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ACCESSION # D197244178

47161

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ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 635539

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	Kevin E. Bell, Data Assessment and Interpretation, R2-12, 373-1629	[] Yes [X] No	08/07/97
	6. Project Title/No./Work Order No. Tank 241-U-110	7. Bldg./Sys./Fac. No. 241-U-110	8. Approval Designator N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-SD-WM-ER-551, Rev. 1	10. Related ECN No(s). ECN-635448	11. Related PO No. N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? [] Yes [X] No

This ECN was generated to include additional explanatory text in the best-basis narrative, and to update the comprehensive radionuclide inventory estimates for the tank.

14a. Justification (mark one)

Criteria Change	[]	Design Improvement	[X]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

Initial release of this document was deficient.

15. Distribution (include name, MSIN, and no. of copies)

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A-7900-013-1

ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1) ECN-635539

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng. K.E. Bell	Kevin E. Bell	8-20-97	PE		
Cog. Mgr. K.M. Hall	Kathleen M. Hall	8/20/97	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other			Other		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

Tank Characterization Report for Single-Shell Tank 241-U-110

Kevin E. Bell
Lockheed Martin Hanford, Corp., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: ECN-635539 UC: 2070
Org Code: 74620 Charge Code: N4G3A
B&R Code: EW 3120074 Total Pages: 285

Key Words: Waste Characterization, Single-Shell Tank, SST, Tank 241-U-110, 241-U-110, U-110, U Farm, Tank Characterization Report, TCR, Waste Inventory, TPA Milestone M-44

Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-U-110. This report supports the requirements of the Tri-Party Agreement Milestone M-44-05.

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AUG 25 1997

Release Approval — Date 8/22/97 — Release Stamp

Approved for Public Release

RECORD OF REVISION	(1) Document Number HNF-SD-WM-ER-551	Page 1

(2) Title
Tank Characterization Report for Single-Shell Tank 241-U-110

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Initially released 05/23/96 on EDT-615395.	K.E. Bell	J.G. Kristofzski
1 RS	Incorporate per ECN-635448.	K.E. Bell K.E. Bell	K.M. Hall Kathleen M. Hall 3/18/97
1-A RS	Incorporate per ECN-635539.	K.E. Bell K.E. Bell	K.M. Hall Kathleen M. Hall 9/30/97

A-7320-005 (08/91) WEF168

3.0 BEST-BASIS INVENTORY ESTIMATE

Information about the chemical and/or physical properties of tank wastes is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, as well as to address regulatory issues. Waste management 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 the wastes into a form that is suitable for long-term storage.

Chemical inventory information generally is derived using two approaches: 1) component inventories are estimated using the results of sample analyses; and 2) component inventories are predicted using a model based on process knowledge and historical information. The most recent model was developed by Los Alamos National Laboratory (LANL) (Agnew et al. 1997). Not surprisingly, information derived from these two different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as standard characterization information for the various waste management activities (Hodgson and LeClair 1996). Appendix D contains the complete narrative regarding the derivation of the inventory estimates presented in Tables 3-1 and 3-2.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-110 (July 2, 1996). (2 Sheets)

Analyte	Total Inventory (kg)	Basis (S, M, C or E)	Comment
Al	150,000	S	
Bi	21,000	S	Potentially too large.
Ca	3,300	S	
Cl	1,000	S	Based on analysis of water leach only.
TIC as CO_3	4,500	S	Based on analysis of water leach only.
Cr	630	S	
F	7,200	S	Based on analysis of water leach only.
Fe	13,000	S	

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-110 (July 2, 1996). (2 Sheets)

Analyte	Total Inventory (kg)	Basis (S, M, C or E)	Comment
Hg	3	S	Method/sample prep: AAS/Acid (Brown and Jensen 1993).
K	78	M	No sample basis
La	0	M	No sample basis
Mn	4,200	S	
Na	110,000	S	
Ni	130	S	
NO_2	9,400	S	Based on analysis of water leach only.
NO_3	46,000	S	Based on analysis of water leach only.
OH	316,000	C	charge balance calculation
Pb	1,100	S	
P as PO_4	47,000	S	
Si	23,000	S	Potentially too large.
S as SO_4	2,500	S	
Sr	520	S	
TOC	980	S	Based on analysis of water leach only.
U_{TOTAL}	11,000	S	
Zr	380	S	

Notes:

