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Inventory Estimates for Single-Shell Tank Leaks in S and SX Tank Farms

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
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TERMS

HDW	Hanford Defined Waste
HLM	Historical Leak Model
MSU	Montana State University
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	reduction-oxidation (process)
SMM	supernatant mixing model
SST	single-shell tanks
TFVZ	Tank Farm Vadose Zone
TRAC	track radioactive components
WMA	Waste Management Area
WSTRS	Waste Status and Transaction Summary

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1.0 INTRODUCTION

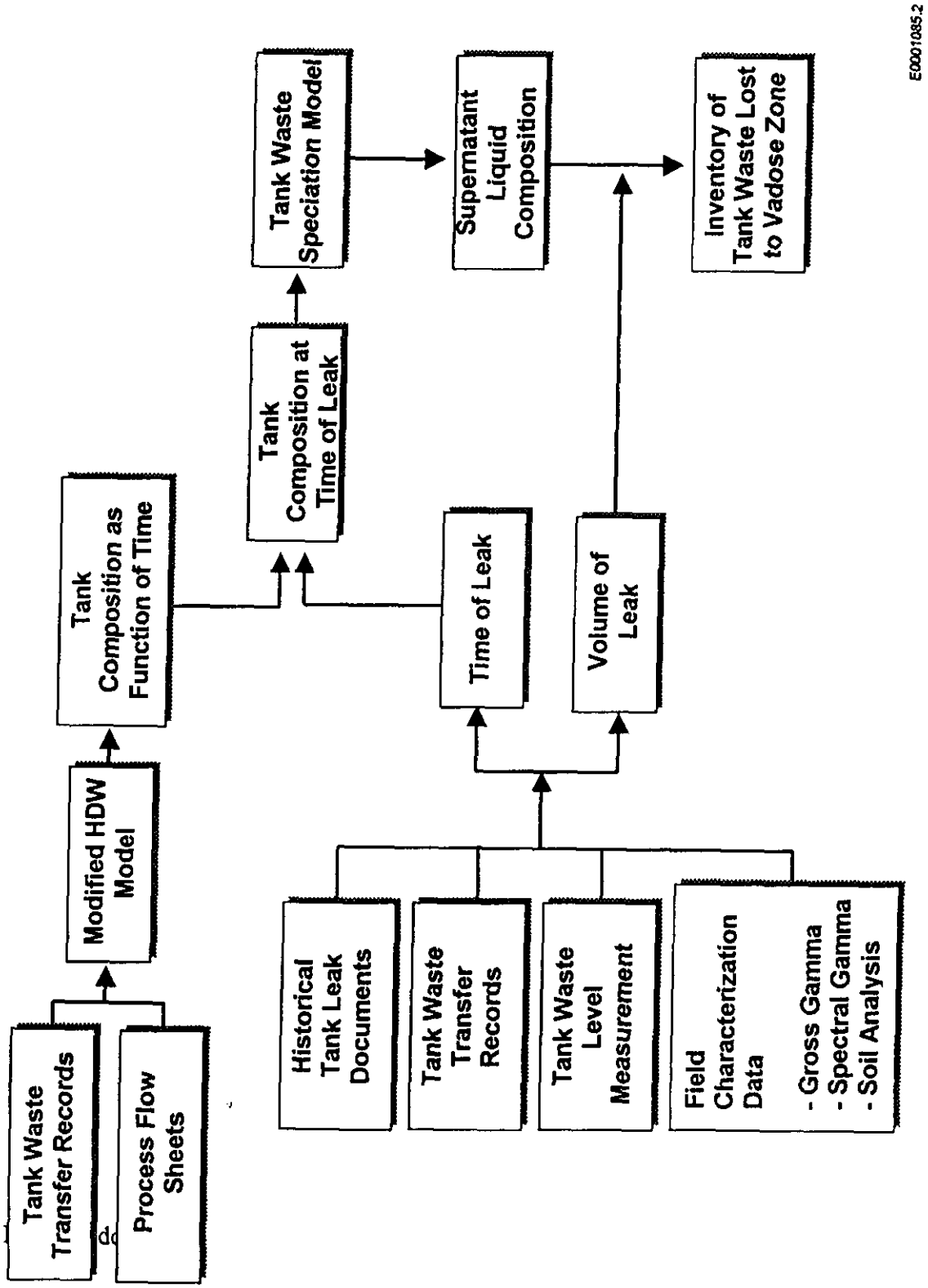
Sixty-seven of the 149 single-shell tanks (SST) containing high-level radioactive waste in the 200 Areas of the Hanford Site are listed as being known or suspected of having leaked during their operational lifetime (Hanlon 2000). The tank farm vadose zone (TFVZ) characterization team is reassessing the tank leak information for the tank farms currently being assessed for compliance with the *Resource Conservation and Recovery Act of 1976* (RCRA). (This assessment currently includes S, SX, B, BX, BY, T, TX, and TY tank farms.) This document focuses on results of this effort for the two tank farms in the S/SX Waste Management Area (WMA) in the 200 West Area.

The information for SSTs known to have leaked or suspected of having leaked is tabulated in Appendix H of the monthly *Waste Tank Summary Report*, commonly referred to as the Hanlon Report (Hanlon 2000). The leak information tabulated in the Hanlon Report consists of data compiled from many sources. In some cases, the leak information for a specific tank comes from a well-documented source; in others, the leak information has little, if any, technical documentation to support listing the tank as having leaked. Unfortunately, many of the cited references are secondary sources such as safety analysis reports, letter reports, and summary-type documents with little or no traceability back to the primary data sources. This reassessment of SST leak information was required to better define the composition and quantities of materials lost to the vadose zone because such data will be required for risk-assessment calculations.

The goal of this task was to develop inventory estimates for chemicals and radionuclides lost to the vadose zone in the S/SX WMA by integrating results from recent field investigations and modeling results with historical tank farm records. The approach used is shown schematically in Figure 1. The baseline spectral gamma-ray logging data reports provided the best prospective of the "nature and extent" of gamma-emitting radionuclide contamination in the S and SX tank farms, compiled to date (DOE-GJPO 1996, DOE-GJPO 1998). The historical tank waste transfer records compiled in the *Waste Status and Transaction Summary* (WSTRS), Rev. 4 (Agnew et al. 1997), provide a means for tracking discrepancies in waste levels in any tank at any point in time. The Hanford Defined Waste (HDW) model (Agnew 1997) is a tool for estimating tank waste compositions as a function of time. The reference list included in Appendix H of the Hanlon Report (Hanlon 2000) is a starting point for uncovering historical SST leak documentation.

Detailed discussions of the S and SX tank farms construction, operations, and tank leak histories are presented in a number of recent documents (Brevick et al. 1996; Brevick. 1994; (DOE-GJPO 1996; DOE-GJPO 1998; DOE 1997; Johnson and Chou 1998, 1999; Jones et al. 1998; Johnson et al. 1999). These documents also discuss intentional waste discharges near the farms. In addition to tank farms operational history, the cited references include discussions of the pertinent geology, hydrology, geochemistry, and the groundwater monitoring system. An assessment of the historical gross gamma-ray logging data collected as part of the leak detection systems also is available (Myers 1999). A statistical analysis of gamma-ray logging data has provided an estimate of ^{137}Cs inventories in the soil around each tank in the SX farm (Goodman 2000).

Figure 1. Historical Tank Leak Inventory Assessment Approach.



Working Definition of "Tank Leaks." From one perspective, all losses of tank waste to the vadose zone inside a farm can be classified as "tank leaks." However, from a vadose zone characterization perspective, distinguishing transfer line leaks and tank overfills from cases where the waste originated from a steel-liner-concrete-shell system failure is useful. In many cases, the gamma logging data provide considerable insight into the origins of tank waste in the vadose zone. Waste plumes originating within 20 ft of the surface can reasonably be attributed to losses from waste transfer pipes or from tank overfill events. Waste plumes originating from the failure of the steel-liner-concrete-shell system would likely be found near or below the base of the tank. Plumes originating from leaks near the base of the tank are expected to exhibit ^{137}Cs gamma-ray activity levels greater than 1,000 pCi/g in bands several feet thick. When limited activity is reported near the base of the tank, the data are more difficult to interpret. Such activity could be exhibited by the edge of a tank leak plume or could have other origins. Nevertheless, without other drivers, such lower activity measurements would not trigger additional investigation. This assessment ignored ^{137}Cs gamma-ray activity of less than 50 pCi/g.

The decision to ignore ^{137}Cs activity at levels less than 50 pCi/g is based on the focus of the tank farm vadose zone characterization efforts. In any radionuclide inventory estimate, the low-level values are not significant when compared with the well-defined tank leak plumes. In addition, any field characterization activity will necessarily focus on the areas of highest contamination.

In developing the inventory estimates reported here, the TFVZ team strongly resisted using "maximum possible" and "most conservative" tank leak volumes frequently quoted in documents such as Hanlon (2000) and Agnew (1998). Rather, the team attempted to develop the most "reasonable" leak volumes and inventories using the preponderance of evidence from the available technical data. However, the approach used to develop inventory estimates is presented along with the results so that data revisions would be reasonably straightforward should different leak volumes be determined.

2.0 RESULTS

2.1 TIME OF LEAKS AND REPORTED LEAK VOLUMES

The time of the leak is critical in developing a tank waste composition using the HDW model and the leak volume is critical in estimating the inventory of lost material. The rationale for leak times used in this assessment and reported leak volumes are discussed by tank in Sections 2.1.1 through 2.1.11.

2.1.1 Tank 241-S-104

This tank has a 758,000-gal capacity. However, in the second quarter of 1965, this tank was filled to 807,000 gal, or about 18 in. above the cascade overflow line (Agnew et al. 1997 and Brevick et al. 1994). In addition to the long-abandoned waste transfer cascade lines, the tank contained six plugged spare inlet ports. Because the spare inlet ports were poorly sealed, when they were covered with liquid waste, the spare inlet ports become a likely pathway for waste losses from the tank. Beginning in the first quarter of 1966, the waste level began to drop. By the fourth quarter of 1970, the total waste volume had dropped to 783,000 gal, still above the cascade overflow line. The tank level measurements indicate that 24,000 gal of waste were lost from this tank. While it is possible the waste overfill in tank 241-S-104 could have resulted in waste cascading to tanks 241-S-105 and -S-106, the waste transfer records for tanks 241-S-105 and -S-106 do not support that hypothesis. Although some water could have been lost through evaporation, most of waste in this tank had been there since 1955. Thus, it is likely that 24,000 gal of tank waste was lost from tank 241-S-104 to the soil column from 1966 through 1970. The inventory associated with the 24,000-gal loss is included in this report.

Tank 241-S-104 was overfilled during the time it was thought to have leaked. Thus, the waste loss could have resulted from waste leaking from one of the six spare inlet ports rather than from a failure of the steel shell liner and concrete shell components of the tank system. In fact, the only drywell showing high levels of ^{137}Cs contamination at tank-base levels is near a set of the spare inlet ports (DOE-GJPO 1998). Recent gamma-ray measurements taken in the soil column between the contaminated drywell and tank 241-S-104 found a band of gamma-ray activity at about the mid-tank level, thus, supporting the hypothesis that the soil contamination may have originated from the spare inlet ports.

2.1.2 Tank 241-SX-104

Hanlon (2000) lists tank SX-104 as a "known or suspected" leaker with a leak volume of 6,000 gal and a leak date of 1988. According to a referenced footnote, this leak volume is "based on measured decreases in tank liquid levels, the most reliable method for determining leak volumes" (Hanlon 2000). However, according to the cited reference (Dunford 1988), the leak volume estimate was a "worst case" estimate based on interstitial liquid level measurements. The interstitial liquid level decreased by 4 to 6 in. over three years. Dunford (1988) also

considers that decreases in the interstitial liquid levels could have resulted from evaporation because the tank was connected to the 241-SX-sludge cooler. However, the ventilation system for the first six tanks in the SX farm is routed through tank SX-109 and then to the sludge cooler. This makes quantifying liquid losses through evaporation for any specific tank in the series impossible. The 6,000-gal volume is a "worst case" leak assuming no evaporation from this high-heat tank over 3 years. In fact, two members of the five-person peer review team noted that the available information indicated that the tank was "sound" (Zimmer 1988). The other three members could not be 95-percent confident that the tank had not leaked. Following procedure, the team listed the tank as an "assumed leaker." Interestingly, a similar apparent loss in interstitial liquids in tank 241-SX-102 in 1993 led to an extensive investigation that concluded the tank had not leaked (Alumkal 1993).

Based on the details of the engineering report (Dunford 1988) and the fact that none of the drywells around this tank show elevated levels of gamma-ray activity, the characterization team assumed that there is not sufficient evidence to list this tank as a suspected leaker.

2.1.3 Tank 241-SX-107

Hanlon (2000) lists a suspected leak date of 1964. Based on waste transfer records, the waste composition remained relatively constant over the period of 1964 through 1967. However, notes in the waste transfer records (Agnew et al. 1997, Anderson 1990) indicate the leak began in 1967. The tank waste composition estimate for tank 241-SX-107 used an average of the projected tank compositions over an assumed leak time of 1964 through 1966. Hanlon (2000) lists a leak volume of less than 5,000 gal for this tank.

2.1.4 Tank 241-SX-108

The first leak was noted in 1964, but the tank was believed to have self-sealed (Raymond and Shdo 1966, WHC 1992a). The major leak from this tank was believed to have begun in 1966. Extensive historical documentation is available for the tank leak (WHC 1992a). The tank waste composition estimate for tank 241-SX-108 used an average of the projected tank compositions over an assumed leak time of 1965 through 1966. Hanlon (2000) lists a leak volume of 2.4 to 35 kgal. Agnew and Corbin (1998) suggest a leak volume of up to 200 kgal.

2.1.5 Tank 241-SX-109

In January 1965, radiation was detected in two laterals under Tank 241-SX-109. The tank was thought to have self-sealed. Liquids were not removed from the tank until 1973 (WHC 1992b). Extensive historical documentation is available for the tank leak (WHC 1992b). The tank waste composition estimate for tank 241-SX-109 used an average of the projected tank compositions over an assumed leak time of 1964 through 1967. Hanlon (2000) suggests a leak volume of less than 10 kgal, but Agnew and Corbin (1998) list an upper band as 111 kgal.

2.1.6 Tank 241-SX-110

Hanlon (2000) lists a leak date of 1976. The waste transfer records indicate this tank was used to store REDOX boiling waste until 1971 when the tank began receiving REDOX ion exchange waste from B Plant. Neither the waste transfer records nor do spectral gamma logging data (DOE-GJPO 1996) indicate a tank leak. No inventory estimate was calculated for this tank.

2.1.7 Tank 241-SX-111

A leak date of 1974 was determined from gamma-ray activity measured in the laterals (Harlow 1974). A leak volume of 500 gal was estimated. The waste transfer records indicate this tank was used to store boiling waste from the reduction-oxidation (REDOX) process until 1971. At that point the tank began receiving evaporator bottoms and REDOX ion exchange waste from B Plant. The waste transfer records do not indicate a tank leak (Agnew et al. 1997). One drywell has significant contamination in the zone from 60 to 90 ft. However, the contamination could be related to the leak from tank 241-SX-108 (Goodman 2000). No inventory estimate was calculated for this tank.

2.1.8 Tank 241-SX-112

Hanlon (2000) lists a leak date of 1969 and a leak volume of 30,000 gallons for this tank. This leak volume cannot be traced back to a primary reference explaining the origins of the volume estimate. Also, the lack of gamma-ray activity in the drywells and laterals fails to support the leak volume estimate. No inventory estimate was calculated for this tank.

