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Preliminary Tank Characterization Report for Single-Shell Tank 241-T-101: 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-T-101 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-T-101:
BEST-BASIS INVENTORY**

June 1997

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U.S. Department of Energy
Richland, Washington

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**PRELIMINARY TANK CHARACTERIZATION REPORT
FOR SINGLE-SHELL TANK 241-T-101:
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-T-101. 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.

REFERENCE

Kupfer, M. J., A. L. Boldt, B. A. Higley, K. M. Hodgson, L. W. Shelton, B. C. Simpson, and R. A. Watrous (LMHC), S. L. Lambert, and D. E. Place (SESC), R. M. Orme (NHC), G. L. Borsheim (Borsheim Associates), N. G. Colton (PNNL), M. D. LeClair (SAIC), R. T. Winward (Meier Associates), and W. W. Schulz (W²S Corporation), 1997, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

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APPENDIX D

**EVALUATION TO ESTABLISH BEST-BASIS
INVENTORY FOR SINGLE-SHELL
TANK 241-T-101**

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APPENDIX D**EVALUATION TO ESTABLISH BEST-BASIS INVENTORY
FOR SINGLE-SHELL TANK 241-T-101**

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-T-101 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

This section briefly describes the sampling events for this tank since 1974. The first two samples were obtained in 1974 and 1975 to estimate the chemical and radionuclide composition of the supernatant. In 1989, another liquid sample was obtained to study the mixing characteristics of this waste with Plutonium Finishing Plant (PFP) current acid waste (CAW) to determine whether the mixture would produce an acceptable, non-transuranic (non-TRU) supernatant. The final set of supernatant samples was obtained in 1993 to evaluate the waste compatibility properties of the supernatant prior to an emergency pumping campaign to transfer all of the remaining supernatant to tank 241-SY-102. Because tank 241-T-101 was declared a ferrocyanide Watch List tank in 1990, this analysis was thought to be necessary before the emergency pumping campaign could take place. The 1993 data provide a comprehensive set of results for the supernatant, but virtually no analytical data for the sludge. Since the last remaining supernatant was transferred to tank 241-SY-102 in 1993, these data are of only limited value with respect to establishing the current waste inventories in this tank.

The waste history of this tank is provided in Anderson (1990) and Agnew et al. (1997a). Tank 241-T-101, operating as the first tank in a metal waste cascade, received metal waste from the first quarter of 1945 until the first quarter of 1946. This waste was removed by sluicing in 1953, and replaced with ferrocyanide treated U Plant waste during fourth quarter of 1953. About half of the ferrocyanide treated supernatant was cribbed in late 1953, while the remaining supernatant and solids were flushed to tank 241-T-107. Metal waste was once again introduced to this tank during the first and second quarters of 1955 with the excess being transferred by cascade to tank 241-T-102. Almost all of the metal waste was sluiced out in 1956, with this tank being declared empty in December 1956 except for a small heel of residual waste. Tank 241-T-101 received several transfers of REDOX coating waste (CWR) supernatants in 1963 and 1964 and a small transfer of CWR waste in 1972. B Plant cesium recovery ion exchange wastes were received in 1972, 1974, 1975 and

1976, with much smaller volumes of saltwell pumped supernatants from other T-farm tanks in 1976, including 224 supernatants from the T-200 series tanks. Tank 241-T-101 was identified as an assumed leaker in October 1992 and approximately 113.5 kL (30 kgal) of pumpable liquid was removed in early 1993 to reduce the leakage potential for this tank. The Hanford Defined Waste (HDW) model (Agnew et al. 1996a) currently provides the only available set of waste composition estimates for this waste.

D2.0 COMPARISON OF COMPONENT INVENTORY ESTIMATES

Before the emergency pumping campaign in 1993, the average waste level was found to be 110.6 cm (43.55 in.) in this tank (Swaney 1993). Approximately 113.5 kL (30 kgal) of supernatant were pumped out in 1993, leaving a residual sludge inventory of 394 kL (104 kgal). This inventory is consistent with current inventory estimates for this tank (386 kL of sludge and 4 kL of supernatant) (Hanlon 1997). The tank farm log data for this tank also shows that the sludge level was 80 cm (31.5 in.) on September 10, 1978, which is equivalent to an inventory of 375.2 kL (99 kgal) of waste.

These logs also provide a data on the waste transfers that occurred between various tanks. Usually, these data have been found to be consistent with the waste transfers reported by Agnew et al. (1997a). In this case, however, there are at least thirteen transfers reported by Agnew that could not be confirmed in the tank logs. These transactions involved the transfer of 242-S evaporator bottoms from tanks 241-S-102 and 241-SY-102 to tank 241-T-101 in 1976 and 1977. These transfers are important because Agnew et al. used these transactions in the HDW model to arrive at some 244 kL (64.5 kgal) of Supernatant Mixing Model 242-T Evaporator salt cake generated from 1965 until 1976 (SMMT2) in tank 241-T-101.