S = Sample-based
M = HDW 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 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-U-110 Decayed to January 1, 1994 (Effective July 2, 1996). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,E, or C)[1]	Comment
^{3}H	0.294	M	
^{14}C	0.35	S	Method/sample prep: RA/Water. Based on analysis of water leach only.
^{59}Ni	0.0239	M	
^{60}Co	0.0117	M	
^{63}Ni	2.1	M	
^{79}Se	0.0176	M	
^{90}Sr	340000	S	Method/sample prep: RA/Fusion
^{90}Y	340000	S	Based on ^{90}Sr
^{93m}Nb	0.0724	M	
^{93}Zr	0.0841	M	
^{99}Tc	7.3	S	Method/sample prep: RA/Water. Based on analysis of water leach only.
^{106}Ru	2.75 E-10	M	
^{113m}Cd	0.171	M	
^{125}Sb	0.0063	M	
^{126}Sn	0.0262	M	
^{129}I	0.00108	M	
^{134}Cs	6.59 E-05	M	
^{137m}Ba	25000	S	based on ^{137}Cs
^{137}Cs	26000	S	Method/sample prep: RA/Fusion
^{151}Sm	66.6	M	
^{152}Eu	0.0109	M	
^{154}Eu	0.157	M	
^{155}Eu	1.65	M	
^{226}Ra	1.72 E-05	M	
^{227}Ac	5.52 E-05	M	
^{228}Ra	1.48 E-10	M	
^{229}Th	2.86 E-08	M	
^{231}Pa	7.89 E-05	M	
^{232}Th	2.60 E-11	M	

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-U-110 Decayed to January 1, 1994 (Effective July 2, 1996). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,E, or C)[1]	Comment
^{232}U	2.64 E-04	M	
^{233}U	1.58 E-05	M	
^{234}U	22.3	M	
^{235}U	1	M	
^{236}U	0.142	M	
^{237}Np	0.00348	M	
^{238}Pu	0.0338	M	
^{238}U	22.5	M	
$^{239/240}Pu$	260	S	Method/sample prep: RA/Fusion
^{241}Am	90	S	Method/sample prep: RA/Fusion
^{241}Pu	0.4	M	
^{242}Cm	4.37 E-05	M	
^{242}Pu	1.22 E-06	M	
^{243}Am	8.14 E-08	M	
^{243}Cm	6.49 E-07	M	
^{244}Cm	1.25 E-06	M	

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

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-U-110

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-U-110

The following evaluation provided a best-basis inventory estimate of chemical and radionuclide components in tank 241-U-110.

D1.0 CHEMICAL INFORMATION SOURCES

Characterization results from the most recent sampling event for this tank are shown in Appendix B. Eight core samples were obtained and analyzed. Tables B3-6 to B3-8 summarize the results from the statistical analysis of data from seven core composites. These tables provide mean concentration values for analytes, along with confidence intervals around the mean values. Component inventories can be calculated by multiplying the concentration of an analyte by the current tank volume and by the density of the waste. The HDW model document (Agnew et al. 1996a) provides tank content estimates, in terms of component concentrations and inventories.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Sample-based inventories, derived from analytical concentration data, and HDW model (Agnew et al. 1996a) inventories, are compared in Tables D2-1 and D2-2. (The chemical species are reported without charge designation per the best-basis inventory convention). The tank volume used to generate these inventories is 704 kL (186 kgal) (Hanlon 1996). The mean density used to calculate the sample-based component inventories is 1.46 g/mL, and the HDW model density is estimated to be 1.35 g/mL. Note the significant differences between the sample-based and HDW model inventories for several of the bulk components; e.g., Al, Bi, Na, NO_3, PO_4 and U, as well as for the weight percent water values.

Table D2-1. Sample- and Historical Tank Content-Based Inventory Estimates for Nonradioactive Components in Tank 241-U-110.

