WPO 37431

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Albuquerque, New Mexico 87185-1328

date : April 25, 1996

to : Distribution

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subject : **Identification of Important Radionuclides Used in 1996 CCA WIPP Performance Assessment**

Recently the data in the Transuranic Waste Baseline Inventory Database (TWBID) has been updated to reflect reassessments of key radionuclides at some of the major transuranic (TRU) waste generation sites. These new TWBID values (Ref. CCA-2) are termed the "CCA data" and they supersede the data currently published in Revision 2 of the Transuranic Waste Baseline Inventory Report (TWBIR, Ref. BIR-2). This memo identifies which of these radionuclides are of most concern to the Performance Assessment (PA) of WIPP. Of the CCA radionuclides, those that are of the most concern to PA and will be studied in the 1996 CCA calculations are shown in Table 1. The basis for their importance is based upon several factors: 1) the subsurface transportability of the radionuclides (solubility in brine, chemical sorption, etc.,), 2) transuranic inventory, and 3) allowable release limits. There are other serious concerns such as the fissile material (e.g., fissile gram equivalent (FGE) of Pu239), Pu239 equivalent activities, etc. But, these would be more applicable to transportation and WIPP operations limits than to WIPP PA and are not addressed in this memo.

In order to understand why the radionuclides in Table 1 are considered the most important, with respect to WIPP PA, one must become familiar with Table 2, which identifies the the release limits per 40CFR191 (Ref. EPA-1). These release limits are normalized to a "Unit of Waste". For the TRU waste to be disposed of in the WIPP, the unit of waste is "An amount of transuranic (TRU) wastes containing one million curies of alpha-emitting transuranic radionuclides with half lives greater than 20 years" (Ref. EPA-1b). The unit of waste is determined in Table 3. From this table it can be seen that of the 135 radionuclides in the current TWBIR, there are reported data for 15 transuranic waste radionuclides that contribute to the unit of waste. In total there are only 17 possible radionuclides that fall into the "transuranic waste" category. The two that are not identified in the TWBIR are: 1) Am242m and 2) Bk247. Since these radionuclides are very proton rich, it is expected that they are very difficult to generate and should not exist in appreciable quantities. The overall quantity of transuranic waste radionuclides from Table 3 that apply to the unit of waste is 4.07E+06 curies, thus the value for the unit of waste is 4.07. From this table it easily identified that the plutonium and americium radionuclides dominate the unit of waste. For releases to the accessible environment that involve a mix of radionuclides, the limits in Table 2 are used to define normalized releases for comparison with the release limits. Now the unit of waste and the specific release limits are used to determine release

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limits and cumulative normalized release limits. (To help describe the 40CFR191 containment requirements, the following two paragraphs were taken as is from Ref RE-1 -- This reference gives a very through introduction to the mechanics of the WIPP PA process and is considered a must for reading if a person wants to be able to understand the results presented in Ref. SNL-1 or any comparable PA reports.) Containments Requirements (40CFR191.13, Ref. EPA-1) specify general limits on the release of transuranic (TRU) waste, high-level waste, or spent nuclear fuel (SNF) from a geologic repository. Environmental Protection Agency (EPA) release limits are defined as the normalizing factors for various radionuclides listed in Table 1 of Appendix A of EPA regulation 40 CFR 191 (see Table 2). According to the Containment Requirements, there must be a reasonable expectation, based on a performance assessment that includes all significant process and events, that the cumulative release of any one radionuclide over 10,000 yr to the accessible environment shall have (these two points alone determine the EPA limits drawn on all WIPP CCDFs):

- less than 1 chance in 10 of exceeding the promulgated EPA radionuclide limits (L_i), and
- less than 1 chance in 1000 of exceeding 10 times those quantities.

For a mix of radionuclides, the sum of all releases, where each radionuclide is normalized with respect to its L_i, shall have:

- less than 1 chance in 10 of exceeding 1, and
- less than 1 chance in 1000 of exceeding 10.

Where the sum of all releases is expressed by:

$$R_j = \frac{1}{f_w}\left(\frac{Q_{1j}}{L_1} + \frac{Q_{2j}}{L_2} + \cdots + \frac{Q_{nRj}}{L_{nR}}\right) = \sum_{i=1}^{nR} \frac{Q_{ij}}{f_w L_i} \le 1 \ (or\ 10) \qquad (1)$$

where

f_w = waste unit factor = $\frac{\sum W_i}{10^6\, Ci}$, see Table 2 for units

W_i = activity in curies (Ci) for α-emitting TRU repository wastes having half-lives ($\tau_{\frac{1}{2}}$) ≥ 20 years

