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# ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 644492

Proj. ECN

| 2. ECN Category (mark one) | 3. Originator's Name, Organization, MSIN, and Telephone No. | 4. USQ Required? | 5. Date |
|---|---|---|---|
| Supplemental [] <br> Direct Revision [X] <br> Change ECN [] <br> Temporary [] <br> Standby [] <br> Supersedure [] <br> Cancel/Void [] | M. J. Kupfer, LMHC, H5-49, 376-6631 | [] Yes [X] No | 08/12/98 |
| | 6. Project Title/No./Work Order No. <br> Tank 241-AY-101 | 7. Bldg./Sys./Fac. No. <br> NA | 8. Approval Designator <br> NA |
| | 9. Document Numbers Changed by this ECN (includes sheet no. and rev.) <br> WHC-SD-WM-ER-605, Rev. 0A | 10. Related ECN No(s). <br> NA | 11. Related PO No. <br> 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) <br> [X] No (NA Blks. 12b, 12c, 12d) | NA | NA <br> Design Authority/Cog. Engineer Signature & Date | NA <br> 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 C, Evaluation to Establish Best-Basis Inventory for Double-Shell Tank 241-AY-101, 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 R1-41 | ~~H6-15~~ | M. J. Kupfer | H5-49 |
| DOE Reading Room | H2-53 | M. D. LeClair (3) | H5-49 |
| TCSRC | R1-10 | L. M. Sasaki | R2-12 |
| K. M. Hall | R2-12 | | |

RELEASE STAMP

SEP 28 1998 DATE HANFORD RELEASE STA: 4 ID: 4

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A-7900-013-1

# ENGINEERING CHANGE NOTICE



1. ECN (use no. from pg. 1): 644492

| 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 | [] | 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 | 9-10-98 | PE | | |
| Cog. Mgr. K. M. Hodgson | K.M. Hodgson | 9-17-98 | QA | | |
| QA | | | Safety | | |
| Safety | | | Design | | |
| Environ. | | | Environ. | | |
| Other L. M. Sasaki R2-12 | L M Sasaki | 9/16/98 | Other | | |

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

# Tank Characterization Report for Double-Shell Tank 241-AY-101

**S. L. Lambert**
COGEMA Engineering Corporation, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: 644492 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 double-shell tank 241-AY-101, 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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**Approved for Public Release**

| RECORD OF REVISION | (1) Document Number WHC-SD-WM-ER-605 | Page 1 |
|---|---|---|

(2) Title
Tank Characterization Report for Double-Shell Tank 241-AY-101

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 09/23/96 on EDT 617545. | R. R. Thompson | J. G. Kristofzski |
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| | | M J Kupfer 9-10-98 | K. M. Hodgson 9-17-98 |

A-7320-005 (08/91) WEF168

# APPENDIX C

# EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR DOUBLE-SHELL TANK 241-AY-101

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# APPENDIX C

# EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR DOUBLE-SHELL TANK 241-AY-101

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 double-shell tank 241-AY-101 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.

## C1.0 CHEMICAL INFORMATION SOURCES

No core samples have yet been taken from tank 241-AY-101. Available composition information for the waste in tank 241-AY-101 is as follows:

- The final report for grab samples taken in February 1996 (Esch 1996) provides analytical results for the supernatant and a portion of the sludge layer. The tank 241-AY-101 chemical and radionuclide inventory was estimated from this data in Appendix A.

- An internal memo that provides analytical results (supernatant only) for grab samples taken in 1985 (Bratzel 1985a).

- An internal memo that provides analytical results (solids only) for grab samples taken in 1985 (Bratzel 1985b).

- An internal memo that discusses the results of a grab sample taken in March 1987 (Herting 1987a) and corrections to the initial estimate (Herting 1987b).

- An internal memo that provides analytical results for two grab samples taken in the summer of 1988 (Edrington 1988).

- An internal memo that provides analytical results for two sludge samples taken on December 29, 1994 (Herting 1996).

## C2.0 COMPARISON OF COMPONENT INVENTORY VALUES

The Hanford Defined Waste (HDW) model provides composition estimates for the waste in tank 241-AY-101 on January 1, 1994. The HDW model estimates are based on a sludge volume of 314 kL (83 kgal) and a supernatant volume of 3,020 kL (798 kgal). The sample-based inventories are derived from the same sludge volume of 314 kL (83 kgal), a supernatant volume present at the time of sampling of 3,229 kL (853 kgal) (Hanlon 1996), a measured sludge density of 1.30 g/mL, a supernatant density of 1.08 g/mL, and the results of analyses of the February 1996 grab sampling event (Appendix A). The inventories are compared in Tables C2-1 and C2-2. This sludge volume was based on a February 2, 1987 level measurement. The volume has been updated to 356 kL (94 kgal) per a May 31, 1996 level measurement. The chemical species are reported without charge designation per the best-basis inventory convention.

