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Preliminary Tank Characterization Report for Single-Shell Tank 241-C-102: Best-Basis Inventory

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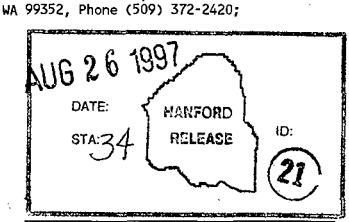
Abstract: An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities. As part of this effort, an evaluation of available information for single-shell tank 241-C-102 was performed, and a best-basis inventory 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-C-102: BEST-BASIS INVENTORY

July 1997

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PRELIMINARY TANK CHARACTERIZATION REPORT FOR SINGLE-SHELL TANK 241-C-102: 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-C-102. 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

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-C-102

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-C-102

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-C-102 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

Two core sampling attempts were made in 1986. The first core from riser 2 was not completed because the rotary sampler struck a concrete block or shield plug on the sludge surface which prevented further penetration in that area. The second core from riser 3 was more successful and partial recoveries were obtained in six of eight segments of the core. Solids from four of these segments (segments 2, 3, 4, and 5) were combined to generate a composite sample for chemical and radionuclide analysis of the waste (Weiss and Schull 1988a). Two different analytical procedures were used. In the first procedure, metals and radionuclides were analytically measured after acid digestion of the sample and strong acid (HNO_3-HF-HCl) digestion of the acid insoluble residue in a teflon-lined Parr bomb. The Parr bomb procedure only dissolved 24 wt% of the acid insoluble residue, including the weight of the interstitial liquid remaining in the centrifuged solids. Metals were determined by inductively coupled plasma spectroscopy (ICP), while anions were measured by Ion Chromatography (IC). In the second procedure, the composite sample was directly dissolved (by HNO_3-HF-HCl) in a Parr bomb, leaving a undissolved residue equivalent to 57 wt% of the original sample, including the weight of residual solution. In general, the highest analyte values were produced in the first procedure, with the only exceptions being Cd, P, Pd, U, and Zr. The most important difference appears to be the analytical results for U where the first procedure produced an estimate of 1,350 μg/g and the second procedure 11,200 μg/g.

Additional analyses were also performed on an archive sample from tank 241-C-102 for analytical procedure development (Hara 1990). This sample was presumably taken from the 1986 core composite, but the analytical report did not specify the nature and origin of this sample. The analyses performed included moisture analysis, water and acid digestion followed by ICP analysis of metals, total inorganic carbon (TIC), total organic carbon (TOC), and IC analysis of anions; KOH-Ni and Na_2O_2-Zr fusion with ICP analysis of metals;

cold vapor atomic absorption (CVAA) analysis of Hg; and graphite furnace AA analysis of As, Pb, Se, Sb, and Tl.

The waste history of this tank is provided in Anderson (1990) and Brevick (1994). Tank 241-C-102 was removed from service in May 1976 and declared to be inactive in 1978. The 1986 core sample is thought to be representative of that portion of the sludge where the four segments of the composite core were taken (segments 2, 3, 4, and 5). Component inventories can be calculated by multiplying the concentration of an analyte by the volume and density of the sludge and liquid layers in the tank. The Hanford Defined Waste (HDW) model (Agnew et al. 1996) also provides an independent set of estimates for component inventories in this tank.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

The 1986 core consisted of eight segments, four of which were combined to make up a composite sample of the waste. Table D2-1 provides information on the amount of sludge and liquid recovered from each segment and sludge layer depth estimates based on field observations, photographs of the sludge surface, and physical dimensions of the sampler (Weiss and Schull 1988a). Core segment identities are important because this data can be used to locate the approximate elevation where the four segments in the composite core were taken. Based on the characteristics of the sampler, each segment should be 2.54 cm (1 in.) in diameter and 48.26 cm (19 in.) long and represent 244.54 cm^3 (96.35 in^3) of waste. A 2.54-cm (1-in.) diameter sampler thus contains 5.067 cm^3 (2 in^3) of sample/cm. The density of the sample can be determined by dividing this volume by the sample weight/cm (including the small volume of liquid in the sample). The sludge level at riser 2 was determined to be 383.5 cm (151 in.) at the time of sampling in 1986, with the surface being cracked and covered with debris in the area around the Food Instrument Corporation (FIC) automatic surface level gauge plummet (Weiss and Schull 1988a, Swaney 1993). Composite photographs of sludge layer show considerable relief with ridges and cracks and different sludge levels at various locations. The measured sludge level at riser 2 appears to be in good agreement with the nominal sludge depth for core 1 (field observations for core 1 did not identify any discrepancy in the expected sludge elevation at riser 2). A significant discrepancy was noted for core 2 at riser 3 where the sludge level was found to be 335.3 cm (132 in.), or about 48.3 cm (19 in.) lower than at riser 2. Although riser 3 is close to riser 2, the sludge level at riser 3 (335.3 cm [132 in.]) agrees with the predicted level (338.1 cm [133 in.]) based on the number of segments in core 2 (seven segments, each 48.3 cm [19 in.] in length).

The sludge volume can be determined by taking the average sludge depth for the two risers (359.4 cm or 141.5 in.) and multiplying this value by the volume factor for a 22.8 m (75 ft) diameter tank (4,110 L/cm). Tank 241-C-102 thus contains 1,522.9 kL (402.3 kgal) of sludge, including 45.9 kL (12 kgal) due to the dish bottom configuration of the 22.86 m

(75 ft) diameter tank. The tank farm surveillance estimate is 1,601 kL (423 kgal), which is based on an average sludge depth of 381 cm (150 in.) of sludge (Hanlon 1996a). The average depth of the cores will be used in this analysis because this is considered to be a more realistic estimate for a sludge surface with ridges and cracks. All of this waste consists of sludge. The sludge layer represented by the four segments in the composite core (segments 2, 3, 4, and 5) is approximately 193 cm (76 in.) thick and extends from the top of the sludge down to a level 166 cm (65.5 in.) from the bottom of the tank (not including the dish bottom). This layer contains approximately 793.3 kL (209 kgal) of sludge or 52.1 percent of the total sludge inventory. The average density of this layer is 1.80 kg/L (Table D2-1).

