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Preliminary Tank Characterization Report for Single-Shell Tank 241-U-103: Best-Basis Inventory

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Abstract: An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for single-shell tank 241-U-103 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

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PRELIMINARY TANK CHARACTERIZATION REPORT FOR SINGLE-SHELL TANK 241-U-103: BEST-BASIS INVENTORY

June 1997

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PRELIMINARY TANK CHARACTERIZATION REPORT FOR SINGLE-SHELL TANK 241-U-103: BEST-BASIS INVENTORY

This document is a preliminary Tank Characterization Report (TCR). It only contains the current best-basis inventory (Appendix D) for single-shell tank 241-U-103. No TCRs have been previously issued for this tank, and current core sample analyses are not available. The best-basis inventory, therefore, is based on an engineering assessment of waste type, process flowsheet data, early sample data, and/or other available information.

The *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes* (Kupfer et al. 1997) describes standard methodology used to derive the tank-by-tank best-basis inventories. This preliminary TCR will be updated using this same methodology when additional data on tank contents become available.

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-U-103

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-U-103

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for single-shell tank 241-U-103 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

D1.0 CHEMICAL INFORMATION SOURCES

Available waste (chemical) information for tank 241-U-103 includes the following:

- Analytical data from S Farm and U Farm tanks with similar salt cake and sludge waste types
- The Hanford Defined Waste (HDW) model document (Agnew et al. 1997a) provides tank content estimates in terms of component concentrations and inventories.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

HDW model inventories are shown in Tables D2-1 and D2-2. No analytical information is available from tank 241-U-103 that can be used to estimate tank inventories for comparison with the HDW model. The tank waste volume assumed by the HDW model is 1,771 kL (468 kgal) waste. The HDW model inventory uses a waste density of 1.64 g/ml. The chemical species are reported without charge designation per the best-basis inventory convention.

Table D2-1. Hanford Defined Waste Model-Based Inventory Estimates for Nonradioactive Components in Tank 241-U-103.

Analyte	HDW[a] inventory estimate (kg)	Analyte	HDW[a] inventory estimate (kg)
Al	76,200	NO_2	191,000
Bi	555	NO_3	547,000
Ca	2,860	OH	308,000
Cl	15,100	Pb	389
Cr	12,600	PO_4	20,900
F	2,480	Si	3,880
Fe	1,890	SO_4	43,600
Hg	3.52	Sr	0
K	4,490	TIC as CO_3	61,400
La	9.72	TOC	22,700
Mn	358	U_{TOTAL}	54,700
Na	579,000	Zr	46.4
NH_3	2,670	H_2O (Wt%)	31.9
Ni	685	density (kg/L)	1.64

HDW = Hanford Defined Waste
[a] Agnew et al. (1997a).

Table D2-2. Hanford Defined Waste Model-Based Inventory Estimates for Selected Radioactive Components in Tank 241-U-103.

Analyte	HDW[a] inventory estimate (Ci)	Analyte	HDW[a] inventory estimate (Ci)
^{14}C	62.7	^{155}Eu	443
^{90}Sr	210,000	^{237}Np	1.61
^{99}Tc	444	$^{239/240}Pu$	104
^{129}I	0.856	^{241}Pu	176
^{137}Cs	485,000	^{241}Am	107
^{154}Eu	1130		

HDW = Hanford Defined Waste
[a] Agnew et al. (1997a), decayed to January 1, 1994.

D3.0 COMPONENT INVENTORY EVALUATION

D3.1 WASTE HISTORY TANK 241-U-103

Tank 241-U-103 is the third tank in a three tank cascade including tanks 241-U-101 and 241-U-102. Tank 241-U-103 first started receiving metal waste (MW) via tank 241-U-102, in the first quarter of 1947 and continued to receive cascaded waste until the second quarter of 1954. From the first quarter of 1952 until the first quarter of 1954 tank 241-U-103 also received Reduction and Oxidation (REDOX) process waste from various U and TX farm tanks, including tanks 241-U-102, 241-U-102, and 241-TX-115 (Agnew et al. 1997b). In the fourth quarter of 1956 the tank was sluiced and declared empty of all MW (Rodenhizer 1987).

Tank 241-U-103 then began receiving water and supernatant waste from tanks 241-SX-102 and 241-S-111 between the first quarter of 1957 until the second quarter of 1975 (Agnew et al. 1997b). During this time the waste was classified as being REDOX high-level (R) waste, the waste type predicted to be in tanks 241-SX-102 and 241-SX-111 at that time.

