THE CONTENTS OF THIS SECTION ARE
THE HIGHEST QUALITY AVAILABLE

INITIAL MD DATE 10/08/2001

4. WASTE RADIOLOGICAL CHARACTERIZATION

This section provides information on the radiological contaminants present in the wastes. Radionuclide inventories are provided for all radionuclides believed present. Source term information for alpha, beta, photon, and neutron emissions in the wastes are also presented. Considerable information describing the derivation of these source terms has been provided as background in order to help provide some implicit perspective on the uncertainties present.

The radiological description of the alpha-contaminated waste stored at the INEL presented herein has been prepared utilizing existing waste management database information records, analytical studies, and process knowledge review. The INEL databases include the Transuranic Waste Database (TWDB), which gives radiological information for the two estimated primary radionuclides at the container level, and the Radioactive Waste Management Information System (RWMIS), which gives radiological information at the shipment level. In addition, files containing actual SWEPP raw neutron assay instrument data were analyzed for additional information.

Table 4-1 presents a radionuclide summary for the INEL alpha-contaminated waste stored at the TSA. This table presents best estimates of radionuclide inventory as derived from the above information sources.

The waste stored at the TSA includes primarily alpha-emitting radionuclides; however, some beta gamma emitting radionuclides are included. Most all waste is contact-handleable, although some small quantities of waste are known to be remote-handled (using the definition of greater than two hundred millirems per hour at contact (>200 mrem/hr). Also some waste containers labeled and carried on inventory records as contact-handled are suspected to be remote handled. Table 4-2 summarizes the known remote handled waste. Tables 4-3 and 4-4 summarize suspect remote handled waste contained in the ALLW and TRUW categories.

4.1 Radiological Information Derived Primarily from Rocky Flats Plant Waste via the INEL Transuranic Waste Database Analysis

The design of a treatment facility for the processing of transuranic-contaminated waste forms must include provisions to assure environmental protection against radiological hazards to personnel. Such design considerations are dependent upon the proper characterization of the photon, electron, alpha, and neutron source terms associated with the transuranic (TRU) and/or non-transuranic (non-TRU) source material entrained within the waste matrices. The Transuranic Waste Database (TWDB) contains records at the container level; however, it does not contain information on the total inventory in storage and only reports radionuclide information for the two primary nuclides. The TWDB database information was analyzed[a] for select radionuclides at 15 years post purification[b] to produce a data set for nuclide mass, and TRU and non-TRU alpha activity information. This data set correlated to approximately two thirds of the total estimated

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a. J. Frasure, and M. L. Apel, *Radionuclide and Alpha Activity Concentration Data for the INEL Stored Waste Reported in the Transuranic Waste Database (TWDB)*, RWMC EDF-716, March 4, 1994.

b. G. K. Becker, *(RWMC EDF 629—Rev. 1), Alpha Activity Distribution Due to Selected TRU and non-TRU Source Materials at 15 Years Post Purification Date*, RWMC EDF-690, December 2, 1993.

Table 4-1. Radionuclide summary for INEL TSA stored waste.

			Estimated Activity By Information Source								
Radionuclide / Mixture	TRU (Y/N)	Radiation Type, Decay (Primary, Secondary)	Half-Life	RWMIS Derived (At Disposal) (Ci)a	RWMIS Derived (Decayed to '93) (Ci)a	TWDB Derived (15 year decay) (alpha Ci)b	Activity Best Estimate (Ci)c,d	Specific Activity (Ci/g)	Notes	Estimated Mass (kg)e	Activity best estimate information source
227Ac	N	beta, gamma	21.77 yr	7.2900e-02	4.0790e-02	-	4.08e-02	7.20E+01		5.67E-07	Note a. RWMIS analysis
241Am	Y	alpha, gamma	432.7 yr	8.7910e+04	8.9780e+04	1.21e+05	1.22e+05	3.20E+00		3.81E+01	Note b. TWDB AM-241+WG PU Am241
242mAm	Y	beta, gamma	141 yr	3.0740e-04	3.0010e-04	-	3.00e-04	9.83E+00		3.05E-08	Note a. RWMIS analysis
243Am	Y	alpha, gamma	7.37E3 yr	3.8020e-01	3.7990e-01	5.99e-03	3.80e-01	1.90E-01		2.00E-03	Note a. RWMIS analysis
137mBa	N	gamma	2.552 m	9.7330e+01	2.2460e+03	-	2.25e+03	0.00E+00	Note i	0.00E+00	Note a. RWMIS analysis
212Bi	N	beta	7.0 m	0.0000e+00	2.6550e+01	-	2.66e+01	1.50E+07		1.77E-09	Note a. RWMIS analysis
