E-03	**<4.74E-03**		MDA
Cm-243	<8.51E-03	<5.68E-03	<1.58E-02	**<1.00E-02**		MDA
Cm-244	1.27E-01	1.12E-01	1.10E-01	**1.17E-01**	*9.56E-03*	15
Cm-245	<8.74E-03	<4.68E-03	<1.30E-02	**<8.80E-03**		MDA
Cm-247	<1.58E-06	<1.49E-06	<5.09E-06	**<2.72E-06**		MDA
Cm-248	<7.03E-05	<6.67E-05	<2.28E-04	**<1.22E-04**		MDA
Cf-249	<1.82E-03	<1.72E-03	<5.90E-03	**<3.15E-03**		MDA
Pa-231	<1.02E-02	7.82E-03	<1.09E-02	≤9.64E-03		*MDA*/20
Pm-147	<1.14E+00	<1.04E+00	<1.31E+00	**<1.16E+00**		Upper limit
Ac-227	<1.92E-05	<1.07E-05	<1.38E-04	**<5.61E-05**		MDA
Al-26	<6.67E-05	<4.90E-05	<5.86E-05	**<5.81E-05**		MDA

Table 22 Radiological Constituents for Tank 18 Sample FTF-2.

Analytes	Run 1 TK18-2-D-1	Run 2 TK18-2-D-2	Run 3 TK18-2-D-3	Average	Stdev.	1 Sigma %Uncertainty
	µCi/g	µCi/g	µCi/g	µCi/g		
H-3	<7.32E-04	<7.84E-04	<7.15E-04	**<7.44E-04**		MDA
C-14	1.67E-02	1.81E-02	1.42E-02	**1.63E-02**	*1.96E-03*	16.67
Ni-59	5.77E-03	<6.04E-03	<4.18E-03	**≤5.33E-03**		18.1/*MDA*
Ni-63	5.00E-01	5.50E-01	5.50E-01	**5.33E-01**	*2.86E-02*	10
Co-60	2.08E-02	1.87E-02	1.39E-02	**1.78E-02**	*3.52E-03*	5
Se-79	<5.41E-05	<3.44E-05	<4.81E-05	**<4.55E-05**		MDA
Sr-90	4.41E+01	3.72E+01	4.55E+01	**4.23E+01**	*4.44E+00*	7.38
Y-90	4.41E+01	3.72E+01	4.55E+01	**4.23E+01**	*4.44E+00*	7.38
Tc-99	2.97E-02	3.42E-02	3.36E-02	**3.25E-02**	*2.44E-03*	5.75
Sb-126	5.14E-04	5.14E-04	4.55E-04	**4.94E-04**	*3.38E-05*	6.25
Sb-126m	5.14E-04	5.14E-04	4.55E-04	**4.94E-04**	*3.38E-05*	6.25
Sn-126	5.14E-04	5.14E-04	4.55E-04	**4.94E-04**	*3.38E-05*	6.25
Cs-135	1.17E-03	1.10E-03	1.14E-03	**1.14E-03**	*3.51E-05*	3.73
Cs-137	3.26E+02	3.14E+02	3.00E+02	**3.13E+02**	*1.31E+01*	5
Ba-137m	3.08E+02	*2.97E+02*	2.84E+02	**2.96E+02**	*1.24E+01*	5
Sm-151	1.30E+00	1.22E+00	2.31E+00	**1.61E+00**	*6.06E-01*	16.83
Eu-152	<4.50E-04	3.72E-04	<4.27E-04	**≤4.17E-04**		8.07/*MDA*
Eu-154	2.09E-02	1.66E-02	1.24E-02	**1.66E-02**	*4.23E-03*	5
Eu-155	9.10E-03	8.69E-03	5.23E-03	**7.67E-03**	*2.13E-03*	5
Th-229	4.68E-05	<9.10E-06	1.65E-04	**≤7.38E-05**		72.24/*MDA*
Th-230	<2.77E-05	7.30E-05	2.54E-04	**≤1.18E-04**		*MDA*/16.57
U-232	1.01E-05	2.46E-05	2.86E-05	**2.11E-05**	*9.73E-06*	53.37
U-233	1.35E-03	1.42E-03	1.34E-03	**1.37E-03**	*4.36E-05*	20
U-234	1.12E-02	1.15E-02	1.13E-02	**1.13E-02**	*1.53E-04*	20
U-235	4.42E-04	4.52E-04	4.33E-04	**4.42E-04**	*9.50E-06*	20
U-236	3.78E-04	3.90E-04	3.81E-04	**3.83E-04**	*6.24E-06*	20
U-238	1.14E-02	1.15E-02	1.11E-02	**1.13E-02**	*2.08E-04*	20
Np-237	5.01E-03	5.44E-03	5.26E-03	**5.24E-03**	*2.16E-04*	20
Pu-238	3.51E+00	3.60E+00	3.60E+00	**3.57E+00**	*5.08E-02*	5.92
Pu-239	8.63E+00	9.11E+00	9.24E+00	**8.99E+00**	*3.21E-01*	20
Pu-240	2.08E+00	2.09E+00	2.09E+00	**2.09E+00**	*5.77E-03*	20
Pu-239/240	1.07E+01	1.12E+01	1.14E+01	**1.11E+01**	*3.32E-01*	5.83
Pu-241	9.19E+00	7.79E+00	1.03E+01	**9.08E+00**	*1.24E+00*	14.90
Pu-242	<2.86E-03	<1.07E-03	<8.19E-04	**<1.58E-03**		DL
Pu-244	<1.33E-05	<4.99E-06	<3.81E-06	**<7.37E-06**		DL
Am-241	4.27E+00	4.06E+00	2.99E+00	**3.77E+00**	*6.91E-01*	5
Am-242m	<8.33E-04	<7.43E-03	<1.27E-04	**<2.80E-03**		MDA
Am-243	3.17E-03	<1.40E-03	<1.60E-03	**≤2.06E-03**		26.1/*MDA*
Cm-242	<6.89E-04	<6.17E-03	<1.05E-04	**<2.32E-03**		MDA
Cm-243	<5.81E-03	<4.01E-03	<1.15E-03	**<3.66E-03**		MDA
Cm-244	1.52E-01	1.23E-01	8.60E-02	**1.20E-01**	*3.32E-02*	15
Cm-245	<5.81E-03	<4.32E-03	<5.90E-04	**<3.58E-03**		MDA
Cm-247	<1.43E-06	<7.16E-07	<2.30E-07	**<7.93E-07**		MDA
Cm-248	<6.40E-05	<3.20E-05	<1.03E-05	**<3.54E-05**		MDA
Cf-249	<1.25E-03	<8.69E-04	<1.16E-04	**<7.44E-04**		MDA
Pa-231	<4.05E-04	1.64E-03	<7.27E-04	**≤9.24E-04**		*MDA*/20
Ra-226	<9.61E-04	<5.55E-02	<2.48E-03	**<1.96E-02**		MDA
Pm-147	<3.12E-01	<3.09E-01	<5.90E-01	**<4.04E-01**		Upper limit
Ac-227	<3.62E-04	<1.38E-04	<5.27E-04	**<3.42E-04**		MDA
Al-26	<4.97E-05	<2.65E-05	<5.02E-05	**<4.21E-05**		MDA

Table 23 Radiological Constituents for Tank 18 Sample FTF-3.

