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SDF Inventory Estimates for Transport Modeling

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ACRONYMS/ABBREVIATIONS

ARP	Actinide Removal Process
DF	Decontamination Factor
MCU	Modular Caustic Side Solvent Extraction Unit
PA	Performance Assessment
SA	Special Analysis
SDU	Saltstone Disposal Unit
SWPF	Salt Waste Processing Facility

1.0 INTRODUCTION

This document details the steps used to develop inventory estimates for use in modeling associated with the Special Analysis (SA) for Saltstone Disposal Unit (SDU) 6 and future transport modeling. In previous inventory estimates, the method employed developed best estimate type values. These values are generally developed by calculating an average inventory and adding conservatism.

These best estimate inventories have been used in previous analyses and knowledge has been gained regarding the impact of inventory amounts to dose results. It has been observed that some radionuclides are more risk significant than others. Based on those observations, these inventory estimates were developed by splitting the radionuclides into two groups, risk significant and non-risk significant.

2.0 METHOD

2.1 Divided approach

A divided approach was taken when developing these inventory estimates. The purpose to having a divided approach was to focus attention on the risk significant radionuclides. The choice of risk significant radionuclides was based on previous modeling results.

The results of the current modeling efforts can be used to confirm the risk significance. Those radionuclides believed to be non-risk significant had inventory estimates that were very conservative. These conservative inventory estimates are easily defensible, as discussed later, and allow attention to be focus on the risk significant radionuclides. These conservative estimates are not predictions of disposal quantities, but are modeling estimates that allow for easy agreement in their bases.

In addition to dividing the radionuclides, disposal operations were assumed to continue further in the future, with an anticipated closure date of 10/1/2032. The current inventory estimates for Vaults 1 and 4 were decayed to 10/1/2032 and no additional changes were made. Since SDU 2 is nearly full, the recent disposed inventory estimates were decayed and used and estimates of additional inventory were made for the remaining space. For the remaining disposal units (SDUs 3, 5, and 6 through 12), estimates of the entire disposal inventory were developed.

2.1.1 Risk Significant Radionuclides

Tc-99, I-129, and Cs-135 were identified as risk significant based on previous modeling efforts. In previous analyses these radionuclides had the highest doses at inventories expected to be present at closure. [SRR-CWDA-2009-00017, SRR-CWDA-2013-00062]

2.1.2 Non-Risk Significant Radionuclides

All other radionuclides were considered non-risk significant. The identification of these radionuclides as non-risk significant is only for inventory estimating purposes. These radionuclide inventory estimates were developed to be significantly conservative (i.e., the modeling inventory estimates are expected to be significantly higher than the actual disposed inventory).

2.2 Inventory Estimate Development

Inventory estimates for each of the current and planned disposal units were developed. Different approaches were used for estimating the final inventories present in each unit at closure.

2.2.1 Vaults 1 & 4

The current Vault 1 and 4 contents were decayed to 10/1/2032 and used exclusively with no additional material assumed to be disposed within these vaults. [SRR-CWDA-2013-00140]

2.2.2 SDU 2

Both SDU 2 units are nearly full. So, the current contents formed the starting point for the SDU 2A and 2B inventories. [SRR-CWDA-2013-00140, X-CLC-Z-00066] The remaining space within each unit was assumed to be completely filled (i.e., no clean cap). An estimate of the inventory contained in the remaining space was made and is discussed below. The estimate of inventory for the remaining space was based on the risk significance of each radionuclide.

For the non-risk significant radionuclides, the remaining disposal space was assumed to be filled with material similar to the material already present. To estimate this additional inventory, a ratio of the empty volume to the remaining volume was multiplied by the current inventory. This inventory was then added to the current inventory.

For the risk significant radionuclides, the material next in line for disposal was used to estimate the additional inventory. The remaining disposal space inventory was estimated by multiplying concentrations, from the material to be disposed of next (i.e., next salt batch), and the remaining disposal volume in SDU 2A and 2B to estimate the additional inventory. This additional inventory was added to the current inventory.

2.2.3 SDUs 3 & 5

SDUs 3 and 5 are the next units to receive material. Since SDU 2 is nearly full, SDUs 3 and 5 will receive material soon. The inventory estimate approach taken depended on the risk significance of each radionuclide.