Starting in the second quarter of 1975 the tank started receiving Evaporator Bottoms (EB) from 242-S and other waste types until receipt of waste during the last quarter of 1977. The tank is presently classified as sound and partially interim isolated and is listed on the Flammable Gas Watch List.

D3.2 CONTRIBUTING WASTE TYPES

The HDW model (Agnew et al. 1997a) predicts that the tank contains a total of 1,771 kL (468 kgal) of waste that consists of 121 kL (32 kgal) of metal waste (MW) and 1,650 kL (436 kgal) of salt cake. The salt cake is divided into two fractions, 1,143 kL (302 kgal) of Supernatant Mixing Model 242-S Evaporator salt cake generated from 1973 until 1976 (SMMS1) and 458 kL (121 kgal) of Supernatant Mixing Model 242-S Evaporator salt cake generated from 1977 until 1980 (SMMS2). The SMMS1 and SMMS2 in Agnew et al. (1997a) does not total 1,650 kL (436 kgal) of waste. Apparently, an additional 49 kL (13 kgal) of supernatant is included in the Supernatant Mixing Model (SMM) composite inventory in Appendix E of Agnew et al.

Tank 241-U-103 was declared empty of metal waste in 1956 (Rodenhizer 1987). No metal waste was reported by the Waste Status and Transaction Record Summary (WSTRS) (Agnew et al. 1997b) to have entered the tank after that time. For this assessment, it will be assumed that the sludge waste is not MW but REDOX high level waste.

The Sort on Radioactive Waste Type (SORWT) model (Hill et al. 1995) lists EB and R (high level REDOX waste) as the primary and secondary waste types, respectively. The EB waste is the generic SORWT definition for salt cake that is roughly equivalent to the SMM waste types.

Hanlon (1997) indicates 1,771 kL (468 kgal) of waste that consists of 121 kL (32 kgal) of sludge, 1,601 kL (423 kgal) of salt cake, and 49 kL (13 kgal) of supernatant. No description of the source of the sludge and salt cake are given.

D3.3 MAJOR ANALYTES OF CONTRIBUTING WASTE TYPES

Agnew et al.'s (1997a) MW layer should contain large quantities of uranium, sodium, phosphate, and iron and smaller quantities of calcium and nitrate. However the MW was recorded to have been sluiced and emptied out of tank 241-U-103 (Rodenhizer 1987) and the engineering evaluation assumes no MW to be in the tank.

The R layer, predicted by Hill et al. (1995), should contain large quantities of aluminum, chromium, iron, sodium, and nitrite. This waste type should also contain appreciable quantities of ^{90}Sr, and ^{137}Cs.

The SMMS waste composition should contain large quantities of sodium, nitrate, nitrite, sulfate, phosphate, carbonate, hydroxide and aluminum; and moderate quantities of calcium, iron, chromium, uranium, potassium, and organic carbon. The plutonium concentration for the SMMS waste type should be much lower than the REDOX cladding waste generated from 1952 to 1960 (CWR1).

D3.4 EVALUATION OF TANK WASTE VOLUME

The surface level of tank 241-U-103 is monitored with an ENRAF (not an acronym, but the capitalized name of the manufacturer) gauge through riser 8. Current (as of March 23, 1997) surface level reading indicates the waste level is 454.56 cm (178.96 in.) measured from bottom center of the tank. This corresponds to a volume of waste of 1,787 kL (472 kgal). This supports the volume listed in Hanlon (1997) of 1771 kL (468 kgal) of waste in the tank.

D3.5 ASSUMPTIONS USED

For this evaluation, the following assumptions and observations are made:

- Only the SMMS1, SMMS2, and REDOX (R) waste streams contributed to solids formation.

- Tank waste volume listed in Agnew et al. (1997a) is 1,771 kL (468 kgal).

- 121 kL (32 kgal) of MW listed in Agnew et al. (1997a) is assumed to be 121 kL of REDOX high-level sludge generated between 1952 to 1957 (R1) based on WSTRS (Agnew et al. 1997b) and Hill et al. (1995).

- Agnew et al. includes 49 kL (13 kgal) of supernatant in his SMM layer. For this assessment it will be assumed the supernatant is part of the top salt cake layer (SMMS2). The assumed SMMS1 and SMMS2 volumes are 1,143 kL (302 kgal) SMMS1 and 507 kL (134 kgal) SMMS2.