Table C2-1. Sampling and Hanford Defined Waste Model Inventory Estimates for Nonradioactive Components in Double-Shell Tank 241-AY-101. (2 Sheets)

| Analyte | February 1996 inventory based on grab sample data[a] (kg) | HDW model inventory[b] (kg) |
|---|---|---|
| Al | 15,800 | 34,300 |
| Bi | <32.6 | 155 |
| Ca | 983 | 3,540 |
| Cl | 2,050 | 8,120 |
| TIC as $CO_3$ | 111,000 | 41,900 |
| Cr | 871 | 5,660 |
| F | 562 | 723 |
| Fe | 4,732 | 8,070 |
| Hg | NR | 1.15 |
| K | 123 | 2,490 |
| La | 852 | 3.87 |
| Mn | 771 | 380 |
| Na | 192,000 | 316,000 |
| Ni | 279 | 2,210 |

Table C2-1. Sampling and Hanford Defined Waste Model Inventory Estimates for Nonradioactive Components in Double-Shell Tank 241-AY-101. (2 Sheets)

| Analyte | February 1996 inventory based on grab sample data[a] (kg) | HDW model inventory[b] (kg) |
|---|---|---|
| $NO_2$ | 114,000 | 109,000 |
| $NO_3$ | 84,000 | 230,000 |
| OH | <404 | 139,000 |
| Pb | 237 | 150 |
| $PO_4$ | 8,550[c] | 5,760 |
| Si | <401 | 9,450 |
| $SO_4$ | 20,500[d] | 31,400 |
| Sr | 53.9 | 0 |
| TOC | 22,100 | 47,000 |
| U | <1,129 | 2,840 |
| Zr | <3.26 | 9.32 |

HDW = Hanford Defined Waste
NR = Not reported
[a] Appendix A of this TCR
[b] Agnew et al. (1997)
[c] The sum of the P as $PO_4$ in the sludge and the $PO_4$ in the supernatant
[d] The sum of the S as $SO_4$ in the sludge and the $SO_4$ in the supernatant.

Table C2-2. Sampling and Hanford Defined Waste Model Inventory Estimates for Radioactive Components in Double-Shell Tank 241-AY-101 (Decayed to January 1, 1994).

| Analyte | February 1996 inventory based on grab sample data[a] (Ci) | HDW Model Inventory[b] (Ci) |
|---|---|---|
| $^{60}Co$ | 910 | 72.6 |
| $^{90}Sr$ | 1.32 E+06 | 1.04 E+06 |
| $^{90}Y$ | 1.32 E+06 | 1.04 E+06 |
| $^{137}Cs$ | 329,000 | 255,000 |
| $^{137}mBa$ | 312,000 | 242,000 |
| $^{239/240}Pu$ | 118 | NR |
| $^{241}Am$ | 16.0 | 4,120 |

HDW = Hanford Defined Waste
NR = Not reported
[a] Appendix A of this TCR
[b] Agnew et al. (1997).

Based on measurements taken in May 1996, the sludge volume in tank 241-AY-101 has been updated to 356 kL (94 kgal) (Hanlon 1997). This makes further comparisons with the HDW model problematic. The supernatant compositions have also changed since 1994 as a result of numerous transfers into the tank and precipitation of solids from the supernatant layer.

## C3.0 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.

### C3.1 INVENTORY EVALUATION FOR THE SUPERNATANT IN TANK 241-AY-101

The HDW model inventories are valid as of January 1, 1994. Since that time, approximately 397 kL (105 kgal) of complexed saltwell liquid and flush water have been added to tank 241-AY-101. Additionally, about 261 kL (69 kgal) of water has evaporated from the tank during the same period. These events have made the HDW model estimates somewhat

outdated, but information found in the HDW model but not in sample results, can still be used for reference purposes.

In Table C3-1, analyte values from several sampling events are shown for the supernatant in tank 241-AY-101. Tank 241-AY-101 is an active receiver; since March 1985, the tank has received dilute non-complexed and dilute complexed waste from B Plant, salt well liquid from single-shell tanks, and waste from the 300 and 400 Areas.

Table C3-1. Supernatant Sample Results for Tank 241-AY-101. (2 Sheets)

| Sample ID | R-3641[a] | TCRC-18[b] | KE-4[c] | 101-AY-4/5[d] | Grab Sample[e] |
|---|---|---|---|---|---|
| Document Date | 2/28/85 | 6/23/87 | 7/20/88 | 2/27/96[e] | 2/24/96 |
| Analyte | μg/mL | μg/mL | μg/mL | μg/mL | μg/mL |
| Al | 1,790 | 1,430 | 1,320 | 20 | <12.1 |
| Ca | 354 | 120 | NR | NR | NR |
| Cl | NR | 461 | 425 | 550 | 636 |
| $CO_3$ | 13,700 | 16,000 | 18,400 | 34,400 | 34,300 |
| Cr | NR | 26 | NR | NR | 105 |
| F | <483 | <380 | 760 | 2.16 | 174 |
| Fe | 19.2 | <2.79 | NR | 9 | <12 |
| K | <395 | 313 | 313 | NR | NR |
| La | <79 | NR | NR | NR | NR |
| Mn | <313 | NR | NR | NR | <2.39 |
| Na | 63,200 | 50,800 | 44,800 | 49,000 | 51,900 |
| Ni | NR | NR | NR | NR | 59 |
| $NO_2$ | 11,300 | 12,800 | 13,600 | 34,400 | 35,300 |
| $NO_3$ | 57,500 | 43,300 | 38,400 | 14,100 | 26,000 |
| OH | 5,120 | 12,910 | 8,060 | NR | <125 |
| Pb | <69.6 | NR | NR | NR | NR |
| $PO_4$ | 845 | <1,420 | 760 | 820 | 1,150 |
| Si | 46.3 | NR | NR | NR | <12 |
| $SO_4$ | 7,390 | 5,280 | 4,990 | 4,850 | 5,870 |
| TOC | 6,780 | 5,210 | 4,460 | 4,460 | 6,850 |
| U | 23.3 | NR | NR | NR | NR |