For the non-risk significant radionuclides, a conservative inventory estimate was used. Each disposal cell/unit was assumed to contain the entire soluble and insoluble (salt) inventory present in both tank farms.

A cell/unit limitation considered here was the estimated concentration relative to the Class C limits since Class C waste will not be disposed of in an SDU. In cases where a radionuclides total tank farm inventory (converted to a concentration using the SDU volume) was greater than the Class C limit, the Class C limit was used for that radionuclide. This applied to the Pu-238, Pu-239, and Pu-240 inventory estimates. An adjustment was made to the Cs-137 inventory, to account for processing through ARP/MCU and SWPF, by applying a DF of 200 to the estimated inventory as this is a majority of the total curies for disposal and it is not appropriate to overstate the total remaining radionuclide inventory. [SRR-LWP-2009-00001]

For the risk significant radionuclides, the salt batches planned for disposal within SDUs 3 and 5 were used. [SRR-LWP-2009-00001] Salt Batches 6 and 7 have been qualified, so concentrations for each of the risk significant radionuclides were used. [SRNL-STI-2012-00707, SRNL-STI-2013-00437] For Salt Batches 8, 9, and 10, concentrations for the material planned

to build these batches was used with the planned volumes. These concentrations were taken from the latest inventory estimate. [SRR-LWP-2013-00066] The inventories for each of the salt batches were added together for a total inventory estimate. An adjustment was made to the Cs-135 inventory, to account for processing through ARP/MCU and SWPF, by applying a DF of 200 to the estimated inventory. [SRR-LWP-2009-00001]

2.2.4 SDUs 6 through 12

SDUs 6 through12 will be the last units filled. The inventory estimate approach taken depended on the risk significance of each radionuclide.

For the non-risk significant radionuclides, a conservative inventory estimate was used. Each disposal unit was assumed to contain the entire soluble and insoluble (salt) inventory present in both tank farms. A limitation considered here was the estimated concentration relative to the Class C limits. In cases where a radionuclides total tank farm inventory was greater than the Class C limit, the Class C limit was used for that radionuclide. This applied to the Pu-238 inventory estimate. An adjustment was made to the Cs-137 inventory, to account for processing through ARP/MCU and SWPF, by applying a DF of 200 to the estimated inventory. [SRR-LWP-2009-00001]

For the risk significant radionuclides, the remaining inventory was spread among these units. Since these units are the last ones planned, the remaining tank farm inventories were applied to these units. The remaining inventory was estimated by subtracting the inventory estimated for disposal in SDUs 3 and 5 from the current total tank farm inventory. Then this inventory was averaged across the planned disposal volume for SDUs 6 through 12. [SRR-LWP-2009-00001] An adjustment was made to the Cs-135 inventory, to account for processing through ARP/MCU and SWPF, by applying a DF of 200 to the estimated inventory. [SRR-LWP-2009-00001]

3.0 RESULTS

Table 3.0-1 shows the estimated inventories for use in transport modeling.