214Bi	N	beta, gamma	19.9 m	4.8000e-02	0.0000e+00	-	0.00e+00	0	Note i	0.00E+00	Note a. RWMIS analysis
249Bk	N	beta, alpha	3.2E2 d	2.1400e-01	5.7090e-04	-	5.71e-04	1.80E+03		3.17E-10	Note a. RWMIS analysis
14C	N	beta	5730 yr	4.2300e-05	4.2250e-05	-	2.38e+00	4.60E+00		5.17E-04	EDF PSPI-015546-08, 10/12/95
144Ce	N	beta, gamma	284.6 d	3.8990e+03	2.7060e+01	-	2.71e+01	3.20E+03		8.46E-06	Note a. RWMIS analysis
249Cf	Y	alpha, gamma	351 yr	9.8900e-03	9.7290e-03	-	9.73e-03	3.10E+00		3.14E-06	Note a. RWMIS analysis
252Cf	N	alpha, neutron, gamma	2.638 yr	6.4860e-02	4.0770e-03	4.62e-04	4.08e-03	6.50E+02		6.28E-09	Note a. RWMIS analysis
242Cm	N	alpha, gamma	162.8 d	3.3210e+00	1.4360e-06	-	1.44e-06	3.30E+03		4.35E-13	Note a. RWMIS analysis
243Cm	Y	alpha, gamma	29.1 yr	1.7210e-02	1.5310e-02	-	1.53e-02	4.20E+01		3.65E-07	Note a. RWMIS analysis
244Cm	N	alpha, gamma	18.1 yr	1.1320e+03	5.3900e+02	-	5.39e+02	8.20E+01		6.57E-03	Note a. RWMIS analysis
246Cm	Y	alpha, gamma	4.76E3 yr	1.5330e-03	1.5300e-03	-	1.53e-03	3.60E-01		4.25E-06	Note a. RWMIS analysis
248Cm	Y	alpha	3.48E5 yr	4.1700e-08	4.1700e-08	-	4.17e-08	4.30E-03		9.70E-09	Note a. RWMIS analysis
58Co	N	gamma	9.1 hr/70.88 d	1.1330e+02	1.1010e-07	-	1.10e-07	3.10E+04		3.55E-15	Note a. RWMIS analysis
60Co	N	beta, gamma	10.47m/5.27yr	2.3260e+02	9.4300e+01	-	1.00e+02	1.10E+03		9.09E-05	Note a. RWMIS analysis Co-60+MAP+EDF PSPI-015546-08, 10/12/95
51Cr	N	gamma	27.7 d	8.4600e+00	0.0000e+00	-	0.00e+00	9.20E+04		0.00E+00	Note a. RWMIS analysis
134Cs	N	beta, gamma	2.91 hr/2.065 yr	9.2960e+02	1.1070e+02	-	1.11e+02	1.20E+03		9.23E-05	Note a. RWMIS analysis
137Cs	N	beta, gamma	30.17 yr	2.3660e+03	2.0030e+03	-	2.26e+03	9.80E+01		2.30E-02	Note a. RWMIS analysis Cs137+(0.5xMFP)+Unidentified b/g
150Eu	N	beta, gamma	12.8 hr/36 yr	4.5000e-05	0.0000e+00	-	0.00e+00	0	Note i	0.00E+00	Note a. RWMIS analysis
152Eu	N	gamma, beta	1.6 hr/13.48 yr	1.7120e-01	6.7560e-02	-	6.76e-02	1.90E+02		3.56E-07	Note a. RWMIS analysis
154Eu	N	gamma	46.1 m/8.59 yr	1.5550e+00	7.1040e-01	-	7.10e-01	1.50E+02		4.74E-06	Note a. RWMIS analysis
155Eu	N	beta, gamma	4.71 yr	7.7750e-01	1.8630e-01	-	1.86e-01	1.40E+03		1.33E-07	Note a. RWMIS analysis
55Fe	N	electron capture	2.73 yr	3.8590e+00	1.1320e+00	-	1.13e+00	2.20E+03		5.15E-07	Note a. RWMIS analysis
59Fe	N	beta, gamma	44.51 d	5.3400e+00	0.0000e+00	-	0.00e+00	4.90E+04		0.00E+00	Note a. RWMIS analysis
3H	N	beta	12.3 yr	1.9500e+00	7.9780e-01	-	2.64e+02	9.76E+03		2.70E-05	Note a. RWMIS analysis + EDF PSPI-015546-08, 10/12/95
129I	N	beta, gamma	1.57E7 yr	-	0.0000e+00	-	1.83e-04	1.60E-04		1.14E-03	EDF PSPI-015546-08, 10/12/95
85Kr	N	beta, gamma	4.448 hr/ 10.73 yr	9.3620e+00	6.8570e+00	-	6.86e+00	4.00E+02		1.71E-05	Note a. RWMIS analysis
MAP	N	(beta, gamma)	10.47 m/ 5.27 yr	5.7550e+00	1.2800e+00	-	0.00e+00	0	Note f, i	0.00E+00	
MFP	N	(beta, gamma)	30 yr	6.2980e+02	4.8330e+02	-	0.00e+00	0	Note g, i	0.00E+00	
54Mn	N	gamma	312.2 d	1.1550e+02	2.2870e-01	-	2.29e-01	8.30E+03		2.76E-08	Note a. RWMIS analysis
95Nb	N	beta, gamma	3.61 d/34.97 d	7.2000e-01	0.0000e+00	-	0.00e+00	3.90E+04		0.00E+00	Note a. RWMIS analysis
59Ni	N	electron capture	7.6E4 yr	-	0.0000e+00	-	0.00e+00	8.10E-02	Note d	0.00E+00	
63Ni	N	beta	100 yr 7.6E4 yr	3.6940e+00	3.5720e+00	-	3.57e+00	4.60E+01		7.77E-05	Note a. RWMIS analysis
237Np	Y	alpha, gamma	2.1E6 yr	3.5520e-01	3.5520e-01	1.94e-01	3.55e-01	6.90E-04		5.15E-01	Note a. RWMIS analysis
233Pa	N	beta, gamma	27 d	1.9730e-03	0.0000e+00	-	0.00e+00	2.10E+04		0.00E+00	Note a. RWMIS analysis
234Pa	N	beta, gamma	1.17m/6.69hr	-	0.0000e+00	-	0.00e+00	0	Note d, i	0.00E+00	
210Pb	N	beta, gamma	22.3 yr	2.1000e-02	1.7560e-02	-	1.76e-02	8.80E+01		2.00E-07	Note a. RWMIS analysis
212Pb	N	beta, gamma	10.64 hr	0.0000e+00	2.6550e+01	-	2.66e+01	1.40E+06		1.90E-08	Note a. RWMIS analysis
214Pb	N	beta, gamma	27 m	4.8000e-02	0.0000e+00	-	0.00e+00	0	Note i	0.00E+00	Note a. RWMIS analysis
147Pm	N	beta, gamma	2.6234 yr	5.4810e+02	2.7260e+01	-	2.73e+01	9.40E+02		2.90E-05	Note a. RWMIS analysis
212Po	N	alpha, gamma	45 s	0.0000e+00	1.7010e+01	-	1.70e+01	0	Note i	0.00E+00	Note a. RWMIS analysis
214Po	N	alpha, gamma	163.7 s	4.8000e-02	0.0000e+00	-	0.00e+00	0	Note i	0.00E+00	Note a. RWMIS analysis
216Po	N	alpha, gamma	0.145 s	0.0000e+00	2.6550e+01	-	2.66e+01	0	Note i	0.00E+00	Note a. RWMIS analysis
218Po	N	alpha, gamma	3.10 m	4.8000e-02	0.0000e+00	-	0.00e+00	0	Note i	0.00E+00	Note a. RWMIS analysis
144Pr	N	beta, gamma	7.2 m/17.28 m	1.5640e+01	2.7180e+01	-	2.72e+01	0	Note i	0.00E+00	Note a. RWMIS analysis
236Pu	N	alpha, gamma	2.87 yr	5.7640e-02	1.4790e-02	-	1.48e-02	5.37E+02		2.75E-08	Note a. RWMIS analysis