- All radionuclide data are corrected to January 1, 1994.

D3.6 BASIS FOR CALCULATIONS USED IN THIS ENGINEERING EVALUATION

Table D3-1 shows the engineering evaluation approaches used on tank 241-U-103.

Table D3-1. Engineering Evaluation Approaches Used On 241-U-103. (2 Sheets)

Type of waste	How calculated	Check method
Supernatant	Assumed no Supernatant	None, even though Hanlon (1997) indicates 13,000 gal supernatant, no method is available to calculate its contribution to the inventory.
Salt cake Volume = 1,650 kL (436 kgal) SMMS1 = 1,143 kL (302 kgal) SMMS2 = 507 kL (134 kgal)	Used sample-based concentrations from tanks with SMMS1 and/or SMMS2 waste types. An average density of 1.63 g/ml is used for SMMS1 waste and 1.56 g/ml for the SMMS2 waste.	None, no sample-based information is available for this tank.

Table D3-1. Engineering Evaluation Approaches Used On 241-U-103. (2 Sheets)

Type of waste	How calculated	Check method
Sludge Volume = 121 kL (32 kgal)	Used the average analyte concentrations from tanks 241-S-102, 241-S-104, and 241-S-107. All have sample data and R1 waste. Only the segments that are believed to have R1 waste were used to calculate the concentration from each tank. Used an average sample-based density of 1.77 g/ml.	None, no sample-based information is available for this tank.

R1 = Reduction and Oxidation high-level waste generated between 1952 to 1957

SMMS1 = Supernatant Mixing Model 242-S Evaporator salt cake generated from 1973 until 1976

SMMS2 = Supernatant Mixing Model 242-S Evaporator salt cake generated from 1977 until 1980

D3.6.1 Basis for Salt Cake Calculations Used in this Engineering Evaluation

Sample-based characterization data for four tanks (241-S-101, 241-S-102, 241-U-106, and 241-U-109 [Kruger et al. 1996, Eggers et al. 1996, Brown et al. 1997, and Baldwin and Stephens 1996, respectively]) known to contain the same SMMS1 salt cake waste type as tank 241-U-103 are summarized in Tables D3-2 and D3-3. Sample-based characterization data for five tanks (241-S-101, 241-S-102, 241-U-102, 241-U-107, and 241-U-109 [Kruger et al. 1996, Eggers et al. 1996, Hu et al. 1997, Jo et al. 1996, Baldwin and Stephens 1996, respectively]) that contain the SMMS2 salt cake also found in tank 241-U-103 are shown in Tables D3-4 and D3-5. The analytical results for these tanks were evaluated at the core segment level and the SMMS1 and SMMS2 salt cakes were identified. The SMMS1 and SMMS2 component concentrations for these tanks were averaged to provide generalized compositions for SMMS1 and SMMS2 salt cakes. For comparison the SMM layer compositions predicted by Agnew et al. (1997a) for tank 241-U-103 are also shown in Tables D3-2 and D3-3. The HDW model does not break down the different concentrations for SMMS1 and SMMS2 salt cakes, therefore, the HDW model concentrations in Table D3-2 through Table D3-5 are a combination of the SMMS1 and SMMS2 concentrations found in tank 241-U-103

As indicated in Table D3-2 the concentrations of major waste components (e.g., Na, Al, NO_3, NO_2, and SO_4) for the four tanks containing SMMS1 salt cake vary between tanks by no more than an approximate factor of three. A major exception is phosphate that exhibits exceptionally high concentrations for tank 241-S-102 waste and, thus, skews the average concentration high for phosphate for the SMMS1 tanks used in this assessment. The variation between several minor components for the four tanks is quite high.

The analyte concentrations for the SMM salt cakes compare within approximately a factor of three for most major components with the predicted SMMS1 composition from the HDW model. However, significant difference occur for several components including F, Fe, PO_4, Mn, and oxalate. However, with the exception of Si, the concentrations of these components for the three other salt cake tanks differ consistently from those for the HDW model estimate. It is, thus, concluded that the concentrations of these components are best represented by the analytical results for tank 241-U-103.

