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ENGINEERING CHANGE NOTICE

1. ECN 649923

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 []	M. J. Kupfer, LMHC, H5-49, 376-6631	[] Yes [x] No	9/9/98
	6. Project Title/No./Work Order No. Tank 241-SX-115	7. Bldg./Sys./Fac. No. NA	8. Approval Designator NA
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-SD-WM-ER-684, Rev. 0	10. Related ECN No(s). NA	11. Related PO No. NA

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)	NA	NA Design Authority/Cog. Engineer Signature & Date	NA Design Authority/Cog. Engineer Signature & Date

13a. Description of Change — 13b. Design Baseline Document? [] Yes [X] No

This ECN compiles all reconciliation changes made to the Best-Basis Inventory in FY 1998 and should replace Appendix D, Evaluation to Establish Best-Basis Inventory for Single-Shell Tank 241-SX-115, of the Tank Characterization Report. The reconciliation process involved correction of errata, reassessment of data outlyers, verification of uranium isotopic distribution and other alpha isotope distribution, and removal of "less than" values, etc. Changes were made to both text and tables. The inventory estimates of several waste components were revised.

14a. Justification (mark one)

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

14b. Justification Details

Tank waste inventory estimates are being provided as standard source term for the various waste management activities. FY 1997 evaluation of available information for all 177 underground storage tanks was performed and published in TCRs, preliminary TCRs, or revisions to existing TCRs. In FY 1998, a reconciliation process is being performed to update the best-basis inventories. This process ensures that the latest inventory estimates are available as a consistent source-term to support the activities of TWRS disposal and other users.

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

Central Files	B1-07	K. M. Hodgson	R2-11
DIMC	H6-15	M. J. Kupfer	R3-75
DOE Reading Room	H2-53	M. D. LeClair (3)	R3-75
TCSRC	R1-10	B. C. Simpson	R2-12
K. M. Hall	R2-12		

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16. Design Verification Required	17. Cost Impact — ENGINEERING		17. Cost Impact — CONSTRUCTION		18. Schedule Impact (days)	
[] 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	[]	Other	[X]
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
NA		

21. Approvals

Signature	Date	Signature	Date
Design Authority		Design Agent	
Cog. Eng. M. J. Kupfer *M J Kupfer*	9-9-98	PE	
Cog. Mgr. K. M. Hodgson *K.M. Hodgson*	9-10-98	QA	
QA		Safety	
Safety		Design	
Environ.		Environ.	
Other B. C. Simpson R2-12 *Brett Simpson*	9/9/98	Other	

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

A-7900-013-3 (05/96) GEF096

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HNF-SD-WM-ER-684, Rev. 0A

Tank Characterization Report for Single-Shell Tank 241-SX-115

D. W. Hendrickson
COGEMA Engineering Corporation, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 649923 UC: 721
Org Code: 7A110 Charge Code: N4G3A
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Key Words: TCR, best-basis inventory, standard inventory

Abstract: The best-basis inventory provides waste inventory estimates that serve as standard characterization source terms for the various waste management activities. To establish a best-basis inventory for single-shell tank 241-SX-115, an evaluation of available information was performed. This work follows the methodology established in *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0A (Kupfer et al. 1997).

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RECORD OF REVISION	(1) Document Number HNF-SD-WM-ER-684	Page 1

(2) Title

Preliminary Tank Characterization Report for Single-Shell Tank 241-SX-115: Best-Basis Inventory

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	Authorized for Release (6) Cog. Mgr. Date
0	(7) Initially released 08/28/97 on EDT 161479	M.J. Kupfer	K.M. Hodgson
0A RS	Incorporate per ECN-649923	M.J. Kupfer	K.M. Hodgson
		MJ Kupfer 9-9-98	K.M. Hodgson 9-10-98

A-7320-005 (08/91) WEF168

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-SX-115

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-SX-115

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-SX-115 was performed and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

The following sections establish a best-basis inventory estimate for chemical and radionuclide components in tank 241-SX-115. A complete list of data sources and inventory evaluations is provided at the end of this section.

D1.0 CHEMICAL INFORMATION SOURCES

The waste in tank 241-SX-115 has not been core sampled and analyzed. A Tank Characterization Report (TCR) for tank 241-SX-115 has not been prepared. The Hanford Defined Waste (HDW) model report (Agnew et al. 1997) provides tank content estimates in terms of component concentrations and inventories.