Analytes	Run 1 TK18-3-D-1	Run 2 TK18-3-D-2	Run 3 TK18-3-D-3	Average	Stdev.	1 Sigma %Uncertainty
	µCi/g	µCi/g	µCi/g	µCi/g		
H-3	<3.03E-03	<2.29E-03	<2.03E-03	**<2.45E-03**		MDA
C-14	1.22E-02	1.04E-02	7.66E-03	**1.01E-02**	*2.27E-03*	7.75
Ni-59	<2.31E-02	1.54E-02	1.09E-02	**≤1.64E-02**		MDA/44.15
Ni-63	3.53E-01	6.53E-01	6.49E-01	**5.52E-01**	*1.72E-01*	20
Co-60	1.75E-02	1.68E-02	1.73E-02	**1.72E-02**	*3.20E-04*	5
Se-79	No yield*	No yield	No yield			No yield
Sr-90	3.64E+01	3.07E+01	4.91E+01	**3.87E+01**	*9.42E+00*	7.96
Y-90	3.64E+01	3.07E+01	4.91E+01	**3.87E+01**	*9.42E+00*	7.96
Tc-99	3.03E-02	3.17E-02	3.43E-02	**3.21E-02**	*2.03E-03*	6.32
Sb-126	5.50E-04	4.55E-04	4.86E-04	**4.97E-04**	*4.82E-05*	6.79
Sb-126m	5.50E-04	4.55E-04	4.86E-04	**4.97E-04**	*4.82E-05*	6.79
Sn-126	5.50E-04	4.55E-04	4.86E-04	**4.97E-04**	*4.82E-05*	6.79
Cs-135	1.50E-04	6.75E-04	6.05E-04	**4.77E-04**	*2.85E-04*	2.42
Cs-137	1.89E+02	1.90E+02	2.12E+02	**1.97E+02**	*1.29E+01*	5
Ba-137m	1.79E+02	1.79E+02	2.00E+02	**1.86E+02**	*1.22E+01*	5
Sm-151	1.03E+00	1.20E+00	1.12E+00	**1.12E+00**	*8.56E-02*	17
Eu-152	<4.55E-04	<4.37E-04	<4.34E-04	**<4.42E-04**		MDA
Eu-154	1.95E-02	1.71E-02	1.74E-02	**1.80E-02**	*1.31E-03*	5
Eu-155	<9.77E-03	<7.79E-03	7.48E-03	**≤8.35E-03**		Upper limit/5
Th-229	4.09E-06	4.32E-05	2.25E-05	**2.33E-05**	*1.96E-05*	48.97
Th-230	3.04E-05	<4.77E-06	5.72E-05	**≤3.08E-05**		25.5/*MDA*
U-232	7.23E-06	1.75E-05	4.63E-05	**2.37E-05**	*2.03E-05*	63.7
U-233	6.02E-04	5.91E-04	5.92E-04	**5.95E-04**	*6.08E-06*	20
U-234	4.31E-03	4.28E-03	4.50E-03	**4.36E-03**	*1.19E-04*	20
U-235	1.64E-04	1.65E-04	1.70E-04	**1.66E-04**	*3.21E-06*	20
U-236	1.51E-04	1.49E-04	1.56E-04	**1.52E-04**	*3.61E-06*	20
U-238	4.27E-03	4.27E-03	4.40E-03	**4.31E-03**	*7.51E-05*	20
Np-237	3.34E-03	3.29E-03	3.15E-03	**3.26E-03**	*9.85E-05*	20
Pu-238	2.49E+00	2.86E+00	2.67E+00	**2.67E+00**	*1.89E-01*	5.54
Pu-239	6.04E+00	7.14E+00	6.57E+00	**6.58E+00**	*5.50E-01*	20
Pu-240	1.39E+00	1.67E+00	1.52E+00	**1.53E+00**	*1.40E-01*	20
Pu-239/240	7.43E+00	8.83E+00	8.11E+00	**8.12E+00**	*6.98E-01*	5.44
Pu-241	7.07E+00	8.11E+00	7.61E+00	**7.60E+00**	*5.18E-01*	14.8
Pu-242	2.86E-04	<1.52E-03	3.27E-04	**≤7.11E-04**		20/*DL*
Pu-244	<1.03E-06	<7.06E-06	<1.01E-06	**<3.03E-06**		DL
Am-241	3.12E+00	2.84E+00	3.10E+00	**3.02E+00**	*1.55E-01*	5
Am-242m	7.21E-03	5.41E-05	<1.56E-04	**<2.47E-03**		23.7/*MDA*
Cm-242	<5.99E-03	4.49E-05	<1.29E-04	**<2.05E-03**		MDA/23.7
Am-243	3.70E-01	2.36E-03	2.59E-03	**1.25E-01**	*2.12E-01*	11.55
Cm-243	<1.67E-01	<2.53E-03	<2.44E-03	**<5.72E-02**		MDA
Cm-244	3.85E+01	1.84E-01	1.59E-01	**1.29E+01**	*2.21E+01*	15
Cm-245	<1.32E-02	<2.12E-03	<2.04E-03	**<5.79E-03**		MDA
Cm-247	<3.17E-07	<1.86E-07	<1.80E-07	**<2.27E-07**		MDA
Cm-248	<1.41E-05	<8.29E-06	<8.02E-06	**<1.02E-05**		MDA
Cf-249	<4.18E-04	<3.28E-04	<3.09E-04	**<3.52E-04**		MDA
Pa-231	<8.70E-04	<1.64E-04	<3.28E-04	**<4.54E-04**		MDA
Pm-147	<5.99E-01	<6.85E-01	<6.53E-01	**<6.46E-01**		Upper limit
Ac-227	<1.06E-04	<2.81E-04	<1.68E-04	**<1.85E-04**		MDA
Al-26	<4.73E-05	<5.05E-05	<5.10E-05	**<4.96E-05**		MDA

* No yield implies that the separation/analytical technique produced no measurable or quantitative information.

Table 24 Radiological Constituents for Tank 18 Sample FTF-4.

Analytes	Run 1 TK18-4-D-1	Run 2 TK18-4-D-2	Run 3 TK18-4-D-3	Average	Stdev.	1 Sigma %Uncertainty
	µCi/g	µCi/g	µCi/g	µCi/g		
H-3	<1.20E-03	<1.37E-03	<2.05E-03	**<1.54E-03**		MDA
C-14	9.19E-03	9.46E-03	8.74E-03	**9.13E-03**	*3.64E-04*	18.35
Ni-59	<6.71E-03	7.48E-03	7.30E-03	**≤7.16E-03**		*MDA*/35.47
Ni-63	6.40E-01	6.40E-01	6.22E-01	**6.34E-01**	*1.04E-02*	20
Co-60	2.68E-02	2.47E-02	5.77E-02	**3.64E-02**	*1.84E-02*	5
Se-79	No yield	No yield	No yield			No yield
Sr-90	5.36E+01	5.14E+01	4.91E+01	**5.14E+01**	*2.25E+00*	7.74
Y-90	5.36E+01	5.14E+01	4.91E+01	**5.14E+01**	*2.25E+00*	7.74
Tc-99	4.59E-02	4.55E-02	4.30E-02	**4.48E-02**	*1.60E-03*	6.50
Sb-126	5.27E-04	6.26E-04	6.35E-04	**5.96E-04**	*6.00E-05*	6.03
Sb-126m	5.27E-04	6.26E-04	6.35E-04	**5.96E-04**	*6.00E-05*	6.03
Sn-126	5.27E-04	6.26E-04	6.35E-04	**5.96E-04**	*6.00E-05*	6.03
Cs-135	1.37E-03	1.35E-03	1.68E-03	**1.47E-03**	*1.85E-04*	0.86
Cs-137	4.01E+02	4.06E+02	4.12E+02	**4.06E+02**	*5.41E+00*	5
Ba-137m	3.79E+02	3.85E+02	3.90E+02	**3.85E+02**	*5.12E+00*	5
Sm-151	1.74E+00	2.69E+00	1.82E+00	**2.09E+00**	*5.27E-01*	17.14
Eu-152	<5.14E-04	<4.55E-04	<6.58E-04	**<5.42E-04**		MDA
Eu-154	2.17E-02	2.18E-02	2.23E-02	**2.19E-02**	*3.32E-04*	6.37
Eu-155	9.28E-03	4.59E-03	7.07E-03	**6.98E-03**	*2.34E-03*	5.0
Th-229	4.82E-05	6.62E-06	1.20E-05	**2.23E-05**	*2.26E-05*	35.84
Th-230*	4.95E-05	2.37E-05	2.14E-05	**3.16E-05**	*1.56E-05*	19.41
U-232	2.16E-05	2.91E-05	6.48E-05	**3.85E-05**	*2.31E-05*	23.11
U-233	5.25E-04	5.67E-04	<1.38E-03	**≤8.24E-04**		20/*DL*
U-234	3.67E-03	3.60E-03	3.26E-03	**3.51E-03**	*2.19E-04*	20
U-235	1.39E-04	1.30E-04	1.26E-04	**1.32E-04**	*6.66E-06*	20
U-236	1.28E-04	1.23E-04	1.10E-04	**1.20E-04**	*9.29E-06*	20
U-238	3.54E-03	3.37E-03	3.37E-03	**3.43E-03**	*9.81E-05*	20
Np-237	3.94E-03	3.60E-03	3.76E-03	**3.77E-03**	*1.70E-04*	20
Pu-238	3.32E+00	3.56E+00	3.08E+00	**3.32E+00**	*2.39E-01*	6.14
Pu-239	6.95E+00	7.04E+00	6.25E+00	**6.75E+00**	*4.32E-01*	20
Pu-240	1.66E+00	1.67E+00	1.46E+00	**1.60E+00**	*1.18E-01*	20
Pu-239/240	8.60E+00	8.69E+00	7.70E+00	**8.33E+00**	*5.48E-01*	6.03
Pu-241	8.29E+00	8.38E+00	7.07E+00	**7.91E+00**	*7.30E-01*	14.9
Pu-242	<5.88E-04	<1.06E-03	<1.04E-03	**<8.96E-04**		DL
Pu-244	<2.74E-06	<4.93E-06	<4.83E-06	**<4.17E-06**		DL
Am-241	3.78E+00	4.00E+00	4.12E+00	**3.97E+00**	*1.74E-01*	5
Am-242m	<2.00E-04	<1.02E-04	7.16E-05	**≤1.25E-04**		*MDA*/45.10
Cm-242	<1.66E-04	<8.42E-05	5.90E-05	**≤1.03E-04**		*MDA*/45.10
Am-243	2.73E-03	5.63E-03	3.21E-03	**3.86E-03**	*1.55E-03*	10.72
Cm-243	<3.23E-03	<5.59E-03	<2.51E-03	**<3.78E-03**		MDA
Cm-244	1.74E-01	3.82E-01	1.86E-01	**2.47E-01**	*1.17E-01*	15
Cm-245	<2.70E-03	<1.73E-03	<2.10E-03	**<2.18E-03**		MDA
Cm-247	<2.45E-07	<1.45E-07	<1.77E-07	**<1.89E-07**		MDA
Cm-248	<1.09E-05	<6.49E-06	<7.88E-06	**<8.44E-06**		MDA
Cf-249	<4.18E-04	<2.82E-04	<3.19E-04	**<3.39E-04**		MDA
Pa-231	<1.33E-04	<2.53E-04	<2.31E-04	**<2.06E-04**		MDA
Pm-147	<3.94E-01	<8.56E-01	<4.64E-01	**<5.71E-01**		Upper limit
Ac-227	<2.86E-04	<1.25E-04	<1.52E-04	**<1.88E-04**		MDA
Al-26	<5.96E-05	<3.17E-05	<9.56E-06	**<3.36E-05**		MDA

Table 25 Radiological Constituents for Tank 18F Sample FTF-5.