Analyte	Sampling Inventory Estimate (kg)	HDW model[1] Inventory Estimate (kg)	Analyte	Sampling Inventory Estimate (kg)	HDW model[1] Inventory Estimate (kg)
Al	150,000	7,900	NO_3	46,000[2]	15,000
As	0.42	NR	OH	NR	46,000 (total)
Ba	66	NR	Pb	1,100	0
Be	3.3	NR	P as PO_4	47,000	81,000
Bi	21,000	9,900	Se	1.8	NR
Ca	3,300	2,200	Si	23,000	1,100
Cl	1,000[2]	330	S as SO_4	2,500	3,400
Cr	630	130	Sr	520	0
F	7,200[2]	1,900	TIC as CO_3	4,500[2]	13,000
Fe	13,000	12,000	Th	1,800	NR
Hg	3.0	13	Tl	3,200	NR
K	NR	78	TOC	980[2]	0
La	NR	0	U_{TOTAL}	11,000	43,000
Mg	2,600	NR	V	69	NR
Mn	4,200	0	Zn	1,100	NR
Mo	50	NR	Zr	380	580
Na	110,000	79,000	H_2O (wt%)	31.5	66
Ni	130	45	density (kg/L)	1.46	1.35
NO_2	9,400[2]	5,100			

Notes:

HDW = Hanford defined waste
NR = Not reported

[1]Agnew et al. (1996a)
[2]Based on analysis of water leach only.

Table D2-2. Sample-Based and Historical Tank Content-Based Inventory Estimates for Radioactive Components in Tank 241-U-110.

Analyte	Sampling inventory estimate (Ci)	HDW model[1] inventory estimate (Ci)	Analyte	Sampling inventory estimate (Ci)	HDW model[1] inventory estimate (Ci)
^{14}C	0.35[2]	NR	$^{239/240}Pu$	260	5.7
^{90}Sr	380,000	730	^{241}Am	90	NR
^{99}Tc	7.3[2]	NR	Total α	170	NR
^{137}Cs	29,000	7,600	Total β	1,000,000	NR

Notes:

HDW = Hanford Defined Waste
NR = Not reported

[1]Agnew et al. (1996a)
[2]Based on analysis of water leach only.

D3.0 COMPONENT INVENTORY EVALUATION

The following evaluation of tank contents is performed in order to identify potential errors and/or missing information that would influence the sample-based and HDW model component inventories.

D3.1 CONTRIBUTING WASTE TYPES

Expected waste types and volumes entering tank 241-U-110, based on waste transfer records, are as follows (Agnew et al. 1996a):

through 1951	1C1	5,277 kL	(1,394 kgal)
through 1955	R1	4,512 kL	(1,192 kgal)
through 1957	RCW	3,051 kL	(806 kgal)
		12,840 kL	3,392 kgal

1C1 = First-cycle decontamination waste
R1 = REDOX concentrated waste (1952-1957)
RCW = REDOX process aluminum cladding waste.

In the bismuth phosphate process, the 1C1 waste stream was neutralized with aluminum cladding waste (CW). This neutralized waste stream, that contains approximately 24 percent CW, is also referred to as 1C1. Cascade overflows from tanks 241-U-110 were to 241-U-111 and 241-U-112. Additional information on the waste transfer history of tank 241-U-110 is provided in Appendix A, Section A3.0.

D3.2 TECHNICAL FLOWSHEET INFORMATION

Technical flowsheet information for 1C1, R1, and RCW streams is provided in Table D3-1. The comparative HDW streams also are provided in this table; however, HDW used only the 1C1 waste stream to account for 614 kL (162 kgal) of tank 241-U-110 waste (the remaining 91 kL [24 kgal] is attributed to metal waste). Note the difference in the NO_3 concentration in the 1C1 flowsheet and defined waste streams. The 1C1 defined waste stream appears to be a "second generation" flowsheet waste stream, derived by Jungfleisch (1984) for an earlier modeling effort.

Expected Solids

SORWT (Hill et al. 1995):	1C1/R1/RCW
HDW (Agnew et al. 1996a):	MW/1C1

MW = Metal waste from the $BiPO_4$ process
SORWT = Sort on Radioactive Waste Type Model

The HDW model (Agnew et al. 1996a) assumes that because the "measured" solids volume defined in Agnew (1996b) did not appear to change with the addition of R1 and RCW streams to the tank, the R1 and RCW streams did not contribute to any of the solids in the waste. This assumption is questionable. Color photographs of the waste inside the tank and of the core composites show that the top layer of the waste is white. Analytical results (Segment 1, Core 8) indicate that these white solids are comprised almost entirely of Al with little or no Bi from a 1C1 waste type. High aluminum concentrations are characteristic of both R1 and RCW streams.

Table D3-1. Technical Flowsheet and Los Alamos National Laboratory Hanford Defined Waste Streams.