Table 4-1. (continued).

Estimated Activity By Information Source

Radionuclide / Mixture	TRU (Y/N)	Radiation Type, Decay (Primary, Secondary)	Half-Life	RWMIS Derived (At Disposal) (Ci)a	RWMIS Derived (Decayed to '93) (Ci)a	TWDB Derived (15 year decay) (alpha Ci)b	Activity Best Estimate (Ci)c,d	Specific Activity (Ci/g)	Notes	Estimated Mass (kg)e	Activity best estimate information source
238Pu	Y	alpha, gamma	87.7 yr	6.7590e+04	6.0800e+04	1.12e+05	1.16e+05	1.70E+01		6.80E+00	Note b. TWDB analysis Pu 238 + WGPu+HSPu
239Pu	Y	alpha, gamma	2.41E4 yr	4.0160e+04	4.0150e+04	3.86e+03	6.87e+04	6.20E-02		1.11E+03	Note b. TWDB analysis Pu 239 + WGPu+HSPu
240Pu	Y	alpha, gamma	6.56E3 yr	9.8370e+03	9.8250e+03	1.18e+03	1.59e+04	2.30E-01		6.90E+01	Note b. TWDB analysis Pu 240 + WGPu+HSPu
241Pu	N	beta, alpha, gamma	14.4 yr	2.8160e+05	1.6110e+05	4.19e+00	1.61e+05	1.04E+02		1.55E+00	Note a. RWMIS analysis, beta emitter
242Pu	Y	alpha, gamma	3.75E5 yr	9.4510e-01	9.4510e-01	1.45e-01	1.04e+00	3.90E-03		2.67E-01	Note b. TWDB analysis Pu 242 + WGPu+HSPu
224Ra	N	alpha, gamma	3.66 d	0.0000e+00	2.6550e+01	-	2.66e+01	1.60E+05		1.66E-07	Note a. RWMIS analysis
226Ra	N	alpha, gamma	1.6E3 yr	4.8020e-02	4.7900e-02	1.09e-01	1.09e-01	1.00E+00		1.09E-04	Note b. TWDB analysis
228Ra	N	beta, gamma	5.76 yr	2.7500e-01	3.0620e-02	-	3.06e-02	2.30E+02		1.33E-07	Note a. RWMIS analysis
106Rh	N	beta, gamma	2.18h/ 29.9s	1.3000e+00	0.0000e+00	-	0.00e+00	0	Note i	0.00E+00	Note a. RWMIS analysis
220Rn	N	alpha, gamma	55.6 s	0.0000e+00	2.6550e+01	-	2.66e+01	0	Note i	0.00E+00	Note a. RWMIS analysis
222Rn	N	alpha, gamma	3.8235 d	4.8000e-02	0.0000e+00	-	0.00e+00	1.50E+05		0.00E+00	Note a. RWMIS analysis
106Ru	N	beta	1.020 yr	1.0620e+02	1.8650e-01	-	1.87e-01	3.40E+03		5.49E-08	Note a. RWMIS analysis
125Sb	N	beta, gamma	2.758 yr	6.0870e+00	1.6470e+00	-	1.65e+00	1.40E+03		1.18E-06	Note a. RWMIS analysis
90Sr	N	beta	29.1 yr	2.1160e+03	1.7780e+03	-	2.02e+03	1.50E+02		1.35E-02	Note a. RWMIS analysis + (0.5xMFP)
182Ta	N	gamma	15.8 m/114.43 d	7.3500e-01	1.5480e-05	-	1.55e-05	6.20E+03		2.50E-12	Note a. RWMIS analysis
99Tc	N	gamma, beta	6.01 hr/2.13E5 yr	1.7600e-03	1.7600e-03	-	5.37e-01	1.70E-02		3.16E-02	Note a. RWMIS analysis + EDF PSPI-015546-08, 10/12/95
228Th	N	alpha, gamma	1.913 yr	0.0000e+00	2.6550e+01	-	2.66e+01	8.30E+02		3.20E-05	Note a. RWMIS analysis
229Th	N	alpha, gamma	7.3E3 yr	-	0.0000e+00	-	0.00e+00	0	Note d, i	0.00E+00	
230Th	N	alpha, gamma	7.54E4 yr	1.9980e-02	1.9980e-02	-	2.00e-02	1.90E-02		1.05E-03	Note a. RWMIS analysis
232Th	N	alpha, gamma	1.4E10 yr	3.3010e-01	3.3010e-01	7.31e+00	7.31e+00	1.10E-07		6.65E+04	Note b. TWDB analysis
234Th	N	beta, gamma	24.10 d	9.2800e-05	0.0000e+00	-	0.00e+00	2.30E+04		0.00E+00	Note a. RWMIS analysis
208Tl	N	beta, gamma	3.053 m	0.0000e+00	9.5400e+00	-	9.54e+00	0	Note i	0.00E+00	Note a. RWMIS analysis
228U	N	alpha, gamma	9.1 m	1.0700e-04	0.0000e+00	-	0.00e+00	0	Note i	0.00E+00	Note a. RWMIS analysis
232U	N	alpha, gamma	70 yr	3.0020e+01	2.6040e+01	-	2.60e+01	2.10E+01		1.24E-03	Note a. RWMIS analysis
233U	N	alpha, gamma	1.592E5 yr	8.9860e+02	8.9850e+02	1.02e+03	1.02e+03	9.50E-03		1.07E+02	Note b. TWDB analysis
234U	N	alpha, gamma	2.46E5 yr	3.3590e+00	5.7780e+00	-	5.78e+00	6.20E-03		9.32E-01	Note a. RWMIS analysis
235U	N	alpha, gamma	7.04E8 yr	6.6690e-02	6.6690e-02	8.61e-02	8.61e-02	2.10E-06		4.10E+01	Note b. TWDB analysis
236U	N	alpha, gamma	2.342E7 yr	1.1990e-03	1.1990e-03	-	1.20e-03	6.30E-05		1.90E-02	Note a. RWMIS analysis
238U	N	alpha, gamma	4.47E9 yr	1.1710e-01	1.1710e-01	1.47e-01	1.47e-01	3.30E-07		4.45E+02	Note b. TWDB analysis
Unidentified b/g	N	(beta, gamma)	30.17 yr	1.4890e+01	1.2440e+01	-	0.00e+00	0.00E+00	Note h	0.00E+00	
90Y	N	gamma, beta	3.19 hr/2.67 d	1.0180e+02	2.0190e+03	-	2.02e+03	2.50E+05		8.08E-06	Note a. RWMIS analysis
65Zn	N	gamma, beta	243.8 d	1.1000e-03	1.8680e-08	-	1.87e-08	8.00E+03		2.34E-15	Note a. RWMIS analysis
95Zr	N	beta, gamma	64.02 d	6.7230e+01	2.3400e-09	-	2.34e-09	2.10E+04		1.11E-16	Note a. RWMIS analysis
					3.7216e+05		4.942e+05			6.827E+04	
WG Pu Mixture	Y	alpha, gamma		-	-	8.89e+04	-				Note b. TWDB analysis
[238Pu]		alpha, gamma	87.7 yr	-	-	[2.0287e+03]	-		Note j		
[239Pu]		alpha, gamma	2.41E4 yr	-	-	[6.4839e+04[	-		Note j		
[240Pu]		alpha, gamma	6.563E3 yr	-	-	[1.4700e+04]	-		Note j		
[241Pu]		beta, alpha, gamma	14.4 yr	-	-	[6.5866e+03]	-		Note j		
[242Pu]		alpha, gamma	3.75E5 yr	-	-	[8.8900e-01]	-		Note j		
[241Am Impurity plus grow in]		alpha, gamma		-	-	[7.4676e+02]	-		Note j		
HS Pu Mixture	Y	alpha, gamma		-	-	1.65e+03	-				Note b. TWDB analysis
[236Pu]		alpha, gamma	2.87 yr	-	-	[1.2600e-02]	-		Note j		
[238Pu]		alpha, gamma	87.7 yr	-	-	[1.6474e+03]	-		Note j		
[239Pu]		alpha, gamma	2.41E4 yr	-	-	[1.1265e+00]	-		Note j		
[240Pu]		alpha, gamma	6.563E3 yr	-	-	[5.8806e-01]	-		Note j		

Table 4-1. (continued).

Radionuclide / Mixture	TRU (Y/N)	Radiation Type, Decay (Primary, Secondary)	Half-Life	Estimated Activity By Information Source: RWMIS Derived (At Disposal) (Ci)a	RWMIS Derived (Decayed to '93) (Ci)a	TWDB Derived (15 year decay) (alpha Ci)b	Activity Best Estimate (Ci)c,d	Specific Activity (Ci/g)	Notes	Estimated Mass (kg)e	Activity best estimate information source
[241Pu]		beta, alpha, gamma	14.4 yr	-	-	[2.7679e-07]	-		Note j		
[242Pu]		alpha, gamma	3.75E5 yr	-	-	[5.0940e-04]	-		Note j		
			Subtotals	5.01e+05 Ci	3.72e+05 Ci	3.30e+05 Ci	4.94e+05 Ci			6.83E+04 kg	

NOTES:

a. Estimated summary information for TSA stored alpha contaminated (CH ALLW + TRUW) waste from analysis of the Radioactive Waste Management Database (RWMIS) information which reports radionuclide information via shipments received, nuclides decayed to the 2 curie daughter level,, includes estimated 8400 curies for 75 m3 remote handled waste in the TSA-ILTSF. Atwood C. L.,M.J. Schlafman, Emperical Distributions of Radionuclides from RWMIS Data, EGG-RAAM-10741, April 1993.

b. B. D. Raivo, TSA (aLLW and TRUW) Waste Radiological Rollup Tables, EDF PSPI-015546-05 rev0, March 21, 1995, plus supporting TWDB analysis EDFs.

c. Best estimate from review and analysis of all non-classified information sources including databases, reports, letters, and other sources. EDF PSPI-015546-12, November 30, 1995.

d. Decay daughter radionuclide activity generally included in parent activity, identification of individual nuclides may be included in list for completeness.

e. Best estimate of nuclide mass derived from best estimate of activity.

f. Mixed Activated Products (MAP) treated as 60Co.

g. Mixed Fission Products (MFP) treated as a mixture of half Cs-137 and half Sr-90.

h. Unidentified beta/gamma emitters treated as Cs-137.

i. The Specific Activity was not available for this Radionuclide.

j. G K. Becker, B. D. Raivo, TSA Waste Alpha Activity Derivation at 15 Year Post Purification, EDF PSPI 015546-10, November 16, 1995.

Table 4-2. Known remote handled waste in the ILTSF.[a]

Category	Volume (m^3)	Activity[a] (Ci)
TRU	—	100
Non-TRU	—	8388
Total	75	8489

a. 1994 National Integrated Database Report (IDB) and as derived from RWMIS analysis, EGG-RAAM-10741, April 1993.

Table 4-3. TSA alpha low-level waste suspect as having some portion being remote handled.[a]

Wastestream ID	Portion suspect as remote handled (m^3)
Alpha Low-Level Waste in TSA	
ID-AEO-104	44.7
ID-ANL-161	0.4
ID-BTO-030	0.4
ID-INL-150	0.3
ID-INL-153N	5.9
ID-RFO-000	1.4
ID-RFO-001	1.1
ID-RFO-002	6.8
ID-RFO-241	21.8
ID-RFO-320	2.9
ID-RFO-330	89.8
ID-RFO-335	0.8
ID-RFO-336	138.3
ID-RFO-337	3.4
ID-RFO-339	0.5
ID-RFO-432	0.4
ID-RFO-440	1.9
ID-RFO-441	1.6
ID-RFO-442	1.4
ID-RFO-463	0.1
ID-RFO-480	32.8
ID-RFO-481	2.0
ID-RFO-9999	150.4
ID-TRA-154N	0.2
Subtotal	509.4

a. As derived from INEL FFCA reporting efforts for waste treatment, EDF PSPI-015546-15, 12/15/95.

