Attachment 1

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Revision 0

Supplement to Evaluation of Naval Reactors Facility Radioactive Waste Disposed of at the Radioactive Waste Management Complex from 1953 to 1999

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5. CONCLUSIONS AND RECOMMENDATIONS

This report documents distribution of the NRF radionuclide source term across all documented NRF waste disposal shipments sent to the SDA during the HDT, RPDT, and RPDT Supplement periods from 1953 through 1999. Best estimates from the three timeframes are presented in Table 5. The combined inventories shown in Table 5 are compiled from separate inventories presented in Sections 3 and 4.

This report presents best-estimate (Appendix A) and upper-bound (Appendix B) radionuclide inventories associated with NRF operations. Estimates are based on totals by waste stream provided by DOE-IBO (Appendix C). Technically defensible estimates of radionuclide activities for individual waste shipments from NRF to the SDA were developed from detailed investigations and reviews of shipping and waste records, nuclear material accountability forms, and extensive deterministic calculations using known irradiation histories of these waste streams.

Table 5. Summary of the Naval Reactors Facility best-estimate radionuclide inventories in waste sent to the Subsurface Disposal Area from 1953 through 1999.

Radionuclide	1953 through 1983 (Ci)	1984 through 1997[a] (Ci)	1994 through 1999[b] (Ci)	Total 1953 through 1999 (Ci)
Am-241	1.18E+01	1.07E-01	1.06E-03	1.19E+01
C-14	6.20E+01	1.08E+01	1.12E+00	7.40E+01
Cl-36	1.63E-01	4.49E-02	8.53E-03	2.16E-01
Co-60	5.77E+05	1.57E+05	1.52E+03	7.36E+05
Cs-137	1.15E+04	1.07E+01	9.95E-01	1.15E+04
H-3	1.66E+02	3.09E+01	1.37E+01	2.10E+02
I-129	8.30E-03	8.83E-04	8.99E-04	1.01E-02
Nb-94	2.55E+01	5.80E+00	2.34E-01	3.15E+01
Ni-59	1.48E+03	3.97E+02	2.36E+01	1.90E+03
Ni-63	1.49E+05	4.10E+04	2.81E+03	1.93E+05
Np-237	4.39E-03	6.54E-07	—	4.39E-03
Pu-238	1.89E+01	7.41E-02	4.55E-03	1.89E+01
Pu-239	4.67E+01	5.51E-02	1.38E-04	4.68E+01
Pu-240	4.07E+01	3.42E-02	1.40E-04	4.07E+01
Pu-241	3.20E+03	4.61E+00	7.38E-02	3.21E+03
Sr-90	6.93E+03	9.78E+00	4.87E-01	6.94E+03
Tc-99	2.65E+00	2.24E-01	2.37E-03	2.88E+00
U-233	3.66E-04	5.89E-05	—	4.25E-04
U-234	8.43E-02	9.63E-05	—	8.44E-02
U-235	1.66E-03	8.88E-07	2.98E-06	1.67E-03
U-236	1.19E-02	3.11E-06	—	1.20E-02
U-238	8.32E-02	3.42E-05	5.26E-08	8.33E-02

[a]Excludes waste stream NRF-MOD-10S.

[b]Includes waste streams NRF-MOD-6S and NRF-MOD-10S.

Attachment 2

INL/EXT-11-23102

Explanation of Significant Differences Between Models Used to Assess Groundwater Impacts for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste and Greater-Than-Class C-Like Waste Environmental Impact Statement (DOE/EIS-0375-D) and the Environmental Assessment for the INL Remote-Handled Low-Level Waste Disposal Project (INL/EXT-10-19168)

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3.2 Remote-Handled Low-Level Waste Environmental Assessment Inventory and Source Release Assumptions

