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Characterization of Radionuclides in Waste Sludges from High Level Waste Tanks 40, 42, and 51

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1.0 Background

Characterization of High Level Waste Sludge by the Concentration Storage and Transfer (CST) Department is outlined in WSRC-TR-94-0579, *High Level Waste Sludge Characterization in Support of Low Level Waste Certification* (Reference 1). The sludge characterization is based on a series of scaling factors for 31 of 34 known sludge-containing waste tanks. Scaling factors were previously compiled and compared with available sample data in WSRC-TR-94-0562, *Characterization of Radionuclides in HLW Sludge Based on Isotopic Distribution in Irradiated Assemblies* (Reference 2). Quantification of sludge-contaminated waste and application of the scaling factors has been performed on a case-by-case basis since approval of the methodology by the Waste Characterization Board in 1994. Scaling factors have been applied to each waste tank individually.

Further examination of historical tank use data contained in the "Waste Transfers and Additions Database," TR93425 b.xls (Reference 3), tank contents (i.e. high heat or low heat fractions of either Purex or H-Modified waste) and waste age (both in Reference 2) allowed consolidation of sludge in waste tanks to be considered.

Procedure WAC 2.02, *Low Level, Hazardous, Mixed and PCB Waste Characterization Requirements,* Rev. 4 (Reference 4) allows for consolidation of waste streams when the following two criteria are met:

1. Performance Assessment (PA) radionuclide scaling factors do not vary from the proposed data set scaling factor by more than a factor of 10, and

2. The fractional activity of the predominant radionuclides (predominant radionuclides being those that make up 10% or greater of the activity) in each data set does not vary by more than a factor of 2 from the fractional activity of the same radionuclide in the proposed data set.

This document contains one such proposed consolidation of sludge-contaminated waste generated from High Level Waste Tanks 40, 42 and 51.

2.0 Introduction

Sludge-contaminated waste consists of waste contaminated with both insoluble species (the sludge fraction) and interstitial supernate. 75-90% of the weight of what is commonly referred to as sludge is interstitial supernate; the remaining 10-25% consists of the insoluble species (Reference 1).

Development of a method for characterization of sludge–contaminated waste must consider both fractions. Separate waste cuts may contain sludge and supernate fractions in varying proportions due to the nature of the job generating the waste and the variability in waste handling techniques. Development of a distribution representative of all sludge-contaminated waste cuts must allow for varying fractions of sludge and supernate contamination.

This document will develop a radionuclide distribution for the sludge fraction of sludge-contaminated waste stored in High Level Waste Tanks 40, 42 and 51 in accordance with the methodology outlined in WAC 2.02 (Rev. 4). A single, comprehensive characterization for supernate has been developed previously (Reference 5). This distribution is based on the assumption that sludge-contaminated waste from tanks 40, 42 and 51 may be co-mingled, and the actual contamination present on waste in a series of containers from these tanks will be representative of the mean radionuclide distribution.

This document also describes the methodology for application of radionuclide distributions representative of the sludge and supernate fractions of sludge-contaminated waste to individual waste packages.

Most of the waste contaminated with sludge from Tanks 40, 42 and 51 will be categorized as Low Level Waste (LLW) and disposed of in the E-area Vaults (EAV). The waste does, however, have the potential to be categorized as TRU and/or mixed waste. Quantification of hazardous constituents and determination of whether the waste is classified as mixed is dependent on the amount of sludge and supernate present on the waste matrix and the nature of the waste matrix, and will be performed on a case-by-case basis. Quantification of radionuclides present in each waste package will be performed as described in Section 5.0.

The radionuclide distribution developed for LLW contaminated with sludge from Tanks 40, 42 and 51 can also be applied to waste classified as transuranic. [Neither WAC 3.06, E-Area TRU Pads Transuranic Waste Acceptance Criteria, Rev. 5 nor Appendix A:34, TRU Waste Container Characterization Form (OSR 29-90) Instruction specifies a methodology for determination of the isotopic distribution in TRU Waste; simply that the methodology be documented.]

This characterization is based primarily on available sample data for tank 42 and 51. Periodic validation of the distribution developed in this document will be performed as discussed in Section 6.

3.0 Development of a Radionuclide Distribution for Sludge Fraction of Sludge-Contaminated Waste

The development of the radionuclide distribution in this section is performed per guidance outlined in WAC 2.02, *Low Level, Hazardous, Mixed and PCB Waste Characterization Requirements,* Rev. 4 (Reference 4).

3.1 Determining the Initial List of Radionuclides

Procedure WAC 2.02 (Rev. 4) stipulates that the characterization of each package of waste having a total activity greater than 2 nanocuries/gram must consider the potential presence of any radionuclide that meets any one of three criteria:

1. The radionuclide is identified in WAC 3.17 as being a Performance Assessment (PA) or Safety Authorization Basis (SAB) radionuclide for a specific Treatment, Storage or Disposal (TSD) facility (Reference 6). For purposes of this distribution, we will use those PA and SAB radionuclides for the EAV.

2. The radionuclide could be present in the waste with a relative activity greater than 1.0% of the total waste stream activity at the time of the characterization.

3. The radionuclide is a detectable transuranic or a fissile radionuclide.

The above criteria are hereafter referred to as "inclusion criteria."

Based on the three inclusion criteria and available process knowledge, the following list of 33 radionuclides (Table 3.1) will be considered when developing the radionuclide distribution of waste packages contaminated with sludge from Tanks 40, 42 and 51.

Table 3.1. Radionuclides Important to Characterization of the Sludge Fraction of Sludge-Contaminated Waste

Radionuclide	Inclusion Criteria			
	PA Limiting	SAB Limiting	Potentially Present At >1% Total Activity	Detectable Fissile or TRU Radionuclide
H-3	PA			
C-14	PA			
Ni-59	PA			
Co-60		SAB		
Se-79			X	
Sr-90		SAB	X	
Y-90			Daughter of Sr-90	
Tc-99	PA			
Ru-106			X	
Rh-106			Daughter of Ru-106	
Sb-125			X	
Sn-126			X	
I-129	PA			
Cs-134			X	
Cs-135			X	
Cs-137	PA	SAB		
Ba-137m			Daughter of Cs-137	
Ce-144			X	
Pr-144			Daughter of Ce-144	
Pr-144m			Daughter of Ce-144	
Pm-147			X	
Eu-154			X	
U-233				Detectable Fissile
U-234	PA			
U-235				Detectable Fissile
Np-237	PA			Detectable TRU
Pu-238		SAB		Detectable TRU
Pu-239	PA	SAB		Detectable Fissile, TRU
Pu-240				Detectable TRU
Pu-241				Detectable Fissile
Pu-242				Detectable TRU
Am-241				Detectable TRU
Cm-244			X	

3.2 Consolidating Sludge from Tanks 40, 42 and 51

WAC 2.02 (Rev. 4) allows for consolidation of waste streams when the following two criteria are met:

1. PA radionuclide scaling factors do not vary from the proposed data set scaling factor by more than a factor of 10, and

2. The fractional activity of the predominant radionuclides (predominant radionuclides being those that make up 10% or greater of the activity) in each data set does not vary by more than a factor of 2 from the fractional activity of the same radionuclide in the proposed data set.

Historical data for tanks under consideration for consolidation are reproduced in Table 3.2.

Table 3.2, Tanks 40, 42 and 51 Historical Data					
Tank No.	**% HM HHW**	**% HM LHW**	**% Purex HHW**	**% Purex LHW**	**Tank Use**
40		10		90	Extended Sludge Processing
42	35	18		47	Extended Sludge Processing
51	0.1	7		92.9	Extended Sludge Processing
Average	11.7	11.7		76.6	

The tanks contain primarily Purex Low Heat Waste (LHW) aged 21-37 years, and are utilized for Extended Sludge Processing (ESP).

Significant process knowledge relating to what is present in the sludge fraction of these waste tanks exists. This process knowledge was used to develop scaling factors (to Sr-90) for sludge fractions (Reference 1) in Tanks 40, 42 and 51. In addition, significant sludge sampling has been conducted on Tanks 42 and 51 (References 7 through 12). No sampling of Tank 40 sludge has been conducted. Tanks 42 and 51 are considered representative of Tank 40 sludge since the slurry in Tank 40 came primarily from the same Waste Receipt Tanks as Tank 51 waste. Tank 51 and Tank 42 have been blended.

Existing scaling factors for radionuclides identified in Section 3.1 were adjusted for decay and compared to scaling factors developed from both the available analytical data as well as data in WCTables (Reference 13). This analysis is documented in Attachments 1a and1b for Tanks 42 and 51, respectively. TRU radionuclides are present in analytical data by at least one order of magnitude greater than process knowledge predicts. Although analytical data indicates that some of the other radionuclides are present in amounts smaller than predicted by process knowledge, analytical data is considered most representative of the actual contents of sludge in these tanks. For this reason, only analytical data will be utilized to develop the radionuclide distribution for sludge in these tanks. Since the analytical data is in good agreement, the average of the analytical data for each isotope in tanks 42 and 51 will be used to develop scaling factors for each radionuclide within the tanks. (Attachments 1a and 1b)

The set of isotope concentrations representative of Tanks 42 and 51 per the methodology above were next compared to each other to determine whether sludge-contaminated waste from these tanks met the two WAC criteria for consolidation.

First, the arithmetic mean concentration for each isotope under consideration was calculated. The concentrations for PA radionuclides for each waste stream were then compared to determine whether they were within an order of magnitude from the proposed data set, or the arithmetic mean set of concentrations. Within PA radionuclides, the greatest deviation from the mean was Ni-59, which varied from the mean by 49%. However, the variation observed is still well within a factor of 10, the first criteria for consolidation. The mean set of scaling factors and the deviations from mean of the PA radionuclides are presented in Attachment 2.

The second criterion applies to predominant radionuclides only. There are two predominant radionuclides in this distribution, Sr-90 and its daughter Y-90. The fractional activities of Sr-90 and Y-90 vary only slightly within the distribution of sludge for each tank, ranging from 0.415 to 0.478. The maximum variation from the proposed data set (the mean distribution) is 11.24% in Tank 51 sludge, which is well within a factor of 2, the second criteria for consolidation. This is also documented in Attachment 2.

Based on the results of the comparison, both consolidation criteria are met, and the sludge fraction of sludge-contaminated waste from Tanks 40, 42 and 51 may be consolidated. The arithmetic

mean of scaling factors for tanks 42 and 51, previously developed in Attachment 2, will be used for the remainder of the development of the radionuclide distribution.

3.3 Excluding Radionuclides from Consideration

Under WAC 2.02 (Rev. 4) radionuclides that meet one of the inclusion criteria outlined in section 3.1 may be excluded from further consideration if one or more of the following conditions exist:

1. There is no reason to expect the radionuclide to be present in the waste stream.
2. Process knowledge shows that the PA radionuclide could not be present in the waste stream at concentrations greater than 1/100th of the Maximum Allowable Lower Limit of Detection (MALLD).
3. Historical representative data shows that a non-PA radionuclide is not present in the waste stream, or, if present, has a concentration below the MALLD.

The above criteria are hereafter referred to as "exclusion criteria."

