AUG 26 1997 (21)
Station 34

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 617615

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) D. E. Place, SESC, H5-27	4. Related EDT No.: NA
5. Proj./Prog./Dept./Div.: Tank 241-TX-111	6. Design Authority/ Design Agent/Cog. Engr.: M. J. Kupfer	7. Purchase Order No.: NA
8. Originator Remarks: Approval and release.		9. Equip./Component No.: NA 10. System/Bldg./Facility: NA
11. Receiver Remarks: 11A. Design Baseline Document? [] Yes [X] No		12. Major Assm. Dwg. No.: NA 13. Permit/Permit Application No.: NA 14. Required Response Date:

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-SD-WM-ER-659	–	0	Preliminary Tank Characterization Report for Single-Shell Tank 241-TX-111: Best-Basis Inventory	NA	1,2		

16. KEY

Approval Designator (F)	Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN
		Design Authority	3		Central Files A3-88
		Design Agent H5-49	3		DOE Reading Room H2-53
1	1	Cog.Eng. M. J. Kupfer [signature] 8-21-97	3		D. E. Place H5-27
1	1	Cog. Mgr. K. M. Hodgson [signature] 8-24-97 R2-11	3		TCSRC R1-10
		QA	3		M. D. LeClair (4) H0-50
		Safety	3		K. M. Hall R2-12
		Env.	3		

18. M. J. Kupfer [signature] 8-21-97 Signature of EDT Originator Date	19. Authorized Representative Date for Receiving Organization	20. K. M. Hodgson [signature] 8-24-97 Design Authority/ Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

Preliminary Tank Characterization Report for Single-Shell Tank 241-TX-111: Best-Basis Inventory

D. E. Place
SGN Eurisys Services Corporation, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 617615 UC: 712
Org Code: 74610 KN Charge Code: N4G3A
B&R Code: EW3120074 Total Pages: 29 KN

Key Words: TCR, best-basis inventory

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-TX-111 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

AUG 26 1997
DATE:
STA: 34
HANFORD RELEASE
ID: 21

Karen H. Noland 8/26/97
Release Approval Date

Release Stamp

Approved for Public Release

HNF-SD-WM-ER-659
Revision 0

PRELIMINARY TANK CHARACTERIZATION REPORT FOR SINGLE-SHELL TANK 241-TX-111: BEST-BASIS INVENTORY

July 1997

D. E. Place
SGN Eurisys Services Corporation
Richland, Washington

Prepared for
U.S. Department of Energy
Richland, Washington

PRELIMINARY TANK CHARACTERIZATION REPORT FOR SINGLE-SHELL TANK 241-TX-111: 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-TX-111. 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.

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-TX-111

This page intentionally left blank.

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-TX-111

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-TX-111 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 chemical and radiological inventory estimates for tank 241-TX-111 consist only of the inventory estimate generated by the Hanford Defined Waste (HDW) model (Agnew et al. 1996).

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

The tank 241-TX-111 chemical and radionuclide inventory predicted by the HDW model (Agnew et al. 1996) is provided in Table D2-1. The chemical species are reported without charge designation per the best-basis inventory convention.

Table D2-1. Hanford Defined Waste Model Prediction of Tank 241-TX-111 Inventory. (2 Sheets)

Analyte	Hanford Defined Waste model[a] (kg)
Al	39,400
Bi	1,960
Ca	1,710
Cl	7,430
CO_3	28,200
Cr	2,340

Table D2-1. Hanford Defined Waste Model Prediction of Tank 241-TX-111 Inventory. (2 Sheets)

Analyte	Hanford Defined Waste model[a] (kg)
F	2,950
Fe	2,060
Hg	4.29
K	2,150
La	2.32 E-04
Mn	154
Na	268,000
Ni	400
NO_2	84,200
NO_3	330,000
OH	108,000
Pb	223
PO_4	24,800
Si	2,240
SO_4	25,200
Sr	4.88 E-05
U	2,820
Zr	252
Radionuclide (Ci)	
^{137}Cs	236,000
^{90}Sr	97,600

[a]Agnew et al. (1996), radionuclides decayed to January 1, 1994.

D3.0 COMPONENT INVENTORY EVALUATION

D3.1 CONTRIBUTING WASTE TYPES

Information concerning the types of wastes contained in tank 241-TX-111 is not entirely consistent. The HDW model (Agnew et al. 1996) includes a sludge layer the is not reported by the Sort on Radioactive Waste Type (SORWT) model (Hill et al. 1995) or the waste tank summary report (Hanlon 1996).

The HDW model (Agnew et al. 1996) predicts that the tank contains first decontamination cycle (1C) waste from the bismuth phosphate process (163 kL [43 kgal] of defined waste 1C2 sludge) and 1,238 kL (327 kgal) Supernatant Mixing Model 242-T Evaporator salt cake generated from 1965 until 1976 (SMMT2). Since the 1C wastes sent to this cascade were generated prior to 1955, the coating wastes associated with the aluminum-clad reactor fuel being processed were combined with the 1C waste in the underground storage tank (Anderson 1990).