Table D3-2. SMMS1 Salt Cake Concentrations. (2 Sheets)

Analyte	241-S-101 segments 2L-4U[a] µg/g	241-S-102 segments 7L-10U[b] µg/g	241-U-106 segments 2U-4L[c] µg/g	241-U-109 segments 5U-8L[d] µg/g	Average concentration[e] µg/g	HDW model SMM concentration for tank 241-U-103[f] µg/g
Al	18,000	15,085	13,620	13,625	15,100	28,300
Ag	12	17	16	NR	15	NR
B	110	75	80	NR	88	NR
Bi	71	76	<DL	<DL	73.5	206
Ca	273	237	336	<DL	282	907
Cl	4,500	4,099	2,926	NR	3,842	5,610
Cr	10,000	4,359	3,170	4,233	5,440	4,660
F	500	13,596	4,669	NR	6,255	920
Fe	508	1,298	3,096	<DL	1,630	402
K	1,109	898	1,309	NR	1,110	1,670
La	<DL	37	43	NR	40	3.6
Mn	266	597	1,189	<DL	684	133
Na	150,000	189,500	170,500	218,300	182,000	209,000
Ni	114	49	304	<DL	155	252
NO_2	91,000	40,100	56,000	42,900	57,500	70,800
NO_3	110,000	99,200	147,200	297,000	163,000	203,000
Pb	91	137	348	NR	192	144
PO_4	9,500	114,500	5,888	5,970	34,000	6,040
P	2,290	33,900	1,949	<DL	12,700	NR
S	5,940	2,683	3,878	NR	4,170	NR
Si	5,269	517	176	<DL	1,990	1,440

Table D3-2. SMMS1 Salt Cake Concentrations. (2 Sheets)

Analyte	241-S-101 segments 2L-4U[a] μg/g	241-S-102 segments 7L-10U[b] μg/g	241-U-106 segments 2U-4L[c] μg/g	241-U-109 segments 5U-8L[d] μg/g	Average concentration[e] μg/g	HDW model SMM concentration for tank 241-U-103[f] μg/g
SO_4	20,700	12,500	10,774	11,100	13,800	15,800
Sr	7	<DL	<DL	NR	7	0
TOC	1,900	5,340	24,626	3,920	8,950	2,271
U	560	1,403	781	<DL	914	1,550
Zn	30	32	54	<DL	39	NR
Zr	14	39	88	NR	47	17.2
Oxalate	15,400	15,700	9,880	NR	13,700	2.99
Radionuclides[g] (μCi/g)						
^{90}Sr	252	23	77	9	90	77.7
^{137}Cs	175	121	175	142	153	180

<DL = Less then the Detectable Limit.
HDW = Hanford Defined Waste
NR = Not reported
SMMS1 = Supernatant Mixing Model 242-S Evaporator salt cake generated from 1973 until 1976
[a] Kruger et al. (1996)
[b] Eggers et al. (1996)
[c] Brown et al. (1997)
[d] Baldwin and Stephens (1996)
[e] Average of tank 241-S-101, 241-S-102, 241-U-106, and 241-U-109 concentrations
[f] Agnew et al. (1996)
[g] Radionuclides are reported as of the date of sample analysis.

Table D3-3. SMMS2 Salt Cake Concentrations. (3 Sheets)

Analyte	241-S-101 segments 1U-2U[a] μg/g	241-S-102 segments 2U-5L[b] μg/g	241-U-102 segments 2U[c] μg/g	241-U-107 segments 2U-6L[d] μg/g	241-U-109 segments 1L-4U[e] μg/g	Average concentration[f] μg/g
Al	16,925	7,450	10,505	10,612	9,487	10,966
Ag	12	17	13	16	NR	14
B	111	58	67	89	NR	81
Bi	51	<DL	<DL	270	<DL	161
Ca	274	233	310	298	<DL	279

Table D3-3. SMMS2 Salt Cake Concentrations. (3 Sheets)