Analyte	Flowsheet 1C1[1] (M)	Def Waste 1C1[2] (M)	Flowsheet 4[4] REDOX[3] (M)	HDW R1[2] (M)	Flowsheet RCW[3] (M)	HDW RCW[2] (M)
NO_3	1.44	0.588	3.62	2.5	0.98	0.88
NO_2	0.058	0.174	0	0	1.27	1.4
SO_4	0.063	0.0616	0.029	0.019	0	0.013
Bi	0.012	0.014	0	0	0	0
Fe	0.032	0.046	0.014	0.0475	0	0.0152
Si	0.031	0.038	0	0.0147	0.020	0.03
U[5]	0.00096	0.0008	0.0075	0.0048	0.001	0.019
Al	0.083	0.233	1.05	0.65	1.7	2
$Cr^{+3/+6}$	0.0033	0.0052	0.053	0.068	0	0.003
PO_4	0.258	0.314	0	0	0	0
F	0.170	0.23	0	0	0	0
Ce	0.0002	NR	0	0	0	0

Notes:

[1]Schneider (1951)
[2]Agnew et al. (1996a)
[3]GE (1951)
[4]REDOX Flowsheet #4 operated until August 1955.
[5]Assumes all U = ^{238}U

D3.3 ESTIMATE OF WASTE INVENTORIES

The following assessment is performed to provide a basis for evaluating the HDW component inventories that are based on the assumption that R1 and RCW did not contribute to solids in tank 241-U-110. For this particular assessment, the following assumptions and observations are made:

- Tank waste mass is calculated using the analytically-based density and the tank volume listed in Hanlon (1996). While this volume may not be correct, both the analytical-based and the model-based inventories are derived using this volume. As a result, inventory comparisons are made on the same volume basis.

- 1C1, R1, and RCW streams contributed to solids formation.

- Only bulk components listed in the technical flowsheets are being evaluated. Initial bulk component concentrations are obtained from technical flowsheets (see Table D3-1).

- No radiolysis of NO_3 to NO_2 and no additions of NO_2 to the waste for corrosion purposes are factored into this independent assessment.

- All Bi, Fe, Si, and U compounds precipitate.

- All NO_3, NO_2, and SO_4 compounds remain dissolved in the interstitial liquid.

- Interstitial liquid is a composite of all wastes. Contributions of dissolved components are weighted by volume of total waste added to tank 241-U-110:

1C1	0.41
R1	0.35
CW	0.24

- Concentration of components in interstitial liquid is based on a void fraction of 0.7.

- Al, Cr, PO_4, and F compounds partition between the liquid and solid phases.

  - Cr remains in the +3 state in 1C1 and in the +6 state in REDOX wastes

  - Al partitioning is 0.6 aqueous, 0.4 solid (based on an evaluation of 1C1-type waste [single-shell tank 241-T-104] by Colton et al. [1995])

  - 0.18M PO_4 and 0.14M F remain in solution and the balance precipitates (based on an evaluation of 1C1-type waste [single-shell tank 241-T-104] by Colton et al. [1995] and in line with solubility information compiled by LANL [Agnew and Watkin 1994]).

- The Na inventory is calculated based on:

  - 1 mole Na for each mole of NO_3, NO_2, and F
  - 2 moles Na for each mole of Si, SO_4, and $Cr_{interstitial}$
  - 3 moles Na for each mole PO_4

- Water mass is the difference between the total waste mass and the dried solids mass. The following oxide factors are used to convert bulk chemical components; e.g., Fe, to chemical species; e.g., Fe_2O_3, for mass balance purposes:

-	Fe (Fe_2O_3)	1.43	U (UO_3)	1.20
-	Bi (Bi_2O_3)	1.12	Cr (Cr_2O_3)	1.46
-	Si (SiO_2)	2.14	Al (60% $Al(OH)_3$	(40% Al_2O_3) 2.49

Sample calculations used in this independent evaluation follow for:

Components assumed to precipitate (Fe, Bi, Si, and U).

(MT = metric tons)

Fe: $[0.032\ moles_{Fe}/L_{1C} \times 1{,}394\ kgal_{1C} + 0.014\ moles_{Fe}/L_R \times 1{,}192\ kgal_R + 0_{RCW}] \times 3{,}785\ L/kgal \times 55.8\ g/mole_{Fe} \times MT/1E6\ g = 13\ MT$

Similarly:

Bi: 13 MT

Si: 6.3 MT

U: 10 MT

Components assumed to remain dissolved in the interstitial liquid (NO_3, NO_2, and SO_4).