Table 4-4. TSA transuranic waste suspect as having some portion being remote handled.[a]

Wastestream ID	Portion suspect as remote handled (m^3)
Transuranic waste in TSA	
CH-ANL-180T[b]	13.6
CH-ANL-182T[b]	0.3
CH-ANL-503T[b]	0.9
CH-ANL-538[b,c]	6.2
ID-AEO-104T	58.8
ID-AEO-107T	6.4
ID-ANL-160T	0.2
ID-BTO-012TN	0.2
ID-BTO-015TN	0.6
ID-BTO-030T	9.5
ID-BTO-040T	15.6
ID-BTO-081TN	3.6
ID-CPP-151T	0.4
ID-CPP-172	27.9
ID-INL-142T	12.1
ID-INL-152TN	2.0
ID-INL-153TN	1.9
ID-INL-157T	0.4
ID-RFO-000T	1.7
ID-RFO-001T	40.2
ID-RFO-002T	20.7
ID-RFO-241T	1.0
ID-RFO-320T	7.5
ID-RFO-330T	52.5
ID-RFO-335T	1.3
ID-RFO-336T	56.4
ID-RFO-337T	1.2
ID-RFO-339T	11.8
ID-RFO-391TN	0.4
ID-RFO-392TN	0.1
ID-RFO-432T	2.1
ID-RFO-440T	3.3
ID-RFO-441T	1.4
ID-RFO-442T	1.0
ID-RFO-463T	0.8
ID-RFO-480T	16.8
ID-RFO-481T	5.9
ID-RFO-9999T	204.8
ID-TAN-200T	0.2
ID-TRA-154TN	1.9
ID-TRA-291T	2.1
Subtotal	595.9

a. As derived from INEL FFCA reporting efforts for waste treatment, EDF PSPI-015546-15, 12/15/95.
b. Non-TSA wastestreams stored at Argonne National Laboratory-West.
c. Entire wastestream volume identified for transfer to WIPP per site treatment plans.

mass in storage. Extrapolations and rollup summaries[c] of this data set were performed to provide estimations which correlated to the total estimate mass in storage. Additionally, the data set was summarized for alpha activity concentration distribution[d] to provide an estimate of the distribution within the data set and the inventory in storage. Source term data (per gram of radionuclide) for photons (gamma spectrum) and electrons due to selected TRU and non-TRU radionuclides associated with the stored waste was also compiled[e] as an aid to facility shielding design and personnel protection.

In addition, actual raw instrument data from SWEPP Passive-Active Neutron assay characterization of approximately 12,000 drums[f] were analyzed[g] for neutron source term information.

This source term data is developed and illustrated for retrievably-stored INEL waste containers generated as a byproduct of operations at the Rocky Flats Plant (RFP). Such data are applicable to the majority of the retrievably-stored waste container population since the RFP fraction constitutes approximately 90–95% by volume. The balance of the retrievably-stored waste container population is from generators such as Mound Laboratory, Battelle Columbus Laboratories, and the Bettis Atomic Power Laboratory. Source term data associated with these generators are briefly addressed in this document. Due to the present unavailability of precise process source composition data for the non-RFP wastes, data for these wastes are not as complete as the RFP source characterization data. Nevertheless, the data provided in this report can be used to support initial waste treatment considerations. It should be recognized, however, that the source characteristics associated with the non-RFP wastes need to be satisfactorily established and evaluated prior to processing.

The Rocky Flats Plant alpha, electron, and photon source term data is prepared from established nuclear constants and related databases. To provide for consistency in the derivation of alpha, electron, and photon source terms, the same fundamental assumptions are applied in all cases. These assumptions are as follows:

- Rocky Flats Plant source characteristics are due to the radionuclides and radionuclidic compounds as specified in Table 4-5
- Nominal isotopic composition of the two radionuclidic compounds specified in Table 4-5 is as per Table 4-6
- Source characterization data as specified account for and include the parent material and all progeny excluding radon isotopes at a 15-year post purification date

c. B. D. Raivo, *TSA Contact Handled (aLLW and TRUW) Waste Radiological Rollup Tables*, EDF PSPI-015546-05, March 21, 1995.

d. B. D. Raivo, *TSA Waste Alpha Activity Concentration Distribution*, EDF PSPI-015546-11, November 20, 1995.

e. G. K. Becker, *Low-Level Alpha Contaminated and Transuranic Waste Photon/Electron Source Term Data*, RWMC EDF-669, January 10, 1994.

f. L. V. East, *SWEPP Passive-Active Neutron Assay Database Description*, RWMC EDF-688, December 13, 1993.

g. L. V. East, *Neutron Source Terms for Rocky Flats-Generated Waste at the INEL*, RWMC EDF-694, January 7, 1994.

Table 4-5. Radionuclides and plutonium mixtures for which data are reported.[a,b]

^{252}Cf	^{239}Pu	^{238}U
^{243}Am	^{238}Pu	^{235}U
^{241}Am	^{236}Pu	^{233}U
^{242}Pu	^{237}Np	^{232}Th
^{241}Pu	WG Pu	^{230}Th
^{240}Pu	HS Pu	^{226}Ra

a. Transuranic Waste Database (TWDB), Idaho National Engineering Laboratory, Idaho Falls, ID, February 1994.

b. EDF RWMC-716, 3/4/94.

Table 4-6. Nominal isotopic composition of plutonium compounds.[a]

Isotopic composition of weapons-grade plutonium: WG Pu		Isotopic composition of heat-source plutonium: HS Pu	
Radionuclide	Mass fraction	Radionuclide	Mass fraction
^{238}Pu	1.2E-04	^{236}Pu	1.0E-06
^{239}Pu	9.38E-01	^{238}Pu	8.35E-01
^{240}Pu	5.82E-02	^{239}Pu	1.4E-01
^{241}Pu	3.4E-03	^{240}Pu	2.0E-02
^{242}Pu	2.4E-04	^{241}Pu	4.0E-03
^{241}Am impurity	200 µg/g WG Pu	^{242}Pu	1.0E-03

a. EDF RWMC-690, 12/2/93.

- 15 year decay/ingrowth time is a representative average waste age for the retrievably-stored waste at the RWMC
- Source self-absorption effects associated with the photon, electron, and alpha data are not accounted for; the specified source term data is simply the theoretical yield.

The RFP neutron source characterization data cannot be calculated directly from the use of nuclear data and a specified set of parent radionuclides or compounds. This is primarily due to the variation in neutron emission rate as a function of the chemical compound and configuration of the alpha-emitting radionuclides. In spite of this complication, it is possible to estimate bounds on the neutron emission rate source term based on measurements acquired at the SWEPP waste examination facility as a function of waste form, i.e., content code.

The source term data for alpha, electron, photon, and neutron radiations associated with the radionuclides and radionuclidic compounds of Table 4-5 are presented in the following four sections. Each section delineates the method of computation, the assumptions employed, and illustrates results as appropriate.

4.1.1 Alpha Data

The alpha source term is specifically defined as the alpha activity due to one gram of parent source material at 15 years post purification date. The computed 15-year decay date alpha activity includes the contribution from the parent radionuclide or compound and the activity associated with all alpha-emitting progeny, i.e., daughter, granddaughter, great granddaughter, etc., in the decay chain. For each parent radionuclide or compound, the alpha activity is categorized into two components defined as TRU and non-TRU. The TRU component consists of alpha-emitting radionuclides with an atomic number greater than 92 and a half-life greater than 20 years. The non-TRU components are those alpha-emitting radionuclide species with atomic numbers of 92 or less and/or half-lives of less than 20 years. The distinction between TRU and non-TRU in the context of Tables 4-7 and 4-8 is not to be confused with the concentration-based definition as per DOE Order 5820.2A.[4-1] The information provided in this section is based on work by Becker (1993),[h] Becker and Raivo (1995),[i] and Raivo (1995).[j]

The process of determining the TRU and non-TRU alpha activity distribution starts by establishing all of the members of the radioactive series decay chain for a given parent source material. Once the various radioactive species constituting a given decay chain have been established, the parent material is assigned an initial (time equals 0) mass of 1.0 gram. The decay computation is then performed which results in a mass value for the various members of the decay chain at 15 years from time zero. Decay half-lives and appropriate branching ratios utilized in the computation for each member of the series decay chain are obtained from Browne and Firestone.[4-2] The decay/ingrowth computational method employed in the analysis is based on a parameterized form of the Bateman equations.

