

Standard Inventory Estimates  
for Wastes Stored in the  
Hanford Site Underground Tanks  
Status Report



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## 1.0 INTRODUCTION

When the primary mission at the Hanford Site changed from plutonium production to environmental restoration in 1988, the U.S. Department of Energy (DOE) established the Tank Waste Remediation System (TWRS) to safely manage and dispose of the radioactive wastes stored in underground tanks. Key waste management activities for TWRS 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.

Information about the chemical and/or physical properties of tank waste is needed to perform the safety analyses, engineering evaluations, and risk assessments associated with these activities, as well as to address regulatory issues. As a first response to these needs, global waste inventories for single-shell tanks (SSTs) and double-shell tanks (DSTs) were established from key historical records, from various chemical flowsheets, and from radionuclide isotope generation and decay calculations. This information was reported in the *Hanford Defense Waste Environmental Impact Statement (HDW-EIS)* (DOE 1987) and also was entered into national databases such as the Integrated Database and the Federal Facility Compliance Act Database.

Tank-specific waste information generally is derived using two approaches: the first approach estimates tank waste inventories based on sample analyses, and the second approach predicts inventories 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. 1995). These two approaches to estimating tank waste inventories do not always produce consistent results. In addition, total (global) component inventories provided by the LANL process knowledge model and those reported in the EIS do not always agree.

The objective of this task is to provide, on both global and tank-by-tank bases, best estimates of waste inventories and associated waste characteristics that will serve as consistent characterization source terms for activities involving the Hanford Site wastes. The work plan for this task is presented in Kupfer et al. (1995). These best-basis estimates are to be incorporated into the existing Tank Characterization Database (TCD) and documented in Tank Characterization Reports (TCRs). This report presents the work conducted during the first quarter of FY 1996 (October through December 1995) in support of the task objective and provides a conduit for review by potential data users. The information in this report is presented as follows:

Overview briefly outlines the plan and schedule for developing best-basis waste inventory and characteristics estimates.

## 2.0 OVERVIEW

The primary objective of this task is to derive best-basis waste inventory and characteristics estimates that will provide consistent data for a multitude of activities. Additional objectives within the work scope include ensuring that this information is incorporated into an existing electronic database and documented in an existing reporting format, and defining a methodology for maintaining and updating these reporting mechanisms.

A schematic of the plan for implementing these objectives is depicted in Figure 2-1. This plan involves evaluation and reconciliation of existing waste information derived from historical bases and from tank sampling data. Major task activities include summarizing data requirements and establishing inventories on both global and individual tank bases. The results from these activities are intended to provide consistent data for several specific purposes (refer to Section 3.0). These results will be included in future TCRs and available in an accessible electronic form via the TCD. Global and tank-specific information also will be used to update national databases.

The schedule for completing task activities is provided in Table 2-1.

Table 2-1. Schedule of Deliverables.

Deliverable	Date
<ul style="list-style-type: none"> <li>Identify data requirements for potential database users</li> </ul>	10/30/95
<ul style="list-style-type: none"> <li>First quarter update on task</li> </ul>	12/29/95
<ul style="list-style-type: none"> <li>Documentation of global waste component inventories and associated bases</li> </ul>	02/12/96
<ul style="list-style-type: none"> <li>Documentation of preliminary results of best-basis waste characteristics estimates for 30 tanks</li> <li>Provide preliminary format of electronic database</li> </ul>	03/08/96
<ul style="list-style-type: none"> <li>Documentation of preliminary results of best-basis waste characteristics estimates for 75 Single-Shell Tanks (SSTs)</li> <li>Provide format of electronic database</li> </ul>	05/27/96
<ul style="list-style-type: none"> <li>Documentation of preliminary results of best-basis waste characteristics estimates for 149 SSTs and 28 double-shell tanks(DSTs)</li> <li>Provide format of electronic database</li> <li>Define preliminary mechanism for update/revision of database</li> </ul>	07/29/96
<ul style="list-style-type: none"> <li>Documentation of task results, including mechanism for update/revision of database</li> <li>Implement electronic database</li> </ul>	09/30/96

### 3.0 DATA REQUIREMENTS

Information about the chemical and/or physical properties of tank wastes is needed for a multitude of activities. These activities include the following:

- Perform safety analyses of tanks farm operations and of tank wastes.
- Perform risk assessments associated with storage and/or processing of tank wastes.
- Develop, design, and implement waste retrieval, treatment, and disposal systems.
- Conduct performance assessments to evaluate long-term dosages and risks from waste form disposal systems.
- Obtain regulatory permits.

Early in the first quarter of FY 1996, existing Data Quality Objective-(DQO) documents were reviewed, and cognizant personnel were contacted to identify specific data requirements associated with the above activities. The identified requirements are summarized in Table 3-1. Appendix A provides an example of the basis for selecting the radionuclide components to be included in the inventory database.

Work during the remainder of FY 1996 is focused on reconciling available data, either from sample analyses or model predictions, to provide best-basis chemical and radiochemical inventories on both global and individual tank bases. The analytes and parameters that appear unshaded in the table are the foundation for these inventories. Information regarding other waste characteristics, will be available for some tanks in FY 1996; however, additional information e.g., shaded areas, will be addressed after FY 1996.

TABLE 3-1. Summary of Data Requirements (Sheet 2 of 4)

Analyte/ Parameter	Function & Operations			Safety/Risk									Regulatory	
	(1) Transfer	(2) Retrieve	(3, 4, 6) Pre-treat/ Dispose	Tank Waste			(13-16) Inhalation	(12) Shielding/ Direct Dose	(15) External Radiation Hazard	(14-20) Long-term Groundwater	(22) Volatile Hazard	(10) Criticality	(11) Air	(21) Ground- water
				(5, 7, 8, 9) Resolution	(22) PA	(1) Transfer								
3-H			X	X							X			IC
14-C			H, L							X	X			
63-Ni									X	X				
60-Co			X	X					X	X				
63-Ni				X						X				
79-Se			X		X					X	X			
90-Sr/Y	X		P, H, L	X	X				X	X				IC
93-Zr/m-Nb			H		X					X				
99-Tc			P, L	X	X					X				
106-Ru									X					
113-Cd/m											X			
126-Sb			H								X			
126-Sn			H		X				X	X				
129-I			P, H, L	X	X				X		X		B	
134-Cs											X			
137-Cs/Ba	X		P, H, L	X	X				X	X			B(as OH)	
151-Sm														
152-Eu										X				
154-Eu			P, L	X					X	X				
156-Eu			P, L											
226-Ra					X					X				IC
227-Ac					X				X					
228-Ra					X					X				IC
229-Th					X									
231-Pa									X					
232-Th			P, H, L											
232-U					X							X		
233-U					X									
234-U					X									
235-U			X		X							X		
236-U					X									
237-Np			P, H, L	X					X					
238-Pu			P, H, L	X					X					
238-U			X							X				
239/240-Pu			P, H, L	X	X				X			X		
241-Am	X		P, H, L	X					X	X				
241-Pu			P, H, L						X	X				
242-Pu			P, H, L											
242-Cm				X										
243-Am														
243-Cm			P, H, L	X										
244-Cm			P, H, L	X					X					
total alpha				X								X		
total beta				X										IC



Table 4-1. Comparison of Los Alamos National Laboratories and 1987 Environmental Impact Statement Chemical Inventories for Single-Shell Tanks.