2.1.9 Tank 241-SX-113

This leak volume was measured during a 1962 tank leak test (Hanson et al.1962). The inventory estimate was developed using the 15,000-gal leak volume.

2.1.10 Tank 241-SX-114

Although this tank is listed as having leaked, no leak volume is given (Hanlon 2000). The waste transfer records indicate that a leak was noted in 1972 when the tank was filled with evaporator bottoms and B Plant isotope recovery waste. The less than 1 pCi/g ^{60}Co found in one drywell (beginning at a depth of 35 ft) supports this leak date. No inventory estimate was calculated for this tank.

2.1.11 Tank 241-SX-115

This tank leaked 50,000 gal in 1965 (Raymond and Shdo 1966, WHC 1992c). Extensive historical documentation is available for the tank leak (WHC 1992c). The inventory estimate was developed using the 50,000 gallon leak volume.

2.2 COMPOSITION OF TANK WASTE AT THE TIME OF LEAK

The TFVZ team efforts to estimate tank compositions at the time of suspected leaks have benefited from the previous modeling efforts to determine current waste inventories for the 177 high-level waste tanks at the Hanford Site (Kupfer et al. 1998). Attempts to estimate tank compositions based on waste process flow sheets and waste transfer records began in the 1970's (Jungfleisch 1984) with the development of the track radioactive components (TRAC) model. In the 1990's, Agnew and coworkers (Agnew et al. 1997) continued this effort by developing the HDW. The HDW model predicts waste concentrations for 26 chemical components and 46 radionuclides in each of the 177 Hanford Site waste tanks as of January 1, 1994. To make this prediction the HDW model merges data from a number of supporting databases and computer models:

- Data on waste receipts from Hanford Site processing plants to tanks and transfers between tanks are summarized in WSTRS, Rev. 4 (Agnew et al. 1997)
- Chemical compositions of processing-plant waste streams are compiled from process flowsheets and other historical operating data
- Radionuclide compositions of processing-plant waste streams were derived from a combination of ORIGEN2 and DKPRO computer codes (Watrous and Wooten 1997)
- Solubility factors for chemicals and radionuclides in alkaline waste systems are based on measurements of actual waste types plus bounding estimates.

Agnew and Corbin (1998) demonstrated that the HDW model could be used to predict tank compositions as a function of time in their efforts to develop a leak model for Hanford Site high-heat tanks.

Following the approach outlined by Agnew and Corbin (1998), the HDW model was used to predict tank waste compositions during the time period the tank most likely leaked. The predicted waste compositions for tanks 241-S-104 and 241-SX-107 through -SX-115 are listed in Table 1. This table contains all of the information reported by the supernatant mixing model (SMM) module of the HDW model. The SMM waste fraction includes supernatant liquids and salt cake components (Agnew 1997).

2.3 AVERAGE REDOX HIGH-LEVEL (BOILING) WASTE COMPOSITION

Based on a review of historical records and the data shown in Table 1, three types of tank waste may have been lost in the SX tank farm. In the mid-1960, at least three of tanks (241-SX-107, -SX-108, and -SX-109) containing REDOX "boiling waste" leaked. At least two of the SX tanks (241-SX-113 and -SX-115) leaked after condensate was added to a "REDOX boiling waste" heel (Hanson et al. 1962, Raymond and Shdo 1966). Based on spectral gamma-ray logging data, one tank (241-SX-114) leaked after receiving waste from a source other than the REDOX Plant (DOE-GJPO 1996). The geostatistical analysis of the gamma-ray logging data from the SX tank farm predicts a major plume under each of the tanks 241-SX-107, -108, and -109. The largest plume (under SX-108) extends to tanks 241-SX-109 and -SX-112.

An "average REDOX boiling waste" composition was calculated by averaging tank waste composition estimates from tanks 241-SX-107, -SX-108, and -SX-109. Table 2 shows the results of this calculation along with the standard deviation and relative standard deviation. The estimated loss per thousand gallons (kgal) (in units of kilogram/kgal and Ci/kgal) are also shown in Table 2. [note: The mixed metric/English units arise because tank leak volumes historically have been, and currently are, listed in kgal (Hanlon 2000) and the desired units for the leak inventories are kilograms (kg) and curies (Ci).]

Table 1a. Summary of Tank Supernate/Salt Concentrations at Time of Leak. (2 sheets)

Tank	S-104	SX-107	SX-108	SX-109	SX-110	SX-111	SX-112	SX-113	SX-114	SX-115
Assumed Leak Date.	1965 (mole/L)	Ave. 64-67 (mole/L)	Ave. 65-66 (mole/L)	Ave. 64-67 (mole/L)	1974 (mole/L)	1973 (mole/L)	1969 (mole/L)	1962 (mole/L)	1972 (mole/L)	1964 (mole/L)
Na^{+}	8.671 E+00	1.873 E+01	1.960 E+01	1.519 E+01	6.068 E+00	5.310 E+00	1.319 E+01	7.982 E+00	8.852 E+00	3.593 E+00
Al^{3+}	1.556 E+00	3.273 E+00	3.361 E+00	2.560 E+00	7.336 E-01	5.270 E-01	2.167 E+00	1.267 E+00	9.692 E-01	8.258 E-01
Total Fe	3.543 E-03	6.878 E-03	7.209 E-03	5.598 E-03	4.216 E-03	5.323 E-03	3.542 E-03	2.967 E-03	7.436 E-03	2.111 E-03
Cr^{3+}	1.647 E-01	3.919 E-01	4.128 E-01	3.211 E-01	6.793 E-02	5.862 E-02	2.065 E-01	1.712 E-01	1.015 E-01	5.088 E-02
Bi^{3+}	8.951 E-09	0.000 E+00	0.000 E+00	0.000 E+00	1.139 E-04	1.179 E-04	6.395 E-06	0.000 E+00	1.475 E-04	6.627 E-08
La^{3+}	2.205 E-14	0.000 E+00	0.000 E+00	0.000 E+00	8.532 E-10	1.326 E-09	1.575 E-11	0.000 E+00	1.720 E-09	1.632 E-13
Hg^{2+}	3.541 E-06	1.154 E-07	1.966 E-09	0.000 E+00	1.518 E-06	1.586 E-06	1.006 E-06	0.000 E+00	1.864 E-06	6.293 E-06
Zr (as $ZrO(OH)_2$)	8.935 E-10	0.000 E+00	0.000 E+00	0.000 E+00	1.953 E-05	1.614 E-05	6.383 E-07	0.000 E+00	1.959 E-05	6.615 E-09
Pb^{2+}	5.666 E-04	1.846 E-05	3.146 E-07	0.000 E+00	2.093 E-04	2.206 E-04	1.596 E-04	0.000 E+00	2.569 E-04	1.007 E-03
Ni^{2+}	3.101 E-03	6.187 E-03	6.488 E-03	5.038 E-03	2.012 E-03	1.942 E-03	3.187 E-03	2.671 E-03	3.005 E-03	1.732 E-03
Sr^{2+}	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00
Mn^{4+}	6.515 E-08	0.000 E+00	0.000 E+00	0.000 E+00	2.254 E-03	3.538 E-03	4.655 E-05	0.000 E+00	4.565 E-03	4.824 E-07
Ca^{2+}	1.595 E-02	3.096 E-02	3.245 E-02	2.520 E-02	1.012 E-02	9.760 E-03	1.594 E-02	1.336 E-02	1.505 E-02	9.502 E-03
K^{+}	3.069 E-02	6.989 E-02	7.386 E-02	5.763 E-02	2.632 E-02	2.451 E-02	5.094 E-02	3.106 E-02	3.951 E-02	1.105 E-02
Density (g/cc)	1.397 E+00	1.840 E+00	1.874 E+00	1.674 E+00	1.255 E+00	1.218 E+00	1.583 E+00	1.349 E+00	1.366 E+00	1.181 E+00
Void Fraction.	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00
wt.% H_2O	5.153 E+01	2.325 E+01	2.089 E+01	3.139 E+01	6.465 E+01	6.807 E+01	3.815 E+01	5.480 E+01	5.276 E+01	7.507 E+01
TOC wt.% C	8.391 E-06	0.000 E+00	0.000 E+00	0.000 E+00	2.959 E-01	3.911 E-01	5.289 E-03	0.000 E+00	4.950 E-01	7.345 E-05
free OH^{-}	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00
OH^{-}	9.009 E+00	1.980 E+01	2.049 E+01	1.571 E+01	4.745 E+00	3.510 E+00	1.331 E+01	7.968 E+00	6.429 E+00	4.171 E+00
NO_3^{-}	3.006 E+00	4.891 E+00	5.464 E+00	4.485 E+00	1.714 E+00	1.534 E+00	3.486 E+00	2.818 E+00	2.476 E+00	1.197 E+00
NO_2^{-}	1.638 E+00	4.485 E+00	4.418 E+00	3.225 E+00	1.256 E+00	1.131 E+00	3.132 E+00	1.336 E+00	1.864 E+00	7.840 E-01
CO_3^{2-}	1.596 E-02	3.096 E-02	3.245 E-02	2.520 E-02	1.802 E-01	2.263 E-01	2.055 E-02	1.336 E-02	3.169 E-01	9.550 E-03
PO_4^{3-}	5.792 E-07	0.000 E+00	0.000 E+00	0.000 E+00	1.140 E-02	1.317 E-02	4.138 E-04	0.000 E+00	1.791 E-02	4.288 E-06
$(SO_4)^{2-}$	3.206 E-02	9.299 E-02	9.229 E-02	6.775 E-02	9.641 E-02	1.226 E-01	6.646 E-02	2.879 E-02	1.714 E-01	1.920 E-02
Si (as SiO_3^{2-})	2.806 E-02	9.803 E-02	9.334 E-02	6.561 E-02	3.481 E-02	3.425 E-02	5.563 E-02	2.229 E-02	5.508 E-02	1.279 E-02
F^{-}	4.617 E-07	0.000 E+00	0.000 E+00	0.000 E+00	5.400 E-03	5.272 E-03	3.299 E-04	0.000 E+00	6.534 E-03	3.418 E-06

Table 1a. Summary of Tank Supernate/Salt Concentrations at Time of Leak. (2 sheets)

Tank	S-104	SX-107	SX-108	SX-109	SX-110	SX-111	SX-112	SX-113	SX-114	SX-115
Assumed Leak Date.	1965 (mole/L)	Ave. 64-67 (mole/L)	Ave. 65-66 (mole/L)	Ave. 64-67 (mole/L)	1974 (mole/L)	1973 (mole/L)	1969 (mole/L)	1962 (mole/L)	1972 (mole/L)	1964 (mole/L)
Cl^-	1.412 E-01	3.215 E-01	3.397 E-01	2.651 E-01	1.017 E-01	8.848 E-02	2.215 E-01	1.429 E-01	1.488 E-01	5.071 E-02
$C_6H_5O_7^{3-}$	4.771 E-07	0.000 E+00	0.000 E+00	0.000 E+00	1.810 E-02	2.602 E-02	3.408 E-04	0.000 E+00	3.548 E-02	3.532 E-06
$EDTA^{4-}$	1.858 E-08	0.000 E+00	0.000 E+00	0.000 E+00	3.213 E-04	4.655 E-04	1.328 E-05	0.000 E+00	5.988 E-04	1.376 E-07
$HEDTA^{3-}$	1.543 E-08	0.000 E+00	0.000 E+00	0.000 E+00	5.799 E-04	9.256 E-04	1.102 E-05	0.000 E+00	1.202 E-03	1.142 E-07
$glycolate^-$	6.734 E-07	0.000 E+00	0.000 E+00	0.000 E+00	3.077 E-02	1.215 E-02	4.811 E-04	0.000 E+00	3.811 E-02	4.985 E-06
$acetate^-$	6.989 E-08	0.000 E+00	0.000 E+00	0.000 E+00	2.233 E-04	5.419 E-05	4.993 E-05	0.000 E+00	3.255 E-05	5.175 E-07
$oxalate^{2-}$	2.888 E-14	0.000 E+00	0.000 E+00	0.000 E+00	1.118 E-09	1.738 E-09	2.063 E-11	0.000 E+00	2.253 E-09	2.138 E-13
DBP	4.231 E-07	0.000 E+00	0.000 E+00	0.000 E+00	1.082 E-02	1.686 E-02	3.023 E-04	0.000 E+00	2.136 E-02	3.133 E-06
butanol	4.231 E-07	0.000 E+00	0.000 E+00	0.000 E+00	1.082 E-02	1.686 E-02	3.023 E-04	0.000 E+00	2.136 E-02	3.133 E-06
NH_3	2.051 E-02	1.122 E-01	1.051 E-01	7.226 E-02	3.248 E-02	3.205 E-02	6.916 E-02	2.123 E-02	5.011 E-02	1.305 E-02
$Fe(CN)_6^{4-}$	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00	0.000 E+00

This chart selects a single waste composition (from a single selected year or average of a range of years) for each tank that leaked. The objective is to provide the Vadose Zone Project with an unambiguous set of leak composition values.

Data Source (HDW model-SMM Concentrations for selected tanks and for each year):

Table 1b. Summary of Tank Supernate/Salt Concentrations at Time of Leak (Radionuclides). (2 sheets)

