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Summary of Results from November 2021 Qualification Samples for Tank Closure Cesium Removal 1A (TCCR 1A)

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EXECUTIVE SUMMARY

Savannah River Remediation (SRR) is currently operating the Tank Closure Cesium Removal 1A (TCCR 1A) process to remove ^{137}Cs from tank waste supernate using an ion exchange process. As part of that process, Savannah River National Laboratory (SRNL) receives and analyzes samples in support of the qualification of each batch to be processed. SRNL recently received supernate samples retrieved from Tank 10H as well as in-tank batch contact samples for characterization in support of qualifying Batch 1 for processing through the TCCR 1A unit.

SRNL received and characterized two sets of dip samples – a preliminary set of samples collected from Tank 10H in July 2021 (one surface and two variable depth samples) and a batch qualification set collected from Tank 10H in November 2021 (one surface and one variable depth sample). In addition, a third set of samples were collected from Tank 10H (two variable depth) at the time the in-tank batch contact test vials were retrieved (10 days after the initial qualification samples were collected).

The two depth samples collected from Tank 10H in July 2021 contained a small amount of fine, dark brown solids, while the surface sample did not contain any visible solids. The density of the surface sample was 2-4% lower than the depth sample filtrates. The sodium concentrations in the depth samples were about 12-13% higher than the surface sample, indicating some stratification within the tank. Analysis of the digested VDS samples showed that the dark brown solids observed were primarily Fe and Mn as indicated by the >2000% increase in concentration of these two elements in the digested slurries when compared to the filtrates. Ca was also observed in the digested slurry samples, where it had been below the detection limit in the filtrate samples. Consistent with the Na concentrations, the ^{137}Cs activity in the depth samples was higher than the surface sample (~21-22%).

The qualification samples (one surface and one depth sample taken at 80”) received in early November 2021 did not contain any significant solids; however, the depth sample appeared slightly hazy. There was a significant difference in the densities of the two samples (1.312 g/mL (0.35% RSD) and 1.387 g/mL(0.83% RSD) for the surface and VDS, respectively), and therefore the samples were not combined for analysis. Due to the difference in densities in these two samples, two additional depth samples were collected from the tank 10 days later; one at a depth of 90” and one at a depth of 80”. These two samples also had significantly different densities (1.301 g/mL (0.46% RSD) versus 1.379 g/mL (0.46% RSD)) indicating stratification in the tank between these two depths. The remaining analyses on the original qualification samples were consistent with the density measurements, showing the salt solution was more concentrated at a depth of 80” compared to the surface. Based on these results, SRR recirculated the tank and repeated the qualification process. The results from the requalification will be documented in a separate report.

The in-tank batch contact samples, consisting of 0.1 g of crystalline silicotitanate (CST, IONSIV^{TM} R9120-B, 30x60) contained within a teabag device, were also received at SRNL in November 2021 after being suspended in Tank 10H for a period of 10 days at depths of 102” and 98” from the bottom of the tank. At SRNL the CST was rinsed to remove excess salt solution and the CST was then air dried before being digested for analysis. Results of the analysis indicated a ^{137}Cs loading of 1.00E+11 ± 3.36E+09 dpm/g or 45.2 ± 1.51 Ci/kg$_{CST}$. This value represents a bounding upper limit as it includes the addition of two sigma uncertainty from replicate analysis of the individual teabag samples as well as the addition of the small amount of ^{137}Cs activity measured in the rinse solutions. The above values are based on the air-dried mass of CST. Correcting to the true dry mass using a F-factor of 0.8107 results in a maximum loading of 55.8 ± 1.86 Ci/kg$_{CST}$. ZAM modeling was performed using the measured composition of the surface qualification sample. The modeling predicted a maximum Cs loading approximately 1.5x higher than the measured result. This is a slightly lower ratio (expected/measured) compared to what was observed for the prior

TCCR in-tank batch contact testing performed for Batches 1A – 3 where the ZAM results were always >2x higher than the measured values.

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CST	crystalline silicotitanate
EDS	energy dispersive X-ray spectroscopy
ELN	Electronic Laboratory Notebook
IC	ion chromatography
ICP-ES	inductively coupled plasma – emission spectroscopy
ICP-MS	inductively coupled plasma – mass spectrometry
LSC	liquid scintillation counting
M&TE	Measurement and Test Equipment
PMP	Polymethylpentene
SaM	Sensing and Metrology
SEM	scanning electron microscopy
SRNL	Savannah River National Laboratory
SRR	Savannah River Remediation
TCCR 1A	Tank Closure Cesium Removal 1A
TIC/TOC	total inorganic carbon/total organic carbon
TTQAP	Task Technical and Quality Assurance Plan
TTR	Technical Task Request
VDS	variable depth sample
XRD	X-ray diffraction
ZAM	ZAM (Zheng, Anthony, and Miller) Isotherm Model

1.0 Introduction

In support of the Tank Closure Cesium Removal 1A (TCCR 1A) program, SRNL analyzed several samples from Tank 10H, including the in-tank crystalline silicotitanate (CST, IONSIV^{TM} R9120-B, 30x60) batch contact equilibrium (or "teabag") samples deployed in that tank. Tank 10H serves as the feed tank for the TCCR 1A system, receiving dissolved salt solution from Tank 9H. Salt was dissolved in Tank 9H in two batches and these batches were transferred to Tank 10H in May and June of 2021. A total of 28,726 gallons comprising Batch 1A were transferred on May 2-3, 2021 and 67,479 gallons comprising Batch 1B were transferred on June 23-25, 2021. SRNL previously received and characterized samples from each of the two Tank 9H dissolved salt batches (Batch 1A and 1B).[1] Approximately 8 days after the transfer of Batch 1B material (July 3, 2021), three samples (HTF-10-21-55, HTF-10-21-56, and HTF-10-21-57) were collected from the tank and delivered to SRNL for characterization as requested by Savannah River Remediation (SRR)[a]. There was no recirculation of Tank 10H performed prior to collecting these samples (surface and two variable depth).

On August 11, 2021 21,680 gallons of domestic water were added to Tank 10H. Recirculation of the tank was planned to immediately follow; however, failure of the pump in Tank 10H caused a delay due to the need for replacement. The pump was replaced in October 2021, and two additions of sodium hydroxide (NaOH) were also made in October – 3,461 gallons on October 19, 2021 and 3,508 gallons on October 25, 2021. Recirculation of the tank began on October 27, 2021 and continued until October 31, 2021. On November 1, 2021 the batch qualification samples (HTF-10-21-103 and HTF-10-21-104) were collected (surface and variable depth) and sent to SRNL for characterization, and the in-tank batch contact test vials were deployed into the tank for a 10-day contact. Following the 10-day contact, the vials were retrieved and sent to SRNL for analysis. The same day the batch contact vials were retrieved from the tank, two additional variable depth samples (HTF-10-21-111 and HTF-10-21-112) were also collected and sent to SRNL for density measurements.

2.0 Experimental Procedure

2.1 Tank 10H Preliminary Samples (HTF-10-21-55, HTF-10-21-56, and HTF-10-21-57)

Three 80-mL dip samples were collected from Tank 10H on July 3, 2021, one surface and two variable depth samples (VDS). The VDS samples were collected from depths of 80" and 65" from the bottom of the tank. The samples were placed into the Shielded Cells and then opened and transferred to clear polymethylpentene (PMP) beakers for observation after shaking by hand (manipulator) to mix. The surface sample (HTF-10-21-55) was colorless and did not contain visible solids, while the two VDS samples (HTF-10-21-56 and HTF-10-21-57) contained a small amount of fine dark brown solids. Photographs of the VDS samples are provided in Figure 3-1. The samples were not combined and were analyzed individually. A portion of each variable depth sample was filtered through a 0.45-µm Nylon filter to generate a filtrate sample that was used for some analyses. The filter papers were removed from the cells and submitted for powder X-ray diffraction (XRD) and scanning electron microscopy (SEM) – energy dispersive X-ray spectroscopy (EDS) analyses. Samples for SEM-EDS were prepared by touching carbon tape to the filter paper multiple times to collect sample. The carbon tape was mounted on aluminum stubs. The densities of both the "as-received" samples as well as the filtrates from the VDS samples were measured in duplicate, using a measurement and test equipment (M&TE) calibrated balance and 2-mL density tubes. Samples used for density measurements were returned to the corresponding sample bottles. Aliquots of the original surface sample and filtrates from the VDS samples were then diluted by a factor of approximately 5 with 3 M HNO_3 and were submitted for the following analyses: inductively coupled plasma – emission spectroscopy (ICP-ES), inductively coupled plasma – mass spectrometry (ICP-MS), gamma spectroscopy,

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[a] The liquid waste contractor changed on 2/27/22 becoming Savannah River Mission Completion (SRMC).

and liquid scintillation counting (LSC) with and without cesium removal. The masses of sample and diluent were used to calculate a dilution factor for each sample, and results reported herein have been corrected for the dilution factor. Unfiltered samples of HTF-10-21-56 and HTF-10-21-57 were digested with aqua regia (2.4 : 1 volume ratio of aqua regia : sample) by heating to 115 °C for 3 hours and were then diluted with distilled and deionized water prior to analysis by ICP-ES, ICP-MS, gamma spectroscopy, and LSC. Weight percent solids measurements were also performed on both the original samples and filtrates from the two VDS samples to determine the quantity of insoluble solids. These measurements were performed by drying a sample to a constant mass at 115 °C for approximately 4 days. Additional samples were later prepared to analyze for the remaining corrosion control species as requested by SRR. Aliquots of the "as-received" surface sample and filtrates from the depth samples were diluted by a factor of approximately 5 with distilled and deionized water and were submitted for ion chromatography (IC) for anions as well as total inorganic carbon/total organic carbon (TIC/TOC) analyses.

2.2 Tank 10H Batch 1 Qualification Samples (HTF-10-21-103 and HTF-10-21-104)

Two 200-mL dip samples were received from Tank 10H on November 2, 2021. One sample was collected from the surface and the other sample was collected from a depth of 80" from the bottom of the tank. Once placed inside the Shielded Cells, the samples were opened and transferred to clear PMP beakers for observation. No significant solids were observed in either sample, although the depth sample was slightly hazy in appearance possibly due to suspended fine particles. Photographs of the samples are provided in Figure 3-10. The densities of the two samples were measured using 2-mL density tubes at ambient temperature (18 °C). Samples used for density measurements were returned to the sample bottles. A portion of the VDS sample was also filtered through a 0.45-μm Nylon filter, and the density of the filtrate was measured. Following the density measurements, aliquots of the as-received samples were diluted with either distilled and deionized water or 3 M nitric acid by a factor of approximately 3 and were submitted to Sensing and Metrology (SaM) for a suite of analysis as described in the Task Technical and Quality Assurance Plan (TTQAP).[2]

2.3 Tank 10H Batch 1 Additional VDS Samples (HTF-10-21-111 and HTF-10-21-112)

Two 200-mL dip samples were received from Tank 10H on November 12, 2021. Sample HTF-10-21-111 was collected from a depth of 90" and HTF-10-21-112 was collected from a depth of 80" from the bottom of the tank. Once placed inside the Shielded Cells, the samples were opened and transferred to clear PMP beakers for observation. Both samples were slightly cloudy in appearance, with HTF-10-21-111 more so than HTF-10-21-112. Photographs of the samples are provided in Figure 3-11. The densities of the two samples were measured using 2-mL density tubes at ambient temperature (21 °C). Samples used for density measurements were returned to the sample bottles.

2.4 Tank 10H In-Tank Batch Contact Samples (HTF-10-21-105 and HTF-10-21-106)

Two modified sample vials containing the CST teabags which had been suspended in Tank 10H supernate at depths of 102" and 98" from the bottom of the tank for a total of ~10 days were received at SRNL on November 12, 2021. The teabags were removed from the sample vials in the Shielded Cells and were processed according to the established procedure.[3] Duplicate aliquots of the CST standard were processed alongside the pair of teabag samples and were submitted for identical analyses. The CST standard is from the same batch of pre-treated CST that was used in the teabags.[4] After completion of air drying (~3 days), the CST was weighed and subjected to hot HF-HNO_3 digestion. Aliquots of the digestion solutions from the teabag samples and the standard samples were then submitted to SaM for a suite of analyses as described in the TTQAP.[2] In addition to the digested CST results, samples of the soak solutions generated during processing of the teabags were also submitted for analysis and the results from those samples are also reported here.

2.5 Modeling Approach

Cesium loading on the CST was predicted using the ZAM isotherm model developed by the research group of Professor Rayford G. Anthony of Texas A&M University. The ZAM program, named after its developers (i.e., Zheng, Anthony, and Miller), was described in detail in a previous ion exchange study at SRNL.[5] In addition, the OLI Studio™ software (Version 10) from OLI Systems, Inc., was used to estimate feed solution density required as input data to the ZAM program. The composition of the qualification surface sample (HTF-10-21-103) was used as input for the OLI and ZAM calculations.

There are two options to predict cesium loading.

- Use of an isotherm: An isotherm provides the equilibrium relation between the concentration of cesium loaded on the CST surface to the concentration of cesium in the solution. The isotherm covers a wide range of liquid-phase cesium concentrations. ZAM can generate equilibrium cesium loading data at a given temperature. Generally, an excellent fit for the ZAM data would be achieved by use of the Freundlich/Langmuir isotherm model.
- Variation of ZAM phase ratio: A phase ratio, ϕ, is defined as the ratio of total liquid volume (mL) processed to the mass of CST resin (g_{CST}). To simulate the saturation of cesium loading on CST for a specified feed, ZAM calculations are performed at increasing phase ratios until the calculated equilibrium liquid cesium concentration approximates (usually accurate up to 4 digits) the feed cesium concentration. The corresponding cesium concentration on CST represents the maximum cesium loading.

The two approaches should deliver practically identical results. The methods were discussed in detail in a previous report.[6]

Note that IE-911 and R9120-B (engineered forms of CST) contain inert binder while ZAM data are based on IE-910 (powdered form) and the true-dry mass of CST (i.e., mass remaining at 460 °C). To compare ZAM predictions with test data using engineered CST, a recommended dilution factor of 0.68[5] is frequently applied to account for the binder effect. Additionally, since test data are based on the air-dried mass of CST, an F-factor of 0.8107, determined in the current work for this CST batch,[4] is needed for conversion to the true-dry mass basis.

2.6 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.[7] This work was performed following the applicable TTQAP.[2] The Task Technical Request (TTR) associated with this work[8] requested a functional classification of Safety Class (see section 9.5 of the TTQAP entitled "Clarification of Safety Class Functional Classification"). To match the requested functional classification, this report and calculations within received a technical review by design verification by document review.[9] Data are recorded in the Electronic Laboratory Notebook (ELN) system.[10]

3.0 Results and Discussion

3.1 Tank 10H Preliminary Samples[11]

The surface sample (HTF-10-21-55) appeared clear and colorless, with no evidence of solids, while the variable depth samples (HTF-10-21-56 and -57) contained a small amount of dark brown solids as shown in Figure 3-1. The photograph in Figure 3-1 was taken after settling overnight; however, one sample was inadvertently dropped while staging for the photo and therefore some solids may have been disturbed.

Figure 3-1. Photographs of Tank 10H VDS samples HTF-10-21-56 and HTF-10-21-57.

The densities of the Tank 10H preliminary samples are reported in Table 3-1. The density of the surface sample was approximately 2% and 4% lower than the variable depth filtrate samples. The densities of the VDS slurries were very similar to the filtrate densities indicating only a small amount of solids are present.

Table 3-1. Density Measurements of Tank 10H Preliminary Samples

Sample	Sample Location	Sample Type	Avg. Density (g/mL)[a]	% RSD[b]
HTF-10-21-55	surface	"as-received"	1.366	0.70
HTF-10-21-56	variable depth	filtrate	1.393	0.18
HTF-10-21-57	variable depth	filtrate	1.419	1.17
HTF-10-21-56	variable depth	"as-received" (slurry)	1.395	1.09
HTF-10-21-57	variable depth	"as-received" (slurry)	1.408	1.16

[a] Temperature during density measurements was 29-30 °C. [b] Percent relative standard deviation from duplicate samples.

To determine the amount of insoluble solid present in the VDS samples, total solids measurements were performed on samples of the filtrate and slurry from both HTF-10-21-56 and -57. The measurements were performed by drying duplicate samples of each (filtrate and slurry) at 115 °C until a constant weight was achieved (4 days). Results from the total solids measurements are provided in Table 3-2, along with the amount of insoluble solids in the slurry calculated using equation 1 shown below.

$$\text{Wt\%}_{\text{insoluble}} = (\text{Wt\%}_{\text{total}} - \text{Wt\%}_{\text{dissolved}}) / (100 - \text{Wt\%}_{\text{dissolved}}) \qquad (1)$$

Table 3-2. Weight Percent Solids Measurements

HTF-10-21-56				
Sample	**Trial 1 (wt%)**	**Trial 2 (wt%)**	**Average (wt%)**	**% RSD[a]**
Filtrate (Dissolved Solids)	44.05	44.01	44.03	0.06
Slurry (Total Solids)	44.05	44.12	44.09	0.11
Insoluble Solids (Calculated)	n/a	n/a	n/a[b]	n/a
HTF-10-21-57				
Sample	**Trial 1 (wt%)**	**Trial 2 (wt%)**	**Average (wt%)**	**% RSD[a]**
Filtrate (Dissolved Solids)	44.49	44.48	44.49	0.02
Slurry (Total Solids)	44.47	44.47	44.47	0.00
Insoluble Solids (Calculated)	n/a	n/a	n/a[b]	n/a

[a]Percent relative standard deviation from duplicate samples. [b]The amount of insoluble solids is too small to be determined via this method. The weight percent solids in the filtrate and slurry were the same within experimental error.

Due to the small amount of sample collected on the filter paper, powder XRD analysis was difficult. Residual salt crystallized on the underside of the filter paper making direct analysis of the solids on the paper impossible. The small amount of material was removed from the filter paper for analysis. Powder XRD results for solids from HTF-10-21-56 are shown in Figure 3-2 and results from HTF-10-21-57 are shown in Figure 3-3. Most of the phases identified can be attributed to residual salt solution that had dried on the sample, except for sodium acetate which may be from the filter paper.

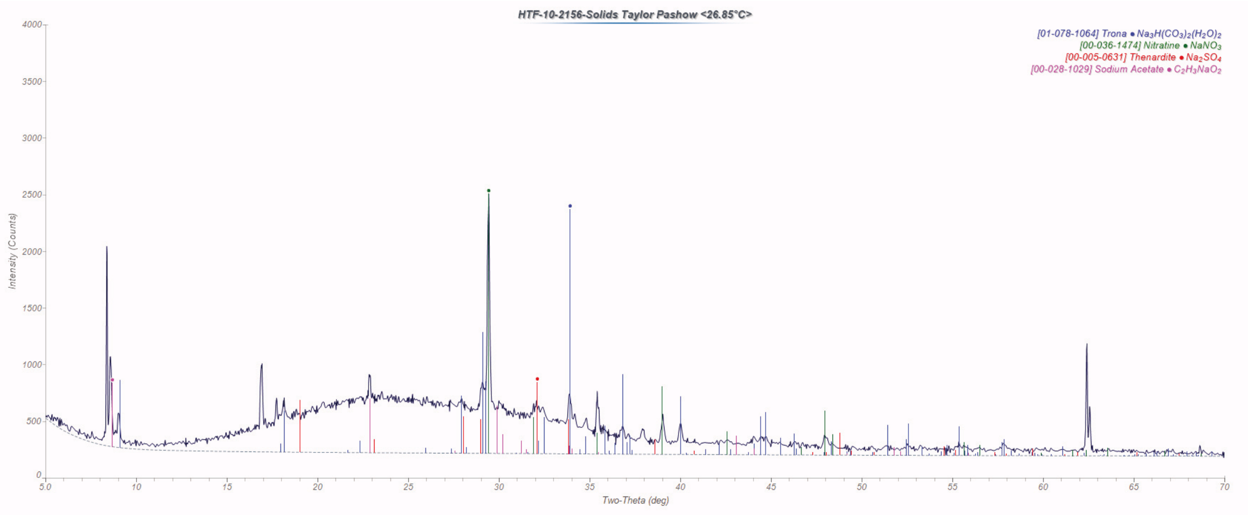

Figure 3-2. Powder XRD of solids collected from HTF-10-21-56.