Analytes	Run 1 TK18-5-D-1	Run 2 TK18-5-D-2	Run 3 TK18-5-D-3	Average	Stdev.	1 Sigma %Uncertainty
	µCi/g	µCi/g	µCi/g	µCi/g		
H-3	<3.01E-03	<3.09E-03	<2.43E-03	**<2.84E-03**		MDA
C-14	7.07E-03	7.75E-03	6.17E-03	**7.00E-03**	*7.91E-04*	23.60
Ni-59	6.40E-03	<6.13E-03	<5.99E-03	**≤6.17E-03**		24.3/*MDA*
Ni-63	4.45E-01	5.27E-01	5.18E-01	**4.97E-01**	*4.52E-02*	10
Co-60	2.55E-02	2.23E-02	2.93E-02	**2.57E-02**	*3.52E-03*	5
Se-79	<1.97E-04	<6.61E-05	<9.16E-05	**<1.18E-04**		MDA
Sr-90	3.41E+01	2.88E+01	3.17E+01	**3.15E+01**	*2.68E+00*	7.53
Y-90	3.41E+01	2.88E+01	3.17E+01	**3.15E+01**	*2.68E+00*	7.53
Tc-99	4.50E-02	4.42E-02	4.50E-02	**4.48E-02**	*4.94E-04*	6.74
Sb-126	6.35E-04	5.18E-04	5.77E-04	**5.77E-04**	*5.86E-05*	6.03
Sb-126m	6.35E-04	5.18E-04	5.77E-04	**5.77E-04**	*5.86E-05*	6.03
Sn-126	6.35E-04	5.18E-04	5.77E-04	**5.77E-04**	*5.86E-05*	6.03
Cs-135	1.43E-03	1.37E-03	1.26E-03	**1.35E-03**	*8.62E-05*	6.09
Cs-137	3.28E+02	3.22E+02	3.23E+02	**3.24E+02**	*3.52E+00*	5
Ba-137m	3.11E+02	3.05E+02	3.05E+02	**3.07E+02**	*3.33E+00*	5
Sm-151	1.20E+00	1.00E+00	7.39E-01	**9.79E-01**	*2.30E-01*	16.60
Eu-152	<5.36E-04	<4.41E-04	<5.27E-04	**<5.02E-04**		MDA
Eu-154	2.34E-02	2.05E-02	2.20E-02	**2.20E-02**	*1.44E-03*	5
Eu-155	<9.68E-03	<8.29E-03	<9.59E-03	**<9.19E-03**		Upper limit
Th-229	<6.22E-06	1.10E-05	<3.54E-06	**≤6.93E-06**		*MDA*/53.50
Th-230	1.92E-05	3.30E-05	3.75E-05	**2.99E-05**	*9.55E-06*	27.3
U-232	3.09E-06	3.49E-06	4.53E-06	**3.70E-06**	*7.43E-07*	171.42
U-233	<4.63E-04	<2.94E-04	2.80E-04	**≤3.46E-04**		*DL*/20
U-234	2.30E-03	2.18E-03	2.18E-03	**2.22E-03**	*6.93E-05*	20
U-235	8.74E-05	8.21E-05	8.20E-05	**8.38E-05**	*3.09E-06*	20
U-236	7.76E-05	7.25E-05	7.22E-05	**7.41E-05**	*3.03E-06*	20
U-238	2.18E-03	2.07E-03	2.09E-03	**2.11E-03**	*5.86E-05*	20
Np-237	4.10E-03	5.08E-03	4.90E-03	**4.69E-03**	*5.22E-04*	20
Pu-238	3.26E+00	3.38E+00	3.51E+00	**3.38E+00**	*1.26E-01*	5.61
Pu-239	7.46E+00	7.72E+00	7.62E+00	**7.60E+00**	*1.31E-01*	20
Pu-240	1.72E+00	1.75E+00	1.77E+00	**1.75E+00**	*2.52E-02*	20
Pu-239/240	9.19E+00	9.46E+00	9.37E+00	**9.34E+00**	*1.38E-01*	5.53
Pu-241	8.56E+00	8.78E+00	8.74E+00	**8.69E+00**	*1.19E-01*	14.80
Pu-242	<1.91E-03	3.74E-04	<8.60E-04	**≤1.05E-03**		*DL*/20
Pu-244	<8.87E-06	<6.82E-07	<4.00E-06	**4.52E-06**		DL
Am-241	4.91E+00	4.32E+00	4.73E+00	**4.65E+00**	*3.02E-01*	5
Am-242m	1.23E-04	1.03E-04	1.45E-04	**1.24E-04**	*2.07E-05*	37.79
Am-243	3.30E-03	3.58E-03	3.40E-03	**3.42E-03**	*1.40E-04*	13.24
Cm-242	1.02E-04	8.51E-05	1.19E-04	**1.02E-04**	*1.71E-05*	37.79
Cm-243	<1.56E-03	<2.76E-03	<1.65E-03	**<1.99E-03**		MDA
Cm-244	2.42E-01	2.27E-01	2.05E-01	**2.25E-01**	*1.91E-02*	15.1
Cm-245	<2.18E-03	<2.30E-03	<2.00E-03	**<2.16E-03**		MDA
Cm-247	<2.18E-07	<2.35E-07	<1.27E-07	**<1.93E-07**		MDA
Cm-248	<9.68E-06	<1.05E-05	<5.68E-06	**<8.60E-06**		MDA
Cf-249	<3.42E-04	<3.60E-04	<3.52E-04	**<3.51E-04**		MDA
Pa-231	<4.09E-04	6.95E-04	1.24E-03	**≤7.81E-04**		*MDA* /20
Pm-147	<1.26E+00	<7.97E-01	<9.41E-01	**<1.00E+00**		Upper limit
Ac-227	<1.05E-04	<1.00E-04	<1.36E-04	**<1.14E-04**		MDA
Al-26	<5.69E-05	<4.40E-05	<6.44E-05	**<5.51E-05**		MDA

Table 26 Radiological Constituents for Tank 18 Sample FTF-8-old.