Tank 241-SX-115 is a known leaker. However, the quantity of material lost to the soil column is currently unknown. No attempt has been made in this assessment to correct for materials lost to the soil column.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Hanlon (1996) states that tank 241-SX-115 contains 45 kL (12 kgal) of solids and no drainable interstitial liquid or pumpable liquid. Agnew et al. (1997) concur with Hanlon's estimate. According to the HDW model, the solid waste in tank 241-SX-115 contains 30.8 wt% water and has a density of 1.73 g/cc. As described more fully later, Agnew et al. hypothesize that the solids in tank 241-SX-115 derive from both Reduction and Oxidation (REDOX) process high-level waste (HLW) and salt cake produced from concentrated REDOX process supernatant liquid added to the tank. An independent analysis of historical waste transaction data, conducted in connection with preparation of this section, indicates that all the solid waste in tank 241-SX-115 derives only from REDOX process HLW. As explained in detail later, the completeness and quality of the historical waste transaction data are insufficient to allow an unequivocal determination of the origin of the solid wastes now in tank 241-SX-115.

HDW model predictions of the inventory of the various analytes in tank 241-SX-115 are listed in Table D2-1. (The chemical species are reported without charge designation per the best-basis inventory convention.)

Table D2-1. Estimated Analyte Inventories for tank 241-SX-115. (2 Sheets)

Analyte	HDW model[a] (kg)
Nonradioactive	
Al	6,360
Bi	0.0326
Ca	270
Cl	149
CO_3	411
Cr	1,040
F	0.153
Fe	1,310
Hg	0.00492
K	38.4
Mn	0.0624
Na	11,300
Ni	87.7
NO_2	3,480
NO_3	14,800
OH	17,100
Pb	0.805
PO_4	0.959
Si	88.1
SO_4	111
Sr	0
TOC	2.04
Zr	0.00142

Table D2-1. Estimated Analyte Inventories for tank 241-SX-115. (2 Sheets)

Analyte	HDW model[a] (kg)
Radioactive[b]	
U_{TOTAL}	82.7 kg
^{239}Pu	12.4 Ci

HDW = Hanford Defined Waste
NR = Not reported
[a] Agnew et al. (1997)
[b] Decayed to January 1, 1994.

D3.0 COMPONENT INVENTORY EVALUATION

The following evaluation of tank contents is performed to identify potential errors and/or missing information that would have an effect upon the HDW model component inventories.

D3.1 CONTRIBUTING WASTE TYPES

Tank 241-SX-115 is the third (million gallon) tank in a cascade that includes tanks 241-SX-113 and 241-SX-114. Tank 241-SX-115 was constructed in the early 1950's and was designed to be a self-boiling tank with the condensate directed back to the tank. Tank 241-SX-115 was connected to an exhauster.

High-level REDOX process waste (R) was first added to tank 241-SX-115 in 1958. In 1959 and 1960, tank 241-SX-115 received additional REDOX process HLW (Brevick et al. 1994, Anderson 1990). In 1965 tank 241-SX-115 also received a one-time addition of concentrated REDOX process HLW supernatant liquid. All the high-level REDOX process waste additions are known or are believed to have contributed to the solid waste (45.4 kL [12 kgal]) now stored in tank 241-SX-115. Beyond such waste additions, there were some liquid transfers into and out of tank 241-SX-115 including water, condensate from self-boiling tanks including tank 241-SX-115 and supernatant liquid from other SX Tank Farm tanks.

Table D3-1 provides a summary of the transactions which may have contributed to the type and volume of wastes now in tank 241-SX-115. These values are taken from the more detailed records of waste transactions compiled by Anderson (1990) and Brevick et al. (1994).

Careful review and analysis of the data summarized in Table D3-1 and other data of Anderson (1990) and Brevick et al. (1994) leads to two possible ways of accounting for the solid waste presently residing in tank 241-SX-115. One of these is due to Agnew et al. (1997)

published in the HDW model (Rev. 4) report. Agnew et al. accept that the volume (measured) of waste now in tank 241-SX -115 is 45.4 kL (12 kgal). They partition the amount of solid waste into two types:

- 22.7 kL (6 kgal) solids of R1 type waste (R waste generated from 1952 until 1957)
- 22.7 kL (6 kgal) of REDOX process salt cake.