According to Anderson, the sludge level in this tank increased from 140 kL (37 kgal) in late 1976 to 390 kL (103 kgal) in late 1977. This increase coincides with a decrease of 772 kL (204 kgal) in the volume of supernatant in this tank, and suggests that this supernatant may have been processed through the 242-S evaporator and returned in the form of salt slurry to tank 241-T-101. Table D2-1 shows the expected composition profile for this supernatant based on a 1975 grab sample from this tank (Wheeler 1975). This sample can be used to estimate the volume of salt cake that might have been produced from 772 kL (204 kgal) of supernatant. (The chemical species are reported without charge designation per the best-basis inventory convention.)

Table D2-1. 1975 Supernatant Composition in Tank 241-T-101^a.

Analyte	Concentration, <i>M</i>	Analyte	Concentration, <i>M</i>
Na	5.66	F	0.00710
Al	0.0905	OH	0.267
NO ₃	3.76	PO ₄	0.0812
NO ₂	0.616	SpG	1.3049
CO ₃	0.343	Water	66.52%

^a Wheeler (1975)

Studies of other salt cakes show about 40 wt% moisture and have a density of about 1.5 kg/L (samples of Supernatant Mixing Model 241-A Evaporator salt cake generated from 1976 until 1980 [SMMA1] from tanks 241-A-102, 241-A-103, 241-AN-102, and 241-AN-107). Based on these values, together with the analytical data in Table D2-1, it appears that 375 kL (99 kgal) of salt cake might have been produced from 772.4 kL (204 kgal) of such supernatant. This estimate and Agnew's estimate of 242 kL (64 kgal) of salt slurry are consistent with the 1977 salt cake transfer reported by Agnew et al. (1997b).

Since nearly identical inventory estimates have been developed from the 1978 and 1993 data for this tank, the best-basis inventory will be based on the commonly accepted value of 386 kL (102 kgal) of sludge and salt cake in this tank (Hanlon 1997). This inventory was also used by Agnew to develop the HDW composition estimates for this waste.

D3.0 COMPONENT INVENTORY EVALUATION

The HDW model is mostly based on process waste production records and waste transaction records for each tank. Primary wastes are process wastes added directly to tank 241-T-101, while secondary wastes were transferred to the tank from another tank. Based on Agnew et al. (1997a), tank 241-T-101 contains the following waste types:

- 7.6 kL (2 kgal) of BiPO₄ metal waste (MW) sludge
- 132.5 kL (35 kgal) of REDOX coating waste (CWR2) sludge
- 246 kL (65 kgal) of SMMT2 salt cake.

Table D3-1 provides estimates of the chemical composition of the waste, based on the HDW model, while Table D3-2 provides similar estimates for radioactive components in this waste.

Table D3-1. Hanford Defined Waste Estimates for Nonradioactive Components in Tank 241-T-101.

Analyte	HDW model sludge inventory ^a (kg)	HDW model salt cake inventory ^a (kg)	HDW model tank inventory ^a (kg)
Al	20,900	605	21,500
Bi	0	14.4	14.4
Ca	1,740	23.8	1,760
Cl	58.3	158	216
CO ₃	3,420	670	4,090
Cr	16.6	122	138
F	0	67	67
Fe	3,430	14.1	3,450
Hg	293	0.0188	293
K	14	134	148
La	0	5.28	5.28
Mn	0	10.2	10.2
Ni	9.38	6.78	16.2
OH	53,300	2,630	55,900
NO ₃	5,380	5,400	10,800
NO ₂	1,490	2,050	3,540
Pb	8,940	1.78	8,940
PO ₄	288	167	455
Si	0.36	50.2	50.6
Na	5,130	5,990	11,100
Sr	0	0	0
SO ₄	188	537	725
TOC	0	235	235
U	18,600	42.3	18,600
Zr	0	0.2	0.2

HDW = Hanford Defined Waste

^aAgnew et al. (1997a).

Table D3-2. Hanford Defined Waste Estimates for Radioactive Components in Tank 241-T-102.

Radionuclide	HDW model sludge inventory ^a (Ci)	HDW model salt cake inventory ^a (Ci)	HDW model tank inventory ^a (Ci)
¹⁴ C	4.01E-02	1.14	1.18
⁶⁰ Co	0.0227	1.32	1.34
⁹⁰ Sr	553	2,930	3,480
⁹⁰ Y	553	2,930	3,480
⁹⁹ Tc	0.189	8.05	8.24
¹³⁷ Cs	626	2,120	2,750
¹⁵⁴ Eu	0.516	19.2	19.8
¹⁵⁵ Eu	10.4	5.94	16.4
²³⁷ Np	0.00190	0.0275	0.0294
²³⁸ Pu	24.9	0.0416	24.9
²³⁹ Pu	691	1.30	692
²⁴⁰ Pu	114	0.227	114
²⁴¹ Am	0.103	1.43	1.53

HDW = Hanford Defined Waste

^a Agnew et al. (1997a), decayed to January 1, 1994.