Table C3-1. Supernatant Sample Results for Tank 241-AY-101. (2 Sheets)

| Sample ID | R-3641[a] | TCRC-18[b] | KE-4[c] | 101-AY-4/5[d] | Grab Sample[e] |
|---|---|---|---|---|---|
| Document Date | 2/28/85 | 6/23/87 | 7/20/88 | 2/27/96[e] | 2/24/96 |
| Analyte | μg/mL | μg/mL | μg/mL | μg/mL | μg/mL |
| Zr | <46.4 | NR | NR | NR | NR |
| $^{90}Sr$[f] (μCi/mL) | 162 | 123 | NR | 2.76 | 1.9 |
| $^{137}Cs$[f] (μCi/mL) | 114 | 99 | NR | 93.1 | 86.7 |
| water (%) | NR | 86.80% | NR | NR | 84.40% |
| density (g/mL) | 1.11 | 1.09 | 1.09 | 1.09 | 1.08 |

TCR = Tank Characterization Report
NR = Not reported
[a] Bratzel (1985a)
[b] Herting (1987)
[c] Edrington (1988)
[d] Herting (1996)
[e] Samples were taken on December 29, 1994 (Esch 1996)
[f] Decayed to January 1, 1994.

Table C3-1 suggests that the supernatant grew increasingly dilute through 1994. The liquid apparently became more concentrated by 1996 after the introduction of large amounts of complexed salt well liquid.

The decrease in Al and OH concentrations between 1988 and 1996 are exceptions to this general trend. The Al concentration, after remaining relatively constant for several years, dropped from 1,320 μg/mL to <12.1 μg/mL during this period. The liquid volume in the tank decreased from 3,562 kL (941 kgal) to 3,229 kL (853 kgal). The hydroxide concentration dropped over 98 percent from 8,060 μg/mL to <125 μg/mL in the same period. $CO_2$ from the air reacts with hydroxide to form carbonates and water (note the increase in $CO_3$ concentration). The reduction in pH allows relatively insoluble compounds of aluminum to form. Much of the increase in solids volume in tank 241-AY-101 is a result of Al precipitation. In all, over 4,670 kg of Al were apparently removed from the supernatant between 1988 and 1996.

The results of the February 1996, supernatant analyses provide the best-basis for inventory estimates in tank 241-AY-101. The large number of transfers into the tank make older sample analyses invalid as bases for inventory development. Between February 1996 and February 1997, in-tank evaporation has reduced the supernatant volume from 3,228 kL (853 kgal) to 3,081 kL (814 kgal). The February 1996, results for the supernatant were adjusted accordingly by multiplying them by the ratio 853/814. The results are shown in Table C3-2.

Table C3-2. Revised Supernatant Concentrations in Tank 241-AY-101. (2 Sheets)

| Analyte | Mean concentration (μg/mL) |
|---|---|
| Al | <12.7 |
| Bi | NR |
| Ca | 126 |
| Cl | 666 |
| $CO_3$ | 35,900 |
| Cr | 110 |
| F | 182 |
| Fe | <12.6 |
| Hg | NR |
| K | 328 |
| La | NR |
| Mn | <2.50 |
| Na | 54,400 |
| Ni | 61.8 |
| $NO_2$ | 37,000 |
| $NO_3$ | 27,200 |
| OH | <131 |
| Pb | NR |
| $PO_4$ | 1,200 |
| Si | <12.6 |
| $SO_4$ | 6,150 |
| Sr | NR |
| TOC | 7,180 |
| U | 24.4 |
| Zr | NR |

Table C3-2. Revised Supernatant Concentrations in Tank 241-AY-101. (2 Sheets)

| Radionuclides[a] | Mean concentration ($\mu$Ci/mL) |
|---|---|
| $^{90}Sr$ | 1.99 |
| $^{137}Cs$ | 90.8 |
| $^{239/240}Pu$ | 0.038 |
| $^{241}Am$ | 0.00512 |

NR = Not reported
[a] Decayed to January 1, 1994.