Table D3-1. Summary of Contributing Waste Types for Tank 241-SX-115[a,b]

Historical waste transaction	Waste type	
	R[c]	R SltCk[d]
Volume waste added, kL (kgal)		
1958	549 (145)	
1959	855 (226)	
1960	2,309 (610)	
1965		7.6 (2)
Volume solids, kL (kgal)		
1958	24.1 (6.38)[e]	
1959	37.6 (9.94)[e]	
1960	101.4 (26.8)[e,f]	
1965		0.23 (0.06)[g]

REDOX = Reduction and Oxidation
[a] From Agnew et al., (1996)
[b] From Anderson (1990)
[c] Reduction and Oxidation (REDOX) Process high-level waste (R)
[d] REDOX Process salt cake waste (R SltCk)
[e] 4.4 vol% of added volume of REDOX process high-level waste (Agnew et al.1996)
[f] Agnew et al. (1996) assumed 2.3 vol% solids from added REDOX process high-level waste.
[g] Solids = 3 vol% of total waste slurry.(Agnew et al. 1995)

The accounting procedure used by Agnew et al. (1997) appears very arbitrary. Thus, they assumed that the present solids volume quoted by Hanlon (1996), namely, 45.4 kL (12 kgal) is exactly correct. Then, they believe that of this total, 22.7 kL (6 kgal) is REDOX process salt cake because of an unexplained gain in measured solids volume of 22.7 kL (6 kgal) which was recorded in the years 1974 to 1993 even though no waste was added to the tank. They ascribe the difference (22.7 kL [6 kgal]) between the measured total solids volume (45.4 kL [12 kgal]) and the volume of salt cake to REDOX process sludge or 22.7 kL (6 kgal).

An alternative way of accounting for the solid waste now in tank 241-SX-115 involves the following analysis and evaluation:

- 24.2. kL (6.4 kgal) solids (4.4 vol% of 549 k L [145 kgal]) of REDOX process HLW produced in 1958 under the conditions of REDOX process Flowsheet No. 5, (Kupfer et al. 1997).

- 37.5 kL (9.9 kgal) solids (4.4 vol% of 855 kL [226 kgal]) of REDOX process HLW produced in 1959 under the conditions of REDOX process Flowsheet No. 6, (Kupfer et al. 1997).

- 101.4 kL (26.8 kgal) of solids (4.4 vol% of 2,309 kL [610 kgal]) of REDOX process HLW produced in 1960 under the conditions of REDOX process Flowsheet No. 6, (Kupfer et al. 1997).

- Negligible volume of REDOX process salt cake added in 1965, i.e., 3 vol% of 7.6 kL (2 kgal) of concentrated REDOX process supernatant liquid.

- Unexplained loss of 117.7 kL (31.1 kgal) of REDOX process sludge in the period 1960 through 1965.

The second alternative, just as the first used by Agnew et al. (1997), accounts for 45.4 kL (12 kgal) of solid waste in tank 241-SX-115. But, in the second case all the solid waste now measured to be in tank 241-SX-115 is assumed to be sludge while Agnew et al. assume an equal mixture of sludge and salt cake. What is the true situation? The answer to this question can only be provided by core sampling and analysis of the solid waste in tank 241-SX-115. The available historical transaction data allow for at least two interpretations of what happened in the past and what is now in the tank.

Expected Solids in Waste

Anderson (1990): R
Agnew et al. (1997): R1, R SltCk
This Evaluation: R

R = Reduction and Oxidation (REDOX) Process high-level waste
R1 = REDOX high-level waste generated between 1952 to 1957
R2 = REDOX high-level waste generated between 1958 to 1966
R SltCk = REDOX Process salt cake waste

Predicted Current Inventory

Agnew et al. (1997)

Waste Type	Waste Volume 45.4 kL (12 kgal)
R1	22.7 kL (6 kgal)
R SltCk	22.7 kL (6 kgal)

Hanlon (1996)

Waste Type	Waste Volume 45.4 kL (12 kgal)
Sludge	

This Evaluation

Waste Type	Waste Volume 45.4 kL (12 kgal)
R (1958 to 1960)	45.4 kL (12 kgal)

D3.2 EVALUATION OF TECHNICAL FLOWSHEET INFORMATION

In Table D3-2 (reproduced from information in Kupfer et al. 1997) are listed compositions for REDOX process HLW produced according to Flowsheets No. 5 and 6. Note that the compositions of REDOX process R1 and R2 waste (Agnew et al. [1997] designations) are listed in Table D2-1 of the best-basis inventory document for tank 241-SX-108 (Kupfer and Schulz 1997).

Table D3-2. Composition of Reduction and Oxidation Process High-Level Waste.[a]

	REDOX process high-level waste Composition *M*	
Analyte	Flowsheet No. 5	Flowsheet No. 6
Al	1.29	0.95
Bi	0	4.9 E-05
Cr	0.17	0.13
Fe	0.0074	0.0075
I	0	4.3 E-05
K	0.0034	0.0034[b]
Mn	0.0034	0.0034[b]
Na	7.1	7.3
NO_3	4.3	3.8
Oxalate	0.0077	0.0080
SO_4	0.023	0.022
U	0.0037[c]	6.7 E-04[c]
Issue Date	8/55	10/60

REDOX = Reduction and oxidation

[a] Adapted from tables in Kupfer et al. (1997)

[b] Not shown on published flowsheet, but $KMnO_4$ usage in REDOX plant is known to have continued until the fall of 1959

[c] Table D2-1, Kupfer et al. (1997).