L_i = the EPA release limit for radionuclide i (see Table 2 for examples and units)

nR = number of radionuclides contributing to the release

R_j = total normalized release (EPA sum) for the jth scenario

Q_{ij} = cumulative release for radionuclide u beyond a specified boundary, $\int_o^{10{,}000yr} q_{ij}\, dt$

q_{ij} = release rate into accessible environment at time t for radionuclide i and scenario j calculated from consequence model(s) (see Chapter 5.0 Ref. RE-1)

The EPA release limits (L_i), for radionuclides i=1, ..., nR are based on generic analyses of hypothetical repositories containing SNF, not TRU waste. The models the contractors for the EPA used to establish the limits considered releases to a river, an ocean, and the land surface. The analysis assumed radionuclides released from the disposal-system boundary were instantaneously deposited into a river, an ocean, or into the land surface. The total cancers per curie were then calculated for each of the three pathways to humans. The most stringent of the three pathways, river water ingestion, was used in calculating the release limits. That is, the release limits are

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addition to limiting the RH-TRU canister surface dose equivalent rate to 1,000 rem/hr also limits the design capacity of (all) transuranics to 6.2 million cubic feet of volume of which no more than 5.1 million curies (Ci) may be RH-TRU. The volume limit for the RH-TRU is identified in the WIPP ROD (Record of Decision) to be 0.25 million cubic feet of volume [Ref. DOE-2]. Also, prior to the WIPP LWA 6.2 million cubic feet volume was assign to CH-TRU waste only (for instance, Ref. DOE-3 identifies that the total volume of WIPP was to be 6.45 million cubic feet -- 6.2 for CH-TRU and 0.25 for RH-TRU) and not CH-TRU plus RH-TRU. The WIPP LWA seems to be patterned after the WIPP C&C agreement [DOE-4]. It is in the WIPP C&C that a misquote was made to the WIPP ROD. The WIPP C&C quotes the WIPP ROD as applying the 6.2 million cubic meters to (all) transuranic waste. Even though the WIPP LWA is technically incorrect, the volumes identified there are to be used for WIPP calculations. More thorough discussion can be found in Ref. SA-1.]

[OR-1]Croff, A.G.; "ORIGEN2: A Users Manual for ORIGEN2 Computer Code," Oak Ridge National Laboratory, July 1980. (Further generalized discussion on ORIGEN2 can be found in Ref. OR-2.) (Detailed information on the validation (as applied to analysis of PWR spent fuel) and functional requirements (related to long-term storage of LWR spent fuel) of ORIGEN2 can be found in Refs. OR-3 and OR-4.)

[OR-2]Croff, A.G.; "ORIGEN2: A Versatile Computer Code for Calculating the Nuclide Compositions and Characteristics of Nuclear Materials," **Nuclear Technology,** Vol. 62, September 1983.

[OR-3]Hermann, O.W., S.M. Bowman, M.C. Brady and C.V. Parks; "Validation of the Scale System for PWR Spent Fuel Isotropic Composition Analyses," ORNL/TM-12667, Oak Ridge National Laboratory, March 1995.

[OR-4]Broadhead, B.L., M.D. DeHart, J.C. Ryman, J.S. Tang and C.V. Parks; "Investigation of Nuclide Importance to Functional Requirements Related to Transport and Long-Term Storage of LWR Spent Fuel," Oak Ridge National Laboratory, June 1995. ORNL/TM-12742,

[RE-1]Rechard, R.P.; "An Introduction to the Mechanics of Performance Assessment Using Examples of Calculations Done for the Waste Isolation Pilot Plant Between 1990 and 1992", SAND93-1378, UC-721, Sandia National Laboratories, Albuquerque, New Mexico, Printed October 1995.

[SA-1]L.C. Sanchez (SNL Org 6741) and S.G. Bertram (SNL Org 6747); Memo to L.E. Shephard (SNL Org 6800), subject: "WIPP Capacity", dated October 6, 1995.

[SNL-1]
Sandia WIPP Project. 1992. *Preliminary Performance Assessment for the Waste Isolation Pilot Plant, December 1992.* (SAND92-0700), Albuquerque, NM; Sandia National Laboratories.

[SNL-2]
L.C. Sanchez (SNL Org 6741); Memo to M. Marietta (SNL Org 6821), dated February 26, 1995.

[SNL-3]
Helton,J.C., J.W. Garner, R.P. Rechard, D.K. Rudeen, and P.N. Swift. 1992; *Preliminary Comparison with 40CFR191, Subpart B for the Waste Isolation Pilot Plant, December 1991. Volume 4: Uncertainty and Sensitivity Analysis Results,* SAND91-0893/4. Albuquerque, NM; Sandia National Laboratories.