In the next section flowsheet, fuel production, and Waste Status and Transaction Record Summary (Agnew et al. 1997b) will be used to independently evaluate the credibility of the HDW model-based estimates for this waste.

D3.1 WASTE TYPES

Generally, three different types of wastes were added to tank 241-T-101. The most important from a volume perspective are salt cake waste, primary and secondary REDOX coating waste (CWR2), and secondary cesium recovery (CSR) ion exchange waste.

D3.2 SALT CAKE WASTE

The salt cake inventory can be estimated from the 1974 and 1975 supernatant samples from this tank. Table D3-3 provides a summary of the estimated salt cake composition based on the supernatant composition in Table D2-1 and assuming that 244 kL (64 kgal) of salt cake were produced in 1977 (Agnew et al. 1997b). Salt cake estimates provided by the HDW model are also shown in this table.

Table D3-3. Estimated Salt Cake Inventories Based on the 1975 Supernatant Composition and Hanford Defined Waste Model for Tank 241-T-101.

Analyte	Salt cake inventory based on 1975 supernatant composition ^a (kg)	SSMT2 salt cake inventory based on HDW model ^b (kg)
Al	1,220	605
Na	64,970	5,990
CO ₃	10,270	670
F	67	67
OH	2,270	2,630
NO ₃	116,400	5,400
NO ₂	14,140	2,050
PO ₄	3,850	167
SO ₄	NR	537
Water, wt. %	40 %	92.5 %
Density, kg/L	1.5 kg/L	1.04 kg/L

HDW = Hanford Defined Waste

NR = Not reported

^a Wheeler (1975)

^b Agnew et al. (1997a)

According to the HDW model, this salt cake contains 92.5 percent moisture, which suggests that this material is really a salt slurry rather than salt cake. Site transfer records also show that the last supernatant was pumped out of this tank under emergency pumping conditions in 1993. If the uppermost layer solids consisted of salt slurry, this layer would have certainly collapsed in 1993. The sludge level measurements obtained in 1978 and 1993, however, are in close agreement, thus indicating the HDW model must be in error regarding

the composition of the salt cake layer in this tank. The waste compatibility study performed in 1993 also indicates that only 113 kL (30 kgal) of pumpable liquids were stored in this tank prior to the 1993 emergency pumping campaign. This small inventory of drainable liquid is consistent as a salt cake rather than salt slurry layer, thus lending additional support to the use of supernatant based salt cake values in Table D3-3 for the best-basis estimate.

D3.3 PRIMARY AND SECONDARY REDOX COATING WASTE

Approximately 1,730 kL (457 kgal) of secondary REDOX coating waste (CWR) were introduced to this tank in 1963 and 1964, with these wastes remaining in this tank until transferred to tank 241-T-103 in 1969. According to the HDW model, REDOX coating waste makes up about 95 percent of the sludge in tank 241-T-101, with the balance consisting of residual metal waste. Because tank 241-T-101 was a secondary receiver of such waste, the absolute quantities of waste that might have been added to this downstream tank are unknown. Flowsheet values can be used to generate upper bounding estimates for silica, aluminum and nickel, assuming that these waste were routed directly to tank 241-T-101.

A spreadsheet analysis of the REDOX fuel fabrication and production records and waste transaction records (Agnew et al. 1997b) shows that 2,030.8 MTUs of (aluminum-clad) REDOX coating waste were transferred to tank 241-S-107 in 1961 and 1962, and subsequently to tanks 241-U-108 and 241-T-101 (in one transfer of 1,635 kL (432 kgal) during the second quarter of 1963 and a second transfer of 95 kL (25 kgal) directly from tank 241-S-107 during the third quarter of 1964). A third transfer of 11.4 kL (3 kgal) of such waste occurred in third quarter of 1972. The number of MTUs can be estimated by allocating the amount of fuel over the period that tank 241-S-107 received REDOX coating waste and transferred this waste to tanks 241-U-108 and 241-T-101. In this case, tank 241-S-107 received essentially all of the REDOX coating waste produced in 1961 and 1962, and transferred the supernatant from this waste to tanks 241-U-108 and 241-T-101 in 1963. On this basis, tank 241-T-101 received 2,003.2 MTU (215.65 gal/MTU) of secondary REDOX coating waste in 1963 and 115.9 MTUs (215.65 gal/MTU) of such waste in 1964. These values were derived from a spreadsheet analysis of the waste transaction records and fuel production records for the indicated periods, with the coating waste volumes (gal/MTU) being computed from these data.