The composition listed in Table D3-2 for REDOX process Flowsheet No. 6 HLW specifies that the waste contained 0.0034 M $KMnO_4$. The published version of Flowsheet No. 6 does not include any mention of $KMnO_4$; information presented in Kupfer et al. (1997) indicates that $KMnO_4$ was used in the REDOX process through most of 1959. Also, note that REDOX process HLW generated under either the conditions of Flowsheets No. 5 and 6 contained almost identical concentrations of precipitable metals, e.g., Fe, Mn, Bi, and U.

D3.3 PREDICTED WASTE INVENTORIES

This section presents results of an independent assessment of the inventories of the various analytes in tank 241-SX-115 waste. A set of simplified assumptions forms the basis for the independent assessment. The assumptions and observations are based upon best technical judgement pertaining to parameters that can significantly influence tank inventories. These parameters include: (a) correct predictions of contributing waste types, (b) accurate predictions of model flowsheet conditions, fuel processed, and waste volumes, (c) accurate prediction of component solubilities, and (d) accurate predictions of physical parameters such as density, percent solids, void fraction (porosity), etc. Of course, as necessary, the assumptions used can be modified to provide a basis for identifying potential errors and/or missing information that could influence either or both sample- and model-based inventories. The simplified assumptions and observations used for predicting the inventory of several analytes in tank 241-SX-115 are:

1. Only the neutralized REDOX process HLW introduced into tank 241-SX-115 contributed to solids formation. Condensates, water, and waste supernatants, either concentrated or dilute, from other SX Tank Farm tanks or evaporators added to tank 241-SX-115 did not contribute any solid waste to the inventory presently in tank 241-SX-115.

2. For all REDOX process HLW added to tank 241-SX-115 the volume of precipitated solids was 4.4 vol% of the total volume of waste slurry.

3. All Bi, Fe, Mn, Si, and U in the REDOX process HLW added to tank 241-SX-115 precipitated as solid compounds.

4. Aside from Bi, Fe, Mn, Si, and U in the REDOX process HLW, all the other analytes partitioned to some extent between solid and liquid phases.

5. Essentially all solid sodium salts, i.e., salt cake, added to the tank in 1965 dissolved in water and other aqueous solutions which were subsequently added to tank 241-SX-115.

6. The concentration of analytes in the REDOX process sludge in tank 241-SX-115 is assumed to be the same as the average concentration of the same analytes in sludge in tanks 241-S-101 (Kruger et al. [1996]), 241-S-104 (DiCenso et al. [1994]), and 241-S-107 (Simpson et al. [1996]).

7. The waste transaction history and waste volume information for tank 241-SX-115 provided in Brevick et al. (1994) is assumed to be correct.

8. Radiolysis of NO_3 to NO_2 and any additions of nitrite to wastes in tank 241-SX-115 for corrosion control purposes are not accounted for in this independent assessment.

D3.4 PREDICTED INVENTORY OF ANALYTES IN TANK 241-SX-115

Contribution to Inventory from REDOX Process HLW.

D3.4.1 Application of Analytical Data for Wastes in Tanks 241-S-101, 241-S-104, and 241-S-107

Table D3-3 lists concentration data determined for samples of sludge from tanks 241-S-101, 241-S-104, and 241-S-107. Also listed in Table D3-3 are the average concentrations (μg/g) for many of the analytes in these tanks. Convincing arguments made in TCRs for tanks 241-S-101, 241-S-104, and 241-S-107 show that the sludge in these tanks derives solely from REDOX process HLW (Hu et al. 1997). The average concentration (μg/g) of analytes determined in tanks 241-S-101, 241-S-104, and 241-S-107 is believed to also represent the composition of the REDOX process HLW sludge in tank 241-SX-115.

The inventory of various analytes in tank 241-SX-115 is calculated by multiplying each of the average analyte concentrations listed in Table D3-3 by 78,800 kg, the mass of solid waste stated (Agnew et al. 1997) to be in tank 241-SX-115. Results of these computations are shown in Table D3-3. For nonradioactive analytes the formula used is (μg/g) x (1 g/ 1 E+06 μg) x (78,800 kg) = kg. For radionuclides the formula used was (μCi/g) x (1 Ci/ 1 E+06 μCi) x (1,000 g/kg) x (78,800 kg) = Ci.

