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ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 635532

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 []	Brett C. Simpson, Data Assessment and Interpretation, R2-12, 373-5915	[] Yes [X] No	08/07/97
	6. Project Title/No./Work Order No. Tank 241-C-112	7. Bldg./Sys./Fac. No. 241-C-112	8. Approval Designator N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-SD-WM-ER-541, Rev. 1	10. Related ECN No(s). ECN-635471	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.

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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)

See attached distribution.

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DATE: AUG 25 1997
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ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1) ECN-635532

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. B.C. Simpson	Brett Simpson	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-C-112

Brett C. Simpson
Lockheed Martin Hanford, Corp., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: ECN-635532 UC: 2070
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Key Words: Waste Characterization, Single-Shell Tank, SST, Tank 241-C-112, 241-C-112, C-112, C 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-C-112. This report supports the requirements of the Tri-Party Agreement Milestone M-44-05.

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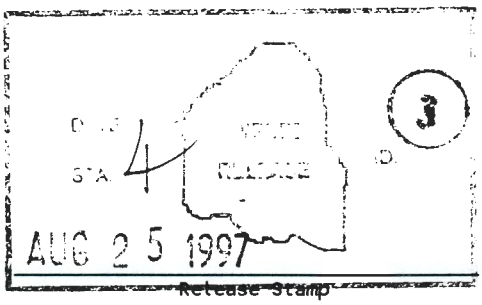
Kara J Broz 8/20/97
Release Approval Date



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(2) Title
Tank Characterization Report for Single-Shell Tank 241-C-112

CHANGE CONTROL RECORD

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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-C-112

Analyte	Total inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	11,800	S	
Bi	740	M	
Ca	16,000	S	
Cl^-	736	S	
TIC as CO_3^{-2}	22,600	S	
Cr	187	S	
F^-	469	S	
Fe	16,200	S	

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-112

Analyte	Total inventory (kg)	Basis (S, M, or E)[1]	Comment
Hg	39.6	M	
K	406	S	
La	39	S	
Mn	192	S	
Na	76,700	S	
Ni	9,190	S	
NO_2^-	36,200	S	
NO_3^-	48,300	S	
OH^-	29,000	E	From charge balance
Pb	1,420	S	
P as PO_4^{-3}	58,400	S	
Si	1,650	S	
SO_4^{-2}	9,310	S	
Sr	207	S	
TOC	1,450	S	
U_{TOTAL}	36,400	S	
Zr	18,9	S	

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

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-C-112 Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{3}H	28.1	S	
^{14}C	2.73	S	
^{59}Ni	9.4	S	
^{60}Co	0.0458	M	
^{63}Ni	921	S	
^{79}Se	0.239	S	
^{90}Sr	1250000	S	
^{90}Y	1250000	S	based on ^{90}Sr
^{93m}Nb	0.172	M	
^{93}Zr	0.204	M	
^{99}Tc	79.7	S	
^{106}Ru	1.16 E-05	M	
^{113m}Cd	0.509	M	
^{125}Sb	0.056	M	
^{126}Sn	0.0656	M	
^{129}I	0.0024	M	
^{134}Cs	0.0203	M	
^{137m}Ba	233000	S	based on ^{137}Cs
^{137}Cs	246000	S	
^{151}Sm	161	M	
^{152}Eu	0.738	M	
^{154}Eu	630	S	
^{155}Eu	825	S	
^{226}Ra	4.71 E-05	M	
^{227}Ac	0.0021	M	
^{228}Ra	6.11 E-04	M	
^{229}Th	2.77 E-04	M	
^{231}Pa	0.00289	M	
^{232}Th	2.85 E-05	M	
^{232}U	0.0316	M	
^{233}U	0.122	M	
^{234}U	1.63	M	

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-C-112 Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{235}U	0.0715	M	
^{236}U	0.0202	M	
^{237}Np	0.347	S	
^{238}Pu	5.54	S	
^{238}U	9.41	M	
$^{239/240}Pu$	69.5	S	
^{241}Am	219	S	
^{241}Pu	165	M	
^{242}Cm	0.097	S	
^{242}Pu	6.02 E-04	M	
^{243}Am	1.17 E-04	M	
^{243}Cm	0.877	S	
^{244}Cm	2.72 E-04	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-C-112

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-C-112

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 chemical information for tank 241-C-112 was performed, and a best-basis inventory was established. This work follows the methodology that was established by the standard inventory task.