Table D2-1. Core Segment Recoveries, Sample Segment Thickness, and Estimated Sludge Levels in Tank 241-C-102.

Date	Riser/ core	Segment	Sample size (cm)	Liquid (mL)	Solid (g)	Potential sample depth (cm [in.])	Sample density (g/mL)[a]
1986	3/2	1	-	0	0	0 (0)	-
		2	15.2	5	163.3	48.3 (19)	2.11
		3	33.0	6	295.9	48.3 (19)	1.77
		4	30.5	50	286.2	48.3 (19)	1.85
		5	38.1	10	318.2	48.3 (19)	1.65
		6	-	0	0	48.3 (19)	-
		7	7.6	2	66.8	48.3 (19)	1.73
		8	31.1	-	173.1	48.3 (19)	1.68
		Total	Total	73	1,303.5	338.1 (133)	Avg. 1.80

[a] Density of sample may be determined by dividing the volume of the sampler (5.067 cm^3 of sample/cm) by the weight of sample/cm.

Table D2-2 provides a summary of the composite sample analytical results and tank inventory estimates based on the estimated volume and density of the sludge (1,522.9 kL [402 kgal] and 1.80 kg/L, respectively). The chemical species are reported without charge designation per the best-basis inventory convention. Since 90 percent of the sludge consists of Plutonium-Uranium Extraction (PUREX) coating waste, it is assumed, for purposes of developing the sample-based estimate, that the upper sludge layer can be used to represent the average composition in the tank. The uranium recovery (UR) and metal waste (MW) layers in the bottom of the tank were not included in the 1986 composite sample. The

archive sample was used for a few anions which were not measured in the composite sample. The other components in the archive sample were not used because the analytical report did not specify the nature and origin of this sample (Hara 1990). It should be noted that analyte concentrations are inconsistent for most components in the core composite and archive samples because of large but indeterminate differences in moisture content and uncertainties as to the location and origin of the archive sample. Moisture levels were not measured in the 1986 composite sample, while the archive sample contained only 4 percent moisture. For purposes of this comparison, cations in the archive sample were normalized to the composite sample aluminum concentration, while anions were normalized to the composite nitrate concentration. Analytical values in Table D2-2 are referenced from Weiss and Schull (1988a) and Hara (1990). Since moisture results are not available, the sum of the component inventory weights represents only about 25 percent of the mass in this tank.

Table D2-2. Analytical Results and Sludge Inventory Estimates for Nonradioactive Components in Tank 241-C-102. (2 Sheets)

Component	Core 2 composite, riser 3[a] (μg/g)	Archive sample[b] (μg/g)	Tank inventory[c] (MT)
Al	35,400	35,400	97.0
Ba	1,100	17.3	3.02
Bi	1,530	NR	4.19
Cd	38.7	12.6	0.11
Ca	3,040	1,479	8.33
Ce	563	9.4	1.54
Cl	NR	917	2.51[d]
Cr	322	44.1	0.88
Co	10.6	NR	0.03
Cu	116	44.1	0.32
F	2,370	705	6.50
Fe	5,320	3,068	14.6
La	74.2	NR	0.20
Pb	512	140	1.40
Mg	1,710	554	4.69
Mo	213	23.6	0.58
Mn	915	362	2.51
Ni	3,960	NR	10.9

Table D2-2. Analytical Results and Sludge Inventory Estimates for Nonradioactive Components in Tank 241-C-102. (2 Sheets)

Component	Core 2 composite, riser 3[a] (μg/g)	Archive sample[b] (μg/g)	Tank inventory[c] (MT)
Nd	70.2	9.5	0.19
P as PO_4	1,676	1,495	4.59
Pd	731	NR	2.0
K	692	NR	1.90
Si	21,500	12,083	58.9
Ag	102	28.3	0.28
Na	49,400	6,702	135.4
Sr	41.7	12.6	0.11
Ti	132	275	0.36
U	1,350	3,666	3.70
Zn	5,490	25.2	15.0
Zr	3,260	208	8.94
NO_3	24,600	24,600	67.4
NO_2	NR	8,036	22.0[d]
SO_4	<20,500	2,071	5.68[d,e]
TIC as CO_3	NR	45,081	123.6[d]
TOC	NR	686	1.88[d]
Density	1.80 kg/L	NR	NR

[a] Based on analytical results from 1986 composite core (acid + Parr bomb) (Weiss and Schull 1988a).

[b] Metals based on KOH fusion results normalized to core composite Al concentration (35,400 μg/g) to compensate for differences in sample moisture content. F, Cl, NO_3, NO_2, SO_4, TIC, and TOC normalized to core composite NO_3 concentration (24,600 μg/g) to adjust for differences in moisture content.

[c] Tank inventory estimates based on core 2 composite analytical results, estimated sludge volume (1,522.9 kL [402 kgal]) and computed sludge density (1.80 kg/L).

[d] Tank inventory estimates based on archive sample analytical results.

[e] SO_4 estimate based on archive sample because of "less than" value from 1986 core composite.

Table D2-3 provides a summary of the composite sludge radionuclide concentrations and tank inventory estimates. The composite sludge values are derived from segments 2, 3, 4, and 5 of core 2. Radionuclide results are decayed to January 1, 1994.

Table D2-3. Analytical Results and Tank Inventory Estimates for Radioactive Components in Tank 241-C-102 (Decayed to January 1, 1994).