In addition, review of those radionuclides that were initially included only because they were expected to be present at greater than 1% of total activity will be performed. If they are determined not to be present at greater than 1% of total activity, they will also be excluded.

Of the 33 radionuclides listed in Table 3.1, one is excluded because it is not expected to be present. This same radionuclide, tritium, is also present at below 1/100 of the MALLD. No non-PA radionuclides are excluded based on the third criteria (non-PA isotopes present at less than the MALLD). Of the 15 radionuclides included because they were expected to be present at more than 1% of total activity, 13 are determined to be present at less than 1% of the total activity. Two of these, however, Pm-147 and Cm-244, are retained in the distribution since they are near 1% of total activity. Calculations supporting this determination are summarized in Attachment 3; the results of the determination are summarized in Attachment 4 and Table 3.3 below.

Table 3.3. Radionuclides Excluded from Consideration, Sludge Fraction

Radionuclide	Exclusion Criteria			
	Not Expected	PA Rads <.01 of MALLD	Non-PA <MALLD	Present at <1% (a)
H-3	X	X		
C-14				
Ni-59				
Co-60				
Se-79				X
Sr-90				
Y-90				
Tc-99				
Ru-106				X
Rh-106				X
Sb-125				X
Sn-126				X
I-129				
Cs-134				X
Cs-135				X
Cs-137				
Ba-137m				
Ce-144				X
Pr-144				X
Pr-144m				X
Pm-147				X(b)
Eu-154				X
U-233				
U-234				
U-235				
Np-237				
Pu-238				
Pu-239				
Pu-240				
Pu-241				
Pu-242				
Am-241				
Cm-244				X(b)

(a) For those radionuclides included only because were thought to have been present at >1% activity
(b) Retained in distribution because they are present at near 1% of total activity
Note: Bold = PA Rads

3.4 Development of the Sludge Fraction Distribution

Thirty-three radionuclides were determined to be important to characterization of the sludge in Tanks 40, 42 and 51. Twelve of these have been excluded per discussion in section 3.3 above, leaving 21 radionuclides to be quantified. Mean scaling factors developed previously to determine compatability of waste in the tanks have been utilized to create an isotopic distribution for this waste stream. The radionuclides, their corresponding scaling factors (to Sr-90) and fractional activity in the waste stream are summarized in Table 3.4 below. Summaries of inclusion and exclusion criteria as well as supporting calculations for the development of the activity distribution are provided in Attachment 4.

Table 3.4. Radionuclide Scaling Factors and Distribution for Waste Sludge from Tanks 40, 42 and 51

Radionuclide	Mean Scaling Factors (Ci/Ci Sr-90)	Mean Distribution, Normalized (%)
C-14	1.48E-06	6.87E-05
Ni-59	1.47E-05	6.84E-04
Co-60	3.73E-04	1.73E-02
Sr-90	1.00E+00	4.65E+01
Y-90	1.00E+00	4.65E+01
Tc-99	7.06E-05	3.28E-03
I-129	3.64E-07	1.69E-05
Cs-137	3.64E-02	1.69E+00
Ba-137m	3.45E-02	1.60E+00
Pm-147	1.92E-02	8.93E-01
U-233	1.10E-05	5.13E-04
U-234	8.93E-06	4.15E-04
U-235	1.18E-07	5.49E-06
Np-237	4.37E-06	2.03E-04
Pu-238	3.78E-02	1.76E+00
Pu-239	2.01E-03	9.35E-02
Pu-240	6.41E-04	2.98E-02
Pu-241	1.07E-02	4.99E-01
Pu-242	9.56E-07	4.44E-05
Am-241	2.40E-03	1.12E-01
Cm-244	6.44E-03	2.99E-01
Total		**1.00E+02**

3.5 Other WAC Criteria

Procedure WAC 3.17, "Low Level Radioactive Waste Acceptance Criteria," (Reference 6) contains specific criteria that a waste box must meet in order to be accepted in specific TSD facilities. In this section, each of these criteria is compared to sludge slurry comprised of insoluble solids with the relative radionuclide abundance as defined in Table 3.4 above.

Analytical data from tanks 42 and 51 provide information to determine Curies/gram insoluble solids of each of the isotopes required for analysis of other WAC Criteria. The activity of the blended waste is calculated based on average Ci/g, along with a conservative value of 300 g insoluble solids in a liter of slurry. [The highest concentration of insoluble solids in sludge slurry to date has been measured at 258 g/L. (Reference 10)] The calculations are summarized in Table 3.5, below.

Table 3.5 Calculation of Blended Activities for Waste Stream 40/42/51				
Isotope	Ci/g insoluble solids, Tank 42	Ci/g insoluble solids, Tank 51	Average Ci/g insoluble solids	Average Ci/gallon sludge slurry
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	5.00E-09	0.00E+00	5.00E-09	5.68E-06
Ni-59	7.41E-08	2.54E-08	4.98E-08	5.65E-05
Co-60	1.24E-06	1.28E-06	1.26E-06	1.43E-03
Sr-90*	5.87E-03	8.95E-04	3.38E-03	3.84E+00
Tc-99	1.89E-07	2.88E-07	2.39E-07	2.71E-04
I-129	1.23E-09	0.00E+00	1.23E-09	1.40E-06
Cs-137	1.82E-04	6.54E-05	1.24E-04	1.40E-01
Ba-137m	1.73E-04	6.18E-05	1.17E-04	1.33E-01
Pm-147	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-233	4.26E-08	3.24E-08	3.75E-08	4.26E-05
U-234	2.93E-08	3.14E-08	3.03E-08	3.44E-05
U-235	3.71E-10	4.32E-10	4.01E-10	4.56E-07
Np-237	1.51E-08	1.85E-08	1.68E-08	1.90E-05
Pu-238	1.09E-04	1.47E-04	1.28E-04	1.45E-01
Pu-239	5.35E-06	8.26E-06	6.80E-06	7.72E-03
Pu-240	1.82E-06	2.47E-06	2.15E-06	2.44E-03
Pu-241	4.19E-05	3.07E-05	3.63E-05	4.12E-02
Pu-242	3.78E-09	2.51E-09	3.15E-09	3.57E-06
Am-241	7.78E-06	8.48E-06	8.13E-06	9.24E-03
Cm-244	6.19E-06	3.74E-05	2.18E-05	2.47E-02
Total	1.23E-02	2.15E-03	7.23E-03	8.21E+00

*Note: Sr-90 exists in equilibrium with its daughter Y-90

The activity of the blended waste stream is 8.21 Ci/gallon sludge slurry. The weighted average activity of individual radionuclides will be used in comparisons to other WAC criteria in the following sections.

3.5.1 Comparison to Package Guidelines

Most sludge-contaminated waste will be disposed of in the E-Area Vaults. Administrative Waste Package Radiological Concentration Guidelines apply to waste disposed of in the EAV. The guidelines applicable to the Low Activity Waste Vault (LAWV), that portion of the EAV reserved for Low Activity Waste (LAW) will be used for comparison since they are the most restrictive of the EAV facilities. LAW is defined as waste that will produce less than or equal to 200 mR/hr at 5 cm from an unshielded final disposal container. Radionuclides present in this waste stream and their corresponding LAWV limits are summarized in Table 3.6 below.

Table 3.6 Comparison of Sludge-Contaminated Waste to LAWV Limits				
Radionuclide	LAWV Limit (Ci/ft3)	LAWV Limit (Ci/B-25)	Sludge Slurry (Ci/gal)	Gal Sludge in B-25 to Reach LAWV Limit
	A	B=A*90 ft3/B-25	C	D=C/B
Sr-90	2.4E+00	2.16E+02	3.84E+00	5.62E+01
Tc-99	1.90E-05	1.71E-03	2.71E-04	6.31E+00
I-129	9.2E-09	8.28E-07	1.40E-06	5.92E-01
Cs-137	8.4E-02	7.56E+00	1.40E-01	5.39E+01
Pu-238	6.9E-03	6.21E-01	1.45E-01	4.27E+00

The most limiting isotope is I-129, which requires 0.6 gallons of sludge slurry in a B-25 to meet the LAWV Limit. 0.6 gallons of sludge slurry would be equivalent to nearly 5 Ci in a B-25, 0.98 Ci of which are transuranics. Any waste box containing 0.98Ci (or 9.8E+8 nCi) in sludge slurry must contain 9.8E+6 grams (or 2,150 lbs.) or more of waste (out of the 5,000-lb. limit) in order to be within the TRU limit of 100 nCi/g transuranics. A box with less than 2,150 lbs. of waste and 0.6 gallons or more of sludge slurry will fail the TRU limits. In practice, very few waste boxes fail TRU limits due to their relatively low curie content. Any box containing TRU waste will, upon entry into WITS, be flagged as TRU and not be sent to the LAWV.

3.5.2 Sum of Fractions Calculation

For acceptance of waste packages sent to the LAWV, the radiological content of the waste package must be compared to the administrative guidelines and shown to satisfy the sum-of-fractions criteria where:

activity concentration of isotope A/limit of isotope A
+ activity concentration of isotope B/limit of isotope B
+ activity concentration of isotope N/limit of isotope N
≤ 1

Table 3.7 below calculates the maximum concentration of sludge slurry on sludge-contaminated waste in order for the sum-of-the-fractions criteria to be met. The criteria are met for a maximum of 7.0E-04 ft3 (or 0.47 gallons) of sludge slurry per B-25. This is equivalent to 3.87 Ci of sludge solids in a B-25, or 0.078 Ci of transuranics for this waste stream. Any waste box containing 0.078 Ci (or 7.8E+07 nCi) in sludge slurry must contain 7.8E+05 g (or 1,700 lbs.) or more of waste (out of the 5,000-lb. limit) in order to be within the TRU limit of 100 nCi/g transuranics. A box with less than 1,700 lbs. of waste and 0.47 gallons or more of sludge slurry will fail the TRU limits. In practice, very few waste boxes fail TRU limits. Any such box will, upon entry into WITS, be flagged as TRU and not be sent to the LAWV.

Table 3.7 Sum-of-Fractions for Sludge Fraction of Sludge-Contaminated Waste

Isotope	Ci/gallon Sludge slurry	Ci/ft3 Sludge	ft3 Sludge/ ft3 Waste	Ci/ft3 Waste	LAWV Limit (Ci/ft3)	Fraction
	A	B=A*7.48	C	D=B*C	E	=D/E
Sr-90	3.84E+00	2.87E+01	7.00E-04	2.01E-02	2.40E+00	8.38E-03
Tc-99	2.71E-04	2.03E-03	7.00E-04	1.42E-06	1.90E-05	7.47E-02
I-129	1.40E-06	1.05E-05	7.00E-04	7.32E-09	9.20E-09	7.96E-01
Cs-137	1.40E-01	1.05E+00	7.00E-04	7.35E-04	8.40E-02	8.75E-03
Pu-238	1.45E-01	1.09E+00	7.00E-04	7.62E-04	6.90E-03	1.10E-01
Sum of Fractions						**9.99E-01**

3.5.3 Nuclear Criticality Safety Criteria

Sludge-contaminated LLW contains an insignificant quantity of fissionable material to impact nuclear criticality criteria. Table 3.8, below, shows the maximum quantity of sludge that could be placed in a B-25 prior to exceeding the 50-g Fissile Gram Equivalent (FGE) U-235 limit. This is equivalent to 118 gallons of sludge slurry, and over 975 curies in a B-25, significantly greater than the TRU waste limit. Any such box will not be sent to the LAWV for disposal, therefore protecting this requirement.