The SORWT model (Hill et al. 1995) lists evaporator bottoms (EB), 1C (first cycle $BiPO_4$ waste), and tri-butyl phosphate (TBP) (U Plant uranium recovery wastes) as the primary, secondary, and tertiary waste types respectively, but credits the entire tank 241-TX-111 volume (1,400 kL [370 kgal]) to salt cake with 34 kL (9 kgal) of interstitial liquid. Hanlon (1996) also indicates that the entire tank inventory is salt cake.

D3.2 EVALUATION OF TECHNICAL FLOWSHEET INFORMATION

Waste transaction records (Agnew et al. 1995) show that the cascade, consisting of tanks 241-TX-109 through 241-TX-112, received 1C wastes between the first quarter of 1949 and the fourth quarter of 1950, between the second quarter of 1952 and the first quarter of 1954, and during the third and fourth quarters of 1954. Waste transaction records indicate that a total of 19,455 kL (5,140 kgal) of combined 1C/cladding waste (1C/CW) was received into tank 241-TX-109 (Agnew et al. 1996). T Plant fuel processing during these periods consisted of approximately 1,473 MTU. The estimated 1C/CW waste volume based on the $BiPO_4$ flowsheet (Schneider 1951) would be 21,726 kL (5,740 kgal), which is 12 percent higher than that indicated by the waste transaction records, but still in reasonably good agreement.

Most of the 1C wastes introduced into tank 241-TX-109 overflowed through the cascade piping to tanks 241-TX-110, 241-TX-111, and 241-TX-112. The waste transaction records show that 8,278 kL (2,187 kgal) of 1C waste was received in tank 241-TX-111. Most of the insoluble solids would have settled in the first two tanks of the cascade, but entrained solids would be expected in the overflow to tank 241-TX-111. The concentration of entrained solids in the 1C wastes received in tank 241-TX-111 would be expected to be low since the sludge level in tank 241-TX-110 was never large, and therefore, the residence time for settling would have been long.

Waste transaction records also indicate that 2,373 kL (627 kgal) of TBP waste was received from tank 241-TY-103 in the fourth quarter of 1954, of which 117 kL (31 kgal) was transferred to tank 241-TX-118. A small quantity of TBP waste (106 kL [28 kgal]) was also received from tank 241-TX-110 via the cascade overflow in the first quarter of 1955. Since the TBP wastes were stored in another tank for several months, no significant solids were expected in the transfer, and the contribution to the final composition of tank 241-TX-111 is expected to be small.

Beginning in the third quarter of 1970 and continuing until the second quarter of 1976, tank 241-TX-111 received concentrated EB from the 242-T Evaporator and recycled supernates to the evaporator via the evaporator feed tank (241-TX-118). Salt cake formed as the concentrated salt solutions cooled and built up a large salt cake layer on top of previously existing sludge. Two airlift circulators were installed in the tank to facilitate evaporative cooling and prevent the formation of a crust which would have impeded evaporative heat removal. A small quantity (53 kL [14 kgal]) of evaporator feed was transferred from tank 241-S-102 in 1976 and early 1977. Supernate remaining in tank 241-TX-111 was removed from the tank in 1977. Salt well pumping of the interstitial liquid was accomplished in 1982 and 1983.

D3.3 DETERMINATION OF WASTE TYPES

The 1C/CW volumes routed to tank 241-TX-109 through the tank 241-TX-112 cascade would result in 1,945 kL (514 kgal) of sludge (concentration factor [CF] of 10 based on tank 241-T-104). Most of this sludge volume would have been retained in the first two tanks of the cascade, but minor concentrations of entrained solids would still be expected in the overflow to tank 241-TX-111.

The HDW model predicts 163 kL (43 kgal) of 1C/CW sludge in tank 241-TX-111, based primarily on a sludge reading during the first quarter of 1970, before the tank had been placed in EB service. As noted by Anderson (1990), there was a significant degree of uncertainty in these sludge level measurements. The HDW model also predicts 1,454 kL (384 kgal) of 1C sludge in tank 241-TX-109, 140 kL (37 kgal) in tank 241-TX-110, and none in tank 241-TX-112.

Assuming that 1,945 kL (514 kgal) of sludge resulted from the 1C/CW waste routed to this four tank cascade, the inventory of tank 241-TX-111 1C sludge could be as high as 352 kL (93 kgal) rather than the reported 163 kL (43 kgal). However, it is much more likely that any additional sludge inventory (if it actually exists) is contained in the first two tanks of the cascade. The 1C sludge inventory for tank 241-TX-111 is assumed to be 163 kL (43 kgal) to be consistent with the HDW model.