	Run 1	Run 2	Run 3			1 Sigma %Uncertainty
Analytes	**TK18-8-D-1**	**TK18-8-D-2**	**TK18-8-D-3**	**Average**	**Stdev.**	
	µCi/g	**µCi/g**	**µCi/g**	**µCi/g**		
H-3	<1.69E-03	<2.66E-03	<2.02E-03	**<2.12E-03**		MDA
C-14	7.52E-03	6.67E-03	7.07E-03	**7.09E-03**	*4.28E-04*	11.70
Ni-59	1.11E-02	<8.02E-03	7.07E-03	**≤8.74E-03**		19.85/*MDA*
Ni-63	5.81E-01	5.63E-01	6.17E-01	**5.87E-01**	*2.75E-02*	10
Co-60	2.56E-02	2.17E-02	2.56E-02	**2.43E-02**	*2.25E-03*	5
Se-79	<8.37E-05	<6.82E-05	<4.33E-05	**<6.51E-05**		MDA
Sr-90	7.48E+01	5.41E+01	5.18E+01	**6.02E+01**	*1.27E+01*	8.11
Y-90	7.48E+01	5.41E+01	5.18E+01	**6.02E+01**	*1.27E+01*	8.11
Tc-99	3.63E-02	3.99E-02	3.25E-02	**3.62E-02**	*3.72E-03*	6.19
Sb-126	6.94E-04	5.81E-04	5.95E-04	**6.23E-04**	*6.15E-05*	6.64
Sb-126m	6.94E-04	5.81E-04	5.95E-04	**6.23E-04**	*6.15E-05*	6.64
Sn-126	6.94E-04	5.81E-04	5.95E-04	**6.23E-04**	*6.15E-05*	6.64
Cs-135	1.37E-03	1.31E-03	1.45E-03	**1.38E-03**	*7.02E-05*	4.34
Cs-137	3.04E+02	3.25E+02	3.34E+02	**3.21E+02**	*1.54E+01*	5
Ba-137m	2.88E+02	3.07E+02	3.16E+02	**3.04E+02**	*1.46E+01*	5
Sm-151	1.88E+00	1.83E+00	1.41E+00	**1.71E+00**	*2.57E-01*	16.83
Eu-152	<4.01E-04	<5.45E-04	<4.08E-04	**<4.51E-04**		MDA
Eu-154	2.53E-02	2.05E-02	2.26E-02	**2.28E-02**	*2.39E-03*	5.0
Eu-155	<1.16E-02	<8.38E-03	<1.08E-02	**<1.02E-02**		Upper limit
Th-229	<1.90E-06	6.80E-06	7.12E-06	**≤5.27E-06**		*MDA*/134.77
Th-230	4.55E-05	5.90E-05	6.04E-05	**5.50E-05**	*8.22E-06*	19.61
U-232	2.38E-06	1.47E-06	4.31E-06	**2.72E-06**	*1.45E-06*	58.59
U-233	9.54E-04	9.91E-04	9.62E-04	**9.69E-04**	*1.95E-05*	20
U-234	5.94E-03	6.01E-03	5.91E-03	**5.95E-03**	*5.13E-05*	20
U-235	2.33E-04	2.36E-04	2.33E-04	**2.34E-04**	*1.73E-06*	20
U-236	2.01E-04	2.04E-04	2.02E-04	**2.02E-04**	*1.53E-06*	20
U-238	6.10E-03	6.17E-03	5.97E-03	**6.08E-03**	*1.01E-04*	20
Np-237	3.50E-03	8.14E-04	3.64E-03	**2.65E-03**	*1.59E-03*	20
Pu-238	3.85E+00	3.68E+00	4.01E+00	**3.85E+00**	*1.69E-01*	5.60
Pu-239	7.83E+00	7.59E+00	8.35E+00	**7.92E+00**	*3.89E-01*	20
Pu-240	1.83E+00	1.78E+00	1.80E+00	**1.80E+00**	*2.52E-02*	20
Pu-239/240	9.64E+00	9.37E+00	1.01E+01	**9.71E+00**	*3.88E-01*	5.54
Pu-241	8.11E+00	8.20E+00	9.46E+00	**8.59E+00**	*7.56E-01*	14.8
Pu-242	<5.98E-04	<6.33E-04	4.29E-04	**≤5.53E-04**		*DL*/20
Pu-244	<2.78E-06	<2.94E-06	<1.74E-07	**1.96E-06**		DL
Am-241	4.39E+00	3.81E+00	4.09E+00	**4.10E+00**	*2.93E-01*	5
Am-242m	1.15E-04	9.37E-05	9.82E-05	**1.02E-04**	*1.14E-05*	MDA
Cm-242	9.50E-05	7.75E-05	8.11E-05	**8.45E-05**	*9.28E-06*	42.24
Am-243	3.20E-03	3.36E-03	3.19E-03	**3.25E-03**	*9.37E-05*	10.41
Cm-243	<2.12E-03	<2.92E-03	<2.83E-03	**<2.62E-03**		MDA
Cm-244	2.32E-01	1.98E-01	2.44E-01	**2.24E-01**	*2.39E-02*	15.1
Cm-245	<1.24E-03	<2.45E-03	<2.14E-03	**<1.94E-03**		MDA
Cm-247	<1.07E-07	<5.14E-07	<4.15E-07	**<3.45E-07**		MDA
Cm-248	<4.77E-06	<2.29E-05	<1.85E-05	**<1.54E-05**		MDA
Cf-249	<1.90E-04	<3.93E-04	<3.32E-04	**<3.05E-04**		MDA
Pa-231	2.87E-04	<6.33E-05	1.39E-04	**≤1.63E-04**		20/*MDA*
Pm-147	<2.28E+00	<1.36E+00	1.51E+00	**<1.72E+00**		Upper limit
Ac-227	<1.05E-04	<7.88E-05	<9.19E-05	**9.17E-05**		MDA
Al-26	<3.86E-05	<6.42E-05	<4.76E-05	**<5.01E-05**		MDA

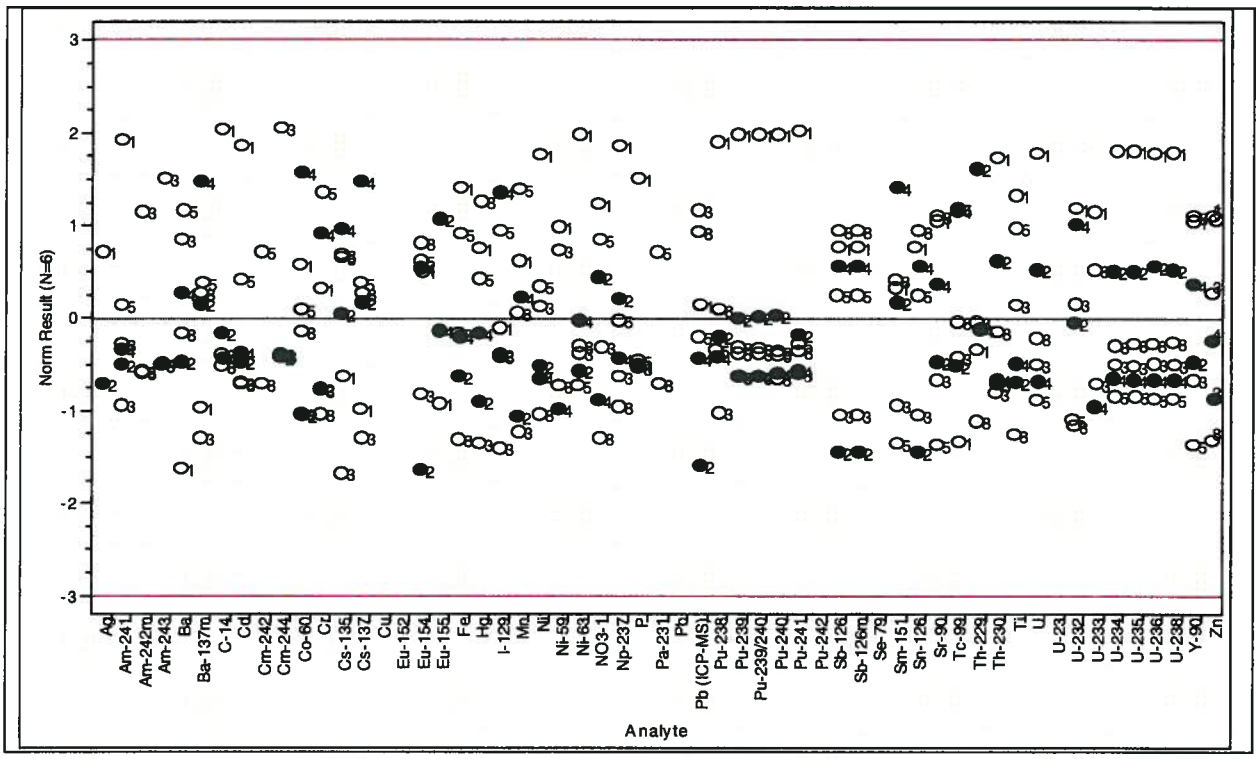

Figure 3 Standardized data versus 3-sigma limits plots for select radionuclides. Open circles are Tank 18F outer zone analytical results while filled circles represent inner Tank 18F analytical results. All six Tank 18F samples are labeled by corresponding samples numbers in Figure 3.

4.0 CONCLUSIONS.

Tank 18F samples were analyzed for radiological, elemental and chemical constituents. It was realized that the attainment of the customer requested limits of 5.0E-5 µCi/g for certain select radionuclides (I-129, Ra-226, Ac-227 and Pa-231) was going to be challenging. Another set of radionuclides (Cl-36, K-40, Pd-107, Pt-193 and Al-26, Zr-93, Nb-94), also with customer requested detection limit of 5.0E-05 µCi/g, required specific method development needs to enable their characterizations. An attempt to attain the customer requested detection limits for these select radionuclides required new or modified analytical methods. Special emphasis was placed on achieving target detection limits for these select radionuclides for at least one sample location and only one replicate per sample was required for these analytes. In these select cases, if all the sample analysis results were below detection limits, then only the lowest detection level obtained by modifying the standard analytical methods was required and thus reported.

In general, there seems to be no measurable cross contamination issues either from the environment of the shielded cell staging and operation areas or the reagents used in sample preparations. A few of the blanks results for Pu-238, and Pu-239 (ARG standards) were within the instrument detection limits although all sample analytical results for Pu-238, and Pu-239 were orders of magnitude higher than blank results for Pu-238, and Pu-239. Some ICP-ES blank analytical results for both Al and Ca were also found to be within the instrument detection limits, with the corresponding samples analyses for these analytes well over these blank detection values.