D1.0 IDENTIFY/COMPILE INVENTORY SOURCES

The inventory sources identified for this best-basis effort include the following:

- Sample data from a 1992 push-mode core sample consisting of three cores: 34, 35, and 36 (Bell 1993).
- The HDW model document (Agnew et al. 1997a) provides tank content estimates in terms of component concentrations and inventories.

D2.0 COMPARE COMPONENT INVENTORY VALUES AND NOTE SIGNIFICANT DIFFERENCES

Tables D-1 and D-2 compare the HDW model inventories and sample-based inventories. (The chemical species are reported without charge designation per the best-basis inventory convention). The tank volume used to generate the HDW inventory is 394 kL (104 kgal) waste (Agnew et al. 1997a). Hanlon (1997) also indicates 394 kL (104 kgal) of waste. Both sources indicate the waste is all sludge. The HDW model density for the sludge waste is estimated to be 1.37 g/mL. The sample-based inventories are based on a volume of 394 kL of solids at a density of 1.65 g/mL.

Table D-1. Sampling-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-C-112.

Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)	Analyte	Sample[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)
Al	11,800	9,550	NO_3^-	48,300	5,940
Bi	n/r	740	OH^-	n/r	26,800
Ca	16,000	9,230	Pb	1,420	2,080
Cl^-	736	550	P as PO_4^{-3}	58,600	9,240
Cr	187	23.6	Si	1,650	380
F^-	469	150	SO_4^{-2}	9,310	742
Fe	16,200	8,490	TIC as CO_3^{-2}	22,600	n/r
$Fe(CN)_6^{-4}$	2,150[3]	26,300	TOC	1,450	7,100
K	406	141	U_{total}	36,400	4,940
Na	76,700	31,000	Zr	18.9	1.24
Ni	9,190	10,500	H_2O (Wt%)	41.6	65.2
NO_2^-	36,200	30,700	density (kg/L)	1.65	1.37

Notes:

n/r = not reported

[1]See Appendix B.
[2]Agnew et al. (1997a)
[3]The estimate was derived from cyanide results.

Table D-2. Sampling and Predicted Inventory Estimates for Radioactive Components in Tank 241-C-112.

Analyte	Sampling[1] Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)	Analyte	Sampling[1] Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)
^{79}Se	0.239	0.043	^{237}Np	0.347	0.0078
^{99}Tc	79.7	1.27	^{238}Pu	5.54	2.21
^{90}Sr	1,300,000	245,000	$^{239/240}Pu$	69.5	139
^{137}Cs	257,000	241,000	^{241}Am	219	5.14
^{155}Eu	825	52.1	^{154}Eu	630[3]	1.01
^{59}Ni	9.4	3.57	^{63}Ni	921	325
^{242}Cm	0.097	0.0015	$^{243/244}Cm$	0.877	0.00085
^{3}H	28.1	1.01	^{14}C	2.73	0.183

Notes:

[1]See Appendix B.
[2]Agnew et al. (1997a)
[3]Segment level result

D3.0 REVIEW AND EVALUATION OF COMPONENT INVENTORIES

D3.1 WASTE HISTORY TANK 241-C-112

This section is a brief synopsis of the most relevant facts regarding the operating history of this tank. Appendix A provides a more detailed description of the waste history for tank 241-C-112.

D3.1.1 Process History for Tank 241-C-112

The first type of waste that tank 241-C-112 received and stored was 1C1 waste from the bismuth phosphate process (1946 to 1952). The supernatant was disposed to tank 241-B-106 in 1952, leaving a heel of 57 kL (15 kgal) of solids and 8 kL (2 kgal) of liquid. The tank was refilled with unscavenged uranium recovery (UR) waste in 1953 and 1954 (Anderson 1990). In late 1955, the supernatant in tank 241-C-112 was transferred to tank 241-C-104. From 1955 to 1958, tank 241-C-112 was used as a primary settling tank for in-tank ferrocyanide scavenging. During ferrocyanide scavenging operations, waste was not cascaded through the

tank 241-C-110, -111, and -112 cascade. The pH was adjusted with HNO_3 and/or NaOH, and $Fe(CN)^{-4}_6$ and Ni^{+2} ions were added to precipitate ^{137}Cs (Sloat 1954). This involved the repeated transfer of scavenged waste into the tank to allow ^{137}Cs and ^{90}Sr bearing particulate material to settle; the resulting decontaminated supernatant was transferred from the tank to cribs. Furthermore, in addition to ^{137}Cs scavenging with ferrocyanide, ^{90}Sr was scavenged using $Ca_3(PO_4)_2$ and $Sr_3(PO_4)_2$ (Sloat 1954 and Sloat 1955). This is the period when tank 241-C-112 accumulated most of its solids contents.