Tank	S-104	SX-107	SX-108	SX-109	SX-110	SX-111	SX-112	SX-113	SX-114	SX-115
Assumed Leak Date. / Radionuclides	1965 (Ci/L)	Ave. 64-67 (Ci/L)	Ave. 65-66 (Ci/L)	Ave. 64-67 (Ci/L)	1974 (Ci/L)	1973 (Ci/L)	1969 (Ci/L)	1962 (Ci/L)	1972 (Ci/L)	1964 (Ci/L)
^{3}H	7.812 E-05	6.640 E-04	6.013 E-04	3.960 E-04	1.661 E-04	1.531 E-04	4.208 E-04	8.092 E-05	2.548 E-04	7.551 E-05
^{14}C	6.059 E-06	3.044 E-05	2.876 E-05	1.996 E-05	2.218 E-05	2.942 E-05	2.028 E-05	6.264 E-06	4.091 E-05	3.657 E-06
^{59}Ni	7.660 E-07	3.543 E-06	3.373 E-06	2.361 E-06	1.201 E-06	1.418 E-06	1.712 E-06	7.828 E-07	2.078 E-06	4.413 E-07
^{63}Ni	7.157 E-05	3.475 E-04	3.291 E-04	2.290 E-04	1.186 E-04	1.403 E-04	1.675 E-04	7.309 E-05	2.053 E-04	4.315 E-05
^{60}Co	2.420 E-06	3.097 E-05	2.744 E-05	1.755 E-05	2.491 E-05	3.360 E-05	1.961 E-05	2.473 E-06	4.646 E-05	3.550 E-06
^{79}Se	1.287 E-06	5.756 E-06	5.507 E-06	3.878 E-06	1.904 E-06	1.984 E-06	3.275 E-06	1.330 E-06	3.107 E-06	7.007 E-07
^{90}Sr	4.961 E-02	1.166 E-01	1.225 E-01	9.516 E-02	5.514 E-02	6.636 E-02	6.020 E-02	5.044 E-02	9.720 E-02	1.777 E-02
^{90}Y	4.962 E-02	1.166 E-01	1.226 E-01	9.519 E-02	5.515 E-02	6.638 E-02	6.022 E-02	5.046 E-02	9.722 E-02	1.777 E-02
^{93}Zr	6.075 E-06	2.853 E-05	2.715 E-05	1.900 E-05	9.435 E-06	9.899 E-06	1.631 E-05	6.278 E-06	1.544 E-05	3.455 E-06
^{93m}Nb	4.963 E-06	2.047 E-05	1.977 E-05	1.407 E-05	6.690 E-06	6.949 E-06	1.154 E-05	5.133 E-06	1.090 E-05	2.510 E-06
^{99}Tc	4.247 E-05	2.435 E-04	2.272 E-04	1.553 E-04	1.593 E-04	2.080 E-04	1.602 E-04	4.385 E-05	2.912 E-04	2.904 E-05
^{106}Ru	1.820 E-11	7.971 E-09	6.766 E-09	4.071 E-09	4.222 E-09	4.573 E-09	4.831 E-09	6.907 E-12	7.089 E-09	8.857 E-10
^{113m}Cd	1.878 E-05	1.334 E-04	1.223 E-04	8.175 E-05	5.331 E-05	5.863 E-05	8.581 E-05	1.935 E-05	8.880 E-05	1.570 E-05
^{125}Sb	3.669 E-06	1.158 E-04	9.998 E-05	6.166 E-05	1.065 E-04	1.452 E-04	7.206 E-05	3.631 E-06	2.000 E-04	1.307 E-05
^{126}Sn	1.976 E-06	8.667 E-06	8.312 E-06	5.868 E-06	2.869 E-06	2.979 E-06	4.920 E-06	2.044 E-06	4.675 E-06	1.054 E-06
^{129}I	8.158 E-08	4.604 E-07	4.302 E-07	2.945 E-07	3.066 E-07	4.016 E-07	3.033 E-07	8.423 E-08	5.616 E-07	5.496 E-08
^{134}Cs	6.935 E-08	7.004 E-06	5.972 E-06	3.617 E-06	9.609 E-07	4.299 E-07	4.180 E-06	6.248 E-08	1.077 E-06	7.764 E-07
^{137}Cs	1.249 E-01	8.378 E-01	7.712 E-01	5.185 E-01	1.272 E-01	5.765 E-02	5.329 E-01	1.288 E-01	1.415 E-01	9.885 E-02
^{137m}Ba	1.182 E-01	7.925 E-01	7.296 E-01	4.905 E-01	1.204 E-01	5.454 E-02	5.042 E-01	1.218 E-01	1.339 E-01	9.351 E-02
^{151}Sm	4.591 E-03	2.021 E-02	1.937 E-02	1.367 E-02	6.685 E-03	6.948 E-03	1.148 E-02	4.746 E-03	1.090 E-02	2.465 E-03
^{152}Eu	4.539 E-07	5.471 E-06	4.860 E-06	3.121 E-06	2.014 E-06	2.388 E-06	2.600 E-06	4.657 E-07	3.527 E-06	6.185 E-07
^{154}Eu	5.843 E-05	7.543 E-04	6.680 E-04	4.271 E-04	3.916 E-04	4.777 E-04	4.733 E-04	5.974 E-05	6.919 E-04	8.618 E-05
^{155}Eu	2.150 E-05	2.785 E-04	2.466 E-04	1.576 E-04	1.160 E-04	1.412 E-04	1.323 E-04	2.198 E-05	2.057 E-04	3.158 E-05
^{226}Ra	8.936 E-11	2.125 E-10	2.235 E-10	1.735 E-10	6.432 E-11	6.273 E-11	1.098 E-10	9.199 E-11	1.017 E-10	2.893 E-11
^{228}Ra	2.064 E-12	9.465 E-15	8.319 E-15	5.265 E-15	1.060 E-08	4.447 E-09	1.474 E-09	6.165 E-16	3.049 E-09	1.528 E-11
^{227}Ac	5.177 E-10	1.234 E-09	1.298 E-09	1.008 E-09	3.845 E-10	3.764 E-10	6.374 E-10	5.341 E-10	5.958 E-10	1.657 E-10

Table 1b. Summary of Tank Supernate/Salt Concentrations at Time of Leak (Radionuclides). (2 sheets)

Tank	S-104	SX-107	SX-108	SX-109	SX-110	SX-111	SX-112	SX-113	SX-114	SX-115
Assumed Leak Date. / Radionuclides	1965 (Ci/L)	Ave. 64-67 (Ci/L)	Ave. 65-66 (Ci/L)	Ave. 64-67 (Ci/L)	1974 (Ci/L)	1973 (Ci/L)	1969 (Ci/L)	1962 (Ci/L)	1972 (Ci/L)	1964 (Ci/L)
^{231}Pa	1.917 E-09	6.197 E-09	6.190 E-09	4.567 E-09	1.971 E-09	2.053 E-09	3.381 E-09	1.986 E-09	3.134 E-09	7.760 E-10
^{229}Th	1.631 E-13	6.367 E-13	5.954 E-13	4.081 E-13	2.714 E-10	1.442 E-10	3.554 E-11	1.176 E-13	1.075 E-10	4.400 E-13
^{232}Th	2.767 E-13	2.681 E-14	2.351 E-14	1.483 E-14	9.589 E-10	7.156 E-10	1.965 E-10	1.635 E-15	6.976 E-10	2.039 E-12
^{232}U	4.198 E-11	6.790 E-11	6.427 E-11	4.481 E-11	1.125 E-07	1.272 E-07	1.496 E-08	1.449 E-11	1.092 E-07	1.808 E-10
^{233}U	8.080 E-11	1.721 E-12	1.715 E-12	1.266 E-12	4.326 E-07	4.899 E-07	5.718 E-08	5.523 E-13	4.218 E-07	5.933 E-10
^{234}U	4.484 E-07	8.120 E-07	8.406 E-07	6.458 E-07	3.239 E-07	3.572 E-07	5.165 E-07	3.297 E-07	5.050 E-07	3.818 E-07
^{235}U	1.894 E-08	3.188 E-08	3.357 E-08	2.623 E-08	1.314 E-08	1.460 E-08	2.051 E-08	1.419 E-08	2.065 E-08	1.473 E-08
^{236}U	1.063 E-08	4.325 E-08	3.908 E-08	2.572 E-08	1.186 E-08	1.202 E-08	2.506 E-08	5.216 E-09	1.755 E-08	2.257 E-08
^{238}U	4.340 E-07	6.400 E-07	6.979 E-07	5.629 E-07	3.227 E-07	3.424 E-07	4.263 E-07	3.365 E-07	4.740 E-07	2.823 E-07
^{Total}U (m)	5.463 E-03	8.064 E-03	8.792 E-03	7.089 E-03	3.662 E-03	4.149 E-03	5.314 E-03	4.234 E-03	5.818 E-03	3.558 E-03
^{237}Np	2.765 E-07	9.534 E-07	9.424 E-07	6.878 E-07	5.653 E-07	7.119 E-07	6.576 E-07	2.846 E-07	1.011 E-06	1.256 E-07
^{238}Pu	2.491 E-07	1.221 E-06	1.121 E-06	7.521 E-07	7.478 E-07	9.538 E-07	5.906 E-07	1.840 E-07	1.358 E-06	3.270 E-07
^{239}Pu	1.567 E-05	3.012 E-05	3.163 E-05	2.461 E-05	2.267 E-05	3.027 E-05	1.560 E-05	1.313 E-05	4.187 E-05	9.276 E-06
^{240}Pu	2.265 E-06	5.382 E-06	5.436 E-06	4.069 E-06	4.002 E-06	5.309 E-06	2.731 E-06	1.879 E-06	7.383 E-06	1.552 E-06
^{241}Pu	1.399 E-05	6.011 E-05	5.611 E-05	3.844 E-05	5.033 E-05	6.614 E-05	2.938 E-05	1.105 E-05	9.275 E-05	1.469 E-05
^{242}Pu	6.017 E-11	3.360 E-10	3.086 E-10	2.071 E-10	2.825 E-10	3.669 E-10	1.620 E-10	5.068 E-11	5.195 E-10	5.893 E-11
^{Total}Pu (g/L)	2.622 E-04	5.089 E-04	5.335 E-04	4.142 E-04	2.509 E-04	3.001 E-04	2.621 E-04	2.196 E-04	4.331 E-04	1.562 E-04
^{241}Am	2.168 E-05	8.798 E-05	8.515 E-05	6.073 E-05	3.039 E-05	3.018 E-05	4.951 E-05	2.239 E-05	4.863 E-05	1.093 E-05
^{243}Am	2.033 E-10	3.430 E-09	3.008 E-09	1.898 E-09	1.159 E-09	9.826 E-10	1.814 E-09	2.094 E-10	1.753 E-09	3.769 E-10
^{242}Cm	1.034 E-08	2.514 E-07	2.183 E-07	1.358 E-07	7.703 E-08	9.701 E-08	8.209 E-08	1.071 E-08	1.414 E-07	2.676 E-08
^{243}Cm	2.370 E-10	2.490 E-08	2.124 E-08	1.288 E-08	7.487 E-09	9.285 E-09	8.166 E-09	2.455 E-10	1.365 E-08	2.598 E-09
^{244}Cm	7.224 E-09	2.482 E-07	2.141 E-07	1.319 E-07	8.013 E-08	9.639 E-08	8.123 E-08	7.484 E-09	1.455 E-07	2.621 E-08

This chart selects a single waste composition (from a single selected year or average of a range of years) for each tank that leaked. Objective is to provide the Vadose Zone Project with an unambiguous set of leak composition values.

Data Source (HDW model-SMM Concentrations for selected tanks and for each year):

Table 2a. Average REDOX Tank Waste Composition Estimate at Time of Leaks (Chemical Units). (2 sheets)

Chemicals Units	Assumed Leak Date. At. Wt (g/mole)	Tank			Average Waste Composition (mol/L)	Standard Deviation (mol/L)	Relative Std. Dev. (%)	Estimated Loss per kgal (kg/kgal)
		SX-107 Ave. 64-67 (mol/L)	SX-108 Ave. 65-66 (mol/L)	SX-109 Ave. 64-67 (mol/L)				
Na^{+}	23	1.87 E+01	1.96 E+01	1.52 E+01	1.78 E+01	2.34 E+00	13	1.56 E+03
Al^{3+}	27	3.27 E+00	3.36 E+00	2.56 E+00	3.06 E+00	4.39 E-01	14	3.14 E+02
Fe^{3+} (total Fe)	56	6.88 E-03	7.21 E-03	5.60 E-03	6.56 E-03	8.51 E-04	13	1.40 E+00
Cr^{3+}	52	3.92 E-01	4.13 E-01	3.21 E-01	3.75 E-01	4.81 E-02	13	7.42 E+01
Bi^{3+}	209	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
La^{3+}	139	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
Hg^{2+}	201	1.15 E-07	1.97 E-09	0.00 E+00	3.91 E-08	6.61 E-08	169	2.99 E-05
Zr (as $ZrO(OH)_2$)	141	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
Pb^{2+}	207	1.85 E-05	3.15 E-07	0.00 E+00	6.26 E-06	1.06 E-05	169	4.92 E-03
Ni^{2+}	58.7	6.19 E-03	6.49 E-03	5.04 E-03	5.90 E-03	7.65 E-04	13	1.32 E+00
Sr^{2+}	119	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
Mn^{4+}	55	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
Ca^{2+}	40	3.10 E-02	3.25 E-02	2.52 E-02	2.95 E-02	3.83 E-03	13	4.49 E+00
K^{+}	39.1	6.99 E-02	7.39 E-02	5.76 E-02	6.71 E-02	8.46 E-03	13	9.97 E+00
$^{Total}U$ (M/L)	238	8.06 E-03	8.79 E-03	7.09 E-03	7.98 E-03	8.55 E-04	11	7.22 E+00
$^{Total}Pu$ (g/L)		5.09 E-04	5.33 E-04	4.14 E-04	4.86 E-04	6.30 E-05	13	1.85 E-03
Density (g/cc)		1.84 E+00	1.87 E+00	1.67 E+00	1.80 E+00	1.07 E-01	6	n/a
Void fraction		0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	n/a
wt.% H_2O		2.33 E+01	2.09 E+01	3.14 E+01	2.52 E+01	5.50 E+00	22	n/a
TOC wt.% C		0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
free OH^{-}	17	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
OH^{-}	17	1.98 E+01	2.05 E+01	1.57 E+01	1.87 E+01	2.58 E+00	14	1.21 E+03

Table 2a. Average REDOX Tank Waste Composition Estimate at Time of Leaks (Chemical Units). (2 sheets)

Chemicals Units	Assumed Leak Date. At. Wt (g/mole)	Tank			Average Waste Composition (mol/L)	Standard Deviation (mol/L)	Relative Std. Dev. (%)	Estimated Loss per kgal (kg/kgal)
		SX-107 Ave. 64-67 (mol/L)	SX-108 Ave. 65-66 (mol/L)	SX-109 Ave. 64-67 (mol/L)				
NO_3^-	62	4.89 E+00	5.46 E+00	4.49 E+00	4.95 E+00	4.92 E-01	10	1.17 E+03
NO_2^-	46	4.49 E+00	4.42 E+00	3.23 E+00	4.04 E+00	7.09 E-01	18	7.07 E+02
CO_3^{2-}	60	3.10 E-02	3.25 E-02	2.52 E-02	2.95 E-02	3.83 E-03	13	6.73 E+00
PO_4^{3-}	95	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
SO_4^{2-}	96	9.30 E-02	9.23 E-02	6.77 E-02	8.43 E-02	1.44 E-02	17	3.08 E+01
Si (as SiO_3^{2-})	76	9.80 E-02	9.33 E-02	6.56 E-02	8.57 E-02	1.75 E-02	20	2.47 E+01
F^-	19	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
Cl^-	35.5	3.21 E-01	3.40 E-01	2.65 E-01	3.09 E-01	3.89 E-02	13	4.17 E+01
$C_6H_5O_7^{3-}$	189	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
$EDTA^{4-}$	280	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
$HEDTA^{3-}$	265	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
$glycolate^-$	75	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
$acetate^-$	59	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
$oxalate^{2-}$	88	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
DBP	161	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
butanol	74	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00
NH_3	17	1.12 E-01	1.05 E-01	7.23 E-02	9.65 E-02	2.13 E-02	22	6.24 E+00
$Fe(CN)_6^{4-}$	212	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	n/a	0.00 E+00

Table 2b. Average REDOX Tank Waste Composition Estimate at Time of Leaks (Radionuclides). (2 sheets)