## C3.2 INVENTORY EVALUATION FOR THE SOLIDS IN TANK 241-AY-101

According to the HDW model, the following waste types contributed to the sludge inventory in tank 241-AY-101:

| | | |
|---|---|---|
| B | B Plant High Level Waste | 49 kL (13 kgal) |
| BL | B Plant Low Level Waste | 19 kL ( 5 kgal) |
| CSR | Cesium Recovery Waste | 26 kL ( 7 kgal) |
| SMM | Supernatant Mixing Model | 68 kL (18 kgal) |
| SRR | Slurried PUREX Plant Sludge | 30 kL ( 8 kgal) |
| | (PUREX = Plutonium-Uranium Extraction) | |
| UNKWN | Unknown | 121 kL (32 kgal) |

The tank layer model (TLM) portion of the HDW model designates 121 kL (32 kgal) of the 314 kL (83 kgal) reported, or 38 percent of the total sludge layer as "unknown." By virtue of this, alone, the sample-based estimates are likely to provide a better basis than the HDW model.

Another 68.1 kL (18 kgal) of sludge is assumed in the HDW model to be salts resulting from the concentration of supernatant as defined in the supernatant mixing model (SMM). The apparent precipitation of aluminum from the supernatant (see Section C3.1) supports this general assumption. The HDW model, however, assumes a general salt cake composition for the precipitated solids.

In the previous section it was estimated that 4,670 kg of Al or 13,490 kg $Al(OH)_3$ may have precipitated from the supernatant in tank 241-AY-101 due to hydroxide depletion. The actual in-tank volume is greater because of variation in particle sizes and void spaces. From Table 4-2, the wt% water in the sludge is 55.8 wt% and the wt% water in the

supernatant/interstitial liquid is 84.4 wt%. The wt% dry solids in the sludge calculated from these values is:

$$(1 - [0.558/0.844])*100 = 33.9 \text{ wt\%}$$

Using this value and the measured sludge density of 1.30 from Table C3-3, produces a sludge volume created by precipitation of $Al(OH)_3$ equal to:

$$V_{sludge} = (13{,}490 \text{ kg}) / (10.339)\ (1{,}300 \text{ kg/kL}) = 30.6 \text{ kl } (8.08 \text{ kgal})$$

which is roughly the difference between the sludge volume measured in 1996 and the sludge volume measured in 1987 [41.6 kL (11 kgal)].

Since the last major transfer of waste out of tank 241-AY-101 in April 1984, there have been three sets of samples taken of the sludge in tank 241-AY-101. These were grab samples taken in 1996, 1994, and 1985. Grab samples of sludges should be viewed with caution. Furthermore, pre-1989 results have not been validated. Results obtained from these sampling events is shown in Table C3-3. None of these samples were taken from the entire sludge layer. The sludge occupies the bottom 86 cm (34 in.) of the tank and solids accumulated since 1987 occupy 10 cm (4 in.) of the sludge layer. The most recent samples (February 1996) were taken 83.8 cm (33 in.) and 63 cm (25 in.) from the bottom of the tank. It's not certain if the pre-1989 sample was actually taken from the very bottom of the tank, but, if so, the drastically different concentrations in the 1985 samples - if they're correct, indicate the presence of at least two layers with very different compositions.

Table C3-3. Sludge Sample Results for Tank 241-AY-101. (3 Sheets)

| Sample ID | R-3642[a] | Grab Sample[b] | 101-AY-1[c] |
|---|---|---|---|
| Sample Date | 14-Mar-85 | 24-Feb-96 | 29-Dec-94 |
| Analyte | μg/g | μg/g | μg/g |
| Al | 33,800 | 59,000 | 50,200 |
| Bi | NR | NR | NR |
| Ca | 8,100 | 3,290 | NR |
| Cl | NR | NR | NR |
| $CO_3$ | NR | NR | 21,250 |
| Cr | 19,300 | 1,780 | 650 |
| F | NR | NR | NR |

Table C3-3. Sludge Sample Results for Tank 241-AY-101. (3 Sheets)

| Sample ID | R-3642[a] | Grab Sample[b] | 101-AY-1[c] |
|---|---|---|---|
| Sample Date | 14-Mar-85 | 24-Feb-96 | 29-Dec-94 |
| -Fe | 117,000 | 15,700 | 12,050 |
| Hg | NR | NR | NR |
| K | NR | NR | 200 |
| La | 18,700 | 2,850 | NR |
| Mn | 29,100 | 2,580 | 2,050 |
| Na | NR | 79,600 | 87,800 |
| Ni | 1,600 | 295 | NR |
| $NO_2$ | NR | NR | 23,500 |
| $NO_3$ | NR | NR | 9,400 |
| OH | NR | NR | NR |
| Pb | 4,800 | NR | NR |
| $PO_4$ | NR | NR | 920[d] |
| Si | 218,000 | 1,210 | NR |
| $SO_4$ | NR | 3,560[e] | 3,200 |
| Sr | NR | NR | NR |
| TOC | 24,800 | 3,730 | 3,100 |
| U | 22,600 | <400 | NR |
| Zr | 6,200 | <7.99 | NR |
| Radionuclides[f] ($\mu$Ci/g) | | | |
| $^{90}Sr$ | 9,000 | 4,850 | 4,450 |
| $^{137}Cs$ | 429 | 89.9 | 104 |
| $^{239}Pu$ | 6.34 | NR | 0.550 |
| $^{241}Am$ | 27.6 | NR | 3.74 |