Table 3.8. Calculation of FGE Equivalent for Sludge Fraction of Sludge-Contaminated Waste							
Radio-nuclide	**Activity in blended waste (Ci/gal)**	**Maximum Gallons of sludge in a B-25 to meet FGE Equivalent**	**Maximum Curies Sludge in a B-25**	**Specific Activity (Ci/g)**	**Maximum Mass (grams) in a B-25**	**Equivalence Factor (from WSRC 1S Manual)**	**FGE U-235 (g)**
	A	B	C=A*B	D	E=C/D	F	G=E*F
U-233	4.26E-05	118.8	5.06E-03	9.648E-03	5.24E-01	1.4	7.34E-01
U-235	4.56E-07	118.8	5.42E-05	2.16E-06	2.51E+01	1.0	2.51E+01
Pu-239	7.72E-03	118.8	9.17E-01	6.2E-02	1.48E+01	1.6	2.36E+01
Pu-241	4.12E-02	118.8	4.89E+00	1.034E+02	4.73E-02	3.5	1.66E-01
Am-242m	0	118.8	0	9.717E+00	0	54.0	0
Cm-243	0	118.8	0	5.253E+01	0	7.8	0
Cm-245	0	118.8	0	1.716E-01	0	24.0	0
Cm-247	0	118.8	0	9.396E-05	0	1.6	0
Cf-249	0	118.8	0	4.078E+00	0	70.0	0
Cf-251	0	118.8	0	1.582E+00	0	140.0	0

3.5.4 Class C Waste Determination

The sludge fraction of sludge-contaminated LLW disposed at the LAWV does not exceed Class C waste criteria. Table 3.9 includes the Class C radionuclide criteria (10 CFR 61.55, Table 1) along with the LAWV and ILV (Intermediate Level Vault) radionuclide criteria. The data indicates that the current LAWV and ILV radionuclide criteria are much more restrictive than the 10 CFR 61 criteria for Class C waste.

Table 3.9. Class C Waste Analysis, Sludge Fraction of Sludge-Contaminated Waste			
Radionuclide	**Class C (Ci/ft3)**	**WAC 3.17 for LAWV (Ci/ft3)**	**WAC 3.17 for ILV (Ci/ft3)**
C-14	2.27E-01	3.7E-04	4.7E-04
Ni-59	6.23E+00	7.0E-03	8.3E-02
Tc-99	8.50E-02	1.9E-05	9.2E-05
I-129	2.27E-03	9.2E-09	2.4E-08
	Class C (nanocurie/g)		
Alpha	1.00E+02	See discussion below	
Pu-241	3.50E+03	See discussion below	
Cm-242	2.00E+04	See discussion below	

Alpha – The alpha criteria is identical to the restriction on the disposal of TRU waste in the waste acceptance criteria.

Pu-241 – Pu-241 can be as high as 21 % of total plutonium activity. Based on the Class C criteria, this would allow 16,500 nanocuries/gram of total plutonium before the criteria would be exceeded. Subtracting the Pu-241 activity results in 13,000 nanocuries/gram of alpha-emitting plutonium isotopes. This exceeds the criteria for TRU waste and would not be allowed.

Cm-242 – Cm-242 is not expected in HLW sludge based on knowledge of the processes that have generated the waste and its 162.5-day half-life.

3.6 Documentation of the Sludge Fraction Distribution

Low level waste stream form WPT-00002-51, included as Attachment 5, documents the distribution from Tanks 40, 42 and 51. For those packages determined to contain sufficient sludge to be determined mixed and/or transuranic, appropriate waste stream forms will be provided for each package.

4.0 Supernate Fraction of Sludge-Contaminated Waste

4.1 Radionuclide Distribution

The radionuclide distribution for the supernate fraction of sludge-contaminated waste has been previously determined and documented. "HLW Supernate Radionuclide Characterization," WSRC-TR-94-0290, Rev. 3, April 19, 1999, identifies 14 radionuclides present in supernate waste. This waste stream represents a single, comprehensive and conservative characterization/certification for all supernate in both F- and H-Areas. The waste stream consists primarily of Cs-137 and its daughter Ba-137m, which together comprise 97% of the total activity in supernate. The fourteen isotopes determined to be present in supernate waste, their relative activity and scaling factors (to Cs-137) for this waste stream are reproduced in Table 4.1 below.

Table 4.1. Validated Radionuclide Distribution and Scaling Factors for HLW Supernate

Radionuclide	Normalized Distribution (%)	Scaling Factors (Ci/Ci Cs-137)
H-3	2.0E-01	4.0E-03
Co-60	1.7E+00	3.4E-02
Sr-90	4.7E-02	9.3E-04
Tc-99	9.1E-03	1.8E-04
I-129	1.1E-05	2.1E-07
Cs-137	5.0E+01	1.0E+00
Ba-137m	4.7E+01	9.4E-01
U-233	2.6E-04	5.2E-06
U-234	7.1E-05	1.4E-06
Pu-238	2.5E-01	5.0E-03
Pu-239	2.9E-03	5.9E-05
Pu-240	1.3E-03	2.6E-05
Pu-241	1.9E-01	3.8E-03
Am-241	1.8E-02	3.5E-04
Total	**1.0E+02**	

4.2 Other WAC Criteria

Comparison of supernate waste to other WAC requirements has been performed previously (Reference 5). The following determinations were made for supernate waste:

- A B-25 container 90% full (81 ft3 waste) can contain up to 0.36 gallons of supernate (1.8 Ci Cs-137), approximately 50-200 times the estimate of supernate expected in a typical B-25 before it is expected to exceed the LAWV Administrative Waste Package Radiological Concentration Guidelines
- Supernate waste passes the sum of fractions calculation
- Supernate waste contains an insignificant quantity of fissionable material to impact nuclear criticality criteria
- Supernate waste does not exceed Class C waste criteria

4.3 Documentation of Supernate Fraction Distribution

Low Level waste stream form WPT-00001, included in Attachment 6, will be used to document the supernate fraction distribution of sludge waste.

5.0 Quantification

5.1 Quantification of Sludge and Supernate Fractions

Quantification of radionuclides in sludge-contaminated waste requires quantification of both the supernate and sludge fractions in each waste cut. Independent quantification of Sr-90, indicative of the sludge fraction, and Cs-137, indicative of the supernate fraction, is key to accurate characterization of sludge-contaminated waste. Both the sludge and supernate fractions and their scaling ratios to Sr-90 and Cs-137, respectively, are reproduced in Attachment 7.

Scaling factors for the sludge fraction are tied to Sr-90. Although Sr-90 is present in the supernate fraction, it comprises less than 1% of total activity in the supernate fraction. For this reason, all Sr-90 identified in the sludge-contaminated waste will be attributed to the sludge fraction. Scaling ratios developed for the sludge fraction will be applied to the Sr-90 identified in sludge-contaminated waste.

Scaling factors for the supernate fraction are tied to Cs-137. Although Cs-137 is present in the sludge fraction, it comprises only about 5% of total activity in the sludge fraction. For this reason, all Cs-137 identified in sludge-contaminated waste will be attributed to the supernate fraction. Scaling ratios developed for supernate will be applied to the Cs-137 identified in sludge-contaminated waste.

The two fractions of sludge-contaminated waste will be manifested separately. The dose of Cs-137 and Sr-90 will be entered into two separate waste streams in WITS, representing the sludge and supernate fractions, respectively, which will calculate curies attributed to each radionuclide identified in the respective distributions. The two waste streams will be combined in WITS to create a single manifest.

5.2 Quantification of Job Control Waste and Other Compactable Sludge-Contaminated Waste

The relative ease with which gamma radiation from Cs-137 is detected makes estimation of the curie content of the supernate fraction of waste straightforward. Dose-to-curie methodologies for

quantification of Cs-137 on waste containers have been developed and are currently in use (References 14 and 15).

Sr-90, a low-energy beta emitter, is not easily measured. Although a Beta Screening Tool (BST) has been developed as an improved alternative method for providing a dose associated with Sr-90 (Reference 16), the BST methodology has not yet been implemented for waste quantification purposes. Until such time as the BST is field implemented, the actual quantity of Sr-90 present in the sludge fraction must be estimated by some other means.

The most conservative approach in quantification of a waste cut is to assume that all measured Cs-137 is attributed to both supernate and sludge fractions. For the sludge fraction, the known Sr-90 to Cs-137 ratio is utilized to estimate the maximum Sr-90 that could be present on the waste cut. This approach results in double-manifesting of the Cs-137, over-manifesting of virtually all of the remaining radionuclides, and significantly over-estimating the sludge fraction (recall that Cs-137 and its daughter Ba-137m comprises over 97% of the activity in supernate, while it comprises less than 5% of the activity in sludge).

It is preferable, therefore, to determine an appropriate split of the measured Cs-137 that can be attributed to the supernate and sludge fractions. In determining the appropriate split between these fractions, one must consider the effects of overestimating one fraction or the other. Over-estimating the sludge fraction will result in

- under-manifesting of radionuclides attributed to supernate only (in this waste stream, the only radionuclide fitting this description is tritium, a PA radionuclide, present at 0.2% of total supernate activity), and

- over-manifesting of transuranics (a higher level of transuranics are present in sludge).

Over-estimating the supernate fraction will result in under-manifesting of radionuclides present in the sludge fraction only. In this waste stream, these include C-14, Ni-59, Y-90, Pm-147, Eu-154, U-235 and Np-237. C-14, Ni-59 and Np-237 are PA radionuclides.

For our purposes, we will consider contamination of waste with settled sludge, thereby maximizing the sludge fraction, to be the most conservative estimate on which to base a split of Cs-137. This is based on the prevailing consideration that sludge contains more transuranics than supernate. Available analytical data to date have measured the maximum concentration of insoluble solids of approximately 258 grams/liter in settled sludge slurry (Reference 7). Given the radionuclide distributions for the sludge and supernate fractions in this report, one can conservatively bound the sludge to supernate ratio based on the maximum concentration of insoluble solids in settled sludge of 300 grams/liter.

For a box of compactable waste, the quantification may be performed as follows:

Given: Cs-137 is present in Tank 40/42/51 unwashed supernate at 7.8 μCi/ml (Ref 10); there are 0.94 L supernate/L slurry (Attachment 1) and Cs-137 is present in tank 40/42/51 sludge at an average of 1.24E-04 Ci/g insoluble solids (Table 3.5). For one liter of slurry, there are (7.8 μCi/ml supernate * 0.94 L supernate/L slurry =) 7.3E-03 Ci Cs-137 attributable to supernate. For this same liter of slurry, there are (300 g insoluble solids/L slurry * 1.24E-04 Ci/g insoluble solids =) 1.96E-02 Ci Cs-137 attributable to insoluble sludge solids. In this liter of slurry, there are a total of (0.0196 + 0.0073 =) 0.027 Ci Cs-137, 27.2% of which are found in the supernate fraction and 72.8% found in the sludge fraction.