[SNL-4]
J.W. Garner (SNL Org 6749); Memo to: C.T. Stockman (SNL Org 6749), Subject: "Radioisotopes to be used in the 1996 CCA Calculations", dated: 3/15/96

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determined such that releases from the disposal system, the land withdrawal boundary for the WIPP [less than the maximum 5 km (~ 3 mi) from the boundary of the disposal region] into a river providing a large population with drinking water, would result in fewer than 1000 cancer deaths over 10,000 yr, a health hazard from the amount of unmined uranium ore needed to produce 100,000 metric tons of reactor fuel (Ref. EPA-2).

Further information can be found in Table 4. This table identifies the 42 radionuclides within the TWBIR that contribute to the release limits. From this table it easily identified that the plutonium and americium radionuclides dominate the EPA units. Also, the total number of EPA units is 10,120 Ci for a unit of waste value of 4.07. This indicates that over the regulatory time frame, on an average, the allowable release of radionuclides is 1/10,120 or ~ 100 ppm (parts per million). In Table 5, there is a list of the radionuclides that are not reported in the TWBIR but are applicable to 40CFR191 (these radionuclides tend to be difficult to produce and are not expected in appreciable amounts). (Should significant quantities of any of these radionuclides be identified in the future, they will be factored into the normalized release calculations.) Also presented in this memo are Tables 6 and 7. These tables, only of minor concern with respect to EPA limits, are shown to give additional information.

From the tables presented in this memo, especially Tables 2, 3 and 4, it should be apparent that the most important radionuclide are the americiums, plutoniums, and uraniums. This was verified by Helton et al. (Ref. SNL-3), and the eight isotopes that dominate the radioactive material that could cross the WIPP regulatory boundary under breach scenarios are: Pu-239, Am-241, Pu-238, Pu-240, Np-237, U-234, U-233, and Th-230. U-234, U-233, and Th-230 are not strictly speaking "transuranic", but are included because they are long-lived daughters of the transuranic radionuclides, and are expected to be present in the TRU waste in non-negligible amounts (either as initial inventory or as ingrowth during the 10,000 year regulatory time frame). This is also demonstrated in Figure 1 which shows the temporal changes in radionuclide activity in a panel of the WIPP repository that occurs as a result of radioactivity decay for the eight most important radionuclides [the plots in Figure are taken from RE-1]. At 10,000 yr, the total normalization activity in a panel for all omitted radionuclides is less than 2 percent of the EPA limit (inclusion of radium-226 drops the total normalized activity to one percent).

REFERENCES

[BIR-1]

DOE (U.S. Department of Energy); Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report; CAO-94-1005; Revision 1; February 1995, Volume 1, Table 4-2, pg. 4-6.

[BIR-2]

DOE (U.S. Department of Energy); Transuranic Waste Baseline Inventory Report; DOE/CAO-95-1121; Revision 2; printed December 1995.

[BIR-2b]

Ibid., Table 3-4, pp. 3-30 → 3-36 (Volume 1).

[BIR-2c]

Ibid., Table 3-4, pg. 3-31 (Volume 1).

[BIR-2d]

Ibid., Table 3-4, pp. 3-27 → 29 (Volume 1).

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[BIR-2e]
Ibid., pg. 1-20 (Volume 1).

[CCA-1]
S. Chakraborti (SAIC/CTAC); Letter to: J. Harvill (ASI/CTAC), Subject: "Revised Radionuclide Data In Support Of The CCA", Dated: April 12, 1996.

[CCA-2]
S. Chakraborti (SAIC/CTAC); Letter to: J. Harvill (ASI/CTAC), Subject: "Final Radionuclide Data In Support Of The CCA", Dated: April 19, 1996. [This letter gives radionuclide data that supersedes Rev. 2 of the TWBIR and should be used in the 1996 CCA calculations for the WIPP facility. This letter also supersedes Ref. CCA-1, which had preliminary values. The reason that that this reference was generated was that after publication of Ref. BIR-2 it was identified that inventory data for several key radionuclides needed to be modified in accordance to new information obtained from the waste generation sites (this information was deemed important enough that the updated information was needed for the 1996 CCA calculations).]

[DOE-1]
DOE (U.S. Department of Energy); Remote-Handled Transuranic Waste Study; DOE/CAO-1095, DOE Carlsbad Area Office; Carlsbad, NM, October 1995.

[DOE-2]
DOE (U.S. Department of Energy), Waste Isolation Pilot Plant (WIPP); Record of Decision, **Federal Register** , Vol. 46, No. 18, pg. 9163, January 28, 1981 (46 FR 9162), Office of Environmental Restoration and Waste Management, Washington, D.C.

[DOE-3]
DOE (U.S. Department of Energy), Final Supplement Environmental Impact Statement, Waste Isolation Pilot Plant; DOE/EIS-0026-FS, January 1990., Volume 2, pg. B-4, Office of Environmental Restoration and Waste Management, Washington, D.C.