Radionuclide	Core 2 composite[a], μCi/g	Tank Inventory,[b] Ci
^{60}Co	0.184	500
^{137}Cs	9.06	24,800
^{154}Eu	0.033	90.5
^{155}Eu	0.033	91.5
$^{239/240}$Pu	2.54	6,960
^{241}Am	0.53	1,450
^{125}Sb	0	0
Total Gamma[c]	6.81	18,700

[a] Based on analytical results from 1986 composite core (acid + Parr bomb) (Weiss and Schull 1988a)

[b] Tank inventory estimates based on core 2 composite analytical results, predicted sludge volume (1,522.9 kL [402 kgal]) and average sludge density (1.80 kg/L)

[c] Total gamma based on acid digestion only (Parr bomb results not included for 1986 core composite). Although total gamma is only 75 percent of ^{137}Cs, it does indicate the general magnitude of the ^{137}Cs concentration.

D2.1 COMPARE SAMPLE AND HANFORD DEFINED WASTE MODEL-BASED INVENTORIES

Sample-based estimates developed from analytical data and HDW model estimates from Los Alamos National Laboratory (LANL) (Agnew et al. 1996) are both potentially useful for estimating component inventories in the tank. The HDW model is mainly based on process production records and waste transaction (Agnew et al. 1995) records for each tank. Primary wastes are process wastes initially added to tank 241-C-102, while secondary wastes were initially added to some other tank. A review of these records shows that tank 241-C-102 received the following wastes:

- 4,012 kL (1,060 kgal) of secondary MW ($BiPO_4$ metal waste) from tank 241-C-101, all of which was sluiced to tank 241-C-103

- 2,090 kL (552 kgal) of primary UR (Uranium Recovery) waste
- 1,518 kL (401 kgal) of primary CWP1 (PUREX coating) waste
- 47,820 kL (12,643 kgal) of primary CWP2 (PUREX coating) waste
- 1,677 kL (443 kgal) of primary TH1 (thoria high level) waste
- 8,561 kL (2,262 kgal) of primary OWW3 (PUREX organic wash) waste
- 30 kL (8 kgal) of BY salt cake
- 1,684 kL (445 kgal) of secondary UR waste
- 4,772 kL (1,261 kgal) of secondary CWP2 (PUREX coating) waste
- 1,984 kL (524 kgal) of secondary CWP2/HS (PUREX coating/Hot Semi-Works) waste
- 42 kL (11 kgal) of secondary P2 (PUREX high level) waste
- 280 kL (74 kgal) of various other supernatants from ITS (BY Tank Farm in-tank solidification) and return supernates from tank 241-C-102.

The HDW model also assumes the following sludge types have accumulated in tank 241-C-102:

- 19 kL (5 kgal) of MW sludge
- 61 kL (16 kgal) of UR sludge
- 125 kL (33 kgal) of CWP1 sludge
- 98 kL (26 kgal) of TH1 sludge
- 954 kL (252 kgal) of CWP2 sludge
- 49 kL (13 kgal) of CWP1/Zr (Zirflex coating waste) sludge
- 295 kL (78 kgal) of (CWP2) sludge (tentatively assigned to CWP2 sludge).

The HDW model is based on an inventory of 1,601 kL (423 kgal) of sludge, which agrees with the tank farm surveillance estimate (Hanlon 1996b), but is about 5 percent higher than the current estimate based on the average sludge depth at risers 2 and 3 (Table D2-1). Sludges formed in this tank were apparently produced from CWP1/CWP2 waste, with small

amounts of TH1, UR, and residual MW. Secondary wastes such as secondary CWP2 and UR are frequently ignored because 80 to 90 percent of the solids in these wastes usually precipitate in the first tank of the cascade. Aluminum, however, behaves differently in that most of the aluminum tends to precipitate in one of the downstream tanks as the pH is reduced due to the absorption of CO_2 from the atmosphere. Table D2-4 compares the sample-based estimates and HDW model estimates for chemical components, while Table D2-5 provides a similar comparison for radioactive components in tank 241-C-102.

Table D2-4. Comparison of Sample-Based and Hanford Defined Waste Model Inventory Estimates for Nonradioactive Components in Tank 241-C-102. (2 Sheets)

Analyte	Sample-based sludge concentration[a] (μg/L)	Sample-based inventory estimate[c] (kg)	HDW model-based inventory estimate[d] (kg)
Ag	102	280	NR
Al	35,400	97,000	217,000
Ba	1,100	3,020	NR
Bi	1,530	4,190	0
Ca	3,040	8,330	18,400
Cd	38.7	110	NR
Cl	917[b]	2,510[b]	820
Ce	563	1,540	NR
Co	10.6	30	NR
Cr	322	880	224
Cu	116	320	NR
F	2,370	6,500	5,150
Fe	5,320	14,600	44,800
Hg	NR	NR	1,560
K	692	1,900	604
Mg	1,710	4,690	NR
Mo	213	580	NR
Mn	915	2,510	0
Na	49,400	135,400	61,800
NH_4	NR	NR	554
Ni	3,960	10,900	334
NO_2	NR	22,000	17,900
NO_3	24,600	67,400	69,200
OH	NR	NR	513,000
La	74.2	200	0

Table D2-4. Comparison of Sample-Based and Hanford Defined Waste Model Inventory Estimates for Nonradioactive Components in Tank 241-C-102. (2 Sheets)

Analyte	Sample-based sludge concentration[a] (μg/L)	Sample-based inventory estimate[c] (kg)	HDW model-based inventory estimate[d] (kg)
Pb	512	1,400	87,300
P as PO_4	1,676	4,590	2,190
Pd	731	2,000	NR
Si	21,500	58,900	60.1
S as SO_4	2,071[b]	5,680	2,670
Sr	41.7	110	0
TIC as CO_3	45,081[b]	123,600	30,200
TOC	686[b]	1,880	25.3
U_{TOTAL}	1,350	3,700	75,500
Zn	5,490	15,000	NR
Zr	3,260	8,940	4,160
H_2O (wt%)	NR	NR	52.8
density (kg/L)	1.80	1.80	1.49

HDW = Hanford Defined Waste
NR = Not reported
[a] Analyte concentrations in sludge derived from 1986 core sample data in Table D2-2
[b] Analytical values from archive sample results in Table D2-2
[c] Sample inventory based on 1,522.9 kL (402.3 kgal) of sludge, with a mean density of 1.80 kg/L
[d] Agnew et al. (1996).