Component	LANL (MT)	1987 EIS (MT)	LANL/1987 EIS
Al <sup>+3</sup>	5.24E+03	3.39E+03 <sup>(a)</sup>	1.54
Bi <sup>+3</sup>	5.10E+02	2.61E+02	1.95
Ca <sup>+2</sup>	5.50E+02	1.28E+02	4.30
Cl <sup>-</sup>	5.97E+02	4.15E+02	1.44
CO <sub>3</sub> <sup>-2</sup>	2.67E+03	1.66E+03	1.61
Cr <sup>+3</sup>	6.50E+02	2.68E+02 <sup>(b)</sup>	2.43
F <sup>-</sup>	2.54E+02	8.12E+02	0.313
Fe <sup>+3</sup>	1.70E+03	6.31E+02	2.69
K <sup>+</sup>	2.53E+02	5.53E+01	4.57
La <sup>+3</sup>	4.01E+01	1.88E+00	21.3
Mn <sup>+4</sup>	1.47E+02	1.20E+02	1.23
Na <sup>+</sup>	2.63E+04	5.73E+04	0.459
Ni <sup>+3</sup>	1.63E+02	2.03E+02	0.803
NO <sub>2</sub> <sup>-</sup>	9.88E+03	6.52E+03	1.51
NO <sub>3</sub> <sup>-</sup>	2.91E+04	1.00E+05	0.291
OH <sup>-total</sup>	1.59E+04	1.06E+04	1.50
Pb <sup>+4</sup>	2.00E+00	2.83E+01	0.071
PO <sub>4</sub> <sup>-3</sup>	3.24E+03	4.73E+03	0.685
Si <sup>+4</sup>	5.31E+02	4.59E+02	1.16
SO <sub>4</sub> <sup>-2</sup>	1.96E+03	1.65E+03	1.19
Sr <sup>+2</sup>	1.57E+02	3.60E+01	4.36
U	1.62E+03	1.61E+03	1.01
Zr <sup>+4</sup>	3.00E+01	3.82E+02	0.079
TOC	1.20E+03	4.73E+02	2.54
Total	1.22E+05	1.92E+05	0.536

EIS = Environmental Impact Statement

LANL = Los Alamos National Laboratory

SST = Single-shell tank

<sup>a</sup>Includes aluminum that may be found in cancrinite (2NaAlSiO<sub>3</sub>·0.52NaNO<sub>3</sub>·0.68H<sub>2</sub>O); total aluminum inventory adjusted from 1987 EIS.

<sup>b</sup>Adjusted from 9.59E+01 MT reported in the 1987 EIS.

- *Identify and compile reported component inventory values from appropriate sources.*

Sources include the HDW-EIS document (DOE 1987), LANL model predictions (Agnew 1995), and ORIGEN2 (Oak Ridge Isotope Generation) model predictions (Schmittroth 1995). Projections based on sample analyses (Colton et al. 1995) provide an additional source of component inventory information; however, these projections are limited to only some SST wastes and should be used solely as an aid to inventory evaluations.

- *Compare inventory values, note differences, and determine whether differences are significant.*

Table 4-2 provides an example of global component inventory comparisons for SST wastes. This example illustrates how HDW-EIS values (DOE 1987) may appear similar to or differ from LANL predicted (model) values. In some instances, e.g., Si, the LANL and HDW-EIS values may appear similar; however, these values may differ from the sample-based projection value. In other instances, a global (combined SST and DST) component inventory may agree with the reported EIS component inventory; however, the SST and DST component inventory values may differ (this is the case for Al).

The following rule is proposed for determining how well reported (HDW-EIS) and predicted (LANL) values agree:

$$\text{If } \frac{|inv_{rep} - inv_{pred}|}{(inv_{rep} + inv_{pred})/2} \times (100) \leq "X" \%, \text{ then the component inventories will be considered to be in agreement.}$$

Note that this calculation only indicates the difference between the reported HDW-EIS and predicted LANL values and does not estimate the true variance from the actual waste inventory. An initial value of  $X = 20$  percent has been assumed as an indication of agreement between the various estimates. An error of 20 percent is unlikely to have major ramifications with respect to system evaluations, safety analyses, and risk assessments. However, if a data user determines this uncertainty to be too large, then a more rigorous review will be implemented. Two components that will likely require a more stringent rule include Na (LLW glass volume impact), and  $^{137}\text{Cs}$  (impact on requirements for removing from supernatant liquors). More specific threshold values for all components are presently being solicited.

- *Where inventory values agree within the defined rule, calculate an average value (or use source that appears to have smaller variance) and use this value as the "best" estimate.*

In the case where LANL reported and HDW-EIS values agree, but differ significantly from values projected from analytical data, further evaluation may be warranted during this initial reconciliation (see the following step) or may not be warranted until individual tank inventory estimates have been completed for all tanks.

- *Where inventory values disagree within the defined rule, evaluate the quality of data from each source; accept or reject a datum on the basis of this evaluation.*

The procedure for assuring data quality for global component inventories is:

1. Critically examine all input data and assumptions used in the HDW-EIS and LANL model inventory calculations to identify any discrepancies, errors, missing information, etc. This examination will include:
    - identifying waste types that contribute to the majority of the component inventory.
    - evaluating process stream compositions from chemical flowsheets.
    - reviewing amount of fuel processed, waste transfers, e.g., crib discharges, purchase records.
    - reviewing assumptions for radionuclide source models, e.g., ORIGEN.
  2. Document all bases and arrive at agreement with majority of technical experts that the revised input data are sound. Establish qualitative confidence levels based on the relative limitations of the source data. Obtain peer review approval of results.
- *Define and document best-basis estimate of global inventory in terms of the major components.*

Global component inventories will be used as a basis for reconciling individual tank waste inventories. The LANL model assumption bases will be adjusted to reflect these component inventories.

different waste phases, the presence of an overall slope to the waste, or "shelving" of evaporator concentrates). The other source of data that can be used in this task are the process and transfer records that recorded the inputs and discharges of a tank over its process history. The overall waste input minus the overall waste discharged will give a rough estimate of the accumulation in a tank.

The results from these two separate data sets are compared and any major discrepancies (10 percent) are reconciled, or additional data assessment is performed to derive a more appropriate waste volume. In the future, topographical mapping may be employed to provide a detailed view of the waste surface. This mapping effort could be easily applied to quantification of the waste volumes. For example:

Tank A-101. This tank has shown a decrease over the past 15 years. The Neutron ILL measurement is about 20 inches higher than the surface measurements. Photos do not show any reason for this. The surface is flat with little roughness. The difference between inventory derived from the surveillance data and the transaction data is less than 10 percent. Therefore, the surface measuring devices will take precedence. For the year 1995, the manual tape and ENRAF have averaged about 342 inches. Therefore, the recommended volume to use is 940,000 gallons.

#### 4.2.3 Methods for Generating Radionuclides

Historically, global inventory values for Hanford Site waste tanks have been generated via reactor fuel activity codes with supplemental separations plant waste analysis data for certain nuclides. To date, analysis of waste samples taken from the tanks has not been relied upon since not enough tanks have been sampled to allow prediction of total quantities. Past calculational methods have been:

- RIBD Code (for fission products) plus hand calculations for activation products.
- The Track Radioactive Components (TRAC) model (Jungfleisch 1984), which used factors derived from the RIBD code.
- The RADNUC code which uses tables of Ci/MTU factors generated by the ORIGEN2 code (Croft 1980).
- A simplified ORIGEN2 code calculation which scales annual radionuclide production proportional to annual fuel exposure (Mega-watt days)

Results from the RIBD Code and TRAC model methods were published as Engineering Support Data for the HDW-EIS (RHO 1985) and are also reported to the

To establish a basis for some of these sample versus code calibrations, the simplified ORIGEN2 method will need to be run in a calibration mode in which just inventories in tanks 241-AZ-101 and 241-AZ-102 are calculated. After the ORIGEN2 model is calibrated, runs to calculate the Global Inventory can then be made.