[DOE-4]
DOE (U.S. Department of Energy) and State of New Mexico (1981 originally); Agreement for Consulation and Cooperation Between Department of Energy and the State of New Mexico on the Waste Isolation Pilot Plant, Updated April 18, 1988; Article VI (WIPP Mission), pg. 7.

[EPA-1]
EPA (Environmental Protection Agency). 1985a. :40 CFR Part 191: Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radionactive Waste: Final Rule," *Federal Register,* **Vol. 50,** No, 182, 38066-38089 (1985).

[EPA-1b]
Ibid., Appendix A to Part 191, Subpart B, Table 1, Note 1 (e).

[EPA-2]
EPA (Environmental Protection Agency). 1985b. *Background Information Document - Final Rule for High-Level and Transuranic Radioactive Wastes,* EPA 520/1-85-023. Washington, DC; U.S. Environmental Protection Agency, Office of Radiation Programs.

[GE-1]General Electric Company (Nuclear Energy Operations), **Nuclides and Isotopes** , Fourteenth Edition, 1989.

[GE-1b]
Ibid., pg. 46.

[LWA-1]
Public Law 102-579, 102d Congress, October 30, 1992; *Waste Isolation Pilot Plant Land Withdrawal Act.;* 1992. Section 7, subparts (a)(1)(A) and (a)(3). [Note, the WIPP LWA in

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[SNL-5]
L.C. Sanchez (SNL Org 6741); Memo to: M. Martell (SNL Org 6747), Subject: "Radionuclide Half-lives and Specific Activities Obtained From ORIGEN2 Data", dated: March 28, 1996.

[YMP-1]
Sandia YMP Project. 1994. *Total-System Performance Assessment for Yucca Mountain - SNL Second Iteration (TSPA-1993), Volume 1.* (SAND93-2675), Albuquerque, NM; Sandia National Laboratories.

[YMP-1b]
Ibid., Table 5-1, pg. 5-1 (Volume 1).

[YMP-1c]
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[YMP-1d]
Ibid., Table 5-7, pg. 5-6 (Volume 1).

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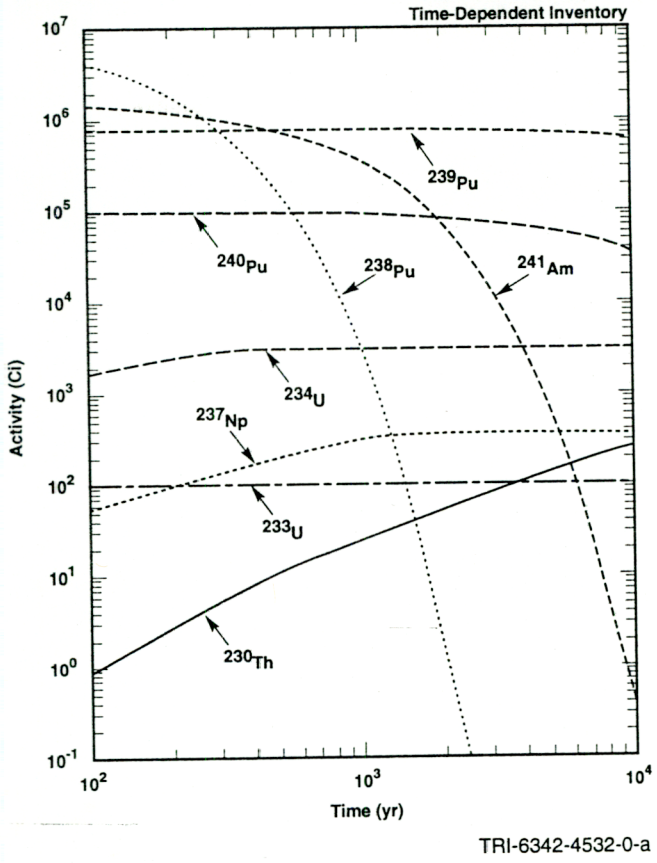