Since the 15 year decay/ingrowth time is relatively short compared to the half-lives of most of the parents and decay chain members addressed in this evaluation, some species will have a minimal ingrowth mass at 15 years. No criteria is set for a minimum calculated mass under which a given chain member is neglected. This is because a radionuclide may have a large specific activity such that its contribution to the 15 year alpha activity is significant despite its seemingly small mass. Thus for the sake of completeness and data integrity, the decay chain is followed all the way to the stable element chain endpoints, typically 8 to 10 generations, to ensure that all alpha activity is accounted for.

Having established the individual masses of the various members of the decay chain at 15 years, it is a simple matter to obtain the alpha activity for the TRU and non-TRU chain members. The alpha activity for each chain member is determined by multiplying the calculated mass in grams by the specific activity (Ci/g) for that particular member to obtain alpha activity (Ci). The alpha-emitting progeny for the decay chain are then grouped into either TRU or non-TRU categories. The total alpha activity per gram of parent source material is then determined by summing all computed decay chain member alpha activities within the category of interest.

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h. G. K. Becker, *(RWMC EDF 629—Rev. 1), Alpha Activity Distribution Due to Selected TRU and non-TRU Source Materials at 15 Years Post Purification Date*, RWMC EDF-690, December 2, 1993.

i. G. K. Becker, B. D. Raivo, *TSA Waste Alpha Activity Derivation at 15 Year Post Purification*, EDF PSPI-015546-10, November 16, 1995.

j. B. D. Raivo, *TSA Waste Alpha Activity Concentration Distribution*, EDF PSPI-015546-11, November 20, 1995.

Table 4-7. Alpha activity due to one gram of TRU parent source material at 15 years post purification.[a]

TRU source material	TRU[b] α activity (Ci)	Non-TRU[c] α activity (Ci)
^{252}Cf	3.694E-03	1.0274E+01
^{243}Am	1.991E-01	5.828E-13
^{241}Am	3.3466	6.00E-10
^{242}Pu	3.926E-03	9.286E-12
^{241}Pu	1.7392	1.2058E-03
^{240}Pu	2.266E-01	1.030E-07
^{239}Pu	6.201E-02	8.288E-10
^{238}Pu	1.5205E+01	7.339E-04
^{236}Pu	1.3853E+01	8.3254E+01
^{237}Np	7.05E-04	3.0206E-08
WG Pu	7.977E-02	4.1946E-06
HS Pu	1.27171E+01	6.948E-04

a. EDF RWMC-690, 12/2/93.

b. Alpha activity from radionuclides with atomic number greater than 92 and half-life greater than 20 years.

c. Alpha activity from radionuclides with atomic number 92 or less and/or half-lives of less than 20 years.

Table 4-8. Alpha activity due to one gram of non-TRU parent source material at 15 years post purification.[a]

Non-TRU source material	TRU[b] α activity (Ci)	Non-TRU[c] α activity (Ci)
^{238}U	—	3.36E-07
^{235}U	—	1.923E-06
^{233}U	—	9.68E-03
^{232}Th	—	2.779E-07
^{230}Th	—	2.009E-02
^{226}Ra	—	2.2426

a. EDF RWMC-690, 12/2/93.

b. Alpha activity from radionuclides with atomic number greater than 92 and half-life greater than 20 years.

c. Alpha activity from radionuclides with atomic number 92 or less and/or half-lives of less than 20 years.

For the case of the radionuclidic compounds, weapons-grade plutonium (WG Pu) and heat-source plutonium (HS Pu), the computation of the TRU and non-TRU alpha activities requires some additional accounting. For such compounds, the total alpha activity in the TRU and non-TRU categories is due to the contribution of each isotopic/radionuclidic component of the parent compound and all of its alpha-emitting progeny weighted by the appropriate parent compound mass fraction. The nominal mass fractions utilized in the computation for the WG Pu and HS Pu alpha activity determinations are shown in Table 4-6. The WG Pu computation also includes the ^{241}Am impurity present at the time zero purification date, which is nominally 200 micrograms ^{241}Am per gram of WG Pu. No impurities are identified for the HS Pu alpha activity calculations.

As indicated in the assumption set, the alpha activity due to the nuclide radon (Rn) is not included in any of the non-TRU alpha activity tabulations. The reasoning behind this exception is that while the waste is containerized it is considered sealed such that radon migration from the waste is nonexistent or minimal. Therefore all radon progeny will become a component of the source term as they are considered to have grown in and become trapped in the waste container over time. When the container is opened for treatment at some date, it is then assumed that the radon isotopes will quickly migrate from the waste matrix. To the extent that radon does migrate from containerized waste forms during storage, the radon progeny fraction of the source term will be conservative.

Table 4-7 contains the distribution between TRU and non-TRU alpha activity for parent source material comprised of the Table 4-5 TRU radionuclides. Also included in Table 4-7 are the TRU and non-TRU alpha activity components for the two radionuclide compounds, WG Pu and HS Pu. The values tabulated in Table 4-8 result from the determination of alpha activity for Table 4-5 parent source material consisting of non-TRU radionuclides only, i.e., alpha emitters with atomic numbers less than or equal to 92 and/or half-lives less than 20 years.

The weapons-grade plutonium (Pu-52) and heat-source plutonium (Pu-83) mixtures as called out in the database inventories require additional analysis to provide useful activity information. Tables 4-9 and 4-10 present nuclide alpha activity fraction at 15 year decay for the weapons grade and heat source plutonium mixtures.

Tables 4-11 through 4-17 present alpha activity per gram at 15 year decay for the nuclides presented in the Tables 4-9 and 4-10 mixture summaries, i.e., Pu-236, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, and Am-241 respectively.

The results of this TWDB analysis enable presentation of alpha activity both at detailed-content code level and at a summary level. The detailed information at the content code level for where information is available is presented in the Appendices A and B profile data. Table 4-18 provides a summary distribution by alpha concentration for the TSA waste in general. Alpha activity in Table 4-18 is presented by interval number, Table 4-19 provides the TRU alpha activity concentrations for the Table 4-18 intervals. Figure 4-1 presents TSA stored waste inventory distribution by alpha activity concentration interval number. Figure 4-2 presents TSA stored waste inventory distribution by alpha activity concentration.

Table 4-9. Plutonium mixture summary for weapons grade plutonium (WG Pu/Pu-52) waste.

WG Pu (Pu-52) composition[a]	Mass fraction at time 0[a]	Daughters	Radiation type, decay (primary, secondary)	Half-life	TRU (Y/N)	Alpha emitter (Y/N)	Total alpha activity of parent + daughters at 15 years per gram isotope (Ci)	Total alpha activity of parent + daughter at 15 years per g-WG-Pu[b] (alpha Ci/g)	Total alpha activity fraction at 15 year decay
^{238}Pu	1.2E-04		alpha, gamma	87.7 yr	Y	Y	(1.5204E+01)	0.00182	0.02282
		^{234}U	alpha, gamma	2.454E5yr	N	Y	(7.3393E-04)		
		^{230}Th	alpha, gamma	7.54E4 yr	N	Y	(4.9797E-08)		
		^{226}Ra	alpha, gamma	1600 yr	N	Y	(1.1067E-10)		
					subtotal alpha =		15.2058		
^{239}Pu	9.38E-01		alpha, gamma	2.41E4 yr	Y	Y	(0.06201)	0.05818	0.72935
		^{235}U	alpha, gamma	7.04E8 yr		Y	(8.288E-10)		
		others	-	-	-	-	-		
					subtotal alpha =		0.06201		
^{240}Pu	5.82E-02		alpha, gamma	6.56E3 yr	Y	Y	(0.2266)	0.01319	0.16535
		^{236}U	alpha, gamma	2.342E7 yr		Y	(1.0302E-07)		
		^{232}Th	alpha, gamma	1.4E10 yr		Y	(3.8545E-17)		
					subtotal alpha =		0.2266015		
^{241}Pu	3.4E-03		beta, alpha, gamma	14.4 yr	N	Y	(1.229E-03)	0.00591	0.07409
		^{241}Am	alpha, gamma	432.7yr		Y	(1.7382)		
		^{237}Np	alpha, gamma	2.1E6yr		Y	(4.8397E-06)		
		^{237}U	beta, gamma	6.75 d		N	-		
		^{233}Pa	beta, gamma	27d		N	-		
		^{233}U	alpha, gamma	1.592E5yr		Y	(1.1141E-10)		
					subtotal alpha =		1.74044		
^{242}Pu	2.4E-04		alpha, gamma	3.75E5 yr	Y	Y	(3.9259E-03)	9.4219E-07	0.00001
		^{238}U	alpha, gamma	4.47E9yr		Y	(9.2881E-12)		
		^{234}Th	beta, gamma	24.1d		N	-		
		^{234}Pa	beta, gamma	1.2m/6.7hr		N	-		
		^{234}U	alpha, gamma	2.46E5yr		Y	(1.9756E-16)		
					subtotal alpha =		0.0039258		
^{241}Am Impurity + Gr	200ug/g		alpha, gamma		Y	Y	(3.3447)	0.00067	0.0084

Table 4-9. (continued).