While many of the target detection limits were met for analytes characterized for in the Tank 18F sector samples, some were not met. In most cases, the relatively high levels of radioactive species of the same element or a chemically similar element precluded the ability to measure some isotopes to very low levels as requested by the customer. SRNL, in conjunction with the customer reviewed all these analytical limit cases and determined that the impacts were negligible and that the data was adequate for use in determining the Tank 18F residual inventory [6].

5.0 REFERENCES

1. Thomas Huff and G.D. Thaxton, "Tanks 18 and 19 Waste Determination Sample Plan" LWO-LWE-2008-00186, Revision 4.
2. Technical Task Request number HLE-TTR-2009-120, Rev.1.
3. S. Harris, "Statistical Analysis of Tank 18F Floor Sample Results" SRNL-STI 2010-00401, July 06, 2010.
4. L. N. Oji, D. Diprete, D.R. Click," Characterization of the Tank 18F Samples" SRNL-STI-2009-00625, Rev.0, December 17, 2009
5. L. N. Oji "Sub-set Analyses Result for Additional Tank 18F Sector Samples: Statistical Review Data", SRNL-L3100-2010-00146, Rev.0.
6. W. B. Dean "Detection Limits not met with Tanks 18 and 19 residual sample analysis", SRR-CWDA-2010-00119, August 17, 2010.

Appendix A

HOMOGENEITY DATA and SELECT SAMPLE BLANKS

Table A-1. Data from homogeneity evaluations using Tank 18F samples

Units in mg/g

	TK 18 1-D-1	TK 18 1-D-2	TK 18 1-D-3	Average	% RSD
Al	111.000	110.000	109.000	110.000	0.909
Ba	0.138	0.134	0.139	0.137	1.931
Cr	0.558	0.514	0.512	0.528	4.924
Fe	97.3	95.9	99.7	97.633	1.968
Mg	37.8	37.5	37.4	37.567	0.554
Mn	10.5	10.3	10.4	10.400	0.962
Si	21.000	20.900	22.900	21.600	5.217
	TK 18 2-D-1	**TK 18 2-D-2**	**TK 18 2-D-3**		
Al	138.000	138.000	140.000	138.667	0.833
Ba	0.192	0.177	0.187	0.185	4.121
Cr	0.473	0.524	0.478	0.492	5.718
Fe	71.6	68.4	68.9	69.633	2.472
Mg	17.7	18.2	17.5	17.800	2.026
Mn	8.16	8.49	8.29	8.313	2.000
Si	29.700	29.500	29.300	29.500	0.678
	TK 18 3-D-1	**TK 18 3-D-2**	**TK 18 3-D-3**		
Al	168.000	167.000	164.000	166.333	1.252
Ba	0.236	0.228	0.242	0.235	2.985
Cr	0.474	0.486	0.463	0.474	2.425
Fe	71.4	75.1	72.2	72.900	2.670
Mg	21.1	20.9	20.7	20.900	0.957
Mn	7.94	7.85	7.77	7.853	1.083
Si	22.100	22.100	22.300	22.167	0.521
	TK 18 4-D-1	**TK 18 4-D-2**	**TK 18 4-D-3**		
Al	172.000	170.000	168.000	170.000	1.176
Ba	0.225	0.214	0.208	0.216	3.998
Cr	0.538	0.545	0.498	0.527	4.812
Fe	76.8	74.3	72.3	74.467	3.028
Mg	15.2	14.8	14.7	14.900	1.776
Mn	10.1	9.54	9.33	9.657	4.122
Si	37.100	35.500	39.800	37.467	5.801
	TK 18 5-D-1	**TK 18 5-D-2**	**TK 18-5-D-3**		
Al	166.000	162.000	164.000	164.000	1.220
Ba	0.258	0.254	0.25	0.254	1.575
Cr	0.539	0.529	0.538	0.535	1.029
Fe	87.3	89.4	89.4	88.700	1.367
Mg	21.9	22	21.8	21.900	0.457
Mn	11	10.7	10.9	10.867	1.406
Si	35.500	34.600	34.600	34.900	1.489
	TK 18 8-old-1	**TK 18 8-old-2**	**TK 18 8-old-3**		
Al	138.000	138.000	141.000	139.000	1.246
Ba	0.244	0.253	0.258	0.252	2.819
Cr	0.62	0.622	0.611	0.618	0.949
Fe	85.4	82.8	85.9	84.700	1.965
Mg	18.5	18.3	18.5	18.433	0.626
Mn	12.3	11.9	12.1	12.100	1.653
Si	36.500	36.300	37.300	36.700	1.442

ARG standards were exposed to shielded cell environment for the duration of sample preparation or digestion and also prepared in the same manner as the samples while cell blanks are reagent solutions which had also undergone the same sample preparations for characterizations

Table A-2

Blank Type	Constituents	Concentration	1 SIGMA % Uncentainty	Units
CELL BLANK_D_1	Cs-137	< 2.68E-02	MDA	uCi/g
CELL BLANK_D_2	Cs-137	< 3.06E-02	MDA	uCi/g
CELL BLANK_D_3	Cs-137	< 3.06E-02	MDA	uCi/g
ARG STD_D_1	Cs-137	< 7.79E-02	MDA	uCi/g
ARG STD_D_2	Cs-137	< 9.19E-02	MDA	uCi/g
ARG STD_D_3	Cs-137	< 1.18E-01	MDA	uCi/g
CELL BLANK_D_1	Am-241	< 1.07E-01	MDA	uCi/g
CELL BLANK_D_2	Am-241	< 9.37E-02	MDA	uCi/g
CELL BLANK_D_3	Am-241	< 8.47E-02	MDA	uCi/g
ARG STD_D_1	Am-241	< 2.88E-01	MDA	uCi/g
ARG STD_D_2	Am-241	< 2.32E-01	MDA	uCi/g
ARG STD_D_3	Am-241	< 2.90E-01	MDA	uCi/g
CELL BLANK_D_3	Sr-90	<3.55E-02	MDA	uCi/g
CELL BLANK_D_1	Sr-90	<1.11E-01	MDA	uCi/g
CELL BLANK_D_2	Sr-90	<4.49E-02	MDA	uCi/g
ARG STD_D_3	Sr-90	<1.04E-01	MDA	uCi/g
ARG STD_D_1	Sr-90	<2.97E-01	MDA	uCi/g
ARG STD_D_2	Sr-90	<1.08E-01	MDA	uCi/g
CELL BLANK_D_1	Pu-241	<7.16E-03	MDA	uCi/g
CELL BLANK_D_2	Pu-241	<1.49E-03	MDA	uCi/g
CELL BLANK_D_3	Pu-241	<1.66E-03	MDA	uCi/g
ARG STD_D_1	Pu-241	<1.46E-02	MDA	uCi/g
ARG STD_D_2	Pu-241	<3.95E-03	MDA	uCi/g
ARG STD_D_3	Pu-241	<4.59E-03	MDA	uCi/g
CELL BLANK_D_1	Pu-238	<6.67E-03	MDA	uCi/g
CELL BLANK_D_2	Pu-238	<5.23E-03	MDA	uCi/g
CELL BLANK_D_3	Pu-238	<1.34E-02	MDA	uCi/g
CELL BLANK_D_1	Pu-239/240	<3.19E-02	MDA	uCi/g
CELL BLANK_D_2	Pu-239/240	<6.49E-03	MDA	uCi/g
CELL BLANK_D_3	Pu-239/240	<1.12E-02	MDA	uCi/g
ARG STD_D_1	Pu-238	<2.85E-02	MDA	uCi/g
ARG STD_D_2	Pu-238	<1.64E-02	MDA	uCi/g
ARG STD_D_3	Pu-238	1.72E-02	102.30	uCi/g
ARG STD_D_1	Pu-239/240	<3.19E-02	MDA	uCi/g
ARG STD_D_2	Pu-239/240	<2.57E-02	MDA	uCi/g
ARG STD_D_3	Pu-239/240	<2.02E-02	MDA	uCi/g