D3.4.2 Alternative Calculation Method for Inventory of Analytes Assumed to Completely Precipitate

Inventories of iron, manganese, bismuth, and uranium added to tank 241-SX-115 were calculated separately for the years: 1958, 1959, and 1960.

Table D3-3. R1 Sludge Concentration Estimate. (2 Sheets)

Analyte	241-S-101 segments 7U-8L[a] (μg/g)	241-S-104 (total sludge concentration)[b] (μg/g)	241-S-107 segments[c] (μg/g)	Average Concentration[d] (μg/g)	HDW[e] sludge layer concentration for tank 241-SX-115 (μg/g)	Sludge Inventory for tank 241-SX-115 (kg)
Al	127,000	117,000	56,400	100,000	80,700	7,890
Bi	<38.8	<45.7	NR	<42.2	0.414	<3.33
Ca	322	247	234	268	13,200	21.1
Cl	2,050	3,200	1,860	2,370	1,890	187
Cr	2,230	2,350	1,180	1,920	13,200	151
F	<65.7	145	150	120	1.94	9.46
Fe	1,960	1,720	1,160	1,613	16,600	127
Hg	NR	<0.126	NR	<0.126		<0.0099
K	539	300	457	432	487	34.0
La	<19.5	<2.07	NR	<10.8		<0.85
Mn	2,750	1,150	83	1,330	0.792	105
Na	112,000	121,000	60,400	97,800	143,000	7,710
Ni	90.7	56	206	118	1,110	9.3
NO_2	31,100	25,900	34,300	30,433	44,100	2,400
NO_3	119,000	191,000	57,600	122,500	188,000	9,660
Pb	37	29.6	33	33.2	10.2	2.62
PO_4	1,360	<2,190	1,630	1,730	12.2	136
Si	1,360	1,330	1,060	1,250	1,120	98.5
SO_4	897	2,270	1,300	1,489	1,410	117
Sr	456	424	378	420	0	33.0
TIC as CO_3	NR	4,140	NR	4,140	5,220	326
TOC	NR	1,730	NR	1,730	25.9	136
U	7,684	6,690	8,685	7,690	1,050	606

Table D3-3. R1 Sludge Concentration Estimate. (2 Sheets)

Analyte	241-S-101 segments 7U-8L[a] (μg/g)	241-S-104 (total sludge concentration)[b] (μg/g)	241-S-107 segments[c] (μg/g)	Average Concentration[d] (μg/g)	HDW[e] sludge layer concentration for tank 241-SX-115 (μg/g)	Sludge Inventory for tank 241-SX-115 (kg)
Zr	36	33.6	131	66.9	0.0180	5.27
Radionuclides (μCi/g)[f]						
^{90}Sr	NR	301	276	288	343	22,700
^{137}Cs	98	60.5	74	77.5	110	6,110
density (g/ml)	1.77	1.64	1.90	1.77	1.73	1.78

HDW = Hanford Defined Waste
NR = Not reported
REDOX = Reduction oxidation process
R1 = REDOX waste generated between 1952 and 1957
[a] Kruger et al. (1996)
[b] DiCenso et al. (1994)
[c] Statistically determined median R1 sludge concentrations for tank 241-S-107 contained in the attachment to Simpson et al. (1996)
[d] Average of analyte concentrations for tank 241-S-101, 241-S-104, and 241-S-107
[e] Agnew et al. 1997
[f] Radionuclides decayed to January 1, 1994.

These calculations utilized data presented in Tables D3-1 and D3-2. Inventories (kg) of each analyte were calculated as the product of the following factors:

- Volume (kgal) of waste slurry added to tank in respective times periods (Table D3-1)
- Molarity of analyte in waste stream (Table D3-2)
- Atomic weight of analyte (g)
- 1.0 E+03 gal/kgal--conversion factor
- 3.785 L/gal--conversion factor

- Kg/1.0 E+03 g--conversion factor

Results of these calculations are summarized below; in all cases, quantities are given as kg.