WG Pu (Pu-52) composition[a]	Mass fraction at time 0[a]	Daughters	Radiation type, decay (primary, secondary)	Half-life	TRU (Y/N)	Alpha emitter (Y/N)	Total alpha activity of parent + daughters at 15 years per gram isotope (Ci)	Total alpha activity of parent + daughter at 15 years per g-WG-Pu[b] (alpha Ci/g)	Total alpha activity fraction at 15 year decay
		^{237}Np	alpha, gamma	2.1E6yr		Y	(1.6726E-05)		
		^{233}Pa	beta, gamma	27d		N	-		
		^{233}U	alpha, gamma	1.592E5yr		Y	(5.4997E-10)		
		^{229}Th	alpha, gamma	7.3E3 yr		Y	(2.6282E-13)		
					subtotal alpha =		3.3466		
							Total =	0.07977	1.000

a. Estimated summary information for TSA stored alpha contaminated (CH ALLW + TRUW) waste from analysis of the Transuranic Waste Database (TWDB) information which reports radionuclide information for two primary radionuclides only per container, nuclides decayed to stable elements, EDF PSPI-015546-10, 11/16/95.

b. Mass fraction at time 0 times the sum of alpha activity of parent and daughters at 15 years per gram isotope.

Table 4-10. Plutonium mixture summary for heat source plutonium (HS Pu/Pu-83) waste.

HS Pu (PU-83) composition[a]	Mass fraction at time 0[a]	Daughters	Radiation type, decay (primary, secondary)	Half-life	TRU (Y/N)	Alpha emitter (Y/N)	Total alpha activity of parent + daughters at 15 years per g isotope (Ci)	Total alpha activity of parent + daughter at 15 years per g-HS-Pu[b] (alpha Ci/g)	Total alpha activity fraction at 15 year decay
^{236}Pu	1E-06		alpha, gamma	2.851 yr	N	Y	(1.3851E+02)	9.7096E-05	7.636E-06
		^{232}U	alpha, gamma	68.9 yr	N	Y	(1.9485E+01)		
		^{228}Th	alpha, gamma	1.913 yr	N	Y	(1.9318E+01)		
		^{224}Ra	alpha, gamma	3.66 d	N	Y	(1.967E+01)		
		^{220}Rn	alpha, gamma	3.825 d	N	Y	-		
		^{216}Po	alpha, gamma	150 msec	N	Y	(4.0996)		
		^{212}Pb	beta, gamma	10.64 hr	N	N	-		
		^{212}Bi	beta, gamma, alpha	1.01 hr	N	Y	(7.4667)		
		^{212}Po	alpha, gamma	45.1 sec	N	Y	(1.3209E+01)		
		^{208}Tl	beta, gamma	3.053 min	N	N	-		
		^{208}Pb	stable	-	-	-	-		
					subtotal alpha=		97.096		
^{238}Pu	0.835		alpha, gamma	87.7 yr	Y	Y	(1.5204E+01)	1.2696E+01	9.9843E-01
		^{234}U	alpha, gamma	2.454E5yr	N	Y	(7.3393E-04)		
		^{230}Th	alpha, gamma	7.54E4 yr	N	Y	(4.9797E-08)		
		^{226}Ra	alpha, gamma	1600 yr	N	Y	(1.1067E-10)		
					subtotal alpha =		15.205		
^{239}Pu	0.14		alpha, gamma	2.41E4 yr	Y	Y	(0.06201)	8.6819E-03	6.8275E-04
		^{235}U	alpha, gamma	7.04E8 yr		Y	(8.288E-10)		
		others	-	-	-	-	-		
					subtotal alpha =		0.06201		
^{240}Pu	0.02		alpha, gamma	6.56E3 yr	Y	Y	(0.2266)	4.532E-03	3.564E-04
		^{236}U	alpha, gamma	2.342E7 yr		Y	(1.0302E-07)		
		^{232}Th	alpha, gamma	1.4E10 yr		Y	(3.8545E-17)		
					subtotal alpha =		0.2266		
^{241}Pu	0.004		beta, alpha, gamma	14.4 yr	N	Y	(1.229E-03	6.96E-03	5.2611E-04
		^{241}Am	alpha, gamma	432.7yr		Y	(1.7382		
		^{237}Np	alpha, gamma	2.1E6yr		Y	(4.8397E-06		
		^{237}U	beta, gamma	6.75 d		N	-		
		^{233}Pa	beta, gamma	27d		N	-		
		^{233}U	alpha, gamma	1.592E5yr		Y	(1.1141E-10)		
					total alpha =		1.7404		

Table 4-10. (continued).

HS Pu (PU-83) composition[a]	Mass fraction at time 0[a]	Daughters	Radiation type, decay (primary, secondary)	Half-life	TRU (Y/N)	Alpha emitter (Y/N)	Total alpha activity of parent + daughters at 15 years per g isotope (Ci)	Total alpha activity of parent + daughter at 15 years per g-HS-Pu[b] (alpha Ci/g)	Total alpha activity fraction at 15 year decay
^{242}Pu	0.001		alpha, gamma	3.75E5 yr	Y	Y	(3.9259E-03)	3.9258E-06	3.0873E-7
		^{238}U	alpha, gamma	4.47E9yr		Y	(9.2881E-12)		
		^{234}Th	beta, gamma	24.1d		N	-		
		^{234}Pa	beta, gamma	1.2m/6.7hr		N	-		
		^{234}U	alpha, gamma	2.46E5yr		Y	(1.9756E-16)		
					subtotal alpha =		0.003926		
							Total =	1.2716E+01	1.000

a. Estimated summary information for TSA stored alpha contaminated (CH ALLW + TRUW) waste from analysis of the Transuranic Waste Database (TWDB) information which reports radionuclide information for two primary radionuclides only per container, nuclides decayed to stable elements, EDF PSPI-015546-10, 11/16/95.

b. Mass fraction at time 0 times the sum of alpha activity of parent and daughters at 15 years per gram isotope.

Table 4-11. Alpha activity at 15 year due to Pu-236 isotope.[a]

Nuclide	Daughters at 15 year	15 year mass fraction	Alpha curies/gram	Alpha curies/gram at 15 years
Pu-236		0.02607	531.3	1.3851E+01
	U-232	0.86985	22.4	1.9485E+01
	Th-228	0.02357	819.6	1.9318E+01
	Ra-224	1.2348E-04	1.593E+05	1.967E+01
	Rn-220	1.2903E-04	Noble gas	—
	Po-216	5.8565E-11	7E+10	4.0996
	Pb-212	1.4955E-05	(beta emmitter) alpha = 0	—
	Bi-212	1.4185E-06	5.2638E+06	7.4667
	Tl-208	2.5704E-08	(beta emmitter) alpha = 0	—
	Po-212	1.128E-08	1.171E+09	1.3209E+01
	Pb-208	8.0224E-02	Stable	—
			Subtotal	9.7096E+01

a. EDF PSPI-015546-10, 11/16/95.

Table 4-12. Alpha activity at 15 year due to Pu-238 isotope.[a]

Nuclide	Daughters at 15 year	15 year Mass Fraction	Alpha Curies/gram	Alpha Curies/gram at 15 years
Pu-238		0.8882	17.119	1.5204E+01
	U-234	0.1179	0.006225	7.3393E-04
	Th-230	2.415E-06	0.02062	4.9797E-08
	Ra-226	1.119E-10	0.9890	1.1067E-10
			Subtotal	1.5205E+01

a. EDF PSPI-015546-10, 11/16/95.