Table A-3

Blank Type	Constituents	Concentration	1 SIGMA % Uncertainty	Units
CELL BLANK_D_1	Ni-63	<1.92E-03	MDA	uCi/g
CELL BLANK_D_2	Ni-63	<1.29E-03	MDA	uCi/g
CELL BLANK_D_3	Ni-63	<1.96E-03	MDA	uCi/g
ARG STD_D_2	Ni-63	<8.74E-03	MDA	uCi/g
ARG STD_D_3	Ni-63	<5.81E-03	MDA	uCi/g
ARG STD_D_1	Ni-63	<7.30E-03	MDA	uCi/g
CELL BLANK_D_1	Ni-59	<3.21E-05	MDA	uCi/g
CELL BLANK_D_2	Ni-59	<6.85E-03	MDA	uCi/g
			MDA	uCi/g
ARG STD_D_1	Ni-59	<4.15E-02	MDA	uCi/g
ARG STD_D_2	Ni-59	<5.77E-02	MDA	uCi/g
ARG STD_D_3	Ni-59	<2.99E-02	MDA	uCi/g
CELL BLANK_D_3	Cs-135	<5.13E-07	MDA	uCi/g
ARG STD_D_3	Cs-135	<1.33E-07	MDA	uCi/g
CELL BLANK_D_2	Pu-239	<5.18E-03	DL	
CELL BLANK_D_2	Pu-240	<1.89E-02	DL	uCi/g
CELL BLANK_D_2	Pu-242	3.29E-04	DL	uCi/g
CELL BLANK_D_2	Pu-244	<1.53E-06	DL	uCi/g
ARG STD_D_2	Pu-239	<2.06E-02	DL	uCi/g
ARG STD_D_2	Pu-240	<7.53E-02	DL	uCi/g
ARG STD_D_2	Pu-242	<1.31E-03	DL	uCi/g
ARG STD_D_2	Pu-244	<6.07E-06	DL	uCi/g
				uCi/g
ARG STD_D_3	Pu-239	1.55E-02	20	uCi/g
ARG STD_D_3	Pu-240	<4.65E-03	DL	uCi/g
ARG STD_D_3	Pu-242	<8.07E-05	DL	uCi/g
ARG STD_D_3	Pu-244	<3.75E-07	DL	uCi/g
CELL BLANK_D_3	Pu-239	<8.94E-03	DL	uCi/g
CELL BLANK_D_3	Pu-240	<3.27E-02	DL	uCi/g
CELL BLANK_D_3	Pu-242	<5.68E-04	DL	uCi/g
ARG STD_D_1	Pu-239	<1.27E-02	DL	uCi/g
ARG STD_D_1	Pu-240	<4.66E-02	DL	uCi/g
ARG STD_D_1	Pu-242	<8.08E-04	DL	uCi/g
ARG STD_D_3	Np-237	<1.82E-05	DL	uCi/g
CELL BLANK_D_3	Np-237	<4.85E-06	DL	uCi/g

Table A-4

Blank Type	Constituents	Concentration	1 SIGMA % Uncentainty	Units
CELL BLANK_D_1	U-233	<1.56E-03	DL	uCi/g
CELL BLANK_D_1	U-234	<1.00E-03	DL	uCi/g
CELL BLANK_D_1	U-235	<3.49E-07	DL	uCi/g
CELL BLANK_D_1	U-236	<1.04E-05	DL	
ARG STD_D_1	U-233	<1.43E-03	DL	uCi/g
ARG STD_D_1	U-234	<9.22E-04	DL	uCi/g
ARG STD_D_1	U-235	<3.21E-07	DL	
ARG STD_D_1	U-236	<9.60E-06	DL	uCi/g
ARG STD_D_1	U-238	<3.91E-06	DL	uCi/g

Table A-5

Blank Type	Constituents	Concentration	1 SIGMA % Uncentainty	Units
CELL BLANK_D_2	Ag	<2.40E-02	DL	Wt%
CELL BLANK_D_2	Al	8.88E-02	10	Wt%
CELL BLANK_D_2	B	<3.00E-02	DL	Wt%
CELL BLANK_D_2	Ba	<4.72E-03	DL	Wt%
CELL BLANK_D_2	Be	<5.60E-04	DL	Wt%
CELL BLANK_D_2	Ca	1.34E-01	10	Wt%
CELL BLANK_D_2	Cd	<1.02E-02	DL	Wt%
CELL BLANK_D_2	Ce	<5.28E-02	DL	Wt%
CELL BLANK_D_2	Cr	<8.40E-03	DL	Wt%
CELL BLANK_D_2	Cu	<1.14E-02	DL	Wt%
CELL BLANK_D_2	Fe	<2.00E-02	DL	Wt%
CELL BLANK_D_2	Gd	<1.09E-02	DL	Wt%
CELL BLANK_D_2	K	<2.79E-01	DL	Wt%
CELL BLANK_D_2	La	<8.64E-03	DL	Wt%
CELL BLANK_D_2	Li	<1.38E-02	DL	Wt%
CELL BLANK_D_2	Mg	<2.00E-03	DL	Wt%
CELL BLANK_D_2	Mn	<8.80E-03	DL	Wt%
CELL BLANK_D_2	Mo	<3.42E-02	DL	Wt%
CELL BLANK_D_2	Ni	<7.44E-02	DL	Wt%
CELL BLANK_D_2	P	<6.79E-02	DL	Wt%
CELL BLANK_D_2	Pb	<5.85E-02	DL	Wt%
CELL BLANK_D_2	S	<1.08E+00	DL	Wt%
CELL BLANK_D_2	Sb	<5.50E-02	DL	Wt%
CELL BLANK_D_2	Si	<1.85E-02	DL	Wt%
CELL BLANK_D_2	Sn	<3.43E-02	DL	Wt%
CELL BLANK_D_2	Sr	<5.60E-04	DL	Wt%
CELL BLANK_D_2	Ti	<8.80E-03	DL	Wt%
CELL BLANK_D_2	U	<3.56E-01	DL	Wt%
CELL BLANK_D_2	V	<4.16E-03	DL	Wt%
CELL BLANK_D_2	Zn	<1.21E-02	DL	Wt%
CELL BLANK_AR_2	Hg	<2.00E-04	DL	Wt%
ARG STD_AR_1	Hg	<4.69E-04	DL	Wt%
ARG STD_AR_2	Hg	<5.51E-04	DL	Wt%
CELL BLANK_AR_3	Hg	<2.00E-04	DL	Wt%

Table A-6 Tank 18F Leachate blanks

Blank Type	Constituents	Concentration	1 SIGMA % Uncentainty	Units
CELL BLANK_W_2	FLUORIDE	<5.00E-02	DL	mg
CELL BLANK_W_2	FORMATE	<5.00E-02	DL	mg
CELL BLANK_W_2	CHLORIDE	<5.00E-02	DL	mg
CELL BLANK_W_2	NITRITE	<5.00E-02	DL	mg
CELL BLANK_W_2	NITRATE	<2.50E-01	DL	mg
CELL BLANK_W_2	PHOSPHATE	<2.50E-01	DL	mg
CELL BLANK_W_2	SULFATE	<5.00E-02	DL	mg
CELL BLANK_W_2	OXALATE	<5.00E-02	DL	mg
CELL BLANK_W_2	BROMIDE	<2.50E-01	DL	mg
			DL	
ARG STD_W_2	FLUORIDE	<5.00E-02	DL	mg
ARG STD_W_2	FORMATE	<5.00E-02	DL	mg
ARG STD_W_2	CHLORIDE	<5.00E-02	DL	mg
ARG STD_W_2	NITRITE	<5.00E-02	DL	mg
ARG STD_W_2	NITRATE	<2.50E-01	DL	mg
ARG STD_W_2	PHOSPHATE	<2.50E-01	DL	mg
ARG STD_W_2	SULFATE	<5.00E-02	DL	mg
ARG STD_W_2	OXALATE	<5.00E-02	DL	mg
ARG STD_W_2	BROMIDE	<2.50E-01	DL	mg
CELL BLANK_W_2	TOTAL CARBON	< 6.25E-02	DL	mg
CELL BLANK_W_2	INORGANIC CARBON	< 6.25E-02	DL	mg
CELL BLANK_W_2	ORGANIC CARBON	< 6.25E-02	DL	mg
			DL	
ARG STD_W_2	TOTAL CARBON	< 6.25E-02	DL	mg
ARG STD_W_2	INORGANIC CARBON	< 6.25E-02	DL	mg
ARG STD_W_2	ORGANIC CARBON	< 6.25E-02	DL	mg
*CELL BLANK_W_1	FLUORIDE	1.99E-01		mg
CELL BLANK_W_1	FORMATE	<3.82E-02	DL	mg
CELL BLANK_W_1	CHLORIDE	5.56E-01		mg
CELL BLANK_W_1	NITRITE	2.88E-01		mg
CELL BLANK_W_1	NITRATE	≤1.91E-01		mg
CELL BLANK_W_1	PHOSPHATE	<1.91E-01	DL	mg
CELL BLANK_W_1	SULFATE	≤1.80E-01		mg
CELL BLANK_W_1	OXALATE	5.79E-01		mg
CELL BLANK_W_1	BROMIDE	<1.91E-01	DL	mg

*Leachate samples with LIMS numbers 300268162, 300268146 and 300268153 were logged in as cell blanks but are actually Tank 18F sample leachates, respectively, FTF-18-new-w-1, FTF-18-new-W-3 and FTF-18-new-w-2. Other than weight percent solids and bulk density information, there are no data presented in this report for sample FTF-18-new because it had lower than expected weight percent solids.

APPENDIX B: SUMMARY OF ANALYTICAL METHODS

Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-ES)
Samples are diluted as necessary to bring analytes within the instrument range. A scandium internal standard is added to all samples after dilution at a concentration of 2 mg/L. The instrument is calibrated daily with a blank and two standards: 5 and 10 mg/L NIST traceable multi-element standards in dilute acid. Background and internal standard correction were applied to the results.