Waste transaction records also show that tank 241-TX-111 received 4,300 kL (1,136 kgal) of concentrated evaporator waste between 1970 and 1976. A substantial salt cake inventory would be expected to have been deposited on top of the sludge layer.

D3.4 COMPOSITION OF TANK 241-TX-111 WASTE

D3.4.1 Composition of 1C Sludges

Several tanks received 1C/CW waste directly from T Plant including tanks 241-T-104, 241-T-107, 241-TX-109, 241-TX-113, 241-U-110, 241-TY-101, and 241-TY-103. Sample data are not available for solid layers in tanks 241-TX-109 or 241-TX-113. The 1C waste was mixed with substantial quantities of other wastes in tanks 241-TY-101, 241-TY-103, and 241-U-110, making it impossible to accurately determine the composition of the 1C/CW waste sludge from these data. Two tanks (241-T-104 and 241-T-107) provide the best examples of T Plant 1C/CW sludge composition. The composition of these two tanks, based on the corresponding TCRs (DiCenso et al. 1994 and Valenzuela and Jensen 1994), is provided in Table D3-1. The average of these two compositions will be used for estimating the sludge composition of tank 241-TX-111.

Table D3-1. Tank Characterization Report Concentrations for Tanks 241-T-104 and 241-T-107. (3 Sheets)

Analyte	Tank 241-T-104[a] (μg/g)	Tank 241-T-107[b] (μg/g)	Average concentration (μg/g)
Ag	6.4	7.37	6.9
Al	16,200	16,300	16,200
Bi	18,900	12,000	15,400
Ca	1,450	760	1,100
Cd	5.44	6.94	6.19
Cl	670	540	605
CO_3	<500	14,800	7,680
Cr	901	360	631
F	8,570	11,400	9,980
Fe	9,020	29,200	19,100
Hg	0.127	0.14	0.13
K	89.0	234	162
La	<10.4	<2	<10

Table D3-1. Tank Characterization Report Concentrations for Tanks 241-T-104 and 241-T-107. (3 Sheets)

Analyte	Tank 241-T-104 (μg/g)	Tank 241-T-107 (μg/g)	Average concentration (μg/g)
Mn	61.8	213	137
Na	64,500	130,200	97,400
Ni	11.3	267	139
NO_2	4,080	11,700	7,890
NO_3	58,000	74,500	66,200
OH	NR	NR	NR
Pb	NR	649	649
P as PO_4	75,700	98,400	87,100
Si	6,520	6,050	6,280
S as SO_4	3,830	9,810	6,820
Sr	99.1	878	489
TOC	706	963	835
U	897	26,400	13,600
Zr	67.5	93	80
Radionuclide	**Tank 241-T-104 (μCi/g)**	**Tank 241-T-107 (μCi/g)**	**Decayed average[a] (μCi/g)**
^{241}Am	0.0173	0.0141	0.0157
^{14}C	<4.5 E-05	1.81 E-04	1.1 E-04
^{60}Co	<3.0 E-04	<0.00199	<9.85 E-04
^{134}Cs	NR	<0.00164	<0.0012
^{137}Cs	0.199	12.0	5.96
^{154}Eu	0.0041	<0.00463	0.0038
^{155}Eu	0.00342	<0.0149	0.0030
^{3}H	<3.38 E-04	0.00124	5.9 E-04
^{129}I	<0.0464	NR	<0.0464
^{237}Np	0.137	NR	0.137
^{238}Pu	<0.018	0.144	0.072
$^{239/240}Pu$	0.14	0.131	0.136

Table D3-1. Tank Characterization Report Concentrations for Tanks 241-T-104 and 241-T-107. (3 Sheets)

Radionuclide	Tank 241-T-104 (μCi/g)	Tank 241-T-107 (μCi/g)	Decayed average[c] (μCi/g)
^{106}Ru	NR	<0.0757	<0.038
^{79}Se	<1.75 E-04	NR	<1.75 E-04
^{90}Sr	2.63	108	54.0
^{99}Tc	5.79 E-04	NR	5.79 E-04
Density (g/mL)	1.29	1.51	1.40
Wt% H_2O	70.5%	56.0%	63.2%

NR = Not reported
[a]DiCenso et al. (1994)
[b]Valenzuela and Jensen (1994)
[c]Decayed to January 1, 1994, to match Hanford Defined Waste model.

D3.4.2 Composition of 242-T Salt Cake

Post-1965 operation of the 242-T Evaporator resulted in 22,672 kL (5,990 kgal) of salt cake which is contained in 26 underground storage tanks in the S, SX, U, T, TX, and TY Tank Farms. The HDW model refers to this salt cake as T2 Sltck on a global basis or as SMMT2 when calculated by the Supernatant Mixing Model (SMM) for an individual tank. The salt cake produced by the 242-T Evaporator from 1965 to 1976 will be referred to as T2 salt cake hereafter in this report. Ninety one percent of the T2 salt cake is contained in the TX Tank Farm. All tanks containing T2 salt cake also contain other waste types.