After ferrocyanide scavenging was completed, tank 241-C-112 received PUREX cladding waste (CWP), which was later pumped out of the tank. In the third and fourth quarters of 1960, a total of 996 kL (263 kgal) of highly alkaline cladding waste was added to the tank, but the reported solids inventory (174 kL [46 kgal]) did not change (Anderson 1990 and Agnew 1997a). Cladding waste solids would have settled on top of the ferrocyanide sludge already present.

Several small transfers with relatively high concentrations of ^{90}Sr occurred after 1958. Waste from the strontium semiworks/hot semiworks was added to the tank with the total volume listed as 2,070 kL (547 kgal) at the end of 1962. (The reported solids inventory was still only 174 kL [46 kgal].) The listed volumes for the first quarter report in 1965 are a total volume of 2,040 kL (538 kgal) and a solids volume of 485 kL (128 kgal) (Anderson 1990). This solids level measurement was apparently the first since additional waste was added to the tank following the last scavenging pump in 1958.

D3.1.2 Major Analytes of Waste Types Transferred into Tank 241-C-112

First-cycle decontamination (1C1) waste entered tank 241-C-112 through cascade lines. This waste was produced by the bismuth phosphate process at B-Plant. Analytes characteristic of 1C1 waste were expected to be present in concentrations around 10,000 μg/g and included iron, bismuth, and phosphate (Schneider 1951 and Agnew et al. 1997a). The 1C1 waste, if present, is expected to be located in the dished region at the tank bottom. Transfer records indicate the sludge was discharged there before the additions of unscavanged UR waste to the tank were made (Agnew et al. 1997b).

The scavenged waste was allowed to settle, and the supernatant was decanted to a crib leaving an accumulation of solids in tank 241-C-112. These solids had a much greater activity than the 1C1 waste from the scavenged ^{137}Cs and ^{90}Sr present. Other compositional changes included much higher levels of calcium, nonradioactive strontium, and nickel than in 1C1 waste (Schneider 1951, Agnew et al. 1997a, Sloat 1954, Sloat 1955, and Schmidt and Stedwell 1955). These solids make up the majority of the tank solids volume and are located on top of the 1C1 sludge waste.

The PUREX cladding waste, produced during the dissolution of aluminum fuel cladding at PUREX, will have a much different composition than 1C1 waste or ferrocyanide scavenging

waste. Cladding waste has comparatively high (greater than 100,000 μg/g) aluminum concentrations and is low in bismuth, phosphate, and other analytes characteristic of 1C and scavenging wastes (Schneider 1951 and Agnew et al. 1997a). The HDW model assumes that CWP waste did not contribute to the solids formation in the tank. However, Hill et al. (1995) predicts CWP to be the tertiary waste type in the tank. Because of uncertainty regarding the flow properties of the waste in tank-to-tank transfers, the contribution of CWP to the tank is not well defined.

Hot semiworks waste was the effluent from strontium recovery operations. It contained elevated concentrations of lead (estimated at greater than 20,000 μg/g) and ^{90}Sr (estimated at greater than 10,000 μCi/g) that distinguished it from the other wastes present. It lacked bismuth, aluminum, nickel, and calcium. Very little hot semiworks waste was generated. This waste is assumed to be the top layer of waste (Agnew et al. 1997a).

D3.2 CONTRIBUTING WASTE TYPES

There are two interpretations of the waste types that contribute to the waste inventory in tank 241-C-112. The interpretations agree about the main waste contributors but differ on the smaller ones. The HDW model (Agnew et al. 1997a) predicts the tank contains a total of 394 kL of solid waste made up of the following five waste types:

1. 57 kL 1C1 waste from the $BiPO_4$ process
2. 273 kL of ferrocyanide sludge produced by in-tank/in-farm scavenging (TFeCN) of which 15 kL is classified as unknown
3. 49 kL CWP1
4. 11 kL CWP2
5. 4 kL of hot semiworks

The sort on radioactive waste type model (Hill et al. 1995) lists four waste types contributing to tank 241-C-112 solids. No quantification is made of their contribution.