#### Proposed Methodology for Generating Tank-by-Tank Radionuclide Inventory Values

One relatively straightforward way of generating tank by tank inventory values is to modify the "Tank Layering Model" (Agnew et al. 1995) (currently under development at LANL) to carry data fields for all 32 key radionuclides. Preliminary discussions with LANL personnel indicates that the Tank Layering Model will need to be fitted with tables of predecayed radionuclide values, representing the production over short historical time periods such as 1944 through 1947. For consistency these tables of periodic inventories will also need to be generated by the same methodology that is used to prepare the Global Inventory.

#### 4.2.4 Cesium-137 and Strontium-90

The two radionuclides,  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ , along with certain others, e.g.,  $^{99}\text{Tc}$ ,  $^{79}\text{Se}$ , the actinide elements, etc., are the most important radioactive constituents of Hanford Site tank wastes. Because of their approximate 30-year half lives,  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  contribute not only almost all of the decay heat associated with the tank wastes but also most of the radioactivity (curie) content of the tank wastes. Systems for disposing of retrieved Hanford Site tank wastes all involve removal of the bulk of the  $^{137}\text{Cs}$  in such wastes; removal of  $^{90}\text{Sr}$  from some retrieved tank wastes may also be necessary or desirable to obtain low-level waste which can be disposed of in near-surface facilities. For economic reasons, i.e., costs involved in designing, constructing, and operating a  $^{137}\text{Cs}$  removal facility, it is particularly important to establish a high-quality "best" estimate of the global inventory of  $^{137}\text{Cs}$  in the 177 underground tanks at the Hanford Site.

For purposes of determining global inventories of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ , it is convenient to consider separately the amounts of these two radionuclides in DSTs from those in SSTs. An abundance of analytical data for wastes in all 28 DSTs indicates that the global inventory of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in the DSTs can be established quickly and confidently. Moreover, initial evaluations indicate that the DST global inventory values of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  established from analytical data are in acceptable agreement with inventories predicted by the LANL model (Agnew 1995).

The problem, therefore, is to establish a "best" estimate of the total inventory of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in the 149 SSTs. A suitable best estimate cannot be obtained from the presently available few analyses of actual SST wastes. The LANL model provides estimates of the total amount of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in the 149 SSTs. Unfortunately, the basis for and validity of the current LANL model predictions of the SST  $^{137}\text{Cs}$  inventory have not been established.

A considerable amount of the data needed to complete the material balance estimation of the  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  content of the SSTs is available in a recently published report (Boldt et al. 1995). Negotiations with Hanford Site B Plant/Waste Encapsulation and Storage Facility (WESF) management have been initiated to obtain updated information concerning disposition of the quantities of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  processed through B Plant and the WSEF. We are also contemplating making a new ORIGEN2 code run to incorporate, as accurately as possible, Hanford Site reactor irradiation conditions and history.

The "best" estimate of the global inventory of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  obtained by material balance analysis will be reconciled to a revised LANL model prediction according to the methodology discussed in Section 4.1. Available analytical data for the inventories of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in wastes in 30 SSTs will be used to the extent possible to help in rejecting or accepting a datum if such action becomes necessary.

#### 4.2.5 Chromium

As shown in Table 4-2, the extrapolation of tank core sample data to project a global SST inventory for chromium (Cr) (244 MT) indicates a fair agreement with EIS data for Cr (268 MT). However, both these values differ significantly with the LANL model estimate (747 MT). In addition, it has been recognized for some time that the 1974 estimate of Cr consumption in separations plants (Allen 1976), presumably the original source of the EIS data base, is significantly larger than values reported in the EIS (697 MT Cr as estimated by Allen (1976) versus 268 MT as reported in the EIS).

To resolve this significant disparity in Cr inventory values, calculations were performed to reevaluate in greater detail the amount of Cr consumed in the REDOX fuels separation plant during its operating lifetime, 1952 through 1966. (Note that as indicated by the sample data shown in Table 4-2, other separations or waste treatment processes did not add significant quantities of Cr.) Six REDOX process flowsheet documents plus monthly reports were inspected to identify dates when changes were made in individual stream flow rates or Cr concentrations. This produced a history of monthly Cr consumption factors (g-moles/MTU) which vary by as much as a factor of 1.8, from highest consumption in the mid 1950s to lowest consumption in the mid 1960s. This consumption data was then combined with a file of historical uranium throughput by month to generate a total consumption value over the life of the REDOX plant. This value was then increased by an assumed 15 percent to allow for flowsheet inefficiencies and periods of rework. A range of results is shown in Table 4-3.

The *Hanford Defense Waste Environmental Impact Statement* engineering support data (RHO 1985, page B-5) gives the total fuel reprocessed at Hanford through 1972 as 94,000 MTU. Approximately 1800 MTU of NPR fuel was processed at REDOX and PUREX (from Roberts 1957). Therefore, it is concluded that the mass of aluminum clad fuel was  $94,000 - 1800 =$  approximately 92,000 MTU.

The aluminum in Al cladding waste then would be approx.

$$(45 \text{ kg/MTU})(92,000 \text{ MTU}) = 4.2 \text{ E}+6 \text{ kgs} = 4.2 \text{ E}+3 \text{ MT Al.}$$

**REDOX Salt Wastes.** The REDOX process used aluminum nitrate nonahydrate (ANN) -  $\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$  as a salting agent for solvent extraction with Hexone. The REDOX flowsheet documents (listed above) show the aluminum use in the process as follows:

<u>Flowsheet</u>	<u>kg Al/MTU</u>	<u>Flowsheet Date</u>
HW-5	129.2	08/16/55
HW-6	96.3	10/17/60
HW-7	56.3	01/19/65
HW-8	75.9	01/19/65
HW-9	77.9	09/6/66

As a preliminary approximation, 100 kg Al/MTU was chosen.

The total REDOX production (again from addition of data in Roberts (1957), was 21,842.4 tons = 19,857 MTU. This includes approximately 136 MTU of N Fuel (reviewing the 1965 and 1966 Hanford Site monthly reports establish the amount of Zirflex Processing in REDOX). Thus, the total Al clad fuel processed in REDOX was  $19,857 - 136 =$  approximately 19,721 MTU.

The Al in the REDOX salt (HLW) waste then would be approximately  $(100 \text{ kg Al/MTU})(19,721 \text{ MTU}) = 2.0 \text{ E}+6 \text{ kgs} = 2.0 \text{ E}+3 \text{ MT Al.}$

#### **Total Aluminum Discharged to Wastes**

$$\text{Total} = 4.2 \text{ E}+3 \text{ plus } 2.0 \text{ E}+3 = 6.2 \text{ E}+3 \text{ MT Al.}$$

#### **Additional Thoughts on Aluminum in Waste**

The above calculations neglect usage of aluminum in other Hanford Site processes such as the aluminum cladding of the thorium target fuels processed at PUREX in 1966 and 1970 for U-233 recovery. It also neglects the use of ANN to complex fluoride ion for stainless steel corrosion control. ANN was used for this purpose in both REDOX, PUREX (during Zirflex processing and any HF flushing), and at PFP. These secondary aluminum

This is not physically possible since a pure  $\text{NaNO}_3$  salt cake with a bulk density of 2.26, has a sodium concentration close 31M. However, the salt cake in the waste tanks contains considerable void spaces that may or may not contain liquid. The liquid, if present, would be at a much lower sodium concentration than 25.6M; in fact, we shouldn't expect sodium concentrations in the interstitial liquid to exceed 12M (Agnew and Watkins 1994).