Radionuclides	Tank			Average Waste Composition (Ci/L)	Standard Deviation (Ci/L)	Relative Std. Dev.	Estimated Loss per Kgal (Ci lost/Kgal)
	SX-107 (Ci/L)	SX-108 (Ci/L)	SX-109 (Ci/L)				
^{3}H	6.64 E-04	6.01 E-04	3.96 E-04	5.54 E-04	1.40 E-04	25	2.10 E+00
^{14}C	3.04 E-05	2.88 E-05	2.00 E-05	2.64 E-05	5.63 E-06	21	1.00 E-01
^{59}Ni	3.54 E-06	3.37 E-06	2.36 E-06	3.09 E-06	6.39 E-07	21	1.18 E-02
^{63}Ni	3.48 E-04	3.29 E-04	2.29 E-04	3.02 E-04	6.38 E-05	21	1.15 E+00
^{60}Co	3.10 E-05	2.74 E-05	1.76 E-05	2.53 E-05	6.96 E-06	27	9.62 E-02
^{79}Se	5.76 E-06	5.51 E-06	3.88 E-06	5.05 E-06	1.02 E-06	20	1.92 E-02
^{90}Sr	1.17 E-01	1.23 E-01	9.52 E-02	1.11 E-01	1.44 E-02	13	4.23 E+02
^{90}Y	1.17 E-01	1.23 E-01	9.52 E-02	1.11 E-01	1.44 E-02	13	4.24 E+02
^{93}Zr	2.85 E-05	2.72 E-05	1.90 E-05	2.49 E-05	5.15 E-06	21	9.46 E-02
^{93m}Nb	2.05 E-05	1.98 E-05	1.41 E-05	1.81 E-05	3.51 E-06	19	6.88 E-02
^{99}Tc	2.44 E-04	2.27 E-04	1.55 E-04	2.09 E-04	4.70 E-05	23	7.93 E-01
^{106}Ru	7.97 E-09	6.77 E-09	4.07 E-09	6.27 E-09	2.00 E-09	32	2.38 E-05
^{113m}Cd	1.33 E-04	1.22 E-04	8.18 E-05	1.12 E-04	2.72 E-05	24	4.27 E-01
^{125}Sb	1.16 E-04	1.00 E-04	6.17 E-05	9.25 E-05	2.79 E-05	30	3.51 E-01
^{126}Sn	8.67 E-06	8.31 E-06	5.87 E-06	7.62 E-06	1.52 E-06	20	2.89 E-02
^{129}I	4.60 E-07	4.30 E-07	2.95 E-07	3.95 E-07	8.84 E-08	22	1.50 E-03
^{134}Cs	7.00 E-06	5.97 E-06	3.62 E-06	5.53 E-06	1.74 E-06	31	2.10 E-02
^{137}Cs	8.38 E-01	7.71 E-01	5.19 E-01	7.09 E-01	1.68 E-01	24	2.69 E+03
^{137m}Ba	7.93 E-01	7.30 E-01	4.91 E-01	6.71 E-01	1.59 E-01	24	2.55 E+03
^{151}Sm	2.02 E-02	1.94 E-02	1.37 E-02	1.77 E-02	3.56 E-03	20	6.74 E+01
^{152}Eu	5.47 E-06	4.86 E-06	3.12 E-06	4.48 E-06	1.22 E-06	27	1.70 E-02
^{154}Eu	7.54 E-04	6.68 E-04	4.27 E-04	6.16 E-04	1.70 E-04	28	2.34 E+00
^{155}Eu	2.78 E-04	2.47 E-04	1.58 E-04	2.28 E-04	6.26 E-05	28	8.65 E-01
^{226}Ra	2.13 E-10	2.23 E-10	1.74 E-10	2.03 E-10	2.63 E-11	13	7.72 E-07

Table 2b. Average REDOX Tank Waste Composition Estimate at Time of Leaks (Radionuclides). (2 sheets)

Radionuclides	Tank			Average Waste Composition (Ci/L)	Standard Deviation (Ci/L)	Relative Std. Dev.	Estimated Loss per Kgal (Ci lost/Kgal)
	SX-107 (Ci/L)	SX-108 (Ci/L)	SX-109 (Ci/L)				
^{228}Ra	9.46 E-15	8.32 E-15	5.26 E-15	7.68 E-15	2.17 E-15	28	2.92 E-11
^{227}Ac	1.23 E-09	1.30 E-09	1.01 E-09	1.18 E-09	1.52 E-10	13	4.48 E-06
^{231}Pa	6.20 E-09	6.19 E-09	4.57 E-09	5.65 E-09	9.39 E-10	17	2.15 E-05
^{229}Th	6.37 E-13	5.95 E-13	4.08 E-13	5.47 E-13	1.22 E-13	22	2.08 E-09
^{232}Th	2.68 E-14	2.35 E-14	1.48 E-14	2.17 E-14	6.19 E-15	28	8.25 E-11
^{232}U	6.79 E-11	6.43 E-11	4.48 E-11	5.90 E-11	1.24 E-11	21	2.24 E-07
^{233}U	1.72 E-12	1.71 E-12	1.27 E-12	1.57 E-12	2.61 E-13	17	5.96 E-09
^{234}U	8.12 E-07	8.41 E-07	6.46 E-07	7.66 E-07	1.05 E-07	14	2.91 E-03
^{235}U	3.19 E-08	3.36 E-08	2.62 E-08	3.06 E-08	3.85 E-09	13	1.16 E-04
^{236}U	4.33 E-08	3.91 E-08	2.57 E-08	3.60 E-08	9.16 E-09	25	1.37 E-04
^{238}U	6.40 E-07	6.98 E-07	5.63 E-07	6.34 E-07	6.77 E-08	11	2.41 E-03
^{237}Np	9.53 E-07	9.42 E-07	6.88 E-07	8.61 E-07	1.50 E-07	17	3.27 E-03
^{238}Pu	1.22 E-06	1.12 E-06	7.52 E-07	1.03 E-06	2.47 E-07	24	3.92 E-03
^{239}Pu	3.01 E-05	3.16 E-05	2.46 E-05	2.88 E-05	3.70 E-06	13	1.09 E-01
^{240}Pu	5.38 E-06	5.44 E-06	4.07 E-06	4.96 E-06	7.74 E-07	16	1.89 E-02
^{241}Pu	6.01 E-05	5.61 E-05	3.84 E-05	5.16 E-05	1.15 E-05	22	1.96 E-01
^{242}Pu	3.36 E-10	3.09 E-10	2.07 E-10	2.84 E-10	6.79 E-11	24	1.08 E-06
^{241}Am	8.80 E-05	8.52 E-05	6.07 E-05	7.80 E-05	1.50 E-05	19	2.96 E-01
^{243}Am	3.43 E-09	3.01 E-09	1.90 E-09	2.78 E-09	7.91 E-10	28	1.06 E-05
^{242}Cm	2.51 E-07	2.18 E-07	1.36 E-07	2.02 E-07	5.95 E-08	29	7.67 E-04
^{243}Cm	2.49 E-08	2.12 E-08	1.29 E-08	1.97 E-08	6.16 E-09	31	7.48 E-05
^{244}Cm	2.48 E-07	2.14 E-07	1.32 E-07	1.98 E-07	5.98 E-08	30	7.53 E-04

2.4 LEAK VOLUME ESTIMATES USING KRIGING RESULTS

The leak volumes reported for tanks 241-S-104, -SX-113, and -SX-115 are well documented (Brevick 1994, Hanson 1962, Raymond and Shdo 1966). However, the leak volumes for a number of SX boiling waste tanks are less certain (Agnew and Corbin1998 and Jones 1999). Our approach for estimating leak volumes has been to divide the estimated ^{137}Cs (in kCi) inventory in the soil around a tank (Goodman 2000) by the ^{137}Cs the activity estimate (in kCi/kgal) for REDOX boiling waste (Table 2). The ^{137}Cs inventory estimates for each SX tank developed from geostatistical analysis of gamma-ray logging data are summarized in Table 3. The estimates include average values and the upper 95 percent estimates decayed to January 1, 2000. Because all other radiochemistry data are decayed to January 1, 1994, we had to adjust the January 1, 2000, data back to January 1, 1994 values for consistency. The tank leak volume estimates listed in Table 3 were calculated using the "Upper 95%" data decayed to January 1, 1994. The "Upper 95%" data were assumed to at least roughly approximate a value that would be equal to or greater than the "true" leak volume 19 times out of 20.

2.5 ESTIMATED INVENTORY LOSS TO THE VADOSE ZONE

The tank waste inventory estimates for losses from the failed REDOX boiling waste tanks (241-SX-107, -SX-108, and -SX-109) were calculated by multiplying the Upper 95% leak volume in thousands of gallons (kgal) (Table 3) by the average REDOX tank waste composition in kilograms per thousand gallons or curies per thousand gallons (Table 2). The inventory estimates for losses are listed in Table 4, along with the inventory estimates for waste lost from tanks 241-S-104, -SX-113, and -SX-115. For tanks 241-S-104, -SX-113, and -SX-115, in each case, the reported leak volume was multiplied by the projected waste composition (Table 1). The calculations for these three tanks are outlined in Tables 5 through 7. All radionuclides listed in Table 4 are decayed to a common date of January 1, 1994.

2.6 SPECIATION CALCULATIONS

As noted in Section 2.5, the waste compositions that the SMM module of the HDW model predicted to be in the high-level waste tanks are a combination of liquid and saltcake. If the liquid phase is assumed to be the primary fraction lost during a tank leak event, a better understanding of the chemical species present may facilitate a better understanding of the leak inventories. For a number of reasons, some caution is required in interpreting chemical speciation modeling results for systems as complicated as the tank waste supernatant liquids. Realistically, the results should be used to identify trends in the waste chemistry, not treated as quantitative values.

Speciation calculations were conducted using the tank waste compositions projected by the HDW model at the times of the leaks (see Table 4) for tanks 241-S-104, -SX-108, and -SX-115. These calculations were completed using the Environmental Simulation Program computer code. The output of the program includes the projected speciation of chemicals in both solution phase, including both ions and ion pairs, and solid phase.

Table 3. Estimated Leak Volumes Using MSU Kriging Analysis Data.

Tank SX-xxx	Depth of Contaminated Zone at > 50pCi/g (M)	Average Total ^{137}Cs Value (Ci) Decayed to 1/1/2000	Average Total ^{137}Cs Value (Ci) Decayed to 1/1/1994	Upper 95% Total ^{137}Cs Values (Ci) Decayed to 1/1/2000	Upper 95% Total ^{137}Cs Values (Ci) Decayed to 1/1/1994	Estimated Leak Volume (Gal) Using data decayed to 1/1/1994	Estimated Upper 95% Leak Volume (Gal) Using data decayed to 1/1/1994	Hanlon Leak Volumes (Gal)
101	2.5 - 5.5	7.55 E-03	8.67 E-03	1.68 E-02	1.93 E-02	3.2 E-03	7.2 E-03	Non-leaker
102	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.0 E+00	0.0 E+00	Non-leaker
103	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.0 E+00	0.0 E+00	Non-leaker
104	2.5 -5.5	2.65 E-04	3.04 E-04	1.56 E-03	1.79 E-03	1.1 E-04	6.7 E-04	6,000
105	17.5 - 20.5	5.52 E-03	6.34 E-03	1.37 E-02	1.57 E-02	2.4 E-03	5.8 E-03	Non-leaker
106	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.0 E+00	0.0 E+00	Non-leaker
107	14.6 - 26.5	8.03 E+03	9.22 E+03	1.49 E+04	1.71 E+04	3.4 E+03	6.4 E+03	<5,000
108	14.5 - 41.5	1.43 E+04	1.64 E+04	3.56 E+04	4.09 E+04	6.1 E+03	1.5 E+04	2,500 to 35,000
109	2.5 - 5.5	3.73 E-04	4.28 E-04	2.19 E-03	2.52 E-03	1.6 E-04	9.3 E-04	None given
109	14.5 - 41.5	7.23 E+02	8.31 E+02	2.32 E+03	2.66 E+03	3.1 E+02	9.9 E+02	<10,000
110	17.5 - 23.5	1.98 E+00	2.27 E+00	1.26 E+01	1.45 E+01	8.4 E-01	5.4 E+00	5,500
111	17.5 - 41.5	2.35 E-01	2.70 E-01	1.15 E+00	1.32 E+00	1.0 E-01	4.9 E-01	500 to 2,000
112	17.5 - 41.6	1.80 E+01	2.07 E+01	9.50 E+01	1.09 E+02	7.7 E+00	4.1 E+01	30,000
113	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.0 E+00	0.0 E+00	15,000
114	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.0 E+00	0.0 E+00	None given
115	17.5 - 26.5	4.1[a]	4.7[a]	17.7[a]	20.3[a]	---	---	50,000

a) The statistical analysis of the gamma for tank SX-115 failed to converge. Thus, these data were not used in leak volume estimates. (See discussion in text and Goodman 2000.)

Table 4a. Estimated Inventory Lost to Vadose Zone in S/SX Tank Farms (Leak Volume). (2 sheets)

		Estimated S-104 Inventory Loss (kg)	Estimated SX-107 Inventory Loss (kg)	Estimated SX-108 Inventory Loss (kg)	Estimated SX-109 Inventory Loss (kg)	Estimated SX-113 Inventory Loss (kg)	Estimated SX-115 Inventory Loss (kg)
	Leak Vol.	24 kgal[a]	6.35 kgal[b]	15.2 kgal[b]	0.989 kgal[b]	15 kgal[a]	50 kgal[a]
Na^{+}		1.82 E+04	9.90 E+03	2.37 E+04	1.54 E+03	1.05 E+04	1.57 E+04
Al^{3+}		3.83 E+03	2.00 E+03	4.78 E+03	3.11 E+02	1.95 E+03	4.24 E+03
Fe (total)		1.81 E+01	8.87 E+00	2.12 E+01	1.38 E+00	9.47 E+00	2.25 E+01
Cr^{3+}		7.81 E+02	4.71 E+02	1.13 E+03	7.33 E+01	5.08 E+02	5.03 E+02
Bi^{3+}		1.71 E-04	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	2.63 E-03
La^{3+}		2.79 E-10	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	4.31 E-09
Hg^{2+}		6.49 E-02	1.90 E-04	4.54 E-04	2.95 E-05	0.00 E+00	2.40 E-01
$ZrO(OH)_2$		1.15 E-05	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	1.77 E-04
Pb^{2+}		1.07 E+01	3.13 E-02	7.48 E-02	4.87 E-03	0.00 E+00	3.96 E+01
Ni^{2+}		1.66 E+01	8.36 E+00	2.00 E+01	1.30 E+00	8.94 E+00	1.93 E+01
Sr^{2+}		0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Mn^{4+}		3.27 E-04	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	5.04 E-03
Ca^{2+}		5.82 E+01	2.85 E+01	6.82 E+01	4.44 E+00	3.05 E+01	7.22 E+01
K^{+}		1.09 E+02	6.33 E+01	1.52 E+02	9.86 E+00	6.92 E+01	8.21 E+01
$^{Total}U$		1.19 E+02	4.58 E+01	1.10 E+02	7.14 E+00	5.74 E+01	1.61 E+02
$^{Total}Pu$		2.39 E-02	1.17 E-02	2.80 E-02	1.82 E-03	1.25 E-02	2.97 E-02
TOC wt.% C		1.28 E+02	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
free OH^{-}		0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
OH^{-}		1.40 E+04	7.66 E+03	1.83 E+04	1.19 E+03	7.72 E+03	1.35 E+04
NO_3^{-}		1.70 E+04	7.40 E+03	1.77 E+04	1.15 E+03	9.96 E+03	3.87 E+03
NO_2^{-}		6.87 E+03	4.49 E+03	1.07 E+04	6.99 E+02	3.50 E+03	9.23 E+03
CO_3^{2-}		8.73 E+01	4.28 E+01	1.02 E+02	6.66 E+00	4.57 E+01	8.35 E+01
PO_4^{3-}		5.02 E-03	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	4.89 E-02
SO_4^{2-}		2.81 E+02	1.95 E+02	4.68 E+02	3.04 E+01	1.58 E+02	3.46 E+02
Si (as SiO_3^{2-})		1.94 E+02	1.57 E+02	3.76 E+02	2.45 E+01	9.66 E+01	2.33 E+02
F^{-}		8.00 E-04	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	4.94 E-02
Cl^{-}		4.57 E+02	2.65 E+02	6.33 E+02	4.12 E+01	2.89 E+02	1.83 E+02
$C_6H_5O_7^{3-}$		8.22 E-03	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	1.27 E-01
$EDTA^{4-}$		1.69 E-06	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	7.32 E-03
$HEDTA^{3-}$		1.41 E-06	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	5.75 E-03
$glycolate^{-}$		6.14 E-05	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	7.10 E-02
$acetate^{-}$		6.37 E-06	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	5.80 E-03
$oxalate^{2-}$		2.63 E-12	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	3.58 E-09
DBP		3.86 E-05	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	9.58 E-02

Table 4a. Estimated Inventory Lost to Vadose Zone in S/SX Tank Farms (Leak Volume). (2 sheets)

		Estimated S-104 Inventory Loss (kg)	Estimated SX-107 Inventory Loss (kg)	Estimated SX-108 Inventory Loss (kg)	Estimated SX-109 Inventory Loss (kg)	Estimated SX-113 Inventory Loss (kg)	Estimated SX-115 Inventory Loss (kg)
	Leak Vol.	24 kgal[a]	6.35 kgal[b]	15.2 kgal[b]	0.989 kgal[b]	15 kgal[a]	50 kgal[a]
Butanol		3.86 E-05	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	4.40 E-02
NH_3		1.87 E+00	3.96 E+01	9.48 E+01	6.17 E+00	2.06 E+01	4.21 E+01
$Fe(CN)_6^{4-}$		0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00

[a]Leak volumes from Hanlon (2000).
[b]Leak volumes estimated from MSU Kriging Analysis of Gamma Logging Data.