The proposed INL disposal facility will accept three primary types of RH-LLW: (1) activated metals, (2) ion-exchange resins, and (3) miscellaneous contaminated debris. The activated metals are generated at INL by ATR Complex operations, Naval Reactors Facility operations, and from processing waste stored in the Radioactive Scrap and Waste Facility at the Materials and Fuels Complex. The activated metals are typically reactor core components replaced during core internal changeouts and are made from stainless steel, inconel, zircaloy, or aluminum. The ion-exchange resins are beads used to purify reactor cooling water as part of routine operations at the Naval Reactors Facility and the ATR Complex. The design life of the proposed RH-LLW disposal facility is 50 years. Disposal inventories for a 50-year period were projected by each of the waste generators; the combined inventory from all generators, in terms of activity, is shown in Table 3.

Table 3. Inventory of radionuclides with half-lives greater than 5 years used in the INL RH-LLW EA groundwater impacts analysis.

Radionuclide	Activated Metals (Ci)	Resins (Ci)	Other (Debris and Surface Contamination) (Ci)	Radionuclide	Activated Metals (Ci)	Resins (Ci)	Other (Debris and Surface Contamination) (Ci)
Ac-227	1.849E-06			Ni-59	3.085E+03	3.034E+01	1.262E+02
Ag-108m	2.917E-05			Ni-63	3.789E+05	3.674E+03	9.621E+03
Am-241	3.059E-01	3.467E-02	4.999E-02	Np-237	8.460E-06	2.667E-04	2.721E-03
Am-242m	2.486E-03	7.906E-06	2.695E-04	Os-194	4.051E-09		
Am-243	7.660E-04	2.728E-05	2.394E-04	Pa-231	8.806E-06		
Ba-133	1.830E-03			Pb-205	8.319E-07		
Be-10	1.804E-04			Pd-107	4.005E-05		2.762E-04
Bi-210m	1.094E-06			Pm-145	1.616E-10		
C-14	3.744E+02	2.638E+00	5.518E+01	Pm-146	8.440E-08		
Ca-41	1.345E-02			Pt-193	9.080E-04		
Cd-113m	5.637E-02			Pu-238	2.488E-01	3.981E-01	5.830E-02
Cf-249	1.408E-12		8.813E-12	Pu-239	3.048E-01	7.226E-02	1.177E-01
Cf-250	1.470E-10			Pu-240	2.399E-01	5.050E-03	2.885E-03
Cf-251	3.334E-15		3.217E-13	Pu-241	2.596E+01	1.135E-01	1.029E+00
Cl-36	1.533E-01			Pu-242	3.161E-04	4.118E-06	6.898E-05
Cm-243	1.564E-03	2.248E-05	3.129E-04	Ra-226	7.999E-11		
Cm-244	3.526E-02	2.495E-02	1.674E-02	Ra-228	2.961E-07		
Cm-245	7.190E-07		7.778E-07	Rb-87	1.277E-06		
Cm-246	5.487E-07		5.150E-07	Re-187	2.142E-05	8.940E-01	
Cm-247	5.023E-15		4.828E-13	Se-79	3.376E-03	9.272E-05	4.968E-03
Co-60	1.325E+06	4.712E+03	1.572E+06	Si-32	6.452E-07	1.960E-08	
Cs-135	2.433E-04		1.522E-02	Sm-147	4.379E-10		
Cs-137	1.901E+01	3.614E+01	6.218E+03	Sm-151	3.300E-01	4.222E-02	4.827E+01
Eu-152	1.893E-01	1.020E+01		Sn-121m	1.377E+02		
Eu-154	6.881E-01	3.008E+01	2.143E+02	Sn-126	1.811E-04		1.677E-05
H-3	3.908E+03	9.834E+00	3.159E-04	Sr-90	9.407E+00	6.165E+01	6.111E+03
Hf-178m	4.012E-08			Tc-99	8.708E+00	5.072E+00	2.946E+00
Hf-182	1.151E-04			Th-229	6.385E-08		

Table 3. (continued).