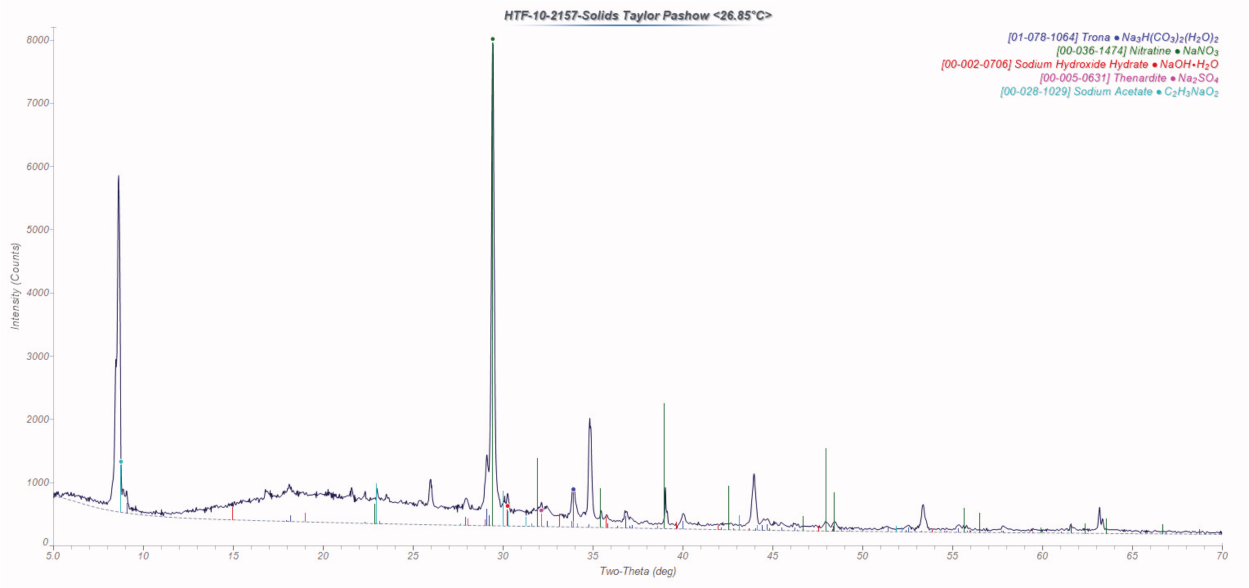

Figure 3-3. Powder XRD of solids collected from HTF-10-21-57.

The SEM-EDS analysis of the solids on the filter paper revealed that the bulk of the sample was made up of Na, O, Al, and S; however, a number of other elements were also detected in portions of the samples including Hg, Ca, U, Mn, Fe, P, Si, and Sb. Representative SEM images and EDS spectra are shown in Figures 3-4 through 3-9 below.

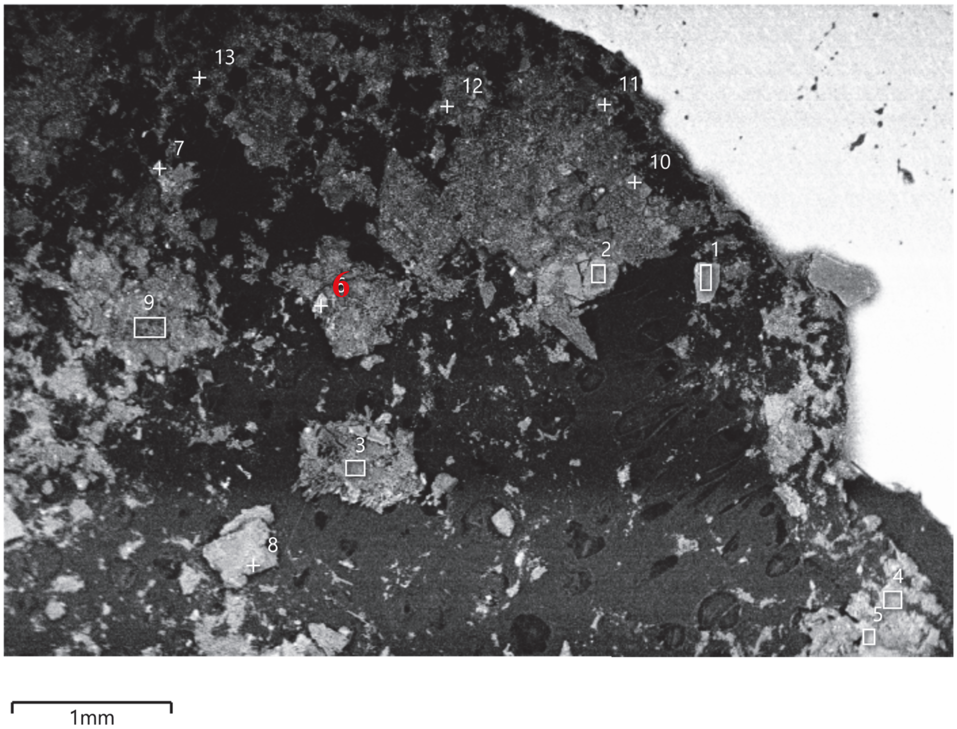

Figure 3-4. SEM image of HTF-10-21-56 solids.

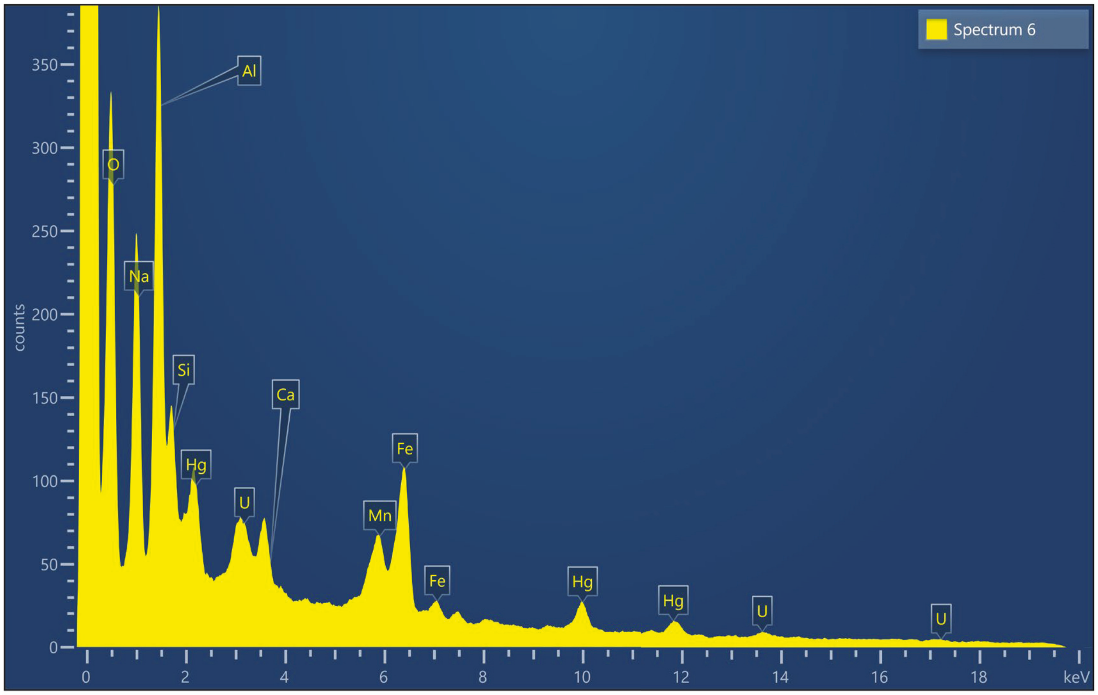

Figure 3-5. EDS spectrum corresponding to point #6 shown in Figure 3-4.

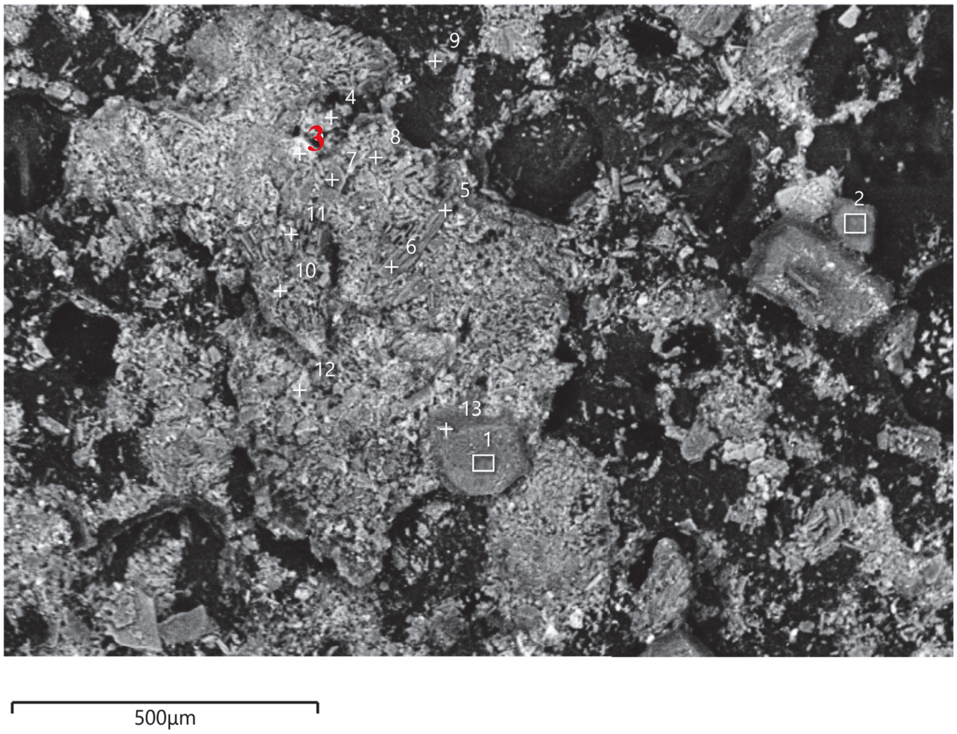

Figure 3-6. SEM image of HTF-10-21-56 solids.

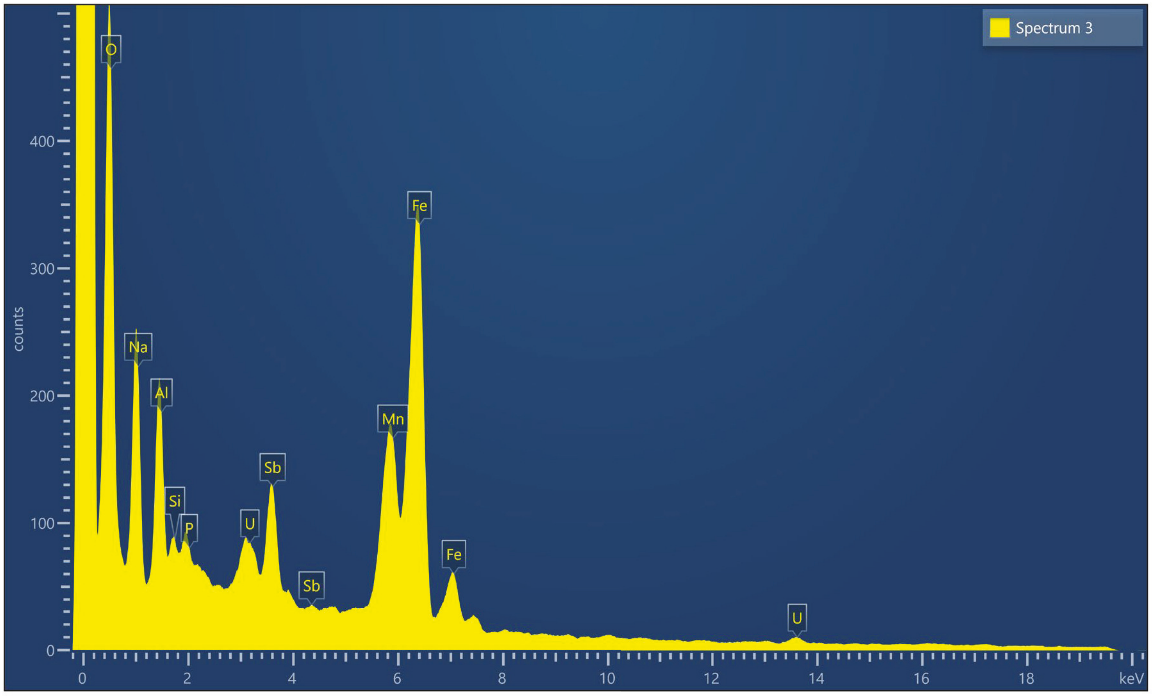

Figure 3-7. EDS spectrum corresponding to point #3 shown in Figure 3-6.

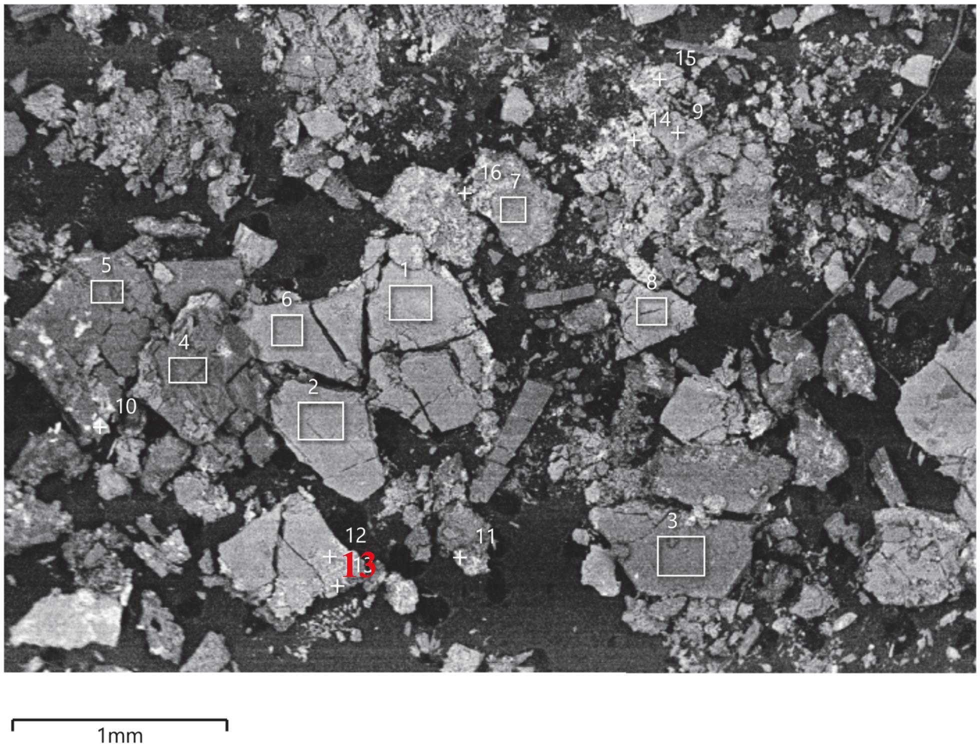

Figure 3-8. SEM image of HTF-10-21-57 solids.

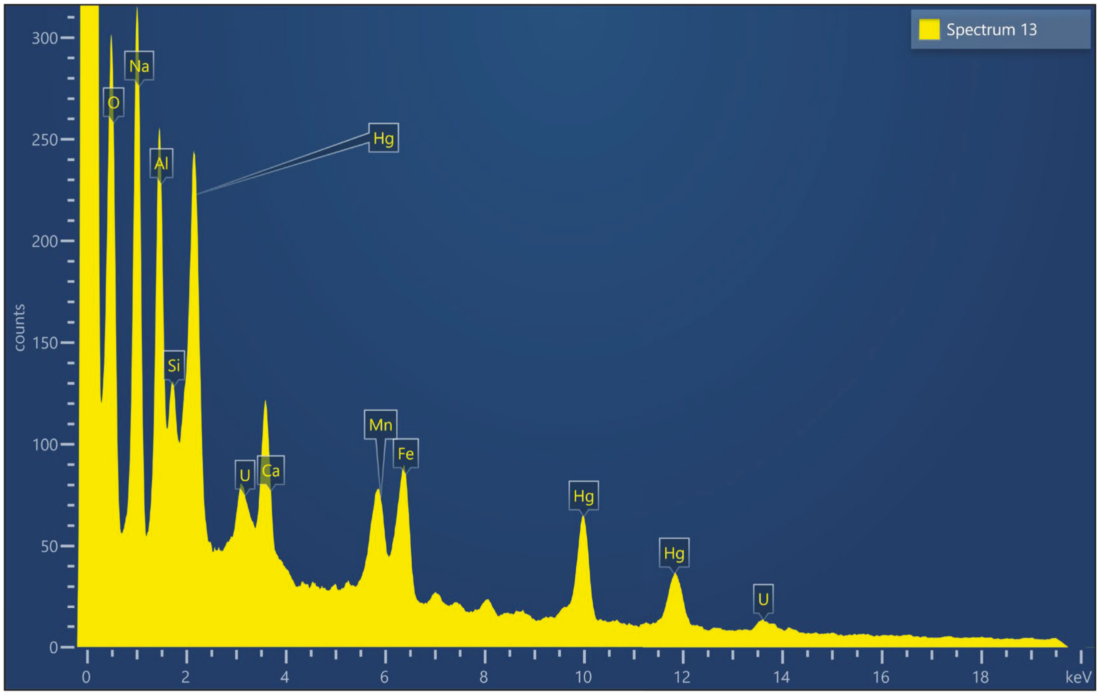

Figure 3-9. EDS spectrum corresponding to point #13 shown in Figure 3-8.

Gamma spectroscopy and LSC were performed on the surface sample as well as both filtrates and digested slurries of the two VDS samples. The results from these analyses are provided in Table 3-3. The activities in the two variable depth samples were similar, and approximately 21-22% higher (^{137}Cs activity) than the surface sample. The ^{137}Cs activities in the filtrates and digested slurry samples were about the same and within the method analytical uncertainty (5%). The alpha activity was below the detection limit in all samples, indicating there was not significant alpha activity in the solids contained in the VDS samples. The original beta activities were also similar between the filtrates and the slurries; however, there was a significant increase in the beta activity remaining after Cs removal in the digested slurry samples when compared to the filtrate samples. This indicates the presence of other (non-Cs) beta emitters in the solids present in the VDS samples, likely ^{90}Sr.