Table 4b. Estimated Inventory Lost to Vadose Zone in S/SX Tank Farms (Radionuclides). (2 sheets)

Radionuclides	Estimated S-104 Inventory Loss (Ci)	Estimated SX-107 Inventory Loss (Ci)	Estimated SX-108 Inventory Loss (Ci)	Estimated SX-109 Inventory Loss (Ci)	Estimated SX-113 Inventory Loss (Ci)	Estimated SX-115 Inventory Loss (Ci)
^{3}H	7.12 E+00	1.34 E+01	3.20 E+01	2.08 E+00	4.61 E+00	1.43 E+01
^{14}C	5.53 E-01	6.37 E-01	1.52 E+00	9.92 E-02	3.57 E-01	6.95 E-01
^{59}Ni	6.99 E-02	7.46 E-02	1.79 E-01	1.16 E-02	4.46 E-02	8.38 E-02
^{63}Ni	6.53 E+00	7.28 E+00	1.74 E+01	1.13 E+00	4.17 E+00	8.20 E+00
^{60}Co	2.21 E-01	6.11 E-01	1.46 E+00	9.52 E-02	1.41 E-01	6.74 E-01
^{79}Se	1.17 E-01	1.22 E-01	2.92 E-01	1.90 E-02	7.58 E-02	1.33 E-01
^{90}Sr	4.52 E+03	2.69 E+03	6.44 E+03	4.19 E+02	2.88 E+03	3.38 E+03
^{90}Y	4.53 E+03	2.69 E+03	6.44 E+03	4.19 E+02	2.88 E+03	3.38 E+03
^{93}Zr	5.54 E-01	6.01 E-01	1.44 E+00	9.36 E-02	3.58 E-01	6.56 E-01
^{93m}Nb	4.53 E-01	4.37 E-01	1.05 E+00	6.80 E-02	2.93 E-01	4.77 E-01
^{99}Tc	3.87 E+00	5.03 E+00	1.21 E+01	7.84 E-01	2.50 E+00	5.52 E+00
^{106}Ru	1.66 E-06	1.51 E-04	3.62 E-04	2.36 E-05	3.94 E-07	1.68 E-04
^{113m}Cd	1.71 E+00	2.71 E+00	6.50 E+00	4.23 E-01	1.10 E+00	2.98 E+00
^{125}Sb	3.35 E-01	2.23 E+00	5.34 E+00	3.48 E-01	2.07 E-01	2.48 E+00
^{126}Sn	1.80 E-01	1.84 E-01	4.40 E-01	2.86 E-02	1.16 E-01	2.00 E-01
^{129}I	7.44 E-03	9.53 E-03	2.28 E-02	1.48 E-03	4.80 E-03	1.04 E-02
^{134}Cs	6.32 E-03	1.33 E-01	3.19 E-01	2.08 E-02	3.56 E-03	1.48 E-01
^{137}Cs	1.14 E+04	1.71 E+04	4.10 E+04	2.67 E+03	7.34 E+03	1.88 E+04
^{137m}Ba	1.08 E+04	1.62 E+04	3.87 E+04	2.52 E+03	6.94 E+03	1.78 E+04
^{151}Sm	4.19 E+02	4.28 E+02	1.03 E+03	6.67 E+01	2.71 E+02	4.68 E+02
^{152}Eu	4.14 E-02	1.08 E-01	2.59 E-01	1.69 E-02	2.65 E-02	1.18 E-01

Table 4b. Estimated Inventory Lost to Vadose Zone in S/SX Tank Farms (Radionuclides). (2 sheets)

Radionuclides	Estimated S-104 Inventory Loss (Ci)	Estimated SX-107 Inventory Loss (Ci)	Estimated SX-108 Inventory Loss (Ci)	Estimated SX-109 Inventory Loss (Ci)	Estimated SX-113 Inventory Loss (Ci)	Estimated SX-115 Inventory Loss (Ci)
^{154}Eu	5.33 E+00	1.49 E+01	3.56 E+01	2.32 E+00	3.41 E+00	1.64 E+01
^{155}Eu	1.96 E+00	5.49 E+00	1.31 E+01	8.55 E-01	1.25 E+00	6.00 E+00
^{226}Ra	8.15 E-06	4.90 E-06	1.17 E-05	7.64 E-07	5.24 E-06	5.50 E-06
^{228}Ra	1.88 E-07	1.85 E-10	4.44 E-10	2.89 E-11	3.51 E-11	2.90 E-06
^{227}Ac	4.72 E-05	2.85 E-05	6.81 E-05	4.43 E-06	3.04 E-05	3.15 E-05
^{231}Pa	1.75 E-04	1.36 E-04	3.26 E-04	2.12 E-05	1.13 E-04	1.47 E-04
^{229}Th	1.49 E-08	1.32 E-08	3.16 E-08	2.05 E-09	6.70 E-09	8.36 E-08
^{232}Th	2.52 E-08	5.24 E-10	1.25 E-09	8.16 E-11	9.32 E-11	3.87 E-07
^{232}U	3.83 E-06	1.42 E-06	3.41 E-06	2.22 E-07	8.26 E-07	3.44 E-05
^{233}U	7.37 E-06	3.78 E-08	9.05 E-08	5.89 E-09	3.15 E-08	1.13 E-04
^{234}U	4.09 E-02	1.85 E-02	4.43 E-02	2.88 E-03	1.88 E-02	7.25 E-02
^{235}U	1.73 E-03	7.37 E-04	1.77 E-03	1.15 E-04	8.09 E-04	2.80 E-03
^{236}U	9.69 E-04	8.69 E-04	2.08 E-03	1.35 E-04	2.97 E-04	4.29 E-03
^{238}U	3.96 E-02	1.53 E-02	3.66 E-02	2.38 E-03	1.92 E-02	5.36 E-02
^{237}Np	2.52 E-02	2.08 E-02	4.97 E-02	3.24 E-03	1.62 E-02	2.39 E-02
^{238}Pu	2.27 E-02	2.49 E-02	5.96 E-02	3.87 E-03	1.05 E-02	6.21 E-02
^{239}Pu	1.43 E+00	6.95 E-01	1.66 E+00	1.08 E-01	7.48 E-01	1.76 E+00
^{240}Pu	2.07 E-01	1.20 E-01	2.87 E-01	1.86 E-02	1.07 E-01	2.95 E-01
^{241}Pu	1.28 E+00	1.24 E+00	2.98 E+00	1.94 E-01	6.30 E-01	2.79 E+00
^{242}Pu	5.49 E-06	6.85 E-06	1.64 E-05	1.07 E-06	2.89 E-06	1.12 E-05
^{241}Am	1.98 E+00	1.88 E+00	4.50 E+00	2.93 E-01	1.28 E+00	2.08 E+00
^{243}Am	1.85 E-05	6.70 E-05	1.60 E-04	1.04 E-05	1.19 E-05	7.16 E-05
^{242}Cm	9.43 E-04	4.87 E-03	1.17 E-02	7.59 E-04	6.11 E-04	5.09 E-03
^{243}Cm	2.16 E-05	4.75 E-04	1.14 E-03	7.39 E-05	1.40 E-05	4.94 E-04
^{244}Cm	6.59 E-04	4.78 E-03	1.14 E-02	7.44 E-04	4.27 E-04	4.98 E-03

Table 5a. Leak Inventory Estimates Based on Concentrations at Time of Leak for Tank S-104 (Chemical Units). (2 sheets)

Chemicals Units	At. Wt (g/mole)	Estimated Waste Composition (Mol/L)	Estimated Loss per kgal (kg/kgal)	Estimated Inventory Assuming 24 kgal Loss (total kg lost)
Na^{+}	23	8.67 E+00	7.58 E+02	1.82 E+04
Al^{3+}	27	1.56 E+00	1.60 E+02	3.83 E+03
Fe^{3+} (total Fe)	56	3.54 E-03	7.54 E-01	1.81 E+01
Cr^{3+}	52	1.65 E-01	3.25 E+01	7.81 E+02
Bi^{3+}	209	8.95 E-09	7.11 E-06	1.71 E-04
La^{3+}	139	2.20 E-14	1.16 E-11	2.79 E-10
Hg^{2+}	201	3.54 E-06	2.70 E-03	6.49 E-02
Zr (as $ZrO(OH)_2$)	141	8.94 E-10	4.79 E-07	1.15 E-05
Pb^{2+}	207	5.67 E-04	4.46 E-01	1.07 E+01
Ni^{2+}	58.7	3.10 E-03	6.92 E-01	1.66 E+01
Sr^{2+}	119	0.00 E+00	0.00 E+00	0.00 E+00
Mn^{4+}	55	6.52 E-08	1.36 E-05	3.27 E-04
Ca^{2+}	40	1.60 E-02	2.42 E+00	5.82 E+01
K^{+}	39.1	3.07 E-02	4.56 E+00	1.09 E+02
$^{Total}U$ (m/L)	238	5.46 E-03	4.94 E+00	1.19 E+02
$^{Total}Pu$ (g/L)	n/a	2.62 E-04	9.96 E-04	2.39 E-02
Density (g/cc)	n/a	1.40 E+00	n/a	n/a
Void Fraction	n/a	0.00 E+00	n/a	n/a
wt.% H_2O	n/a	5.15 E+01	n/a	n/a
TOC wt.% C	n/a	8.39 E-06	5.32 E+00	1.28 E+02
free OH^{-}	17	0.00 E+00	0.00 E+00	0.00 E+00
OH^{-}	17	9.01 E+00	5.82 E+02	1.40 E+04
NO_3^{-}	62	3.01 E+00	7.08 E+02	1.70 E+04
NO_2^{-}	46	1.64 E+00	2.86 E+02	6.87 E+03
CO_3^{2-}	60	1.60 E-02	3.64 E+00	8.73 E+01
PO_4^{3-}	95	5.79 E-07	2.09 E-04	5.02 E-03
SO_4^{2-}	96	3.21 E-02	1.17 E+01	2.81 E+02
Si (as SiO_3^{2-})	76	2.81 E-02	8.10 E+00	1.94 E+02
F^{-}	19	4.62 E-07	3.33 E-05	8.00 E-04
Cl^{-}	35.5	1.41 E-01	1.90 E+01	4.57 E+02
$C_6H_5O_7^{3-}$	189	4.77 E-07	3.43 E-04	8.22 E-03
$EDTA^{4-}$	280	1.86 E-08	7.06 E-08	1.69 E-06
$HEDTA^{3-}$	265	1.54 E-08	5.86 E-08	1.41 E-06
$glycolate^{-}$	75	6.73 E-07	2.56 E-06	6.14 E-05

Table 5a. Leak Inventory Estimates Based on Concentrations at Time of Leak for Tank S-104 (Chemical Units). (2 sheets)

Chemicals Units	At. Wt (g/mole)	Estimated Waste Composition (Mol/L)	Estimated Loss per kgal (kg/kgal)	Estimated Inventory Assuming 24 kgal Loss (total kg lost)
$acetate^-$	59	6.99 E-08	2.66 E-07	6.37 E-06
$oxalate^{2-}$	88	2.89 E-14	1.10 E-13	2.63 E-12
DBP	161	4.23 E-07	1.61 E-06	3.86 E-05
Butanol	74	4.23 E-07	1.61 E-06	3.86 E-05
NH_3	17	2.05 E-02	7.79 E-02	1.87 E+00
$Fe(CN)_6^{4-}$	212	0.00 E+00	0.00 E+00	0.00 E+00

Table 5b. Leak Inventory Estimates Based on Concentrations at Time of Leak for Tank S-104 (Radionuclides). (2 sheets)

Radionuclides	Estimated Waste Composition (Ci/L)	Estimated Loss per kgal (Ci/kgal)	Estimated Inventory Assuming 24 kgal Loss (total Ci lost)
^{3}H	7.81 E-05	2.97 E-01	7.12 E+00
^{14}C	6.06 E-06	2.30 E-02	5.53 E-01
^{59}Ni	7.66 E-07	2.91 E-03	6.99 E-02
^{63}Ni	7.16 E-05	2.72 E-01	6.53 E+00
^{60}Co	2.42 E-06	9.20 E-03	2.21 E-01
^{79}Se	1.29 E-06	4.89 E-03	1.17 E-01
^{90}Sr	4.96 E-02	1.89 E+02	4.52 E+03
^{90}Y	4.96 E-02	1.89 E+02	4.53 E+03
^{93}Zr	6.08 E-06	2.31 E-02	5.54 E-01
^{93m}Nb	4.96 E-06	1.89 E-02	4.53 E-01
^{99}Tc	4.25 E-05	1.61 E-01	3.87 E+00
^{106}Ru	1.82 E-11	6.92 E-08	1.66 E-06
^{113m}Cd	1.88 E-05	7.14 E-02	1.71 E+00
^{125}Sb	3.67 E-06	1.39 E-02	3.35 E-01
^{126}Sn	1.98 E-06	7.51 E-03	1.80 E-01
^{129}I	8.16 E-08	3.10 E-04	7.44 E-03
^{134}Cs	6.94 E-08	2.64 E-04	6.32 E-03
^{137}Cs	1.25 E-01	4.75 E+02	1.14 E+04
^{137m}Ba	1.18 E-01	4.49 E+02	1.08 E+04
^{151}Sm	4.59 E-03	1.74 E+01	4.19 E+02
^{152}Eu	4.54 E-07	1.72 E-03	4.14 E-02
^{154}Eu	5.84 E-05	2.22 E-01	5.33 E+00

Table 5b. Leak Inventory Estimates Based on Concentrations at Time of Leak for Tank S-104 (Radionuclides). (2 sheets)

Radionuclides	Estimated Waste Composition (Ci/L)	Estimated Loss per kgal (Ci/kgal)	Estimated Inventory Assuming 24 kgal Loss (total Ci lost)
^{155}Eu	2.15 E-05	8.17 E-02	1.96 E+00
^{226}Ra	8.94 E-11	3.40 E-07	8.15 E-06
^{228}Ra	2.06 E-12	7.84 E-09	1.88 E-07
^{227}Ac	5.18 E-10	1.97 E-06	4.72 E-05
^{231}Pa	1.92 E-09	7.29 E-06	1.75 E-04
^{229}Th	1.63 E-13	6.20 E-10	1.49 E-08
^{232}Th	2.77 E-13	1.05 E-09	2.52 E-08
^{232}U	4.20 E-11	1.60 E-07	3.83 E-06
^{233}U	8.08 E-11	3.07 E-07	7.37 E-06
^{234}U	4.48 E-07	1.70 E-03	4.09 E-02
^{235}U	1.89 E-08	7.20 E-05	1.73 E-03
^{236}U	1.06 E-08	4.04 E-05	9.69 E-04
^{238}U	4.34 E-07	1.65 E-03	3.96 E-02
^{237}Np	2.76 E-07	1.05 E-03	2.52 E-02
^{238}Pu	2.49 E-07	9.46 E-04	2.27 E-02
^{239}Pu	1.57 E-05	5.95 E-02	1.43 E+00
^{240}Pu	2.27 E-06	8.61 E-03	2.07 E-01
^{241}Pu	1.40 E-05	5.32 E-02	1.28 E+00
^{242}Pu	6.02 E-11	2.29 E-07	5.49 E-06
^{241}Am	2.17 E-05	8.24 E-02	1.98 E+00
^{243}Am	2.03 E-10	7.73 E-07	1.85 E-05
^{242}Cm	1.03 E-08	3.93 E-05	9.43 E-04
^{243}Cm	2.37 E-10	9.01 E-07	2.16 E-05
^{244}Cm	7.22 E-09	2.74 E-05	6.59 E-04