1959

Iron:	145 kgal x 0.0074 mole/L x 3.785 L/gal x 1.0 E+03 gal/kgal x kg/1.0 E+03 g x 55.85 g/mole = 227 kg
Manganese:	103 kg
Uranium	483 kg

1959:

Iron:	226 kgal x 0.0074 mole/L x 3.785 L/gal x 1.0 E+03 gal/kgal x kg/1.0 E+03 g x 55.85 g/mole = 354 kg
Manganese:	160 kg
Uranium:	753 kg

1960

Iron:	610 kgal x 0.0075 mole/L x 3.785 L/gal x 1.0 E+03 gal/kgal x kg/1.0 E+03 g x 55.85 g/mole = 967 kg
Bismuth:	23.6 kg
Uranium:	368 kg
Manganese:	431 kg

Total inventories of precipitable metals calculated by the alternate inventory determination method are:

Iron:	1,548 kg
Bismuth:	23.6 kg
Manganese:	694 kg
Uranium:	1,604 kg

But, these totals are for all the iron, bismuth, manganese, and uranium added to tank 241-SX-115. As noted earlier, 117.3 kL (31 kgal) of solid sludge somehow appears to have disappeared from the tank. Taking this loss into account, only 12/43.16 fraction of the original solids remain, or:

Iron:	430 kg
Bismuth:	6.56 kg
Manganese:	193 kg
Uranium:	446 kg

The inventory values calculated for bismuth and manganese are about two to three times the values listed in Table D3-3. The uranium is two-thirds the value in Table D3-3. Such agreement supports use of the average of analyte concentration data for tanks 241-S-101, 241-S-104, and 241-S-107 to estimate the inventory of analytes in the sludge in tank 241-SX-115.

The iron inventory listed in Table D3-3 (127 kg) is only about one-third that calculated from waste volumes and iron concentrations. There are many possible reasons for the difference in iron inventories: flowsheet iron concentrations are too high, iron did not completely precipitate, and there are faulty analyses for iron in sludges in tanks 241-S-101, 241-S-104, and 241-S-107, etc. Apparently, the only way to resolve the issue is to sample and analyze sludge from tank 241-SX-115.

Comments and observations concerning comparison of HDW model and independent assessment inventory predictions for various analytes are also made in this section.

Caveat

The HDW model inventory predictions for tank 241-SX-115 were made on the basis that the solids now in the tank originated from REDOX process HLW and REDOX process salt cake. On the other hand, independent engineering assessments were made on the basis that solids in the tank originated from REDOX process HLW. This difference in prediction bases should always be kept in mind when comparing HDW model predictions to independent assessment values.

Inventory Comparisons

The HDW and the engineering assessment inventories are compared in Table D3-4 and in the observations that follow the table.

Table D3-4. Estimated Analyte Inventories for tank 241-SX-115. (2 Sheets)

Analyte	HDW model[a] (kg)	Independent assessment[b] (kg)
Nonradioactive		
Al	6,360	7,890
Bi	0.0326	<3.33
Ca	270	21.1
Cl	149	187
CO_3	411	326
Cr	1,040	151
F	0.153	9.46
Fe	1,310	127
Hg	0.00492	<0.0099

Table D3-4. Estimated Analyte Inventories for tank 241-SX-115. (2 Sheets)

Analyte	HDW model[a] (kg)	Independent assessment[b] (kg)
K	38.4	34.0
La	5.34 E-08	<0.85
Mn	0.0624	105
Na	11,300	7,710
Ni	87.7	9.3
NO_2	3,480	2,400
NO_3	14,800	9,660
Pb	0.805	2.62
PO_4	0.959	136
Si	88.1	98.5
SO_4	111	117
Sr	NR	33.0
TOC	2.04	136
Zr	0.00142	5.27
Radioactive[c]		
^{90}Sr	27,000 Ci	22,700 Ci
^{137}Cs	8,630 Ci	6,110 Ci
U_{TOTAL}	82.7 kg	606 kg
^{239}Pu	12.4 Ci	NR

HDW = Hanford Defined Waste
NR = Not reported
[a] Agnew et al. (1997)
[b] This Report
[c] Decayed to January 1, 1994.

Observations

Aluminum. The HDW model prediction of the aluminum content of tank 241-SX-115 (6,360 kg) is in very good agreement with that predicted by the independent assessment (7,890 kg). This agreement is somewhat surprising considering that different bases for the waste content of the tank were used for each method. The independent assessment prediction is used as the best-basis inventory value.

Bismuth. The HDW model (Rev. 4) predicts tank 241-SX-115 to contain only 0.0326 kg of bismuth whereas the independent engineering assessment shows the presence of as much as an 100 fold high inventory of bismuth, namely <3.33 kg. The HDW model estimate is considered incorrect because at least some of the REDOX process HLW introduced into tank 241-SX-115 is known to have contained a small, but measurable, concentration of bismuth. The engineering assessment value of 3.33 kg is taken as the best-basis estimate of the bismuth content of tank 241-SX-115.