Only 8 tanks containing T2 salt cake have been core sampled (241-S-107, 241-U-102, 241-U-105, 241-U-107, 241-TX-107, 241-TX-116, 241-TY-102. and 241-TY-103). Only three of these tanks (241-U-102, 241-U-105, and 241-TX-116) have T2 salt cake layers large enough to be differentiated from the other tank wastes in core sample data.

T2 salt cake was formed in tanks 241-U-102 and 241-U-105 in 1975 through 1976. The core sampling of tanks 241-U-102 and 241-U-105 were performed in early 1996. Based on the HDW model, segments 4, 5, and 6 for the two cores from tank 241-U-102 and segment 8 of two cores from tank 241-U-105 are expected to be representative of the T2 salt cake waste type. The recent analytical data should meet all *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Ecology (1994) requirements. Descriptions of the core sampling events and analytical data are available in the respective Tank Characterization Reports (Hu et al. 1997 and Brown and Franklin 1996).

T2 salt cake was deposited in tank 241-TX-116 between 1966 and 1971. The tank 241-TX-116 core sample was taken with the initial prototype of a rotary core sampler from 1976 to 1977 (Allen 1977). Sample recoveries were relatively poor. Additionally, analytical methods, data sets and quality assurance differed significantly from current practices. However, this sample event provides the only available composition data for early production of the T2 salt cake waste type. Inclusion of an early T2 salt cake type is important since 242-T Evaporator feeds and operating practices changed over time. The analytical data are provided in a letter report (Horton 1977). Core segments 1 through 4 are expected to be representative T2 salt cake. It was necessary to correct the analytical results to a silica-free basis since approximately 95 MT of diatomaceous earth (92 percent SiO_3) had been added to tank 241-TX-116. The silica from the diatomaceous earth had migrated into the top four core segments (approximately 203 cm [80 in.]) of the salt cake.

The composition data for tanks 241-U-102, 241-U-105, and 241-TX-116 are summarized in Table D3-2. The analytical results for tanks 241-U-102 and 241-U-105 are mass-weighted averages based on the mass of the partial core segment corresponding to each analytical result. Mass-weighted averages, rather than simple arithmetic averages, were calculated because the core segments were not of equal length and the mass of the partial core segments analyzed varied from approximately 30 g to 250 g. Similarly, a mass-weighted average was created for the combination of the T2 salt cake in the two U Farm tanks (81.5% tank 241-U-102 and 18.5 % tank 241-U-105). The analytical results for tank 241-TX-116 core segments were simply averaged since the core segments were of equal length. The T2 salt cake prediction is the arithmetic average of the U Tank Farm and tank 241-TX-116 concentrations. The data for tank 241-TX-116 were intentionally given more emphasis (50 percent of the predicted concentration) in the generalized T2 salt cake prediction as it represents an operating period that is more applicable to the TX Tank Farm. The global HDW model composition for T2 salt cake (T2 SltCk) is included in the Table D3-2 for comparison.

Table D3-2. Composition of T2 Salt Cakes (3 Sheets).

Analyte	241-U-102 T2 salt cake wt. avg.[a,b] (μg/g)	241-U-105 T2 salt cake wt. avg.[a,c] (μg/g)	U Tank Farm T2 salt cake wt. avg.[a] (μg/g)	241-TX-116 T2 salt cake mean[d,e] (μg/g)	T2 salt cake prediction[f] (μg/g)	HDW T2 SltCk[g] (μg/g)
Ag	11.6	19.7	13.1	NR	13.1	NR
Al	18,000	12,900	17,100	38,000	27,500	17,912
Bi	<70.5	<47.2	<66.2	NR	<66.2	220.81
Ca	308	253	298	NR	298	1,462
Cd	<5.94	12.8	<7.21	NR	<7.21	NR
Cl	5,100	5,790	5,230	NR	5,230	3,327.8

Table D3-2. Composition of T2 Salt Cakes (3 Sheets).