Table D2-5. Comparison of Sample-based and Hanford Defined Waste Model-Based Estimates for Radioactive Components in Tank 241-C-102 [a,b,c].

Analyte	Sample-based inventory estimate[a] (Ci)	HDW model inventory estimate[b] (Ci)	Analyte	Sample-based inventory estimate[a] (Ci)	HDW model inventory estimate[b] (Ci)
^{60}Co	500	NR	$^{239/240}Pu$	6,960	2,520
^{90}Sr	NR	3,790[b]	^{241}Am	1,450	NR
^{137}Cs	24,800	2,930[b]	^{79}Se	0	NR
^{154}Eu	90.5	NR	^{155}Eu	91.5	

HDW = Hanford Defined Waste
NR = Not reported
[a] Sample based estimates derived from 1986 composite core sample data Table D2-2
[b] Agnew et al. (1996)
[c] All radionuclides have been decayed to January 1, 1994.

Note that significant differences exist between the sample and HDW estimates for Al, Bi, Ca, Fe, Ni, Na, Pb, PO_4, Si, SO_4, U, Zr, and TIC. In the following section, flowsheet, fuel production and tank transaction (Agnew et al. 1995) records will be used to independently evaluate the credibility of the sample and HDW estimates for this waste.

D3.0 COMPONENT INVENTORY EVALUATION

According to the tank transaction (Agnew et al. 1995) and fuel production records, 27,929.76 MTU of (Al-clad) PUREX coating waste were transferred to tank 241-C-102 from 1960 to 1969. Table D3-1 provides the estimated distribution of PUREX coating waste to the BY and C Tank Farms based on the fuel and waste transaction records for these tanks. The aluminum-alloy jacket around the fuel normally contains 0.046 kg Si/MTU, while the Al-Si braze metal used in the bonding layer adds another 1.269 kg Si/MTU (see Kupfer et al. 1997) for the silica discussion [Section 5.19] and the coating waste discussion for aluminum clad fuel from the $BiPO_4$ and REDOX processes [Appendices C and D]). Therefore, about 36.7 MT of Si should be in the PUREX coating waste or CWP1 layer in this tank. According to the PUREX flowsheet (Crawley and Harmon 1960), about 96.7 MT of Si (0.07 g moles/L) could have been added to this tank (if the volume of rinse water is ignored). If rinse water is included, the potential amount of Si would be about 35.8 MT (0.026 g moles/L, which also agrees with Anderson's (1990) estimate for Al-clad PUREX coating waste, 0.2 g moles/L). The flowsheet-based Si estimate may be lower than the sample-based estimate (58.93 MT) because: (1) samples may be overstating the actual amount of Si in the waste, or (2) the Al-Si bonding layer may have contained considerably more Si than indicated in the fuel records. In any event, the sample-based estimate is clearly more reasonable than the HDW-based Si estimate (0.06 MT).

Table D3-1. Distribution of PUREX Coating Waste (CWP1/CWP2) Produced from 1956 to 1972[a].

Tanks (241-)	Volume of PUREX coating waste added to each tank, kL (kgal)	Equivalent MTU of Al-clad coating waste in each tank	Amount of Si added to each tank, Kg
BY-103	4,394 (1,161)	1,094.7	1,440
C-101	2,483 (656)	2,522.0	3,320
C-102	49,337 (13,035)	27,929.8	36,700
C-103	1,813 (479)	1,838.5	2,418
C-104	20,768 (5,487)	7,544.4	9,920
C-105	11,926 (3,151)	11,218.7	14,750
C-106	1,590 (420)	1,691.7	2,225
C-107	5,780 (1,527)	3,694.7	4,860
C-108	1,900 (502)	1,098.9	1,445
C-111	1,313 (347)	934.3	1,229
C-112	693 (183)	779.4	1,025

CWP1 = PUREX Coating Waste generated from 1956 through 1960
CWP2 = PUREX Coating Waste generated from 1961 through 1972
[a] Based on PUREX fuel production records (1956-1972) and waste transaction records (Agnew et al. 1995) for BY and C tank farms.

The sample-based Pb inventory (1.4 MT) is clearly much lower than the HDW estimate (87.3 MT) and related estimates developed for lead dipped, Al-clad fuel (72.2 MT based on the number of MTU added to tank 241-C-102, Table D3-1). The historical records show that 213 MT of Pb may have been added via the lead dip process to 82,400 MTU of Al-clad fuel produced after March 1954 (see Section 7.1 and Table 7.0-1 of Kupfer et al. 1997). The lead residue from this process was apparently incorporated into all of the PUREX coating wastes added to tanks 241-C-102 and 241-C-105. Based on the projected amount of lead in the intermetallic bonding layer of this fuel, large inventories of Pb should be present in the coating wastes of tanks 241-C-102 and 241-C-105. However, multiple core samples from tank 241-C-105 show very little Pb in this waste (0.48 MT). If the amount of Pb in tank 241-C-105 waste is extrapolated to tank 241-C-102, based on the relative volumes of CWP waste added to each tank, approximately 2.0 MT of Pb should be found in tank 241-C-102, compared to the sample-based estimate of 1.4 MT. On the basis of this comparison, it appears that the sample-based Pb inventory in tank 241-C-102 is probably correct.