D3.4 SILICA

The aluminum alloy jacket around the fuel typically contains 0.046 kg Si/MTU, while the Al-Si braze metal used in the bonding layer adds another 1.269 kg Si/MTU (Kupfer et al. 1997). Therefore, the upper bounding limit for Si in the REDOX coating waste would be 2,787 kg (compared to the HDW estimate of 0.36 kg).

According to the REDOX flowsheet (Crawley and Harmon 1960), the REDOX coating waste typically contained about 40 pounds of Na_2SiO_3 per 8 ton batch of fuel. This stream would have added, at most, about 1,216 kg of Si to tank 241-T-101, based on the number of MTUs of REDOX fuel processed in 1961 and 1962. The REDOX flowsheet is 44 percent of the amount of Si derived from the fuel and waste transaction records for this process (2,787 kg); however, both estimates indicate that a substantial Si inventory is present in tank 241-T-101.

For coating waste, tank 241-T-102 represents the best comparison case because this tank also received secondary Al-clad coating waste. If coating waste had been sent directly to tank 241-T-102, the sludge layers in this tank should have contained about 1,102 kg of Si. However, as a secondary receiver, only 417 kg of Si were actually found in tank 241-T-102 waste. On this basis, about 1,055 kg of Si should be found in the tank 241-T-101 sludge (compared to 0.3 kg of Si predicted by the HDW model).

D3.5 ALUMINUM AND NICKEL

Other components were also contained in the REDOX coating waste transfers, including 99,809 kg of Al and 996 kg of Ni (47.1 kg of Al and 0.47 kg of Ni per MTU, Kupfer et. al. 1997). Aluminum-clad fuels produced after 1959 contained about 1 percent Ni in the Al alloy jacket (Kupfer et al. 1997).

Most of the Al was dissolved as sodium aluminate and transferred in the supernatant to one of the downstream receiver tanks. The upper bounding Al inventory can be estimated from the split factors developed from the tank 241-C-102/241-T-102 cascade for secondary (Al-clad) coating wastes. Based on the total amount of Al in the coating waste and the fraction of Al that precipitated in the tank 241-C-102 sludge, it appears that about 90 percent of the Al was transferred, in the form of soluble sodium aluminate, to tank 241-T-102. Most of this Al precipitated from the supernatant over the five year period that these wastes were stored in tank 241-T-102 (due to the absorption of CO_2 from the atmosphere).

From the transfer records (Agnew et al. 1997b), it appears that secondary coating wastes were also stored in tank 241-T-101 for a similar period of time (6 years). If this tank received 90 percent of the aluminum in the coating waste, and all of this aluminum precipitated in the sludge, the expected inventory would be 89,800 kg of Al in this tank. In the HDW model, only 20,900 kg of Al are predicted to be in this tank.

Based on similar analogies for Ni, approximately 98 percent of the Ni settled in the primary receiver tank of the 241-C-102/241-T-102 cascade. This value was derived from the best-basis inventory estimates for these tanks (Lambert 1997, Baldwin et al. 1997)(using flowsheet estimates and sample data for tanks 241-C-102 and 241-T-102). On this basis, 20 kg of Ni are expected to be found in the tank 241-T-101 sludge, compared to the HDW model prediction of 9.338 kg of Ni.

D3.6 COMMON SLUDGE LAYERS

Common sludge layers in other tanks can also be used to estimate the composition of tank 241-T-101 waste. Tank 241-T-101 received secondary REDOX coating waste, while tanks 241-C-102 and 241-C-105 received primary coating wastes of similar composition from the PUREX process. Tank 241-C-104 also received PUREX coating waste, but this waste only represents 56 percent of the total sludge inventory in this tank. As for the other tanks, PUREX coating waste is thought to represent about 90 percent of the sludge in tank 241-C-105 and 85 percent of the sludge in tank 241-C-102. The following estimates were produced by multiplying the amount of each component (in the 241-C-102/241-C-105 waste) by the volume of coating waste sent to tank 241-T-101 (1,730 kL [457 kgal]) divided by the volume of coating waste sent to tanks 241-C-102 (49,370 kL [13,044 kgal]) or 241-C-105 (11,930 kL [3,151 kgal]) (Kupfer et al. 1997). Another set of estimates was also produced from tank 241-T-102 waste, with indicated corrections for the more dilute concentration of this waste. These estimates are summarized in Table D3-4, together with the HDW model predictions for tank 241-T-101.