Analyte	241-S-101 segments 1U-2U[a] μg/g	241-S-102 segments 2U-5L[b] μg/g	241-U-102 segments 2U[c] μg/g	241-U-107 segments 2U-6L[d] μg/g	241-U-109 segments 1L-4U[e] μg/g	Average concentration[f] μg/g
Cl	4,607	2,981	4,550	2,515	3,560	3,643
Cr	8,163	1,577	2,417	2,570	2,570	3,459
F	638	267	896	501	299	520
Fe	453	65	565	767	1,630	696
K	1,225	748	1,360	914	NR	1,062
Mn	541	26	137	330	<DL	258
Na	153,000	207,000	176,000	205,667	237,333	195,800
Ni	115	19	77	56	<DL	67
NO_2	58,150	28,939	36,250	27,600	42,900	38,768
NO_3	218,500	514,000	293,000	455,333	407,333	377,633
Pb	66	47	<DL	149	NR	87
PO_4	9,230	15,589	19,950	13,509	5,970	12,850
P	2,333	2,860	6,187	2,580	7,780	4,348
S	4,713	1,325	4,037	1,090	NR	2,791
Si	<DL	219	148	194	1,220	445
SO_4	21,185	8,553	12,785	4,112	11,000	11,527
Sr	48	<DL	<DL	9	NR	28
TOC	NR	1,898	6,417	2,414	2,330	3,265
U	1,497	<DL	<DL	430	<DL	964
Zn	33	21	33	29	NR	29
Zr	13	<DL	<DL	13	NR	13

Table D3-3. SMMS2 Salt Cake Concentrations. (3 Sheets)

Analyte	241-S-101 segments 1U-2U[a] µg/g	241-S-102 segments 2U-5L[b] µg/g	241-U-102 segments 2U[c] µg/g	241-U-107 segments 2U-6L[d] µg/g	241-U-109 segments 1L-4U[e] µg/g	Average concentration[f] µg/g
Radionuclide[g] (Ci)						
^{90}Sr	252	NR	<DL	0.297	4.81	86
^{137}Cs	160.15	NR	136.5	62.06	89.1	112

<DL = Less than detectable limit
HDW = Hanford Defined Waste
NR = Not reported
SMMS2 = Supernatant Mixing Model 242-S Evaporator salt cake generated from 1977 until 1980
[a] Kruger et al. (1996)
[b] Eggers et al. (1996)
[c] Hu et al. (1997)
[d] Jo et al. (1996)
[e] Baldwin and Stephens (1996)
[f] Average of tank 241-S-101, 241-S-102, 241-U-102, 241-U-107, and 241-U-109 concentrations
[g] Radionuclides are reported as of the date of sample analysis.

D3.6.2 Basis for Sludge Calculations Used In This Engineering Evaluation

Sample-based sludge values and R1 sludge concentrations from other tanks in the S Tank Farm with R waste, are used to calculate the sludge concentration for tank 241-U-103. Sample data from tanks 241-S-102, 241-S-104, and 241-S-107 were used to produce average analyte concentrations for R1 sludge waste. To calculate the average concentration, the volumes and predicted location of the sludge were taken from Agnew et al. (1997a) for the tanks' R1 waste. All the tanks except 241-S-104, which is a total core composite, have both mixed R1 and CWR1 waste layers reported by Agnew et al. (1997a). The sample data were then reviewed, and only the segments that were located within the predicted sludge location from Agnew et al. (1997a) were used in deriving an average concentration. The average concentration and density from each tank and the segments used in the calculation is shown below in Table D3-4. The predicted concentration from the HDW model for tank 241-U-103 is not shown since it is based on MW not R waste.

Table D3-4. R1 Sludge Concentration Estimate. (2 Sheets)

Analyte	241-S-101 segments 7U-8L[a] (μg/g)	241-S-104 (total sludge concentration)[b] (μg/g)	241-S-107 segments[c] (μg/g)	Average Concentration[d] (μg/g)
Al	127,000	117,000	56,400	100,000
Bi	<38.8	<45.7	NR	<42.2
Ca	322	247	234	268
Cl	2,050	3,200	1,860	2,370
Cr	2,230	2,350	1,180	1,920
F	<65.7	145	150	<120
Fe	1,960	1,720	1,160	1,613
Hg	NR	<0.126	NR	<0.126
K	539	300	457	432
La	<19.5	<2.07	NR	<10.8
Mn	2,750	1,150	83	1,330
Na	112,000	121,000	60,400	97,800
Ni	90.7	56	206	118
NO_2	31,100	25,900	34,300	30,433
NO_3	119,000	191,000	57,600	122,500
Pb	37	29.6	33	33.2
PO_4	1,360	<2,190	1,630	<1,730
Si	1,360	1,330	1,060	1,250
SO_4	897	2,270	1,300	1,489
Sr	456	424	378	420
TIC as CO_3	NR	4,140	NR	4,140
TOC	NR	1,730	NR	1,730
U	7,684	6,690	8,685	7,690
Zr	36	33.6	131	66.9
Radionuclides[e] (μCi/g)				
^{90}Sr	NR	301	276	288
^{137}Cs	98	60.5	74	77.6