Analyte	241-U-102 T2 salt cake wt. avg.[a,b] (μg/g)	241-U-105 T2 salt cake wt. avg.[a,c] (μg/g)	U Tank Farm T2 salt cake wt. avg.[a] (μg/g)	241-TX-116 T2 salt cake mean[d,e] (μg/g)	T2 salt cake prediction[f] (μg/g)	HDW T2 SltCk[g] (μg/g)
CO_3	53,500	36,500	50,300	58,000	54,200	17,093
Cr	2,310	2,100	2,270	353	1,310	4259.6
F	<125	1,110	<307	3,540	<1,920	930.79
Fe	391	2,270	737	23,900	12,300	620.58
Hg	NR	NR	NA	NR	NA	1.1338
K	1750	1,470	1,700	NR	1,700	1060.7
La	<35.2	29.7	<34.2	NR	<34.2	1.0 E-04
Mn	123	743	237	NR	237	160.31
Na	262,600	220,500	254,800	166,700	210,800	192,764
Ni	91.5	89.5	91.1	NR	91.1	405.82
NO_2	56,700	40,100	53,600	7,840	30,700	46,096
NO_3	284,700	395,700	305,200	308,700	306,946	268,197
OH	NR	NR	NA	NA	NA	68,079
Pb	<119	214	<136	NR	<136	109.91
P as PO_4	5,050	14,100	6,720	8,620	7,670	7,707.9
Si	152	232	167	NR	167	1,817.7
S as SO_4	17,900	8,350	16,200	16,400	16,300	13,823
Sr	<7.04	<4.72	<6.61	NR	<6.61	0
TOC	8,810	11,000	9,210	NR	9,210	5,191
U	<353	545	<388	NR	<388	2,174.3
Zr	10.8	45.4	17.2	NR	17.2	14.707
Radionuclide[h] (μCi/g)						
^{241}Am	<37.0	<0.95	<30.3	NR	<30.3	0.0285
^{60}Co	<0.155	0.086	<0.142	NR	<0.142	0.027
^{134}Cs	NR	NR	NA	9.64 E-04	9.64 E-04	0.0016
^{137}Cs	197	145	188	34.8	111	163.24
^{154}Eu	<0.475	0.61	<0.499	NR	<0.499	0.431
^{155}Eu	<1.10	0.82	<1.05	NR	<1.05	0.1849

Table D3-2. Composition of T2 Salt Cakes (3 Sheets).

Analyte	241-U-102 T2 salt cake wt. avg.[a,b] (μg/g)	241-U-105 T2 salt cake wt. avg.[a,c] (μg/g)	U Tank Farm T2 salt cake wt. avg.[a] (μg/g)	241-TX-116 T2 salt cake mean[d,e] (μg/g)	T2 salt cake prediction[f] (μg/g)	HDW T2 SltCk[g] (μg/g)
Density (g/mL)	1.66	1.73	1.70[i]	NR	1.70	1.634

HDW = Hanford Defined Waste
NA = Not applicable
NR = Not reported
[a] Weighted average based on the weight of each partial core segment analyzed
[b] Hu et al. (1997)
[c] Brown and Franklin (1996)
[d] Silica-free basis due to the addition of diatomaceous earth to this tank
[e] Horton (1977)
[f] Average of U Tank Farm and tank 241-TX-116 data
[g] Agnew et al. (1997)
[h] Decayed to January 1, 1994
[i] A simple average is used for the density.

D3.5 PREDICTED INVENTORY FOR TANK 241-TX-111

The chemical and radionuclide inventory of tank 241-TX-111 can be estimated from the sludge and salt cake volumes (163 kL [43 kgal] and 1,238 kL [327 kgal], respectively), densities (1.4 and 1.7 g/mL respectively), and the average of chemical/radionuclide concentrations calculated for 1C/CW sludges and T2 salt cake wastes that have been analyzed. The resulting inventories are provided in Table D3-3. The inventories estimated by the HDW model (Agnew et al. 1996) are included in the table for comparison.

Table D3-3. Estimated Chemical and Radionuclide Inventory for Tank 241-TX-111. (2 Sheets)

Analyte	1C/CW sludge layer (kg)	T2 salt cake layer[a] (kg)	TX-111 inventory (kg)	HDW model inventory (kg)
Ag	1.57	27.6	29.2	NR
Al	3,700	58,000	61,700	39,400
Bi	3,520	<139	3,660[c]	1,960
Ca	252	626	878	1,710
Cd	1.41	<15.2	<16.6	NR
Cl	138	11,000	11,100	7,430
CO_3	1,750	114,000	115,700	28,200
Cr	144	2,760	2,900	2,340
F	2,280	<4,040	<6,320	2,950
Fe	4,350	25,900	30,300	2,060
Hg	0.030	NR	NA	4.29
K	36.8	3,570	3,610	2,150
La	<2.3	<72.0	<74.3	2.32 E-04
Mn	31.3	499	530	154
Na	22,200	443,500	465,700	268,000
Ni	31.7	192	224	400
NO_2	1,800	64,700	66,500	84,200
NO_3	15,100	645,800	660,900	330,000
OH	NR	NA	NA	108,000
Pb	148	<287	<435	223
P as PO_4	19,800	16,100	36,000	24,800
Si	1,430	352	1,780	2,240
S as SO_4	1,560	34,300	35,800	25,200
Sr	111	<13.9	<125	4.88 E-05
TOC	190	19,400	19,600	11,853
U	3,110	<817	<3,930	2,820‘
Zr	18.3	36.2	54.5	252

Table D3-3. Estimated Chemical and Radionuclide Inventory for Tank 241-TX-111. (2 Sheets)