Figure 4-2 represents a more detailed analysis of SST sodium data. Salt cake, supernatant, and sludge volumes were taken from Hanlon, 1995. The sodium concentration in the sludge was assumed to be 5.26M. The dry salt cake was assumed to be 100 percent  $\text{NaNO}_3$ . The graph was generated by varying the concentration of sodium in the liquid phase and the porosity of the salt cake in the SSTs. The 61 percent porosity is the current baseline value used in waste volume projections (Strode 1995) because volumes of saltwell liquid retrieved recently correspond to a 61 percent porosity rather than the 45 percent porosity value used previously.

The SST liquid curves intersect the 61 percent porosity line at values between  $3.1\text{E}+04$  and  $4.4\text{E}+04$  MT. At 45 percent porosity, the range is  $3.8\text{E}+04$  to  $4.7\text{E}+04$  MT. This reconciles with the LANL value.

The DST sodium estimates from LANL ( $1.08\text{E}+04$  MT) and the current TWRS baseline ( $1.11\text{E}+04$  MT) agree to within 3 percent.

What accounts for the difference between the LANL and EIS estimates? One explanation that might account for some of the discrepancy may lie in different assumptions about the amount of sodium that was cribbed. Although what the original data source(s) was for the HDW-EIS inventories is not definite, it appears that G. K. Allen's study (Allen 1976) and probably ERDA 1538 were among the original sources in the document path that led to the creation of the HDW-EIS inventories. In his notes, Allen estimated that  $11.1\text{E}+04$  MT of sodium was cribbed while LANL estimates that  $2.11\text{E}+04$  MT was sent to the ground, a number that agrees very well with an independent study by Waite (Waite 1991). Waite's estimate was  $2.26\text{E}+04$  MT of sodium.

The different assumptions about cribbing would account for some of the discrepancy, but given the critical importance of sodium in regard to facility design, it is essential that a much more rigorous reconciliation procedure be adopted. It may even be necessary to research monthly and quarterly status reports as well as evaporator campaign reports to find information about sodium concentrations and total waste inventories. It may be possible and necessary to establish the total waste volume reported before any significant salt cake formation occurred. This will facilitate calculation of total sodium based on assumed or reported sodium concentrations in the aqueous phase.

#### 4.2.8 Chloride

Chloride salts are only slightly soluble in typical nuclear waste glasses. Such salts can contribute to the formation of troublesome secondary molten salt phases during waste vitrification operations. An accurate estimate of the chlorine (as chloride) content of SST and DST wastes is needed to support formulation of suitable glasses for immobilization of the Hanford Site low-active waste (LAW).

Available estimates of the chloride inventory in the Hanford Site tank wastes are shown in Table 4-1. The chloride inventory (674 MT) determined from analyses (Shelton 1994) of actual waste agrees very well with that predicted (650 MT) by the LANL model. The chloride inventory (40 MT) reported earlier in the HDW-EIS (DOE 1987) is known to be in error since no consideration was given to the amount (typically 1 wt%) of chloride present in the commercial NaOH used extensively at the Hanford Site.

The chloride inventories from LANL model predictions and from analytical data differ by only about 4 percent, well within the defined (20 percent) acceptance criterion. Thus, based on this preliminary assessment, the best basis global chloride inventory value is 662 MT, the average of data from the two sources.

#### 4.2.9 Silicon

Extrapolation of sample data projects an estimate of 730 MT of silicon in the SST waste. The LANL model estimates 410 MT of silicon (Brevick et al. 1994a, 1994b, 1995a, 1995b). A number of sources for silicon in the waste have been identified to date. These sources include the following:

- Al-Si bond layer in the aluminum clad fuel
- Impurities in fuel components (uranium, aluminum alloys, etc.)
- Chemicals added during processing
- Impurities in process chemicals
- Diatomaceous earth and Portland cement additions to the tanks
- Soil disposed of in the tanks
- Blowsand accumulations in tank pits.

Resolution of the contribution of the Al-Si bond layer is dependant on resolving the fuel processed issues. Significant progress has been made in evaluating impurity sources as well as direct additions to the tanks. The tanks are known to have received diatomaceous earth, cement, and soil additions. Blowsand is known to have entered the tanks. Process flowsheets have yet to be reviewed.

The approach proposed for estimating the total amount of iron in the waste is to (1) use core samples and chemical purchase records to determine the corrosion source term for PUREX, (2) use Schofield's corrosion estimate for the PUREX dissolvers to predict the amount of iron produced from corrosion in the REDOX and BiPO<sub>4</sub> processes, adding an allowance for corrosion from the evaporators, and (3) use LANL and Allen's flowsheet and purchase record information to estimate the amount of process related iron in the waste. In parallel, we should also evaluate N. G. Colton's data (Colton et al. 1995) for the 27 SSTs where we have reasonable core sample results and compare these results to the LANL estimates for the same waste types. According to Colton's estimates, these tanks contain 457 MT of Fe, compared to 781 MT from LANL's TLM model (Agnew et al. 1995). On average, the LANL TLM estimates seem to be high by a factor of 1.7 for this population of tanks. These tanks mostly contain BiPO<sub>4</sub> first cycle, second cycle and 224 waste, uranium recovery waste, salt cake and REDOX and PUREX coating wastes, but not high-level PUREX and REDOX wastes.

#### 4.2.11 Minor Elements

Minor elements, are those elements not tracked on process flowsheets. Inventories of these components are required by some data users (e.g., Cu, Co, Pb, Table 3-1). Minor elements may have been introduced into the tank waste by any of the following mechanisms.

- Fission products, activation products and actinides generated by irradiation of fuel
- Impurities in fuel components (uranium, aluminum alloys, etc.)
- Chemicals used in the plants, but not shown on process flowsheets
- Chemicals used by tank farms
- Impurities in process chemicals
- Materials disposed of in the tanks
- Shipments from the 100/300 areas
- Diatomaceous earth and Portland cement additions to the tanks
- Soil disposed of in the tanks
- Blowsand accumulations in tank pits.