Table 3-3. Alpha, Beta and Gamma Activities in Tank 10H Preliminary Samples

	^{137}Cs (dpm/mL)	Alpha Activity (dpm/mL)	Beta Activity (dpm/mL	Cs Removed	
				Alpha Activity (dpm/mL)	**Beta Activity (dpm/mL)**
HTF-10-21-55	2.77E+08 (5.26% RSD)	< 1.15E+05 (MDA)	3.51E+08 (0.04% RSD)	< 2.58E+04 (Upper Limit)	5.17E+05 (2.07% RSD)
HTF-10-21-56 Filtrate	3.36E+08 (1.00% RSD)	< 1.17E+05 (MDA)	4.05E+08 (0.55% RSD)	< 4.12E+04 (Upper Limit)	6.99E+05 (3.16% RSD)
HTF-10-21-56 Slurry	3.19E+08 (3.71% RSD)	< 2.14E+05 (Upper Limit)	4.10E+08 (3.85 %RSD)	< 4.80E+05 (Upper Limit)	2.15E+07 (2.75% RSD)
% Difference[a]	-4.89%	n/a	1.25%	n/a	2972%
HTF-10-21-57 Filtrate	3.38E+08 (1.32% RSD)	< 1.18E+05 (MDA)	4.12E+08 (0.06% RSD)	< 3.61E+04 (Upper Limit)	6.40E+05 (0.55% RSD)
HTF-10-21-57 Slurry	3.30E+08 (0.90% RSD)	< 1.70E+05 (MDA)	4.22E+08 (0.94% RSD)	< 3.09E+05 (Upper Limit)	1.60E+07 (4.36% RSD)
% Difference[a]	-2.44%	n/a	2.58%	n/a	2379%

[a] Percent difference is defined here as (Slurry-Filtrate)/Filtrate x 100%.

The ICP-ES results of the Tank 10H Batch 1 preliminary samples are shown in Tables 3-4 through 3-6. Comparison of the surface sample to the VDS filtrate samples shows the VDS samples are more concentrated salt solutions than the surface, consistent with the higher density values, indicating some stratification within the tank. The sodium concentrations of the VDS samples are ~12-13% higher than the surface sample. Other elements, including Cr and K, are approximately 20% higher in the VDS samples compared to the surface. The sulfur concentration in the VDS samples is more than double the concentration in the surface sample indicating a much higher sulfate concentration in the depth samples. When comparing the filtrate and digested slurry analysis for the VDS samples it is clear that the dark brown solids observed in the original samples are primarily Fe and Mn as indicated by the roughly > 2000% increase in concentration of these two elements in the digested slurries when compared to the filtrates. Calcium was also detected in the digested slurry samples where it had been below detection in the surface samples. The magnitude of increase of Ca compared to Fe and Mn is difficult to assess due to the relatively high detection limit reported for Ca in the filtrate samples. The Ca concentration is similar in magnitude to that of Mn in the digested slurry samples. The presence of Fe, Mn, and Ca was also confirmed in the EDS analysis of the solids.

Table 3-4. ICP-ES Results for the Tank 10H Surface Sample (HTF-10-21-55)

Element	HTF-10-21-55 Avg. (mg/L)	%RSD[a]
Ag	< 0.597	n/a
Al	2946	1.42%
B	< 57.7	n/a
Ba	< 0.497	n/a
Be	< 0.282	n/a
Ca	< 11.1	n/a
Cd	< 1.40	n/a
Ce	< 3.29	n/a
Co	< 1.76	n/a
Cr	27.1	1.62%
Cu	< 8.20	n/a
Fe	< 2.74	n/a
Gd	< 3.61	n/a
K	340	2.24%
La	< 1.08	n/a
Li	< 95.0	n/a
Mg	< 7.11	n/a
Mn	< 1.39	n/a
Mo	15.5	4.64%
Na	153138	1.25%
Nb	< 26.2	n/a
Ni	< 3.37	n/a
P	110	1.54%
Pb	< 28.0	n/a
S	3511	1.59%
Sb	< 21.4	n/a
Si	< 25.2	n/a
Sn	< 15.2	n/a
Sr	< 0.282	n/a
Th	< 14.3	n/a
Ti	< 3.35	n/a
U	< 17.0	n/a
V	< 10.3	n/a
Zn	< 2.79	n/a
Zr	< 0.920	n/a

[a] Percent relative standard deviation from duplicate samples.

Table 3-5. ICP-ES Results for the Tank 10H VDS Sample (HTF-10-21-56)

Element	Filtrate Avg. (mg/L)	%RSD[a]	Digested Slurry Avg. (mg/L)	%RSD[a]	Change (Slurry – Filtrate) (mg/L)	% Change from filtrate to slurry
Ag	< 0.594	n/a	< 0.605	n/a	n/a	n/a
Al	3074	5.13%	3034	3.58%	-40.2	-1.31%
B	< 57.4	n/a	< 53.2	n/a	n/a	n/a
Ba	< 0.495	n/a	< 0.667	n/a	n/a	n/a
Be	< 0.281	n/a	< 0.287	n/a	n/a	n/a
Ca	< 11.1	n/a	30.3	4.56%	> 19.2	> 173%
Cd	< 1.39	n/a	< 0.621	n/a	n/a	n/a
Ce	< 3.27	n/a	< 2.22	n/a	n/a	n/a
Co	< 1.75	n/a	< 1.79	n/a	n/a	n/a
Cr	33.0	4.61%	32.9	3.60%	-0.049	-0.15%
Cu	< 8.17	n/a	< 4.38	n/a	n/a	n/a
Fe	< 2.73	n/a	77.6	3.68%	> 74.9	> 2740%
Gd	< 3.59	n/a	< 1.269	n/a	n/a	n/a
K	406	1.90%	407	7.26%	1.11	0.27%
La	< 1.07	n/a	< 0.665	n/a	n/a	n/a
Li	< 94.6	n/a	< 5.04	n/a	n/a	n/a
Mg	< 7.08	n/a	< 0.805	n/a	n/a	n/a
Mn	< 1.39	n/a	33.0	3.29%	> 31.6	> 2280%
Mo	17.8	4.78%	16.7	1.78%	-1.11	-6.26%
Na	170990	0.25%	170160	3.48%	-831	-0.49%
Nb	< 26.1	n/a	< 64.1	n/a	n/a	n/a
Ni	< 3.35	n/a	< 3.78	n/a	n/a	n/a
P	134	10.0%	138	4.51%	3.9	2.93%
Pb	< 27.9	n/a	< 6.44	n/a	n/a	n/a
S	7671	0.24%	7350	4.03%	-320.3	-4.18%
Sb	< 21.3	n/a	< 18.6	n/a	n/a	n/a
Si	< 25.0	n/a	< 17.9	n/a	n/a	n/a
Sn	< 15.1	n/a	< 15.5	n/a	n/a	n/a
Sr	< 0.281	n/a	< 0.287	n/a	n/a	n/a
Th	< 14.2	n/a	< 8.08	n/a	n/a	n/a
Ti	< 3.33	n/a	< 0.831	n/a	n/a	n/a
U	< 16.9	n/a	< 17.2	n/a	n/a	n/a
V	< 10.3	n/a	< 2.11	n/a	n/a	n/a
Zn	< 2.78	n/a	< 2.61	n/a	n/a	n/a
Zr	< 0.916	n/a	< 0.936	n/a	n/a	n/a

[a] Percent relative standard deviation from duplicate samples.

Table 3-6. ICP-ES Results for the Tank 10H VDS Sample (HTF-10-21-57)

Element	Filtrate Avg. (mg/L)	%RSD[a]	Digested Slurry Avg. (mg/L)	%RSD[a]	Change (Slurry – Filtrate) (mg/L)	% Change from filtrate to slurry
Ag	< 0.620	n/a	< 0.609	n/a	n/a	n/a
Al	3141	0.74%	3223	1.24%	81.9	2.61%
B	< 59.9	n/a	< 53.6	n/a	n/a	n/a
Ba	< 0.517	n/a	< 0.672	n/a	n/a	n/a
Be	< 0.293	n/a	< 0.289	n/a	n/a	n/a
Ca	< 11.6	n/a	24.1	16.9%	> 12.6	> 109%
Cd	< 1.45	n/a	< 0.626	n/a	n/a	n/a
Ce	< 3.42	n/a	< 2.24	n/a	n/a	n/a
Co	< 1.82	n/a	< 1.79	n/a	n/a	n/a
Cr	32.7	0.60%	34.3	0.87%	1.54	4.71%
Cu	< 8.52	n/a	< 4.42	n/a	n/a	n/a
Fe	< 2.85	n/a	59.5	4.01%	> 56.7	> 1988%
Gd	< 3.75	n/a	< 1.279	n/a	n/a	n/a
K	403	0.49%	438	2.73%	34.5	8.55%
La	< 1.12	n/a	< 0.669	n/a	n/a	n/a
Li	< 98.7	n/a	< 5.07	n/a	n/a	n/a
Mg	< 7.39	n/a	< 0.812	n/a	n/a	n/a
Mn	< 1.45	n/a	25.0	2.79%	> 23.5	> 1627%
Mo	17.9	0.98%	17.0	0.00%[b]	-0.87	-4.87%
Na	173083	1.73%	179456	0.55%	6373	3.68%
Nb	< 27.2	n/a	< 64.5	n/a	n/a	n/a
Ni	< 3.50	n/a	< 3.81	n/a	n/a	n/a
P	142	0.81%	145.0	1.37%	3.15	2.22%
Pb	< 29.1	n/a	< 6.50	n/a	n/a	n/a
S	8189	0.41%	8065	0.49%	-124	-1.52%
Sb	< 22.2	n/a	< 18.7	n/a	n/a	n/a
Si	< 26.1	n/a	< 17.9	n/a	n/a	n/a
Sn	< 15.8	n/a	< 15.6	n/a	n/a	n/a
Sr	< 0.293	n/a	< 0.289	n/a	n/a	n/a
Th	< 14.8	n/a	< 8.15	n/a	n/a	n/a
Ti	< 3.48	n/a	< 0.837	n/a	n/a	n/a
U	< 17.6	n/a	< 17.4	n/a	n/a	n/a
V	< 10.7	n/a	< 2.12	n/a	n/a	n/a
Zn	< 2.90	n/a	< 2.62	n/a	n/a	n/a
Zr	< 0.956	n/a	< 0.943	n/a	n/a	n/a

[a] Percent relative standard deviation from duplicate samples. [b] Duplicate samples gave identical results.

A summary of the anion concentrations measured in the surface and variable depth filtrates is provided in Table 3-7. Consistent with the ICP-ES results, the anion results also show the depth samples are more concentrated than the surface sample. The most significant differences observed were for sulfate, where the concentration in the depth samples is on the order of double the concentration in the surface sample, as well as nitrite where there is also a significant difference in concentration between the surface and depth samples.

Table 3-7. Anion and Carbon Results for the Tank 10H Batch 1 Preliminary Samples

Analyte	HTF-10-21-55[a]	%RSD[b]	HTF-10-21-56[c]	%RSD[b]	HTF-10-21-57[c]	%RSD[b]
Free OH^- (M)	0.313	4.98%	0.406	4.15%	0.424	4.17%
NO_3^- (M)	4.71	0.29%	4.75	0.79%	4.94	2.49%
SO_4^{2-} (M)	0.099	0.80%	0.178	0.00%	0.203	6.61%
NO_2^- (M)	0.571	0.01%	0.820	0.75%	0.874	1.62%
F^- (M)	< 0.026	n/a	< 0.026	n/a	< 0.026	n/a
Cl^- (M)	< 0.014	n/a	< 0.011	n/a	< 0.011	n/a
Br^- (M)	< 0.031	n/a	< 0.031	n/a	< 0.031	n/a
HCO_2^- (M)	< 0.011	n/a	< 0.011	n/a	< 0.011	n/a
PO_4^{3-} (M)	< 0.005	n/a	< 0.005	n/a	< 0.005	n/a
$C_2O_4^{2-}$ (M)	< 0.006	n/a	< 0.006	n/a	< 0.006	n/a
CO_3^{2-} (M)	0.93	1.55%	1.01	1.27%	1.02	0.61%
TOC (mg/L)	181	2.84%	195	1.13%	198	0.75%

[a]Surface sample. [b]The %RSD is the relative standard deviation of duplicate measurements. The reported method uncertainty is 10% at 1 sigma. [c]Variable depth filtrate samples.

The isotopic distribution of Cs based on the mass spectrometry results of surface and VDS filtrates is provided in Table 3-8. The total Cs calculated using the isotopic ratios from the ICP-MS data and the ^{137}Cs amount from the gamma data is 9.10 mg/L for the surface sample and 12.2 and 12.3 mg/L for the VDS filtrate samples. The value for the surface sample is about 8.6% higher than the sum of the Cs isotope masses reported by ICP-MS (8.38 mg/L). The total Cs values for the depth filtrate samples are significantly higher (38% and 36%) than the corresponding sum of the Cs isotope masses reported by ICP-MS (8.88 and 9.02 mg/L). The relatively low ^{137}Cs mole fractions in the depth samples are not consistent with the previous isotopic distributions seen in Tank 9H and 10H samples, but the cause of the discrepancy is undetermined at this time. The total Cs calculated using the isotopic ratios from the ICP-MS data and the ^{137}Cs amount from the gamma data for the VDS digested slurry samples are 8.93 mg/L and 9.89 mg/L for HTF-10-21-56 and -57, respectively. These values are much more consistent with the sum of the Cs isotope masses reported by ICP-MS than the filtrate results. The sum of Cs isotopes (133, 134, 135, and 137) in the HTF-10-21-56 digested slurry sample was 9.16 mg/L and for the HTF-10-21-57 digested slurry was 9.34 mg/L. The full suites of ICP-MS results are provided in Tables 3-9 through 3-13.

Table 3-8. Cs Isotopes from ICP-MS for the Tank 10H Preliminary Samples

HTF-10-21-55				
Isotope	**Mean Concentration (mg/L)**	**%RSD**[a]	**Isotopic Distribution, Mass %**	**Mole Fraction**
Cs-133	6.44	8.86	76.9	0.773
Cs-134	< 5.02E-03	n/a	< 0.06	< 0.0006
Cs-135	0.617	7.72	7.37	0.073
Cs-137	1.32	7.19	15.8	0.154
HTF-10-21-56 Filtrate				
Isotope	**Mean Concentration (mg/L)**	**%RSD**[a]	**Isotopic Distribution, Mass %**	**Mole Fraction**
Cs-133	6.94	0.02	78.2	0.786
Cs-134	< 5.10E-03	n/a	< 0.06	< 0.0006
Cs-135	0.668	2.22	7.53	0.075
Cs-137	1.26	0.02	14.2	0.139
HTF-10-21-56 Digested Slurry				
Isotope	**Mean Concentration (mg/L)**	**%RSD**[a]	**Isotopic Distribution, Mass %**	**Mole Fraction**
Cs-133	6.82	2.94	74.4	0.749
Cs-134	1.70E-02	1.37	0.19	0.002
Cs-135	0.628	1.90	6.85	0.068
Cs-137	1.70	4.35	18.5	0.181
HTF-10-21-57 Filtrate				
Isotope	**Mean Concentration (mg/L)**	**%RSD**[a]	**Isotopic Distribution, Mass %**	**Mole Fraction**
Cs-133	7.06	0.44	78.3	0.786
Cs-134	< 5.18E-03	n/a	< 0.06	< 0.0006
Cs-135	0.676	0.32	7.50	0.074
Cs-137	1.29	0.45	14.3	0.139
HTF-10-21-57 Digested Slurry				
Isotope	**Mean Concentration (mg/L)**	**%RSD**[a]	**Isotopic Distribution, Mass %**	**Mole Fraction**
Cs-133	7.05	0.48	75.5	0.759
Cs-134	1.35E-02	0.15	0.14	0.001
Cs-135	0.662	1.18	7.09	0.070
Cs-137	1.61	0.50	17.3	0.169

[a] Percent relative standard deviation from duplicate samples. The reported method uncertainty is 20% at two sigma.

Table 3-9. ICP-MS Results for Tank 10H Batch 1 Preliminary Surface Sample (HTF-10-21-55)

m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]
59	< 5.02E+00	n/a	**134**	< 5.02E+00	n/a	**180**	< 5.02E+00	n/a
84	< 5.02E+00	n/a	**135**	6.20E+02	7.72%	**181**	< 7.53E+00	n/a
85	7.95E+02	9.89%	**136**	< 5.02E+00	n/a	**182**	5.79E+01	9.97%
86	< 5.02E+00	n/a	**137**	1.33E+03	7.19%	**183**	3.13E+01	7.60%
87	1.70E+03	10.9%	**138**	2.27E+01[c]	n/a	**184**	6.73E+01	8.65%
88	< 1.51E+01	n/a	**139**	< 5.02E+00	n/a	**185**	< 5.02E+00	n/a
89	< 5.02E+00	n/a	**140**	< 5.02E+00	n/a	**186**	6.43E+01	9.64%
90	5.17E+00	3.19%	**141**	< 5.02E+00	n/a	**187**	< 5.02E+00	n/a
91	< 5.02E+00	n/a	**142**	< 5.02E+00	n/a	**188**	< 5.02E+00	n/a
92	8.55E+01	9.71%	**143**	< 5.02E+00	n/a	**189**	< 5.02E+00	n/a
93	< 5.02E+00	n/a	**144**	< 5.02E+00	n/a	**191**	< 5.02E+00	n/a
94	5.58E+01	14.4%	**145**	< 5.02E+00	n/a	**193**	< 5.02E+00	n/a
95	4.80E+03	13.1%	**146**	< 5.02E+00	n/a	**194**	< 5.02E+00	n/a
96	1.02E+02	11.5%	**147**	< 5.02E+00	n/a	**195**	< 5.02E+00	n/a
97	4.39E+03	12.5%	**148**	< 5.02E+00	n/a	**196**	9.90E+00	8.49%
98	4.37E+03	14.2%	**149**	< 5.02E+00	n/a	**198**	4.68E+02	17.1%
99	2.78E+03	7.56%	**150**	< 5.02E+00	n/a	**203**	< 5.02E+00	n/a
100	4.61E+03	12.1%	**151**	< 5.02E+00	n/a	**204**	2.78E+02	16.6%
101	3.07E+02	23.5%	**152**	< 5.02E+00	n/a	**205**	< 5.02E+00	n/a
102	2.67E+02	21.3%	**153**	< 5.02E+00	n/a	**206**	3.79E+02	6.54%
103	6.15E+02	15.2%	**154**	< 5.02E+00	n/a	**207**	3.26E+02	5.94%
104	1.50E+02	22.4%	**155**	< 5.02E+00	n/a	**208**	7.95E+02	6.03%
105	< 5.02E+01	n/a	**156**	< 5.02E+00	n/a	**229**	< 5.02E+00	n/a
106	< 5.02E+01	n/a	**157**	< 5.02E+00	n/a	**230**	< 5.02E+00	n/a
107	< 2.01E+01	n/a	**158**	< 5.02E+00	n/a	**232**	8.99E+00	21.7%
108	< 2.51E+01	n/a	**159**	< 5.02E+00	n/a	**233**	7.76E+00[d]	n/a
109	< 7.53E+00	n/a	**160**	< 5.02E+00	n/a	**234**	< 5.02E+00	n/a
110	< 1.26E+01	n/a	**161**	< 5.02E+00	n/a	**235**	4.89E+01	35.4%
111	< 5.02E+00	n/a	**162**	< 5.02E+00	n/a	**236**	1.31E+01	37.2%
112	8.39E+00	11.4%	**163**	< 5.02E+00	n/a	**237**	1.49E+01	56.8%
113	< 7.53E+00	n/a	**164**	< 5.02E+00	n/a	**238**	4.57E+02	13.7%
114	8.38E+00	9.86%	**165**	< 5.02E+00	n/a	**239**	< 5.02E+01	n/a
116	1.21E+02	5.86%	**166**	< 5.02E+00	n/a	**240**	< 5.02E+00	n/a
117	8.67E+01	8.18%	**167**	< 5.02E+00	n/a	**241**	< 5.02E+00	n/a
118	2.41E+02	9.27%	**168**	< 5.02E+00	n/a	**242**	< 5.02E+00	n/a
119	8.42E+01	9.77%	**169**	< 5.02E+00	n/a	**243**	< 5.02E+00	n/a
120	3.29E+02	9.15%	**170**	< 5.02E+00	n/a	**244**	< 5.02E+00	n/a
121	5.47E+00[b]	n/a	**171**	< 5.02E+00	n/a	**245**	< 5.02E+00	n/a
122	8.41E+01	9.77%	**172**	< 5.02E+00	n/a	**246**	< 5.02E+00	n/a
123	< 5.02E+00	n/a	**173**	< 5.02E+00	n/a	**247**	< 5.02E+00	n/a
124	1.35E+02	12.1%	**174**	< 5.02E+00	n/a	**248**	< 5.02E+00	n/a
125	< 5.02E+00	n/a	**175**	< 5.02E+00	n/a	**249**	< 5.02E+00	n/a
126	4.47E+02	7.49%	**176**	< 5.02E+00	n/a	**250**	< 5.02E+00	n/a
128	< 5.02E+00	n/a	**177**	< 5.02E+00	n/a	**251**	< 5.02E+00	n/a
130	< 5.02E+00	n/a	**178**	< 5.02E+00	n/a			
133	6.44E+03	8.86%	**179**	< 5.02E+00	n/a			

[a] The %RSD is based on the standard deviation of duplicate samples. The reported method uncertainty is 20% at two sigma. [b] Single result above the method detection limit. The duplicate sample had a reported concentration of < 4.99 µg/L. [c] Single result above the method detection limit. The duplicate sample had a reported concentration of < 5.05 µg/L. [d] Single result above the method detection limit. The duplicate sample had a reported concentration of < 4.99 µg/L.