Ion Chromatography for Anions (IC-Anions)
For IC Anions, samples were diluted with a carbonate/bicarbonate diluent as necessary to bring analytes to within instrument calibration. A 3-point calibration curve is run daily on the instrument with concentrations of 10, 25 and 50 μg/mL.

Atomic Absorption Spectroscopy (AA)
Arsenic, selenium, potassium (ICP-ES or AA), and mercury are analyzed by AA. The mercury was determined using the cold vapor technique. Samples were diluted as necessary to bring analytes within the instrument calibration range. An instrument calibration is performed daily with a blank and two or three point standard. The standard is run for each element at the beginning of the day, after each five sample runs and at the end of the day.

Inductively Coupled Plasma – Mass Spectroscopy (ICP-MS)
Samples were run concurrently with a laboratory control standard (LCS) containing V, Co, As, Sr, Mo, Ru, Ag, Cd, Sb, Cs, Ba, La, Eu, Ho, Yb, Tl, Pb, Th, and U. This LCS provided a mass response covering most of the mass range of interest. The following describes the calculation of the analytes of interest from the mass values:

Co mass 59
^{99}Tc mass 99. Subject to interference when Ru is present in the sample.
Ag mass 107, 109
Pb mass 206, 207,208
Sn mass 117, 118,120, 122, 124
^{233}U mass 233
^{234}U mass 234
^{235}U mass 235
^{236}U mass 236
^{238}U mass 238
^{237}Np mass 237
^{239}Pu mass 239
^{240}Pu mass 240
^{242}Pu mass 242. Assumes no ^{242}Cm present in sample.

Other Specialty Separations and Preparations.

Ni-59/63
Aliquots of peroxide fusion dissolution were spiked with an elemental nickel carrier. The nickel species were extracted from the matrix using a dimethylglyoxime (DMG) based extractant. Ni-59 concentrations were measured using thin-windowed, semi-planar high purity germanium spectrometers to quantify low energy photon/x-ray emissions from Ni-59. Ni-63 concentrations were measured by liquid scintillation analysis. Elemental nickel carrier yields were measured for each separated aliquot by ICP-ES, and were used to correct the radioactive nickel species' results for any nickel losses incurred during the radiochemical separations.

Se-79
Aliquots of solids material were weighed, spiked with an elemental selenium carrier and digested in concentrated acid. The selenium species were extracted from the matrix using a combination of resin decontamination, selenium metal precipitation, and TBP-based liquid-liquid extractions. The purified selenium products were analyzed by liquid scintillation to measure Se-79, and by neutron activation analysis to measure elemental selenium carrier yields for each aliquot. The selenium carrier yield for each aliquot was used to correct the Se-79 value for any selenium losses from the radiochemical separations.

Cs-137/Cs-134
The solid material was too concentrated in radioactive cesium to be measured directly. Aliquots of peroxide fusion dissolution were analyzed by coaxial high purity germanium gamma-ray spectrophotometers to measure Cs-137 and Cs-134.

Sr-90
The solid material was too concentrated in Sr-90 to be analyzed directly. Aliquots of peroxide fusion dissolutions were spiked with elemental strontium carrier. The strontium species were extracted from the matrix using a crown-ether-based solid phase extractant. Sr-90 concentrations were measured by liquid scintillation analysis. Elemental strontium carrier yields were measured for each aliquot by neutron activation analysis, and were used to correct the Sr-90 value for any strontium losses incurred during the radiochemical separations.

Tc-99
Tc-99m tracer was generated in the SRNL Cf-252 neutron activation analysis facility by activating Mo-99 to Tc-99m via neutron irradiation. The Tc-99m was extracted from the Mo-99 target material with methyl isobutyl ketone (MIBK). Aliquots of solids material were weighed and digested in concentrated acid after the addition of Tc-99m tracer. The technetium species were extracted from the matrix using an Aliquat-336 based solid phase extractant. Tc-99 concentrations were measured by liquid scintillation analysis. Tc-99m yields were measured for each aliquot with a NaI well gamma spectrometer, and were used to correct the Tc-99 values for any technetium losses incurred during the radiochemical separations.

Pm-147/Sm-151

The solid material was too concentrated in Sm-151 to be analyzed directly. Aliquots of peroxide fusion dissolution were spiked with an elemental samarium carrier. The promethium and samarium species were extracted from the matrix using a combination of resins Octylphenyl-N,N-di-isobutyl carbamoylphosphine oxide/tri-n-butyl phosphate (one CMPO/TBP) and di(2-ethylhexyl) orthophosphoric acid (one HDEHP based). Sm-151 and Pm-147 concentrations were measured by liquid scintillation analysis. The matrix was high in Sm-151, but the short-lived Pm-147 component of the material had decayed below noise levels of the analysis. Elemental samarium carrier yields were measured by neutron activation analysis, and were used to correct the analyses for any samarium losses from the radiochemical separations. The separation was designed to extract both Sm and Pm together; a Pm spike was analyzed with the samples for confirmation.

Pu-238, 239/240, 241

The solid material was too concentrated in plutonium to be analyzed directly. Aliquots of peroxide fusion dissolutions were spiked with Pu-236 tracer. The plutonium was extracted from the matrix using thenoyltrifluoroacetone (TTA) following a series of oxidation-state adjustments. The TTA extracts were mounted on stainless steel counting plates and counted for Pu-238, Pu-239, and Pu-240 using passivated, implanted, planar silicon (PIPS) alpha spectrometers. Each separation was traced based on the Pu-236 recovery. Aliquots of sample were also subjected to Cs-removal with Bio-Rad AMP resin and extracted using TEVA columns (TEVA Brand name for one of Eichrom's resins). The Pu-containing extracts were measured by liquid scintillation analysis to determine Pu-241 concentration.

Am-241, 242m, 243, Cm-242, 243, 244, 245, 247, 248, Cf-249, 251, 252

Aliquots of solids material were weighed, and digested in concentrated acid. The americium, curium and californium species were extracted from the matrix using a CMPO/TBP based solid phase extractant and purified further with an HDEHP based solid phase extractant. Am-241, 243, Cm-243, 245, 247, Cf-249 and 251 concentrations were measured using low energy photon/x-ray, thin-windowed, semi-planar high purity germanium spectrometers. Cm-242, 244, 248, Cf-252 concentrations were measured using passivated, implanted, planar silicon (PIPS) alpha spectrometers. Am-241 quantities had been measured from the cesium removed gamma analyses, all results were traced with the Am-241 present in the sample matrix. The tracer yields were used to correct the various results for any losses from the radiochemical separations.

Ra-226

Aliquots of solids material were weighed and digested in concentrated acid. The Ra-226 was extracted from the matrix using a combination of resin decontamination and ion exchange. A blank spiked sample of Ra-226 was subjected to the extraction to serve as a separation yield monitor. The purified Ra-226 was sealed in polypropylene tubes and stored for several daughter Rn-222 half-lives. The Ra-226 progeny daughter isotope Pb-212 was then analyzed using a high purity germanium well gamma ray spectrophotometer and results were corrected for the blank spike Ra-226 recoveries.

Pa-231

Aliquots of solids material were weighed, spiked with a Pa-233 tracer and digested in concentrated acid. The digestates were decontaminated with ammonium phospho-molybdate and quaternary amine based resins. Protactinium species were then extracted from the matrix using a CMPO/TBP based extractant. Pa-231 and Pa-233 concentrations were measured using low energy photon/x-ray, thin-windowed, semi-planar high purity germanium spectrometers. The Pa-233 tracer yields were decay corrected and then used to correct the Pa-231 analyses for any losses from the radiochemical separations. The abundance of Pa-233 in the aliquots facilitated a simpler method for some of the samples. The Pa-231:Pa-233 value was determined for unspiked sample aliquots subjected to the same separation and counting described in the previous paragraph. This ratio was then multiplied by the Np-237 (and Pa-233) result from the Np-237 analysis to obtain a Pa-231 value.

Gross Alpha/Gross Beta

The solid material was too concentrated to be analyzed directly. Aliquots of peroxide fusion dissolution were added to liquid scintillation cocktail and analyzed for gross alpha and gross beta activity using liquid scintillation analysis. Alpha/beta spillover was determined for each aliquot analyzed, and subsequently used for accurately determining alpha and beta activity, via the addition of a known amount of plutonium to an identical aliquot of each sample.

I-129

The solid material was used for the I-129 separation and analysis. KI carrier was added to aliquots of the solids material and nitric acid. Actinide and ammonium phospho-molybdate (AMP) resins were then added to the mixture to facilitate removal of interfering isotopes. Sodium sulfite was added to the material to reduce the iodine. Silver nitrate was added to the solution to precipitate the iodine as AgI, which was separated via filtration. The filtrate was analyzed for I-129 content using low energy photon/x-ray, thin-windowed, semi-planar high purity germanium spectrometers. Elemental iodine yields were measured by neutron activation analysis, and were used to correct the I-129 results for each aliquot for any iodine losses incurred during the radiochemical separation.