Table C3-3. Sludge Sample Results for Tank 241-AY-101. (3 Sheets)

| Sample ID | R-3642[a] | Grab Sample[b] | 101-AY-1[c] |
|---|---|---|---|
| Sample Date | 14-Mar-85 | 24-Feb-96 | 29-Dec-94 |
| density, g/mL | NR | 1.30 | 1.38 |

NR = Not reported
[a] Bratzel (1985b), sample taken from bottom of tanks
[b] Esch (1996)
[c] Herting (1996)
[d] P as $PO_4$
[e] S as $SO_4$
[f] Decayed to January 1, 1994.

The results from the 1985 samples deviate substantially from the post-1989 data. The deviation may be a result of analytical error, or it may be a consequence of multiple layers in the tank. The increase in Al concentration is explained by the precipitation of aluminum compounds from the supernatant between 1988 and 1996. From the previous discussion, it's apparent that there are at least two distinct layers in the sludge: (1) one layer that was present before the precipitation of aluminum salts, (2) the other being the precipitated aluminum that formed as a result of hydroxide depletion. The latter layer is included in the 1994 and 1996 samples that occupy the upper 23 cm (9 in.) of the sludge layer. The remaining 63 cm (25 in.) can be represented by the 1985 samples providing that the sample results are accurate.

The service history of tank 241-AY-101 during the early 1980's is similar to tank 241-AY-102, the only other tank in the 241-AY tank farm. Throughout this period, most of the waste received by these tanks came from B Plant. In Table C3-4, the 1985 sludge data for tank 241-AY-101 is compared to the results of the 1987 core sample taken from tank 241-AY-102.

Table C3-4. Comparison of Sludge Data for Tanks 241-AY-101 and 241-AY-102.

| Analyte | Tank 241-AY-101 sludge concentrations ($\mu$g/g)[a] | Tank 241-AY-102 sludge concentrations ($\mu$g/g)[b] |
|---|---|---|
| Al | 33,800 | 37,800 |
| Ca | 8,100 | 14,000 |
| Cr | 19,300 | 3,510 |
| Fe | 117,000 | 83,700 |
| La | 18,700 | 3,960 |
| Mn | 29,100 | 8,780 |
| Na | NR | 41,400 |
| Ni | 1,600 | 3,020 |
| Si | 218,000 | 12,100 |
| TOC | 24,800 | 45,800 |
| U | 22,600 | 14,800 |
| Zr | 6,200 | 575 |
| $^{90}Sr$[c] ($\mu$g/g) | 9,000 | 23,600 |
| $^{137}Cs$[c] ($\mu$g/g) | 429 | 270 |

NR = Not reported
[a] Bratzel (1985b)
[b] Scheele et al. (1990)
[c] Decayed to January 1, 1994.

Table C3-4 indicates some similarities between the two sludge analyses. The extremely high Si concentration in the tank 241-AY-101 sample is very suspicious, but in general, the agreement between the samples suggests that the 1985 samples taken from tank 241-AY-101 may be representative of B-plant waste. On this account, the sludge in tank 241-AY-101 is best represented by partitioning the sludge into two layers: (1) the first layer, extending from 63.5 cm (25 in.) to 86 cm (34-in.) from the bottom of the tank, is represented by an average of the 1994 and 1996 sample results, and (2) the bottom layer is represented by the 1985 sampling results. The total sludge inventory is projected to be 356 kL (94 kgal) based on the May 31, 1996 sludge level measurements. This inventory is consistent with 86 cm (34-in.) of total sludge in the tank.

Based on these assumptions, mass weighted average concentrations for the sludge were calculated and are shown in Table C3-5. Concentrations found in one data set but not in the other are applied to the lacking data set. These values were computed by averaging the February 1996 and December 1994 sludge data and multiplying the result by 0.2647 to represent the upper sludge layer, and multiplying the R-3642 data in Table C3-3 by 0.7353 to represent the lower sludge layer.

This method may produce considerable uncertainty for inventory estimates for some analytes. Since the thermal modeling results are available for this tank (Sathyanarayana, 1997), these results were used to estimate the $^{90}Sr$ inventory. The $^{90}Sr$ estimate was derived by subtracting the $^{137}Cs$ contribution (7,100 BTU/hr) from the projected heat load (41,000 BTU/hr) and assigning the remaining fraction (33,900 BTU/hr) to $^{90}Sr$ in the sludge. The $^{90}Sr$ result (1.48 E+06 Ci) is very close to the $^{90}Sr$ value in appendix A of the TCR (1.24 E+06 Ci)

Table C3-5. Revised Sludge Concentrations in Tank 241-AY-101. (2 Sheets)

| Analyte | Mass weighted average ($\mu$g/g) |
|---|---|
| Al | 39,300 |
| Bi | NR |
| Ca | 6,830 |
| Cl | NR |
| $CO_3$ | 21,300 |
| Cr | 14,500 |
| F | NR |
| Fe | 89,700 |
| Hg | NR |
| K | 200 |
| La | 14,500 |
| Mn | 22,000 |
| Na | 83,700 |
| Ni | 1,250 |
| $NO_2$ | 23,500 |
| $NO_3$ | 9,400 |