Using this split of the total Cs-137 present on the waste box, one can calculate the Cs-137 curies in the supernate fraction (27.2% of the total) and sludge fraction (72.8% of the total). Using the ratio of Sr-90 to Cs-137 in the sludge fraction from Attachment 7 (1.0/0.0364), we can determine the total Ci Sr-90 in the sludge fraction. The relative abundance of radionuclides in both the supernate and sludge fractions can then be calculated from their scaling factors to Cs-137 and Sr-90, respectively (see Attachment 7).

Deviation from this conservative approach may be considered on a case-by-case basis. Such other considerations may include, but are not limited to, one or more of the following:

- maintenance of a well-stirred tank that would result in contamination of waste with sludge slurry rather than settled sludge
- origin of the waste material, which may limit its exposure to sludge contamination
- analytical or survey data which may be indicative of a higher supernate fraction.

When application of an alternative approach is to be utilized, the technical basis must be documented.

5.3 Quantification of Non-Compactable Sludge-Contaminated Waste

Estimation of the quantity of Cs-137 present on non-compactable waste (e.g., equipment) is performed on a case-by-case basis. This is done by individual Dose-to-Curie runs, which take into account the specific geometry of the waste. (Reference 17). These are performed by Solid Waste Management Department personnel.

Application of BST methodology to non-compactable waste to determine the amount of Sr-90 present is not appropriate since the waste itself shields beta radiation and would therefore result in unrealistically low measured values. Estimation of Sr-90 present in cuts of non-compactable waste will be performed by estimation of the amount of Cs-137 attributed to the sludge fraction in combination with the known relationship between Sr-90 and Cs-137. This will be performed in the same method outlined in section 5.2 for compactable waste.

Additional considerations for deviation from the conservative approach identified in section 5.2 (contamination of waste with settled sludge) for non-compactable waste include

- washing or other processing of the waste after its removal from the waste tank.

6.0 Periodic Review and Validation

Provisions of Procedure WAC 2.02 (Rev. 4) require generators of routine wastes, including sludge-contaminated waste, to review each waste stream at least annually and validate radionuclide distributions at least every two years.

In addition to the annual review, review of the radionuclide distribution for sludge in tanks 40, 42 and 51 will be conducted on a more frequent basis if required to address process changes that may affect the distribution. These changes consist of anything that would cause the mean radionuclide distribution to change to the degree that the difference between the distribution documented in this report and the revised distribution exceeds the consolidation criteria identified in section 3.2 of this report. These changes may include, but are not limited to, the following:

- Addition of sludge waste into tanks 40, 42, or 51 from a waste tank other than these tanks
- Processing conducted in tanks 40, 42 or 51 that may result in a change in the distribution

7.0 References

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Attachment 1

Development of Scaling Factors for Tanks 40, 42 and 51

Attachment 1a

Comparison of Tank 42 PK to Analyzed and WCS-derived Sludge Scaling Factors for Consolidation

	Concentration of Insoluble Isotope in Sludge Slurry (uCi/gal))				Scaling Factors (Ci/Ci Sr-90)		
Isotope	Tank 42 25L Sample (Ref 1)	Tank 42 5L Sample (Ref 2)	DWPF Macro Batch 2 Sample (Ref 3)	Average Concentration from Sample Data	Average SFs from Sample Data	Tank 42 WCS Tables (Ref 4)	Tank 42 Decay-Corrected Fill Data (Ref 5)
H-3							
C-14			5.00E-03	5.00E-03	8.52E-07	7.55E-08	6.70E-08
Ni-59			7.41E-02	7.41E-02	1.26E-05	3.36E-05	3.48E-05
Co-60	1.96E+00	9.78E-01	7.93E-01	1.24E+00	2.12E-04	2.10E-03	5.60E-04
Se-79			9.62E-02	9.62E-02	1.64E-05	1.75E-05	1.83E-05
Sr-90	7.13E+03	5.61E+03	4.88E+03	5.87E+03	1.00E+00	1.00E+00	1.00E+00
Y-90	7.13E+03	5.61E+03	4.88E+03	5.87E+03	1.00E+00	1.00E+00	1.00E+00
Tc-99			1.89E-01	1.89E-01	3.22E-05	2.97E-04	3.10E-04
Ru-106		2.95E+00		2.95E+00	5.02E-04	1.41E-07	4.60E-08
Rh-106						1.41E-07	4.60E-08
Sb-125		1.36E+00	3.02E-01	8.32E-01	1.42E-04	1.54E-04	7.45E-05
Sn-126			3.70E-02	3.70E-02	6.29E-06	1.63E-05	1.69E-05
I-129			1.23E-03	1.23E-03	2.10E-07	1.03E-09	1.08E-09
Cs-134						1.08E-05	4.26E-06
Cs-135			7.76E-04	7.76E-04	1.32E-07	1.98E-07	
Cs-137	1.70E+02	2.07E+02	1.67E+02	1.81E+02	3.09E-02	5.52E-02	5.54E-02
Ba-137m	1.61E+02	1.96E+02	1.58E+02	1.71E+02	2.92E-02	5.22E-02	5.24E-02
Ce-144		2.61E+00		2.61E+00	4.44E-04	4.09E-08	9.33E-09
Pm-147						4.03E-03	2.01E-03
Eu-154	2.05E+01	1.74E+01	1.16E+01	1.65E+01	2.81E-03	1.01E-02	3.02E-02
U-233	3.39E-02	4.36E-02	4.94E-02	4.23E-02	7.20E-06	1.80E-06	9.80E-06
U-234	2.36E-02	3.09E-02	3.27E-02	2.91E-02	4.95E-06	6.62E-07	6.84E-06
U-235	3.94E-04	3.90E-04	3.18E-04	3.67E-04	6.26E-08	1.56E-08	1.14E-07
Np-237		1.55E-02	1.46E-02	1.51E-02	2.57E-06	5.45E-07	1.29E-06
Pu-238	1.11E+02	1.04E+02	1.13E+02	1.09E+02	1.86E-02	7.69E-03	3.12E-02
Pu-239	5.50E+00	5.02E+00	5.53E+00	5.35E+00	9.11E-04	3.07E-04	1.55E-03
Pu-240	1.66E+00	1.80E+00	2.01E+00	1.82E+00	3.11E-04	1.10E-04	4.68E-04
Pu-241	5.96E+01	3.39E+01	3.21E+01	4.19E+01	7.13E-03	6.54E-04	1.67E-02
Pu-242	3.85E-03	3.31E-03	4.19E-03	3.78E-03	6.44E-07	1.01E-07	2.94E-05
Am-241	7.42E+00	8.39E+00	7.54E+00	7.78E+00	1.33E-03	1.33E-03	2.08E-03
Cm-244	7.64E+00	5.91E+00	5.00E+00	6.19E+00	1.05E-03	8.68E-06	8.24E-06
Total	1.48E+04	1.18E+04	1.03E+04	1.23E+04	2.09E+00	2.13E+00	2.19E+00

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Attachment 1a

Comparison of Tank 42 PK to Analyzed and WCS-derived Sludge Scaling Factors for Consolidation

	Calculation of Scaling Factors from 25L Sample (Ref 1)						
	Sludge Slurry			Interstitial Supernate			
Isotope	wt% (g/g total solids)	Specific activity, Ci/g	uCi/g total solids	wt% (g/g supernate)	uCi/ml Supernate	Adjusted uCi/g Sludge Solids	SF
H-3		9.71E+03					
C-14		4.46E+00					
Ni-59		8.08E-02					
Co-60		1.13E+03	1.55E+00			1.96E+00	2.75E-04
Se-79		6.96E-02					
Sr-90		1.39E+02	5.63E+03			7.13E+03	1.00E+00
Y-90		5.43E+05				7.13E+03	1.00E+00
Tc-99		1.70E-02					
Ru-106		1.47E+09					
Rh-106		2.71E+09					
Sb-125		1.03E+03					
Sn-126		2.84E-02					
I-129		1.77E-04					
Cs-134		1.29E+03					
Cs-135		1.15E-03					
Cs-137		8.65E+01	1.56E+02		8.25E+00	1.70E+02	2.39E-02
Ba-137m						1.61E+02	2.26E-02
Ce-144		3.19E+03					
Pm-147		9.27E+02					
Eu-154		2.64E+02	1.62E+01			2.05E+01	2.88E-03
U-233	2.86E-04	9.65E-03	2.76E-02	2.99E-08	3.06E-04	3.39E-02	4.76E-06
U-234	3.09E-04	6.22E-03	1.92E-02	3.23E-08	2.13E-04	2.36E-02	3.31E-06
U-235	1.48E-02	2.16E-06	3.20E-04	1.55E-06	3.55E-06	3.94E-04	5.52E-08
Np-237		7.05E-04					
Pu-238	5.14E-04	1.71E+01	8.79E+01	2.88E-10	5.22E-03	1.11E+02	1.56E-02
Pu-239	7.00E-03	6.20E-02	4.34E+00	3.92E-09	2.58E-04	5.50E+00	7.71E-04
Pu-240	5.79E-04	2.27E-01	1.31E+00	3.24E-10	7.80E-05	1.66E+00	2.33E-04
Pu-241	4.57E-05	1.03E+02	4.71E+01	2.56E-11	2.79E-03	5.96E+01	8.36E-03
Pu-242	7.73E-05	3.93E-03	3.04E-03	4.33E-11	1.80E-07	3.85E-03	5.40E-07
Am-241		3.43E+00	5.86E+00			7.42E+00	1.04E-03
Cm-244		8.09E+01	6.03E+00			7.64E+00	1.07E-03
Total						1.48E+04	

given:		calculated:	
g diss slds/g slurry	7.6%	g slurry/L slurry	1170
g tot slds/g slurry	28.0%	g diss solids/L slurry	69.03
g insol slds/g slurry	22.1%	L supernate/L slurry	0.86
g sol slds/g slurry	5.9%	g insol slds/L slurry	258.57
spg supernate	1.06	g total solids/L slurry	327.6
spg slurry	1.17	g insol slds/tot slds	78.9%

g U/g supernate	2.78E-04
g U/g slurry	2.66E+00
g Pu/g supernate	4.60E-09
g Pu/g slurry	8.22E-03

Attachment 1a

Comparison of Tank 42 PK to Analyzed and WCS-derived Sludge Scaling Factors for Consolidation