Table D3-4. Comparison of Common Sludge Layer Derived Estimates for Al-Clad Coating Waste and HDW Derived Estimates for the Sludge Composition in Tank 241-T-101. (2 Sheets)

Analyte	Estimated inventory based on tank 241-C-105 ^a (kg)	Estimated inventory based on tank 241-C-102 ^b (kg)	Estimated inventory based on tank 241-T-102 ^c (kg)	HDW estimates for tank 241-T-101 ^e (kg)
Al	2,744	2,219	94,400 ^d	20,900
Bi	119	24	< 674	0
Cr	25	48	177	16.6
Fe	413	381	2,186	3,430
Pb	40	34	233	8,940
Mg	133	127	< 135	NR
Mn	71	89	115	0
Ni	307	77	8.5	9.38
NO ₃	1,907	795	9,303	5,380
NO ₂	623	NR	2,036	1,490
PO ₄	1302	373	760	288
Si	1,666	1,429	393	0.36

Table D3-4. Comparison of Common Sludge Layer Derived Estimates for Al-Clad Coating Waste and HDW Derived Estimates for the Sludge Composition in Tank 241-T-101. (2 Sheets)

Analyte	Estimated inventory based on tank 241-C-105 ^a (kg)	Estimated inventory based on tank 241-C-102 ^b (kg)	Estimated inventory based on tank 241-T-102 ^c (kg)	HDW estimates for tank 241-T-101 ^e (kg)
Na	3,830	3,979	6,798	5,130
SO ₄	161	< 787	417	188
U	105	365	< 2,695	18,600
Zn	426	0.6	97	NR
Zr	253	30	< 13.5	0

HDW = Hanford Defined Waste

^aCommon sludge layer estimate based on tank 241-C-102 sludge composition multiplied by fraction of REDOX coating waste routed to tank 241-T-101 (1,730 kL [457 kgal]) divided by volume routed to tank 241-C-102 (49,370 kL [13,044 kgal]). Tank 241-C-102 composition estimates referenced in Weiss and Schull (1988).

^bCommon sludge layer estimate based on tank 241-C-105 sludge composition multiplied by fraction of REDOX coating waste routed to tank 241-T-101 (1,730 kL [457 kgal]) divided by volume routed to tank 241-C-105 (11,930 kL [3,151 kgal]). Tank 241-C-105 composition estimates referenced in Weiss and Schull (1988b).

^cCommon sludge layer estimate based on tank 241-T-102 sludge composition multiplied by fraction of secondary REDOX coating waste sent to tank 241-T-101 (1,730 kL [457 kgal]) divided by volume of secondary PUREX coating waste sent to tank 241-T-102 (1,840 kL [485 kgal])

^dThe Al estimate was increased by a factor of 2.62 (564 gal/MTU divided by 215 gal/MTU) to correct for the more dilute Al concentration in PUREX coating waste.

^eHDW based inventory estimate from Table D3-1.

The common sludge layer derived estimates for Al, Fe, NO₃, NO₂, Pb, Na, and U are generally lower than the HDW model predictions for this waste. This table also shows that large quantities of Fe were probably added from another source, possibly from the cesium recovery (CSR) ion exchange wastes added to tanks 241-T-101 and 241-T-102.

The HDW model predictions for Fe, Ni, PO₄ and Na are in good agreement with estimates derived from tank 241-T-102 waste, because both tanks received similar volumes of secondary coating waste and large volumes of cesium recovery waste from B Plant. For Cr, PO₄, Na, and SO₄, the HDW model predictions are also in good agreement with the common sludge layer estimates, which may not be a meaningful comparison because these components were also present in the cesium recovery wastes from B Plant (Table D3-5).

D3.7 SECONDARY CESIUM RECOVERY ION EXCHANGE WASTE

About 5,325 kL (1,407 kgal) of secondary cesium recovery (CSR) ion exchange waste were also transferred to tank 241-T-101 from the third quarter of 1972 to the second quarter of 1976. All of these wastes were actually produced in B Plant in 1972 and 1973. In the B Plant flowsheets for this process, two separate feedstocks were identified as cesium ion exchange feeds, high-level PUREX supernatants (PSN) and more dilute PUREX supernatants from sluicing (PSS) (Larson 1967). Table D3-5 summarizes the average concentration profiles for these feeds, together with the estimated amount of each component that might have been added in 5,325 kL (1,407 kgal) of PSN or PSS supernatant sent to tank 241-T-101. While the general source of the cesium recovery supernatants can be established from flowsheets, it is not possible at this time to determine the exact fraction of PSN and PSS in the final effluent stream to tank 241-T-101. However, based on B Plant cesium recovery records, it appears that 72 percent of the feed in 1972 and 1973 consisted of PUREX supernatant (PSN) and 28 percent PUREX sluicing supernatant (PSS), with small amounts of current acid waste (CAW) (Uebelacker 1967).

Table D3-5. Projected Inventory of Cesium Recovery Waste Sent to Tank 241-T-101.