Radionuclide[b]	1C/CW sludge layer (Ci)	T2 salt cake layer [a] (Ci)	Total TX-111 inventory (Ci)	HDW model inventory (Ci)
^{241}Am	3.58	<63,800	NA	NR
^{14}C	0.0257	NR	NA	NR
^{60}Co	<0.225	<299	NA	NR
^{134}Cs	<0.267	2.03	2.03	NR
^{137}Cs	1,360	234,000	235,400	236,000
^{154}Eu	0.862	<1,050	NA	NR
^{155}Eu	0.678	<2,200	NA	NR
^{3}H	0.134	NR	NA	NR
^{129}I	<10.6	NR	NA	NR
^{237}Np	31.2	NR	NA	NR
^{238}Pu	16.3	NR	NA	NR
$^{239/240}Pu$	30.9	NR	NA	NR
^{106}Ru	<8.68	NR	NA	NR
^{79}Se	<0.04	NR	NA	NR
^{90}Sr	12,300	NR	NA	97,600
^{99}Tc	0.132	NR	NA	NR

HDW = Hanford Defined Waste, Agnew et al. (1996)
NA = Not applicable
NR = Not reported
[a]Estimate calculated using the T2 salt cake prediction
[b]Radionuclides decayed to January 1, 1994
[c]The "less than" designator was not carried to the "TX-110 inventory" column because the salt cake contribution to the Bi inventory was insignificant compared to the sludge layer contribution.

D3.6 COMPARISON OF TANK 241-TX-111 INVENTORY ESTIMATES

The lack of sample-based inventory data adds considerable uncertainty to estimation of chemical and radionuclide inventories for tank 241-TX-111. The use of waste composition data from tanks 241-T-104, 241-T-107, 241-U-102, 241-U-105, and 241-TX-116 to represent the wastes in tank 241-TX-111 is a reasonable approach. However, it should be noted that the operating history of tank 241-TX-111 is different from any other Hanford Site tank containing similar waste types.

The tank 241-TX-111 inventories predicted by the HDW model and the estimate based on waste analyses in other tanks are generally of the same order of magnitude, although the HDW is generally somewhat lower. Part of the explanation for this difference may be that the HDW model calculated density for the salt cake in tank 241-TX-111 is 1.41 g/cc based on the sodium, aluminum, and hydroxide concentrations, which is a much lower density than is generally found when salt cakes are actually analyzed. The calculated density is used in determining the HDW model inventory for all analytes.

Aluminum. The estimated aluminum inventory is 57 percent higher than that predicted by the HDW model. Part of this difference is due to the low salt cake density calculated by the HDW model (1.41 g/cc), as compared to the 1.7 g/mL estimated based on the analytical results from tanks 241-U-102 and 241-U-105. Additionally, the tank 241-TX-116 analytical results show a much higher aluminum concentration. The estimated aluminum inventory will be used for the best-basis.

Bismuth. The HDW model seems to underestimate the bismuth inventory for 1C/CW waste tanks. Part of this discrepancy results from the HDW model assumption that 27 percent of the bismuth is soluble. Another factor is that the total of the waste volume transactions for 1C/CW wastes received in tank 241-TX-109 is about 12 percent lower than that predicted from the $BiPO_4$ flowsheet.

Carbonate and Hydroxide. The estimated tank 241-TX-111 carbonate inventory is 4.1 times the HDW model inventory, whereas the estimated hydroxide inventory is only 64 percent of that predicted by the HDW model. The hydroxide ion in Hanford Site waste tanks is converted to carbonate by the absorption of carbon dioxide from the ambient air. The one mole of absorbed carbon dioxide will react with two moles of hydroxide ion to form one mole of carbonate ion. The rate is difficult to model at best, and is accelerated by use of airlift circulators such as those installed in tank 241-TX-111. Conversion of 49,600 kg of hydroxide to carbonate would account for the difference in the carbonate inventories. The HDW model does not adequately account for the absorption of carbon dioxide from the atmosphere.

Fluorides. The estimated fluoride inventory is about twice that predicted by the HDW model. This is likely the result of the HDW model assumptions that sodium fluoride is the only chemical compound containing fluoride and that it does not precipitate. The formation of insoluble fluoride compounds (such as sodium fluorophosphate) may be causing some fluoride to precipitate and remain in the tank.

Iron. The estimated iron inventory is skewed by the high iron concentration (2.4 wt%) reported for tank 241-TX-116. A later analysis of the salt cake in tank 241-TX-116 (Schulz 1980) indicated very little insoluble material. The high iron concentration is not likely for a salt cake since iron is insoluble in alkaline solutions and would not have been present in the evaporator feeds in significant concentrations. Therefore, the HDW model provides a better best basis.

Nitrate. The estimated nitrate inventory is twice that predicted by the HDW model. Nearly all of the nitrate is associated with the salt cake. The HDW model salt cake inventory is predicted by the Supernatant Mixing Model (SMM), and it is, therefore, difficult to determine the cause of this discrepancy. The global HDW model T2 salt cake concentrations (see Table D3-2) are very reasonable, indicating that either the problem lies within the SMM model or that some feed inputs have been missed.