Table 4-13. Alpha activity at 15 year due to Pu-239 isotope.[a]

Nuclide	Daughters at 15 year	15 year mass fraction	Alpha curies/gram	Alpha curies/gram at 15 years
Pu-239		.99957	.06204	0.06201
	U-235	4.312E-04	1.922E-06	8.288E-10
	Others	E-15	—	—
			Subtotal	0.06201

a. EDF PSPI-015546-10, 11/16/95.

Table 4-14. Alpha activity at 15 year due to Pu-240 isotope.[a]

Nuclide	Daughters at 15 year	15 year mass fraction	Alpha curies/gram	Alpha curies/gram at 15 years
Pu-240		.99842	0.22696	0.2266
	U-236	.00158	6.508E-05	1.0302E-07
	Th-232	3.515E-10	1.0967E-07	3.8545E-17
			Subtotal	0.2266

a. EDF PSPI-015546-10, 11/16/95.

Table 4-15. Alpha activity at 15 year due to Pu-241 isotope.[a]

Nuclide	Daughters at 15 year	15 year Mass Fraction	Alpha Curies/gram	Alpha Curies/gram at 15 years
Pu-241		0.48577	0.00253	1.229E-03
	Am-241	0.50736	3.426	1.7382
	Np-237	6.8693E-03	7.0454E-04	4.8397E-06
	U-237	1.5044E-08	(beta emmitter) alpha = 0	—
	Pa-233	2.3431E-10	(beta emmitter) alpha = 0	—
	U-233	1.1565E-08	9.6332E-03	1.1141E-10
			Subtotal	1.7394

a. EDF PSPI-015546-10, 11/16/95.

Table 4-16. Alpha activity at 15 year due to Pu-242 isotope.[a]

Nuclide	Daughters at 15 year	15 year mass fraction	Alpha curies/gram	Alpha curies/gram at 15 years
Pu-242		0.99997	3.926E-03	3.9259E-03
	U-238	2.763E-05	3.3616E-07	9.2881E-12
	Th-234	4.0544E-16	(beta emmitter) alpha = 0	—
	Pa-234	0	(beta emmitter) alpha = 0	—
	U-234	3.1701E-14	6.225E-03	1.9756E-16
			Subtotal	3.9259E-03

a. EDF PSPI-015546-10, 11/16/95.

Table 4-17. Alpha activity at 15 year due to Am-241 isotope.[a]

Nuclide	Daughters at 15 year	15 year mass fraction	Alpha curies/gram	Alpha curies/gram at 15 years
AM-241		0.97626	3.426	3.3447
	Np-237	0.02374	7.0454E-04	1.6726E-05
	Pa-233	8.1426E-10	(beta emmitter) alpha = 0	—
	U-233	5.7091E-08	9.6332E-03	5.4997E-10
	Th-229	1.2362E-12	0.2126	2.6282E-13
			Subtotal	3.3447

a. EDF PSPI-015546-10, 11/16/95.

Table 4-18. TSA stored waste distribution by alpha concentration.[a]

Interval[b]		Gross mass identified in TWDB radionuclide analysis[c] (g)	Waste mass identified in TWDB radionuclide analysis[c] (g)	Percent distribution of total gross mass identified[b]	Estimated percent distribution for total TSA stored waste mass[d]	Cummulative percent distribution
	0	5.16E+09	3.99E+09	23.755 %	23.8 %	23.8 %
	1	4.09E+09	3.44E+09	18.842 %	18.8 %	42.6 %
	2	3.10E+09	2.48E+09	14.300 %	14.3 %	56.9 %
	3	2.20E+09	1.58E+09	10.122 %	10.1 %	67.0 %
	4	8.12E+08	6.09E+08	3.742 %	3.7 %	70.8 %
	5	5.96E+08	4.50E+08	2.749 %	2.7 %	73.5 %
	6	4.63E+08	3.55E+08	2.135 %	2.1 %	75.6 %
	7	3.73E+08	2.85E+08	1.720 %	1.7 %	77.4 %
	8	2.94E+08	2.27E+08	1.354 %	1.4 %	78.7 %
	9	2.70E+08	2.13E+08	1.242 %	1.2 %	80.0 %
	10	2.51E+08	2.01E+08	1.156 %	1.2 %	81.1 %
	11	2.17E+08	1.72E+08	0.998 %	1.0 %	82.1 %
	12	1.71E+09	1.42E+09	7.864 %	7.9 %	90.0 %
	13	9.63E+08	8.26E+08	4.439 %	4.4 %	94.4 %
	14	4.39E+08	3.80E+08	2.022 %	2.0 %	96.4 %
	15	2.50E+08	2.22E+08	1.150 %	1.2 %	97.6 %
	16	1.36E+08	1.15E+08	0.627 %	0.6 %	98.2 %
	17	8.07E+07	6.76E+07	0.372 %	0.4 %	98.6 %
	18	4.75E+07	3.83E+07	0.219 %	0.2 %	98.8 %
	19	3.51E+07	2.66E+07	0.162 %	0.2 %	99.0 %
	20	2.61E+07	2.03E+07	0.120 %	0.1 %	99.1 %
	21	1.11E+08	8.35E+07	0.510 %	0.5 %	99.6 %
	22	2.83E+07	1.91E+07	0.131 %	0.1 %	99.7 %
	23	1.80E+07	1.12E+07	0.083 %	<0.1 %	99.8 %
	24	9.92E+06	7.12E+06	0.046 %	<0.1 %	99.9 %
	25	9.41E+06	4.60E+06	0.043 %	<0.1 %	99.9 %
	26	3.34E+06	2.24E+06	0.015 %	<0.1 %	99.9 %
	27	2.57E+06	1.64E+06	0.012 %	<0.1 %	99.9 %
	28	1.29E+06	8.14E+05	0.006 %	<0.1 %	99.9 %
	29	1.10E+06	6.40E+05	0.005 %	<0.1 %	99.9 %
	30	8.84E+06	5.99E+06	0.041 %	<0.1 %	100.0 %
	31	4.83E+06	2.93E+06	0.022 %	<0.1 %	100.0 %
	32	4.03E+05	1.91E+05	0.002 %	<0.1 %	100.0 %
	33	0	0	0.000 %	<0.1 %	100.0 %
	34	5.94E+05	0.00E+00	0.003 %	<0.1 %	100.0 %
Total	34	2.17E+10g 2.17E+07kg	1.73E+10g 1.73E+07kg	100 %		100 %

a. EDF PSPI-015546-11, 11/20/95.

b. Interval ranges are identified in Table 4-19.

c. The total gross mass identified in the TWDB analysis (2.17E+07kg) represents approximately 70% of the total estimated stored waste gross mass (12E+06kg(ALLW)+19E+06kg(TRUW)=3.1E+07kg).

d. Best estimate of distribution by alpha concentration for the total stored waste (mass basis).