Table D3-4. R1 Sludge Concentration Estimate. (2 Sheets)

Analyte	241-S-101 segments 7U-8L[a] (μg/g)	241-S-104 (total sludge concentration)[b] (μg/g)	241-S-107 segments[c] (μg/g)	Average Concentration[d] (μg/g)
density (g/ml)	1.77	1.64	1.90	1.77

HDW = Hanford Defined Waste
NR = Not reported
REDOX = Reduction oxidation process
R1 = REDOX waste generated between 1952 and 1957
[a] Kruger et al. (1996)
[b] DiCenso et al. (1994)
[c] Statistically determined median R1 sludge concentrations for tank 241-S-107 contained in the attachment to Simpson et al. (1996)
[d] Average of analyte concentrations for tank 241-S-101, 241-S-104, and 241-S-107
[e] Radionuclides decayed to January 1, 1994.

D3.7 ESTIMATED COMPONENT INVENTORIES

The chemical inventory of tanks 241-U-103 is estimated from the assumed salt cake and sludge volumes (Table D3-1) and the average concentrations in Table D3-2 through D3-4. The resulting inventories are provided in Table D3-7. The inventories estimated by the HDW model are included for comparison.

Table D3-5. Comparison of Selected Component Inventory Estimates for Tank 241-U-103. (2 Sheets)

Component	Engineering evaluation (kg) sludge	Engineering evaluation (kg) salt cake	Engineering evaluation total (kg)	HDW estimated (kg)
Bi	<9.05	264	<273	555
K	92.6	2,900	2,290	4,490
La	<2.32	74	<76.3	9.72
NO_2	6,520	138,000	145,000	191,000
NO_3	26,300	603,000	629,000	547,000
Mn	285	1,480	1,760	358
SO_4	319	34,800	35,100	43,600

Table D3-5. Comparison of Selected Component Inventory Estimates for Tank 241-U-103. (2 Sheets)

Component	Engineering evaluation (kg) sludge	Engineering evaluation (kg) salt cake	Engineering evaluation total (kg)	HDW estimated (kg)
Cr	411	12,900	13,300	12,600
Ca	57.5	761	818	2,860
Ni	25.3	342	367	685
PO_4	<371	73,400	73,800	20,900
F	<25.7	12,100	12,100	2,480
Al	21,400	36,800	58,200	76,200
Fe	346	3,600	3,900	1,890
U	1,650	2,470	4,120	54,700
Na	21,000	494,000	515,000	579,000
^{90}Sr (Ci)[a]	61,700	249,000	311,000	210,000
^{137}Cs (Ci)[a]	16,600	394,000	401,000	485,000
H_2O (percent)	NR	28.2	28.2	31.9

HDW = Hanford Defined Waste
NR = Not reported
[a] Radionuclides decayed to January 1, 1994.

Aluminum. The aluminum inventory is over predicted by the HDW model (76,200 kg) compared to the engineering assessment (58,200 kg). The HDW model does not predict any aluminum in the sludge. The 76,200 kg from the HDW model is actually more than twice the salt cake inventory of 36,800 kg calculated from the engineering evaluation. The engineering evaluation is used as the best-basis for aluminum.

Manganese. Potassium permanganate was used in the REDOX process until 1959, thus manganese is expected to be found in tanks containing waste from that process. Since the HDW model predicts MW as the sludge type, and no Mn is reported to be present in the MW, an accurate comparison of MW to R1 is not reasonable and the engineering estimate is used for Mn. The R1 Sludge composition estimate developed in this engineering assessment for Mn was 1,330 μg/g. Interestingly, the SMMS1 salt cake composition estimate for Mn was 684 μg/g--much higher than would be expected based on solubility considerations, and the SMMS2 salt cake composition estimate is 258 μg/g. It should be noted that there are large ranges in the SMMS1, SMMS2, and R1 data sets for Mn.

Nitrate, Nitrite, and Sulfate. The HDW Model prediction of the NO_3, NO_2, and SO_4 content of tank 241-U-103 is in good agreement with that calculated for the engineering evaluation (see Table D3-7). The engineering evaluation results are used as the best-basis inventory value for all three compounds.