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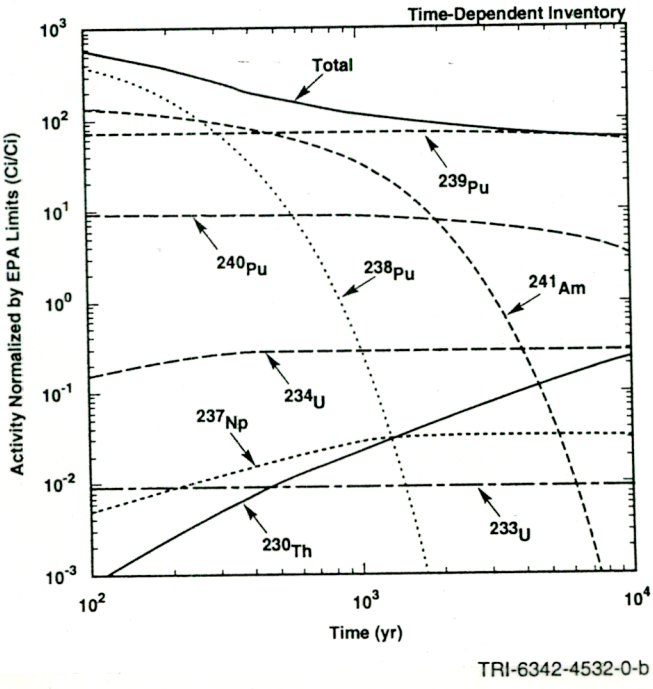

(b)

Figure 1. Changes in radionuclide activity of waste in (based on the inventory used in the 1991 performance assessment calculations) a) activity unnormalized, b) and the one WIPP panel normalized by number of panels in the WIPP (9.49), waste factor 4.225 (million curies in 1992), and the EPA release limits (usually 1000) [Taken from Ref. RE-1].

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Table 1.
Key Radionuclides of Concern to 1992 6 WIPP PA (a)

Am-241	Cm-248	Pu-238	Ra-226	U-233
Am-243	Cs-137	Pu-239	Ra-228	U-234
Cf-252	Np-237	Pu-240	Sr-90	U-235
Cm-243	Pa-231	Pu-241	Th-229	U-236
Cm-244	Pb-210	Pu-242	Th-230	U-238
Cm-245	Pm-147	Pu-244	Th-232	

(a) Not shown are decay daughters that are be calculated within the PA codes for the 1996 CCA calculations. (See Ref. SNL-4)

Table 2.
Release Limits for the Containment Requirements (a)

Radionuclide	Release Limit per 1000 MTHM (b) or Other Unit of Waste (c) (Ci)
Americium (Am)-241 or -243	100
Carbon (C)-14	100
Cesium (Cs)-135 or -137	1,000
Iodine (I)-129	100
Neptunium (Np)-237	100
Plutonium (Pu)-238, -239, -240, or -242	100
Radium (Ra)-226	100
Strontium (Sr)-90	1,000
Technetium (Tc)-99	10,000
Thorium (Th)-230 or -232	10
Tin (Sn)-126	1,000
Uranium (U)-233, -234, -235, -236, or -238	100
Any other alpha-emitting radionuclide with a half-life greater than 20 years	100
Any other radionuclide with a half-life greater than 20 years that does not emit alpha particles	1,000

(a) Based on Table I of Appendix A of Ref. EPA-1
(b) Metric tons of heavy metal exposed to a burnup between 25,000 and 40,000 MWd/tonne heavy metal.
(c) For TRU waste the unit of waste is "An amount of Transuranic (TRU) wastes containing one million curies of alpha-emitting transuranic radionuclides with half lives greater than 20 years" (Ref. EPA-1b).

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Table 3.
40CFR191 Unit of Waste for WIPP TRU Waste (a)