Table C3-5. Revised Sludge Concentrations in Tank 241-AY-101. (2 Sheets)

| Analyte | Mass weighted average ($\mu$g/g) |
|---|---|
| OH | NR |
| Pb | 4,800 |
| $PO_4$ | 900 |
| Si | 1,210[a] |
| $SO_4$ | 3,380 |
| Sr | NR |
| TOC | 19,100 |
| U | 22,600 |
| Zr | 6,200 |
| Radionuclides[b] | Mass weighted average ($\mu$Ci/g) |
| $^{60}Co$ | 2.96 |
| $^{90}Sr$ | 3,200[c] |
| $^{137}Cs$ | 341 |
| $^{239/240}Pu$ | 4.81 |
| $^{241}Am$ | 21.3 |
| Density, g/mL | 1.34 |

NR = Not reported

[a] Discounted the R-3642 sample value for Si (Bratzel 1985b) as it was suspect.

[b] Decayed to January 1, 1994.

[c] Computed from the estimated heat load, sludge volume of 356 kL and sludge density of 1.3 g/mL.

The best-basis sludge density was found to be 1.34 g/ml for tank 241-AY-101. This value is based on an average of two grab samples taken on February 24, 1996 and December 29, 1994. The February 1996 sample was obtained from a depth of 63 cm from the bottom of the tank. The sludge layer in this tank was found to be 86 cm thick. Because these samples were taken from the upper part of the sludge layer, this layer was obviously disturbed during the course of sampling and these densities may not reflect the actual density of the

consolidated sludge layer in this tank. Since these samples were the only ones available, this data was used to develop the best-basis estimates for this tank.

## C4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Inventories based on the 1985, 1994, and 1996 sampling events and waste layer volumes derived in this engineering assessment should serve as the best-basis inventories in tank 241-AY-101 for the following reasons:

1. The liquid volume has decreased since the last sampling event, necessitating an upward adjustment to the latest supernatant analytical results.

2. Indications of precipitation of significant quantities of Al from the supernatant lead to the conclusion that the sludge layer is stratified into at least two layers, which approximately correspond to the sample location and sample values of the sludge samples taken from this tank.

3. The HDW model predictions of the supernatant are not as accurate due to subsequent transfers into the tank.

4. The HDW model predictions of the sludge are based on an outdated sludge volume, and 38 percent of the sludge is designated as unknown in the model.

**Total Hydroxide.** Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valence of other analytes. This charge balance approach is consistent with that used by Agnew et al. (1997).

**Radionuclides.** 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. In general, waste samples have been routinely analyzed for only $^{90}Sr$, $^{137}Cs$, $^{239/240}Pu$, and total uranium, while other key radionuclides such as $^{60}Co$, $^{99}Tc$, $^{129}I$, $^{241}Am$, etc., have been infrequently analyzed. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models that 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 model results (Agnew et al. 1997). Best-basis values for the total inventories may be a combination of model results and sample or engineering assessment-based results where available. For a discussion of typical error between model derived values and sample derived values (see Kupfer et al. 1997, Section 6.1.10).

Although the supernatant composition has been altered since January 1, 1994, the HDW model estimates for those radionuclides not found in the sample data are included as the best-basis values. The only significant changes since January 1, 1994 have been the addition of 287.6 kL (76 kgal) of complexed saltwell liquid and 18.9 kL (5 kgal) of NaOH (the rest being flush water additions and water evaporation).

Best-basis inventory estimates for tank 241-AY-101 are presented in Tables C4-1 through C4-6. The inventory values reported in Tables C4-5 and C4-6 are subject to change. Refer to the Tank Characterization Database (TCD) (LMHC 1998) for the most current inventory values. Radionuclide values are decayed to January 1, 1994.

Table C4-1. Supernatant Inventory Estimates for Nonradioactive Components in Tank 241-AY-101 as of February 28, 1997. (2 Sheets)

| Analyte | Supernatant inventory[a] (kg) | Basis (S, M, C, or E)[1] | Comment |
|---|---|---|---|
| Al | <39.1 | S | |
| Bi | NR | | |
| Ca | 388 | S | |
| Cl | 2,050 | S | |
| TIC as $CO_3$ | 111,000 | S | |
| Cr | 339 | S | |
| F | 561 | S | |
| Fe | <38.8 | S | |
| K | 1,010 | S | Based on 7/88 concentration adjusted for evaporation |
| La | NR | | |
| Mn | <7.7 | S | |
| Na | 168,000 | S | Charge balance = 136,000 |
| Ni | 190 | S | |
| $NO_2$ | 114,000 | S | |
| $NO_3$ | 83,800 | S | |
| $OH_{TOTAL}$ | <404 | S | |

Table C4-1. Supernatant Inventory Estimates for Nonradioactive Components in Tank 241-AY-101 as of February 28, 1997. (2 Sheets)

| Analyte | Supernatant inventory[a] (kg) | Basis (S, M, C, or E)[1] | Comment |
|---|---|---|---|
| Pb | NR | | |
| P as $PO_4$ | 3,700 | S | |
| Si | <38.8 | S | |
| S as $SO_4$ | 18,900 | S | |
| Sr | NR | | |
| TOC | 22,100 | S | |
| $U_{TOTAL}$ | 75.1 | S | Based on 2/85 concentration adjusted for evaporation |
| Zr | NR | | |

[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 $SiO_3$
NR = Not reported
[a] Based on the supernatant mean concentrations (Table C3-2), a supernatant volume of 3,081 kL (814 kgal), and a supernatant density of 1.08 g/mL.