According to Agnew and Watkin (1994), tank 241-C-105 supernate contains 0.00059 g moles/L of Pb and tank 241-C-103 supernate contains 0.00166 g moles/L of Pb. If these estimates are considered to be upper and lower bounding values for PUREX coating waste, the coating waste supernates from tank 241-C-102 may have transported from 6 to 17 MT of Pb out of the tank. Based on the maximum value in the Agnew and Watkin data base (0.006 g moles/L in tank 241-AW-105), approximately 61.3 MT of Pb might have been conveyed out of tank 241-C-102. These values tend to place an upper and lower limit on the total amount of Pb from this source, with current estimates ranging from 21.8 MT to 185 MT in 82,400 MTU of lead dip, Al-clad fuel. Another possible source of Pb is lead nitrate used for PUREX fission product recovery (1960 to 1966), for B Plant strontium recovery and waste fractionation (1965 to 1967), and in the Semiworks pilot plant (1955 to 1967) (Klem 1990).

Other components were also introduced with the PUREX coating waste, including 1,315.5 MT of Al and 13.15 MT of Ni (47.1 kg of Al and 0.47 kg of Ni per MTU, see the Al inventory evaluation in Section 5.1.2.1 and Ni estimates in Table 7.0-4 of Kupfer et al. (1997). Al-clad fuels produced after 1959 contained about 1 percent Ni in the Al alloy jacket. Most of this Al was dissolved as sodium aluminate and was transferred as such with the supernate to other tanks. However, about 129.3 MT of Al, 5.95 MT of Fe and 172.6 MT of Na should have been retained in tank 241-C-102 based on the amount of Al-clad coating waste added to tanks 241-C-102 and 241-C-105 and the amount of Al, Fe, and Na in the tank 241-C-105 CWP1 waste (31.3 MT of Al, 5.4 MT of Fe and 56.5 MT of Na). Also, 0.23 MT of Al, 2.47 MT of Fe, and 13.65 MT of Na may have been added with the UR waste based on the relative volumes of UR waste added to tanks 241-C-102 and 241-TY-105 and the amount of Al, Fe, and Na in tank 241-TY-105 waste (2.6 MT of Al, 27.8 MT of Fe, and 154.3 MT of Na) (see the Waste Transaction Records and Colton 1995). PUREX coating and Uranium Recovery wastes have thus contributed 129.53 MT of Al, 13.15 MT of Ni, 8.42 MT of Fe and 186.2 MT of Na to 241-C-102 waste. These values are reasonably close to the sample estimates of 97.04 MT of Al, 10.86 MT of Ni, 14.58 MT of

Fe, and 135.4 MT of Na, and help to confirm the validity of the sample-based estimates for these components. Sample-based estimates for Al, Ni, and Na appear to be 25 to 37 percent lower than common sludge layer derived estimates for these components, while the sample estimate for Fe is 43 percent higher.

Similar methods can also be used to estimate the amount of PO_4 in residual metal waste and UR waste. Residual metal waste apparently contains about 0.49 MT of PO_4, based on the amount of uranium in the sludge (from the analysis of tank 241-T-101 MW sludge in GE [1951]). Another 13.79 MT of PO_4 may have been added with the primary UR waste and 0.38 MT with the secondary UR waste, based on the relative volumes of UR waste and the composition of similar wastes in tanks 241-TY-105 and 241-TY-106 (Colton 1995). Tank 241-C-102 was filled with UR waste from the third quarter 1953 until the first quarter 1954, while tank 241-TY-105 was filled with similar waste from the first quarter 1953 until the third quarter 1954, thus overlapping in time and presumably in waste content. These wastes may have added a total of 14.66 MT of PO_4 to tank 241-C-102, compared to the sample-based estimate of 4.59 MT and HDW estimate of 2.19 MT. The sample-based estimate, however, does not include the UR and MW layers in the bottom of tank 241-C-102 because these layers were not sampled during the 1986 sampling campaign.

A spreadsheet analysis of the UR process was also performed to assess the likely PO_4 inventory in the UR waste receiver tanks. The results show that tank 241-C-102 may have received as much as 26.49 MT of PO_4, in contrast the common sludge layer derived estimate of 14.66 MT. This estimate assumes that the PO_4 solubility limit is 22 g/L and is based on spreadsheet analysis of recently declassified sluicing records for the UR process, waste transaction records for tank 241-C-102, fuel production and $BiPO_4$ metal waste flowsheet estimates (in Appendixes B and D), the UR process flowsheet (GE 1951) and cribbing records for the B-028 and B-030 cribs (Waite 1991). Based on analysis of 307 supernate samples, the upper and lower solubility limits for PO_4 appear to range from 17.1 to 11.4 g/L (Agnew and Watkin 1994). With a revised limit of 17.1 g/L, the total amount of PO_4 could be as high as 32.44 MT in tank 241-C-102. Agnew and Watkin's solubility limits for PO_4, however, are not consistent with the waste transaction records and measured PO_4 inventories in tanks 241-BX-107, 241-BX-109, 241-TY-105, and 241-TY-106 (which were used as a basis for the 22 g/L solubility limit). While the solubility limit for PO_4 may be in dispute, it will be assumed for purposes of this analysis that the common sludge layer approach adequately represents the likely PO_4 inventory in tank 241-C-102.

Another comparison of interest relates to the amount of Zr in this waste. According to the waste transaction records, there are only three tanks that received Zirflex coating waste between 1967 and 1972 (tanks 241-C-102, 241-C-104, and 241-S-107). Tank 241-C-102 received 649.63 MTU of such waste from 1967 to 1969 (see Kupfer et al. 1997, Appendix B, and the waste transaction records for tank 241-C-102). Mark IV (0.947 percent enriched) Zircaloy-2[1] flex fuel contains 70.35 kg of Zr/MTU (RHO 1980). Based on these values, about 45.7 MT of Zr should be in the tank 241-C-102 waste. The PUREX flowsheet

[1]Zircaloy and Zircaloy-2 are trademarks of Teledyne Wah Chang, Albany, Oregon.

for N Reactor fuels (Jacobs and Allen 1985) also can be used to assess the potential Zr inventory in this tank. This reference indicates that 47.1 MT of Zr and 74.31 MT of F would have been added to tank 241-C-102 based on the fuel and waste transaction records. The 1986 composite core, however, indicates this tank only contains 8.93 MT of Zr and 6.5 MT of F (Table D2-2).