Sodium. The predicted HDW sodium inventory is about 58 percent that predicted from data for tanks 241-T-104 and 241-T-107. The HDW model density calculated by the HDW model is 1.41 g/cc, which is about 17 percent below that normally expected for a salt cake. The global HDW model T2 salt cake sodium concentration is very reasonable (see Table D3-2). Either there is an internal problem in the SMM model calculations or some feed inputs have been missed.

Total Hydroxide. 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).

Cesium-137 and Strontium-90. The heat load for tank 241-TX-111 has been estimated at 6,155 BTU/h (Kummerer 1995). This corresponds to a maximum of 270,000 Ci ^{90}Sr (0.0228 BTU/h/Ci ^{90}Sr) or a maximum of 382,000 Ci ^{137}Cs (0.0161 BTU/h/Ci ^{137}Cs). About 62 percent of the heat load appears to be the result of ^{137}Cs based on the estimated ^{137}Cs inventory. There is consequently a strong possibility of higher ^{137}Cs and/or ^{90}Sr inventories in tank 241-TX-111. The higher ^{90}Sr inventory estimated by the HDW model will be used as the best basis to better account for the tank heat load.

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. Not surprisingly, the information derived from these different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as the standard characterization for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for tank 241-TX-111 was performed including the following:

- T Plant $BiPO_4$ reactor fuel processing to confirm 1C/CW waste volumes transferred into the tanks 241-TX-109 through 241-TX-112 cascade and to predict the quantity of resulting sludge.

- Waste transactions and operating data to confirm that salt cake was retained in tank 241-TX-111.

- Composition data from two waste tanks (241-T-104 [DiCenso et al. 1994] and 241-T-107 [Valenzuela and Jensen 1994]) that are expected to have similar sludge compositions and three waste tanks (241-U-102 [Hu et al. 1997], 241-U-105 [Brown and Franklin 1996], and 241-TX-116 [Horton 1977]) that are expected to have similar salt cake compositions.

- An inventory estimate generated by the HDW model (Agnew et al. 1996)

Based on this evaluation, a best-basis inventory was developed. No analytical data are available for the sludge or salt cake remaining in tank 241-TX-111 because no samples have been taken. The estimated inventory was, therefore, based on the composition of the 1C/CW wastes in tanks 241-T-104 and 241-T-107 and the T2 salt cakes in tanks 241-U-102, 241-U-105, and 241-TX-116 since the wastes in these tanks have actually been analyzed. The HDW model inventories were used when no other data were available or when analytical data were suspect.

The waste in tank 241-TX-111 consists of combined $BiPO_4$ first decontamination cycle (1C) and coating wastes generated by T Plant during processing of irradiated, aluminum-clad reactor fuel (163 kL [43 kgal]) and salt cake produced by the 241-T Evaporator (1,238 kL [327 kgal]). The 1C/CW sludge layer has been in contact with large volumes of supernates, including salt solutions with sodium hydroxide concentrations of up to 3 molar. Leaching of some sludge components may have occurred and remaining sludge may differ from that predicted from other tanks containing 1C/CW wastes. The best-basis inventory for tank 241-TX-111 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.

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 HDW Rev. 3 chemical values to be updated to HDW Rev. 4 chemical values.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-TX-111 (Effective January 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	61,700	E	
Bi	3,660	E	Concentration varies between 1C wastes.
Ca	880	E	
Cl	11,100	E	
TIC as CO_3	116,000	E	
Cr	2,900	E	
F	<6,320	E	
Fe	2,060	M	
Hg	4.3	M	
K	3,610	E	
La	<74.3	E	
Mn	530	E	
Na	466,000	E	
Ni	220	E	Concentration varies significantly between 1C waste tanks.
NO_2	66,500	E	
NO_3	660,900	E	
OH_{TOTAL}	146,000	C	
Pb	220	M/E	
P as PO_4	36,000	E	Concentration varies between 1C waste tanks.
Si	1,800	E	
S as SO_4	35,800	E	
Sr	<125	E	Inventory is likely to be < 2.5 kg based on maximum ^{90}Sr inventory.
TOC	19,600	E	
U_{TOTAL}	2,820	M	Concentration varies significantly between 1C waste tanks.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-TX-111 (Effective January 31, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Zr	54	E	