Na-22, Al-26, Co-60, Nb-94, Rh-106, Ru-106, Sb-125, Sb-126, Sn-126, Sb-126m, Te-125m, Ce-144, Pr-144, Eu-152, Eu-154, Eu-155, Am-241, Ra-228, Ac-227

Aliquots of the solids material were dissolved using a mixture of concentrated hydrochloric, nitric, and hydrofluoric acid. Following digestion, the solutions were subjected to a Cs-removal process utilizing Bio Rad AMP-1 resin. The Cs-removed digestates were analyzed by coaxial high purity germanium spectrophotometers to measure the gamma-emitting radionuclides listed above.

Nb-94 and K-40

The Cs-removed digestates were decontaminated further using additional Bio-Rad AMP-1 treatments as well as treatments designed to extract tri- and tetravalant interferences. The treated solutions were then analyzed for extended periods of time to reach lower detection limits for Nb-94 and K-40 than were achievable from the Cs-removal process alone.

C-14

The solid material was used for the C-14 separation and analysis. Aliquots of the material were added to a mixture of sodium hydroxide, and sodium carbonate/sodium hydroxide. A series of oxidation and reduction steps designed to liberate C-14 containing carbon dioxide were carried out, which selectively trapped the C-14 in various solutions. Finally, C-14 containing carbon dioxide was captured in Carbosorb E and measured by liquid scintillation analysis.

Th-229/230

Aliquots of solids material were weighed, spiked with a Th-229 radioactive tracer and digested in concentrated acid. Duplicate aliquots of solids materials were weighed and digested in concentrated acid with no tracer added. Thorium was extracted from the matrix using two stages of a quaternary amine based solid phase extraction and purified further via co-precipitation with cerium. Th-229 and Th-230 concentrations were measured using passivated, implanted, planar silicon (PIPS) alpha spectrometers. The Th-229 tracer yields were used to correct the various analytes for any thorium losses from the radiochemical separations.

U-232

Aliquots of solids material were weighed and digested in concentrated acid. Uranium was extracted from the matrix using two stages of a diamyl, amylphosphonate (DAAP)-based solid phase extraction and purified further via co-precipitation with cerium. U-232, U-233, and U-238 activities were measured using passivated, implanted, planar silicon (PIPS) alpha spectrometers. U-232/U-238 activity ratios were generated and were multiplied by U-238 activities measured with the ICP-MS to determine U-232 activities in the samples.

U Separation for MS

To lower detection limits for U-233, 234, and 236 from the ICP-MS analyses on peroxide fusion dissolution of Tank 19 solids, aliquots of dissolution were purified with a DAAP based solid phase extraction. The purified aliquots were analyzed by the ICP-MS to measure U-233/U-235, U-234/U-235, and U-236/U-235 mass ratios. Those ratios were applied to U-235 concentrations measured by the ICP-MS directly on aliquots of dissolution to quantify U-233, U-234, and U-236 concentrations.

Pu Separation for MS

To lower detection limits for Pu-242 and Pu-244 from the ICP-MS analyses on peroxide fusion dissolution of Tank 19 solids, aliquots of dissolution were purified with a quaternary amine based solid phase extraction. The purified aliquots were analyzed by the ICP-MS to measure Pu-242/Pu-239, and Pu-244/Pu-239 mass ratios. Those ratios were applied to Pu-239 concentrations measured by the ICP-MS directly on aliquots of dissolution to quantify Pu-242 and Pu-244 concentrations.

Cs-135 Separation for MS

To lower detection limits for Cs-135 from the ICP-MS analyses on peroxide fusion dissolution of Tank 19 solids, aliquots of dissolution were purified with a solvent-solvent Caustic Side Solvent Extraction (CSSX)-based extraction system. The purified aliquots were analyzed by the ICP-MS to measure Cs-135/Cs-137 mass ratios. Those ratios were converted to activity ratios and applied to the Cs-137 activities measured by coaxial high purity germanium gamma-ray spectrophotometers directly on aliquots of dissolution to quantify Cs-135 concentrations.

Np-237

To lower detection limits for Np-237 from the ICP-MS analyses on peroxide fusion dissolution of Tank 19 solids, aliquots of dissolution were spiked with Np-239 and then purified with a quaternary amine based solid phase extraction. The purified aliquots were analyzed by low energy photon/x-ray, thin-windowed, semi-planar high purity germanium spectrometers to yield the Np-239 recoveries and by the ICP-MS to measure Np-237. The Np-237 values were corrected with the decay-corrected Np-239 recoveries and/or the Np-237 blank spike sample run concurrently through the process.

Zr-93

Aliquots of solids material were weighed, and digested in concentrated acid. Zirconium was then extracted from the matrix using a CMPO/TBP based extractant. The purified aliquots were analyzed by the ICP-MS to measure Zr-93. The Zr-93 values were corrected with the Zr recoveries of the blank spike sample run concurrently through the process.

Pd-107

Aliquots of solids material were weighed, and digested in concentrated acid. The isobaric Ag-107 interference was reduced using a AgCl precipitation/filtering process. The purified aliquots were analyzed by the ICP-MS to measure Pd-107. The Pd-107 values were corrected for any remaining Ag-107 traces using the Ag-107/Ag-109 ratio.

Cl-36

Aliquots of solids material were weighed and and then digested in concentrated acid. The acid leachates were subjected to numerous resin based decontamination steps. Chlorine was then separated from the the non-volatile components of the matrix via steam distillation. Several additional resins were used to further decontaminate the distillate. In some cases the decontamination steps were followed up with a AgCl precipitation. Aliquots of the Cl-36-containing distillate were analyzed by liquid scintillation analysis. In cases where AgCl precipitation was used, the precipitate was counted used GFPC analysis. Aliquots of distillate, or the AgCl precipitate, was then activated by neutron activation analysis to determine Cl losses during the processes, and to correct Cl-36 results for those losses. The HCl used to digest the samples initially was used to trace Cl-36 throughout the processes.

Tritium

Aliquots of solids material were weighed and leached using nitric acid. The acid leachates were subjected to tritium separations via steam distillation, and aliquots of the tritium-containing distillate were analyzed by liquid scintillation analysis.

Pt-193

Aliquots of solids material were weighed, spiked with an elemental Pt carrier and then digested in concentrated acid. The platinum species were extracted from the matrix. Pt-193 concentrations were measured using thin-windowed, semi-planar high purity germanium spectrometers to quantify low energy photon/x-ray emissions from Pt-193. Elemental platinum carrier yields were measured for each separated aliquot by ICP-ES, and were used to correct the radioactive platinum species' results for any platinum losses incurred during the radiochemical separations.

Weight Fraction Solids Analysis

The weight percent total solids in the sample were measured in the Shielded Cells using a conventional drying oven at 110 °C. An aliquot of each air-dried Tank 18F sample was placed in a container. The container was placed in the oven. The weights of the dried sample were checked periodically over 72 hours until two consecutive weights yield comparable results. The weight fraction solid was calculated by dividing the dry weight of the sample by the initial wet weight of the sample.

Aqua Regia Digestions (AQR)

Samples were digested according to procedure L16.1, ADS-2226. In a typical digestion, ~0.3 g of wet material from a Tank 19 sample tube was placed into a Teflon® digestion vessel. Then, 9 mL (hydrochloric acid) HCl, 3 mL (nitric acid) HNO_3 and 1 mL (hydrofluoric acid) HF was added to the Teflon® vessel. The Teflon® vessel was sealed and heated for a period of no more than 4 hours at 115 °C. The sample was then cooled and diluted to 50 mL (for samples to undergo a preparation step for Np-237 followed by inductively coupled plasma mass spectroscopy analysis, three samples in total) or 100 mL (for samples to undergo inductively coupled atomic emission spectroscopy, atomic absorption, and inductively coupled plasma mass spectroscopy analysis, three samples in total) using a volumetric flask. Six samples, in total, from each hemisphere were digested by aqua regia. Concurrently, as each Tank 19 sample tube was being sampled to grab ~0.3 grams of wet material for digestion purposes, ~0.3 grams of additional wet material was taken from the same Tank 19 sample tube and placed in an alumina crucible and dried at 110 °C. This process was repeated for each digestion. The process was performed to determine the weight percent dried solids in each digestion for comparison to the peroxide fusion digestions.

Sodium Peroxide/Hydroxide Fusions (PF)

Samples were digested according to procedure L16.1, ADS 2502. In a typical digestion, ~0.3 grams of wet material from a Tank 19 sample tube was placed into a zirconium (Zr) crucible with a known weight. The material in the crucible was dried until two consecutive weights were within ±0.02 grams. The remaining material in the crucible was fused at 675 °C using a mixture of sodium peroxide (1.5 grams) and sodium hydroxide (1.0 grams). After the sample was cooled, water was added to dissolve the fused material and the solution was acidified by the addition of 25 mL HCl. The sample was diluted to 100 mL. Six samples were digested for each hemisphere for analysis (three samples for a preparation step for Np-237 followed by inductively coupled plasma mass spectroscopy analysis, and three samples for inductively coupled atomic emission spectroscopy and inductively coupled plasma mass spectroscopy analysis).

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