Component	PSS waste composition ^a , <i>M</i>	PSN waste composition ^a , <i>M</i>	PSS inventory added to tank 241-T-101 ^b , kg	PSN inventory added to tank 241-T-101 ^b , kg
Al	0.046	NR	6,701	NR
Cl	0.002	0.078	379	14,730
CO ₃	0.71	0.73	229,735	244,100
Cr	0.0081	NR	2,270	NR
NO ₃	0.92	0.52	307,600	173,900
NO ₂	0.47	2.8	116,600	694,620
PO ₄	0.031	0.013	15,880	6,660
Si	0.005	NR	758	NR
Na	3.8	5.15	471,360	638,800
SO ₄	0.37	0.13	199,570	67,300

NR = Not reported

PUREX = Plutonium-uranium extraction

PSN = PUREX supernatants

PSS = PUREX supernatants from sluicing

^aBased on typical PSN and PSS compositions (Larson 1967)

^bThese estimates assume 5,393 kL of PSN or PSS waste transferred to tank 241-T-101.

According to estimates in this table, cesium recovery wastes contained much higher levels of Cl, CO₃, Cr, NO₃, NO₂, PO₄, Na, and SO₄ than might have been expected from the HDW model for this tank (Table D3-3). Since all of these components are readily soluble, most of these components were probably transported to one of the downstream tanks (241-T-102, 241-T-103, 241-S-110, 241-SX-106, and 241-U-103 from 1972 to 1976). The low Al inventory in PSS waste is noteworthy because this is consistent with earlier view that most of the Al was probably added, by means of precipitation, from the REDOX coating wastes stored in this tank from 1963 to 1969. The low Si inventory in PSS waste (758 kg) is also suggestive of another major source of Si, such as the REDOX coating wastes from Al-clad fuel.

D3.8 BISMUTH PHOSPHATE METAL WASTE

Hanford sluicing records show that most of the metal waste was removed from tank 241-T-101 in 1953 and 1956 (Rodenhizer 1987). A small residual heel of 7.6 kL (2 kgal) of metal waste is thought to have been left after the 1956 sluicing campaign (Agnew et al. 1997b, Anderson 1990). Based on known composition of tank 241-T-101 metal waste (1.53 g moles of uranium/kg of metal waste) and assumed density of 1.74 kg/L, about 4,800 kg of uranium would be expected in this heel (compared to the HDW model prediction of 18,600 kg of uranium) (GE 1951, Agnew et al. 1997a). This heel is also expected to have about 638 kg of PO₄ and 1,520 to 3,480 kg of CO₃ (0.51 g moles of PO₄/kg of metal waste and 1.92 to 4.4 g moles of CO₃/kg of metal waste sludge) (GE 1951). These estimates are generally consistent with the HDW model predictions for CO₃ and PO₄, but are lower than expected for uranium.

The sluicing records from this era show that 81,800 kg of uranium were left in tanks 241-T-101, 241-T-102 and 241-T-103 after the last sluicing campaign (McDonald 1959). If this information is correct, the residual metal waste heel could be as high as 40 kL (10.7 kgal) in tank 241-T-101, with corresponding inventories of 25,800 kg of uranium, 5,000 to 11,400 kg of CO₃ and 2,000 kg of PO₄. In view of the high uranium inventory that might be present in this, the first tank of a three tank cascade, the HDW model predictions for uranium, CO₃ and PO₄ will be used as the best-basis estimates for the sludge layer.

D3.9 CESIUM AND STRONTIUM

Tank 241-T-101 has an estimated heat load of 4,188 BTU/h or 1,228 watts (Kummerer 1995). This heat load corresponds to 260,000 Ci of ¹³⁷Cs or 184,000 Ci of ⁹⁰Sr, values that are well above the HDW model predictions for this tank (2,750 Ci of ¹³⁷Cs and 3,480 Ci of ⁹⁰Sr, decayed to January 1, 1994). In addition to other sources of cesium and strontium, a significant fraction of cesium may have been added to tank 241-T-101 during the third and fourth quarters of 1972 (via the Redox supernatant from tanks 241-SX-114 and 241-SX-105). Due to the absence of sample data, the best-basis ¹³⁷Cs and ⁹⁰Sr estimates will be projected from the thermal modelling results, using the radionuclide ratios provided in the

HDW model. Based on this assessment, 93,000 Ci of ^{137}Cs and 118,000 Ci of ^{90}Sr are assumed to be present in this waste. These values match the thermal release characteristics of this waste.