Nuclide			WIPP TRU Waste				
ID (b)	Decay Mode (c)	Half-Life (c)	Total Inventory [Curies] (d)		Transuranic Inventory [α-Curies] (e)		% of Unit of Waste
			CH	RH	CH	RH	(%)
Ac225	α,γ	10.0 d	2.88E+00	1.17E-01			
Ac227	α,β⁻,γ	21.77 a	6.08E-01	7.57E-04			
Ac228	α,β⁻,γ	6.15 h	7.46E-01	7.77E-02			
Ag109m	*ITe⁻*	39.8 s	1.57E+01	NR			
Ag110	β⁻,γ,ε	24.6 s	7.07E-09	1.74E-09			
Ag110m	β⁻,γ,*ITe⁻*	249.8 d	5.31E-07	1.31E-07			
Am241	α,γ,*SF*	432.7 a	4.42E+05	5.96E+03	**4.42E+05**	**5.96E+03**	**11.0**
Am242	β,γ,ε*e⁻*	16.02 h	1.75E+00	NR			
Am242m	α,*ITe⁻*	141. h	1.75E+00	NR			
Am243	α,β⁻,γ	7.37E+03 a	3.26E+01	2.28E-04	**3.26E+01**	**2.28E-04**	**8.01E-04**
Am245	β⁻,γ	2.05 h	1.33E-09	2.87E-16			
At217	α,β⁻,γ	32 ms	2.88E+00	1.17E-01			
Ba137m	*IT*	2.552 m	7.63E+03	2.04E+05			
Bi210	α,β⁻,γ	5.01 d	2.55E+00	7.16E-06			
Bi211	α,β⁻,γ	2.14 m	6.09E-01	7.58E-04			
Bi212	α,β⁻,γ	1.009 h	2.71E+01	7.36E-02			
Bi213	α,β⁻,γ	45.6 m	2.88E+00	1.17E-01			
Bi214	α,β⁻,γ	19.9 m	1.16E+01	3.58E-05			
Bk249	α,β⁻,γ	3.2E+02 d	9.16E-05	1.98E-11			
Bk250	β⁻,γ	3.217 h	4.37E-11	NR			
C14	β⁻	5730 a	1.08E+01	2.05E+00			
Cd109	γ,ε	462.0 d	1.57E+01	NR			
Cd113m	β⁻,*IT*	14.1 a	1.82E-06	5.46E-07			
Ce144	β⁻,γ	284.6 d	6.26E-02	5.13E+00			
Cf249	α,γ,*SF*	351 a	6.42E-02	4.47E-03	6.42E-02	4.47E-03	1.69E-06
Cf250	α,γ,*SF*	13.1 a	3.30E-01	NR			
Cf251	α,γ	9.0E+02 a	3.78E-03	NR	3.78E-03	NR	9.28E-08
Cf252	α,γ,*SF*	2.638 a	2.39E+02	1.29E+00			
Cm242	α,γ,*SF*	162.8 d	1.14E+00	NR			
Cm243	α,γ,*SF*,ε	29.1 a	2.72E+00	4.95E+01	**2.72E+00**	**4.95E+01**	**1.28E-03**
Cm244	α,γ,*SF*	18.1 a	3.15E+04	3.15E+02			
Cm245	α,γ,*SF*	8.5E+03 a	1.15E+02	1.46E-06	**1.15E+02**	**1.46E-06**	**2.82E-03**
Cm246	α,γ,*SF*	4.76E+03 a	1.02E-01	NR	1.02E-01	NR	2.51E-06
Cm247	α,γ	1.56E+07 a	3.21E-09	NR	3.21E-09	NR	7.88E-14
Cm248	α,*SF*	3.48E+05 a	8.95E-02	2.05E-04	**8.95E-02**	**2.05E-04**	**2.20E-06**
Co58	β⁺,γ,ε	70.88 d	3.05E-13	1.24E-11			
Co60	β⁻,γ	5.271 a	6.46E+01	1.04E+04			
Cr51	εγ	27.70 d	NR	3.04E-06			
Cs134	β⁻,γ,ε	2.065 a	1.34E-02	1.84E+01			
Cs135	β⁻	2.3E+06 a	5.02E-04	1.17E-04			
Cs137	β⁻,γ	30.17 a	8.06E+03	**2.16E+05 (g)**			
Es254	α,γ	276 d	4.24E-11	NR			

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Table 3 Continued.
40CFR191 Unit of Waste for WIPP TRU Waste (a)

Nuclide			WIPP TRU Waste				
ID (b)	Decay Mode (c)	Half-Life (c)	Total Inventory [Curies] (d)		Transuranic Inventory [α-Curies] (e)		% of Unit of Waste
			CH	RH	CH	RH	(%)
Eu150	γ,ε	36 a	3.51E-05	NR			
Eu152	β⁻,γ,εβ⁺	13.48 a	1.26E+00	1.22E+03			
Eu154	β⁻,γ,εγ	8.59 a	1.15E+00	5.91E+02			
Eu155	β⁻,γ	4.71 a	9.46E-01	1.18E+02			
Fe55	ε	2.73 a	1.91E-05	1.69E-01			
Fe59	β⁻,γ	44.51 d	2.64E-07	NR			
Fr221	α,γ	4.8 m	2.88E+00	1.17E-01			
Fr223	α,β⁻,γ	21.8 m	8.39E-03	1.04E-05			
H3	β⁻	12.3 a	8.69E-01	6.60E-02			
I129	β⁻,γ	1.57E+07 a	7.05E-07	NR			
Kr85	β⁻,γ	10.73 a	2.02E-01	1.68E+00			
Mn54	εγ	312.2 d	8.51E-04	2.35E-02			
Nb95	β⁻,γ	34.97 d	2.54E-09	6.69E-01			
Nb95m	β⁻,γ,*IT*	3.61 d	8.50E-12	2.24E-03			
Ni59	ε	7.6E+04 a	7.52E-03	NR			
Ni63	β⁻	100. a	9.19E-01	9.88E-01			
Np237	α,γ	2.14E+06 a	5.61E+01	2.85E+00	**5.61E+01**	**2.85E+00**	**1.45E-03**
Np238	β,γ	2.117 d	8.77E-03	NR			
Np239	β⁻,γ	2.355 d	3.26E+01	2.28E-04			
Np240‡	β,γ	1.032 h	NR	NR			
Np240m	β⁻,γ,*IT*	7.22 m	1.50E-06	2.21E-11			
Pa231	α,γ	3.28E+04 a	4.51E-01	1.91E-03			
Pa233	β⁻,γ	27.0 d	5.61E+01	2.85E+00			
Pa234	β⁻,γ	6.69 h	5.14E-02	1.36E-02			
Pa234m	β⁻,γ,*IT*	1.17 m	3.96E+01	1.05E+01			
Pb209	β⁻	3.25 h	2.88E+00	1.17E-01			
Pb210	α,β⁻,γ	22.3 a	2.55E+00	7.16E-06			
Pb211	β⁻,γ	36.1 m	6.09E-01	7.58E-04			
Pb212	β⁻,γ	10.64 hr	2.71E+01	7.36E-02			
Pb214	β⁻,γ	27 m	1.16E+01	3.58E-05			
Pd107	β⁻,γ	6.5E+06 a	7.41E-05	1.73E-05			
Pm147	β⁻,γ	2.6234 a	7.87E+00	1.07E+01			
Po210	α,γ	138.38 d	2.55E+00	7.16E-06			
Po211	α,γ	0.516 s	1.71E-03	2.12E-06			
Po212	α	0.298 μs	1.73E+01	4.72E-02			
Po213	α	4 μs	2.82E+00	1.15E-01			
Po214	α,γ	163.7 μs	1.16E+01	3.57E-05			
Po215	α,β⁻,γ	1.780 ms	6.09E-01	7.58E-04			
Po216	α,γ	0.145 s	2.71E+01	7.36E-02			
Po218	α,β⁻,γ	3.10 m	1.16E+01	3.58E-05			
Pr144	β⁻,γ	17.28 m	6.18E-02	5.07E+00			
Pu236	α,γ,*SF*	2.87 a	1.04E-02	NR			