Tank 241-C-102 also contains approximately 77.36 kL (20.4 kgal) of UR waste and 1,380 kL (364.5 kgal) of CWP1/CWP2 (PUREX coating) waste, based on comparable volumes of UR and CWP waste in tanks 241-TY-105 (UR) and 241-C-105 (CWP), respectively (Table D3-2). The waste transaction records also show that 64 percent of the PUREX coating waste had already been added to 241-C-102 before the first Zircaloy-2[1] fuel was processed through PUREX. From these values, it appears that the Zr-rich layer extends from the 222.5 cm (87.5 in.) elevation to the top of the sludge layer in 241-C-102 (including corrections for the volume of sludge in the dished bottom). This zone corresponds to all of segments 2 and 3 and the upper 40 percent of segment 4, all of which were sampled during the 1986 sampling campaign. While the Zr-rich layers may not have been sampled because of incomplete sample recoveries from these segments, it appears more logical to assume that most of the Zirflex waste was actually sent to other tanks, such as 241-C-104, and that the waste transaction records for this waste are not correct.

The sample-based Zr estimate (8.93 MT) is consistent with a total inventory of 14.09 MT of F, based on the PUREX Zirflex flowsheet. According to Agnew and Watkin (1994), the lower solubility limit for F is 2.66 g/L. Since 4,427 L of Zirflex waste per MTU of NPR fuel was produced in PUREX, about 7.65 MT of F would have dissolved in the 241-C-102 supernate transferred to other tanks (PUREX flowsheet, Jacobs and Allen 1985). By difference, it appears that 6.44 MT of F should still be in tank 241-C-102, mostly in the form of insoluble NaF. This estimate closely matches the 1986 composite sample inventory estimate of 6.5 MT of F.

During the first thorium campaign, 1,676 kL (443 kgal) of high level thorium (TH1) waste was sent to tank 241-C-102. According to Allen (1976) this waste contained 1,820 kg of $KMnO_4$, producing about 632 kg of Mn in the waste. The volume of thorium waste is almost impossible to determine because common sludge layers have not been readily identified in other tanks. Approximately 8,561 kL (2,262 kgal) of OWW3 (PUREX organic wash) waste also was added to tank 241-C-102. This waste nominally contained 0.004 g moles/L MnO_2 (Anderson 1990). Based on this concentration, OWW3 waste would have added another 1.88 MT of Mn, producing a total inventory of 2.51 MT which exactly matches the sample-based estimate for Mn.

The MW sluicing records show that 46.4 MTU were left in the tanks 241-C-101, 241-C-102, and 241-C-103 cascade (declassified sluicing records). While most of this inventory probably exists in the dished bottoms of these tanks, these records do not provide the basis for distributing uranium among the tanks in this cascade. Tank 241-C-103

[1]Zircaloy and Zircaloy-2 are trademarks of Teledyne Wah Chang, Albany, Oregon.

apparently contains 3.4 MT of uranium based on multiple core samples (Weiss and Schull 1988b), but the dished bottom was not adequately sampled by these cores. Therefore, in this study it will be assumed that 33 percent (or 15.5 MT) of this uranium were distributed to tank 241-C-102. This estimate is bounded by the upper and lower values from the tank 241-C-102 composite core sample (30.7 and 3.7 MT of U). Since the composite sample did not include material from the bottom of the tank the lower value is likely to be more representative of the upper sludge layers in this tank. The assumed uranium inventory (15.5 MT) is equivalent to 28.3 kL (7.48 kgal) of residual MW sludge based on a density of 1.5 kg/L and the MW composition for 241-T-101 MW sludge (GE 1951).

Tank 241-C-102 samples also show that 4.19 MT of Bi exist in this waste. This inventory is not consistent with the $BiPO_4$ flowsheet developed by Schneider in 1951 (Appendix C). According to Schneider (1951) the metal waste stream contained 0.08 kg of Bi/MTU processed. The amount of Bi in tank 241-C-102 corresponds to the amount that would have been added in the MW from 52,000 MTU, while only 7,800 MTU were processed through the $BiPO_4$ process. Aside from Bi in 1C, 2C, and 224 $BiPO_4$ wastes, bismuth or sodium bismuthate ($NaBiO_3$) was only used in one other process, the Redox process. There are no known sources of reduction and oxidation (REDOX) waste in tank 241-C-102. A small amount of Bi was apparently added from unknown sources to tank 241-C-105 (0.34 MT). If all of this Bi is assumed to be associated with PUREX coating waste, only 1.4 MT of Bi would have been added to tank 241-C-102 from this source. Al-clad fuels apparently contained very little Bi (< 0.1 MT in the Al-Si layer and < 0.25 MT in the Al jacket) (Section 7.1). Thus, it appears likely that the metal waste may have contained more than the indicated amount of Bi (0.08 kg/MTU).

Table D3-2 provides data on the volume of UR and CWP waste in tanks 241-TY-105 and 241-C-105, respectively, and the predicted volume of such waste in tank 241-C-102. This table also provides an estimate of residual MW based on the composition of tank 241-T-101 MW sludge (GE 1951).

Table D3-2. Estimated Volume of Uranium Recovery, CWP1, and Residual Metal Waste in Tank 241-C-102 Based on Similar Wastes in Other Tanks.