NO_3: $[0.41_{1C} \times 1.44\ moles_{NO3}/L_{1C} + 0.35_R \times 3.62\ moles_{NO3}/L_R + 0.24_{RCW} \times 0.98\ moles_{NO3}/L_{RCW}] \times 0.7_{porosity} \times 3{,}785\ L/kgal \times 186\ kgal_{241\text{-}U\text{-}110\ waste} \times 62\ g/mole_{NO3} \times MT/1E6\ g = 64\ MT$

NO_2: 7.4 MT

SO_4: 1.7 MT

Components assumed to partition between aqueous and solid phases (Al, Cr, PO_4, and F).

Total Al: $[0.41_{1C} \times 0.083\ moles_{Al}/L_{1C} + 0.35_R \times 1.05\ moles_{Al}/L_R + .24_{RCW} \times 1.7\ moles_{Al}/L_{RCW}] = 0.809\ moles_{Al}/L$

Al_{solids}: $0.4 \times 0.809\ moles_{Al}/L \times 3{,}785\ L/kgal \times 3{,}392\ kgal \times 27\ g/mole_{Al} \times MT/1E6\ g = 112\ MT$

$Al_{interstitial}$: $0.6 \times 0.809\ moles_{Al}/L \times 0.7_{porosity} \times 3{,}785\ L/kgal \times 186\ kgal_{241\text{-}U\text{-}110\ waste} \times 27\ g/mole_{Al} \times MT/1E6\ g = 6.4\ MT$

Total Al: 118 MT

$Cr_{(solids)}$: $0.0033\ moles_{Cr+3}/L_{1C} \times 1{,}394\ kgal_{1C} \times 3{,}785\ L/kgal \times 52\ g/mole_{Cr} \times MT/1E6\ g = 0.90\ MT$

$Cr_{(interstitial)}$: $[0.41_{1C} \times 0 + 0.35_R \times 0.053\ moles_{Cr+6}/L_R + 0.24_{RCW} \times 0] \times 0.7_{porosity} \times 3{,}785\ L/kgal \times 186\ kgal_{241\text{-}U\text{-}110\ waste} \times 52\ g/mole_{Cr+6} \times MT/1e6g = 0.47\ MT$

Total Cr: 1.4 MT

$PO_{4(solids)}$: $0.078\ moles_{PO4}/L_{1C} \times 3{,}785\ L/kgal \times 1{,}394\ kgal_{1C} \times 95\ g/mole_{PO4} \times MT/1E6\ g = 39\ MT$

$PO_{4(interstitial)}$: $[0.41_{1C} \times 0.18\ moles_{PO4}/L_{1C} + 0.35_R \times 0 + 0.24_{RCW} \times 0] \times 0.7_{porosity} \times 3{,}785\ L/kgal \times 186\ kgal_{241\text{-}U\text{-}110\ waste} \times 95\ g/mole_{Al} \times MT/1E6\ g = 3.4\ MT$

Total PO_4: 43 MT

$F_{(solids)}$: $0.030\ moles_F/L_{1C} \times 3{,}785\ L/kgal \times 1{,}394\ kgal_{1C} \times 19\ g/mole_F \times MT/1E6\ g = 3.0\ MT$

$F_{(interstitial)}$: $[0.41_{1C} \times 0.14\ moles_F/L_{1C} + 0.35_R \times 0 + 0.24_{RCW} \times 0] \times 0.7_{porosity} \times 3{,}785\ L/kgal \times 186\ kgal_{241\text{-}U\text{-}110\ waste} \times 19\ g/mole_F \times MT/1E6\ g = 0.54\ MT$

Total F: 3.5 MT

Water Mass

Waste: $186\ kgal \times 3{,}785\ L/kgal \times 1.46\ kg/L \times 1MT/1E3\ kg = 1{,}030\ MT$

Dried solids: $(1.43 \times 13\ MT)_{Fe} + (1.12 \times 13\ MT)_{Bi} + (2.14 \times 6.3\ MT)_{Si} + (1.20 \times 10\ MT)_U + 64\ MT_{NO3} + 7.4\ MT_{NO2} + 1.7\ MT_{SO4} + (2.49 \times 118\ MT)_{Al} + (1.46 \times 1.4\ MT)_{Cr} + 43\ MT_{PO4} + 3.5\ MT_F + 74\ MT_{Na} = 548\ MT$

Water: 1,030 MT - 548 MT = 482 MT (47 percent)

Estimated component inventories from this independent evaluation are compared with sample- and HDW model-based inventories for selected components in Table D3-2. Observations regarding these inventories are noted, by component, in the following text.