Table 3.0-1 - Inventory Estimates for Use in Transport Modeling

	Vault 1	Vault 4	SDU 2A	SDU 2B	SDU 3A	SDU 3B	SDU 5A	SDU 5B
Radionuclide	Ci	Ci	Ci	Ci	Ci	Ci	Ci	Ci
H-3	5.8E+00	1.0E+01	3.4E-01	2.7E-01	8.2E+02	8.2E+02	8.2E+02	8.2E+02
C-14	1.3E+00	6.6E+00	2.4E+00	2.3E+00	5.8E+02	5.8E+02	5.8E+02	5.8E+02
Al-26	2.6E-01	9.1E-01	9.1E-04	8.7E-04	2.4E+01	2.4E+01	2.4E+01	2.4E+01
Cl-36	1.9E-07	2.9E-02	1.7E-04	2.1E-04	9.5E-01	9.5E-01	9.5E-01	9.5E-01
K-40	1.9E-07	2.9E-02	1.7E-04	2.0E-04	9.5E-01	9.5E-01	9.5E-01	9.5E-01
Co-60	6.0E-05	8.3E-03	1.1E-05	1.2E-05	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Ni-59	2.3E-03	8.0E-02	1.0E-03	7.0E-04	2.6E+00	2.6E+00	2.6E+00	2.6E+00
Ni-63	1.1E-01	2.7E+00	3.9E-02	2.7E-02	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Se-79	3.4E-01	9.7E+00	1.3E-01	1.3E-01	8.9E+01	8.9E+01	8.9E+01	8.9E+01
Sr-90	7.8E-03	1.6E+03	7.0E+00	8.2E+00	3.6E+06	3.6E+06	3.6E+06	3.6E+06
Zr-93	6.9E-01	6.7E+00	2.8E-01	3.7E-01	9.5E+01	9.5E+01	9.5E+01	9.5E+01
Nb-94	2.0E-03	8.9E-02	1.8E-03	1.4E-03	5.4E-04	5.4E-04	5.4E-04	5.4E-04
Tc-99	5.5E+01	6.4E+02	1.2E+02	1.4E+02	5.4E+02	5.4E+02	5.4E+02	5.4E+02
Pd-107	8.4E-03	3.5E-02	6.1E-03	6.0E-03	9.5E-01	9.5E-01	9.5E-01	9.5E-01
Sn-126	1.2E+00	2.1E+00	7.5E-01	6.6E-01	3.9E+02	3.9E+02	3.9E+02	3.9E+02
I-129	2.0E-01	2.8E-01	8.5E-02	7.9E-02	9.6E-02	9.6E-02	9.6E-02	9.6E-02
Cs-135	9.8E-02	1.7E+00	5.6E-01	4.7E-01	9.0E-03	9.0E-03	9.0E-03	9.0E-03
Cs-137	4.5E+00	1.2E+05	2.6E+03	3.2E+03	2.3E+05	2.3E+05	2.3E+05	2.3E+05
Sm-151	4.2E-03	1.8E+01	1.3E-01	1.1E-01	3.7E+03	3.7E+03	3.7E+03	3.7E+03
Eu-152	7.1E-04	3.4E-02	4.6E-05	4.9E-05	7.8E+00	7.8E+00	7.8E+00	7.8E+00
Eu-154	1.5E-04	9.2E-01	4.7E-04	8.6E-04	9.6E+01	9.6E+01	9.6E+01	9.6E+01
Pt-193	1.3E+00	6.9E+00	9.3E-01	9.9E-01	7.3E+01	7.3E+01	7.3E+01	7.3E+01
Ra-226	4.6E-07	3.0E-05	1.3E-04	4.9E-04	1.3E+01	1.3E+01	1.3E+01	1.3E+01
Ra-228	7.8E-07	2.1E-05	1.4E-07	1.9E-07	2.3E-02	2.3E-02	2.3E-02	2.3E-02
Ac-227	8.1E-07	1.1E-05	1.4E-04	2.3E-07	8.4E-02	8.4E-02	8.4E-02	8.4E-02
Th-229	2.1E-04	3.8E-02	2.3E-03	3.9E-03	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Th-230	4.9E-05	2.7E-03	3.0E-01	1.1E+00	1.3E+01	1.3E+01	1.3E+01	1.3E+01
Th-232	7.7E-06	2.1E-04	1.3E-05	1.8E-05	2.3E-01	2.3E-01	2.3E-01	2.3E-01
Pa-231	2.9E-06	3.8E-05	3.3E-02	1.5E-06	1.5E-01	1.5E-01	1.5E-01	1.5E-01
U-232	5.7E-04	1.0E-01	9.6E-03	9.1E-03	6.8E-02	6.8E-02	6.8E-02	6.8E-02
U-233	7.8E-02	8.7E+00	9.6E-01	1.3E+00	1.6E+01	1.6E+01	1.6E+01	1.6E+01
U-234	1.0E-01	5.7E+00	6.2E-01	8.2E-01	9.3E+00	9.3E+00	9.3E+00	9.3E+00
U-235	2.5E-03	3.4E-02	1.3E-03	1.3E-03	3.8E-01	3.8E-01	3.8E-01	3.8E-01
U-236	6.5E-03	8.1E-02	6.4E-03	8.5E-03	4.3E-01	4.3E-01	4.3E-01	4.3E-01
U-238	1.1E-02	7.9E-02	2.2E-02	2.7E-02	1.6E+01	1.6E+01	1.6E+01	1.6E+01
Np-237	3.9E-03	5.6E-01	1.8E-01	9.2E-02	2.7E+01	2.7E+01	2.7E+01	2.7E+01
Pu-238	8.7E-03	2.7E+02	4.3E+00	4.0E+00	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Pu-239	1.7E-02	5.8E+01	5.7E-01	6.1E-01	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Pu-240	1.7E-02	7.2E+01	5.7E-01	6.1E-01	1.5E+03	1.5E+03	1.5E+03	1.5E+03
Pu-241	9.8E-03	4.3E+01	3.1E-01	2.9E-01	1.6E+04	1.6E+04	1.6E+04	1.6E+04
Pu-242	1.6E-03	4.1E+00	3.8E-01	5.0E-01	4.5E+00	4.5E+00	4.5E+00	4.5E+00
Pu-244	1.0E-05	1.6E-02	1.8E-03	2.3E-03	2.1E-02	2.1E-02	2.1E-02	2.1E-02
Am-241	1.8E-03	1.9E+01	3.2E-02	4.5E-02	1.4E+04	1.4E+04	1.4E+04	1.4E+04
Am-242m	6.3E-05	1.7E-02	6.9E-03	6.2E-03	9.1E+00	9.1E+00	9.1E+00	9.1E+00
Am-243	1.4E-03	5.0E-01	4.9E-03	4.6E-03	6.9E-02	6.9E-02	6.9E-02	6.9E-02
Cm-243	3.2E-04	2.0E-03	2.4E-04	2.4E-04	2.6E-02	2.6E-02	2.6E-02	2.6E-02
Cm-244	1.7E-03	1.8E+01	2.0E-02	3.7E-02	9.4E+01	9.4E+01	9.4E+01	9.4E+01
Cm-245	2.8E-04	1.1E-03	1.9E-04	2.0E-04	5.6E-01	5.6E-01	5.6E-01	5.6E-01