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Table 3 Continued.
40CFR191 Unit of Waste for WIPP TRU Waste (a)

Nuclide			WIPP TRU Waste				
ID (b)	Decay Mode (c)	Half-Life (c)	Total Inventory [Curies] (d)		Transuranic Inventory [α-Curies] (e)		% of Unit of Waste
			CH	RH	CH	RH	(%)
Pu238	α,γ,*SF*	87.7 a	**2.61E+06 (f)**	1.45E+03	**2.61E+06**	**1.45E+03**	**64.1**
Pu239	α,γ,*SF*	2.410E+04 a	7.85E+05	1.03E+04	**7.85E+05**	**1.03E+04**	**19.5**
Pu240	α,γ,*SF*	6.56E+03 a	2.10E+05	5.07E+03	**2.10E+05**	**5.07E+03**	**5.28**
Pu241	α,β⁻,γ	14.4 a	2.31E+06	1.42E+05			
Pu242	α,γ,*SF*	3.75E+05 a	1.17E+03	1.50E-01	**1.17E+03**	**1.50E-01**	**2.87E-02**
Pu243	β⁻,γ	4.956 h	3.21E-09	NR			
Pu244	α,*SF*	8.0E+07 a	1.50E-06	2.21E-11	**1.50E-06**	**2.21E-11**	**3.68E-11**
Ra223	α,γ	11.435 d	6.09E-01	7.58E-04			
Ra224	α,γ	3.66 d	2.71E+01	7.36E-02			
Ra225	β⁻,γ	14.9 d	2.88E+00	1.17E-01			
Ra226	α,γ	1.60E+03 a	1.16E+01	3.58E-05			
Ra228	β⁻,γ	5.76 a	7.47E-01	7.77E-02			
Rh106	β⁻,γ	29.9 s	2.90E-02	1.09E+01			
Rn219	α,γ	3.96 s	6.09E-01	7.58E-04			
Rn220	α,γ	55.6 s	2.71E+01	7.36E-02			
Rn222	α,γ	3.8235 d	1.16E+01	3.58E-05			
Ru106	β⁻	1.02 a	2.90E-02	1.09E+01			
Sb125	β⁻,γ	2.758 a	1.21E-01	1.89E+00			
Sb126	β⁻,γ	12.4 d	1.35E-04	3.16E-05			
Sb126m	γ,ε*e*⁻	19.0 m	9.65E-04	2.25E-04			
Se79	β⁻	6.5E+04 a	4.35E-04	1.02E-04			
Sm151	β⁻,γ	90 a	1.47E+00	3.57E-01			
Sn119m	γ,*ITe*⁻	293 d	4.14E-06	9.59E-07			
Sn121m	β⁻,γ,*ITe*⁻	55 a	2.66E-02	6.69E-03			
Sn126	β⁻,γ	1.0E+05 a	9.65E-04	2.25E-04			
Sr89†	β⁻,γ	50.52 d	NR	NR			
Sr90	β⁻	29.1 a	6.85E+03	2.09E+05			
Ta182	β⁻,γ	114.43 d	NR	4.21E-08			
Tc99	β⁻,γ	2.13E+05 a	2.52E+01	5.85E-03			
Te125m	γ,*ITe*⁻	58 d	2.95E-02	4.65E-01			
Te127	β⁻,γ	9.4 h	1.30E-07	1.71E-09			
Te127m	β⁻,γ,*ITe*⁻	109 d	1.33E-07	1.75E-09			
Th227	α,γ	18.72 d	6.01E-01	7.47E-04			
Th228	α,γ	1.913 a	2.71E+01	7.36E-02			
Th229	α,γ	7.3E+03 a	2.88E+00	1.17E-01			
Th230	α,γ	7.54E+04 a	8.06E-02	7.56E-03			
Th231	β⁻,γ	1.063 d	1.28E+01	4.63E+00			
Th232	α,γ	1.4E+10 a	9.13E-01	9.25E-02			
Th234	β⁻,γ	24.10 m	3.96E+01	1.05E+01			
Tl207	β⁻,γ	4.77 m	6.07E-01	7.56E-04			
Tl208	β⁻,γ	3.053 m	9.73E+00	2.65E-02			