Table 3-10. ICP-MS Results for Tank 10H Batch 1 Preliminary VDS Filtrate (HTF-10-21-56 Filtrate)

m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]
59	< 5.10E+00	n/a	**134**	< 5.10E+00	n/a	**180**	< 5.10E+00	n/a
84	< 5.10E+00	n/a	**135**	6.69E+02	2.22%	**181**	< 7.64E+00	n/a
85	8.76E+02	0.09%	**136**	< 5.10E+00	n/a	**182**	6.09E+01	1.36%
86	< 5.10E+00	n/a	**137**	1.26E+03	0.02%	**183**	3.41E+01	1.58%
87	1.85E+03	1.13%	**138**	9.72E+00[b]	n/a	**184**	7.26E+01	1.29%
88	< 1.53E+01	n/a	**139**	< 5.10E+00	n/a	**185**	< 5.10E+00	n/a
89	< 5.10E+00	n/a	**140**	< 5.10E+00	n/a	**186**	6.79E+01	0.72%
90	< 5.10E+00	n/a	**141**	< 5.10E+00	n/a	**187**	< 5.10E+00	n/a
91	< 5.10E+00	n/a	**142**	< 5.10E+00	n/a	**188**	< 5.10E+00	n/a
92	9.27E+01	0.18%	**143**	< 5.10E+00	n/a	**189**	< 5.10E+00	n/a
93	< 5.10E+00	n/a	**144**	< 5.10E+00	n/a	**191**	< 5.10E+00	n/a
94	6.09E+01	0.35%	**145**	< 5.10E+00	n/a	**193**	< 5.10E+00	n/a
95	5.35E+03	0.38%	**146**	< 5.10E+00	n/a	**194**	< 5.10E+00	n/a
96	1.12E+02	1.60%	**147**	< 5.10E+00	n/a	**195**	< 5.10E+00	n/a
97	4.75E+03	0.94%	**148**	< 5.10E+00	n/a	**196**	1.07E+01	2.92%
98	4.83E+03	1.48%	**149**	< 5.10E+00	n/a	**198**	5.38E+02	0.20%
99	2.97E+03	0.01%	**150**	< 5.10E+00	n/a	**203**	< 5.10E+00	n/a
100	5.06E+03	1.25%	**151**	< 5.10E+00	n/a	**204**	3.15E+02	0.56%
101	3.58E+02	0.68%	**152**	< 5.10E+00	n/a	**205**	< 5.10E+00	n/a
102	3.16E+02	0.44%	**153**	< 5.10E+00	n/a	**206**	3.61E+02	1.00%
103	6.86E+02	1.30%	**154**	< 5.10E+00	n/a	**207**	3.13E+02	0.22%
104	1.70E+02	1.29%	**155**	< 5.10E+00	n/a	**208**	7.62E+02	1.80%
105	< 5.10E+01	n/a	**156**	< 5.10E+00	n/a	**229**	< 5.10E+00	n/a
106	< 5.10E+01	n/a	**157**	< 5.10E+00	n/a	**230**	< 5.10E+00	n/a
107	< 2.04E+01	n/a	**158**	< 5.10E+00	n/a	**232**	1.11E+01	1.54%
108	< 2.55E+01	n/a	**159**	< 5.10E+00	n/a	**233**	7.95E+00	0.38%
109	< 7.64E+00	n/a	**160**	< 5.10E+00	n/a	**234**	< 5.10E+00	n/a
110	< 1.27E+01	n/a	**161**	< 5.10E+00	n/a	**235**	6.21E+01	0.88%
111	< 5.10E+00	n/a	**162**	< 5.10E+00	n/a	**236**	1.71E+01	1.19%
112	9.30E+00	6.34%	**163**	< 5.10E+00	n/a	**237**	2.06E+01	1.54%
113	< 7.64E+00	n/a	**164**	< 5.10E+00	n/a	**238**	5.10E+02	0.39%
114	9.07E+00	7.67%	**165**	< 5.10E+00	n/a	**239**	< 5.10E+01	n/a
116	1.29E+02	0.89%	**166**	< 5.10E+00	n/a	**240**	< 5.10E+00	n/a
117	9.37E+01	1.71%	**167**	< 5.10E+00	n/a	**241**	< 5.10E+00	n/a
118	2.57E+02	1.68%	**168**	< 5.10E+00	n/a	**242**	< 5.10E+00	n/a
119	9.07E+01	2.77%	**169**	< 5.10E+00	n/a	**243**	< 5.10E+00	n/a
120	3.48E+02	3.34%	**170**	< 5.10E+00	n/a	**244**	< 5.10E+00	n/a
121	6.25E+00	13.7%	**171**	< 5.10E+00	n/a	**245**	< 5.10E+00	n/a
122	9.29E+01	5.27%	**172**	< 5.10E+00	n/a	**246**	< 5.10E+00	n/a
123	< 5.10E+00	n/a	**173**	< 5.10E+00	n/a	**247**	< 5.10E+00	n/a
124	1.45E+02	2.46%	**174**	< 5.10E+00	n/a	**248**	< 5.10E+00	n/a
125	< 5.10E+00	n/a	**175**	< 5.10E+00	n/a	**249**	< 5.10E+00	n/a
126	4.85E+02	2.48%	**176**	< 5.10E+00	n/a	**250**	< 5.10E+00	n/a
128	< 5.10E+00	n/a	**177**	< 5.10E+00	n/a	**251**	< 5.10E+00	n/a
130	< 5.10E+00	n/a	**178**	< 5.10E+00	n/a			
133	6.94E+03	0.02%	**179**	< 5.10E+00	n/a			

[a]The %RSD is based on the standard deviation of duplicate samples. The reported method uncertainty is 20% at two sigma. [b]Single result above the method detection limit. The duplicate sample had a reported concentration of < 5.09 µg/L.

Table 3-11. ICP-MS Results for Tank 10H Batch 1 Preliminary VDS Filtrate (HTF-10-21-57 Filtrate)

m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]
59	< 5.18E+00	n/a	**134**	< 5.18E+00	n/a	**180**	< 5.18E+00	n/a
84	< 5.18E+00	n/a	**135**	6.79E+02	0.32%	**181**	< 7.77E+00	n/a
85	8.98E+02	1.85%	**136**	< 5.18E+00	n/a	**182**	6.27E+01	0.49%
86	< 5.18E+00	n/a	**137**	1.29E+03	0.45%	**183**	3.52E+01	0.96%
87	1.91E+03	0.13%	**138**	2.35E+01	107%	**184**	7.33E+01	0.26%
88	< 1.55E+01	n/a	**139**	< 5.18E+00	n/a	**185**	< 5.18E+00	n/a
89	< 5.18E+00	n/a	**140**	< 5.18E+00	n/a	**186**	6.83E+01	2.06%
90	5.44E+00[b]	n/a	**141**	< 5.18E+00	n/a	**187**	< 5.18E+00	n/a
91	< 5.18E+00	n/a	**142**	< 5.18E+00	n/a	**188**	< 5.18E+00	n/a
92	9.63E+01	1.50%	**143**	< 5.18E+00	n/a	**189**	< 5.18E+00	n/a
93	< 5.18E+00	n/a	**144**	< 5.18E+00	n/a	**191**	< 5.18E+00	n/a
94	5.97E+01	1.89%	**145**	< 5.18E+00	n/a	**193**	< 5.18E+00	n/a
95	5.46E+03	0.08%	**146**	< 5.18E+00	n/a	**194**	< 5.18E+00	n/a
96	1.12E+02	0.94%	**147**	< 5.18E+00	n/a	**195**	< 5.18E+00	n/a
97	4.92E+03	1.13%	**148**	< 5.18E+00	n/a	**196**	1.09E+01	8.96%
98	4.88E+03	0.38%	**149**	< 5.18E+00	n/a	**198**	5.70E+02	0.69%
99	2.98E+03	0.26%	**150**	< 5.18E+00	n/a	**203**	< 5.18E+00	n/a
100	5.13E+03	0.71%	**151**	< 5.18E+00	n/a	**204**	3.31E+02	1.07%
101	3.69E+02	1.50%	**152**	< 5.18E+00	n/a	**205**	< 5.18E+00	n/a
102	3.26E+02	0.79%	**153**	< 5.18E+00	n/a	**206**	3.17E+02	1.05%
103	7.13E+02	0.30%	**154**	< 5.18E+00	n/a	**207**	2.77E+02	0.88%
104	1.78E+02	3.21%	**155**	< 5.18E+00	n/a	**208**	6.66E+02	0.76%
105	< 5.18E+01	n/a	**156**	< 5.18E+00	n/a	**229**	< 5.18E+00	n/a
106	< 5.18E+01	n/a	**157**	< 5.18E+00	n/a	**230**	< 5.18E+00	n/a
107	< 2.07E+01	n/a	**158**	< 5.18E+00	n/a	**232**	9.98E+00[c]	n/a
108	< 2.59E+01	n/a	**159**	< 5.18E+00	n/a	**233**	8.71E+00	5.19%
109	< 7.77E+00	n/a	**160**	< 5.18E+00	n/a	**234**	< 5.18E+00	n/a
110	< 1.29E+01	n/a	**161**	< 5.18E+00	n/a	**235**	1.03E+02	40.0%
111	< 5.18E+00	n/a	**162**	< 5.18E+00	n/a	**236**	2.25E+01	19.1%
112	9.15E+00	1.39%	**163**	< 5.18E+00	n/a	**237**	2.55E+01	2.88%
113	< 7.77E+00	n/a	**164**	< 5.18E+00	n/a	**238**	5.92E+02	16.8%
114	9.57E+00	10.1%	**165**	< 5.18E+00	n/a	**239**	< 5.18E+01	n/a
116	1.26E+02	0.33%	**166**	< 5.18E+00	n/a	**240**	< 5.18E+00	n/a
117	9.14E+01	0.71%	**167**	< 5.18E+00	n/a	**241**	< 5.18E+00	n/a
118	2.57E+02	1.59%	**168**	< 5.18E+00	n/a	**242**	< 5.18E+00	n/a
119	9.00E+01	3.48%	**169**	< 5.18E+00	n/a	**243**	< 5.18E+00	n/a
120	3.49E+02	1.74%	**170**	< 5.18E+00	n/a	**244**	< 5.18E+00	n/a
121	< 5.18E+00	n/a	**171**	< 5.18E+00	n/a	**245**	< 5.18E+00	n/a
122	9.52E+01	5.35%	**172**	< 5.18E+00	n/a	**246**	< 5.18E+00	n/a
123	< 5.18E+00	n/a	**173**	< 5.18E+00	n/a	**247**	< 5.18E+00	n/a
124	1.42E+02	0.30%	**174**	< 5.18E+00	n/a	**248**	< 5.18E+00	n/a
125	< 5.18E+00	n/a	**175**	< 5.18E+00	n/a	**249**	< 5.18E+00	n/a
126	4.82E+02	1.31%	**176**	< 5.18E+00	n/a	**250**	< 5.18E+00	n/a
128	< 5.18E+00	n/a	**177**	< 5.18E+00	n/a	**251**	< 5.18E+00	n/a
130	< 5.18E+00	n/a	**178**	< 5.18E+00	n/a			
133	7.06E+03	0.44%	**179**	< 5.18E+00	n/a			

[a] The %RSD is based on the standard deviation of duplicate samples. The reported method uncertainty is 20% at two sigma. [b] Single result above the method detection limit. The duplicate sample had a reported concentration of < 5.22 µg/L. [c] Single result above the method detection limit. The duplicate sample had a reported concentration of < 5.22 µg/L.

Table 3-12. ICP-MS Results for Tank 10H Batch 1 Preliminary VDS Digested Slurry Sample (HTF-10-21-56 Slurry)

m/z	Avg. Conc. (µg/L)	% RSD[a]	% Change from Filtrate	m/z	Avg. Conc. (µg/L)	% RSD[a]	% Change from Filtrate	m/z	Avg. Conc. (µg/L)	% RSD[a]	% Change from Filtrate
59[*]	2.27E+01	1.41%	> 346%	**134**	2.56E+01	1.37%	> 402%	**180**	< 1.01E+01	n/a	n/a
84	< 1.01E+01	n/a	n/a	**135**	6.51E+02	1.90%	-2.74%	**181**	< 1.01E+01	n/a	n/a
85	8.45E+02	5.21%	-3.53%	**136**	< 1.01E+01	n/a	n/a	**182**	5.54E+01	0.72%	-9.06%
86	1.07E+01	5.19%	> 111%	**137**	1.74E+03	4.35%	37.3%	**183**	3.25E+01	0.71%	-4.83%
87	1.80E+03	3.84%	-2.53%	**138**	2.56E+02	2.86%	2532%	**184**	6.69E+01	0.25%	-7.84%
88	1.71E+02	2.74%	> 1019%	**139**	2.48E+02	2.34%	> 4761%	**185**	< 1.01E+01	n/a	n/a
89	9.81E+01	11.5%	> 1825%	**140**	1.03E+03	2.47%	> 20018%	**186**	6.16E+01	1.03%	-9.25%
90	1.34E+02	6.33%	> 2533%	**141**	2.08E+02	0.19%	> 3982%	**187**	< 1.01E+01	n/a	n/a
91	1.18E+02	3.02%	> 2223%	**142**	3.32E+02	3.12%	> 6416%	**188**	< 1.01E+01	n/a	n/a
92	2.02E+02	3.97%	118%	**143**	2.00E+02	2.16%	> 3822%	**189**	< 1.01E+01	n/a	n/a
93	1.44E+02	6.15%	> 2735%	**144**	2.16E+02	1.13%	> 4143%	**191**	< 1.01E+01	n/a	n/a
94	1.79E+02	5.66%	194%	**145**	1.42E+02	0.88%	> 2679%	**193**	< 1.01E+01	n/a	n/a
95	5.20E+03	3.63%	-2.76%	**146**	1.13E+02	0.80%	> 2118%	**194**	< 1.01E+01	n/a	n/a
96	2.19E+02	3.33%	95%	**147**	7.18E+01	3.65%	> 1308%	**195**	< 1.01E+01	n/a	n/a
97	4.75E+03	3.83%	0.04%	**148**	6.88E+01	1.08%	> 1251%	**196**	4.01E+01	1.02%	273%
98	4.71E+03	3.41%	-2.51%	**149**	< 1.01E+01	n/a	n/a	**198**	2.61E+03	3.32%	384%
99	3.07E+03	4.09%	3.18%	**150**	6.38E+01	1.18%	> 1151%	**203**	< 1.01E+01	n/a	n/a
100	4.91E+03	3.47%	-3.02%	**151**	< 1.01E+01	n/a	n/a	**204**	1.45E+03	2.98%	361%
101	5.28E+02	1.87%	47.3%	**152**	2.09E+01	5.04%	> 311%	**205**	< 1.01E+01	n/a	n/a
102	4.58E+02	4.77%	44.9%	**153**	< 1.01E+01	n/a	n/a	**206**	4.59E+02	0.47%	27.4%
103	7.35E+02	3.72%	7.28%	**154**	< 1.01E+01	n/a	n/a	**207**	4.07E+02	2.87%	29.9%
104	3.03E+02	2.42%	78.4%	**155**	< 1.01E+01	n/a	n/a	**208**	9.77E+02	3.14%	28.2%
105	3.69E+02	4.77%	> 625%	**156**	< 1.01E+01	n/a	n/a	**229**	< 1.01E+01	n/a	n/a
106	2.83E+02	5.07%	> 455%	**157**	< 1.01E+01	n/a	n/a	**230**	< 1.01E+01	n/a	n/a
107	6.57E+02	2.88%	> 3126%	**158**	< 1.01E+01	n/a	n/a	**232**	3.56E+03	2.75%	32060%
108	< 1.01E+01	n/a	n/a	**159**	< 1.01E+01	n/a	n/a	**233**	6.90E+01	1.38%	768%
109	4.86E+02	1.90%	> 6255%	**160**	< 1.01E+01	n/a	n/a	**234**	2.27E+01	1.98%	> 345%
110	< 1.01E+01	n/a	n/a	**161**	< 1.01E+01	n/a	n/a	**235**	4.97E+02	2.38%	701%
111	< 1.01E+01	n/a	n/a	**162**	< 1.01E+01	n/a	n/a	**236**	1.46E+02	3.10%	754%
112	1.93E+01[b]	n/a	107%	**163**	< 1.01E+01	n/a	n/a	**237**	6.63E+01	1.96%	221%
113	< 1.01E+01	n/a	n/a	**164**	< 1.01E+01	n/a	n/a	**238**	1.37E+04	2.21%	2589%
114	1.56E+01	49.0%	72.0%	**165**	< 1.01E+01	n/a	n/a	**239**	< 3.60E+01	n/a	n/a
116	2.31E+02	3.74%	78.8%	**166**	< 1.01E+01	n/a	n/a	**240**	< 1.01E+01	n/a	n/a
117	8.82E+01	6.45%	-5.87%	**167**	< 1.01E+01	n/a	n/a	**241**	< 1.01E+01	n/a	n/a
118	2.60E+02	4.77%	0.91%	**168**	< 1.01E+01	n/a	n/a	**242**	< 1.01E+01	n/a	n/a
119	2.99E+02	3.61%	229%	**169**	< 1.01E+01	n/a	n/a	**243**	< 1.01E+01	n/a	n/a
120	3.33E+02	6.97%	-4.17%	**170**	< 1.01E+01	n/a	n/a	**244**	< 1.01E+01	n/a	n/a
121	6.73E+00	0.82%	7.77%	**171**	< 1.01E+01	n/a	n/a	**245**	< 1.01E+01	n/a	n/a
122	8.73E+01	3.30%	-6.07%	**172**	< 1.01E+01	n/a	n/a	**246**	< 1.01E+01	n/a	n/a
123	< 1.01E+01	n/a	n/a	**173**	< 1.01E+01	n/a	n/a	**247**	< 1.01E+01	n/a	n/a
124	1.38E+02	3.99%	-5.03%	**174**	< 1.01E+01	n/a	n/a	**248**	< 8.09E+01	n/a	n/a
125	< 1.01E+01	n/a	n/a	**175**	< 1.01E+01	n/a	n/a	**249**	< 1.01E+01	n/a	n/a
126	4.79E+02	3.02%	-1.21%	**176**	< 1.01E+01	n/a	n/a	**250**	< 1.01E+01	n/a	n/a
128	1.28E+01	7.39%	> 152%	**177**	< 1.01E+01	n/a	n/a	**251**	< 1.31E+01	n/a	n/a
130	6.18E+01	9.30%	> 1113%	**178**	< 1.01E+01	n/a	n/a				
133	6.82E+03	2.94%	-1.78%	**179**	< 1.01E+01	n/a	n/a				

[*]Shaded cells indicate masses where the difference between the filtrate and digested slurry is greater than 20% (ICP-MS method uncertainty). [a]The %RSD is based on the standard deviation of duplicate samples. The reported method uncertainty is 20% at two sigma. [b]Single result above the method detection limit. The duplicate sample had a reported concentration of < 1.01E+01 µg/L.