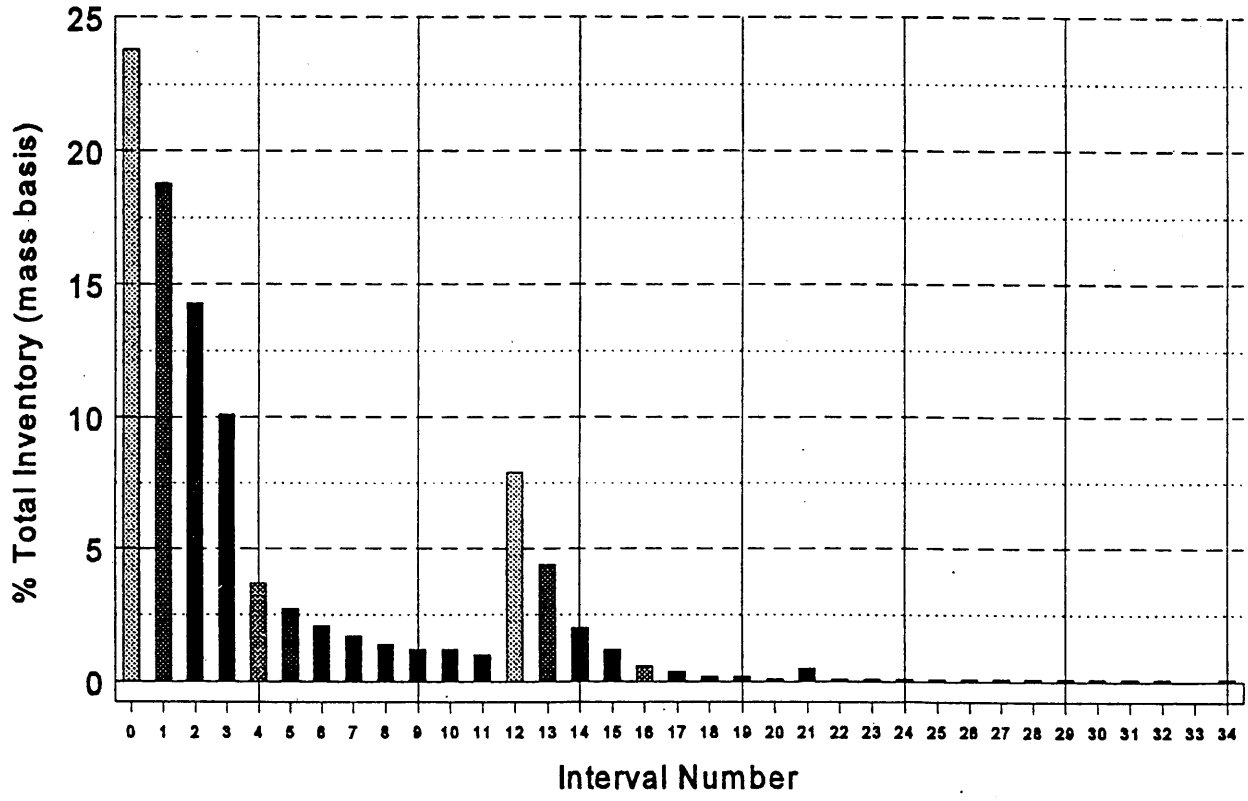

Figure 4-1. TSA Stored Waste Distribution by Alpha Activity Concentration Interval Number.

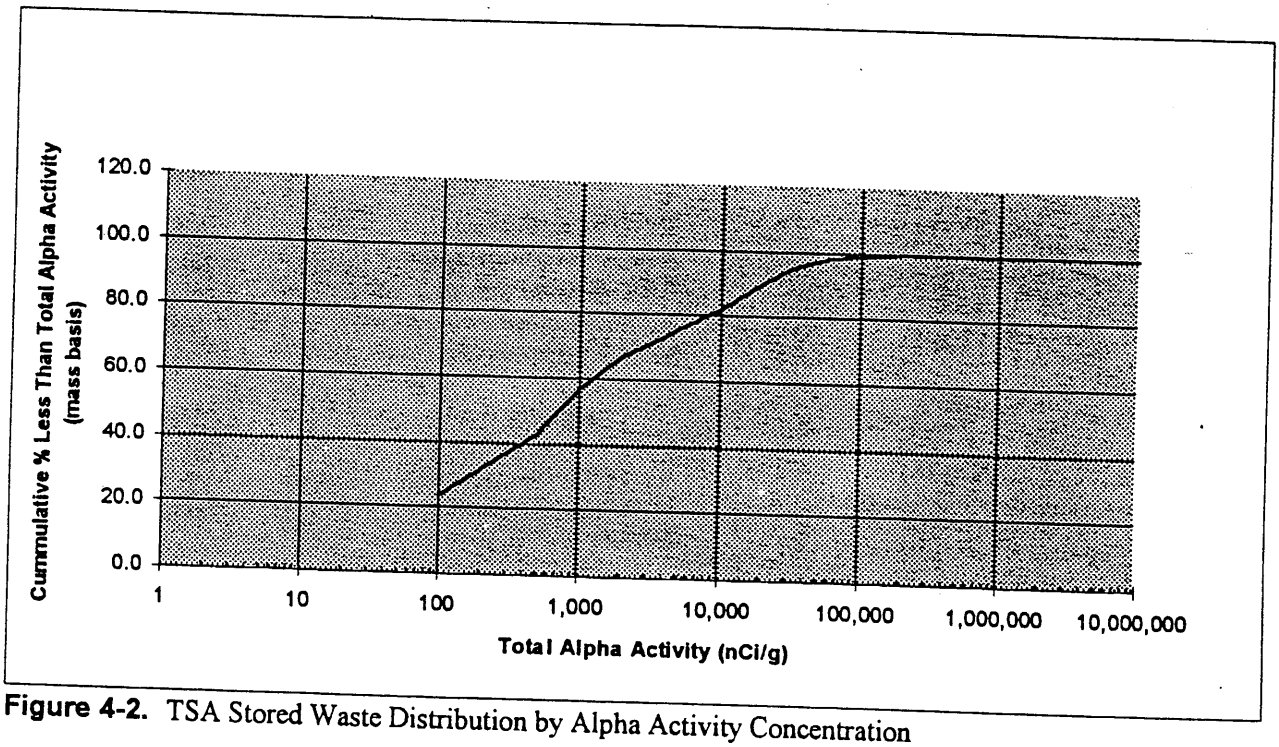

Figure 4-2. TSA Stored Waste Distribution by Alpha Activity Concentration

Table 4-19. TRU alpha activity concentration intervals.[a]

Interval number			Interval description		
0			TRU alpha activity conc	<	100 nCi/g[b]
1	100 nCi/g	≤	TRU alpha activity conc	<	500 nCi/g
2	500 nCi/g	≤	TRU alpha activity conc	<	1,000 nCi/g
3	1,000 nCi/g	≤	TRU alpha activity conc	<	2,000 nCi/g
4	2,000 nCi/g	≤	TRU alpha activity conc	<	3,000 nCi/g
5	3,000 nCi/g	≤	TRU alpha activity conc	<	4,000 nCi/g
6	4,000 nCi/g	≤	TRU alpha activity conc	<	5,000 nCi/g
7	5,000 nCi/g	≤	TRU alpha activity conc	<	6,000 nCi/g
8	6,000 nCi/g	≤	TRU alpha activity conc	<	7,000 nCi/g
9	7,000 nCi/g	≤	TRU alpha activity conc	<	8,000 nCi/g
10	8,000 nCi/g	≤	TRU alpha activity conc	<	9,000 nCi/g
11	9,000 nCi/g	≤	TRU alpha activity conc	<	10,000 nCi/g
12	10,000 nCi/g	≤	TRU alpha activity conc	<	20,000 nCi/g
13	20,000 nCi/g	≤	TRU alpha activity conc	<	30,000 nCi/g
14	30,000 nCi/g	≤	TRU alpha activity conc	<	40,000 nCi/g
15	40,000 nCi/g	≤	TRU alpha activity conc	<	50,000 nCi/g
16	50,000 nCi/g	≤	TRU alpha activity conc	<	60,000 nCi/g
17	60,000 nCi/g	≤	TRU alpha activity conc	<	70,000 nCi/g
18	70,000 nCi/g	≤	TRU alpha activity conc	<	80,000 nCi/g
19	80,000 nCi/g	≤	TRU alpha activity conc	<	90,000 nCi/g
20	90,000 nCi/g	≤	TRU alpha activity conc	<	100,000 nCi/g
21	100,000 nCi/g	≤	TRU alpha activity conc	<	200,000 nCi/g
22	200,000 nCi/g	≤	TRU alpha activity conc	<	300,000 nCi/g
23	300,000 nCi/g	≤	TRU alpha activity conc	<	400,000 nCi/g
24	400,000 nCi/g	≤	TRU alpha activity conc	<	500,000 nCi/g
25	500,000 nCi/g	≤	TRU alpha activity conc	<	600,000 nCi/g
26	600,000 nCi/g	≤	TRU alpha activity conc	<	700,000 nCi/g
27	700,000 nCi/g	≤	TRU alpha activity conc	<	800,000 nCi/g
28	800,000 nCi/g	≤	TRU alpha activity conc	<	900,000 nCi/g
29	900,000 nCi/g	≤	TRU alpha activity conc	<	1,000,000 nCi/g
30	1,000,000 nCi/g	≤	TRU alpha activity conc	<	2,500,000 nCi/g
31	2,500,000 nCi/g	≤	TRU alpha activity conc	<	5,000,000 nCi/g
32	5,000,000 nCi/g	≤	TRU alpha activity conc	<	7,500,000 nCi/g
33	7,500,000 nCi/g	≤	TRU alpha activity conc	<	10,000,000 nCi/g
34	10,000,000 nCi/g	≤	TRU alpha activity conc		

a. EDF RWMC-716, 3/4/94.

b. TRU alpha activity concentration per gross mass (nCi/g).