Tank	Waste	Waste kL (kgal)	Sludge kL (kgal)	Similar waste added to tank 241-C-102 kL (kgal)	Sludge in tank 241-C-102 kL (kgal)
241-TY-105	UR	23,607 (6,237)[a]	874 (231)[b]	2,089 (552)[a]	77.4 (20.44)[d]
241-C-105	CWP	11,926 (3,151)[a]	333.5 (88.1)[c]	49,337 (13,035)[a]	1,379 (364.5)[d]
241-T-101	MW				28.3 (7.48)[e]

CWP = PUREX Coating Waste
MW = $BiPO_4$ Metal Waste
UR = Uranium Recovery
[a] Agnew et al. (1995)
[b] Hanlon (1996b)
[c] Best-Basis Inventory for Single-Shell Tank 241-C-105
[d] Based on the volume of waste added to 241-C-102 divided by the volume of waste added to reference tank multiplied by the amount of characteristic sludge in the reference tank.
[e] Based on 15.5 MT of uranium in the residual metal waste, an assumed density of 1.5 kg/L and the composition of MW in tank 241-T-101 (GE 1951).

Table D3-3 compares the sludge volume estimates developed from common sludge layers in other tanks to estimates derived from the HDW model.

Table D3-3. Comparison of 241-C-102 Sludge Volume Estimates Derived from Common Sludge Layers to Hanford Defined Waste Model Estimates. (2 sheets)

Characteristic sludge layer	Current estimate based on common sludge layers in other tanks	HDW model estimate
MW	28.3 kL (7.5 kgal)	19 kL (5 kgal)
UR	77.2 kL (20.4 kgal)	61 kL (16 kgal)
CWP	1,380 kL (364.5 kgal)	1,423 kL (376 kgal)
TH1	37.5 kL (9.9 kgal) (by difference)	98 kL (26 kgal)

Table D3-3. Comparison of 241-C-102 Sludge Volume Estimates Derived from Common Sludge Layers to Hanford Defined Waste Model Estimates. (2 sheets)

Characteristic sludge layer	Current estimate based on common sludge layers in other tanks	HDW model estimate
Total	1,522 kL (402.3 kgal)	1,601 kL (423 kgal)

CWP = PUREX Coating Waste
HDW = Hanford Defined Waste
MW = $BiPO_4$ Metal Waste
TH1 = Thoria High Level
UR = Uranium Recovery.

This comparison shows a surprising level of agreement between the common sludge layer estimates and HDW estimates for most wastes, except TH1 (high-level thorium) waste in tank 241-C-102.

Tank 241-C-102 has an estimated heat load of 12,952 BTU/h or 3,790 watts (Kummerer 1995). This heat load corresponds to 803,000 Ci of ^{137}Cs or 565,000 Ci of ^{90}Sr, values that are considerably higher than the HDW estimates for this tank (3,790 Ci of ^{137}Cs and 2,930 Ci of ^{90}Sr). If the sample values are correct, tank 241-C-102 waste only contains 24,800 Ci of ^{137}Cs, which would produce a heat load of 400 BTU/h. Unless a large amount of ^{90}Sr is present, this small amount of ^{137}Cs is totally inconsistent with the measured vapor space temperature (89 °F) and projected heat load for this tank. Tank 241-C-105 also received a considerable amount of PUREX coating waste and has an estimated heat load of 25,000 BTU/h. Since the ^{137}Cs inventory in tank 241-C-102 appears low, it will be assumed for purposes of this analysis that the amount of ^{137}Cs and ^{90}Sr in tank 241-C-102 is equivalent to 50 percent of the amount in tank 241-C-105, based on the relative heat loads for each tank. The assumed values for tank 241-C-102 are therefore 1.82E+05 Ci of ^{90}Sr and 6.25E+04 Ci of ^{137}Cs (decayed to January 1,1994).

Sample-based estimates for tank 241-C-102 are generally compatible with fuel and waste transaction record estimates for Si and Ni, and common sludge layer estimates for Pb, Al, Fe, Ni, and Na. For these components, the sample-based estimates are much better than the HDW derived estimates. Sample estimates for Zr and F also appear to be more reasonable than the HDW estimates based on the waste transaction records for Zirflex waste, while sample estimates for Mn were found to be exceptionally close to flowsheet and process derived values. While sample estimates appear to be acceptable for most components, certain problems were identified in the sample values for PO_4, ^{137}Cs, and ^{90}Sr. These sampling problems may have occurred because the PO_4 and ^{90}Sr rich bottom layers were not included in the 1986 composite core sample. The ^{137}Cs and ^{90}Sr estimates were corrected by computing new values based on the relative heat loads predicted for tanks 241-C-102 and 241-C-105 and the radionuclide inventories in tank 241-C-105. Since most of the PO_4 was introduced with UR waste, the revised PO_4 inventory is based on the UR sludge layer in tank 241-TY-105.

A spreadsheet analysis of the Uranium Recovery process and the measured PO_4 inventories in various tanks also calls into question the PO_4 solubility limits computed by the HDW model Rev. 3 (Agnew et al. 1996) from a large population of supernate samples. The HDW Rev. 3 PO_4 solubility estimates are probably low because most samples were not fully saturated in PO_4. By the same token, more Bi appears to be in 241-C-102 waste than can be explained by the $BiPO_4$ flowsheet (Schneider 1951). It appears that the metal waste from this process contained more Bi than currently indicated in the flowsheet. Also, much less Pb was found in the 241-C-102 and 241-C-105 wastes than might be indicated from the fuel fabrication records for lead dip, Al-clad fuel. Most of Pb was apparently dissolved in the coating waste and conveyed to one of the downstream tanks. Finally, the common sludge layer approach appears to be reasonable for 241-C-102 because the sludge volumes predicted from this approach seem to agree surprising well with the sludge volumes predicted by the HDW model.

Based on this comparison, the 1986 composite core appears to offer the most reliable and consistent set of estimates currently available for this tank. This sample will be used to develop the best-basis inventory for most components, with PO_4, U, ^{137}Cs, and ^{90}Sr being based on other criteria.