Table 3.0-1 - Inventory Estimates for Use in Transport Modeling (continued)

	SDU 6	SDU 7	SDU 8	SDU 9	SDU 10	SDU 11	SDU 12
Radionuclide	Ci	Ci	Ci	Ci	Ci	Ci	Ci
H-3	8.2E+02	8.2E+02	8.2E+02	8.2E+02	8.2E+02	8.2E+02	8.2E+02
C-14	5.8E+02	5.8E+02	5.8E+02	5.8E+02	5.8E+02	5.8E+02	5.8E+02
Al-26	2.4E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01	2.4E+01
Cl-36	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01
K-40	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01
Co-60	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00	7.1E+00
Ni-59	2.6E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00	2.6E+00
Ni-63	1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.8E+02	1.8E+02
Se-79	8.9E+01	8.9E+01	8.9E+01	8.9E+01	8.9E+01	8.9E+01	8.9E+01
Sr-90	3.6E+06	3.6E+06	3.6E+06	3.6E+06	3.6E+06	3.6E+06	3.6E+06
Zr-93	9.5E+01	9.5E+01	9.5E+01	9.5E+01	9.5E+01	9.5E+01	9.5E+01
Nb-94	5.4E-04	5.4E-04	5.4E-04	5.4E-04	5.4E-04	5.4E-04	5.4E-04
Tc-99	3.7E+03	3.7E+03	3.7E+03	3.7E+03	3.7E+03	3.7E+03	3.7E+03
Pd-107	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01	9.5E-01
Sn-126	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02	3.9E+02
I-129	1.6E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00	1.6E+00
Cs-135	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01
Cs-137	2.3E+05	2.3E+05	2.3E+05	2.3E+05	2.3E+05	2.3E+05	2.3E+05
Sm-151	3.7E+03	3.7E+03	3.7E+03	3.7E+03	3.7E+03	3.7E+03	3.7E+03
Eu-152	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00	7.8E+00
Eu-154	9.6E+01	9.6E+01	9.6E+01	9.6E+01	9.6E+01	9.6E+01	9.6E+01
Pt-193	7.3E+01	7.3E+01	7.3E+01	7.3E+01	7.3E+01	7.3E+01	7.3E+01
Ra-226	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01
Ra-228	2.3E-02	2.3E-02	2.3E-02	2.3E-02	2.3E-02	2.3E-02	2.3E-02
Ac-227	8.4E-02	8.4E-02	8.4E-02	8.4E-02	8.4E-02	8.4E-02	8.4E-02
Th-229	1.7E+01	1.7E+01	1.7E+01	1.7E+01	1.7E+01	1.7E+01	1.7E+01
Th-230	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01	1.3E+01
Th-232	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01
Pa-231	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01
U-232	6.8E-02	6.8E-02	6.8E-02	6.8E-02	6.8E-02	6.8E-02	6.8E-02
U-233	1.6E+01	1.6E+01	1.6E+01	1.6E+01	1.6E+01	1.6E+01	1.6E+01
U-234	9.3E+00	9.3E+00	9.3E+00	9.3E+00	9.3E+00	9.3E+00	9.3E+00
U-235	3.8E-01	3.8E-01	3.8E-01	3.8E-01	3.8E-01	3.8E-01	3.8E-01
U-236	4.3E-01	4.3E-01	4.3E-01	4.3E-01	4.3E-01	4.3E-01	4.3E-01
U-238	1.6E+01	1.6E+01	1.6E+01	1.6E+01	1.6E+01	1.6E+01	1.6E+01
Np-237	2.7E+01	2.7E+01	2.7E+01	2.7E+01	2.7E+01	2.7E+01	2.7E+01
Pu-238	1.9E+04	1.9E+04	1.9E+04	1.9E+04	1.9E+04	1.9E+04	1.9E+04
Pu-239	9.6E+03	9.6E+03	9.6E+03	9.6E+03	9.6E+03	9.6E+03	9.6E+03
Pu-240	1.9E+03	1.9E+03	1.9E+03	1.9E+03	1.9E+03	1.9E+03	1.9E+03
Pu-241	1.6E+04	1.6E+04	1.6E+04	1.6E+04	1.6E+04	1.6E+04	1.6E+04
Pu-242	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00
Pu-244	2.1E-02	2.1E-02	2.1E-02	2.1E-02	2.1E-02	2.1E-02	2.1E-02
Am-241	1.4E+04	1.4E+04	1.4E+04	1.4E+04	1.4E+04	1.4E+04	1.4E+04
Am-242m	9.1E+00	9.1E+00	9.1E+00	9.1E+00	9.1E+00	9.1E+00	9.1E+00
Am-243	6.9E-02	6.9E-02	6.9E-02	6.9E-02	6.9E-02	6.9E-02	6.9E-02
Cm-243	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02	2.6E-02
Cm-244	9.4E+01	9.4E+01	9.4E+01	9.4E+01	9.4E+01	9.4E+01	9.4E+01
Cm-245	5.6E-01	5.6E-01	5.6E-01	5.6E-01	5.6E-01	5.6E-01	5.6E-01