Table 3-13. ICP-MS Results for Tank 10H Batch 1 Preliminary VDS Digested Slurry Sample (HTF-10-21-57 Slurry)

m/z	Avg. Conc. (µg/L)	% RSD[a]	% Change from Filtrate	m/z	Avg. Conc. (µg/L)	% RSD[a]	% Change from Filtrate	m/z	Avg. Conc. (µg/L)	% RSD[a]	% Change from Filtrate
59[*]	1.93E+01	7.19%	> 273%	**134**	2.01E+01	0.15%	> 288%	**180**	< 1.02E+01	n/a	n/a
84	< 1.02E+01	n/a	n/a	**135**	6.80E+02	1.18%	0.18%	**181**	< 1.02E+01	n/a	n/a
85	9.08E+02	1.39%	1.13%	**136**	< 1.02E+01	n/a	n/a	**182**	5.82E+01	1.15%	-7.18%
86	< 1.02E+01	n/a	n/a	**137**	1.64E+03	0.50%	27.5%	**183**	3.31E+01	0.67%	-5.91%
87	1.90E+03	0.14%	-0.62%	**138**	1.97E+02	6.70%	737%	**184**	6.90E+01	1.76%	-5.78%
88	1.33E+02	1.69%	> 759%	**139**	1.83E+02	0.11%	> 3427%	**185**	< 1.02E+01	n/a	n/a
89	7.30E+01	2.66%	> 1310%	**140**	7.54E+02	2.87%	> 14453%	**186**	6.52E+01	0.09%	-4.59%
90	1.07E+02	5.57%	1864%	**141**	1.56E+02	3.54%	> 2909%	**187**	< 1.02E+01	n/a	n/a
91	9.02E+01	4.09%	> 1642%	**142**	2.45E+02	1.99%	> 4629%	**188**	< 1.02E+01	n/a	n/a
92	1.81E+02	2.38%	87%	**143**	1.46E+02	2.35%	> 2710%	**189**	< 1.02E+01	n/a	n/a
93	1.13E+02	1.24%	> 2079%	**144**	1.60E+02	1.38%	> 2993%	**191**	< 1.02E+01	n/a	n/a
94	1.54E+02	2.57%	158%	**145**	1.05E+02	3.85%	> 1931%	**193**	< 1.02E+01	n/a	n/a
95	5.41E+03	0.15%	-0.84%	**146**	8.22E+01	2.33%	> 1487%	**194**	< 1.02E+01	n/a	n/a
96	1.98E+02	0.56%	76.5%	**147**	5.18E+01	4.81%	> 900%	**195**	< 1.02E+01	n/a	n/a
97	4.93E+03	0.02%	0.35%	**148**	5.09E+01	2.68%	> 882%	**196**	3.84E+01	3.84%	252%
98	4.90E+03	0.68%	0.46%	**149**	< 1.02E+01	n/a	n/a	**198**	2.39E+03	2.02%	319%
99	3.12E+03	0.09%	4.65%	**150**	4.64E+01	7.88%	> 796%	**203**	< 1.02E+01	n/a	n/a
100	5.08E+03	0.06%	-0.93%	**151**	< 1.02E+01	n/a	n/a	**204**	1.33E+03	1.20%	301%
101	5.20E+02	0.05%	40.8%	**152**	1.43E+01	4.97%	> 175%	**205**	< 1.02E+01	n/a	n/a
102	4.46E+02	1.81%	37.0%	**153**	< 1.02E+01	n/a	n/a	**206**	4.13E+02	0.15%	30%
103	7.75E+02	0.23%	8.60%	**154**	< 1.02E+01	n/a	n/a	**207**	3.57E+02	1.24%	29%
104	2.98E+02	0.89%	67.6%	**155**	< 1.02E+01	n/a	n/a	**208**	8.72E+02	0.06%	31%
105	3.85E+02	1.36%	> 643%	**156**	< 1.02E+01	n/a	n/a	**229**	< 1.02E+01	n/a	n/a
106	2.91E+02	0.06%	> 461%	**157**	< 1.02E+01	n/a	n/a	**230**	< 1.02E+01	n/a	n/a
107	5.46E+02	2.93%	> 2534%	**158**	< 1.02E+01	n/a	n/a	**232**	2.73E+03	1.92%	27286%
108	< 1.02E+01	n/a	n/a	**159**	< 1.02E+01	n/a	n/a	**233**	5.57E+01	0.57%	539%
109	3.72E+02	3.41%	> 4691%	**160**	< 1.02E+01	n/a	n/a	**234**	1.87E+01	0.46%	> 260%
110	< 1.02E+01	n/a	n/a	**161**	< 1.02E+01	n/a	n/a	**235**	4.10E+02	1.66%	298%
111	< 1.02E+01	n/a	n/a	**162**	< 1.02E+01	n/a	n/a	**236**	1.19E+02	2.02%	429%
112	1.12E+01	6.30%	22.4%	**163**	< 1.02E+01	n/a	n/a	**237**	5.92E+01	0.22%	132%
113	1.06E+01[b]	n/a	> 36.4%	**164**	< 1.02E+01	n/a	n/a	**238**	1.07E+04	2.69%	1706%
114	1.06E+01[b]	n/a	11.2%	**165**	< 1.02E+01	n/a	n/a	**239**	< 3.28E+01	n/a	n/a
116	2.02E+02	5.35%	60.5%	**166**	< 1.02E+01	n/a	n/a	**240**	< 1.02E+01	n/a	n/a
117	8.90E+01	0.49%	-2.66%	**167**	< 1.02E+01	n/a	n/a	**241**	< 1.02E+01	n/a	n/a
118	2.65E+02	2.26%	3.12%	**168**	< 1.02E+01	n/a	n/a	**242**	< 1.02E+01	n/a	n/a
119	2.52E+02	3.54%	180%	**169**	< 1.02E+01	n/a	n/a	**243**	< 1.02E+01	n/a	n/a
120	3.39E+02	0.57%	-2.77%	**170**	< 1.02E+01	n/a	n/a	**244**	< 1.02E+01	n/a	n/a
121	5.51E+00	2.85%	> 6.37%	**171**	< 1.02E+01	n/a	n/a	**245**	< 1.02E+01	n/a	n/a
122	9.27E+01	1.68%	-2.62%	**172**	< 1.02E+01	n/a	n/a	**246**	< 1.02E+01	n/a	n/a
123	< 1.02E+01	n/a	n/a	**173**	< 1.02E+01	n/a	n/a	**247**	< 1.02E+01	n/a	n/a
124	1.39E+02	2.98%	-1.65%	**174**	< 1.02E+01	n/a	n/a	**248**	< 6.10E+01	n/a	n/a
125	< 1.02E+01	n/a	n/a	**175**	< 1.02E+01	n/a	n/a	**249**	< 1.02E+01	n/a	n/a
126	4.94E+02	2.57%	2.54%	**176**	< 1.02E+01	n/a	n/a	**250**	< 1.02E+01	n/a	n/a
128	< 1.02E+01	n/a	n/a	**177**	< 1.02E+01	n/a	n/a	**251**	< 1.02E+01	n/a	n/a
130	4.79E+01	1.78%	> 824%	**178**	< 1.02E+01	n/a	n/a				
133	7.05E+03	0.48%	-0.20%	**179**	< 1.02E+01	n/a	n/a				

[*]Shaded cells indicate masses where the difference between the filtrate and digested slurry is greater than 20% (ICP-MS method uncertainty). [a]The %RSD is based on the standard deviation of duplicate samples. The reported method uncertainty is 20% at two sigma. [b]Single result above the method detection limit. The duplicate sample had a reported concentration of < 1.02E+01 µg/L.

3.2 Tank 10H Qualification Samples and Additional Depth Samples

The Tank 10H surface qualification sample (HTF-10-21-103) appeared clear and colorless, while the depth sample (HTF-10-21-104) appeared slightly hazy, but did not contain significant solids. A photograph of the samples is shown in Figure 3-10. The two additional depth samples (HTF-10-21-111 and -112) appeared cloudier than the earlier depth sample (-104); with HTF-10-21-111 being the cloudiest of all four samples. A photograph of the later samples is shown in Figure 3-11.

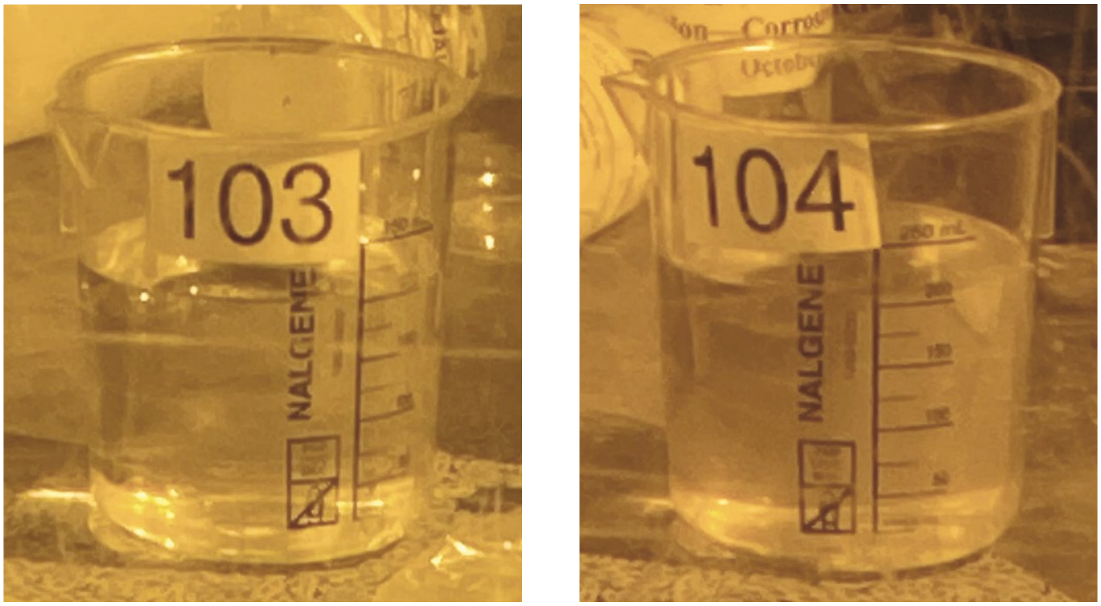

Figure 3-10. Photograph of samples HTF-10-21-103 (left) and HTF-10-21-104 (right)

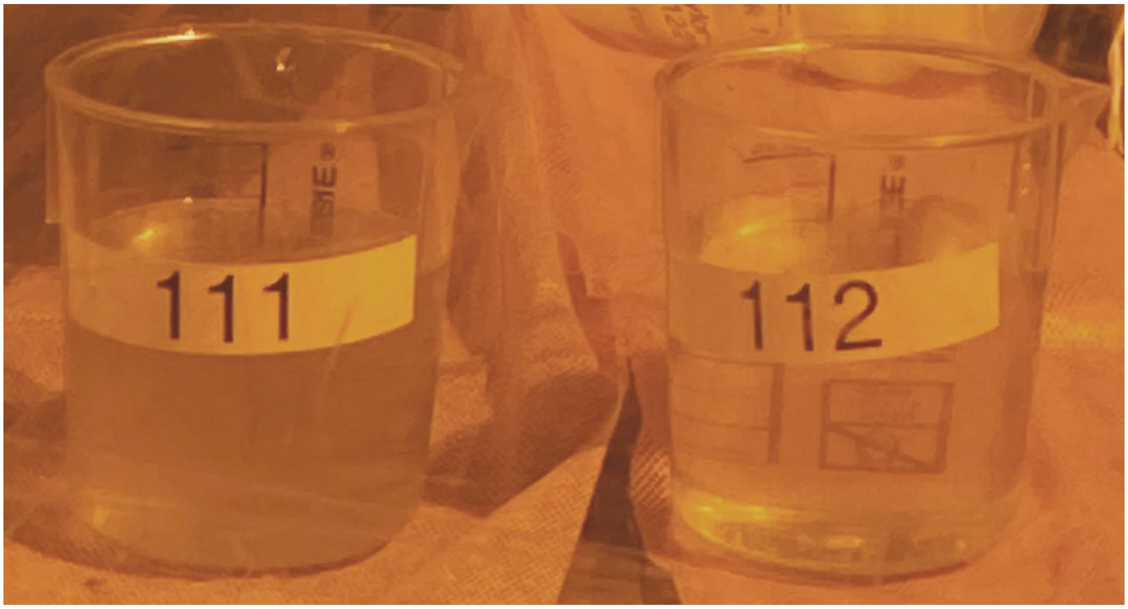

Figure 3-11. Photograph of samples HTF-10-21-111 (left) and HTF-10-21-112 (right)

The densities of the Tank 10H qualification samples are summarized in Table 3-14. The densities of all samples were measured "as-received", and in addition a portion of HTF-10-21-104 was filtered through a 0.45-µm Nylon filter, and the density of the filtrate was measured.

Table 3-14. Density Measurements of Tank 10H Qualification Samples

Sample	Sample Depth	Sample Type	Avg. Density (g/mL)[a]	% RSD[b]
HTF-10-21-103	surface (~119” from tank bottom)	“as-received”	1.312	0.350
HTF-10-21-104	80” from tank bottom	“as-received”	1.387	0.829
HTF-10-21-104	80” from tank bottom	filtrate	1.391	1.27
HTF-10-21-111	90” from tank bottom	“as-received”	1.301	0.462
HTF-10-21-112	80” from tank bottom	“as-received”	1.379	0.462

[a] Temperature during density measurements was 18 °C for HTF-10-21-103 and -104 and was 21 °C for HTF-10-21-111 and -112. [b] Percent relative standard deviation from replicate measurements.

The ICP-ES results of the Tank 10H qualification samples are shown in Table 3-15. Comparison of the surface sample to the VDS (HTF-10-21-104) shows the depth sample is a more concentrated salt solution than the surface, consistent with the higher density, indicating some stratification within the tank. The sodium concentration of the VDS is ~26% higher than the surface sample. Other elements including Al, Cr, Mo, P, and S ranged from 33 to 43% higher in the VDS compared to the surface sample. A summary of the anion concentrations measured in the qualifications samples is shown in Table 3-16. In general, the anion concentrations in the depth sample were on the order of 30% higher than the surface sample, except for free hydroxide and carbonate. The carbonate concentration was approximately 11% higher in the depth sample compared to the surface sample, while the free hydroxide concentration was 35% lower. The sum of cations and anions were in good agreement, with the difference being ~6% for the surface sample and ~0.9% for the depth sample, with anions higher in both cases.

Table 3-15. ICP-ES Results for the Tank 10H Batch 1 Qualification Samples (HTF-10-21-103 and -104)

Element	HTF-10-21-103 (M)	%RSD[a]	HTF-10-21-104 (M)	%RSD[a]	% Difference[b]
Ag	< 2.69E-06	n/a	< 2.77E-06	n/a	n/a
Al	8.35E-02	0.58%	1.18E-01	1.15%	41.6%
B	< 2.44E-04	n/a	< 2.51E-04	n/a	n/a
Ba	< 2.66E-06	n/a	< 2.74E-06	n/a	n/a
Be	< 1.37E-05	n/a	< 1.41E-05	n/a	n/a
Ca	< 5.67E-05	n/a	< 5.83E-05	n/a	n/a
Cd	< 3.20E-06	n/a	< 3.29E-06	n/a	n/a
Ce	< 3.07E-05	n/a	< 3.16E-05	n/a	n/a
Co	< 1.06E-05	n/a	< 1.09E-05	n/a	n/a
Cr	3.89E-04	0.31%	5.33E-04	1.35%	37.0%
Cu	< 1.18E-05	n/a	< 1.22E-05	n/a	n/a
Fe	< 2.65E-05	n/a	< 2.73E-05	n/a	n/a
Gd	< 3.33E-06	n/a	< 3.43E-06	n/a	n/a
K	< 1.06E-02	n/a	< 1.09E-02	n/a	n/a
La	< 1.72E-06	n/a	< 1.77E-06	n/a	n/a
Li	< 1.46E-03	n/a	< 1.50E-03	n/a	n/a
Mg	< 3.28E-05	n/a	< 3.38E-05	n/a	n/a
Mn	< 2.49E-05	n/a	< 2.56E-05	n/a	n/a
Mo	1.12E-04	1.15%	1.49E-04	0.33%	33.1%
Na	6.20E+00	0.35%	7.80E+00	0.53%	25.9%
Nb	< 1.66E-04	n/a	< 1.71E-04	n/a	n/a
Ni	< 1.42E-05	n/a	< 1.46E-05	n/a	n/a
P	2.36E-03	1.81%	3.22E-03	0.40%	36.2%
Pb	< 2.74E-05	n/a	< 2.82E-05	n/a	n/a
S	8.00E-02	0.65%	1.14E-01	1.34%	43.1%
Sb	< 1.60E-05	n/a	< 1.65E-05	n/a	n/a
Si	< 3.60E-04	n/a	< 3.71E-04	n/a	n/a
Sn	< 1.14E-04	n/a	< 1.17E-04	n/a	n/a
Sr	< 2.51E-05	n/a	< 2.59E-05	n/a	n/a
Th	< 1.89E-05	n/a	< 1.95E-05	n/a	n/a
Ti	< 3.01E-05	n/a	< 3.10E-05	n/a	n/a
U	< 3.55E-05	n/a	< 3.65E-05	n/a	n/a
V	< 4.66E-05	n/a	< 4.80E-05	n/a	n/a
Zn	< 9.88E-06	n/a	< 1.02E-05	n/a	n/a
Zr	< 4.23E-06	n/a	< 4.35E-06	n/a	n/a

[a] Percent relative standard deviation from duplicate samples. The reported method uncertainty ranged from 10 to 10.8%. [b] Percent difference is defined here as (VDS-Surface)/Surface x 100%.