1. Tributyl phosphate uranium-extraction process at U Plant (TBP-F) was the primary waste type.
2. 1C1 from the $BiPO_4$ process at B and T Plants was a secondary waste type.
3. PUREX Plant aluminum fuel cladding waste was a tertiary waste type.

4. Ion exchange from the cesium recovery process at B Plant was another waste type.

D3.3 EVALUATION OF TANK WASTE VOLUME

The tank has a capacity of 2,010 kL (530 kgal). Hanlon (1997) reports an estimated volume of 394 kL (104 kgal) of waste consisting entirely of sludge. No description of sludge types or source is given. The analytical and surveillance data suggest the sludge is heterogeneous and has significantly different chemical compositions depending on waste depth. The current surveillance readings report a waste level at 85.4 cm (33.6 in.) which corresponds to approximately 397 kL (105 kgal) of total waste supporting the Hanlon (1997) estimate.

D3.4 ASSUMPTIONS USED IN THIS EVALUATION

For this evaluation, the following assumptions and observations were made:

1. The tank volume listed is equal to the value in Hanlon (1997), 394 kL. The material has a density of 1.65 g/mL. Tank 241-C-112 waste is 100 percent sludge.

2. The core composite mean values were considered adequate and appropriate for calculation of an overall inventory.

3. No aging or degradation of components such as ferrocyanide or nitrate was assumed. All radionuclides were decayed to January 1, 1994.

D3.5 ESTIMATED COMPONENT INVENTORIES

The chemical inventory for selected constituents in tank 241-C-112 is estimated from the assumed sludge volume. Table D-1 shows the resulting inventory estimates. The inventory estimated by the HDW model is included for comparison. Discrepancies between HDW model inventories and data-derived inventories were noted; possible reasons for the discrepancies are explained below.

Aluminum. The HDW model and sample data estimates are in good agreement and have an RPD of 21 percent. The aluminum concentration in the tank is highly variable (RSD of the mean = 65 percent) as expected from the tank's process history. The HDW model indicates four general waste types contributing to the sludge in tank 241-C-112. Two waste types (1C1 and CWP1) have aluminum concentrations at or above one weight percent. There was sufficient CWP1 in the tank to account for the aluminum concentrations observed. The higher aluminum concentration locations on top of the TFeCN waste also agree with the process

history. However, CWP1 has extremely high (approximately 10 weight percent) aluminum concentrations. Although the sample data indicates a decrease in aluminum as a function of depth in the waste, the initial concentrations are not as high as other tanks with cladding waste, thereby suggesting mixing or dilution of the waste. The CWP1 may have been principally a supernatant transfer, thus there may have been signficant soluble aluminum that was transferred which precipitated from the change in pH. There appears to be an incomplete description of the solubility behavior for this analyte. In further agreement with process history, aluminum concentration, as a function of depth through the tank sample data, decreases to small concentrations where the HDW model predicts waste types that have much smaller concentrations or no aluminum present.

Calcium. The HDW model appears to quantify the calcium inventory acceptably, with an RPD of 53 percent with the sample-based estimate. The calcium data appear to be much less variable with an RSD of 17.4 percent. Calcium was widely used in the ferrocyanide scavenging process, and substantial documentation exists to quantify its use and distribution (General Electric 1958). No strong trends in concentration as a function of depth were noted when inspecting the data.

Ferrocyanide. Very little, if any, ferrocyanide appears to remain after 40 years; however, some cyanide is marginally detectable. Abundant evidence supports it was present in the past (elevated nickel and calcium concentrations, high ^{137}Cs activity, and extensive process documentation). Little cyanide is detectable, and only very modest exotherms (less than 120 J/g dry) are observed, thereby strongly suggesting the ferrocyanide has degraded and supporting the waste aging hypothesis indicated by Lilga et al. (1992, 1993, 1994, 1995, and 1996).

Iron. Iron was present in all waste types added to tank 241-C-112. Sample data indicates it is widely distributed through the tank, vertically within a core and horizontally between cores. Iron was a principal component in the ferrocyanide scavenging and bismuth phosphate processes. The reason for the difference between the iron inventories, derived from sample data and HDW model estimate, is not clear. The observed sample concentrations are highly variable, and sample data values range from 7,500 μg/g to 44,500 μg/g. However, the relative standard deviation (RSD) of the mean was 6.2 percent, suggesting a strong central tendency. This discrepancy, coupled with the difference in densities used in estimates, may be responsible for most of the observed difference.