	Calculation of Scaling Factors from 5L Sample (Ref 2)					
	Slurry		Interstitial Supernate			
Isotope	wt% (g/g total solids)	uCi/g total solids	mg/L supernate	uCi/ml supernate	Adjusted uCi/g Sludge Solids	SF
H-3						
C-14						
Ni-59						
Co-60		8.62E-01			9.78E-01	1.74E-04
Se-79						
Sr-90		4.94E+03		8.00E-03	5.61E+03	1.00E+00
Y-90					5.61E+03	1.00E+00
Tc-99						
Ru-106		2.60E+00			2.95E+00	5.26E-04
Rh-106						
Sb-125		1.20E+00			1.36E+00	2.43E-04
Sn-126						
I-129						
Cs-134						
Cs-135						
Cs-137		1.94E+02		2.23E+00	2.07E+02	3.69E-02
Ba-137m					1.96E+02	3.49E-02
Ce-144		2.30E+00			2.61E+00	4.66E-04
Pm-147						
Eu-154		1.53E+01			1.74E+01	3.10E-03
U-233	3.98E-04	3.84E-02	6.03E-05	5.82E-07	4.36E-02	7.77E-06
U-234	4.38E-04	2.72E-02	6.64E-05	4.13E-07	3.09E-02	5.51E-06
U-235	1.59E-02	3.44E-04	2.41E-03	5.21E-09	3.90E-04	6.96E-08
Np-237		1.37E-02			1.55E-02	2.77E-06
Pu-238	5.37E-04	9.18E+01	0.00E+00	0.00E+00	1.04E+02	1.86E-02
Pu-239	7.13E-03	4.42E+00	0.00E+00	0.00E+00	5.02E+00	8.95E-04
Pu-240	6.97E-04	1.58E+00	0.00E+00	0.00E+00	1.80E+00	3.20E-04
Pu-241	2.90E-05	2.99E+01	0.00E+00	0.00E+00	3.39E+01	6.05E-03
Pu-242	7.42E-05	2.92E-03	0.00E+00	0.00E+00	3.31E-03	5.90E-07
Am-241		7.39E+00			8.39E+00	1.50E-03
Cm-244		5.21E+00			5.91E+00	1.05E-03
Total					1.18E+04	

given:		calculated:	
g diss slds/g slurry	2.3%	g slurry/L slurry	1130
g tot slds/g slurry	16.0%	g diss solids/L slurry	22.261
g insol slds/g slurry	14.1%	L supernate/L slurry	0.95
g sol slds/g slurry	2.0%	g insol slds/L slurry	159.33
spg supernate	1.02	g total solids/L slurry	180.8
spg slurry	1.13	g insol slds/tot slds	88.1%

mg U/L supernate	4.00E-01
g U/g slurry	2.64E+00
g Pu/g supernate	ND
g Pu/g slurry	8.47E-03

Attachment 1a

Comparison of Tank 42 PK to Analyzed and WCS-derived Sludge Scaling Factors for Consolidation

	Calculation of Scaling Factors from Tank 42/51 Sample (DWPF Macro Batch 2) (Ref 3)						Calculation of Scaling Factors from WCS Data (Ref 4)		Calculation of Scaling Factors from Fill Data (Ref 5)	
	Slurry		Interstitial Supernate							
Isotope	wt% (g/g total solids)	uCi/g total solids	mg/L supernate	uCi/ml supernate	Adjusted uCi/g Sludge Solids	SF	Tk 42 WCS Tables, Ci/gal	SFs	Tk 42 Fill Data, SFs	Decay Corrected to Year 2000
H-3										
C-14	9.91E-08	4.42E-03			5.00E-03	1.03E-06	4.29E-02	7.55E-08	2.97E-08	3.35E-08
Ni-59	8.10E-05	6.54E-02			7.41E-02	1.52E-05	1.91E+01	3.36E-05	1.54E-05	1.74E-05
Co-60	6.19E-08	7.00E-01			7.93E-01	1.63E-04	1.19E+03	2.10E-03	2.80E-04	2.80E-04
Se-79	1.22E-04	8.49E-02			9.62E-02	1.97E-05	9.95E+00	1.75E-05	8.10E-06	9.16E-06
Sr-90	3.10E-03	4.31E+03		7.83E-03	4.88E+03	1.00E+00	5.68E+05	1.00E+00	5.00E-01	5.00E-01
Y-90	3.10E-03	1.68E+07			4.88E+03	1.00E+00	5.68E+05	1.00E+00	5.00E-01	5.00E-01
Tc-99	1.10E-03	1.87E-01	2.68E-01		1.89E-01	3.88E-05	1.69E+02	2.97E-04	1.37E-04	1.55E-04
Ru-106							8.04E-02	1.41E-07	6.40E-07	2.30E-08
Rh-106							8.04E-02	1.41E-07	6.40E-07	2.30E-08
Sb-125	2.58E-08	2.67E-01			3.02E-01	6.19E-05	8.78E+01	1.54E-04	1.19E-04	3.73E-05
Sn-126	1.15E-04	3.26E-02			3.70E-02	7.58E-06	9.24E+00	1.63E-05	7.48E-06	8.47E-06
I-129	6.16E-04	1.09E-03			1.23E-03	2.53E-07	5.87E-04	1.03E-09	4.76E-10	5.39E-10
Cs-134							6.13E+00	1.08E-05	1.02E-05	2.13E-06
Cs-135	6.45E-05	7.42E-04	1.14E-02		7.76E-04	1.59E-07	1.13E-01	1.98E-07		
Cs-137	1.84E-04	1.59E+02	3.21E-02	2.44E+00	1.67E+02	3.42E-02	3.14E+04	5.52E-02	2.77E-02	2.77E-02
Ba-137m					1.58E+02	3.23E-02	2.97E+04	5.22E-02	2.62E-02	2.62E-02
Ce-144							2.32E-02	4.09E-08	3.55E-07	4.67E-09
Pm-147							2.29E+03	4.03E-03	3.33E-03	1.00E-03
Eu-154	3.89E-06	1.03E+01			1.16E+01	2.38E-03	5.75E+03	1.01E-02	1.66E-02	1.51E-02
U-233	4.52E-04	4.36E-02	9.91E-05		4.94E-02	1.01E-05	1.02E+00	1.80E-06	4.90E-06	4.90E-06
U-234	4.65E-04	2.89E-02	1.02E-04		3.27E-02	6.71E-06	3.76E-01	6.62E-07	3.42E-06	3.42E-06
U-235	1.30E-02	2.81E-04	3.14E-03		3.18E-04	6.53E-08	8.88E-03	1.56E-08	5.68E-08	5.68E-08
Np-237	1.83E-03	1.29E-02			1.46E-02	3.00E-06	3.10E-01	5.45E-07	5.70E-07	6.44E-07
Pu-238	5.81E-04	9.94E+01			1.13E+02	2.31E-02	4.37E+03	7.69E-03	1.56E-02	1.56E-02
Pu-239	7.87E-03	4.88E+00			5.53E+00	1.13E-03	1.74E+02	3.07E-04	7.73E-04	7.73E-04
Pu-240	7.82E-04	1.78E+00			2.01E+00	4.12E-04	6.26E+01	1.10E-04	2.34E-04	2.34E-04
Pu-241	2.75E-05	2.83E+01			3.21E+01	6.58E-03	3.72E+02	6.54E-04	8.36E-03	8.36E-03
Pu-242	9.41E-05	3.70E-03			4.19E-03	8.59E-07	5.73E-02	1.01E-07	1.47E-05	1.47E-05
Am-241	1.94E-04	6.66E+00			7.54E+00	1.55E-03	7.58E+02	1.33E-03	1.04E-03	1.04E-03
Cm-244	5.46E-06	4.42E+00			5.00E+00	1.03E-03	4.93E+00	8.68E-06	4.44E-06	4.12E-06
Total					1.03E+04					1.10E+00

given:		calculated:	
g diss slds/g slurry	2.6%	g slurry/L slurry	1100
g tot slds/g slurry	18.8%	g diss solids/L slurry	24.2
g insol slds/g slurry	16.6%	L supernate/L slurry	0.89
g sol slds/g slurry	2.2%	g insol slds/L slurry	182.6
spg supernate	1.03	g total solids/L slurry	206.8
spg slurry	1.1	g insol slds/tot slds	88.3%

mg U/L supernate	
g U/g slurry	1.94E+00
g Pu/g supernate	
g Pu/g slurry	9.35E-03

Attachment 1b

Comparison of Tank 51 PK to Analyzed and WCS-derived Sludge Scaling Factors for Consolidation

	Concentration of Isotope in Insoluble Sludge Solids (uCi/g)					Scaling Factors (Ci/Ci Sr-90)		
Isotope	Unwashed Sludge Sample (Ref 1)	Washed Sludge Sample (Ref 1)	Sludge Sample (Ref 2)	Sludge Sample (Ref 3)	Average concentration from Sample Data	Scaling Factors from Analytical Data	Tank 51 WCS (Ref 4)	Tank 51 Decay-Corrected Fill Data (Ref 5)
H-3								
C-14							1.59E-06	1.86E-06
Ni-59			2.54E-02		2.54E-02	2.84E-05	1.05E-04	1.20E-04
Co-60	1.36E+00	1.19E+00			1.28E+00	1.43E-03	3.64E-03	3.16E-03
Se-79			1.46E-02		1.46E-02	1.63E-05	1.62E-05	1.66E-05
Sr-90	9.26E+02	8.21E+02	8.18E+02	1.01E+03	8.95E+02	1.00E+00	1.00E+00	1.00E+00
Y-90	9.26E+02	8.21E+02	8.18E+02	1.01E+03	8.95E+02	1.00E+00	1.00E+00	1.00E+00
Tc-99			2.89E-01	2.88E-01	2.88E-01	3.22E-04	2.77E-04	2.86E-04
Ru-106							9.96E-07	4.72E-07
Rh-106							9.96E-07	4.72E-07
Sb-125							8.36E-04	6.28E-04
Sn-126			8.54E-03		8.54E-03	9.55E-06	2.21E-05	2.38E-05
I-129							1.13E-09	1.19E-09
Cs-134							5.40E-05	3.16E-05
Cs-135							1.85E-07	
Cs-137	7.41E+01	6.46E+01	6.49E+01	5.80E+01	6.54E+01	7.31E-02	5.99E-02	1.20E-01
Ba-137m	7.01E+01	6.11E+01	6.14E+01	5.48E+01	6.18E+01	6.91E-02	5.67E-02	1.13E-01
Ce-144							2.56E-07	8.98E-08
Pm-147							1.99E-02	1.48E-02
Eu-154	1.92E+00	1.81E+00			1.86E+00	2.08E-03	1.22E-02	2.50E-02
U-233	3.76E-02	3.40E-02	3.41E-02	2.41E-02	3.24E-02	3.62E-05	2.96E-06	3.22E-07
U-234	3.73E-02	3.36E-02	3.33E-02	2.11E-02	3.14E-02	3.50E-05	1.88E-06	1.03E-21
U-235	4.90E-04	4.39E-04	4.53E-04	3.46E-04	4.32E-04	4.83E-07	2.05E-07	2.96E-09
Np-237			1.85E-02	1.06E-02	1.45E-02	1.62E-05	1.15E-06	4.42E-06
Pu-238	1.43E+02	1.78E+02	1.79E+02	8.55E+01	1.47E+02	1.64E-01	4.69E-02	7.26E-03
Pu-239	1.06E+01	8.68E+00	8.93E+00	4.84E+00	8.26E+00	9.23E-03	5.47E-03	7.72E-05
Pu-240	3.60E+00		2.35E+00	1.59E+00	2.51E+00	2.81E-03	1.39E-03	5.38E-05
Pu-241			4.18E+01	1.96E+01	3.07E+01	3.43E-02	7.06E-03	1.88E-03
Pu-242			2.11E-03	3.26E-03	2.69E-03	3.00E-06	1.63E-06	7.84E-08
Am-241	9.69E+00	7.92E+00	8.09E+00	8.24E+00	8.48E+00	9.48E-03	6.39E-04	4.60E-04
Cm-244	1.02E+02	1.57E+01	1.59E+01	1.54E+01	3.74E+01	4.18E-02	6.59E-06	4.56E-10
Total	2.27E+03	1.98E+03	1.20E+03	1.26E+03		2.41E+00	2.22E+00	2.29E+00