Chromium. The HDW model predicts the waste in tank 241-SX-115 to contain about six times as much chromium as does the independent assessment, 1,040 kg versus 151 kg. This difference reflects, to some extent, the difference in the amounts of chromium in REDOX process HLW assumed to partition to the solid phase. Also, in the HDW model a significant amount of chromium was contributed to the solids in the tank from the REDOX process salt cake assumed to be present in the tank; the independent assessment is made on the basis that REDOX process salt cake is not present in tank 241-SX-115. The 151 kg value is accepted as the best-basis inventory estimate.

Iron. The independent assessment value for the inventory of iron in tank 241-SX-115 is only about one-tenth the amount predicted to be in the tank by the HDW model. The HDW model assumes that the concentration of iron in the REDOX process HLW added to the tank was a factor of five to six times higher than the published Flowsheet 5 and 6 values, 0.048*M* versus 0.0075 *M*. The value of 127 kg iron is selected as the best-estimate inventory number even though a separate analysis, based upon the volume of waste added to the tank and the estimated concentration of iron in the waste, indicates that the iron content of tank 241-SX-115 could be as high as 1,548 kg.

Manganese. The HDW model (Rev. 4) predicts that tank 241-SX-115 contains only 0.0624 kg of manganese. This value is absurdly low considering the presence of at least 0.0034*M* manganese in most of the REDOX process HLW added to the tank. The 0.0624 kg value either reflects an incorrect calculation or an erroneous assumption about the solubility of manganese. Manganese surely would have precipitated when REDOX process HLW was made alkaline. The best-estimate value for the manganese inventory of tank 241-SX-115 is 105 kg, a value derived in the independent assessment and one in reasonable agreement with a separate analysis, based upon the volume of waste added to the tank and the estimated concentration of manganese in the waste, which indicates the manganese content of tank 241-SX-115 could be as high as 694 kg.

Nickel. The independent assessment predicts only 9.3 kg of nickel in tank 241-SX-115 whereas the HDW model prediction is 87.7 kg. The HDW model nickel inventory reflects an incorrect assumption concerning the amount of corrosion of stainless steel equipment in the REDOX plant.

Nitrate. The independent assessment predicts tank 241-SX-115 to contain only about half as much nitrate as predicted by the HDW model. This result is the expected one since the salt cake assumed to be present in the HDW model analysis should have contributed much nitrate. The independent assessment value of 9,660 kg nitrate is taken as the best-basis estimate.

Potassium. The independent assessment predicts tank 241-SX-115 to contain 34.0 kg of potassium, whereas the HDW model predicts 38.4 kg of potassium are present. The HDW model did not take into account potassium added as $KMnO_4$ (see discussion on manganese); in spite of this fact, the HDW model estimate is in excellent agreement with the value obtained in the independent engineering assessment. The independent assessment value of 34.0 kg is selected as the best-basis estimate of the inventory of potassium in tank 241-SX-115.

Sodium. The independent engineering assessment predicts tank 241-SX-115 to contain slightly over half as much sodium as predicted by the HDW model. This result which parallels the situation with the nitrate content of this tank is not unexpected since the salt cake, assumed to be present in the HDW model base assumption, would contain considerable amounts of both sodium and nitrate. In any event, the engineering assessment value of 7,710 kg sodium is taken as the best-basis estimate.

Sulfate. The sulfate content of the solids in tank 241-SX-115 as determined by the independent engineering assessment is 117 kg. This value is in excellent agreement with the value of 111 kg of sulfate predicted by the HDW model. Such agreement must be considered fortuitous considering that different prediction bases were used in the two prediction approaches. The value of 117 kg of sulfate is chosen as the best-basis estimate.

Uranium. The HDW model predicts the waste in tank 241-SX-115 to only contain 82.7 kg of uranium, whereas the independent assessment, based upon the average analytically determined uranium content of sludges in tanks 241-S-101, 241-S-104, and 241-S-107 predicts tank 241-SX-112 to contain 606 kg of uranium. On the other hand, an engineering assessment based upon the volume of REDOX process HLW added to the tank leads to a calculated uranium inventory of 1,609 kg. The value of 606 kg uranium is selected as the best-basis inventory estimate.

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. This charge balance approach is consistent with that used by Agnew et al. (1997).

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

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

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

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-SX-115 was performed, and a best basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task. The following information was utilized as part of this evaluation:

- Inventory estimates generated by HDW model (Agnew et al. 1997)
- Average of analyte concentrations in REDOX process HLW sludges in tanks 241-S-101 (Kruger et al. 1996), 241-S-104 (DiCenso et al. 1994), and 241-S-107 (Simpson et al. 1996)
- Inventory estimates generated by a tank-specific assessment process utilizing chemical process flowsheets and a detailed historical waste transaction data base.