Table D3-2. Comparison of Selected Component Inventory Estimates for Tank 241-U-110 Waste.

Component	This Evaluation (kg)	Sample-Based (kg)	HDW Model (kg)
Fe	13,000	13,000	12,000
Bi	13,000	21,000	9,900
Si	6,300	23,000	1,100
U	10,000	11,000	43,000
NO_3	64,000	46,000	15,000
NO_2	7,400	9,400	5,100
SO_4	1,700	2,500	3,400
Al	118,000	150,000	7,900
Cr	1,400	630	130
PO_4	43,000	47,000	81,000
F	3,500	7,200	1,900
Na	74,000	110,000	79,000
H_2O (%)	47	31.5	66

Iron. The sample-based and HDW model inventories compare favorably with each other and with the inventory estimated in this evaluation. However, the fact that the sample-based and HDW model inventories compare fairly well may be coincidental. The HDW model inventory is based predominantly on the 1C1 waste stream with 0.03M Fe because of chemicals added in the process and 0.016M Fe assumed from corrosion; Fe in the R1 waste stream was not taken into account. The LANL corrosion source term is based on plutonium-uranium extraction (PUREX)-related data and may not be applicable to 1C1 waste streams.

Bismuth. The sample-based inventory is larger and the HDW model inventory is smaller than the inventory estimated in this evaluation. The statistical mean concentration (20,600 μg Bi/g waste), used to calculate the sample-based inventory, reflects the average concentration in the bottom portion (Segment 4 of a core) of the tank (24,600 μg Bi/g waste). If the average concentration of Bi from segments 1 - 4 or segments 2 - 4 in the trending table is used to calculate the sample-based inventory, the inventory is 12 MT or 15 MT, respectively. If the average concentration from Core 15 composite (90 percent recovery) is used, the inventory is 12 MT. The HDW model inventory reflects the LANL assumption that approximately 780 μg Bi/mL remains in solution (or that only 73 percent of the Bi precipitates).

Silicon. The sample-based inventory is larger than the inventory estimated in this evaluation, but the HDW inventory is much smaller. This evaluation does not, however, account for any blowsand; i.e., dirt, that may have entered the tank. The lower HDW model inventory reflects the LANL assumptions (1) that approximately 900 μg Si/mL remains in solution and (2) that R1 waste (approximately 0.015M Si) did not contribute to the solids in this tank. However, analytical data for Si from fused samples may be highly biased because there were results reported for only 3 of the 8 core composites. The statistical mean for these data (22,000 μg Si/g waste) was used to calculate the sample-based inventory.

Uranium. The sample-based inventory compares favorably with the inventory estimated in this evaluation. The HDW model inventory is approximately four times higher than the sample-based and estimated inventories. The inventory derived in this evaluation is based on U contributions from 1C1, R1, and RCW waste streams; the HDW model inventory is based on U contributions from MW (0.16M U) and 1C1 waste streams. If MW comprises the bottom layer of the waste in the tank, the highest U concentrations should appear in Segment 4 from each core sample (unless the sampler failed to retrieve any of the MW heel assumed by LANL). The highest U concentration appears in Segment 2 (second segment from the top), and the lowest U concentration appears in Segment 1 (top segment). These trends are more consistent with a layering scheme based on 1C1, R1, and RCW streams than a layering scheme based on MW and 1C1 waste streams.

Nitrate. The HDW model inventory is smaller than the sample-based inventory, and both of these inventories are smaller than the inventory estimated in this evaluation. The inventory derived in this evaluation is based on a composite of 1C1, R1, and RCW streams and does not account for any dilution by process water or other dilute waste streams that may have entered the tank or for any radiolysis of NO_3 to NO_2. The HDW model inventory is derived from the LANL 1C1 defined waste stream and does not account for any contributions from R1 and RCW streams that passed through the tank. As noted earlier, the NO_3 concentration in this defined waste stream is approximately two and a half times lower than the NO_3 concentration in the technical flowsheet. The sample-based inventory could be larger than 46 MT if cancrinite [$Na_8(AlSiO_4)_6(NO_3)_2$] is present in the waste. Nitrate in cancrinite would not dissolve in a water leach; as a result, the concentration of NO_3 in the water leach, which is used to derive the sample-based inventory, would not reflect the total NO_3 concentration.