4.0 ASSUMPTIONS

The tank farm soluble and insoluble inventories were based on *9/30/2013 – September 2013 Curie and Volume Inventory Report*. [SRR-LWP-2013-00066]

Concentrations for Cl-36, K-40, Zr-93, Pd-107, and Pt-193 are not estimated in the recent monthly inventory report. [SRR-LWP-2013-00066] Concentrations were conservatively estimated for these radionuclides and are listed in Table 4.0-1. These values were conservatively chosen based on recent Tank 50 analyses. [SRR-CWDA-2013-00140]

Table 4.0-1 Assumed Concentrations for Various Radionuclides

	Assumed Concentrations (pCi/ml)
Cl-36	1E+01
K-40	1E+01
Zr-93	1E+03
Pd-107	1E+01
Pt-193	1E+03

Radionuclides with tank farm inventories estimated to be less than 1E-10 Ci were not included. Inventories less than this level will have a minimal dose impact. Radionuclides with estimated inventories less than 1E-10 Ci were Cf-249, Cf-251, Cm-247, Cm-248.

A decay date of 10/1/2032 was used. [SRR-LWP-2009-00001] Only decay was considered (i.e., no ingrowth). Since the modeling evaluates long term time periods (thousands of years), the short term impact of no in-growth from approximately 20 year decay is minimal.

The ratio of grout volume to salt solution volume was assumed to be 1.76. [SRR-LWP-2009-00001]

A DF of 200 was applied to Cs-135 and Cs-137 inventory estimates to account for ARP/MCU and SWPF processing. [SRR-LWP-2009-00001]

5.0 LIMITATIONS

These estimates should only be used for dose modeling. These estimates were developed using a approach that is only appropriate for considering dose impacts and transport of the various radionuclides. For the non-risk significant radionuclides, the estimates were developed with significant conservatisms.

6.0 RECOMMENDATION

The inventories listed in Table 3.0-1 were developed for use in transport modeling.

7.0 REFERENCES

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