The results from this evaluation support using a predicted inventory based primarily on results from a tank-specific assessment process utilizing the average of analyte concentrations for REDOX process waste sludges in tanks 241-S-101, 241-S-104, and 241-S-107 for the following reasons:

1. The waste in tank 241-SX-115 has not been analyzed; it is not possible to use a predicted inventory based on analytical results.

2. The tank-specific assessment correctly predicts, based upon a careful and meticulous review of historical waste transaction records, that only REDOX process HLW of all the wastes introduced into tank 241-SX-115 contributed to the solid waste in the tank.

3. The HDW model incorrectly attributes part of the solids now in tank 241-SX-115 to salt cake precipitated from one addition of concentrated REDOX process HLW supernatant. Such analysis ignores the large volumes of water that were added to the tank subsequent to precipitation of any salt cake solids. Experimental evidence exists (Schulz 1980) that strongly suggests any precipitated salt cake would have readily dissolved.

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. For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10.

The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (TCD) (LMHC 1998) for the most current inventory values.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-SX-115 (Effective March 11, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C)[1]	Comment
Al	7,890	E	
Bi	3.33	E	
Ca	21.1	E	
Cl	187	E	
TIC as CO_3	326	E	
Cr	151	E	
F	9.46	E	
Fe	127	E	
Hg	0	E	Simpson 1998
K	34.0	E	
La	0	E	None expected
Mn	105	E	
Na	7,710	E	
Ni	9.3	E	
NO_2	2,400	E	
NO_3	9,660	E	
OH_{TOTAL}	17,200	C	
Pb	2.62	E	
PO_4	136	E	
Si	98.5	E	
SO_4	117	E	
Sr	33.0	E	
TOC	136	E	

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-SX-115 (Effective March 11, 1997). (2 Sheets)

Analyte	Total inventory (kg)	Basis (S, M, E, or C)[1]	Comment
U_{TOTAL}	606	E	
Zr	5.27	E	

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

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-SX-115 Decayed to January 1, 1994 (Effective March 11, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	5.73	M	
^{14}C	0.311	M	
^{59}Ni	0.492	M	
^{60}Co	0.254	M	
^{63}Ni	46.5	M	
^{79}Se	0.169	M	
^{90}Sr	22,700	E	
^{90}Y	22,700	E	Referenced to ^{90}Sr
^{93}Zr	0.798	M	
^{93m}Nb	0.648	M	
^{99}Tc	2.38	M	
^{106}Ru	5.41E-05	M	
^{113m}Cd	1.21	M	
^{125}Sb	0.865	M	
^{126}Sn	0.259	M	
^{129}I	0.00452	M	
^{134}Cs	0.0529	M	
^{137}Cs	6,110	E	
^{137m}Ba	5,780	E	Referenced to ^{137}Cs
^{151}Sm	602	M	
^{152}Eu	0.360	M	
^{154}Eu	6.08	M	
^{155}Eu	17.7	M	
^{226}Ra	3.52E-05	M	
^{227}Ac	1.71E-04	M	
^{228}Ra	3.58E-04	M	
^{229}Th	8.62E-06	M	

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-SX-115 Decayed to January 1, 1994 (Effective March 11, 1997). (2 Sheets)

Analyte	Total inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{231}Pa	2.51E-04	M	
^{232}Th	4.79E-06	M	
^{232}U	0.0117	E/M	Based on total uranium ratioed to HDW estimates for U isotopes.
^{233}U	0.0448	E/M	Based on total uranium ratioed to HDW estimates for U isotopes.
^{234}U	0.231	E/M	Based on total uranium ratioed to HDW estimates for U isotopes.
^{235}U	0.00939	E/M	Based on total uranium ratioed to HDW estimates for U isotopes.
^{236}U	0.00908	E/M	Based on total uranium ratioed to HDW estimates for U isotopes.
^{237}Np	0.0111	M	
^{238}Pu	0.204	M	
^{238}U	0.202	E/M	Based on total uranium ratioed to HDW estimates for U isotopes.
^{239}Pu	12.4	M	
^{240}Pu	1.82	M	
^{241}Am	2.83	M	
^{241}Pu	11.8	M	
^{242}Cm	0.00369	M	
^{242}Pu	5.59E-05	M	
^{243}Am	8.63E-05	M	
^{243}Cm	8.45E-05	M	
^{244}Cm	6.57E-05	M	

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

D5.0 APPENDIX D REFERENCES

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