Phosphate. There is a large difference between the engineering assessment tank inventory estimate (73,800 kg) and the HDW model estimate (20,900 kg). The engineering assessment value is biased high because of one extremely high phosphate value in the data set used to develop the SMMS1 salt cake composition estimate (see Table D3-2). If the phosphate data from tank 241-S-102 are eliminated from the SMMS1 composition estimate then engineering assessment and the HDW estimate would be in reasonable agreement. However, since the HDW model failed to predict the high phosphate value for 241-S-102, it should not be taken as a reliable indicator for phosphate in tank 241-U-103.

Chromium. The HDW model prediction of the chromium content of tank 241-U-103 is in good agreement with that calculated by the engineering assessment (12,600 kg versus 13,000 kg). The sample data are used as the best-basis inventory value.

Sodium. The HDW model prediction of the sodium content of tank 241-U-103 is in excellent agreement with that calculated by the engineering assessment (579,000 kg versus 515,000 kg). Almost all the sodium is found in the SMM waste where the sample data and HDW model are consistent with each other. The engineering assessment is used as the best-basis inventory value.

Calcium. The calcium found in tanks containing REDOX waste is believed to have been an impurity in the commercial grade sodium hydroxide used in the neutralization of high-level waste in the process. The calcium value developed in this engineering assessment (818 kg) is about one fourth of the HDW model value (2,860 kg). Since many calcium salts of anions such as carbonate, oxalate and phosphate are insoluble and the concentrations of these anions are essentially unknown, it is not surprising that Ca values differ between this engineering assessment and the HDW model. The majority of the calcium discrepancies can be traced back to the salt cake where the HDW value is over three times that of the SMM engineered inventory. The reason for this is not known at this time.

Fluoride. There is a large difference between the engineering assessment tank inventory estimate (12,100 kg) and the HDW model estimate (2,480 kg). The engineering assessment value is biased high because of one extremely high fluoride value in the data set used to develop the SMMS1 salt cake composition estimate (see Table D3-2). If the fluoride data from tank 241-S-102 are eliminated from the SMMS1 composition estimate then engineering assessment would still over predict the fluoride compared to the HDW model. However, since tank 241-S-102 also contained high concentrations of phosphates, it is reasonable to assume the solids contain the precipitated fluorophosphate double salt, $Na_7(PO_4)F \cdot 19H_2O$. The engineering evaluation results are used as the best-basis value for fluoride.

Iron. The Fe inventory estimate is about two times higher in the engineering estimate than in the HDW model. The Fe value determined in the engineering assessment for the salt cake is approximately 2.6 times the HDW model value. As shown in Table D3-2 and D3-3, the data set used to estimate Fe in the SMMS1 salt cake varies from 3,096 μg/g to less than detection limit and varies from 65 to 1,630 μg/g for the SMMS2 salt cake. The HDW model predicts over 55 percent of the tank Fe inventory to be in the sludge while the engineering assessment indicates less than 11 percent of the Fe total mass to be in the sludge. Without analytical data from tank 241-U-103 and with the use of MW (Agnew et al. 1997a) instead of R1, it is difficult to defend the choice of one value over the other in the sludge comparisons.

Nickel. The nickel inventory from the HDW model (685 kg) is about twice the inventory calculated in the engineering evaluation (367 kg). The reason for this difference is not known and, since the two calculations assume different sludge types, it is difficult to compare the two values. The engineering evaluation inventory of 310 kg is used as the best basis.

Uranium. The HDW model, which predicts MW at the bottom of the tank, indicates 54,700 kg of uranium compared to the engineering assessment value of 4,120 kg. Of the 54,700 kg of uranium for the HDW model 50,500 kg is predicted to be in the sludge (MW). Rodenhizer (1987) indicates the MW to have been sluiced from the tank and therefore the engineering evaluation is used for the best basis for tank 241-U-103.

Total Hydroxide. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valence of other analytes. In some cases, this approach requires that other analyte (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments, the number of significant figures is not increased. This charge balance approach is consistent with that used by Agnew et al. (1997a).

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D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessment associated with waste management activities, as well as regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage.

Chemical and radiological inventory information are generally derived using three approaches: (1) component inventories are estimated using the results of sample analyses, (2) component inventories are predicted using the HDW Model based on process knowledge and historical information, or (3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data.