Table 6a. Inventory Lost at Tank SX-113. (2 sheets)

Leak Date 1962, Leak Vol. 15,000 gal				
	Mols/L	Atomic Wt. g/mole	Kg/Kgal	Total Kg's
Na^{+}	7.98 E+00	2.30 E+01	6.98 E+02	1.05 E+04
Al^{3+}	1.27 E+00	2.70 E+01	1.30 E+02	1.95 E+03
$^{Total}Fe$	2.97 E-03	5.60 E+01	6.31 E-01	9.47 E+00
Cr^{3+}	1.71 E-01	5.20 E+01	3.38 E+01	5.08 E+02
Bi^{3+}	0.00 E+00	2.09 E+02	0.00 E+00	0.00 E+00
La^{3+}	0.00 E+00	1.39 E+02	0.00 E+00	0.00 E+00
Hg^{2+}	0.00 E+00	2.01 E+02	0.00 E+00	0.00 E+00

Table 6a. Inventory Lost at Tank SX-113. (2 sheets)

Leak Date 1962, Leak Vol. 15,000 gal				
	Mols/L	Atomic Wt. g/mole	Kg/Kgal	Total Kg's
Zr (as $ZrO(OH)_2$)	0.00 E+00	1.41 E+02	0.00 E+00	0.00 E+00
Pb^{2+}	0.00 E+00	2.07 E+02	0.00 E+00	0.00 E+00
Ni^{2+}	2.67 E-03	5.87 E+01	5.96 E-01	8.94 E+00
Sr^{2+}	0.00 E+00	1.19 E+02	0.00 E+00	0.00 E+00
Mn^{4+}	0.00 E+00	5.50 E+01	0.00 E+00	0.00 E+00
Ca^{2+}	1.34 E-02	4.00 E+01	2.03 E+00	3.05 E+01
K^{+}	3.11 E-02	3.91 E+01	4.62 E+00	6.92 E+01
$^{Total}U$ (M)	4.23 E-03	2.38 E+02	3.83 E+00	5.74 E+01
$^{Total}Pu$ (g/L)	2.20 E-04	--	8.34 E-04	1.25 E-02
TOC wt.% C	0.00 E+00		0.00 E+00	0.00 E+00
free OH^-	0.00 E+00	1.70 E+01	0.00 E+00	0.00 E+00
OH^-	7.97 E+00	1.70 E+01	5.15 E+02	7.72 E+03
NO_3^-	2.82 E+00	6.20 E+01	6.64 E+02	9.96 E+03
NO_2^-	1.34 E+00	4.60 E+01	2.34 E+02	3.50 E+03
CO_3^{2-}	1.34 E-02	6.00 E+01	3.05 E+00	4.57 E+01
PO_4^{3-}	0.00 E+00	9.50 E+01	0.00 E+00	0.00 E+00
SO_4^{2-}	2.88 E-02	9.60 E+01	1.05 E+01	1.58 E+02
Si (as SiO_3^{2-})	2.23 E-02	7.60 E+01	6.44 E+00	9.66 E+01
F^-	0.00 E+00	1.90 E+01	0.00 E+00	0.00 E+00
Cl^-	1.43 E-01	3.55 E+01	1.93 E+01	2.89 E+02
$C_6H_5O_7^{3-}$	0.00 E+00	1.89 E+02	0.00 E+00	0.00 E+00
$EDTA^{4-}$	0.00 E+00	2.80 E+02	0.00 E+00	0.00 E+00
$HEDTA^{3-}$	0.00 E+00	2.65 E+02	0.00 E+00	0.00 E+00
$glycolate^-$	0.00 E+00	7.50 E+01	0.00 E+00	0.00 E+00
$acetate^-$	0.00 E+00	5.90 E+01	0.00 E+00	0.00 E+00
$oxalate^{2-}$	0.00 E+00	8.80 E+01	0.00 E+00	0.00 E+00
DBP	0.00 E+00	1.61 E+02	0.00 E+00	0.00 E+00
Butanol	0.00 E+00	7.40 E+01	0.00 E+00	0.00 E+00
NH3	2.12 E-02	1.70 E+01	1.37 E+00	2.06 E+01
$Fe(CN)_6^{4-}$	0.00 E+00	2.12 E+02	0.00 E+00	0.00 E+00

Table 6b. Inventory Lost at Tank SX-113 (Radionuclides). (3 sheets)

Leak Date 1962, Leak Vol. 15,000 gal			
Radionuclides	(Ci/L)	(Ci/gal)	Total Ci
^{3}H	8.09 E-05	3.08 E-04	4.61 E+00
^{14}C	6.26 E-06	2.38 E-05	3.57 E-01
^{59}Ni	7.83 E-07	2.97 E-06	4.46 E-02

Table 6b. Inventory Lost at Tank SX-113 (Radionuclides). (3 sheets)

Leak Date 1962, Leak Vol. 15,000 gal			
Radionuclides	(Ci/L)	(Ci/gal)	Total Ci
^{63}Ni	7.31 E-05	2.78 E-04	4.17 E+00
^{60}Co	2.47 E-06	9.40 E-06	1.41 E-01
^{79}Se	1.33 E-06	5.05 E-06	7.58 E-02
^{90}Sr	5.04 E-02	1.92 E-01	2.88 E+03
^{90}Y	5.05 E-02	1.92 E-01	2.88 E+03
^{93}Zr	6.28 E-06	2.39 E-05	3.58 E-01
^{93m}Nb	5.13 E-06	1.95 E-05	2.93 E-01
^{99}Tc	4.38 E-05	1.67 E-04	2.50 E+00
^{106}Ru	6.91 E-12	2.62 E-11	3.94 E-07
^{113m}Cd	1.93 E-05	7.35 E-05	1.10 E+00
^{125}Sb	3.63 E-06	1.38 E-05	2.07 E-01
^{126}Sn	2.04 E-06	7.77 E-06	1.16 E-01
^{129}I	8.42 E-08	3.20 E-07	4.80 E-03
^{134}Cs	6.25 E-08	2.37 E-07	3.56 E-03
^{137}Cs	1.29 E-01	4.89 E-01	7.34 E+03
^{137m}Ba	1.22 E-01	4.63 E-01	6.94 E+03
^{151}Sm	4.75 E-03	1.80 E-02	2.71 E+02
^{152}Eu	4.66 E-07	1.77 E-06	2.65 E-02
^{154}Eu	5.97 E-05	2.27 E-04	3.41 E+00
^{155}Eu	2.20 E-05	8.35 E-05	1.25 E+00
^{226}Ra	9.20 E-11	3.50 E-10	5.24 E-06
^{228}Ra	6.17 E-16	2.34 E-15	3.51 E-11
^{227}Ac	5.34 E-10	2.03 E-09	3.04 E-05
^{231}Pa	1.99 E-09	7.55 E-09	1.13 E-04
^{229}Th	1.18 E-13	4.47 E-13	6.70 E-09
^{232}Th	1.63 E-15	6.21 E-15	9.32 E-11
^{232}U	1.45 E-11	5.51 E-11	8.26 E-07
^{233}U	5.52 E-13	2.10 E-12	3.15 E-08
^{234}U	3.30 E-07	1.25 E-06	1.88 E-02
^{235}U	1.42 E-08	5.39 E-08	8.09 E-04
^{236}U	5.22 E-09	1.98 E-08	2.97 E-04
^{238}U	3.37 E-07	1.28 E-06	1.92 E-02
^{237}Np	2.85 E-07	1.08 E-06	1.62 E-02
^{238}Pu	1.84 E-07	6.99 E-07	1.05 E-02
^{239}Pu	1.31 E-05	4.99 E-05	7.48 E-01
^{240}Pu	1.88 E-06	7.14 E-06	1.07 E-01
^{241}Pu	1.11 E-05	4.20 E-05	6.30 E-01
^{242}Pu	5.07 E-11	1.93 E-10	2.89 E-06
^{241}Am	2.24 E-05	8.51 E-05	1.28 E+00

Table 6b. Inventory Lost at Tank SX-113 (Radionuclides). (3 sheets)

Leak Date 1962, Leak Vol. 15,000 gal			
Radionuclides	(Ci/L)	(Ci/gal)	Total Ci
^{243}Am	2.09 E-10	7.96 E-10	1.19 E-05
^{242}Cm	1.07 E-08	4.07 E-08	6.11 E-04
^{243}Cm	2.46 E-10	9.33 E-10	1.40 E-05
^{244}Cm	7.48 E-09	2.84 E-08	4.27 E-04

Table 7a. Inventory Lost at Tank SX-115. (2 sheets)

Leak date:1964, Leak volume = 50,000 gal				
Units:	Atomic Wt. g/mole	Mols/L	kg/kgal	Total kg
Na^{+}	23	3.59 E+00	3.14 E+02	1.57 E+04
Al^{3+}	27	8.26 E-01	8.47 E+01	4.24 E+03
$^{Total}Fe$	56	2.11 E-03	4.49 E-01	2.25 E+01
Cr^{3+}	52	5.09 E-02	1.01 E+01	5.03 E+02
Bi^{3+}	209	6.63 E-08	5.26 E-05	2.63 E-03
La^{3+}	139	1.63 E-13	8.62 E-11	4.31 E-09
Hg^{2+}	201	6.29 E-06	4.81 E-03	2.40 E-01
Pb^{+2}	207	1.01 E-03	7.92 E-01	3.96 E+01
Ni^{2+}	58.7	1.73 E-03	3.86 E-01	1.93 E+01
Sr^{2+}	119	0.00 E+00	0.00 E+00	0.00 E+00
Mn^{4+}	55	4.82 E-07	1.01 E-04	5.04 E-03
Ca^{2+}	40	9.50 E-03	1.44 E+00	7.22 E+01
K^{+}	39.1	1.11 E-02	1.64 E+00	8.21 E+01
$^{Total}U$ (M)	238	3.56 E-03	3.22 E+00	1.61 E+02
$^{Total}Pu$ (g/L)		1.56 E-04	5.94 E-04	2.97 E-02
Density (g/cc)		1.18 E+00		
wt.% H_2O		7.51 E+01		
TOC wt.% C		7.35 E-05		
free OH^{-}	17	0.00 E+00	0.00 E+00	0.00 E+00
OH^{-}	17	4.17 E+00	2.69 E+02	1.35 E+04
NO_3^{-}	62	1.20 E+00	7.73 E+01	3.87 E+03
NO_2^{-}	46	7.84 E-01	1.85 E+02	9.23 E+03
CO_3^{2-}	60	9.55 E-03	1.67 E+00	8.35 E+01
PO_4^{3-}	95	4.29 E-06	9.78 E-04	4.89 E-02
SO_4^{2-}	96	1.92 E-02	6.93 E+00	3.46 E+02
Si (as SiO_3^{2-})	76	1.28 E-02	4.67 E+00	2.33 E+02
F^{-}	19	3.42 E-06	9.87 E-04	4.94 E-02
Cl^{-}	35.5	5.07 E-02	3.66 E+00	1.83 E+02
$C_6H_5O_7^{3-}$	189	3.53 E-06	2.54 E-03	1.27 E-01

Table 7a. Inventory Lost at Tank SX-115. (2 sheets)

Leak date:1964, Leak volume = 50,000 gal				
Units:	Atomic Wt. g/mole	Mols/L	kg/kgal	Total kg
$EDTA^{4-}$	280	1.38 E-07	1.46 E-04	7.32 E-03
$HEDTA^{3-}$	265	1.14 E-07	1.15 E-04	5.75 E-03
$glycolate^{-}$	75	4.99 E-06	1.42 E-03	7.10 E-02
$acetate^{-}$	59	5.17 E-07	1.16 E-04	5.80 E-03
$oxalate^{2-}$	88	2.14 E-13	7.15 E-11	3.58 E-09
DBP	161	3.13 E-06	1.92 E-03	9.58 E-02
Butanol	74	3.13 E-06	8.81 E-04	4.40 E-02
NH_3	17	1.30 E-02	8.43 E-01	4.21 E+01
$Fe(CN)_6^{4-}$	212	0.00 E+00	0.00 E+00	0.00 E+00

Table 7b. Inventory Lost at Tank SX-115 (Radionuclides). (2 sheets)

Leak date:1964, Leak volume = 50,000 gal			
Radionuclides	Ci/L	Ci/kgal	Total Ci
^{3}H	7.55 E-05	2.87 E-01	1.43 E+01
^{14}C	3.66 E-06	1.39 E-02	6.95 E-01
^{59}Ni	4.41 E-07	1.68 E-03	8.38 E-02
^{63}Ni	4.32 E-05	1.64 E-01	8.20 E+00
^{60}Co	3.55 E-06	1.35 E-02	6.74 E-01
^{79}Se	7.01 E-07	2.66 E-03	1.33 E-01
^{90}Sr	1.78 E-02	6.75 E+01	3.38 E+03
^{90}Y	1.78 E-02	6.75 E+01	3.38 E+03
^{93}Zr	3.46 E-06	1.31 E-02	6.56 E-01
^{93m}Nb	2.51 E-06	9.54 E-03	4.77 E-01
^{99}Tc	2.90 E-05	1.10 E-01	5.52 E+00
^{106}Ru	8.86 E-10	3.37 E-06	1.68 E-04
^{113m}Cd	1.57 E-05	5.96 E-02	2.98 E+00
^{125}Sb	1.31 E-05	4.97 E-02	2.48 E+00
^{126}Sn	1.05 E-06	4.01 E-03	2.00 E-01
^{129}I	5.50 E-08	2.09 E-04	1.04 E-02
^{134}Cs	7.76 E-07	2.95 E-03	1.48 E-01
^{137}Cs	9.89 E-02	3.76 E+02	1.88 E+04
^{137m}Ba	9.35 E-02	3.55 E+02	1.78 E+04
^{151}Sm	2.47 E-03	9.37 E+00	4.68 E+02
^{152}Eu	6.18 E-07	2.35 E-03	1.18 E-01
^{154}Eu	8.62 E-05	3.28 E-01	1.64 E+01
^{155}Eu	3.16 E-05	1.20 E-01	6.00 E+00
^{226}Ra	2.89 E-11	1.10 E-07	5.50 E-06

Table 7b. Inventory Lost at Tank SX-115 (Radionuclides). (2 sheets)

Leak date:1964, Leak volume = 50,000 gal			
Radionuclides	Ci/L	Ci/kgal	Total Ci
^{228}Ra	1.53 E-11	5.81 E-08	2.90 E-06
^{227}Ac	1.66 E-10	6.30 E-07	3.15 E-05
^{231}Pa	7.76 E-10	2.95 E-06	1.47 E-04
^{229}Th	4.40 E-13	1.67 E-09	8.36 E-08
^{232}Th	2.04 E-12	7.75 E-09	3.87 E-07
^{232}U	1.81 E-10	6.87 E-07	3.44 E-05
^{233}U	5.93 E-10	2.25 E-06	1.13 E-04
^{234}U	3.82 E-07	1.45 E-03	7.25 E-02
^{235}U	1.47 E-08	5.60 E-05	2.80 E-03
^{236}U	2.26 E-08	8.58 E-05	4.29 E-03
^{238}U	2.82 E-07	1.07 E-03	5.36 E-02
^{237}Np	1.26 E-07	4.77 E-04	2.39 E-02
^{238}Pu	3.27 E-07	1.24 E-03	6.21 E-02
^{239}Pu	9.28 E-06	3.52 E-02	1.76 E+00
^{240}Pu	1.55 E-06	5.90 E-03	2.95 E-01
^{241}Pu	1.47 E-05	5.58 E-02	2.79 E+00
^{242}Pu	5.89 E-11	2.24 E-07	1.12 E-05
^{241}Am	1.09 E-05	4.15 E-02	2.08 E+00
^{243}Am	3.77 E-10	1.43 E-06	7.16 E-05
^{242}Cm	2.68 E-08	1.02 E-04	5.09 E-03
^{243}Cm	2.60 E-09	9.87 E-06	4.94 E-04
^{244}Cm	2.62 E-08	9.96 E-05	4.98 E-03

The first step in any solution chemical speciation calculation is a charge-balance calculation. This calculation is based on the premise that all aqueous salt solutions are electrically neutral. That is, the concentration of positively charged ions (cations) must equal the concentration of negatively charged ions (anions). To force this condition on the data sets used in the speciation calculations, the hydroxide concentration was assumed to be 0.1 molar and the sodium ion concentration was allowed to float. The temperature of the tank supernatant liquid was assumed to be 100 °C for tanks 241-S-104 and -SX-108 and 75 °C. for tank 241-SX-115.