D3.10 SUMMARY

The Al inventory estimate developed from the fuel and waste transfer records (89,800 kg), and from tank 241-T-102 waste (94,400 kg in Table D3-3), appear to be more reasonable than the HDW model prediction for this tank (20,900 kg). Based on the similarities between tanks 241-T-101 and 241-T-102, most of the Al in the 241-T-101 waste was probably precipitated from the secondary coating wastes stored in this tank from 1964 to 1969. Similarly, the upper bounding estimates for Si, corrected for the split factor developed from the 241-C-102/241-T-102 cascade, seems to be a better value than the HDW model prediction (0.3 kg). Other values in the HDW model, specifically those developed for CO_3 , Fe, Ni, PO_4 , Na, and U, are consistent with other sources of information, including common sludge layers from other tanks, flowsheet estimates for B Plant wastes or historical sluicing records for this tank.

Somewhat better estimates were also developed for the salt cake wastes based on the composition of the 1974 and 1975 supernatant samples from this tank. These salt cake estimates appear to be more reasonable than HDW predictions for the amount of Al, CO_3 , F, NO_3 , NO_2 , Si, Na, and SO_4 in the salt cake fraction from this tank. In part, this conclusion is based on the behavior of the salt cake layer in this tank during the emergency pumping campaign in 1993. Since the salt cake layer appears to have less moisture than indicated in the HDW model, the supernatant based salt cake inventory projections are judged to be more reasonable than the HDW model predictions for this layer. Finally, the HDW model predictions for ^{137}Cs and ^{90}Sr are much lower than the values derived from the thermal modelling results for this tank. Thus, better estimates were developed from the thermal modelling results for ^{137}Cs and ^{90}Sr , using the fractional ratio of these radionuclides in the HDW model. The best-basis inventory estimates for sludge, salt cake, and total tank inventories are summarized in Table D3-6, using the HDW model predictions for most components, flowsheet derived estimates for Al and Si in the sludge layer, salt cake derived estimates for Al, CO_3 , F, NO_3 , NO_2 , Si, Na, and SO_4 in the salt cake layer, and thermal modelling results and the HDW model for ^{137}Cs and ^{90}Sr . The HDW model was used to predict all of the remaining radionuclides in this waste.

Table D3-6. Best-Basis Estimates for Nonradioactive Components in Tank 241-T-101.

Analyte	Best-basis sludge inventory (kg)	Best-basis salt cake inventory (kg)	Best-basis tank inventory (kg)
Al	89,800	1,220	91,020
Bi	0	14.4	14.4
Ca	1,740	23.8	1,760
Cl	58.3	158	216
CO ₃	3,420	10,270	13,690
Cr	16.6	122	138
F	0	67	67
Fe	3,430	14.1	3,450
Hg	293	0.0189	293
K	14	134	148
La	0	5.28	5.28
Mn	0	10.2	10.2
Ni	9.38	6.78	16.2
OH	53,300	2,270	55,570
NO ₃	5,380	116,400	121,800
NO ₂	1,490	14,140	15,630
Pb	8,940	1.78	8,940
PO ₄	290	3,850	4,140
Si	1,050	50.2	1,100
Na	5,130	64,970	70,100
Sr	0	0	0
SO ₄	188	537	725
TOC	0	235	235
U	18,600	42.3	18,600
Zr	0	0.2	0.2

Table D3-7. Best-Basis Estimates for Radioactive Components in Tank 241-T-101.

Radionuclide	Best-basis sludge inventory (Ci)	Best-basis salt cake inventory (Ci)	Best-basis tank inventory (Ci)
¹⁴ C	0.0401	1.14	1.18
⁶⁰ Co	0.0227	1.32	1.34
⁹⁰ Sr	115,000 ^b	2,930	118,000 ^a
⁹⁰ Y	115,000 ^b	2,930	118,000 ^a
⁹⁹ Tc	0.189	8.05	8.24
¹³⁷ Cs	626	92,000 ^b	93,000 ^a
¹⁵⁴ Eu	0.516	19.2	19.8
¹⁵⁵ Eu	10.4	5.94	16.4
²³⁷ Np	0.00190	0.0275	0.0294
²³⁸ Pu	24.9	0.0416	24.9
²³⁹ Pu	691	1.30	692
²⁴⁰ Pu	114	0.227	114
²⁴¹ Am	0.103	1.43	1.53

^a Based on tank heat load

^b By difference between the total tank inventory and the HDW value for the other waste layer.

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

Chemical and radionuclide inventory estimates are derived from one of three sources of information: (1) sample analyses and sample derived inventory estimates, (2) component inventories predicted by the HDW model based on process knowledge and historical tank transfer information, or (3) a tank-specific process estimate based on process flowsheets, reactor fuel data, essential materials records, or comparable sludge layers and sample information from other tanks.