Nitrite. The inventory estimated in this evaluation is approximately 20 percent less than the sample-based inventory. The inventory derived in this evaluation does not account for any NO_2 from radiolysis of NO_3 or for any NO_2 additions for corrosion purposes. The HDW model inventory does not account for any contribution from the RCW (1.27M NO_2) and is smaller than the sample-based inventory.

Sulfate. The HDW model inventory is larger than the sample-based inventory, and both of these inventories are larger than the inventory estimated in this evaluation. As mentioned previously, the HDW model inventory does not account for any contributions from the R1 and RCW streams that passed through the tank. The SO_4 concentration in the R1 waste stream is more dilute than the SO_4 concentration in the 1C1 waste stream. A further dilution effect might be expected from the RCW because no SO_4 was intentionally added to this waste stream.

Aluminum. The inventory estimated in this evaluation is within 20 percent of the sample-based inventory. Both of these inventories are significantly larger than the HDW model inventory. The HDW model inventory reflects the LANL assumptions (1) that R1 and RCW streams did not contribute to any of the solids in this tank and (2) that 70 percent of the Al remains in solution (30 percent precipitates).

Chromium. The HDW model inventory is derived from 0.0052M Cr in the 1C1 defined waste stream. This concentration is approximately two times higher than the concentration derived from the technical flowsheet and may include a Cr corrosion source term. Even though the 1C1 defined waste stream has a potentially inflated Cr concentration, the HDW model inventory derived from this concentration is still smaller than the sample-based inventory by a factor of five. The HDW model inventory does not account for any Cr from the R1 waste that was added to the tank. Both the HDW model and sample-based inventories are smaller than the inventory estimated in this evaluation. As mentioned earlier, this evaluation does not account for any dilution of dissolved components by process water or other dilute waste streams.

Phosphate. Phosphate originated from the 1C1 waste stream (PO_4 was not added to R1 or RCW). As a result, the HDW model inventory, derived from the 1C1 waste stream, and the inventory estimated in this evaluation should be comparable. The HDW model inventory is larger than the inventory estimated in this evaluation, and the sample-based inventory. The HDW model inventory reflects the LANL assumptions (1) that the PO_4 concentration in the LANL 1C1 defined waste stream is 0.314M (in comparison to 0.258M derived from the technical flowsheet) and (2) that 0.15M remains in solution (in contrast to this evaluation that assumes 0.18M remains in solution). In addition, the HDW model assumes a larger contribution of 1C1 waste in the tank than assumed for this evaluation.

Fluoride. The inventory estimated in this evaluation is lower than the sample-based inventory. Both of these inventories are larger than the HDW model inventory. The HDW model inventory reflects the assumption that all of the 0.23M F in the defined waste stream remains in solution; this evaluation assumes 0.14M remains in solution (0.057M precipitates). Because the phosphate content is high in this tank, the high fluoride content in the sample may be attributed to formation of a sodium fluoride-diphosphate double salt ($Na_7F(PO_4)_2 \cdot 19H_2O$) (Herting 1996).

Sodium. The HDW model inventory reflects the 0.59M NO_3 concentration used to define the 1C1 waste stream (refer to discussion on nitrate). If the NO_3 concentration (as HNO_3) is >0.59M, then the Na concentration would be higher, and the resulting Na inventory larger, because of the additional NaOH required to neutralize the acid.

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 was consistent with that used by Agnew et al. (1996a).

Water. The percent water estimated in this evaluation compares favorably with the percent water determined from the analysis of core samples. These values are considerably lower than the HDW model percent water value. Conversely, the solids mass calculated in this evaluation and reported in the TCR is higher than the solids mass predicted by the LANL model.

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

The sample-based data set provides the best basis for estimating the tank 241-U-110 waste inventory for the following reasons:

1. Data from seven core composite samples were used to estimate the component inventories. The core sample recovery was incomplete; however, assuming the core and segment samples that were recovered represent a random sample from tank 241-U-110, the concentration estimates are unbiased estimates of true unknown mean concentrations.

2. Results from this evaluation indicate that some of the assumptions governing the HDW model inventory are questionable. These assumptions include the following:

    - Only 1C1 contributed to the waste composition

- Corrosion source terms for Fe and Cr that are based on PUREX-related data are applicable to 1C1 waste

- The starting NO_3 concentration in the 1C1 waste stream was 0.5M.