Bold isotopes=PA Rads for EAV

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2. WSRC-TR-95-0487, N. E. Bibler and O. B. Hodoh, Calculating Waste Acceptance Radionuclides in DWPF Tank 51 Sludge Only Glass, Rev. 1, 10/15/96

3. WSRC-TR-94-0505, N. E. Bibler,W. F. Kinard, R. A. Dewberry and C. J. Coleman, A Method for the Determination of Waste Acceptance Radionuclides in DWPF Glass and Demonstration of that Method Using SRS Tank 51 Radioactive Sludge and Glass, 10/20/94

4. M:\Waste\Hlcats\WCSystem\WCSTables.xls.SldgInv(new), 9/14/99

5. WSRC-TR-94-0562, G. K. Georgeton and J. R. Hester, "Characterization of Radionuclides in HLW Sludge Based on Isotopic Distribution in Irradiated Assemblies (U)," WSRC-TR-94-0562, Rev. 1, January 27, 1995

Attachment 1b

Comparison of Tank 51 PK to Analyzed and WCS-derived Sludge Scaling Factors for Consolidation

	Calculation of Scaling Factors from Unwashed Sludge Sample (Ref 1)						
	Sludge Slurry			Interstitial Supernate			
Isotope	wt% (g/g total solids)	Specific activity, Ci/g	uCi/g total solids	ppm (E-6 g/g supernate)	uCi/ml Supernate	Adjusted uCi/g Sludge Solids	Scaling Factors
H-3		9.71E+03					
C-14		4.46E+00					
Ni-59		8.08E-02					
Co-60		1.13E+03	8.30E-01			1.36E+00	1.47E-03
Se-79		6.96E-02					
Sr-90		1.39E+02	5.64E+02			9.26E+02	1.00E+00
Y-90		5.43E+05				9.26E+02	1.00E+00
Tc-99		1.70E-02					
Ru-106		1.47E+09					
Rh-106		2.71E+09					
Sb-125		1.03E+03					
Sn-126		2.84E-02					
I-129		1.77E-04					
Cs-134		1.29E+03					
Cs-135		1.15E-03					
Cs-137		8.65E+01	7.01E+01		7.80E+00	7.41E+01	7.99E-02
Ba-137m						7.01E+01	7.56E-02
Ce-144		3.19E+03					
Pm-147		9.27E+02					
Eu-154		2.64E+02	1.17E+00			1.92E+00	2.07E-03
U-233	2.38E-04	9.65E-03	2.30E-02	2.69E-03	2.78E-05	3.76E-02	4.05E-05
U-234	3.66E-04	6.22E-03	2.28E-02	7.09E-04	4.72E-06	3.73E-02	4.03E-05
U-235	1.38E-02	2.16E-06	2.98E-04	1.12E-02	2.59E-08	4.90E-04	5.29E-07
Np-237		7.05E-04					
Pu-238	5.10E-04	1.71E+01	8.72E+01	1.52E-04	2.77E-03	1.43E+02	1.55E-01
Pu-239	1.04E-02	6.20E-02	6.45E+00	3.09E-03	2.05E-04	1.06E+01	1.14E-02
Pu-240	9.66E-04	2.27E-01	2.19E+00	5.04E-04	1.22E-04	3.60E+00	3.89E-03
Pu-241	nd	1.03E+02	nd				
Pu-242	4.19E-05	3.93E-03	1.65E-03				
Am-241		3.43E+00	5.90E+00			9.69E+00	1.05E-02
Cm-244		8.09E+01	6.24E+01			1.02E+02	1.11E-01
Total						2.27E+03	

given:		calculated:	
g diss slds/g slurry	11.4%	g slurry/L slurry	1180
g tot slds/g slurry	24.8%	g diss solids/L slurry	114.46
g insol slds/g slurry	15.1%	L supernate/L slurry	0.94
g sol slds/g slurry	9.7%	g insol slds/L slurry	178.18
spg supernate	1.07	g total solids/L slurry	292.64
spg slurry	1.18	g insol slds/tot slds	60.9%

ppm (E-6 gU/g supnt)	1.97E+00
g U/g slurry	3.11E-02
ppm (E-6 gU/g slry)	3.60E-03
g Pu/g slurry	1.20E-04

Attachment 1b

Comparison of Tank 51 PK to Analyzed and WCS-derived Sludge Scaling Factors for Consolidation

	Calculation of Scaling Factors from Washed Sludge Sample (Ref 1)						Calculation of Scaling Factors from Reference 2			
	Slurry		Interstitial Supernate							
Isotope	wt% (g/g total solids)	uCi/g total solids	ppm (E-6 g/g supernate)	uCi/ml Supernate	Adjusted uCi/g Sludge Solids	Scaling Factor	wt% (g/g total solids)	uCi/g total solids	uCi/g sludge solids	Scaling Factor
H-3										
C-14										
Ni-59							2.40E-05	1.94E-02	2.54E-02	3.10E-05
Co-60		9.10E-01			1.19E+00	1.45E-03				
Se-79							1.60E-05	1.11E-02	1.46E-02	1.78E-05
Sr-90		6.27E+02			8.21E+02	1.00E+00	4.50E-04	6.25E+02	8.18E+02	1.00E+00
Y-90					8.21E+02	1.00E+00				
Tc-99							1.30E-03	2.20E-01	2.89E-01	3.53E-04
Ru-106										
Rh-106										
Sb-125										
Sn-126							2.30E-05	6.53E-03	8.54E-03	1.04E-05
I-129										
Cs-134										
Cs-135										
Cs-137		6.21E+01		2.70E+00	6.46E+01	7.88E-02	7.20E-05	6.23E+01	6.49E+01	7.93E-02
Ba-137m					6.11E+01	7.45E-02		5.89E+01	6.14E+01	7.50E-02
Ce-144										
Pm-147										
Eu-154		1.38E+00			1.81E+00	2.20E-03				
U-233	2.69E-04	2.59E-02	1.13E-04	1.11E-06	3.40E-02	4.14E-05	2.70E-04	2.60E-02	3.41E-02	4.17E-05
U-234	4.13E-04	2.57E-02	2.81E-04	1.78E-06	3.36E-02	4.09E-05	4.10E-04	2.55E-02	3.33E-02	4.08E-05
U-235	1.55E-02	3.35E-04	3.23E-03	7.12E-09	4.39E-04	5.34E-07	1.60E-02	3.46E-04	4.53E-04	5.53E-07
Np-237							2.00E-03	1.41E-02	1.85E-02	2.26E-05
Pu-238	7.97E-04	1.36E+02	1.75E-05	3.05E-04	1.78E+02	2.17E-01	8.00E-04	1.37E+02	1.79E+02	2.19E-01
Pu-239	1.07E-02	6.63E+00	2.35E-04	1.49E-05	8.68E+00	1.06E-02	1.10E-02	6.82E+00	8.93E+00	1.09E-02
Pu-240	0.000792	1.80E+00	ND	ND	2.35E+00	2.87E-03	7.90E-04	1.79E+00	2.35E+00	2.87E-03
Pu-241	ND		ND	ND			3.10E-05	3.19E+01	4.18E+01	5.11E-02
Pu-242	4.05E-05	1.59E-03	ND	ND	2.08E-03	2.54E-06	4.10E-05	1.61E-03	2.11E-03	2.58E-06
Am-241		6.05E+00			7.92E+00	9.65E-03	1.80E-04	6.18E+00	8.09E+00	9.89E-03
Cm-244		1.20E+01			1.57E+01	1.91E-02	1.50E-05	1.21E+01	1.59E+01	1.94E-02
Total					1.98E+03			9.42E+02	1.20E+03	

given:		calculated:	
g diss slds/g slurry	4.9%	g slurry/L slurry	1100
g tot slds/g slurry	17.8%	g diss solids/L slurry	46.2
g insol slds/g slurry	13.6%	L supernate/L slurry	0.92
g sol slds/g slurry	4.2%	g insol slds/L slurry	149.6
spg supernate	1.02	g total solids/L slurry	195.8
spg slurry	1.1	g insol slds/tot slds	76.4%

ppm (E-6 gU/g supnt)	4.52E-01
g U/g slurry	3.21E-02
ppm (E-6 gU/g slry)	2.70E-04
g Pu/g slurry	1.20E-04

Attachment 1b

Comparison of Tank 51 PK to Analyzed and WCS-derived Sludge Scaling Factors for Consolidation

	Calculation of Scaling Factors from Reference 3				Calculation of Scaling Factors from WCS Data (Ref 4)		Calculation of Scaling Factors from Tank Fill Data (Ref 5)	
Isotope	wt% (g/g total solids)	uCi/g total solids	uCi/g sludge solids	Scaling Factor	Tk 51 WCS Tables, Ci/gal	Scaling Factor	Tk 51 Fill Data, Scaling Factors	Decay Corrected to Year 2000
H-3								
C-14					2.58E-07	1.59E-06	8.22E-07	9.29E-07
Ni-59					1.70E-05	1.05E-04	5.29E-05	5.98E-05
Co-60					5.90E-04	3.64E-03	2.70E-03	1.58E-03
Se-79					2.62E-06	1.62E-05	7.35E-06	8.32E-06
Sr-90	7.30E-04	1.01E+03	1.01E+03	1.00E+00	1.62E-01	1.00E+00	5.00E-01	5.00E-01
Y-90				1.00E+00	1.62E-01	1.00E+00	5.00E-01	5.00E-01
Tc-99	1.70E-03	2.88E-01	2.88E-01	2.84E-04	4.49E-05	2.77E-04	1.26E-04	1.43E-04
Ru-106					1.62E-07	9.96E-07	6.56E-06	2.36E-07
Rh-106					1.62E-07	9.96E-07	6.56E-06	2.36E-07
Sb-125					1.36E-04	8.36E-04	1.00E-03	3.14E-04
Sn-126					3.59E-06	2.21E-05	1.05E-05	1.19E-05
I-129					1.84E-10	1.13E-09	5.26E-10	5.95E-10
Cs-134					8.76E-06	5.40E-05	7.55E-05	1.58E-05
Cs-135					3.00E-08	1.85E-07		
Cs-137	6.70E-05	5.80E+01	5.80E+01	5.72E-02	9.72E-03	5.99E-02	5.95E-02	5.99E-02
Ba-137m		5.48E+01	5.48E+01	5.41E-02	9.20E-03	5.67E-02	5.63E-02	5.67E-02
Ce-144					4.15E-08	2.56E-07	3.41E-06	4.49E-08
Pm-147					3.23E-03	1.99E-02	2.46E-02	7.42E-03
Eu-154					1.99E-03	1.22E-02	1.37E-01	1.25E-02
U-233	2.50E-04	2.41E-02	2.41E-02	2.38E-05	4.80E-07	2.96E-06	1.43E-07	1.61E-07
U-234	3.40E-04	2.11E-02	2.11E-02	2.08E-05	3.05E-07	1.88E-06	4.55E-22	5.15E-22
U-235	1.60E-02	3.46E-04	3.46E-04	3.41E-07	3.33E-08	2.05E-07	1.31E-09	1.48E-09
Np-237	1.50E-03	1.06E-02	1.06E-02	1.04E-05	1.87E-07	1.15E-06	1.95E-06	2.21E-06
Pu-238	5.00E-04	8.55E+01	8.55E+01	8.43E-02	7.61E-03	4.69E-02	3.34E-03	3.63E-03
Pu-239	7.80E-03	4.84E+00	4.84E+00	4.77E-03	8.88E-04	5.47E-03	3.41E-05	3.86E-05
Pu-240	7.00E-04	1.59E+00	1.59E+00	1.57E-03	2.26E-04	1.39E-03	2.38E-05	2.69E-05
Pu-241	1.90E-05	1.96E+01	1.96E+01	1.93E-02	1.15E-03	7.06E-03	1.08E-03	9.41E-04
Pu-242	8.30E-05	3.26E-03	3.26E-03	3.22E-06	2.64E-07	1.63E-06	3.46E-08	3.92E-08
Am-241	2.40E-04	8.24E+00	8.24E+00	8.13E-03	7.94E-05	6.39E-04	2.05E-04	2.30E-04
Cm-244	1.90E-05	1.54E+01	1.54E+01	1.52E-02	1.07E-06	6.59E-06	3.00E-06	2.28E-10
Total		1.26E+03	1.26E+03					1.14E+00