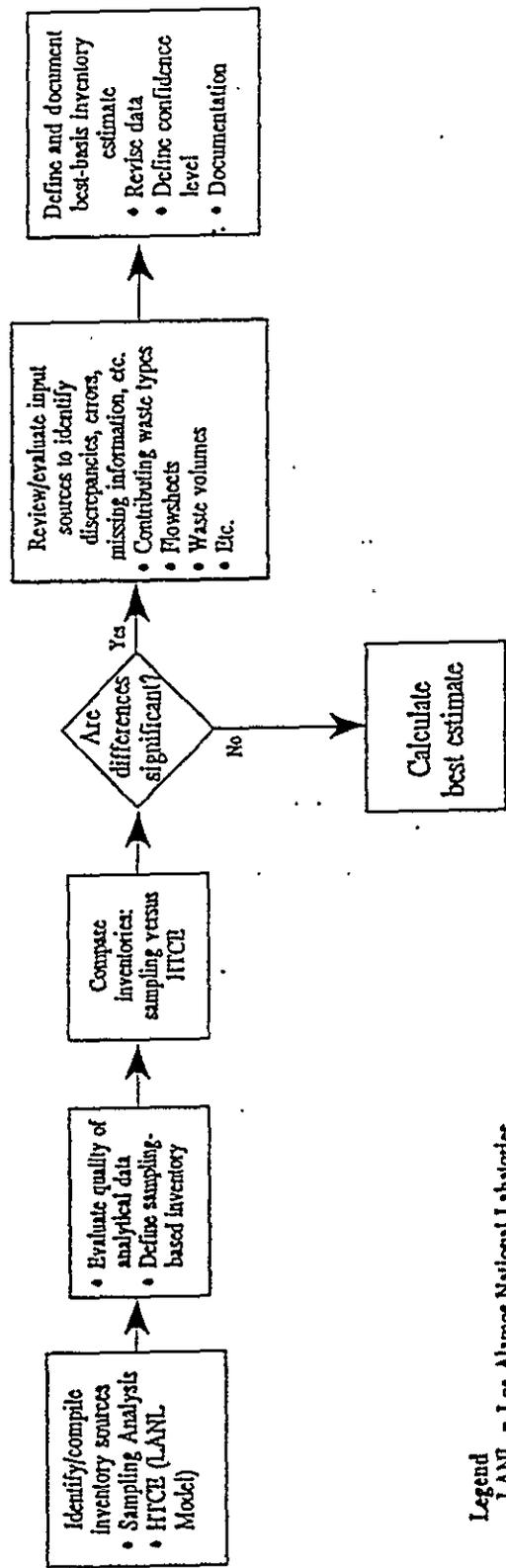
Each of these sources will need to be considered to see if significant quantities of minor chemicals may have been introduced into the tank waste. To date identification of minor components has been limited to impurities introduced by fuel fabrication.

#### Fuel Fabrication

Fuel fabrication methods changed over the years to save costs, and in response to increasingly severe reactor conditions. These methods included:

zirconium clad fuel was processed by PUREX. The data compiled by Raab was not intended to tally all zirconium clad fuel that was processed by PUREX. Since Raab only provided data on 5 of the 18 process runs with zirconium clad fuel, it is likely that substantially more N Reactor fuel was processed. Monthly operation reports for PUREX were reviewed but the information found was insufficient to establish the tons of Zirconium clad fuel processed before 1983.

Figure 5-1. Quality Plan for Reconciling Individual Tank Inventories.



Legend  
LANL - Los Alamos National Laboratories  
HITCE - Historical Tank Content Estimates

14649QUANT.3277105-1.WFO

- *If significant differences are noted, evaluate the quality of data from each source; accept or reject a datum on the basis of this evaluation.*

Where little or no analytical information exists for a tank, model predications must serve as the basis for the inventory. The procedure for assuring data quality for component inventories is as follows:

1. Critically examine all input data and assumptions used in the sampling-based and HTCE inventory calculations to identify any discrepancies, errors, missing information, etc. This examination will include the following:
    - Identifying waste types that contribute to the majority of the component inventory.
    - Evaluating process stream compositions from chemical flowsheets.
    - Reviewing waste transaction records.
    - Reviewing model assumptions.
  2. Document all bases and arrive at agreement with majority of technical experts that the revised input data are sound. Obtain peer review approval of results.
- *Define and document best-basis inventory and waste characteristics estimate.*

Qualitative confidence levels, based on the relative limitations of the source data, will be included .

## 5.2 EXAMPLE OF A BEST-BASIS INVENTORY ESTIMATE: SST U-110

The following example illustrates how the methodology outlined in Section 5.1 is used to establish a best-basis inventory estimate for U-110.

- **Identify/compile inventory sources**

The Tank Characterization Report (TCR) for Single-Shell Tank 241-U-110 [5] provides characterization results from the most recent sampling event for this tank. Eight core samples were obtained and analyzed. Tables 7.2 A - F in the TCR summarize the results from the statistical analysis of data from 7 core composites. These tables provide high, low, and mean concentration values for analytes, along with confidence intervals

Table 5-1. Sampling- and Historical Tank Content-based Inventory  
Estimates for Nonradioactive Components.

Analyte	Sampling [5] Inv Estimate (MT)	HTC [5] Inv Estimate (MT)	Analyte	Sampling [5] Inv Estimate (MT)	HTC [4] Inv Estimate (MT)
Al	150	16	Ni	0.13	0.46
Ag	NR	NR	NO <sub>2</sub>	9.4 <sup>(a)</sup>	4.4
As	0.00042	NR	NO <sub>3</sub>	46 <sup>(a)</sup>	23
Ba	0.066	NR	OH		44 (total)
Be	0.0033	NR	oxalate	NR	NR
Bi	21	7.2	Pb	1.1	NR
Ca	3.3	0.88	Pd	NR	NR
Ce	NR	0	P as PO <sub>4</sub>	48	60
Cd	NR	NR	Pt	NR	NR
Cl	1.0 <sup>(a)</sup>	0.34	Rh	NR	NR
Co	NR	NR	Ru	NR	NR
Cr	0.63	0.29	Sb	NR	NR
Cr <sup>+3</sup>	NR	NR	Se	0.0018	NR
Cr <sup>+6</sup>	NR	NR	Si	23	1.7
Cs	NR	NR	S as SO <sub>4</sub>	2.6	6.3
Cu	NR	NR	Sr	0.52	NR
F	7.2 <sup>(a)</sup>	4.0	Te	NR	NR
Fe	13	11	TIC as CO <sub>2</sub>	4.5 <sup>(a)</sup>	2.8
FeCN/CN	NR	NR	Th	1.8	NR
formate	NR	NR	Ti	3.2	NR
Hg	0.0030	NR	TOC	0.98 <sup>(a)</sup>	0
K	NR	0	U <sub>total</sub>	11	8.5
La	NR	0	V	0.069	NR
Mg	2.6	NR	W	NR	NR
Mn	4.2	0	Zn	1.1	NR
Mo	0.050	NR	Zr	0.38	0.43
Na	110	64	H <sub>2</sub> O (Wt%)	40	75
Nd	NR	NR	density (kg/L)	1.46	1.25
NH <sub>4</sub>	NR	NR			

\*Based on analysis of water leach only.

Table 5-3. Technical Flowsheet and Los Alamos National Laboratory Defined Waste Streams.

Analyte	Flowsheet 1C [10] (M)	Def Waste 1C [1] (M)	Flowsheet 4 <sup>(a)</sup> REDOX [6] (M)	Def Waste R1 [1] (M)	Flowsheet RCW [6] (M)	Def Waste RCW [1] (M)
NO <sub>3</sub>	1.59	0.5	3.62	2.3	0.98	0.8
NO <sub>2</sub>	0.216	0.174	0	0	1.27	1.4
SO <sub>4</sub>	0.054	0.06	0.029	0.015	0	0
Bi	0.012	0.014	0	0	0	0
Fe Fe <sub>corr</sub> <sup>(b)</sup>	0.0263	0.03 0.016	0.014	0.0075 0.04	0	0.0152
Si	0.0329	0.038	0	0.0147	0.020	0.03
U	0.0006	0.0008	0.0075	0.0048	0.001	0.019
Al	0.288	0.233	1.05	0.65	1.7	2
Cr <sup>+3/+6</sup>	0.0017	0.0052	0.053	0.068	0	0
PO <sub>4</sub>	0.279	0.314	0	0	0	0
F	0.197	0.23	0	0	0	0
Ce	0.0002	NR	0	0	0	0

<sup>a</sup>REDOX Flowsheet #4 operated until August, 1955.