Results for the speciation calculations are listed in Tables 8 through 10 for tanks 241-S-104, -SX-108, and -SX-115, respectively. These waste compositions were selected for speciation analysis because they represent three different waste types. Tank 241-S-104 received both REDOX cladding waste and REDOX high-level waste. The tank waste self-concentrated for a number of years. Tank 241-SX-108 was an active REDOX boiling waste tank during the times it likely leaked and tank 241-SX-115 contained somewhat diluted REDOX high-level waste. Tank 241-SX-108 results would apply to all of the SX boiling waste leaks. The tank SX-115 results would likely be applicable to the tank SX-113 leak.

Table 8. Tank S-104 Speciation Study. (4 sheets)

Phases---------->	Aqueous	Solid
Temperature, °C	100	100
Pressure, atm	1	1
pH	11.4	
Total mol/L	5.25 E+01	1.51 E+00
H_2O in mol/L	4.31 E+01	
Ion Pairs	Ion Pairs (mol/L)	Solids (mol/L)
HNO_2	2.29 E-09	
NH_3	2.15 E-02	
$CaSO_4$	1.07 E-06	
CsCl	1.22 E-06	
Cs glycol	1.97 E-12	
$CsNO_3$	2.96 E-05	
$Fe(III)OH_3$	2.27 E-10	
H_2SiO_3	1.16 E-08	
$Al(OH)_3$	9.24 E-08	1.46 E+00
$Bi(OH)_3$	1.22 E-09	
$HgOH_2$	3.65 E-06	
K acetate	1.98 E-10	
KCl	5.88 E-05	
K glycolate	2.25 E-09	
$CaCO_3$	3.53 E-06	1.63 E-02
Na acetate	5.80 E-08	
NaF	3.12 E-07	
Na glycolate	5.11 E-07	
$NaHCO_3$	4.60 E-06	
$NaHSiO_3$	3.98 E-04	
$NaNO_2$	5.03 E-01	
$NaNO_3$	1.25 E+00	
NH_4 acetate	1.22 E-13	
NH_4NO_3	4.31 E-05	
$NiOH_2$	2.87 E-09	3.25 E-03
CaH_2SiO_4	6.91 E-07	
PbO	2.02 E-10	

Table 8. Tank S-104 Speciation Study. (4 sheets)

$Pu(IV)OH_4$	2.80 E-09	1.12 E-06
SiO_2	5.47 E-08	
Sr glycol 2	2.95 E-17	
$SrHPO_4$	3.08 E-15	
$SrNO_3^2$	5.64 E-04	
Ions	mol/L	
OH	1.04 E-01	
$Al(OH)_4$ ion	1.43 E-01	
$Bi(OH)_4$ ion	8.16 E-09	
Ca acetate ion	1.42 E-11	
Ca citrate ion	2.16 E-10	
Ca EDTA ion	9.29 E-09	
CaF ion	3.31 E-11	
Ca glycol ion	3.37 E-10	
Ca ion	2.16 E-04	
$CaNO_3$ ion	5.08 E-09	
CaOH ion	2.17 E-04	
$CaPO_4$ ion	1.76 E-09	
Citrate ion	1.63 E-08	
Cl ion	1.48 E-01	
CO_3 ion	3.55 E-04	
CrO_4 ion	1.73 E-01	
Cs citrate ion	7.56 E-13	
Cs $glycol_2$ ion	5.38 E-18	
Cs ion	1.47 E-05	
$CsSO_4$ ion	3.03 E-08	
EDTA ion	1.42 E-13	
$Fe(III)OH_4$ ion	1.19 E-06	
F ion	1.72 E-07	
Glycolate ion	1.91 E-07	
H_2SiO_4 ion	2.80 E-10	
H_3SiO_4 ion	2.00 E-05	
HCO_3 ion	1.22 E-06	
$HCrO_4$ ion	4.70 E-07	

Table 8. Tank S-104 Speciation Study. (4 sheets)

$HSeO_3$ ion	6.31 E-12	
$Hg(OH)_3$ ion	6.65 E-08	
$HPbO_2$ ion	1.11 E-08	
HPO_4 ion	2.11 E-10	
$HSiO_3$ ion	1.78 E-10	
K citrate ion	2.07 E-09	
K ion	3.20 E-02	
KSO_4 ion	8.45 E-05	
$NaCO_3$ ion	8.33 E-05	
Na citrate ion	4.81 E-07	
Na ion	3.88 E+00	
$NaSO_4$ ion	1.50 E-03	
NH_2CO_2 ion	1.43 E-08	
NH_4 ion	5.98 E-06	
NH_4SO_4 ion	2.88 E-08	
$NiOH_3$ ion	5.78 E-08	
NiOH EDTA ion	1.01 E-08	
NO_2 ion	1.21 E+00	
NO_3 ion	1.90 E+00	
Acetate ion	1.50 E-08	
PO_4 ion	3.87 E-10	
SeO_3 ion	1.29 E-06	
SeO_4 ion	1.15 E-06	
SiO_3 ion	4.97 E-10	
SO_4 ion	3.20 E-02	
Sr acetate ion	3.93 E-12	
Sr citrate ion	4.83 E-11	
Sr EDTA ion	7.31 E-11	
SrF ion	3.67 E-12	
Sr glycol ion	3.97 E-11	
Sr ion	4.26 E-05	
$SrNO_3$ ion	2.05 E-04	
SrOH ion	2.64 E-05	
$SrPO_4$ ion	5.46 E-12	

Table 8. Tank S-104 Speciation Study. (4 sheets)

$Tc(VII)O_4$ ion	2.65 E-05	
$UO_2(CO_3)_2$ ion	2.66 E-16	
$UO_2(CO_3)_3$ ion	1.21 E-13	
UO_2 ion	2.33 E-26	
Solids		mol/L
$Ca_5OH(PO_4)_3$		5.77 E-07
FeOOH		3.71 E-03
MnO_2		6.83 E-08
$Na_2U_2O_7$		2.86 E-03
$NaAlSiO_4$		2.90 E-02
$PbOH_2$		5.94 E-04
ZrO_2		9.37 E-10
Total g/L	1.23 E+03	1.22 E+02
Enthalpy, J/L	-1.47 E+07	-1.99 E+06
Density, g/L	1.23 E+03	2.48 E+03
Osmotic pressure, atm	3.90 E+02	
Redox pot, volts	3.98 E-02	
E-Con, 1/ohm-cm	7.00 E-01	
E-Con, cm2/ohm-mol	3.93 E+01	
Absolute viscosity, cP	6.27 E-01	
Relative viscosity	2.23 E+00	
Ionic strength	5.30 E+00	

Table 9. Tank SX-108 Speciation Study. (4 sheets)

Phases---------->	Aqueous	Solid
Temperature, C	100.00	100.00
Pressure, atm	1.00	1.00
pH	11.95	
Total mol/L	4.93 E+01	6.21 E+00
H_2O	32.79	
Ion Pairs	Ion Pairs (mol/L)	Solids (mol/L)

Table 9. Tank SX-108 Speciation Study. (4 sheets)

HNO_2	1.98 E-09	
$AlOH_3$	6.82 E-08	5.80 E+00
CsCl	5.02 E-06	
$CsNO_3$	5.52 E-05	
$Fe(III)OH_3$	1.11 E-10	
H_2SiO_3	4.53 E-10	
$CaCO_3$	2.60 E-06	5.91 E-02
$HgOH_2$	2.11 E-09	
KCl	5.63 E-04	
CaH_2SiO_4	4.86 E-08	
$NaHCO_3$	1.05 E-05	
$NaHSiO_3$	1.30 E-04	
$NaNO_2$	3.19 E+00	
$NaNO_3$	4.10 E+00	
$NiOH_2$	2.12 E-09	1.24 E-02
$CaSO_4$	8.97 E-08	
PbO	2.25 E-10	
$Pu(IV)OH_4$	2.06 E-09	4.19 E-06
SiO_2	3.21 E-09	
$Sr(NO_3)_2$	3.71 E-04	
Ions	**mol/L**	
OH ion	9.12 E-02	
$Al(OH)_4$ ion	2.67 E-01	
Ca ion	2.99 E-05	
$CaNO_3$ ion	6.42 E-11	
CaOH ion	6.91 E-05	
Cl ion	3.80 E-01	
CO_3 ion	1.25 E-03	
C_4O_4 ion	1.93 E-02	
Cs ion	1.48 E-05	

Table 9. Tank SX-108 Speciation Study. (4 sheets)

$CsSO_4$ ion	1.49 E-08	
$Fe(III)(OH)_4$ ion	1.42 E-06	
H_2SiO_4 ion	3.51 E-12	
H_3SiO_4 ion	1.42 E-06	
HCO_3 ion	1.11 E-06	
$HCrO_4$ ion	1.30 E-08	
$HSeO_3$ ion	5.59 E-12	
$HPbO_2$ ion	2.24 E-08	
K ion	8.19 E-02	
KSO_4 ion	9.56 E-05	
$NaCO_3$ ion	5.19 E-04	
Na ion	4.54 E+00	
$NaSO_4$ ion	1.20 E-03	
$NiNO_3$ ion	3.03 E-15	
$NiOH_3$ ion	1.04 E-07	
NO_2 ion	1.76 E+00	
NO_3 ion	2.02 E+00	
$Pb(NO_2)_3$ ion	2.30 E-11	
SeO_3 ion	5.58 E-06	
SeO_4 ion	5.57 E-06	
SiO_3 ion	9.40 E-12	
SO_4 ion	2.77 E-02	
Sr ion	6.06 E-06	
$SrNO_3$ ion	7.47 E-05	
SrOH ion	1.12 E-05	
$Tc(VII)O_4$ ion	4.16 E-06	
$UO_2CO_3^2$ ion	8.52 E-17	
$UO_2CO_3^3$ ion	3.13 E-13	
Solids		mol/L
$CaOH_2$		2.87 E-03

Table 9. Tank SX-108 Speciation Study. (4 sheets)

FeOOH		1.38 E-02
$KTc(VII)O_4$		2.52 E-04
Na_2SO_4		1.27 E-01
$Na_2U_2O_7$		8.42 E-03
$NaAlSiO_4$		1.79 E-01
$PbOH_2$		5.64 E-07
Total g/L	1.52 E+03	2.98 E+02
Enthalpy, kJ/L	-1.43 E+04	-4.75 E+03
Density, g/L	1.52 E+03	2.48 E+03
Osmotic pressure, atm	9.83 E+02	
Redox pot, volts	3.88 E+00	
E-Con, 1/ohm-cm	8.33 E-01	
E-Con, cm2/ohm-mol	2.11 E+01	
Absolute viscosity, cP	1.12 E+00	
Relative viscosity	3.98 E+00	
Ionic strength	7.90 E+00	

Table 10. Tank SX-115 Speciation Study. (6 sheets)

Phases---------->	Aqueous	Solid
Temperature, C	75.00	75.00
Pressure, atm	1.00	1.00
pH	10.94	
Total mol/L	54.41	0.95
----------	mol/L	
H_2O	50.22	
Ion Pairs	**Ion Pairs (mol/L)**	**Solids (mol/L)**
HNO_2	4.05 E-09	
NH_3	1.32 E-02	
$CaSO_4$	3.45 E-06	

Table 10. Tank SX-115 Speciation Study. (6 sheets)

Cs acetate	9.47 E-13	
CsCl	8.18 E-08	
Cs glycol	6.30 E-12	
$CsNO_3$	3.43 E-06	
$Fe(III)OH_3$	7.80 E-11	
H_2SiO_3	5.65 E-07	
$Al(OH)_3$	4.07 E-08	8.30 E-01
$Bi(OH)_3$	3.61 E-08	
$Hg(OH)_2$	6.45 E-06	
K acetate	8.12 E-10	
KCl	4.04 E-06	
K glycolate	8.53 E-09	
$Mn(NO_3)_2$	1.52 E-10	
$CaCO_3$	5.39 E-06	9.34 E-03
Na acetate	2.50 E-07	
NaF	1.28 E-06	
Na glycolate	2.00 E-06	
$NaHCO_3$	5.38 E-06	
$NaHSiO_3$	1.84 E-03	
$NaNO_2$	8.98 E-02	
$NaNO_3$	1.90 E-01	
NH_4NO_3	1.60 E-04	
$NiOH_2$	4.51 E-09	1.78 E-03
CaH_2SiO_4	2.14 E-06	
PbO	1.29 E-09	
$Pu(IV)OH_4$	2.02 E-09	6.56 E-07
SiO_2	1.41 E-06	
$Sr(NO_3)_2$	1.10 E-05	
Ions	mol/L	
OH ion	2.11E-02	

Table 10. Tank SX-115 Speciation Study. (6 sheets)

$Al(OH)_4$ ion	8.42 E-03	
$Bi(OH)_4$ ion	3.21 E-08	
Ca acetate ion	1.92 E-10	
Ca citrate ion	1.21 E-08	
Ca EDTA ion	4.52 E-08	
Ions	mol/L	
CaF ion	1.49 E-10	
Ca glycol ion	4.52 E-09	
Ca ion	3.58 E-04	
$CaNO_3$ ion	3.26 E-07	
CaOH ion	3.64 E-05	
$CaPO_4$ ion	6.89 E-09	
Citrate ion	5.34 E-07	
Cl ion	5.22 E-02	
CO_3 ion	3.86 E-04	
CrO_4 ion	5.23 E-02	
Cs citrate ion	3.54 E-12	
Cs $glycol_2$ ion	1.00 E-16	
Cs ion	5.31 E-06	
$CsSO_4$ ion	1.64 E-08	
$Fe(III)(OH)_4$ ion	6.68 E-08	
F ion	2.24 E-06	
Glycolate ion	3.11 E-06	
H_2SiO_4 ion	4.15 E-08	
H_3SiO_4 ion	1.60 E-04	
HCO_3 ion	6.27 E-06	
$HCrO_4$ ion	3.95 E-07	
$HSeO_3$ ion	2.51 E-11	
$Hg(NH_3)_2$ ion	8.35 E-10	
$Hg(OH)_3$ ion	1.79 E-08	

Table 10. Tank SX-115 Speciation Study. (6 sheets)