Lead. Process history suggests a small amount of lead is present in a relatively high concentration. Evidence from sample data supports this description. The sample data and HDW model estimates agree relatively well (RPD = 37.7 percent). An inspection of sample data shows lead is irregularly distributed as a function of depth and from side-to-side in the tank (RSD = 52 percent). A small amount of waste highly concentrated in lead (such as the hot semiworks waste), together with modest tank transfer activity, may account for the observed behavior.

Lanthanum and manganese. Sample data show traces of lanthanum and manganese, suggesting impurities in the process chemicals or mixing with waste types that contained these materials. They are not indicated as principal process chemicals in the waste types added to tank 241-C-112.

Nickel. The HDW model and sample data estimates indicate elevated concentrations and inventories of nickel and close agreement regarding the magnitude of the nickel inventory (RPD = 13.4 percent). The nickel precipitates in the waste are very insoluble and may not be fully quantitated by the acid digestion preparation. However, for this analyte, the fusion results are suspect because of possible cross-contamination from the fusion preparation (nickel crucible use). Therefore, acid digestion results were used to estimate the inventory and may understate the nickel concentration. The acid digestion results show an RSD of 25.4 percent, suggesting moderate to high variability.

Nitrite. The HDW model and sample data estimates are in reasonable agreement (RPD = 16.4 percent). There is modest variability with these measurements (RSD of the mean = 13.2 percent).

Nitrate, phosphate (phosphorous), and sodium. Substantial differences are observed between the HDW model and sampling data estimates. These differences may be attributed to source term discrepancies and assumptions regarding the distribution of all three anions and assumptions regarding the possible decomposition of nitrate in the HDW model. The sample data for these analytes are not highly variable (RSD of the mean for nitrate = 12.6 percent; phosphorous = 25 percent; sodium = 2.5 percent). Phosphate is much more variable because of its solubility properties (RSD = 41.5 percent).

Silicon. Silicon is not indicated as a principal process chemical in any wastes proposed as depositing solids, except for CWP. Substantial differences are observed between the HDW model and sampling data estimates. These differences may be attributed to source term discrepancies and assumptions regarding the distribution of this analyte. The concentration and distribution behavior of silicon matches well with the elevated aluminum concentrations observed. The concentration of silicon is less variable than aluminum (RSD of the mean = 24.1 percent) and depends on the sample preparation method (only the fusion preparation appears to fully quantitate silicon). These corresponding behaviors suggest that aluminum and silicon were deposited together.

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. (1997a).

Strontium and strontium-90. Sample data show traces of strontium in the waste. Calcium phosphate and strontium phosphate precipitations were used to scavenge ^{90}Sr from tank 241-C-112 waste (Sloat 1954 and 1955). Strontium impurities in the process chemicals or slight mixing with wastes containing strontium may have also contributed to the nonradioactive strontium in tank 241-C-112 waste.

For ^{90}Sr, substantial differences were observed between the HDW model and sampling data estimates. The sample-based inventory is five times the HDW model inventory. This difference may be attributed to the distribution of ^{90}Sr observed in the tank. Elevated ^{90}Sr levels were observed in the wastes, with extremely high values (400 to 1,300 μCi/g) found on the tops of cores 34 and 36. Core 35 had an average concentration of 3,200 μCi/g. Core 34 concentrations remained very high (averaging over 1,000 μCi/g), while in core 36 they decreased as a function of depth but remained relatively high (averaging approximately 150 μCi/g).

This behavior was expected from the process history associated with this tank. Hot semiworks waste was believed to have very high concentrations of ^{90}Sr. Furthermore, in addition to ^{137}Cs scavenging with ferrocyanide, ^{90}Sr was scavenged using $Ca_3(PO_4)_2$ and $Sr_3(PO_4)_2$, suggesting that the strontium and ^{90}Sr concentrations in these wastes would be higher than those observed for bismuth phosphate, cladding waste, or uranium recovery waste.