<sup>b</sup>Fe contribution from corrosion.

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

- Tank waste mass is calculated using the measured density and the tank volume listed in Hanlon [7]. While this volume may or may not be correct, both the analytical-based and the model-based inventories are derived using this volume. As a result, inventory comparisons are made on the same volume basis.
- 1C, R, and RCW streams contributed to solids formation.
- Only bulk components listed in the technical flowsheets are being evaluated. Initial bulk component concentrations are obtained from technical flowsheets (refer to Table 5-3 below).

-	Fe (Fe <sub>2</sub> O <sub>3</sub> )	1.43	U (UO <sub>3</sub> )	1.20
-	Bi (Bi <sub>2</sub> O <sub>3</sub> )	1.12	Cr (Cr <sub>2</sub> O <sub>3</sub> )	1.46
-	Si (SiO <sub>2</sub> )	2.14	Al (60% Al(OH) <sub>3</sub> (40% Al <sub>2</sub> O <sub>3</sub> )	2.49

Sample calculations used in this independent evaluation follow for:

components assumed to precipitate (Fe, Bi, Si, U).

$$\text{Fe: } 0.0263 \text{ moles}_{\text{Fe}}/\text{L}_{\text{IC}} \times 1394 \text{ kgal}_{\text{IC}} + 0.014 \text{ moles}_{\text{Fe}}/\text{L}_{\text{R}} \times 1192 \text{ kgal}_{\text{R}} + 0_{\text{RCW}} \times 3785 \text{ L/kgal} \times 55.8 \text{ g/mole}_{\text{Fe}} \times \text{MT}/1\text{e}6 \text{ g} = 11 \text{ MT}$$

$$\text{Bi: } 13 \text{ MT}$$

$$\text{Si: } 6.6 \text{ MT}$$

$$\text{U: } 9.5 \text{ MT}$$

components assumed to remain dissolved in the interstitial liquid (NO<sub>3</sub>, NO<sub>2</sub>, SO<sub>4</sub>).

$$\text{NO}_3: (0.41_{\text{IC}} \times 1.59 \text{ moles}_{\text{NO}_3}/\text{L}_{\text{IC}} + 0.35_{\text{R}} \times 3.62 \text{ moles}_{\text{NO}_3}/\text{L}_{\text{R}} + 0.24_{\text{RCW}} \times 0.98 \text{ moles}_{\text{NO}_3}/\text{L}_{\text{RCW}}) \times 0.7_{\text{porosity}} \times 3785 \text{ L/kgal} \times 186 \text{ kgal}_{\text{U-110 waste}} \times 62 \text{ g/mole}_{\text{NO}_3} \times \text{MT}/1\text{e}6 \text{ g} = 66 \text{ MT}$$

$$\text{NO}_2: 8.9 \text{ MT}$$

$$\text{SO}_4: 1.5 \text{ MT}$$

components assumed to partition between aqueous and solid phases (Al, Cr, PO<sub>4</sub>, F).

$$\text{total Al: } (0.41_{\text{IC}} \times 0.288 \text{ moles}_{\text{Al}}/\text{L}_{\text{IC}} + 0.35_{\text{R}} \times 1.05 \text{ moles}_{\text{Al}}/\text{L}_{\text{R}} + 0.24_{\text{RCW}} \times 1.7 \text{ moles}_{\text{Al}}/\text{L}_{\text{RCW}}) = 0.894 \text{ moles}_{\text{Al}}/\text{L}$$

$$\text{Al}_{\text{solids}}: 0.4 \times 0.894 \text{ moles}_{\text{Al}}/\text{L} \times 3785 \text{ L/kgal} \times 3392 \text{ kgal} \times 27 \text{ g/mole}_{\text{Al}} \times \text{MT}/1\text{e}6 \text{ g} = 120 \text{ MT}$$

$$\text{Al}_{\text{interstitial}}: 0.6 \times 0.894 \text{ moles}_{\text{Al}}/\text{L} \times 0.7_{\text{porosity}} \times 3785 \text{ L/kgal} \times 186 \text{ kgal}_{\text{U-110 waste}} \times 27 \text{ g/mole}_{\text{Al}} \times \text{MT}/1\text{e}6 \text{ g} = 7.1 \text{ MT}$$

$$\text{total Al: } 130 \text{ MT}$$

Estimated component inventories from this independent evaluation are compared with sampling- and HTCE-based inventories for selected components in Table 5-4. Observations regarding these inventories are noted, by component, in the following text.

Table 5-4. Comparison of Selected Component Inventory Estimates for U-110 Waste.

Component	This Evaluation (MT)	Sampling-based (MT)	HTCE (MT)
Fe	11	13	11
Bi	13	21	7.2
Si	6.6	23	1.7
U	9.5	11	8.5
NO <sub>3</sub>	66	46	23
NO <sub>2</sub>	8.9	9.4	4.4
SO <sub>4</sub>	1.5	2.6	6.3
Al	130	150	16
Cr	0.94	0.63	0.29
PO <sub>4</sub>	53	48	60
F	6.2	7.2	4.0
Na	87	110 (calculated 104)	64 (calculated 65)
H <sub>2</sub> O (%)	41	40 (calculated 32)	75 (calculated 73)

**Iron.** The sampling-based and HTCE inventories compare favorably with each other and with the inventory estimated in this evaluation. However, the fact that the sampling-based and HTCE inventories compare fairly well may be circumstantial. The HTCE inventory is based predominantly on the 1C waste stream with 0.03M Fe due to chemicals added in the process and 0.016M Fe assumed from corrosion; Fe in the R waste stream (0.014M) was not taken into account. The LANL corrosion source term is based on PUREX-related data and may not be applicable to 1C waste streams. Analytical data from a tank that received only 1C waste (T-104) indicates 9000 µg Fe/g waste. The anticipated Fe concentration, using 0.0263M from the 1C technical flowsheet, a volume percent of 13.7 (consistent with LANL assumptions), and the analytical measured density of 1.2 g/mL, is 8900 µg Fe/g waste. The difference between these measured and calculated concentrations does not suggest a large corrosion source term.

[ $\text{Na}_2(\text{AlSiO}_4)_6(\text{NO}_3)_2$ ] is present in the waste. Nitrate in cancrinite would not dissolve in a water leach; and as a result, the concentration of  $\text{NO}_3$  in the water leach, that is used to derive the sampling-based inventory, would not reflect the total  $\text{NO}_3$  concentration.

**Nitrite.** The inventory estimated in this evaluation and the sampling-based inventory are fairly close (approximately 9 MT), although the inventory derived in this evaluation does not account for any  $\text{NO}_2$  from radiolysis of  $\text{NO}_3$  or for any  $\text{NO}_2$  additions for corrosion purposes. The HTCE inventory does not account for any contribution from the RCW (1.27M  $\text{NO}_2$ ) and is smaller than the sampling-based inventory.

**Sulfate.** The HTCE inventory is larger than the sampling-based inventory, and both of these inventories are larger than the inventory estimated in this evaluation. As mentioned previously, the HTCE inventory does not account for any contributions from the R and RCW streams that passed through the tank. The  $\text{SO}_4$  concentration in the R waste stream is more dilute than the  $\text{SO}_4$  concentration in the 1C waste stream. A further dilution effect might be expected from the RCW because no  $\text{SO}_4$  was intentionally added to this waste stream.