Table C4-2. Supernatant Inventory Estimates for Radioactive Components in Tank 241-AY-101 as of February 28, 1997. (Decayed to January 1, 1994)

| Analyte | Total inventory[a] (Ci) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| $^{90}Sr$ | 6,130 | S | |
| $^{90}Y$ | 6,130 | S | Referenced to $^{90}Sr$ |
| $^{137}Cs$ | 280,000 | S | |
| $^{137m}Ba$ | 265,000 | S | Referenced to $^{137}Cs$ |
| $^{239/240}Pu$ | 117 | S | |
| $^{241}Am$ | 15.8 | S | |

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997)
E = Engineering assessment-based
[a] Based on the supernatant mean concentration (Table C3-2), a supernatant volume of 3,081 kL (814 kgal), and a supernatant density of 1.08 g/mL.

Table C4-3. Sludge Inventory Estimates for Nonradioactive Components in Tank 241-AY-101 as of February 28, 1997. (2 Sheets)

| Analyte | Sludge inventory[a] (kg) | Basis (S, M, C, or E)[1] | Comment |
|---|---|---|---|
| Al | 18,700 | S | |
| Bi | NR | | |
| Ca | 3,260 | S | |
| Cl | NR | | |
| TIC as $CO_3$ | 10,200 | S | |
| Cr | 6,910 | S | |
| F | NR | | |
| Fe | 42,800 | S | |
| K | 95.4 | S | |
| La | 6,910 | S | |
| Mn | 10,500 | S | |
| Na | 39,900 | S | |
| Ni | 596 | S | |
| $NO_2$ | 11,200 | S | |
| $NO_3$ | 4,480 | S | |
| $OH_{TOTAL}$ | 120,000 | C | |
| Pb | 2,290 | S | |
| $PO_4$ | 429 | S | |
| Si | 577 | S | Based on 2/96 concentration only. |
| $SO_4$ | 1,610 | S | |
| Sr | NR | | |
| TOC | 9,110 | S | |

Table C4-3. Sludge Inventory Estimates for Nonradioactive Components in Tank 241-AY-101 as of February 28, 1997. (2 Sheets)

| Analyte | Sludge inventory[a] (kg) | Basis (S, M, C, or E)[1] | Comment |
|---|---|---|---|
| $U_{TOTAL}$ | 10,800 | S | |
| Zr | 2,960 | S | |

[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 $SiO_3$.
NR = Not reported
[a] Based on a sludge volume of 356 kL (94 kgal), a sludge density of 1.34 g/mL, and sludge mass weighted average concentrations defined in Table C3-5.

Table C4-4. Sludge Inventory Estimates for Radioactive Components in Tank 241-AY-101 as of February 28, 1997. (Decayed to January 1, 1994)

| Analyte | Total inventory[a] (Ci) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| $^{60}Co$ | 1,410 | S | |
| $^{90}Sr$ | 3.74 E+06 | S | |
| $^{90}Y$ | 3.74 E+06 | S | Referenced to $^{90}Sr$ |
| $^{137}Cs$ | 163,000 | S | |
| $^{137m}Ba$ | 154,000 | S | Referenced to $^{137}Cs$ |
| $^{239/240}Pu$ | 2,290 | S | |
| $^{241}Am$ | 10,200 | S | |

[1]S = Sample-based
M = Hanford Defined Waste model-based (Agnew et al. 1997)
E = Engineering assessment-based
[a] Based on a sludge volume of 356 kL (94 kgal), a sludge density of 1.34 g/mL, and sludge mass weighted average concentrations defined in Table C3-5.

Table C4-5. Best-Basis Total Inventory Estimates for Nonradioactive Components in Tank 241-AY-101 (Effective February 28, 1997). (2 Sheets)

| Analyte | Total inventory (kg) | Basis (S, M, C, or E)[1] | Comment |
|---|---|---|---|
| Al | 18,800 | S | |
| Bi | 0 | E | Bi is relatively insoluble in the supernates added to this tank |
| Ca | 3,650 | S | |
| Cl | 2,050 | S | |
| TIC as $CO_3$ | 121,000 | S | |
| Cr | 7,250 | S | |
| F | 561 | S | |
| Fe | 42,800 | S | |
| Hg | 0 | E | Simpson 1998 |
| K | 1,100 | S | |
| La | 6,910 | S | |
| Mn | 10,500 | S | |
| Na | 208,000 | S | |
| Ni | 786 | S | |
| $NO_2$ | 125,000 | S | |
| $NO_3$ | 88,300 | S | |
| $OH_{TOTAL}$ | 97,200 | C | |
| Pb | 2,290 | S | |
| $PO_4$ | 4,130 | S | IC analysis |
| Si | 616 | S/E | Upper bound |
| $SO_4$ | 20,500 | S | IC analysis |
| Sr | 35.5 | S/E | Assuming 30% of Sr consists of $^{90}Sr$ |
| TOC | 31,200 | S | |