Table 3-16. Anion and Carbon Results for the Tank 10H Batch 1 Qualification Samples (HTF-10-21-103 and -104)

Analyte	HTF-10-21-103	%RSD[a]	HTF-10-21-104	%RSD[a]	% Difference[b]
Free OH^- (M)	0.698	1.24%	0.452	25.1%	-35.2%
NO_3^- (M)	3.87	0.127%	4.99	2.25%	28.9%
SO_4^{2-} (M)	0.0920	0.242%	0.118	6.72%	28.7%
NO_2^- (M)	0.444	0.0133%	0.607	0.0954%	36.6%
F^- (M)	< 0.0156	n/a	< 0.0152	n/a	n/a
Cl^- (M)	< 0.00833	n/a	< 0.00813	n/a	n/a
Br^- (M)	< 0.0185	n/a	< 0.0180	n/a	n/a
HCO_2^- (M)	< 0.00656	n/a	< 0.00640	n/a	n/a
PO_4^{3-} (M)	< 0.00311	n/a	< 0.00304	n/a	n/a
$C_2O_4^{2-}$ (M)	0.00409	0.184%	0.00535	1.09%	30.7%
CO_3^{2-} (M)	0.655	14.4%	0.726	0.789%	10.8%
TOC (mg/L)	200	18.0%	224	0.183%	11.9%

[a]Percent relative standard deviation from duplicate samples. The reported method uncertainty is 10%. [b]Percent difference is defined here as (VDS-Surface)/Surface x 100%.

Gamma spectroscopy and LSC (with and without Cs removal) were performed on the two qualification samples (HTF-10-21-103 and HTF-10-21-104) and the results are summarized in Table 3-17. The gamma and beta activity in the variable depth sample was approximately 36% higher than the surface sample. The alpha activity was below the detection limit in all samples. There was a significant increase (~3X) in the beta activity remaining after Cs removal in the VDS sample indicating higher concentrations of other (non-Cs) beta emitters in the VDS samples, likely ^{90}Sr. This was consistent with the measured ^{90}Sr activity in the two samples, where the activity in the VDS was ~4.4X the activity in the surface sample. A summary of other radionuclide activities in the Tank 10H qualification samples is provided in Table 3-18.

Table 3-17. Alpha, Beta and Gamma Activities in Tank 10H Qualification Samples

	^{137}Cs (dpm/mL)	Alpha Activity (dpm/mL)	Beta Activity (dpm/mL)	Cs Removed	
				Alpha Activity (dpm/mL)	**Beta Activity (dpm/mL)**
HTF-10-21-103	2.20E+08 (0.56% RSD)	< 6.45E+04	2.70E+08 (1.65% RSD)	< 3.05E+04	4.77E+05 (0.20% RSD)
HTF-10-21-104	3.00E+08 (3.49% RSD)	< 6.85E+04	3.66E+08 (0.48% RSD)	< 5.53E+04	1.42E+06 (42.2% RSD)
% Difference[a]	36.3%	n/a	35.7%	n/a	198%

[b]Percent difference is defined here as (VDS-Surface)/Surface x 100%.

Table 3-18. Summary of Radionuclides Measured in the Tank 10H Batch 1 Qualification Samples (HTF-10-21-103 and -104)

Radionuclide	HTF-10-21-103 (dpm/mL)	%RSD[a]	Avg. Method Unc.	HTF-10-21-104 (dpm/mL)	%RSD[a]	Avg. Method Unc.
^{60}Co	< 1.97E+01	n/a	MDA[b]	< 2.21E+01	n/a	MDA
^{90}Sr	1.74E+05	7.14%	19.0%	7.62E+05	58.1%	21.2%
^{99}Tc	8.38E+04	2.50%	10.7%	1.30E+05	2.80%	11.0%
^{106}Ru	< 1.93E+02	n/a	MDA	< 2.31E+02	n/a	MDA
^{125}Sb	< 1.36E+02	n/a	MDA	< 1.70E+02	n/a	MDA
^{126}Sb	7.61E+02	3.91%	5.00%	1.00E+03	0.47%	5.00%
^{126}Sn	7.61E+02	3.91%	5.00%	1.00E+03	0.47%	5.00%
^{129}I	6.90E+00	23.1%	12.9%	9.52E+00	13.1%	7.37%
^{144}Ce	< 2.47E+02	n/a	MDA	< 3.78E+02	n/a	MDA
^{154}Eu	< 5.68E+01	n/a	MDA	1.22E+02	52.9%	12.7%
^{238}Pu	2.90E+04	11.7%	6.24%	4.89E+04	8.00%	5.93%
$^{239/240}$Pu	3.90E+02	17.0%	10.4%	7.63E+02	9.60%	9.23%
^{241}Pu	3.04E+03	16.0%	15.8%	4.53E+03	2.13%	15.5%
^{241}Am	< 3.60E+02	n/a	MDA	6.63E+02[c]	n/a	24.2%

[a]The %RSD is based on the standard deviation of duplicate samples. [b]MDA = minimum detectable activity. [c]Single replicate above the detection limit. The duplicate sample was < 4.91E+02 dpm/mL.

The isotopic distribution of Cs based on the mass spectrometry results of the surface and VDS samples is provided in Table 3-19. The total Cs calculated using the isotopic ratios from the ICP-MS data and the ^{137}Cs amount from the gamma data is 7.08 mg/L for the surface sample and 9.79 mg/L for the VDS sample. The value for the surface sample is 10.8% higher than the sum of the Cs isotope masses reported by ICP-MS (6.40 mg/L). The total Cs value for the depth sample is 12.0% higher than the sum of the Cs isotope masses reported by ICP-MS (8.74 mg/L). The full suites of ICP-MS results are provided in Tables 3-20 through 3-21.

Table 3-19. Cs Isotopes from ICP-MS for the Tank 10H Qualification Samples

HTF-10-21-103				
Isotope	**Mean Concentration (mg/L)**	**%RSD[b]**	**Isotopic Distribution, Mass %**	**Mole Fraction**
Cs-133	4.90	1.09	76.7	0.771
Cs-134	1.32E-03[a]	n/a	0.0206	2.06E-04
Cs-135	0.462	1.11	7.23	0.072
Cs-137	1.03	1.16	16.1	0.157
HTF-10-21-104				
Isotope	**Mean Concentration (mg/L)**	**%RSD[b]**	**Isotopic Distribution, Mass %**	**Mole Fraction**
Cs-133	6.72	0.03	76.9	0.774
Cs-134	1.70E-03	11.5	0.0195	1.94E-04
Cs-135	0.627	0.34	7.18	0.071
Cs-137	1.39	0.08	15.9	0.155

[a]Single replicate above the detection limit. [b]Percent relative standard deviation from duplicate samples. The reported method uncertainty is 20% at two sigma.

Table 3-20. ICP-MS Results for Tank 10H Batch 1 Qualification Surface Sample (HTF-10-21-103)

m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]
59	1.96E+00	31.70%	**134**	1.71E+00[b]	n/a	**180**	< 1.49E+00	n/a
84	< 1.49E+00	n/a	**135**	4.63E+02	1.11%	**181**	< 1.49E+00	n/a
85	5.92E+02	0.02%	**136**	< 2.97E+00	n/a	**182**	4.15E+01	1.41%
86	< 2.97E+00	n/a	**137**	1.03E+03	1.16%	**183**	2.34E+01	2.03%
87	1.31E+03	0.58%	**138**	1.16E+01	4.00%	**184**	4.88E+01	1.80%
88	1.01E+01	4.88%	**139**	< 1.49E+00	n/a	**185**	< 1.49E+00	n/a
89	< 1.49E+00	n/a	**140**	1.71E+00	0.79%	**186**	4.55E+01	0.62%
90	4.42E+00	5.77%	**141**	< 1.49E+00	n/a	**187**	1.76E+00	1.06%
91	< 2.97E+00	n/a	**142**	< 1.49E+00	n/a	**188**	< 1.49E+00	n/a
92	5.72E+01	3.21%	**143**	< 1.49E+00	n/a	**189**	< 1.49E+00	n/a
93	6.77E+00	1.72%	**144**	< 1.49E+00	n/a	**191**	< 1.49E+00	n/a
94	3.86E+01	2.10%	**145**	< 1.49E+00	n/a	**193**	< 1.49E+00	n/a
95	3.27E+03	0.79%	**146**	< 1.49E+00	n/a	**194**	< 1.49E+00	n/a
96	6.79E+01	1.12%	**147**	< 1.49E+00	n/a	**195**	< 1.49E+00	n/a
97	3.16E+03	0.86%	**148**	< 1.49E+00	n/a	**196**	5.31E+00	1.29%
98	2.99E+03	0.15%	**149**	< 1.49E+00	n/a	**198**	< 1.49E+00	n/a
99	2.01E+03	0.65%	**150**	< 1.49E+00	n/a	**203**	< 1.49E+00	n/a
100	3.20E+03	0.18%	**151**	< 1.49E+00	n/a	**204**	< 1.49E+00	n/a
101	1.68E+02	0.87%	**152**	< 1.49E+00	n/a	**205**	< 1.49E+00	n/a
102	1.49E+02	0.56%	**153**	< 1.49E+00	n/a	**206**	2.71E+02	0.08%
103	3.83E+02	0.67%	**154**	< 1.49E+00	n/a	**207**	2.32E+02	0.12%
104	7.88E+01	0.43%	**155**	< 1.49E+00	n/a	**208**	5.66E+02	0.52%
105	8.71E+00	3.01%	**156**	< 1.49E+00	n/a	**229**	< 1.49E+00	n/a
106	8.84E+00	26.30%	**157**	< 1.49E+00	n/a	**230**	< 1.49E+00	n/a
107	3.89E+00	1.80%	**158**	1.80E+00	2.11%	**232**	6.63E+00	17.89%
108	1.73E+00	9.88%	**159**	< 1.49E+00	n/a	**233**	3.46E+00	2.03%
109	< 1.49E+00	n/a	**160**	1.60E+00	4.51%	**234**	< 1.49E+00	n/a
110	< 1.49E+00	n/a	**161**	< 1.49E+00	n/a	**235**	2.65E+01	0.17%
111	1.93E+00	6.07%	**162**	< 1.49E+00	n/a	**236**	7.16E+00	2.05%
112	6.22E+00	4.53%	**163**	< 1.49E+00	n/a	**237**	7.44E+00	0.06%
113	< 1.49E+00	n/a	**164**	< 1.49E+00	n/a	**238**	3.04E+02	0.76%
114	5.97E+00	0.54%	**165**	< 1.49E+00	n/a	**239**	2.05E+00	0.53%
116	7.95E+01	0.43%	**166**	< 1.49E+00	n/a	**240**	< 1.49E+00	n/a
117	5.64E+01	0.53%	**167**	< 1.49E+00	n/a	**241**	< 1.49E+00	n/a
118	1.57E+02	0.69%	**168**	< 1.49E+00	n/a	**242**	< 1.49E+00	n/a
119	5.43E+01	0.92%	**169**	< 1.49E+00	n/a	**243**	< 1.49E+00	n/a
120	2.15E+02	0.25%	**170**	< 1.49E+00	n/a	**244**	< 1.49E+00	n/a
121	< 2.97E+00	n/a	**171**	< 1.49E+00	n/a	**245**	< 1.49E+00	n/a
122	5.58E+01	2.89%	**172**	< 1.49E+00	n/a	**246**	< 1.49E+00	n/a
123	1.61E+00[b]	n/a	**173**	< 1.49E+00	n/a	**247**	< 1.49E+00	n/a
124	8.76E+01	0.04%	**174**	< 1.49E+00	n/a	**248**	< 1.49E+00	n/a
125	< 1.49E+00	n/a	**175**	< 1.49E+00	n/a	**249**	< 1.49E+00	n/a
126	2.79E+02	1.15%	**176**	< 1.49E+00	n/a	**250**	< 1.49E+00	n/a
128	< 1.49E+00	n/a	**177**	< 1.49E+00	n/a	**251**	< 1.49E+00	n/a
130	< 1.49E+00	n/a	**178**	< 1.49E+00	n/a			
133	4.90E+03	1.09%	**179**	< 1.49E+00	n/a			

[a] The %RSD is based on the standard deviation of duplicate samples. The reported method uncertainty is 20% at two sigma. [b] Single result above the method detection limit. The duplicate sample had a reported concentration of < 1.50E+00 µg/L.

Table 3-21. ICP-MS Results for Tank 10H Batch 1 Qualification VDS (HTF-10-21-104)

m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]	m/z	Avg. Conc. (µg/L)	% RSD[a]
59	1.69E+00	3.33%	**134**	2.22E+00	11.5%	**180**	< 1.50E+00	n/a
84	< 1.50E+00	n/a	**135**	6.29E+02	0.34%	**181**	< 1.50E+00	n/a
85	8.05E+02	0.59%	**136**	< 3.00E+00	n/a	**182**	5.08E+01	0.43%
86	< 3.00E+00	n/a	**137**	1.39E+03	0.08%	**183**	2.83E+01	0.83%
87	1.79E+03	0.18%	**138**	1.54E+01	9.17%	**184**	6.04E+01	1.76%
88	1.46E+01	5.07%	**139**	4.84E+00	26.52%	**185**	< 1.50E+00	n/a
89	3.72E+00	19.09%	**140**	2.94E+01	24.71%	**186**	5.60E+01	1.01%
90	7.39E+00	7.03%	**141**	4.98E+00	23.87%	**187**	2.25E+00	0.24%
91	5.75E+00	14.02%	**142**	9.08E+00	26.35%	**188**	< 1.50E+00	n/a
92	7.83E+01	1.18%	**143**	4.83E+00	24.52%	**189**	< 1.50E+00	n/a
93	7.73E+00	15.01%	**144**	5.15E+00	23.39%	**191**	< 1.50E+00	n/a
94	5.33E+01	0.73%	**145**	3.54E+00	23.99%	**193**	< 1.50E+00	n/a
95	4.39E+03	0.39%	**146**	2.94E+00	25.17%	**194**	< 1.50E+00	n/a
96	9.23E+01	0.77%	**147**	1.88E+00	21.10%	**195**	1.59E+00	9.20%
97	4.26E+03	0.27%	**148**	2.10E+00[b]	n/a	**196**	9.24E+00	2.23%
98	4.00E+03	0.53%	**149**	< 1.50E+00	n/a	**198**	< 1.50E+00	n/a
99	2.71E+03	0.34%	**150**	1.98E+00[b]	n/a	**203**	< 1.50E+00	n/a
100	4.30E+03	0.27%	**151**	< 1.50E+00	n/a	**204**	< 1.50E+00	n/a
101	2.30E+02	0.06%	**152**	< 1.50E+00	n/a	**205**	< 1.50E+00	n/a
102	2.02E+02	1.26%	**153**	< 1.50E+00	n/a	**206**	3.30E+02	0.22%
103	5.17E+02	0.26%	**154**	< 1.50E+00	n/a	**207**	2.84E+02	0.23%
104	1.07E+02	0.58%	**155**	< 1.50E+00	n/a	**208**	6.93E+02	0.16%
105	1.45E+01	1.60%	**156**	1.63E+00[b]	n/a	**229**	< 1.50E+00	n/a
106	1.33E+01	6.07%	**157**	< 1.50E+00	n/a	**230**	< 1.50E+00	n/a
107	1.34E+01	8.11%	**158**	1.85E+00	0.82%	**232**	1.10E+02	23.47%
108	2.33E+00	2.66%	**159**	< 1.50E+00	n/a	**233**	6.98E+00	5.86%
109	8.09E+00	13.67%	**160**	1.62E+00	0.88%	**234**	< 1.50E+00	n/a
110	< 1.50E+00	n/a	**161**	< 1.50E+00	n/a	**235**	5.20E+01	5.95%
111	2.17E+00	0.47%	**162**	< 1.50E+00	n/a	**236**	1.45E+01	6.34%
112	7.90E+00	0.74%	**163**	< 1.50E+00	n/a	**237**	1.26E+01	2.97%
113	< 3.00E+00	n/a	**164**	< 1.50E+00	n/a	**238**	7.85E+02	11.75%
114	7.86E+00	1.93%	**165**	< 1.50E+00	n/a	**239**	3.44E+00	3.92%
116	1.09E+02	0.15%	**166**	< 1.50E+00	n/a	**240**	< 1.50E+00	n/a
117	7.58E+01	0.97%	**167**	< 1.50E+00	n/a	**241**	< 1.50E+00	n/a
118	2.11E+02	0.29%	**168**	< 1.50E+00	n/a	**242**	< 1.50E+00	n/a
119	7.74E+01	1.69%	**169**	< 1.50E+00	n/a	**243**	< 1.50E+00	n/a
120	2.88E+02	0.36%	**170**	< 1.50E+00	n/a	**244**	< 1.50E+00	n/a
121	3.35E+00	1.43%	**171**	< 1.50E+00	n/a	**245**	< 1.50E+00	n/a
122	7.56E+01	0.18%	**172**	< 1.50E+00	n/a	**246**	< 1.50E+00	n/a
123	< 3.00E+00	n/a	**173**	< 1.50E+00	n/a	**247**	< 1.50E+00	n/a
124	1.18E+02	1.35%	**174**	< 1.50E+00	n/a	**248**	< 3.00E+00	n/a
125	< 1.50E+00	n/a	**175**	< 1.50E+00	n/a	**249**	< 1.50E+00	n/a
126	3.66E+02	2.32%	**176**	< 1.50E+00	n/a	**250**	< 1.50E+00	n/a
128	< 1.50E+00	n/a	**177**	< 1.50E+00	n/a	**251**	< 1.50E+00	n/a
130	1.91E+00	18.36%	**178**	< 1.50E+00	n/a			
133	6.72E+03	0.03%	**179**	< 1.50E+00	n/a			

[a] The %RSD is based on the standard deviation of duplicate samples. The reported method uncertainty is 20% at two sigma. [b] Single result above the method detection limit. The duplicate sample had a reported concentration of < 1.51E+00 µg/L.

3.3 Tank 10H In-Tank Batch Contact Samples

Duplicate aliquots of the solutions generated from digestion of the CST contained in the teabags and the CST digestion standards, as well as the soak solutions, were submitted for replicate gamma spectroscopy analysis. Soak solutions were all 65 mL in volume. The individual results of these analyses, as well as the average and standard deviations of the replicates are shown in Table 3-22. The activity per gram is calculated based on the air-dried mass of CST that was used for the digestion.

Table 3-22. ^{137}Cs Activity from Gamma Counting for In-Tank Batch Contact Samples, Digestion Standards, and Soak Solutions

	Replicate 1	Replicate 2	Average	St. Dev.	%RSD[a]
Teabag B1	9.21E+10 dpm/g	9.46E+10 dpm/g	9.34E+10 dpm/g	1.77E+09 dpm/g	1.89%
Teabag B2	9.98E+10 dpm/g	9.84E+10 dpm/g	9.91E+10 dpm/g	9.90E+08 dpm/g	1.00%
CST Standard B1	< 4.66E+06 dpm/g	< 4.44E+06 dpm/g	< 4.55E+06 dpm/g	n/a	n/a
CST Standard B2	< 3.04E+06 dpm/g	< 3.96E+06 dpm/g	< 3.50E+06 dpm/g	n/a	n/a
Teabag B1 – 0.01 M NaOH soak	1.86E+06 dpm/mL	1.85E+06 dpm/mL	1.86E+06 dpm/mL	7.07E+03 dpm/mL	0.381%
Teabag B1 – DI Water soak	2.59E+04 dpm/mL	2.86E+04 dpm/mL	2.73E+04 dpm/mL	1.91E+03 dpm/mL	7.01%
Teabag B2 – 0.01 M NaOH soak	2.29E+06 dpm/mL	2.20E+06 dpm/mL	2.25E+06 dpm/mL	6.36E+04 dpm/mL	2.83%
Teabag B2 – DI Water soak	1.70E+05 dpm/mL	1.74E+05 dpm/mL	1.72E+05 dpm/mL	2.83E+03 dpm/mL	1.64%

Units: Cs-137 dpm/g air-dried CST; Cs-137 dpm/mL of soak solution.[a]The %RSD is based on the standard deviation of the replicate samples. The reported method uncertainty is 5% at one sigma.