**Aluminum.** The inventory estimated in this evaluation is within 15 percent of the sampling-based inventory. Both of these inventories are significantly larger than the HTCE inventory. The HTCE inventory reflects the LANL assumptions (1) that R and RCW streams did not contribute to any of the solids in this tank and (2) that 70 percent of the Al remains in solution (30 percent precipitates).

**Chromium.** The HTCE inventory is derived from 0.0052M Cr in the 1C defined waste stream. This concentration is approximately three times higher than the concentration derived from the technical flowsheet and may include a Cr corrosion source term. Analytical data from a tank that received only 1C waste (T-104) indicates 916  $\mu\text{g}$  Cr/g waste. The anticipated Cr concentration, using 0.0017M derived from the 1C technical flowsheet, a volume percent of 13.7 (consistent with LANL assumptions), and the analytical measured density of 1.2 g/mL, is 540  $\mu\text{g}$  Cr/g waste. If the difference between these measured and calculated concentrations is used to calculate a corrosion source term, the source term might be closer to 0.0012M than 0.0035M. Even though the 1C defined waste stream has a potentially inflated Cr concentration, the HTCE inventory derived from this concentration is still smaller than the sampling-based inventory by a factor of two. The HTCE inventory does not account for any Cr from the R waste that was added to the tank. Both the HTCE and sampling-based inventories are smaller than the inventory estimated in this evaluation. As mentioned earlier, this evaluation does not account for any dilution of dissolved components by process water or other dilute waste streams.

**Phosphate.** Phosphate originated from the 1C waste stream ( $\text{PO}_4$  was not added to R or RCW). As a result, the HTCE inventory, derived from the 1C waste stream, and the inventory estimated in this evaluation should be comparable. The HTCE inventory is larger than the inventory estimated in this evaluation, and both of these inventories are larger than

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

- Only 1C contributed to the waste composition
- Corrosion source terms for Fe and Cr that are based on PUREX-related data are applicable to 1C waste
- The starting  $\text{NO}_3$  concentration in the 1C waste stream was  $0.5M$ .

Table 5-5. Comparison of Component Inventory Estimates.  
(Percentage of the Difference Divided by the Mean  
using Component Inventory Pairs)

Component	$\frac{ Inv_{this\ eval} - Inv_{sample} }{[(Inv_{this\ eval} + Inv_{sample})/2]} \times 100 (\%)$	$\frac{ Inv_{this\ eval} - Inv_{HTCE} }{[(Inv_{this\ eval} + Inv_{HTCE})/2]} \times 100 (\%)$	$\frac{ Inv_{sample} - Inv_{HTCE} }{[(Inv_{sample} + Inv_{HTCE})/2]} \times 100 (\%)$
Fe	17	0	17
Bi	47	57	98
Si	110	120	170
U	15	11	26
$\text{NO}_3$	36	97	67
$\text{NO}_2$	5.5	68	73
$\text{SO}_4$	54	120	83
Al	14	160	160
Cr	40	110	74
$\text{PO}_4$	10	12	22
F	15	43	57
Na	23	31	53
$\text{H}_2\text{O}$	2.5	59	61

Table 5-6. Best-basis Inventory Estimates for Nonradioactive Components. (Sheet 2 of 4)

Analyte (Method/ Sample Prep)	Mean Conc μg/g	Low 95% CI μg/g	High 95% CI μg/g	HTCE conc w/in CI? (Y/N)	Bulk Tank Inv (MT)	Wash Factor [9]	Leach Factor [9]
Cr (ICP/Acid)	612	323	902	Y	0.63		
Cr <sup>+3(a)</sup>	114	—	—	NA	0.12		
Cr <sup>+6(a)</sup> (ICP/Water)	498	232	764	NA	0.51		
Cs	NR						
Cu	NR						
F (IC/Water)	7050	5200	8910	N	7.2		
Fe (ICP/Acid)	12,600	8860	16,200	Y	13		
FeCN/CN	ND			Y	ND		
formate	NR						
Hg (AAS/Acid)	2.96	0	8.38	NA	0.0030		
K	NR						
La	NR						
Mg (ICP/Fusion)	2540	471	4610	NA	2.6		
Mn (ICP/Acid)	4080	2830	5340	N	4.2		
Mo (ICP/Acid)	49	34	64	NA	0.050		
Na (ICP/Fusion)	111,000	92,000	131,000	N	110		

<sup>a</sup>Cr in the water leach is assumed to be Cr<sup>+6</sup>, and Cr<sup>+3</sup> is assumed to be the difference between the Cr<sub>total</sub> and Cr<sup>+6</sup>.

Table 5-6. Best-basis Inventory Estimates for Nonradioactive Components (Sheet 4 of 4)

Analyte (Method/ Sample Prep)	Mean Conc μg/g	Low 95% CI μg/g	High 95% CI μg/g	HTCE conc w/in CI? (Y/N)	Bulk Tank Inv (MT)	Wash Factor [9]	Leach Factor [9]
Sr (ICP/Fusion)	505	350	659	NA	0.52		
Te	NR						
TIC as CO <sub>3</sub> (C/Water)	4350	1900	6790	Y	4.5		
Th (ICP/Acid)	1790	748	2840	NA	1.8		
Tl (ICP/Acid)	3080	1260	4900	NA	3.2		
TOC as C (C/Water)	955	436	1470	N	0.98		
U <sub>total</sub> (ICP/Acid)	11,000	8820	13,200	Y	11		
V (ICP/Acid)	67	50	84	NA	0.069		
W	NR						
Zn (ICP/Fusion)	1080	0	3010	NA	1.1		
Zr	372	100	644	Y	0.38		
H <sub>2</sub> O (Wt%)	40.0				40		
Density (kg/L)	1.46				1.46		

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Table A-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
$^3\text{H}$	2,4	Tritium is within the 99 percentile groundwater hazard in accordance with Oak Ridge Isotope Generation (ORIGEN) decayed to 1990, however, it drops out of the 99 percentile after less than 300 years decay. The half-life of tritium (12.3 years) is short compared with travel time to the groundwater, so most analysts exclude it in performance assessment work. However, there are about 275,000 Ci (as of 1990) of tritium in tanks (not counting indeterminate losses), and it is volatile as well as mobile. It may be an air permit issue for the melter, and it still may be a groundwater concern, at least on the short-term. Because of these concerns, it is included in the list of predominant radionuclides, although it should be excluded in long-term tank waste performance assessment work. Also, best estimates of this radionuclide are needed because it is a "radionuclide of interest" relative to the Nuclear Regulatory Commission's determination of low-level waste (Boldt et al. 1995)
$^{14}\text{C}$	2,4	The radionuclide is within the 99 percentile groundwater hazard in accordance with Track Radioactive Components (TRAC), but not ORIGEN. Since TRAC is not too reliable, an argument can be made to exclude it from tank performance assessment work. However, the radionuclide is also volatile, and therefore could be an airborne concern, both from an air permit and an occupational exposure standpoint. Also, best estimates of this radionuclide are needed because it is a "radionuclide of interest" relative to the U.S. Nuclear Regulatory Commission's (NRC) determination of low-level waste.
$^{59}\text{Ni}$	2	This radionuclide is within the 99 percentile groundwater hazard in accordance with TRAC, but not ORIGEN. Since TRAC is not too reliable, an argument can be made to exclude it from tank performance assessment work. Best estimates are needed.
$^{60}\text{Co}$	4,5	Best estimates of this radionuclide are needed because of the short-term shielding concerns. It should not be included in tank performance assessment work.