Table C4-5. Best-Basis Total Inventory Estimates for Nonradioactive Components in Tank 241-AY-101 (Effective February 28, 1997). (2 Sheets)

| Analyte | Total inventory (kg) | Basis (S, M, C, or E)[1] | Comment |
|---|---|---|---|
| $U_{TOTAL}$ | 10,900 | S | |
| Zr | 2,960 | S | |

[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 C4-6. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AY-101, decayed to January 1, 1994 (Effective February 28, 1997). (3 Sheets)

| Analyte | Total inventory (Ci) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| $^{3}H$ | 329 | M | |
| $^{14}C$ | 57.8 | M | |
| $^{59}Ni$ | 34.6 | M | |
| $^{60}Co$ | 1,410 | S | |
| $^{63}Ni$ | 3,430 | M | |
| $^{79}Se$ | 32.6 | M | |
| $^{90}Sr$ | 1.48 E+06 | E | Computed from the estimated heat load |
| $^{90}Y$ | 1.48 E+06 | E | Referenced to $^{90}Sr$ |
| $^{93}Zr$ | 148 | M | |
| $^{93m}Nb$ | 109 | M | |
| $^{99}Tc$ | 412 | M | |
| $^{106}Ru$ | 1.64 | M | |
| $^{113m}Cd$ | 635 | M | |
| $^{125}Sb$ | 337 | M | |
| $^{126}Sn$ | 51.1 | M | |
| $^{129}I$ | 0.797 | M | |

Table C4-6. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AY-101, decayed to January 1, 1994 (Effective February 28, 1997). (3 Sheets)

| Analyte | Total inventory (Ci) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| $^{134}Cs$ | 10.6 | M | |
| $^{137}Cs$ | 443,000 | S | |
| $^{137m}Ba$ | 419,000 | S | Referenced to $^{137}Cs$ |
| $^{151}Sm$ | 109,000 | M | |
| $^{152}Eu$ | 81.4 | M | |
| $^{154}Eu$ | 5,700 | M | |
| $^{155}Eu$ | 4,270 | M | |
| $^{226}Ra$ | 0.00225 | M | |
| $^{227}Ac$ | 0.0116 | M | |
| $^{228}Ra$ | 0.145 | M | |
| $^{229}Th$ | 0.00347 | M | |
| $^{231}Pa$ | 0.0202 | M | |
| $^{232}Th$ | 0.0144 | M | |
| $^{232}U$ | 2.34 | S/M | Based on total U: Used HDW isotopic ratios |
| $^{233}U$ | 8.99 | S/M | Based on total U: Used HDW isotopic ratios |
| $^{234}U$ | 3.99 | S/M | Based on total U: Used HDW isotopic ratios |
| $^{235}U$ | 0.162 | S/M | Based on total U: Used HDW isotopic ratios |
| $^{236}U$ | 0.137 | S/M | Based on total U: Used HDW isotopic ratios |
| $^{237}Np$ | 1.40 | M | |
| $^{238}Pu$ | 206 | S/M | Based on $^{239}Pu$: Used HDW isotopic ratios |
| $^{238}U$ | 3.64 | S/M | Based on total U: Used HDW isotopic ratios |

Table C4-6. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-AY-101, decayed to January 1, 1994 (Effective February 28, 1997). (3 Sheets)

| Analyte | Total inventory (Ci) | Basis (S, M, or E)[1] | Comment |
|---|---|---|---|
| $^{239}Pu$ | 1,850 | S/M | Based on $^{239/240}Pu$: Used HDW isotopic ratios |
| $^{240}Pu$ | 559 | S/M | Based on $^{239/240}Pu$: Used HDW isotopic ratios |
| $^{241}Am$ | 10,200 | S | |
| $^{241}Pu$ | 14,300 | S/M | Based on $^{239}Pu$: Used HDW isotopic ratios |
| $^{242}Cm$ | 14.2 | S/M | Based on $^{241}Am$: Used HDW isotopic ratios |
| $^{242}Pu$ | 0.101 | S/M | Based on $^{239}Pu$: Used HDW isotopic ratios |
| $^{243}Am$ | 1.04 | S/M | Based on $^{241}Am$: Used HDW isotopic ratios |
| $^{243}Cm$ | 1.66 | S/M | Based on $^{241}Am$: Used HDW isotopic ratios |
| $^{244}Cm$ | 62.8 | S/M | Based on $^{241}Am$: Used HDW isotopic ratios |

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

## C5.0 APPENDIX C REFERENCES

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