[1]S = Sample-based
M = Hanford Defined Waste model-based, Agnew et al. (1996)
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 f r Radioactive Components in Tank 241-TX-111 Decayed to January 1, 1994 (Effective January 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	186	M	
^{14}C	25.8	M	
^{59}Ni	1.93	M	
^{60}Co	29.3	M	
^{63}Ni	189	M	
^{79}Se	2.89	M	
^{90}Sr	1.03 E+05	M	
^{90}Y	1.03 E+05	E/M	
^{93m}Nb	10.3	M	
^{93}Zr	14.2	M	
^{99}Tc	184	M	
^{106}Ru	0.00582	M	
^{113m}Cd	73.6	M	
^{125}Sb	128	M	
^{126}Sn	4.36	M	
^{129}I	0.354	M	
^{134}Cs	2.0	E	
^{137m}Ba	223,000	E	Based on 137Cs
^{137}Cs	235,400	E	
^{151}Sm	10,200	M	
^{152}Eu	3.89	M	
^{154}Eu	507	M	
^{155}Eu	233	M	
^{226}Ra	1.34 E-04	M	
^{227}Ac	8.66 E-04	M	
^{228}Ra	0.197	M	
^{229}Th	0.00456	M	
^{231}Pa	0.00384	M	

Table D4-2. Best-Basis Inventory Estimate f r Radioactive Components in Tank 241-TX-111 Decayed to January 1, 1994 (Effective January 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{232}Th	0.0121	M	
^{232}U	0.985	M	
^{233}U	3.78	M	
^{234}U	3.19	M	
^{235}U	0.138	M	
^{236}U	0.0509	M	
^{237}Np	0.661	M	
^{238}Pu	1.31	M	
^{238}U	3.41	M	
^{239}Pu	52.1	M	
^{240}Pu	8.15	M	
^{241}Am	53.1	M	
^{241}Pu	85.9	M	
^{242}Cm	0.15	M	
^{242}Pu	4.71 E-04	M	
^{243}Am	0.0019	M	
^{243}Cm	0.0138	M	
^{244}Cm	0.123	M	

[1]S = Sample-based
M = Hanford Defined Waste model-based, Agnew et al. (1997)
E = Engineering assessment-based
NR = Not Reported.

D5.0 APPENDIX D REFERENCES

Agnew, S. F., R. A. Corbin, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1995, *Waste Status and Transaction Record Summary (WSTRS Rev. 2)*, WHC-SD-WM-TI-615, -614, -669, -689, Rev. 2, Los Alamos National Laboratory, Los Alamos, New Mexico.

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. FitzPatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3*, LA-UR-96-858, Los Alamos National Laboratory, Los Alamos, New Mexico.

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. FitzPatrick, K. A. Jurgensen, T. P. Ortiz and B. L. Young, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, LA-UR-96-3860, Los Alamos National Laboratory, Los Alamos, New Mexico.

Allen, G. K., 1977, *Salt Cake and Sludge Characterization Program 241-TX-116 Hot Test and Subsequent Cold Test Results*, RHO-CD-3, Rockwell Hanford Operations, Richland, Washington.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

Brown, T. M., and J. D. Franklin, 1996, *Tank Characterization Report for Single-Shell Tank 241-U-105*, WHC-SD-WM-ER-617, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

DiCenso, A. T., L. C. Amato, J. D. Franklin, G. L. Nuttall, K. W. Johnson, and B. C. Simpson, 1994, *Tank Characterization Report for Single-Shell Tank 241-T-104*, HNF-~~WHC~~-SD-WM-ER-372, Rev. 0, Westinghouse Hanford Company, Richland, Washington. KN

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order, as amended*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Hanlon, B. M., 1996, *Waste Tank Summary Report for Month Ending August 31, 1996*, WHC-EP-0182-101, Westinghouse Hanford Company, Richland, Washington.

Hill, J. G., G. S. Anderson, and B. C. Simpson, 1995, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*, PNL-9814, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

Hodgson, K. M. and M. D. LeClair, 1996, *Work Plan for Defining A Standard Inventory Estimate for Wastes Stored in Hanford Site Underground Tanks*, WHC-SD-WM-WP-311, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.

Horton, J. E., 1977, *Physical and Chemical Characterization of Tank 116-TX*, Letter to G. K. Allen, Atlantic Richfield Hanford Company, Richland, Washington.

Hu, T. A., L. C. Amato, R. T. Winward, and R. D. Cromar, 1997, *Tank Characterization Report for Single-Shell Tank 241-U-102*, HNF-SD-WM-ER-618, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

Kummerer, M., 1995, *Heat Removal Characteristics of Waste Storage Tanks*, WHC-SD-WM-SARR-010, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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 (W^2S 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.

Schneider, K. L., 1951, *Flow Sheets and Flow Diagrams of Precipitation Separations Process*, HW-23043, Hanford Atomic Products Operation, Richland, Washington.

Schulz, W. W., 1980, *Removal of Radionuclides from Hanford Defense Waste Solutions*, RHO-SA-51, Rockwell Hanford Operations, Richland, Washington.

Valenzuela, B. D., and L. Jensen, 1994, *Tank Characterization Report for Single-Shell Tank 241-T-107*, WHC-SD-WM-ER-382, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Watrous, R. A., and D. W. Wootan, 1997, *Activity of Fuel Batches Processed Through Hanford Separations Plants, 1944 Through 1989,* HNF-SD-WM-TI-794, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.