Sulfate. The sample data derived inventory for sulfate is an order of magnitude higher than the HDW model predicted inventory. In the HDW model, sulfate was found in modest concentrations in the majority of waste types added to tank 241-C-112. It was a process chemical used in the ferrocyanide scavenging campaign. The reason for the difference is probably the solubility assumptions made regarding sulfate in the HDW model. The HDW model assumes no sulfate precipitates with the waste solids (that is, it remains in the interstitial liquids). The sample data ranges from 7,800 μg/g to 13,500 μg/g with an RSD of the mean of about 11 percent; therefore, its distribution behavior does not seem to be contributing to the discrepancy.

Uranium. Uranium values from sample data results indicate a U inventory seven times the amount reported in the HDW model. The higher U concentrations in subsegments 2B and 2C of core 36 indicate mixing with, or scavenging of, uranium bearing waste. The CWP1 waste added to the scavenged waste from tank 241-C-105 could contain substantial concentrations of uranium from dissolution of the fuel core material during decladding. Substantial variability is associated with the sample data (RSD of the mean = 76 percent). The differences observed between the estimates and the sample data behavior may be attributed to significant source term discrepancies in the scavenging campaign and assumptions regarding the solubility/mobility of uranium in the tank farms.

Cesium-137. The HDW model and sample data estimates for the inventory of ^{137}Cs are close (RPD = 6.4 percent). However, there is significant (RSD = 100 percent) variability associated with the data.

D4.0 BEST-BASIS INVENTORY ESTIMATE

As part of this effort, an evaluation of available chemical information for tank 241-C-112 was performed and included the following. .

- The inventory estimate generated by the HDW model (Agnew et al. 1997a)
- An inventory evaluation from 1992 core sample data

Based on this evaluation, a best-basis inventory was developed for tank 241-C-112 (see Tables D-3 and D-4). The sample-based inventory was chosen as the best basis for most analytes for the following reasons:

- Sample-based data trends for specific analytes (aluminum, calcium, lead, nickel, ^{137}Cs, and ^{90}Sr) support the profile suggested in the waste transfer records.
- There is no independent data source from which to derive an inventory.

Several assumptions made in the HDW model are questionable for this tank. These assumptions include the following.

- Assumption of little or no U in any UR scavenged waste
- Inadequate source term and/or solubility descriptions for several principal analytes (sodium, nitrate, uranium, sulfate, and phosphate).
- For those analytes where no values were available from the sample-based inventory, HDW model values were used.

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. 1997a). The best-basis value for any one analyte

may be either a model result or a sample or engineering assessment-based result if available. (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10.

Table D-3. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-112, Effective May 31, 1997 (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, E or C)[1]	Comment
Al	11,800	S	
Bi	740	M	
Ca	16,000	S	
Cl	736	S	
TIC as CO_3	22,600	S	
Cr	187	S	
F	469	S	
Fe	16,200	S	
Hg	39.6	M	
K	406	S	
La	39	S	
Mn	192	S	
Na	76,700	S	
Ni	9,190	S	
NO_2	36,200	S	
NO_3	48,300	S	
OH	51,900	C	From charge balance
Pb	1,420	S	
P as PO_4	58,400	S	
Si	1,650	S	
SO_4	9,310	S	
Sr	207	S	
TOC	1,450	S	

Table D-3. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-112, Effective May 31, 1997 (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, E or C)[1]	Comment
U_{TOTAL}	36,400	S	
Zr	18.9	S	

Note:

[1]S = sample-based (see Appendix B), 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-C-112 Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{3}H	28.1	S	
^{14}C	2.73	S	
^{59}Ni	9.4	S	
^{60}Co	0.0458	M	
^{63}Ni	921	S	
^{79}Se	0.239	S	
^{90}Sr	1250000	S	
^{90}Y	1250000	S	based on ^{90}Sr
^{93m}Nb	0.172	M	
^{93}Zr	0.204	M	
^{99}Tc	79.7	S	
^{106}Ru	1.16 E-05	M	
^{113m}Cd	0.509	M	
^{125}Sb	0.056	M	
^{126}Sn	0.0656	M	
^{129}I	0.0024	M	
^{134}Cs	0.0203	M	
^{137m}Ba	233000	S	based on ^{137}Cs
^{137}Cs	246000	S	
^{151}Sm	161	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-C-112 Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{152}Eu	0.738	M	
^{154}Eu	630	S	
^{155}Eu	825	S	
^{226}Ra	4.71 E-05	M	
^{227}Ac	0.0021	M	
^{228}Ra	6.11 E-04	M	
^{229}Th	2.77 E-04	M	
^{231}Pa	0.00289	M	
^{232}Th	2.85 E-05	M	
^{232}U	0.0316	M	
^{233}U	0.122	M	
^{234}U	1.63	M	
^{235}U	0.0715	M	
^{236}U	0.0202	M	
^{237}Np	0.347	S	
^{238}Pu	5.54	S	
^{238}U	9.41	M	
$^{239/240}Pu$	69.5	S	
^{241}Am	219	S	
^{241}Pu	165	M	
^{242}Cm	0.097	S	
^{242}Pu	6.02 E-04	M	
^{243}Am	1.17 E-04	M	
^{243}Cm	0.877	S	
^{244}Cm	2.72 E-04	M	