An effort is currently underway to provide waste inventory estimates that will serve as the standard characterization data for various waste management activities. As part of this effort, a survey and analysis of various sources of information relating to the chemical and radionuclide component inventories in tank 241-T-101 was performed, including the following:

1. Component inventory estimates provided by the HDW model (Agnew et al. 1997a).
2. Evaluation of upper bounding estimates for secondary (Al-clad) REDOX coating (CWR2) waste and secondary cesium recovery (CSR) ion exchange waste, based on process flowsheets, fuel and waste transaction records for this tank.
3. Analysis of CWR2 sludge based on common sludge layers in tanks 241-C-102, 241-C-105, and 241-T-102, together with waste transaction records for these tanks.
4. Analysis of residual metal waste based on the composition of tank 241-T-101 MW (GE 1951).
5. Evaluation of the estimated thermal loads provided by the HDW estimates for ^{90}Sr and ^{137}Cs relative to thermal modelling results for this tank.

Based on this analysis, a best-basis inventory was developed. The waste in tank 241-T-101 primarily consists of salt cake, secondary (Al-clad) REDOX coating (CWR2) waste, secondary cesium recovery (CSR) ion exchange waste and a small amount of residual metal waste (MW) from the BiPO_4 process. The best-basis inventory for tank 241-T-101 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.

Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences 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).

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 , $^{239/240}\text{Pu}$, 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.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-T-101 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C) ¹	Comment
Al	91,020	E	Based on upper bounding estimate from flowsheet and tank 241-T-102
Bi	14.4	M	
Ca	1,760	M	
Cl	216	M	
TIC as CO ₃	13,690	E	Based on salt cake produced from tank 241-T-101 supernatant
Cr	138	M	
F	67	M/E	Based on salt cake/HDW model
Fe	3,450	M	
Hg	293	M	
K	148	M	
La	5.3	M	
Mn	10.2	M	
Na	70,100	E	Based on salt cake produced from tank 241-T-101 supernatant
Ni	16.2	M	
NO ₂	15,630	E	Based on salt cake produced from tank 241-T-101 supernatant
NO ₃	121,800	E	Based on salt cake produced from tank 241-T-101 supernatant
OH _{TOTAL}	187,000	C	Based on charge balance
Pb	8,940	M	
P as PO ₄	4,140	E	Based on salt cake estimate
Si	1,100	E	Based on upper bounding flowsheet estimate and split factor for tank 241-T-102
S as SO ₄	725	M	Based on salt cake
Sr	0	M	
TOC	235	M	
U _{TOTAL}	18,600	M	

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Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in
Tank 241-T-101 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C) ¹	Comment
Zr	0.2	M	

¹S = 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
CO₃, NO₂, NO₃, PO₄, SO₄, and SiO₃

NR = Not reported.

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-T-101 Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory	Basis	Comment
³ H	6.18	M	
¹⁴ C	1.18	M	
⁵⁹ Ni	0.0633	M	
⁶⁰ Co	1.34	M	
⁶³ Ni	6.26	M	
⁷⁹ Se	0.0918	M	
⁹⁰ Sr	118,000	E	Based on thermal model
⁹⁰ Y	118,000	E	Referenced to ⁹⁰ Sr
^{93m} Nb	0.324	M	
⁹³ Zr	0.452	M	
⁹⁹ Tc	8.24	M	
¹⁰⁶ Ru	2.26 E-04	M	
^{113m} Cd	2.49	M	
¹²⁵ Sb	5.85	M	
¹²⁶ Sn	0.138	M	
¹²⁹ I	0.0159	M	
¹³⁴ Cs	0.0201	M	
^{137m} Ba	88,000	E	Referenced to ¹³⁷ Cs
¹³⁷ Cs	93,000	E	Based on thermal model
¹⁵¹ Sm	324	M	
¹⁵² Eu	0.275	M	
¹⁵⁴ Eu	19.8	M	
¹⁵⁵ Eu	16.4	M	
²²⁶ Ra	4.48 E-06	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank
241-T-101 Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total inventory	Basis	Comment
²²⁷ Ac	2.25 E-05	M	
²²⁸ Ra	6.48 E-05	M	
²²⁹ Th	3.05 E-06	M	
²³¹ Pa	9.55 E-05	M	
²³² Th	2.15 E-05	M	
²³² U	0.00298	M	
²³³ U	0.0096	M	
²³⁴ U	8.47	M	
²³⁵ U	0.328	M	
²³⁶ U	0.493	M	
²³⁷ Np	0.0294	M	
²³⁸ Pu	24.9	M	
²³⁸ U	6.21	M	
²³⁹ Pu	692	M	
²⁴⁰ Pu	114	M	
²⁴¹ Am	1.53	M	
²⁴¹ Pu	1,020	M	
²⁴² Cm	0.00598	M	
²⁴² Pu	0.0027	M	
²⁴³ Am	5.90 E-05	M	
²⁴³ Cm	4.50 E-04	M	
²⁴⁴ Cm	0.00466	M	

¹S = Sample-based

M = Hanford Defined Waste model-based

E = Engineering assessment-based

NR = Not Reported.

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