Two aliquots of the CST standard were digested alongside the CST from the teabags in the Shielded Cells, and solutions from these digestions were analyzed by gamma spectroscopy as well as ICP-MS. The main purpose of these standards is to confirm complete digestion of the CST; however, they also serve as a blank to detect cross contamination of the samples during handling and digestion in the Shielded Cells. As can be seen in Table 3-22, both standards had ^{137}Cs activities below the method detection limit and, therefore, indicate no significant level of contamination that would have affected the results. The amount of ^{137}Cs found in the soak solutions used for rinsing the teabags was also low. The amount of ^{137}Cs in the combined 0.01 M NaOH and deionized water solutions for each teabag amounted to less than 2% of the ^{137}Cs found on the CST. The ICP-MS analysis of the standards showed Ti, Nb, and Zr concentrations within the control limits established during the development of the standard.[4] The Ti, Nb, and Zr concentrations measured for the teabag samples were also within the standard control limits indicating complete dissolution. The full suite of ICP-MS results for the in-tank batch contact samples and digestion standards are provided in Tables 3-24 and 3-25, respectively. The masses from 106 to 112 are due to the presence of mono oxides of Zr and Nb. The masses from 176-180 are from hafnium (Hf) which is a known contaminant of the Zr in the CST.

As described in Task 8 of the TTR,[8] the ^{137}Cs loading for a single in-tank batch contact teabag is calculated by adding the ^{137}Cs found in the two associated soak solutions (average plus 2 sigma analytical uncertainty[b]) to the ^{137}Cs activity calculated from the average of replicate analyses of a single teabag sample (plus 2 sigma analytical uncertainty[b]). Those results, along with the average and standard deviation of the two individual teabags, are provided in Table 3-23.

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[b] The 2-sigma analytical uncertainty refers to 2 standard deviations of the replicate analyses.

Table 3-23. Calculated ^{137}Cs Loadings on the Individual In-Tank Batch Contact Samples.

	^{137}Cs Loading (dpm/g)	**^{137}Cs Loading (Ci/kg$_{CST}$)**
Teabag B1	9.81E+10	4.42E+01
Teabag B2	1.03E+11	4.63E+01
Average	1.00E+11	4.52E+01
Standard Deviation	3.36E+09	1.51E+00

[a]Values include the 2 sigma uncertainties of the CST and soak solution measurements.

As stated above the ^{137}Cs loadings reported in Tables 3-22 and 3-23 are based on the air-dried mass of CST used for the digestions. To compare these results directly with the ZAM (Zheng, Anthony, Miller) modeling results, the loadings should be corrected for the true dry mass (i.e., mass remaining at 460 °C). For this batch of pretreated CST, the mass remaining at 460 °C was 81.07 wt %, which gives an F-factor of 0.8107.[4] The average ^{137}Cs loading from the duplicate teabags, corrected to the true dry mass, is 55.8 ± 1.86[c] Ci/kg$_{CST}$. The uncertainty represents the standard deviation of the replicate teabag loadings; however, the reported analytical uncertainty for the gamma spectroscopy measurement is 5% at one sigma.

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[c] Standard deviation from Table 3-23 corrected to the true dry mass.

Table 3-24. ICP-MS Results for In-Tank Batch Contact Samples (Teabags B1 and B2)

m/z	Avg. Conc. (µg/g)	%RSD[a]	m/z	Avg. Conc. (µg/g)	%RSD[a]	m/z	Avg. Conc. (µg/g)	%RSD[a]
Ti	1.42E+05	7.89%	133	2.11E+03	5.87%	178	5.60E+02	5.63%
59	9.46E-01	28.11%	134	6.97E-01	0.20%	179	2.79E+02	6.34%
84	< 5.14E-01	n/a	135	2.03E+02	6.07%	180	7.16E+02	6.20%
85	1.36E+01	1.77%	136	6.89E-01	1.40%	181	1.78E+02	7.04%
86	8.19E-01	8.60%	137	4.77E+02	3.97%	182	8.75E-01	27.84%
87	3.19E+01	3.61%	138	6.25E+00	3.97%	183	5.46E-01[c]	n/a
88	7.36E+00	4.07%	139	5.82E-01	5.61%	184	9.48E-01	22.99%
89	2.02E+00	2.99%	140	1.31E+01	8.27%	185	< 5.14E-01	n/a
Zr	9.68E+04	7.10%	141	< 5.14E-01	n/a	186	9.39E-01	27.48%
92	1.53E+04	7.29%	142	1.94E+00	10.69%	187	< 5.14E-01	n/a
Nb	1.16E+05	7.18%	143	< 5.14E-01	n/a	191	< 5.14E-01	n/a
94	1.59E+04	7.44%	144	< 5.14E-01	n/a	193	< 5.14E-01	n/a
95	1.05E+00[b]	n/a	145	< 5.14E-01	n/a	194	< 5.14E-01	n/a
96	2.39E+03	6.94%	146	< 5.14E-01	n/a	195	2.41E+00	4.74%
97	5.59E-01[b]	n/a	147	< 5.14E-01	n/a	196	5.57E+00	2.75%
98	1.23E+00[b]	n/a	148	< 5.14E-01	n/a	198	3.24E+00	9.18%
99	< 5.14E-01	n/a	149	< 5.14E-01	n/a	203	7.38E+00	7.87%
100	5.28E-01[b]	n/a	150	< 5.14E-01	n/a	204	1.84E+01	18.63%
101	< 1.54E+00	n/a	151	< 5.14E-01	n/a	205	< 5.14E-01	n/a
102	8.53E-01	12.97%	152	< 5.14E-01	n/a	206	1.53E+01	9.91%
103	7.60E-01	17.23%	153	< 5.14E-01	n/a	207	< 5.14E-01	n/a
104	< 5.14E-01	n/a	154	< 5.14E-01	n/a	208	9.21E+01	2.37%
105	< 5.14E-01	n/a	155	< 5.14E-01	n/a	229	7.84E+01	1.96%
106	5.41E+01	7.89%	156	< 5.14E-01	n/a	230	1.91E+02	2.37%
107	5.28E+01	73.30%	157	< 5.14E-01	n/a	232	< 5.14E-01	n/a
108	1.96E+01	8.44%	158	< 5.14E-01	n/a	233	< 5.14E-01	n/a
109	1.51E+02	31.52%	159	< 5.14E-01	n/a	234	< 5.14E+00	n/a
110	2.85E+01	5.10%	160	< 5.14E-01	n/a	235	5.97E-01	11.24%
111	2.15E+00	8.87%	161	< 5.14E-01	n/a	236	< 5.14E-01	n/a
112	6.87E+00	5.72%	162	< 5.14E-01	n/a	237	4.63E+00	9.15%
113	< 1.03E+00	n/a	163	< 5.14E-01	n/a	238	1.20E+00	11.35%
114	< 5.14E-01	n/a	164	< 5.14E-01	n/a	239	1.69E+00	6.81%
116	< 5.14E-01	n/a	165	< 5.14E-01	n/a	240	5.31E+01	16.48%
117	< 5.14E-01	n/a	166	< 5.14E-01	n/a	241	5.18E-01	5.42%
118	< 5.14E-01	n/a	167	< 5.14E-01	n/a	242	< 5.14E-01	n/a
119	1.08E+00	19.46%	168	< 5.14E-01	n/a	243	< 5.14E-01	n/a
120	5.06E-01[b]	n/a	169	< 5.14E-01	n/a	244	< 5.14E-01	n/a
121	< 5.14E-01	n/a	170	< 5.14E-01	n/a	245	< 5.14E-01	n/a
122	< 5.14E-01	n/a	171	< 5.14E-01	n/a	246	< 5.14E-01	n/a
123	< 5.14E-01	n/a	172	< 5.14E-01	n/a	247	< 5.14E-01	n/a
124	< 5.14E-01	n/a	173	< 5.14E-01	n/a	248	< 5.14E-01	n/a
125	< 5.14E-01	n/a	174	2.98E+00	6.14%	249	< 5.14E-01	n/a
126	6.36E-01[c]	n/a	175	< 5.14E-01	n/a	250	< 5.14E-01	n/a
128	< 5.14E-01	n/a	176	9.93E+01	6.39%	251	< 5.14E-01	n/a
130	< 5.14E-01	n/a	177	3.81E+02	5.70%			

[a] The %RSD is based on the standard deviation of duplicate samples. [b] Single replicate above the detection limit (Teabag B1). Replicate value (Teabag B2) was < 5.38E-01 µg/g. [c] Single replicate above the detection limit (Teabag B2). Replicate value (Teabag B1) was < 4.90E-01 µg/g.

Table 3-25. ICP-MS Results for CST Digestion Standards

m/z	Avg. Conc. (µg/g)	%RSD[a]	m/z	Avg. Conc. (µg/g)	%RSD[a]	m/z	Avg. Conc. (µg/g)	%RSD[a]
Ti	1.43E+05	8.32%	133	< 4.95E-01	n/a	178	5.69E+02	3.15%
59	< 6.44E-01	n/a	134	< 4.95E-01	n/a	179	2.84E+02	3.84%
84	< 4.95E-01	n/a	135	< 4.95E-01	n/a	180	7.31E+02	2.97%
85	< 4.95E-01	n/a	136	< 4.95E-01	n/a	181	1.73E+02	3.66%
86	5.11E-01[b]	n/a	137	< 4.95E-01	n/a	182	9.69E-01[c]	n/a
87	< 4.95E-01	n/a	138	2.20E+00	18.39%	183	5.23E-01[c]	n/a
88	3.99E+00	12.22%	139	5.15E-01	1.97%	184	1.13E+00[c]	n/a
89	1.74E+00	0.30%	140	1.25E+01	3.58%	185	< 4.95E-01	n/a
Zr	9.45E+04	3.05%	141	< 4.95E-01	n/a	186	1.07E+00[c]	n/a
92	1.50E+04	4.23%	142	1.78E+00	5.18%	187	< 4.95E-01	n/a
Nb	1.14E+05	4.10%	143	< 4.95E-01	n/a	191	< 4.95E-01	n/a
94	1.55E+04	3.96%	144	< 4.95E-01	n/a	193	< 4.95E-01	n/a
95	< 4.95E-01	n/a	145	< 4.95E-01	n/a	194	< 4.95E-01	n/a
96	2.33E+03	4.52%	146	< 4.95E-01	n/a	195	2.50E+00	6.79%
97	< 4.95E-01	n/a	147	< 4.95E-01	n/a	196	5.76E+00	4.19%
98	< 4.95E-01	n/a	148	< 4.95E-01	n/a	198	3.21E+00	2.68%
99	< 4.95E-01	n/a	149	< 4.95E-01	n/a	203	7.28E+00	3.67%
100	< 4.95E-01	n/a	150	< 4.95E-01	n/a	204	< 4.95E-01	n/a
101	< 4.95E-01	n/a	151	< 4.95E-01	n/a	205	< 4.95E-01	n/a
102	< 4.95E-01	n/a	152	< 4.95E-01	n/a	206	< 4.95E-01	n/a
103	< 4.95E-01	n/a	153	< 4.95E-01	n/a	207	< 4.95E-01	n/a
104	< 4.95E-01	n/a	154	< 4.95E-01	n/a	208	< 4.95E-01	n/a
105	< 4.95E-01	n/a	155	< 4.95E-01	n/a	229	< 4.95E-01	n/a
106	5.30E+01	3.57%	156	< 4.95E-01	n/a	230	< 4.95E-01	n/a
107	2.02E+01	3.51%	157	< 4.95E-01	n/a	232	< 4.95E-01	n/a
108	1.92E+01	2.83%	158	< 4.95E-01	n/a	233	< 4.95E-01	n/a
109	1.21E+02	3.48%	159	< 4.95E-01	n/a	234	< 4.96E+00	n/a
110	2.83E+01	4.75%	160	< 4.95E-01	n/a	235	< 4.95E-01	n/a
111	2.20E+00	3.75%	161	< 4.95E-01	n/a	236	< 4.95E-01	n/a
112	6.78E+00	4.43%	162	< 4.95E-01	n/a	237	< 4.95E-01	n/a
113	< 9.91E-01	n/a	163	< 4.95E-01	n/a	238	< 4.95E-01	n/a
114	< 4.95E-01	n/a	164	< 4.95E-01	n/a	239	< 4.95E-01	n/a
116	< 4.95E-01	n/a	165	< 4.95E-01	n/a	240	< 4.95E-01	n/a
117	< 4.95E-01	n/a	166	< 4.95E-01	n/a	241	< 4.95E-01	n/a
118	< 4.95E-01	n/a	167	< 4.95E-01	n/a	242	< 4.95E-01	n/a
119	< 4.95E-01	n/a	168	< 4.95E-01	n/a	243	< 4.95E-01	n/a
120	< 4.95E-01	n/a	169	< 4.95E-01	n/a	244	< 4.95E-01	n/a
121	< 4.95E-01	n/a	170	< 4.95E-01	n/a	245	< 4.95E-01	n/a
122	< 4.95E-01	n/a	171	< 4.95E-01	n/a	246	< 4.95E-01	n/a
123	< 4.95E-01	n/a	172	< 4.95E-01	n/a	247	< 4.95E-01	n/a
124	< 4.95E-01	n/a	173	< 4.95E-01	n/a	248	< 4.95E-01	n/a
125	< 4.95E-01	n/a	174	3.00E+00	3.19%	249	< 4.95E-01	n/a
126	< 4.95E-01	n/a	175	< 4.95E-01	n/a	250	< 4.95E-01	n/a
128	< 4.95E-01	n/a	176	1.01E+02	2.84%	251	< 4.95E-01	n/a
130	< 4.95E-01	n/a	177	3.87E+02	3.81%			

[a] The %RSD is based on the standard deviation of duplicate samples. [b] Single replicate above the detection limit (Standard B1). Replicate value (Standard B2) was < 4.81E-01 µg/g. [c] Single replicate above the detection limit (Standard B2). Replicate value (Standard B1) was < 5.10E-01 µg/g.

Loading of several other elements was observed on the teabag CST based on the ICP-MS and ICP-ES data. A summary of loading of other elements on the CST is provided in Table 3-26 in order of decreasing loading. A number of these elements are also present in the standard samples, indicating they are trace components of the as-manufactured and pretreated CST. Therefore, concentrations in both the teabag CST and standard CST are shown. The full ICP-ES results for the teabag samples and standards are provided in Table 3-27.

Table 3-26. Comparison of Cs Loading With That of Other Elements on the CST.[a]

Element	Avg. Amount in Teabags (mmol/g_{CST})	Avg. Amount in Standards (mmol/g_{CST})	Net Loading (Teabag-standard) (mmol/g_{CST})
Na	3.51E+00	3.01E+00	5.02E-01
Al	8.23E-02	4.80E-02	3.43E-02
Cs	2.18E-02	< 1.48E-05	2.18E-02
Ca	9.52E-03	< 4.63E-04	> 9.06E-03
Fe	6.97E-03	4.78E-03[b]	2.18E-03
Pb	1.77E-03	< 8.44E-06	> 1.76E-03
Cr	7.85E-04[c]	< 1.05E-04	> 6.80E-04
Rb	5.32E-04	< 1.16E-05	> 5.21E-04
U	2.51E-04[d]	< 1.05E-05[e]	> 2.40E-04
Sr	1.02E-04	5.52E-05	4.65E-05
Co	1.60E-05	< 1.09E-05	> 5.11E-06
Y	2.27E-05	1.96E-05	3.09E-06
^{237}Np	7.12E-06	< 2.09E-06	> 5.03E-06
^{239}Pu	2.17E-06	< 2.07E-06	> 9.33E-08

[a]Values have not been corrected for the F-factor. [b]Large discrepancy between the two standard samples (43.4 %RSD), Standard B1 had an Fe loading of 185 µg/g and Standard B2 had an Fe loading of 389 µg/g. [c]Large discrepancy between the two teabag samples (43.7 %RSD), Teabag B1 had a Cr loading of 53.4 µg/g and Teabag B2 had a Cr loading of 28.2 µg/g. [d]Sum of isotopes 233, 235, 236, and 238. Isotope 234 was below the detection limit. [e]Sum of isotopes 233, 234, 235, 236, and 238. All isotopes were below the detection limit in the standard samples.

Table 3-27. ICP-ES Results for the In-Tank Batch Contact Samples (Teabags B1 and B2) and Associated Digestion Standards

Element	Avg. Conc. In Teabag Samples (µg/g)	%RSD[a]	Avg. Conc. In Standard Samples (µg/g)	%RSD[a]
Ag	< 546	n/a	< 527	n/a
Al	2220	13.4%	1295	3.82%
Ba	< 181	n/a	< 174	n/a
Be	< 9.34	n/a	< 9.00	n/a
Ca	382	7.23%	< 18.6	n/a
Cd	< 3.97	n/a	< 3.83	n/a
Ce	< 169	n/a	< 163	n/a
Co	< 296	n/a	< 285	n/a
Cr	40.8	43.7%	< 5.47	n/a
Cu	< 412	n/a	< 398	n/a
Fe	389	0.36%	267	43.4%
Gd	< 6.07	n/a	< 5.85	n/a
K	< 1520	n/a	< 1465	n/a
La	< 5.09	n/a	< 4.91	n/a
Li	< 160	n/a	< 154	n/a
Mg	< 77.0	n/a	< 74.3	n/a
Mn	< 31.5	n/a	< 30.4	n/a
Mo	< 8.78	n/a	< 8.46	n/a
Na	80800	4.38%	69250	4.19%
Ni	< 51.6	n/a	< 49.65	n/a
P	< 56.1	n/a	< 54.1	n/a
Pb	< 376	n/a	< 362	n/a
S	< 149	n/a	< 144	n/a
Sb	< 14.0	n/a	< 13.5	n/a
Sn	< 119	n/a	< 115	n/a
Sr	< 19.4	n/a	< 18.7	n/a
Th	< 1205	n/a	< 1160	n/a
Ti	138000	7.17%	135000	3.14%
U	< 779	n/a	< 750	n/a
V	< 68.5	n/a	< 66.0	n/a
Zn	< 3.02	n/a	< 2.91	n/a
Zr	94150	6.83%	92500	3.06%

[a] The %RSD is based on the standard deviation of duplicate samples. The reported analytical method uncertainties (at two sigma) are 10%.

A summary of other radionuclide data for the in-tank batch contact samples as well as the CST digestion standards is provided in Table 3-28. The gamma emitting isotopes were measured by gamma spectroscopy after Cs removal, the ^{90}Sr and Pu isotopes were measured after separation, and the total alpha and beta were measured by LSC both with and without Cs removal. Based on the cesium results it is assumed that radionuclide losses to the wash solutions are small relative to the amounts recovered from the teabags.