Radionuclide	Activated Metals (Ci)	Resins (Ci)	Other (Debris and Surface Contamination) (Ci)	Radionuclide	Activated Metals (Ci)	Resins (Ci)	Other (Debris and Surface Contamination) (Ci)
Ho-166m	5.571E-08			Th-230	6.821E-08		
I-129	1.335E-05	1.330E-01	3.714E-04	Th-232	1.562E-07		1.559E-07
Ir-192m	1.112E-05			U-232	1.246E-04		2.344E-04
K-40	1.107E-06	1.260E-03		U-233	1.145E-04		3.439E-06
La-137	2.376E-06			U-234	2.628E-04	9.244E-04	1.261E-05
Lu-176	1.504E-08			U-235	8.190E-06	2.061E-05	5.143E-03
Mo-93	1.993E+00		2.710E+01	U-236	2.272E-05	1.064E-04	1.647E-07
Nb-93m	5.938E+02	2.161E-04	1.038E+02	U-238	2.891E-04	4.305E-08	1.619E+01
Nb-94	1.020E+02	2.120E+00	6.575E+00	Zr-93	4.362E+01	4.649E-02	5.149E-02

In the groundwater impacts analysis (INL 2011) for the INL RH-LLW disposal facility, the differential release from the different waste forms was considered. Assumptions used in the RH-LLW EA by waste type are as follows:

- **Radionuclides in resins** were assumed to be sorbed to the resins. Once contacted by infiltrating water, the radionuclides would partition into the infiltrating water and be transported into the vault environment. The vault environment was assumed to contain sand and cement. For conservatism, partitioning of radionuclides to the resins, sand, and cement within the vault environment was neglected.
- **Radionuclides on debris** were assumed to be released into the vault environment once contacted by infiltrating water. As with the resin waste form, sorption was neglected in the vault environment.
- **Radionuclides in activated metals** were assumed to be released as the activated metals corrode. The most conservative corrosion rates at INL were determined for immersion tests conducted at INTEC (1,312 to 1,968 years/mm), where Type 304 stainless steel coupons were subjected to a magnesium chloride solution at a 6-m burial depth temperature and oxygen content. The magnesium chloride solution was used in the studies at INTEC to represent the long-term use of a dust suppressant at the Radioactive Waste Management Complex. A value similar in magnitude was recommended for use at the Subsurface Disposal Area by Nagata and Banaee (1996). This value (4,500 years/mm or 2.22E-05 cm/year) comes from corrosion of sensitized Type 304 stainless steel buried in soils near Toppenish, Washington. These two rates are both greater than the rates measured by Adler-Flitton et al. (2011) for activated metal types expected to be deposited in the proposed RH-LLW facility. Based on direct testing of coupons buried 1.22 m (4 ft) and 3.05 m (10 ft) below ground surface near the Radioactive Waste Management Complex, Adler Flitton et al. (2011) measured corrosion rates for aluminum, zircaloy, inconel, and various types of stainless steel (304, 316L, and 316L welded) after 1 year, 3 years, 6 years, and 12 years of burial. Corrosion rates decreased with burial depth and with time of burial for all reported results.

  In addition to corrosion data, a geometric shape factor (surface-area-to-volume ratio) is required to calculate the fractional release of radionuclides from activated metal components. Based on a study of power reactors (Oztunali and Roles 1986), a surface-area-to-volume ratio of 0.535 cm^{-1} was used for typical INL-type reactor components. Combining the Nagata and Banaee (1996) corrosion rate (2.22E-05 cm/year) and the Oztunali and Roles (1986) geometry factor (0.535 cm^{-1}) results in a fractional release rate from stainless steel of 1.19E-05/year. In comparison, fractional release rates using average 12-year corrosion rates from Adler-Flitton et al. (2011) for different metal types (see Table 4), are lower by one to three orders of magnitude. For conservatism, a 1.19E-05/year fractional