The best-basis inventory estimates are provided in Tables D4-1 and D4-2. Note that Bi and Si inventories are flagged as being potentially too large; however, no adjustments to these inventories are being made at this time. These inventories will be revised, if necessary, during reconciliation of all tank-specific inventories with the global inventories. 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 Hanford Defined Waste 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 Hanford Defined Waste 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 FY 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-U-110 (July 2, 1996). (2 Sheets)

Analyte	Total Inventory (kg)	Basis (S, M, C or E)	Comment
Al	150,000	S	
Bi	21,000	S	Potentially too large.
Ca	3,300	S	
Cl	1,000	S	Based on analysis of water leach only.
TIC as CO_3	4,500	S	Based on analysis of water leach only.
Cr	630	S	
F	7,200	S	Based on analysis of water leach only.
Fe	13,000	S	
Hg	3	S	Method/sample prep: AAS/Acid (Brown and Jensen 1993).
K	78	M	No sample basis
La	0	M	No sample basis
Mn	4,200	S	
Na	110,000	S	
Ni	130	S	
NO_2	9,400	S	Based on analysis of water leach only.
NO_3	46,000	S	Based on analysis of water leach only.
OH	316,000	C	charge balance calculation
Pb	1,100	S	
P as PO_4	47,000	S	
Si	23,000	S	Potentially too large.
S as SO_4	2,500	S	
Sr	520	S	
TOC	980	S	Based on analysis of water leach only.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-U-110 (July 2, 1996). (2 Sheets)

Analyte	Total Inventory (kg)	Basis (S, M, C or E)	Comment
U_{TOTAL}	11,000	S	
Zr	380	S	

Notes:

S = Sample-based
M = HDW 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-U-110 Decayed to January 1, 1994 (Effective July 2, 1996). (3 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,E, or C)[1]	Comment
^{3}H	0.294	M	
^{14}C	0.35	S	Method/sample prep: RA/Water. Based on analysis of water leach only.
^{59}Ni	0.0239	M	
^{60}Co	0.0117	M	
^{63}Ni	2.1	M	
^{79}Se	0.0176	M	
^{90}Sr	340000	S	Method/sample prep: RA/Fusion
^{90}Y	340000	S	Based on ^{90}Sr
^{93m}Nb	0.0724	M	
^{93}Zr	0.0841	M	
^{99}Tc	7.3	S	Method/sample prep: RA/Water. Based on analysis of water leach only.
^{106}Ru	2.75 E-10	M	
^{113m}Cd	0.171	M	
^{125}Sb	0.0063	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-U-110 Decayed to January 1, 1994 (Effective July 2, 1996). (3 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,E, or C)[1]	Comment
^{126}Sn	0.0262	M	
^{129}I	0.00108	M	
^{134}Cs	6.59 E-05	M	
^{137m}Ba	25000	S	based on ^{137}Cs
^{137}Cs	26000	S	Method/sample prep: RA/Fusion
^{151}Sm	66.6	M	
^{152}Eu	0.0109	M	
^{154}Eu	0.157	M	
^{155}Eu	1.65	M	
^{226}Ra	1.72 E-05	M	
^{227}Ac	5.52 E-05	M	
^{228}Ra	1.48 E-10	M	
^{229}Th	2.86 E-08	M	
^{231}Pa	7.89 E-05	M	
^{232}Th	2.60 E-11	M	
^{232}U	2.64 E-04	M	
^{233}U	1.58 E-05	M	
^{234}U	22.3	M	
^{235}U	1	M	
^{236}U	0.142	M	
^{237}Np	0.00348	M	
^{238}Pu	0.0338	M	
^{238}U	22.5	M	
$^{239/240}Pu$	260	S	Method/sample prep: RA/Fusion
^{241}Am	90	S	Method/sample prep: RA/Fusion
^{241}Pu	0.4	M	
^{242}Cm	4.37 E-05	M	
^{242}Pu	1.22 E-06	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-U-110 Decayed to January 1, 1994 (Effective July 2, 1996). (3 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,E, or C)[1]	Comment
^{243}Am	8.14 E-08	M	
^{243}Cm	6.49 E-07	M	
^{244}Cm	1.25 E-06	M	

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

D5.0 APPENDIX D REFERENCES

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