Attachment 2

Comparison of Tanks 40, 42 and 51 Consolidation

Attachment 2

Comparison of Tank 40, 42 and 51 Sludge Isotope Concentrations for Consolidation

	Concentration of Isotope in Insoluble Sludge Solids (uCi/g)			PA Rads, Variation from Mean Concentration		
Isotope	**Tank 42**	**Tank 51**	**Mean Concentration**	**Tank 42**	**Tank 51**	Mean Distribution
H-3						0.00E+00
C-14	5.00E-03		5.00E-03	**0.00%**		6.92E-07
Ni-59	7.41E-02	2.54E-02	4.98E-02	**48.98%**	**-48.98%**	6.88E-06
Co-60	1.24E+00	1.28E+00	1.26E+00			1.74E-04
Se-79	9.62E-02	1.46E-02	5.54E-02			7.66E-06
Sr-90	5.87E+03	8.95E+02	3.38E+03			4.68E-01
Y-90	5.87E+03	8.95E+02	3.38E+03			4.68E-01
Tc-99	1.89E-01	2.88E-01	2.39E-01	**-20.82%**	**20.82%**	3.30E-05
Ru-106	2.95E+00		2.95E+00			4.08E-04
Rh-106	2.95E+00		2.95E+00			4.08E-04
Sb-125	8.32E-01		8.32E-01			1.15E-04
Sn-126	3.70E-02	8.54E-03	2.28E-02			3.15E-06
I-129	1.23E-03		1.23E-03	**0.00%**		1.70E-07
Cs-134						0.00E+00
Cs-135	7.76E-04		7.76E-04			1.07E-07
Cs-137	1.81E+02	6.54E+01	1.23E+02	**46.99%**	**-46.99%**	1.71E-02
Ba-137m	1.71E+02	6.18E+01	1.17E+02			1.61E-02
Ce-144	2.61E+00		2.61E+00			3.61E-04
Pm-147						0.00E+00
Eu-154	1.65E+01	1.86E+00	9.18E+00			1.27E-03
U-233	4.23E-02	3.24E-02	3.74E-02			5.17E-06
U-234	2.91E-02	3.14E-02	3.02E-02	**-3.75%**	**3.75%**	4.18E-06
U-235	3.67E-04	4.32E-04	4.00E-04			5.53E-08
Np-237	1.51E-02	1.45E-02	1.48E-02	**1.91%**	**-1.91%**	2.05E-06
Pu-238	1.09E+02	1.47E+02	1.28E+02			1.77E-02
Pu-239	5.35E+00	8.26E+00	6.80E+00	**-21.40%**	**21.40%**	9.41E-04
Pu-240	1.82E+00	2.51E+00	2.17E+00			3.00E-04
Pu-241	4.19E+01	3.07E+01	3.63E+01			5.02E-03
Pu-242	3.78E-03	2.69E-03	3.23E-03			4.47E-07
Am-241	7.78E+00	8.48E+00	8.13E+00			1.13E-03
Cm-244	6.19E+00	3.74E+01	2.18E+01			3.01E-03
Total	1.23E+04	2.15E+03	7.23E+03			1.00E+00

	Fractional Activity			Predominant Rads, Variation from Mean Concentration	
Isotope	**Tank 42**	**Tank 51**	**Mean Concentration**	**Tank 42**	**Tank 51**
Sr-90	4.78E-01	4.15E-01	4.68E-01	2.04%	-11.24%
Y-90	4.78E-01	4.15E-01	4.68E-01	2.04%	-11.24%

Bold=PA Rads for EAV

*Source=WSRC-TR-94-0562; scaling ratios for Cs-135 developed based on ratio to Cs-137 utilized in Waste Characterization System, which was based on 5-year old waste tables in DPSTD-80-39 "Preliminary Technical Data Summary, DWPF Stage 2," Table 13.6-5, dated 12/80

Attachment 3

Sludge Waste Stream 40/42/51, Exclusion Criteria

Attachment 3. Tanks 40/42/51 Sludge Waste Stream Exclusion Criteria

				Comparison to MALLD				
Isotope	Distribution	<1% of dist?(a)	Not Expected	Mean uCi Isotope/g sludge	MALLD, uCi/g	1/100 MALLD, uCi/g	PA Rads <1/100 MALLD?	Non-PA <MALLD?
H-3	0.00E+00		x		1.00E-04	1.00E-06	yes	NA
C-14	6.92E-07			5.00E-03	1.00E-05	1.00E-07	no	NA
Ni-59	6.88E-06			4.98E-02	1.00E-04	1.00E-06	no	NA
Co-60	1.74E-04			1.26E+00	1.00E-04	1.00E-06		no
Se-79	7.66E-06	yes		5.54E-02				
Sr-90	4.68E-01			3.38E+03	1.00E-04	1.00E-06		no
Y-90	4.68E-01	no		3.38E+03	1.00E-04	1.00E-06		no
Tc-99	3.30E-05			2.39E-01	1.00E-06	1.00E-08	no	NA
Ru-106	4.08E-04	yes		2.95E+00				
Rh-106	4.08E-04	yes		2.95E+00				
Sb-125	1.15E-04	yes		8.32E-01				
Sn-126	3.15E-06	yes		2.28E-02				
I-129	1.70E-07			1.23E-03	1.00E-06	1.00E-08	no	NA
Cs-134	2.44E-05	yes		0.00E+00				
Cs-135	1.07E-07	yes		7.76E-04				
Cs-137	1.71E-02			1.23E+02	1.00E-05	1.00E-07	no	NA
Ba-137m	1.61E-02	no		1.17E+02	1.00E-05	1.00E-07		no
Ce-144	3.61E-04	yes		2.61E+00				
Pr-144	3.61E-04	yes		2.61E+00				
Pr-144m	3.61E-04	yes		2.61E+00				
Pm-147	8.99E-03	yes(b)		0.00E+00				
Eu-154	1.27E-03	yes		9.18E+00				
U-233	5.17E-06			3.74E-02	1.00E-06	1.00E-08		no
U-234	4.18E-06			3.02E-02	1.00E-06	1.00E-08	no	NA
U-235	5.53E-08			4.00E-04	1.00E-06	1.00E-08		no
Np-237	2.05E-06			1.48E-02	1.00E-06	1.00E-08	no	NA
Pu-238	1.77E-02			1.28E+02	1.00E-06	1.00E-08		no
Pu-239	9.41E-04			6.80E+00	1.00E-06	1.00E-08	no	NA
Pu-240	3.00E-04			2.17E+00	1.00E-06	1.00E-08		no
Pu-241	5.02E-03			3.63E+01	1.00E-05	1.00E-07		no
Pu-242	4.47E-07			3.23E-03	1.00E-06	1.00E-08		no
Am-241	1.13E-03			8.13E+00	1.00E-05	1.00E-07		no
Cm-244	3.01E-03	yes(b)		2.18E+01	1.00E-06	1.00E-08		no
Total	1.01E+00			7.24E+03				

Bold = PA radionuclides
(a) for those radionuclides included only because they were expected to be present at >1% of total activity
(b) not excluded from distribution since they are near 1% of total activity
(c) grams radioisotopes only

Attachment 4

Sludge Waste Stream 40/42/51, Developing the Final List of Radionuclides

Attachment 4. Tank 40/42/51 Sludge Waste Stream
Developing the Final List of Radionuclides and Activity Distribution

	inclusion criteria						exclusion criteria				Distribution		
Initial List	PAL	SAB	>1%	detect TRU	detect Fissile	remarks	<1%(a)	not expect'd	PA Rads <=.01MALLD	non-PA <MALLD	RADs remaining after excl criteria	fractional distribution	re-normalized distribution
H-3	x							x	x				
C-14	x										**C-14**	6.92E-07	6.87E-05
Ni-59	x										**Ni-59**	6.88E-06	6.84E-04
Co-60		x									Co-60	1.74E-04	1.73E-02
Se-79			x				x						
Sr-90		x									Sr-90	4.68E-01	4.65E+01
Y-90			x			daughter Sr-90					Y-90	4.68E-01	4.65E+01
Tc-99	x										**Tc-99**	3.30E-05	3.28E-03
Ru-106			x				x						
Rh-106			x			daughter Ru-106	x						
Sb-125			x				x						
Sn-126			x				x						
I-129	x										**I-129**	1.70E-07	1.69E-05
Cs-134			x				x						
Cs-135			x				x						
Cs-137	x	x									**Cs-137**	1.71E-02	1.69E+00
Ba-137m			x			Daughter Cs-137					Ba-137m	1.61E-02	1.60E+00
Ce-144			x				x						
Pr-144			x			Daughter Ce-144	x						
Pr-144m			x			Daughter Ce-144	x						
Pm-147			x				x(b)				Pm-147	8.99E-03	8.93E-01
Eu-154			x				x						
U-233					x						U-233	5.17E-06	5.13E-04
U-234	x										U-234	4.18E-06	4.15E-04
U-235					x						U-235	5.53E-08	5.49E-06
Np-237	x			x							**Np-237**	2.05E-06	2.03E-04
Pu-238		x		x							Pu-238	1.77E-02	1.76E+00
Pu-239	x	x		x	x						**Pu-239**	9.41E-04	9.35E-02
Pu-240				x							Pu-240	3.00E-04	2.98E-02
Pu-241					x						Pu-241	5.02E-03	4.99E-01
Pu-242				x							Pu-242	4.47E-07	4.44E-05
Am-241				x							Am-241	1.13E-03	1.12E-01
Cm-244			x				x(b)				Cm-244	3.01E-03	2.99E-01
												1.01E+00	1.00E+02