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

Chemical and radionuclide inventory estimates are generally derived from one of three sources of information: (1) sample analysis 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 241-C-102 was performed, including:

1. Data from the 1986 composite core sample (Weiss and Schull 1988a).

2. Data from the 1986 archive sample (Hara 1990).

3. Component inventory estimates provided by the HDW model (Agnew et al. 1996).

4. Evaluation of Si, Al, Ni and Pb inventories based on fuel fabrication and production records and tank waste transactions for tank 241-C-102.

5. Analysis of the Al, Fe and Na inventories based on common sludge layers and the waste transaction records for other tanks.

6. Evaluation of Zr and F inventories based on Zirflex fuel fabrication and production records, waste transaction records, solubility estimates and tank samples.

7. Estimates of the PO_4 inventory based on spreadsheet analysis of the Uranium Recovery process, metal waste sluicing and crib disposal records.

Based on this analysis, a best-basis inventory was developed. The 1986 core sample results were used to generate estimates for the chemical and radionuclide components in this waste. The waste in 241-C-102 primarily consists of PUREX coating (CWP1/CWP2) waste, Uranium Recovery (UR) waste, residual metal waste (MW) and high level thorium (TH1) waste. The best-basis inventory for tank 241-C-102 is presented in Tables D4-1 and D4-2. The quality of these estimates is generally considered to be in the medium or intermediate category because 90 percent of this waste consists of only one waste type, CWP waste, and process estimates for Si, Ni, and Mn are reasonably close to sample estimates, while common sludge layer estimates for Al, Fe, Pb, and Na are also consistent with sample values.

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. (1997).

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. 1997). 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.

Best-basis tables for chemicals and only four radionuclides (^{90}Sr, ^{137}Cs, Pu and U) were being generated in 1996, using values derived from an earlier version (Rev. 3) of the HDW model. When values for all 46 radionuclides became available in Rev. 4 of the HDW model, they were merged with draft best-basis chemical inventory documents. Defined scope of work in fiscal year 1997 did not permit Rev. 3 chemical values to be updated to Rev. 4 chemical values.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-102 (Effective January 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	97,000	S	Weiss and Schull 1988a
Bi	4,200	S	Weiss and Schull 1988a
Ca	8,330	S	Weiss and Schull 1988a
Cl	2,500	S	Weiss and Schull 1988a
TIC as CO_3	123,600	S	Weiss and Schull 1988a
Cr	880	S	Weiss and Schull 1988a
F	6,500	S	Weiss and Schull 1988a
Fe	14,600	S	Weiss and Schull 1988a
Hg	1,560	M	
K	1,900	S	Weiss and Schull 1988a
La	200	S	Weiss and Schull 1988a
Mn	2,510	S	Weiss and Schull 1988a
Na	135,400	S	Weiss and Schull 1988a
Ni	10,900	S	Weiss and Schull 1988a
NO_2	22,000	S	Weiss and Schull 1988a
NO_3	69,400	S	Weiss and Schull 1988a
OH_{TOTAL}	144,000	C	Mass balance calculation
Pb	1,400	S	Weiss and Schull 1988a
PO_4	14,700	E	Weiss and Schull 1988a
Si	58,900	S	Weiss and Schull 1988a
SO_4	5,680	S	Weiss and Schull 1988a
Sr	110	S	Weiss and Schull 1988a
TOC	1,880	S	Weiss and Schull 1988a
U_{TOTAL}	15,500	E	Declassified MW Sluicing Records

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-102 (Effective January 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Zr	8,940	S	Weiss and Schull 1988a

[1]S = Sample-based
M = Hanford Defined Waste model-based
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 Estimate for Radioactive Components in Tank 241-C-102 Decayed to January 1, 1994 (Effective January 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	1.46	M	
^{14}C	0.211	M	
^{59}Ni	0.0409	M	
^{60}Co	500	S	Weiss and Schull 1988a
^{63}Ni	4.02	M	
^{79}Se	0.0442	M	
^{90}Sr	182,000	E	Heat Load in Reference to 241-C-105
^{90}Y	182,000	E	Referenced to ^{90}Sr
^{93m}Nb	0.14	M	
^{93}Zr	0.187	M	
^{99}Tc	1.23	M	
^{106}Ru	8.96 E-04	M	
^{113m}Cd	0.763	M	
^{125}Sb	0	S	Weiss and Schull 1988a
^{126}Sn	0.0615	M	
^{129}I	0.00257	M	
^{134}Cs	0.12	M	
^{137m}Ba	59,100	E	Referenced to ^{137}Cs
^{137}Cs	62,500	E	Heat Load in Reference to 241-C-105
^{151}Sm	129	M	
^{152}Eu	1.03	M	
^{154}Eu	90.5	S	Weiss and Schull 1988a
^{155}Eu	91.5	S	Weiss and Schull 1988a
^{226}Ra	7.53 E-04	M	
^{227}Ac	17.7	M	
^{228}Ra	5.39	M	
^{229}Th	0.159	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-C-102 Decayed to January 1, 1994 (Effective January 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{231}Pa	29.7	M	
^{232}Th	0.0321	M	
^{232}U	3.59	M	
^{233}U	14	M	
^{234}U	22.5	M	
^{235}U	0.935	M	
^{236}U	0.629	M	
^{237}Np	0.00893	M	
^{238}Pu	102	M	
^{238}U	21.4	M	
$^{239/240}Pu$	6,960	S	Weiss and Schull 1988a
^{241}Am	1,450	S	Weiss and Schull 1988a
^{241}Pu	7,900	M	
^{242}Cm	0.0355	M	
^{242}Pu	0.03	M	
^{243}Am	1.67 E-04	M	
^{243}Cm	0.00323	M	
^{244}Cm	0.0719	M	

[1]S = Sample-based
M = Hanford Defined Waste model-based
E = Engineering assessment-based.

D5.0 APPENDIX D REFERENCES

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