Table A-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
$^{99}\text{Tc}$	2,4,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with TRAC and ORIGEN. Best estimates are needed and it should be included in performance assessment work.
$^{106}\text{Ru}$	4	With a half-life of only 368 days, $^{106}\text{Ru}$ is not a long-term environmental hazard. However, it can be very volatile and it is therefore a potential short-term airborne concern. The inventory (1990) according to ORIGEN is about 636,000 Ci. Best estimates are needed.
$^{113\text{m}}\text{Cd}$	4	This radionuclide is potentially volatile, posing a short-term airborne concern. It is not a long-term tank performance assessment concern but best estimates are needed.
$^{125}\text{Sb}$	4	Like $^{113\text{m}}\text{Cd}$ , this radionuclide is a potential short-term airborne concern because it is volatile, best estimates are needed.
$^{126}\text{Sn}$	3,5,6	This radionuclide, with its daughters, is the predominant gamma emitter on a long-term basis. Best estimates are needed and it should be included in performance assessment work. It could also be a shielding concern in highly differentiated waste from which the $^{137}\text{Cs}$ has been removed.
$^{129}\text{I}$	2,4,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with TRAC and ORIGEN. The radionuclide is one of the few that has a concentration factor in the food chain relative to the airborne pathway. Best estimates are needed and it should be included in performance assessment work.
$^{134}\text{Cs}$	4	This isotope is not within the 99 percentile inhalation or groundwater hazard. However, since cesium is potentially volatile, it could be an air permit issue. It is within the 99.93 percentile with respect to volatility, although the $^{137}\text{Cs}$ would certainly "wash out" any dose or inhalation concerns. Best estimates are needed but it should not be included in tank performance assessment work.

Table A-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
$^{229}\text{Th}$	0	This radionuclide is not within the 99 percentile inhalation hazard in accordance with TRAC or ORIGEN. Assuming this radionuclide is not mobile it should not be included in tank performance assessment work. The need for best estimates is questionable.
$^{231}\text{Pa}$	1,6	This radionuclide is within the 99 percentile inhalation hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in performance assessment work.
$^{232}\text{Th}$	0	This radionuclide is not within the 99 percentile inhalation, groundwater or external radiation hazard in accordance with TRAC or ORIGEN. It should not be included in tank performance assessment work. The need for best estimates is questionable.
$^{232}\text{U}$	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in performance assessment work.
$^{233}\text{U}$	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in performance assessment work.
$^{234}\text{U}$	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in performance assessment work.
$^{235}\text{U}$	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in performance assessment work.
$^{236}\text{U}$	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in performance assessment work.

Table A-1. Predominant Radionuclides in Single-Shell  
and Double-Shell Tanks.

Isotope	Notes	Comments
<sup>241</sup> Pu	5	This radionuclide is within the 99 percentile inhalation hazard in accordance with TRAC, but drops out of the 99 percentile after less than 300 years decay. It does not appear within the 99 percentile in accordance with ORIGEN. It should not be considered in tank performance assessment work. However, best estimates of this radionuclide are needed because it is the parent of <sup>241</sup> Am. <sup>241</sup> Am is responsible for the external radiation from plutonium, and in some instances the isotope can be significant with respect to shielding.
<sup>241</sup> Am	1,5	This radionuclide is within the 99 percentile inhalation hazard in accordance with TRAC and ORIGEN. Best estimates are needed and the radionuclide should be included in performance assessment work.
<sup>243</sup> Am	0	This radionuclide is not within the 99 percentile inhalation or groundwater hazard in accordance with TRAC or ORIGEN. The radionuclide should not be included in tank performance assessment work. The need for best estimates for this radionuclide is questionable. This radionuclide is an alpha emitter, and therefore is a transuranic. However, it is assumed that it is not prevalent enough to be a "radionuclide of interest" relative to the Nuclear Regulatory Commission's determination of low level waste. This assumption is also made for other alpha emitting transuranic radionuclides with half-lives greater than 20 years, including: <sup>242</sup> Am and <sup>243</sup> Cm.
<sup>244</sup> Cm	2	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN, but drops out of the 99 percentile after less than 300 years decay. Best estimates are needed but this radionuclide should not be included in long-term tank performance assessment work.

NOTES:

<sup>o</sup>These radionuclides do not meet the criteria for predominant radionuclides given above, but are included here because they have been used in past performance assessment work. The need for best estimates of these radionuclides is questionable.

APPENDIX B

UPDATING THE TCD WITH HISTORICAL CHARACTERIZATION DATA

For two years, ICF Kaiser Hanford has been collecting and compiling data from older sample and analysis events of single and double-shell tanks. Recently, in support of both the accelerated safety analysis and privatization efforts, ICF Kaiser Hanford began to assemble all of the hard copy sample data into an electronic format. The format that ICF Kaiser Hanford used was a Paradox<sup>1</sup> database with one row entered for each analytical measurement. Over the next four months, ICF Kaiser Hanford will complete the work of creating an electronic data set for all of the known (older) tank sample analyses.

The next step in the process of creating electronic characterization data is to transfer all known tank characterization data into TCD. Once the older tank characterization data has been entered into the Paradox data set, it will be transferred into TCD (which is the official characterization database). Transfer of data from the Kaiser data set to TCD will be performed by both ICF Kaiser Hanford staff and PNNL staff. After the transfer of the ICF Kaiser Hanford data set into TCD, all known characterization data (both old and new) will reside in TCD. This will mean that users of tank characterization data will only have to refer to one source, TCD, for characterization data needs.

The final step required in updating TCD with older sample data is to perform a quality check of the data. Quality checking of the data will be performed by Westinghouse Hanford Company as a function of the Inventory validation task. The evaluation of separate tank inventories requires that both old and new data be reconciled against the current inventory estimates. As older characterization data is being evaluated, data quality fields in TCD will be filled out. By having data quality fields in TCD, characterization data users will be aware of characterization data that is of poor quality or no longer representative of tank contents.

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<sup>1</sup>Paradox is a registered trade name of Borland International, Scotts Valley, California.

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1.7.2  
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Date: January 10, 1996  
Subject: REVIEW OF PROGRESS REPORT ON TANK WASTE INVENTORY ESTIMATE TASK

To: Distribution

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Reference: WHC-SD-WM-WP-311, Rev. 0, "Work Plan for Defining a Standard Inventory Estimate for Wastes Stored in Hanford Site Underground Tanks", dated September 1995.

A major effort, under the overall direction of the Characterization Project began on October 1, 1995, to determine and report best-basis estimates of the inventories of selected analytes and other characteristics for waste in the Hanford Single-Shell Tanks and Double-Shell Tanks. Both global (all tanks) and tank-by-tank estimates for the individual analytes are being compiled. The overall goal of this inventory assessment effort is to provide a reliable and standard data base for use by everyone involved in or concerned with the continued safety of Hanford tank wastes and their eventual retrieval, pretreatment, vitrification, and disposal. A Work Plan describing the methodology to be followed in the inventory assessment effort was published previously (Reference).

Progress made during the first quarter of FY 1995<sup>6</sup> to compile best-basis estimates of the global inventories of selected analytes is summarized in the attached report. In addition to presenting and discussing the source and utility of available global inventory data, this report further amplifies and illustrates the methodology being followed to obtain best-basis estimates of analyte inventories.

All readers of this report, particularly those who expect to be end users of the inventory data, are requested to comment on some specific points of interest, namely:

- o Additions to or deletions from the list of selected analytes.  
(See attachment, Table 3-1)
- o The methodology used to compare and reconcile inventory data from several sources, e.g., analytical and tank inventory model predictions.  
(See attachment, sections 4.1 and 5.1)