Table 3-28. Other Radionuclide Activities in the In-Tank Batch Contact Samples and CST Digestion Standards (Not Corrected for the F-Factor)

Isotope	Avg. Activity in Teabag CST ($\text{dpm/g}_{\text{CST}}$)	%RSD[a]	Avg. Analytical 1-sigma Unc.	Avg. Activity in Standard CST ($\text{dpm/g}_{\text{CST}}$)	%RSD[a]	Avg. Analytical 1-sigma Unc.
^{60}Co	< 2.48E+03	n/a	MDA	< 1.78E+03	n/a	MDA
^{90}Sr	7.41E+07	26.5%	24.4%	1.70E+05	62.8%	31.2%
^{106}Ru	< 2.19E+04	n/a	MDA	< 9.53E+03	n/a	MDA
^{125}Sb	< 1.54E+04	n/a	MDA	< 4.44E+03	n/a	MDA
^{126}Sb	6.93E+03	3.06%	7.05%	< 2.16E+03	n/a	MDA
^{126}Sn	6.93E+03	3.06%	7.05%	< 3.48E+03	n/a	MDA
^{135}Cs	6.17E+05	4.70%	5.06%	< 4.46E+01	n/a	MDA
^{144}Ce	< 4.20E+04	n/a	MDA	< 9.22E+03	n/a	MDA
^{154}Eu	< 8.01E+03	n/a	MDA	< 2.84E+03	n/a	MDA
^{238}Pu	7.40E+06	5.83%	6.06%	< 3.68E+03	n/a	MDA
$^{239/240}$Pu	1.05E+05	3.38%	9.46%	< 3.10E+03	n/a	MDA
^{241}Pu	7.06E+06	30.0%	16.0%	1.18E+04[b]	n/a	33.0%
^{241}Am	< 6.05E+04	n/a	MDA	< 1.13E+04	n/a	MDA
Alpha Count[c]	< 1.73E+07	n/a	Upper Limit/ MDA	< 2.94E+07	n/a	MDA
Beta Count[c]	1.13E+11	5.66%	10.0%	< 2.66E+07	n/a	MDA
Alpha Count[d]	< 1.09E+07	n/a	Upper Limit	< 5.75E+04	n/a	MDA
Beta Count[d]	1.60E+08	17.7%	10.0%	4.44E+05	106%	20.5%

[a] The %RSD is based on the standard deviation of duplicate samples. [b] Result from a single standard sample rather than the average. The other sample was below the detection limit (< 1.07E+05 dpm/g). [c] From LSC without Cs removal. [d] From LSC after Cs removal.

In addition to analyzing the digested CST, the rinse solutions generated from rinsing the teabags prior to disassembly were analyzed. As reported above, the amount of ^{137}Cs found in the soak solutions was very low. Adding the amount of ^{137}Cs in the combined 0.01 M NaOH and deionized water solutions for each teabag increased the ^{137}Cs on the CST in teabags by 1.2% and 1.7% for teabags B1 and B2, respectively. Duplicate aliquots of each soak solution were also analyzed by ICP-ES and those results are provided in Table 3-29. As can be seen in the table, the soak solutions showed very low concentrations of a few elements, with a composition that is consistent with residual salt solution being retained in the teabags. The average measured sodium concentration of the 0.01 M NaOH rinses was 0.095 M, which is equivalent to ~ 0.8 mL of the Tank 10H supernate being diluted into the 65 mL of 0.01 M NaOH rinse solution. The DI water rinses contained ~ 39 mg/L Na (Teabag B1) and ~ 169 mg/L Na (Teabag B2), which is equivalent to ~ 1.2 mL or ~5.4 mL, respectively, of the first rinse (0.01 M NaOH) being carried over into the water rinse.

Table 3-29. Full ICP-ES Results for the Soak Solutions

Element	Avg. Concentration in 0.01 M NaOH rinse solutions (mg/L)	%RSD[a]	Avg. Concentration in DI water rinse solutions (mg/L)	%RSD[a]
Ag	< 0.276	n/a	< 0.276	n/a
Al	32.5	2.92%	2.52[b]	0.00%
B	< 0.0451	n/a	< 0.045	n/a
Ba	< 0.00669	n/a	< 0.00669	n/a
Be	< 0.00211	n/a	< 0.00211	n/a
Ca	< 0.0389	n/a	< 0.0389	n/a
Cd	< 0.00615	n/a	< 0.00615	n/a
Ce	< 0.129	n/a	< 0.129	n/a
Co	< 0.0114	n/a	< 0.0114	n/a
Cr	0.358	7.85%	< 0.0320	n/a
Cu	< 0.0148	n/a	< 0.0148	n/a
Fe	< 0.189	n/a	< 0.189	n/a
Gd	< 0.0118	n/a	< 0.0118	n/a
K	< 5.880	n/a	< 5.88	n/a
La	< 0.00745	n/a	< 0.00745	n/a
Li	< 0.174	n/a	< 0.174	n/a
Mg	< 0.0136	n/a	< 0.0136	n/a
Mn	0.260[b]	10.1%	< 0.0330	n/a
Mo	0.167	2.85%	< 0.0180	n/a
Na	2178	0.78%	104	72.3%
Ni	< 0.0310	n/a	< 0.0310	n/a
P	1.14	8.89%	< 0.111	n/a
Pb	< 0.0972	n/a	< 0.0972	n/a
S	42.1	9.07%	3.86[b]	0.37%
Sb	< 0.0334	n/a	< 0.0334	n/a
Si	< 0.301	n/a	< 0.301	n/a
Sn	< 0.321	n/a	< 0.321	n/a
Sr	< 0.0377	n/a	< 0.0377	n/a
Th	< 0.257	n/a	< 0.257	n/a
Ti	< 0.0247	n/a	< 0.0247	n/a
U	< 0.144	n/a	< 0.144	n/a
V	< 0.109	n/a	< 0.109	n/a
Zn	< 0.00459	n/a	< 0.00459	n/a
Zr	< 0.0110	n/a	< 0.0110	n/a

[a]The %RSD is based on the standard deviation of four samples (duplicates for each teabag). [b]Average and %RSD of duplicate samples from one soak solution as the other was below the detection limit.

3.4 ZAM Modeling Results

The measured composition of the Tank 10H Batch 1 surface qualification sample (HTF-10-21-103) was used as input for the ZAM modeling calculations. The ionic charges of the measured concentrations are not balanced. The total positive charge is 6.2 eq/L while the total negative charge is -6.6 eq/L. In the past, the total charge of anions is usually less than the total charge of cations; and therefore, the common practice has been to increase the Cl^- concentration to achieve the charge balance, since the change in chloride concentration has a minimal impact on cesium loading. Since that is not possible for this case, two options were considered for balancing the charges in the Batch 1 solution.

1. Adjustment of anions: All anion concentrations are equally decreased by multiplying by 0.9382 to have a complete charge balance. This is shown in Column 3 of Table 3-30.

2. Adjustment of Na^+: The Na^+ concentration is increased from 6.2 M to 6.6084 M. This is shown in Column 4 of Table 3-30.

Table 3-30 shows the second option (i.e., Na^+ adjustment) provides a more accurate density in comparison with the measured density of 1.312 g/mL at 18 °C. Therefore, Option 2 (Na^+ adjustment) was selected as the adjusted composition for modeling purposes. It should be noted, however, that the Na^+ concentration used as input has the largest effect on the Cs loading predicted by the model. Each 1% increase in Na^+ concentration correlates to a 2.1% decrease in predicted Cs loading.[6]

Table 3-30. TCCR 1A Batch 1 Measured Concentrations at 29.1 ºC

Component	**Tank 10H TCCR 1A Batch 1 Measured Concentrations (M)**	**Tank 10H TCCR 1A Batch 1 Anion Adjusted Concentrations (M)**	**Tank 10H TCCR 1A Batch 1 Na^+ Adjusted Concentrations (M)**
Na^+	6.20	6.20	6.6084
K^+	$< 1.06x10^{-2}$	0	0
Cs^+	$5.30x10^{-5}$	$5.30x10^{-5}$	$5.30x10^{-5}$
Rb^+	$2.22 x10^{-5}$	$2.22 x10^{-5}$	$2.22 x10^{-5}$
Total Sr	$1.40x10^{-7}$	$1.40x10^{-7}$	$1.40x10^{-7}$
Pb^{2+}	$5.23x10^{-6}$	$5.23x10^{-6}$	$5.23x10^{-6}$
OH^-	0.698	0.655	0.698
NO_3^-	3.87	3.631	3.87
NO_2^-	0.444	0.417	0.444
$Al(OH)_4^-$	0.0835	0.078	0.0835
CO_3^{2-}	0.66	0.619	0.66
SO_4^{2-}	0.0920	0.086	0.0920
Cl^-	< 0.00833	0	0
F^-	< 0.0156	0	0
PO_4^{3-}	< 0.00311	0	0
$C_2O_4^{2-}$	0.00409	0.00384	0.00409
CrO_4^{2-}	$3.89x10^{-4}$	3.650E-04	$3.89x10^{-4}$
Measured Density (g/cm^3) at 18 °C	1.312		
OLI Density (g/cm^3) at 18 °C		1.292	1.308
OLI Density (g/cm^3) at 29.1 °C		1.285	1.302

The CST isotherm was determined by use of the Freundlich/Langmuir Hybrid model to fit the ZAM data. The isotherm parameters are listed in Table 3-31. With the parameters listed, the expression reduces to a Langmuir isotherm.

Freundlich/Langmuir Hybrid isotherm model:

$$q = \frac{\eta_{CF} C_T \rho_{Bed} C_p}{\beta + C_p}$$

q: Cesium loading on CST (mol_{Cs}/L_{Bed})
C_p: Liquid-phase cesium concentration (mol_{Cs}/L)
C_T: Total cesium ion-exchange capacity of CST ($mmol_{Cs}/g_{CST,powder}$)
η_{CF}: Dilution/Correction factor ($g_{CST,powder}/g_{CST,eng}$)
ρ_{Bed}: Bed density ($g_{CST,eng}/mL_{Bed}$)
β: Langmuir isotherm parameter

Table 3-31. Isotherm Parameters

Adjustment	T (^{0}C)	η_{CF}	C_T ($mmol_{Cs}/g_{CST}$)	$\rho_{Bed,dry}$[a] (g_{CST}/ml_{Bed})	β
Option 1	29.1	1.0	0.58	0.999	3.9108E-4
Option 2	29.1	1.0	0.58	0.999	4.4936E-4

[a] Dry bed density calculated from bed density (1.232 g/mL) and F-factor (0.8107).[4]

The maximum cesium loading was calculated by the method of phase ratio variation. Cesium loadings at 29.1 °C are given in Table 3-32 and are on a true dry mass basis (i.e., accounting for the F-factor). The ZAM loading value (engineered form) is ~1.5x larger than the measured teabag result. This is a lower ratio compared to what was observed for prior TCCR in-tank batch contact testing where the ZAM results were typically >2x higher than the measured values.[12,13,14] The measured teabag loading is likely slightly lower than the maximum equilibrium loading achievable as previous laboratory testing of the teabag devices indicated that the loading obtained in an unagitated experiment is approximately 6% lower than obtained for a continuously stirred experiment.[15]

Table 3-32. Maximum Cesium Loading at 29.1 °C

Case	q (Powder Form)[a]		q (Engineered Form)[b]		Teabag	
Batch 1 Sample	$mmol_{Cs}/g_{CST}$	Ci/kg_{CST}	$mmol_{Cs}/g_{CST}$	Ci/kg_{CST}	$mmol_{Cs}/g_{CST}$	Ci/kg_{CST}
	0.0612	122	0.0416	82.7	0.0281	55.8

[a] Calculated from ZAM. [b] Applied dilution factor η_{df} of 0.68 to ZAM values.

Cesium loading and isotherms for both the anion adjusted and Na^+ adjusted compositions are shown in Figure 3-12, along with the teabag result. A dilution factor (η_{df}) of 0.459 was required to match the experimental data with the calculated isotherm for the Na^+ adjusted composition.

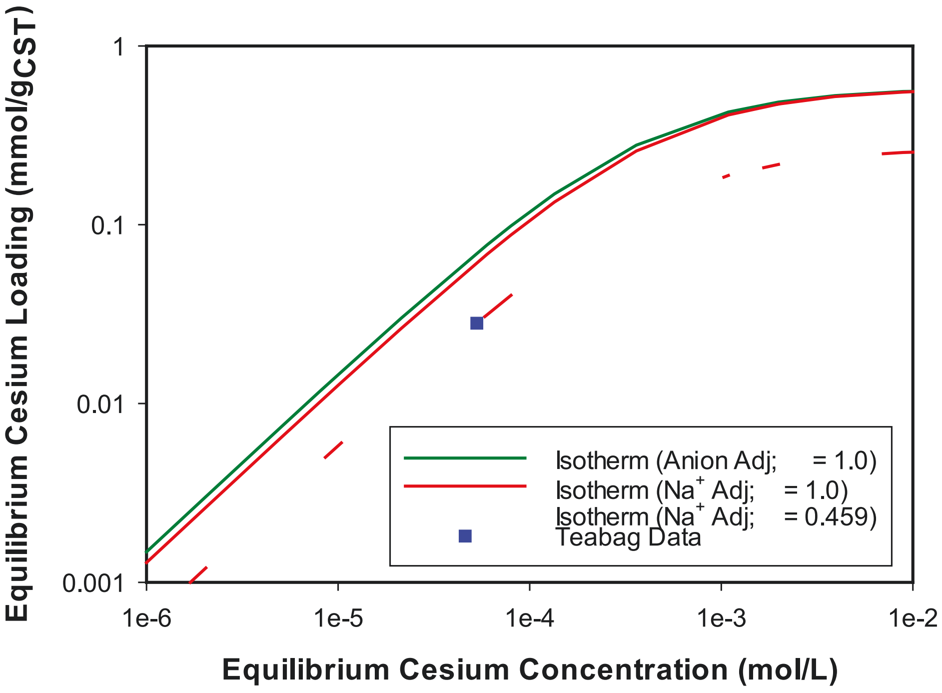

Figure 3-12. TCCR 1A Batch 1 Isotherms at 29.1 °C.

4.0 Conclusions

SRNL received and characterized two sets of dip samples collected from Tank 10H (a preliminary set received in July 2021 and a qualification set received in November 2021) in support of Batch 1 qualification for TCCR 1A. The depth samples collected in July 2021 contained a small amount of brown solids, while the November 2021 samples contained no significant solids. Density measurements of the November samples indicated stratification within the tank, which was also supported by the remaining analyses showing the depth sample was a more concentrated salt solution.

Duplicate in-tank batch contact samples consisting of 0.1 g of crystalline silicotitanate (CST) contained within teabag devices were also received and characterized by SRNL after being submerged in Tank 10H for a period of 10 days. The CST was rinsed to remove excess salt solution and the CST was then air dried before being digested for analysis. Results of the analysis indicated a ^{137}Cs loading of 1.00E+11 ± 3.36E+09 dpm/g or 45.2 ± 1.51 Ci/kg$_{CST}$. This value represents a bounding upper limit as it includes the addition of two sigma uncertainty from replicate analysis of the individual teabag samples as well as the addition of the small amount of ^{137}Cs activity measured in the rinse solutions. The above values are based on the air-dried mass of CST. Correcting to the true dry mass using a F-factor of 0.8107 results in a maximum loading of 55.8 ± 1.86 Ci/kg$_{CST}$. ZAM modeling was performed using the measured composition of the surface qualification sample. The modeling predicted a maximum Cs loading approximately 1.5x higher than the measured result. This is a slightly lower ratio (expected/measured) compared to what was observed for the prior TCCR in-tank batch contact testing performed for Batches 1A – 3 where the ZAM results were always >2x higher than the measured values.

5.0 Future Work

Due to the stratification within the tank, SRR recirculated the tank prior to repeating the qualification process (additional Tank 10H supernate samples and deployment of additional in-tank batch contact tests). Results from analysis of the requalification samples will be documented in a future report.

6.0 References

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[1] K. M. L. Taylor-Pashow, “Characterization of Tank 9H Dissolution Batches in Support of Tank Closure Cesium Removal (TCCR) 1A Batch 1 Preparations”, SRNL-STI-2021-00385, Rev. 0, August 2021.
[2] K. M. L. Taylor-Pashow and W. D. King, “Task Technical and Quality Assurance Plan for Analysis of Tank 10H and Tank 11H Samples in Support of Tank Closure Cesium Removal (TCCR) 1A”, SRNL-RP-2021-04002, Rev. 0, July 1, 2021.
[3] SRNL Manual L29, Procedure ITS-0230, Rev. 0 “Receipt and Preparation of Samples from In-Tank Batch Contact Testing”, October 18, 2018.
[4] W. D. King, S. Taylor, and S. E. Aleman, “CST R9120-B 30x60 Media Pretreatment and Digestion Standard Development to Support Tank Closure Cesium Removal 1A (TCCR-1A) Operations”, SRNL-STI-2020-00435, Rev. 0, January 2021.
[5] L. L. Hamm, T. Hang, D. J. McCabe, and W. D. King, “Preliminary Ion Exchange Modeling for Removal of Cesium from Hanford Waste Using Hydrous Crystalline Silicotitanate Material,” WSRC-TR-2001-00400, July 2002.
[6] T. Hang, D. J. McCabe, L. L. Hamm, and J. L. Wohlwend, “Modeling Ion Exchange Performance of Crystalline Silicotitanate to Support SRS Tank 10H Closure,” SRNL-STI-2017-00336, Rev. 0, July 2017.
[7] “Savannah River National Laboratory Technical Report Design Check Guidelines” WSRC-IM-2002-00011, Rev. 2, August 2004.
[8] J. B. Goldblatt and K. R. Miklia, “TCCR Sampling for Tank 10 Post-Recirculation, Tank 11 Production for Batch Qualification, and DWPF Waste Qualification”, X-TTR-H-00119, Rev. 0, June 2021.
[9] Savannah River Site Manual E7 “Conduct of Engineering”, Procedure 2.60 Rev. 20 “Technical Reviews”, November 9, 2021.
[10] SRNL Electronic Laboratory Notebook #E7518-00472-02.
[11] K. M. L. Taylor-Pashow, “Summary of Results from Tank 10H Tank Closure Cesium Removal (TCCR) Batch 1 Preliminary Samples”, SRNL-L3100-2021-00022, Rev. 1, September 2021.
[12] K. M. L. Taylor-Pashow, T. Hang, and C. A. Nash, “Summary of Expedited Results from Samples Supporting Tank Closure Cesium Removal (TCCR) Batch 1A and Modeling Results for Cs Loading on CST”, SRNL-L3100-2019-00002, Rev. 2, February 19, 2019.
[13] K. M. L. Taylor-Pashow, T. Hang, and C. A. Nash, “Summary of Expedited Results from Samples Supporting Tank Closure Cesium Removal (TCCR) Batch 2 and Modeling Results for Cs Loading on CST”, SRNL-L3100-2019-00017, Rev. 0, May 21, 2019.
[14] K. M. L. Taylor-Pashow, T. Hang, and C. A. Nash, “Summary of Analytical Results from Samples Supporting Tank Closure Cesium Removal (TCCR) Batch 3 and Modeling Results for Cs Loading on CST”, SRNL-STI-2020-00293, Rev. 0, August 2020.
[15] C. A. Nash and T. Hang, “Stagnant and Stirred 10-Day Teabag Test Supporting Tank Closure Cesium Removal”, SRNL-L3160-2019-00001, Rev. 0, May 13, 2019.

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