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

D5.0 APPENDIX D REFERENCES

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. FitzPatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997a, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, LA-UR-96-3860, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

Agnew, S. F., P. Baca, R. A. Corbin, T. B. Duran, and K. A. Jurgensen, 1997b, *Waste Status and Transaction Record Summary, WSTRS Rev. 4*, LA-UR-97-311, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

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

Bell, M. L., 1993, *Single-Shell Tank Waste Characterization Project and Safety Analysis Project, Core 34, 35, and 36, Tank 241-C-112*, WHC-SD-WM-DP-026, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

General Electric, 1958, *Record of Scavenged TBP Waste*, General Electric Company, Richland, Washington

Hanlon, B. M., 1997, *Waste Tank Summary Report for Month Ending February 28, 1997*, HNF-EP-0182-107, Lockheed Martin Hanford Corporation, 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, 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.

Kupfer, M. J., A. L. Boldt, B. A. Higley, L. W. Shelton, R. A. Watrous, S. L. Lambert, D. E. Place, R. M. Orme, G. L. Borsheim, N. G. Colton, M. D. LeClair, D. Hedengren, R. T. Winward, and W. W. Schulz, 1996, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

Lilga, M. A., M. R. Lumetta, W. F. Reimath, R. A. Romine, and G. F. Schiefelbein, 1992, *Ferrocyanide Safety Project, Subtask 3.4, Aging Studies FY 1992, Annual Report*, PNL-8387, Pacific Northwest Laboratory, Richland, Washington.

Lilga, M. A., M. R. Lumetta, and G. F. Schiefelbein, 1993, *Ferrocyanide Safety Project, Task 3 Ferrocyanide Aging Studies FY 1993 Annual Report*, PNL-8888, Pacific Northwest Laboratory, Richland, Washington.

Lilga, M. A., E. V. Aldersen, D. J. Kowalski, M. R. Lumetta, and G. F. Schiefelbein, 1994, *Ferrocyanide Safety Project, Task 3 Ferrocyanide Aging Studies FY 1994 Annual Report*, PNL-10126, Pacific Northwest Laboratory, Richland, Washington.

Lilga, M. A., E. V. Aldersen, R. T. Hallen, M. O. Hogan, T. L. Hubler, G. L. Jones, D. J. Kowalski, M. R. Lumetta, G. F. Schiefelbein, and M. R. Telander, 1995, *Ferrocyanide Safety Project: Ferrocyanide Aging Studies - FY 1995 Annual Report*, PNL-10713, Pacific Northwest Laboratory, Richland, Washington.

Lilga, M. A., R. T. Hallen, E. V. Aldersen, M. O. Hogan, T. L. Hubler, G. L. Jones, D. J. Kowalski, M. R. Lumetta, W. F. Riemath, R. A. Romine, G. F. Schiefelbein, and M. R. Telander, 1996, *Ferrocyanide Safety Project: Ferrocyanide Aging Studies - Final Report*, PNNL-11211, Pacific Northwest National Laboratory, Richland, Washington.

Schmidt, W. C., and M. J. Stedwell, 1954, *Production Test 221-T-18 Scavenging of First Cycle Waste*, HW-33252, General Electric Company, Richland, Washington.

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

Sloat, R. J., 1954, *TBP Plant Nickel Ferrocyanide Scavenging Flowsheet*, HW-30399, General Electric Company, Richland, Washington.

Sloat, R. J., 1955, *In-Farm Scavenging Operating Procedure and Control Data*, HW-38955, Rev. 1, General Electric 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.

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