HP_2O_7 ion	1.61 E-23	
$HPbO_2$ ion	1.59 E-08	
HPO_4 ion	1.83 E-09	
$HSiO_3$ ion	2.22 E-07	
K citrate ion	1.10 E-08	
K ion	1.13 E-02	
KSO_4 ion	5.44 E-05	
MnCl ion	2.03 E-11	
Mn EDTA ion	1.18 E-10	
Mn ion	6.68 E-10	
Na_2F ion	1.41 E-10	
$NaCO_3$ ion	7.34 E-05	
Na citrate ion	3.07 E-06	
Na EDTA ion	2.97 E-12	
Na ion	1.97 E+00	
$NaSO_4$ ion	1.54 E-03	
NH_2CO_2 ion	6.02 E-08	
NH_4 ion	3.04 E-05	
NH_4SO_4 ion	2.66 E-07	
Ni EDTA ion	5.84 E-09	
Ni ion	1.22 E-12	
$Ni(OH)_3$ ion	2.48 E-08	
Ni(OH) EDTA ion	9.02 E-08	
NO_2 ion	7.16 E-01	
Ions	mol/L	
NO_3 ion	1.04 E+00	
Acetate ion	2.81 E-07	
PO_4 ion	1.25 E-09	
SeO_3 ion	1.15 E-06	
SeO_4 ion	1.56 E-07	

Table 10. Tank SX-115 Speciation Study. (6 sheets)

SiO_3 ion	1.90 E-07	
SO_4 ion	1.81 E-02	
Sr acetate ion	9.00 E-12	
Sr citrate ion	3.10 E-10	
Sr EDTA ion	3.69 E-11	
SrF ion	7.24 E-12	
Sr glycol ion	8.33 E-11	
Sr ion	1.11 E-05	
$SrNO_3$ ion	1.31 E-05	
SrOH ion	5.74 E-07	
$SrPO_4$ ion	3.15 E-12	
$Tc(VII)O_4$ ion	1.78 E-05	
$UO_2CO_3^2$ ion	2.70 E-14	
$UO_2CO_3^3$ ion	9.91 E-12	
Solids		mol/L
$Ca_5(OH)(PO_4)_3$		4.19 E-06
FeOOH		2.17 E-03
MnO_2		4.95 E-07
$Na_2U_2O_7$		1.83 E-03
$NaAlSiO_4$		1.11 E-02
$Pb(OH)_2$		1.04 E-03
ZrO_2		6.80 E-09
Total g/L	1.08 E+03	7.63 E+01
Enthalpy, cal/L	-3.62 E+06	-2.66 E+05
Density, g/L	1.08 E+03	2.48 E+03
Osmotic pressure, atm	1.24 E+02	
Redox pot, volts	8.39 E-02	
E-Con, 1/ohm-cm	3.34 E-01	
E-Con, cm^2/ohm-mol	4.20 E+01	

Table 10. Tank SX-115 Speciation Study. (6 sheets)

Absolute viscosity, cP	4.90 E-01	
Relative viscosity	1.30 E+00	
Ionic strength	2.27 E+00	

3.0 DISCUSSION

3.1 UNCERTAINTY IN TANK LEAK INVENTORY ESTIMATES

Although the uncertainty in the inventory estimates developed in this analysis and presented in this document cannot be quantified, we can compare some HDW-derived waste composition estimates with laboratory analytical data. The relative agreement between modeled results and the laboratory data probably provide the best quality assessment available at this time.

The Raymond and Shdo Report (1966) provides analytical data for the supernatant liquid in tanks 241-SX-108 and -SX-115 near the times these tanks leaked. Raymond and Shdo report ^{137}Cs activity in tank 241-SX-108 to be 7.22 Ci/gal in December 1965 and in tank -SX-115 to be 0.763 Ci/gal in September 1964. In October 1962, the ^{137}Cs activity in tank 241-SX-113 was measured to be 0.52 Ci/gal (Hanson et al. 1962). The ^{137}Cs activities were decayed to a common date of January 1, 1994, and are compared with ^{137}Cs data reported in Table 11.

Table 11. Comparison of ^{137}Cs Activities* from HDW Model Results and Analytical Data.

Tank	HDW Model Values (Ci/L)	Analytical Data (Ci/L)
SX-108	0.77	1.0
SX-113	0.13	0.067
SX-115	0.099	0.10

*All activities are decayed to a common date of January 1, 1994.

The leak inventory estimates are directly related to the leak volume estimates. The leak volumes from tanks 241-SX-113 and -SX-115 are well documented. The leak volume estimates for tanks 241-SX-107, -SX-108, and -SX-109 are derived from ^{137}Cs activity estimates coming from kriging analysis. The "Upper 95%" ^{137}Cs inventory estimates were used to weight the basis for the estimated leaks volumes to the high side.

A major uncertainty associated with the kriging analysis is the lack of data below the laterals. However, we expect to address this uncertainty with a slant borehole drilled under tank 241-SX-108 (HNF-5995, Rev. 0 [Henderson 1999]). The waste loss estimate from tank 241-S-104 appears to be consistent with observed decreases in tank liquid levels.

3.2 GAMMA-RAY LOGGING DATA KRIGING COMPARISONS

The leak estimates developed from kriging analysis (Goodman 2000) rely on both calibrated spectral and uncalibrated gross gamma-ray logging data and very limited sets of uncalibrated gross gamma data from the laterals under tanks 241-SX-105 and -SX-107 through -SX-115. A major section of the kriging analysis report (Goodman 2000) focused on developing a self-consistent set of gamma data. The data sets for tank 241-SX-115 failed to converge and were not used in the 241-SX-115 inventory estimate.

The ^{137}Cs inventory estimate developed by kriging analysis (Goodman 2000) for the soil column surrounding tanks in the SX tank farm is 52.9 kCi (decayed to 2000) or 60.8 kCi (decayed to 1994). However, if one includes the ^{137}Cs estimates from leaks in tanks 241-SX-113 (7.34 kCi) and -SX-115 (18.8 kCi) (see Table 4), the total ^{137}Cs inventory estimate for the SX farm would be 86.9 kCi (decayed to January 1, 1994). DOE-GJPO (2000) completed a preliminary kriging analysis of their SX farm spectral gamma data and estimated a total ^{137}Cs activity of 6.79 kCi (decayed to 2000) (or 7.80 kCi decayed to January 1, 1994). The Montana State University (MSU) (Goodman 2000) results and the DOE-GJPO (2000) results are compared in Table 12. The MACTEC-ERS ^{137}Cs estimate does not contain gamma data from the laterals. Thus, a lower estimate of ^{137}Cs activity would be expected for SX farm. Another interesting observation is that including gamma data down to 0.5 pCi/g (DOE-GJPO 2000), rather than the 50 pCi/g used in the Goodman (2000) analysis and this effort, increased the total activity estimate for the SX farm by far less than 1 percent. This indicates that ignoring the lower levels of activity around the farm has no significant impact on overall ^{137}Cs inventory estimates.

3.3 COMPARISON OF SX FARM TOTAL ^{137}CS INVENTORY ESTIMATES

Estimates of total ^{137}Cs inventory in the SX tank farm are available from a number of sources. Hanlon (2000) maintains a partial historical estimate of amounts of ^{137}Cs lost from various SX tanks. As already noted, both MSU (Goodman 2000) and DOE-GJPO (2000) have developed total tank farm inventory estimates using kriging analysis of gamma-ray logging data, but the estimates were calculated using different software packages and different subsets of the gamma-ray logging database. However, neither kriging analysis picked up the ^{137}Cs activity from well-documented leak events in tanks 241-SX-113 and -SX-115, because of the lack of pertinent gamma-ray logging data available from around these tanks. The total ^{137}Cs activity estimate developed in this effort combined MSU kriging analysis results with historical records and waste composition modeling results. Finally, Agnew and Corbin (1998) developed a ^{137}Cs inventory estimate for tanks SX-108, SX-109, SX-111, and SX-112 as part of the Historical Leak Model (HLM) development. These estimates of total ^{137}Cs inventory are shown in Table 13.

The two "kriging" studies appear to agree reasonably well. The MACTEC-ERS kriging analysis used only the spectral gamma logging database, which did not contain any of the gamma-ray data from the laterals, and is suggested to represent a "lower bound" value. However, all the spectral gamma-ray logging data were collected using calibrated tools and following a well-documented quality assurance program. The MSU ^{137}Cs estimate is about an order of magnitude higher than the MACTEC-ERS estimate. However, if the "Average" rather

than the "Upper 95%" values had been used, the total ^{137}Cs inventory estimate would have been decreased by a factor of 3. Thus, a ^{137}Cs inventory estimate based on the "Average" value would have only been about double the MACTEC-ERS estimate. A factor of 2 difference between the results of the two studies is consistent with Goodman's (2000) suggestion that the gamma data from the laterals would contribute about half of the overall ^{137}Cs activity.

Table 12. Total Activity Estimate for SX Tank Farm Using Kriging Analysis of Gamma-Ray Logging Data (Activity decayed to 1/1/2000).

Tank	MSU Upper 95% Cs-137 Activity Estimates: Threshold Level*								
	5.00 E+00 (pCi)	5.00 E+01 (pCi)	5.00 E+02 (pCi)	5.00 E+03 (pCi)	5.00 E+04 (pCi)	5.00 E+05 (pCi)	5.00 E+06 (pCi)	5.00 E+07 (pCi)	5.00 E+08 (pCi)
SX-101	Not reported	2.09 E+10	0	0	0	0	0	0	0
SX-102	Not reported	0	0	0	0	0	0	0	0
SX-103	Not reported	0	0	0	0	0	0	0	0
SX-104	Not reported	1.56 E+09	0	0	0	0	0	0	0
SX-105	Not reported	1.34 E+10	0	0	0	0	0	0	0
SX-106	Not reported	0	0	0	0	0	0	0	0
SX-107	Not reported	1.49 E+16	1.49 E+16	1.49 E+16	1.49 E+16	1.47 E+16	1.36 E+16	9.64 E+15	0
SX-108	Not reported	3.56 E+16	3.56 E+16	3.56 E+16	3.55 E+16	3.50 E+16	3.11 E+16	5.43 E+14	0
SX-109	Not reported	2.32 E+15	2.32 E+15	2.30 E+15	2.16 E+15	1.35 E+15	0	0	0
SX-110	Not reported	1.98 E+12	1.97 E+12	1.91 E+12	1.77 E+12	8.93 E+11	0	0	0
SX-111	Not reported	2.35 E+11	1.60 E+11	4.37 E+10	0	0	0	0	0
SX-112	Not reported	9.50 E+13	9.32 E+13	8.33 E+13	5.51 E+13	0	0	0	0
SX-113	Not reported	0	0	0	0	0	0	0	0
SX-114	Not reported	0	0	0	0	0	0	0	0
SX-115		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
MSU Sum		5.29 E+16	5.29 E+16	5.29 E+16	5.26 E+16	5.11 E+16	4.47 E+16	1.02 E+16	
MACTEC-ERS Kriging Estimate for Total Cs-137 Inventory Estimate:									
	(pCi)	(pCi)	(pCi)	(pCi)	(pCi)	(pCi)	(pCi)	(pCi)	(pCi)
	6.79 E+15	6.78 E+15	6.78 E+15	6.77 E+15	6.69 E+15	6.35 E+15	5.39 E+15	2.67 E+15	7.24 E+12

*Note: The "Threshold level" includes all activities at that level or higher.

MSU = Montana State Uniiversity

Table 13. Total SX Farm Cs-137 Inventory Estimates.

	Total kCi	
MSU Kriging total ^{137}Cs	52.9	Decayed to 1/1/2000
MACTEC-ERS Kriging Total ^{137}Cs	6.8	Decayed to 1/1/2000
^{137}Cs sum (this assessment)*	86.9	Decayed to 1/1/1994
^{137}Cs estimate from Hanlon (2000)	127 to 251	Decayed to various dates near 1970.
^{137}Cs estimate from Hanford Leak Model**	1,010	Decayed to 1/1/1994

*This assessment includes Cs-137 estimates from tanks SX-113 and SX-115.

**Based on estimated leak volume of 413 Kgal from tanks SX-108, SX-109, SX-111, and SX-112 (Agnew and Corbin 1998).

MSU = Montana State University

The historical results from Hanlon (2000) reflect ^{137}Cs activities determined or estimated in the mid to late 1960's and should be reduced by a factor of 2, that is, by one half-life, to be comparable with other numbers reported in Table 13. The Hanlon value also included a 40 kCi estimate for a leak from tank 241-SX-112 in 1969. However, in this assessment, this leak volume has been discounted. Neither the laterals or drywells around this tank have sufficient ^{137}Cs activity to justify such a leak volume, nor have any historical records been found (to date) to support that leak volume. This decision will be reversed if additional documentation can be found.

The ^{137}Cs inventory estimate for the four SX tanks calculated with the HLM (Agnew and Corbin 1998) (1,010 kCi) appears to be unreasonably high. The MSU kriging analysis study projects an estimate of approximately 38 kCi for the combined leaks from these four tanks. That is more than a factor of 25 lower than the value estimated by the HLM. The differences in total ^{137}Cs inventories come from vastly different leak volume estimates. The HLM projected that 413 kgal of waste was leaked from these four tanks, whereas leak volumes listed in Table 3 would suggest a leak volume of around 16 kgal. The 16 kgal leak estimate for these four tanks is consistent with the spectral and gross gamma-ray logging data from the laterals and drywells, and soil analysis data. Even with the overall uncertainty in the other ^{137}Cs inventory estimates given in Table 13, accepting the HLM results as being realistic is very difficult. A recent assessment of the H LM methodology suggested that the approach was not valid (Jones 1999). Most disconcerting was the fact that the published version of the HLM does not provide sufficient information to allow the reported tank leak volumes to be verified. Without the ability to verify the methodology, the reported leak volumes must be regarded as speculation.

4.0 CONCLUSIONS

The recommended status for tanks in the S/SX WMA is presented in Table 14. These recommendations are specifically focused on the S/SX WMA vadose characterization activities. The tank leak inventory estimates provided in this report are based on the best available information and should provide a reasonable approach for ranking the impacts of tank leak events on the vadose zone in this WMA. The lack of an inventory estimate for any tank should not be interpreted as "the tank did not leaked" but rather that the impact of any leak (as measured by gamma-ray logging data) from that tank is not significant when compared to the major tank leak events in this WMA.

Table 14. Summary of Results Based on Current Analysis.

Tank	Past Leak Event?	Probable Leak Date	Probable Leak Volume* (kgal)	Comments	References
S-104	yes	66 - 70	24.0	Likely a tank overfill rather than leak.	Agnew 1997, Brevick 1964
SX-101	no	n/a	n/a	Near-surface contamination.	
SX-102	no	n/a	n/a		
SX-103	no	n/a	n/a		
SX-104	no	n/a	n/a	Near-surface contamination.	Dunford 1988 Zimmer 1988
SX-105	no	n/a	n/a		
SX-106	no	n/a	n/a		
SX-107	yes	1967	6.4	Activity mostly under tank.	
SX-108	yes	64 and 66-67	15.3	Appears to have largest gamma plume.	Raymond and Shdo 1966, WHC 1992a
SX-109	yes	1965 - ??	1.0	May have leaked small amounts over several years.	WHC 1992b
SX-110	yes	??	---	Little to suggest a tank leak.	
SX-111	yes	1974	---	Likely a 500-gal leak.	Hanlon 1974
SX-112	yes	1969	---	Reported 30-kgal leak volume cannot be documented.	
SX-113	yes	1962	15.0	Leaked during planned tank leak test.	Hansen et al. 1962

Table 14. Summary of Results Based on Current Analysis.

Tank	Past Leak Event?	Probable Leak Date	Probable Leak Volume* (kgal)	Comments	References
SX-114	yes	1972	---		
SX-115	yes	1965	50.0	Leaked during $NaNO_3$ recovery. Activity mostly under tank.	Raymond and Shdo 1966, WHC 1992c

*Based on this work.

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