Bold = PA rads

(a) for those radionuclides included only because they were expected to be present at >1% of total activity

(b) not excluded from distribution since they are near 1% of total activity

Attachment 5

Waste Characterization Form for Sludge Fraction, WPT-00002-51

OSR 29-82# (Rev 07-16-99)

Ref. 1S Manual, Appendix A-17 Instructions

EAV/CIF Low Level Waste Stream Characterization

1. Waste Stream ID	2. Generating Facility	3. Waste Organization	4. Building Name	5. Effective Date
WPT-00002-51	WPT	In Tank Precipitation	241-197H	4/1/2000

6. WITS Stream Description	7. Reason for Submittal	8. WCF No.	9. Rev
Sludge-cont'd waste from HLW tks 40, 42, 51	Correct Stream		

10. Activity Generating Waste	11. Physical Form	12. TSD Facility/Location
ITP/ESP Operations	Combustible	EAV-LAW Vault 1

13. Valid Calculation Method for Waste	14. STC Constant	15. STC Min Value	16. DTC Waste Form
☐ Char by Pack ☐ Dose-to-Curie ☐ Smear to Curie ☒ Curies or RAD Weight	N/A	N/A	N/A

17. Assigned Container Types	18. DTC Containers	19. Waste Description	Vol %
B-12 (14)	N/A	Contaminated Equipment	50
B-25 (Yellow)-Light (6)		Job Control Waste	50
Waste Disposal Cask (385)			
ITP Slurry Pump Box - 15K			
ITP Slurry Pump Box - 30K			

20. WITS ID	21. Tech Baseline	22. Container Document No.	23. Deviation Document No.
WPT-00002-51	HLW-STE-99-0361	N/A	

24. GCO Name	25. GCO Address	26. GCO Phone	27. CERCLA	28. Waste < 2 nCi/g
R. S. Lewis	241-197H	208-0351	☐ Yes ☒ No	☐ Yes ☐ No

29. Source(s) ☐ Yes ☒ No

30. PCB Category ☐ PCB Bulk ☐ PCB Remediation ☒ N/A ☐ PCB Laboratory ☐ PCB Article ☐ PCB Decontamination

31. Comments

32. Meas Tech ☐ Sample and Analysis ☒ Process Knowledge

33. Currently Assigned Isotopes

Isotope	Ci %	Basis for Exclusion*	Isotope	Ci %	Basis for Exclusion*
C-14	6.87E-05		H-3	0.00E+00	not present per process knowlg
Ni-59	6.84E-04				
Co-60	1.73E-02				
Sr-90	4.65E+01				
Y-90	4.65E+01				
Tc-99	3.28E-03				
I-129	1.69E-05				
Cs-137	1.69E+00				
Ba-137m	1.60E+00				
Pm-147	8.93E-01				
U-233	5.13E-04				
U-234	4.15E-04				
U-235	5.49E-06				
Np-237	2.03E-04				
Pu-238	1.76E+00				
Pu-239	9.35E-02				
Pu-240	2.98E-02				
Pu-241	4.99E-01				
Pu-242	4.44E-05				
Am-241	1.12E-01				
Cm-244	2.99E-01				

*PA Isotopes Only

Total 1.00E+02 %

34. GCO Signature**	Date	Environmental Compliance Authority Signature	Date
R. Rebecca Lewis	3/28/00	Arnold Campbell	04/18/2000
Solid Waste Approval	Date	WITS Data Input Signature	Date

**Generator Certification Statement: "I certify that to the best of my knowledge, the data submitted provides a true and accurate description of the waste."

Back of
OSR 29-82# (Rev 07-16-99)

EAV/CIF Low Level Waste Stream Characterization

Waste Stream ID	WCF No.	Rev	WITS ID
WPT-00002-51			WPT-00002-51

CIF Section

35. Major Waste Components

Description	Concentration Wt%	Description	Concentration Wt%
NA	NA		

36. Chemicals/Organics/Metals	Concentration, PPM	Chemicals/Organics/Metals	Concentration, PPM
NA	NA		

37. Properties

Heat Value (BTU/lb)	Ash Content (Weight %)	Total Halogens (Weight %)

No. of Liquid Layers in Waste	Water (Weight%)

Liquid Layer Description	Vol % Liquid Layer	pH	Spec Gravity	Est Viscosity(CP)	Total Susp Solids (Wt%)	Total Diss Solids (Wt%)

Attachment 6

Waste Characterization Form for Supernate Fraction, WPT-00001

OSR 29-82# (Rev 07-16-99)

Ref. 1S Manual, Appendix A-17 Instructions

EAV/CIF Low Level Waste Stream Characterization

1. Waste Stream ID	2. Generating Facility	3. Waste Organization	4. Building Name	5. Effective Date
WPT-00001	WPT	In Tank Precipitation	241-197H	10/1/99

6. WITS Stream Description	7. Reason for Submittal	8. WCF No.	9. Rev
Supernate Portion, Sludge Waste, HLW tks	New Waste Stream		

10. Activity Generating Waste	11. Physical Form	12. TSD Facility/Location
ITP/ESP Operations	Combustible	EAV-LAW Vault 1

13. Valid Calculation Method for Waste	14. STC Constant	15. STC Min Value	16. DTC Waste Form
☐ Dose-to-Curie ☐ Smear to Curie ☒ Curies or RAD Weight ☐ Char by Pack	N/A	N/A	N/A

17. Assigned Container Types	18. DTC Containers	19. Waste Description	Vol %
B-12 (14)	N/A	Contaminated Equipment	50
B-25 (Yellow)-Light (6)	N/A	Job Control Waste	50
ITP Slurry Pump Box - 15K			
ITP Slurry Pump Box - 30K			

20. WITS ID	21. Tech Baseline	22. Container Document No.	23. Deviation Document No.
WPT-00001	WSRC-TR-94-00290, Rev. 3	N/A	

24. GCO Name	25. GCO Address	26. GCO Phone	27. CERCLA	28. Waste < 2 nCi/g
R. S. Lewis	241-197H	208-0351	☐ Yes ☒ No	☐ Yes ☒ No

29. Source(s)	30. PCB Category
☐ Yes ☒ No	☐ PCB Bulk ☒ N/A ☐ PCB Article ☐ PCB Remediation ☐ PCB Laboratory ☐ PCB Decontamination

31. Comments

32. Meas Tech ☐ Sample and Analysis ☒ Process Knowledge

33. Currently Assigned Isotopes

Isotope	Ci %	Basis for Exclusion*	Isotope	Ci %	Basis for Exclusion*
H-3	2.0E-01				
Co-60	1.7E+00				
Sr-90	4.7E-02				
Tc-99	9.1E-03				
I-129	1.1E-05				
Cs-137	5.0E+01				
Ba-137m	4.7E+01				
U-233	2.6E-04				
U-234	7.1E-05				
Pu-238	2.5E-01				
Pu-239	2.9E-03				
Pu-240	1.3E-03				
Pu-241	1.9E-01				
Am-241	1.8E-02				

*PA Isotopes Only

Total 1.00E+02 %

34. GCO Signature**	Date	Environmental Compliance Authority Signature	Date
Solid Waste Approval	Date	WITS Data Input Signature	Date

**Generator Certification Statement: "I certify that to the best of my knowledge, the data submitted provides a true and accurate description of the waste."

EAV/CIF Low Level Waste Stream Characterization

Waste Stream ID	WCF No.	Rev	WITS ID
WPT-00001			WPT-00001

CIF Section

35. Major Waste Components

Description	Concentration Wt%	Description	Concentration Wt%
NA	NA		

36. Chemicals/Organics/Metals	Concentration, PPM	Chemicals/Organics/Metals	Concentration, PPM
NA	NA		

37. Properties

Heat Value (BTU/lb)	Ash Content (Weight %)	Total Halogens (Weight %)

No. of Liquid Layers in Waste	Water (Weight%)

Liquid Layer Description	Vol % Liquid Layer	pH	Spec Gravity	Est Viscosity(CP)	Total Susp Solids (Wt%)	Total Diss Solids (Wt%)

Attachment 7

Sludge Waste Stream 40/42/51, Sludge and Supernate Fractions Activity Distributions

Attachment 7. Tanks 40/42/51 Sludge Waste Stream
Sludge and Supernate Fractions Activity Distributions

	SLUDGE FRACTION			SUPERNATE FRACTION		
Radionuclide	activity fraction	normalized distribution	scaling factors Ci/Ci Sr-90	activity fraction (%)	normalized distribution	scaling factors Ci/Ci Cs-137
H-3				2.00E-01	2.01E-01	4.00E-03
C-14	6.92E-07	6.87E-05	1.48E-06			
Ni-59	6.88E-06	6.84E-04	1.47E-05			
Co-60	1.74E-04	1.73E-02	3.73E-04	1.70E+00	1.71E+00	3.40E-02
Sr-90	4.68E-01	4.65E+01	1.00E+00	4.70E-02	4.73E-02	9.30E-04
Y-90	4.68E-01	4.65E+01	1.00E+00			
Tc-99	3.30E-05	3.28E-03	7.06E-05	9.10E-03	9.15E-03	1.80E-04
I-129	1.70E-07	1.69E-05	3.64E-07	1.10E-05	1.11E-05	2.10E-07
Cs-137	1.71E-02	1.69E+00	3.64E-02	5.00E+01	5.03E+01	1.00E+00
Ba-137m	1.61E-02	1.60E+00	3.45E-02	4.70E+01	4.73E+01	9.40E-01
Pm-147	8.99E-03	8.93E-01	1.92E-02			
U-233	5.17E-06	5.13E-04	1.10E-05	2.60E-04	2.62E-04	5.20E-06
U-234	4.18E-06	4.15E-04	8.93E-06	7.10E-05	7.14E-05	1.40E-06
U-235	5.53E-08	5.49E-06	1.18E-07			
Np-237	2.05E-06	2.03E-04	4.37E-06			
Pu-238	1.77E-02	1.76E+00	3.78E-02	2.50E-01	2.51E-01	5.00E-03
Pu-239	9.41E-04	9.35E-02	2.01E-03	2.90E-03	2.92E-03	5.90E-05
Pu-240	3.00E-04	2.98E-02	6.41E-04	1.30E-03	1.31E-03	2.60E-05
Pu-241	5.02E-03	4.99E-01	1.07E-02	1.90E-01	1.91E-01	3.80E-03
Pu-242	4.47E-07	4.44E-05	9.56E-07			
Am-241	1.13E-03	1.12E-01	2.40E-03	1.80E-02	1.81E-02	3.50E-04
Cm-244	3.01E-03	2.99E-01	6.44E-03			
	1.01E+00	1.00E+02		9.94E+01	1.00E+02	

Bold = PA Rads