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-U-103 was performed, and a best basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task. The following information was utilized as part of this evaluation:

- The inventory estimate generated by the HDW model (Agnew et al. 1997a)

- An engineering evaluation that produced a predicted SMMS inventory and R1 sludge inventory based on methodology developed by evaluation of similar waste in the S and U tank farms.

- An engineering evaluation for the sludge in tank 241-U-103 based on sample data from tanks 241-S-101 (Kruger et al. 1996), 241-S-102 (Eggers et al. 1996), 241-S-104 (DiCenso et al. 1994), 241-S-107 (Simpson et al. 1996), 241-U-102 (Hu et al. 1997), 241-U-106 (Brown et al. 1997), 241-U-107 (Jo et al. 1996), and 241-U-109 (Baldwin and Stephens 1996).

Based on this evaluation, a best-basis inventory was developed for tank 241-U-103 for which sampling information is not available. The engineering evaluation inventory was chosen as the best basis for those analytes for which sample-based analytical values were available, from similar S and U tank farm tanks, for the following reasons:

- The sample-based inventory analytical concentrations of the other S and U tanks containing SMMS1 and SMMS2 compared favorably with each other for SMMS1 and SMMS2 salt cake.

- No methodology is available to fully predict SMMS salt cake from process flowsheet or historical records.

- Since the MW was recorded as being emptied from the tank in 1956 (Rodenhizer 1987) the sludge values from the HDW model are not adequate for comparison and the R1 sludge engineering assessment is used.

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and total uranium (or total beta and total alpha), while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1997, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclides in any of 177 tanks are reported in the HDW Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result if available. (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10.

The best-basis inventory for tank 241-U-103 is presented in Tables D4-1 and D4-2. The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-103 (Effective May 31, 1997).

Analyte	Total inventory (kg)	Basis (S, M, E or C)[1]	Comment
Al	58,200	E	
Bi	<273	E	
Ca	818	E	
Cl	10,500	E	
TIC as CO_3	61,400	M	
Cr	13,300	E	
F	12,100	E	
Fe	3,900	E	
Hg	3.52	M	
K	2,990	E	
La	<76.3	E	
Mn	1,760	E	
Na	515,000	E	
Ni	367	E	
NO_2	145,000	E	
NO_3	629,000	E	
OH_{TOTAL}	171,000	C	
Pb	433	E	
PO_4	73,800	E	
Si	4,320	E	
SO_4	35,100	E	
Sr	125	E	
TOC	19,700	E	
U_{TOTAL}	4,120	E	
Zr	112	E	

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997a)
E = Engineering assessment-based
C = Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3.

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-103, Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	427	M	
^{14}C	92.7	M	
^{59}Ni	4.09	M	
^{60}Co	69.6	M	
^{63}Ni	401	M	
^{79}Se	6.23	M	
^{90}Sr	311,000	E	
^{90}Y	311,000	E	Referenced to ^{90}Sr
^{93}Zr	30.6	M	
^{93m}Nb	22.2	M	
^{99}Tc	444	M	
^{106}Ru	0.0126	M	
^{113m}Cd	161	M	
^{125}Sb	301	M	
^{126}Sn	9.42	M	
^{129}I	0.856	M	
^{134}Cs	5.09	M	
^{137}Cs	411,000	E	
^{137m}Ba	389,000	E	Referenced to ^{137}Cs
^{151}Sm	21,900	M	
^{152}Eu	7.46	M	
^{154}Eu	1,130	M	
^{155}Eu	443	M	
^{226}Ra	2.84 E-04	M	
^{227}Ac	0.00175	M	
^{228}Ra	0.292	M	
^{229}Th	0.00683	M	
^{231}Pa	0.00784	M	
^{232}Th	0.0192	M	
^{232}U	1.49	M	

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-U-103, Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{233}U	5.71	M	
^{234}U	18.2	M	
^{235}U	0.811	M	
^{236}U	0.155	M	
^{237}Np	1.61	M	
^{238}Pu	2.60	M	
^{238}U	18.7	M	
^{239}Pu	61	M	
^{240}Pu	15.1	M	
^{241}Am	1,910	E	
^{241}Pu	176	M	
^{242}Cm	0.285	M	
^{242}Pu	9.67 E-04	M	
^{243}Am	0.00379	M	
^{243}Cm	0.0264	M	
^{244}Cm	0.257	M	

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997a)
E = Engineering assessment-based.

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D5.0 APPENDIX D REFERENCES

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