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Table 3 Continued.
40CFR191 Unit of Waste for WIPP TRU Waste (a)

Nuclide			WIPP TRU Waste				
ID (b)	Decay Mode (c)	Half-Life (c)	Total Inventory [Curies] (d)		Transuranic Inventory [α-Curies] (e)		% of Unit of Waste
			CH	RH	CH	RH	(%)
Tl209	β^-,γ	2.2 m	6.22E-02	2.53E-03			
Tl210‡	β,γ	1.30 m	NR	NR			
U232	α,γ,SF	70 a	2.58E+01	NR			
U233	α,γ,SF	1.592E+05 a	1.79E+03	1.58E+02			
U234	α,γ,SF	2.46E+05 a	4.65E+02	4.27E+01			
U235	α,γ,SF	7.04E+08 a	1.28E+01	4.63E+00			
U236	α,γ,SF	2.342E+07 a	3.33E-01	9.68E-02			
U237	β^-,γ	6.75 d	5.66E+01	3.48E+00			
U238	α,γ,SF	4.47E+09 a	3.96E+01	1.05E+01			
U240	β^-,γ	14.1 h	1.50E-06	2.21E-11			
Y90	β^-,γ	2.67 d	6.85E+03	2.09E+05			
Zn65†	$\beta^+,\gamma,\varepsilon$	243.8 d	NR	NR			
Zr93	β^-,γ	1.5E+06 a	5.63E-03	1.32E-03			
Zr95	β^-,γ	64.02 d	1.15E-09	3.02E-01			
		Sum =	6.42E+06 **(h)**	1.02E+06 **(i)**	(4.048E+06) **4.048E+06 (j)**	(2.283E+04) **2.283E+04 (k)**	100.00 %
		Sum =	7.44E+06 **(l)**		(4.07E+06) **4.07E+06** **(Unit of Waste = 4.07) (m)**		
Top 5 Radionuclides							
Pu238	α,γ,SF	87.7 a	**2.61E+06 (f)**	1.45E+03	**2.61E+06**	**1.45E+03**	**64.1**
Pu239	α,γ,SF	2.410E+04 a	7.85E+05	1.03E+04	**7.85E+05**	**1.03E+04**	**19.5**
Am241	α,γ,SF	432.7 a	4.42E+05	5.96E+03	**4.42E+05**	**5.96E+03**	**11.0**
Pu240	α,γ,SF	6.56E+03 a	2.10E+05	5.07E+03	**2.10E+05**	**5.07E+03**	**5.28**
Pu242	α,γ,SF	3.75E+05 a	1.17E+03	1.50E-01	**1.17E+03**	**1.50E-01**	**2.87E-02**

NR Not Reported by sites (see Ref. CCA-2).

‡ Data values for radionuclides were previously reported in Rev. 1 of WTWBIR (Ref. BIR-1).

† Data values for radionuclides were previously reported in Rev. 2 of TWBIR (Ref. BIR-2).

(a) Radionuclide inventory information taken from Transuranic Waste Baseline Inventory Database (TWBID), Ref. CCA-2. (in total, 135 radionuclides are inventoried in the TWBID)

(b) Radionuclides in bold are those 29 incorporated into the WIPP PA database, Ref. SNL-4.

(c) Decay mode and half-life information taken from the Chart of the Nuclides, 14th Ed. Ref. GE-1. [It is better for technical calculations, to use halflives that are extracted from the databases of ORIGEN2 [Ref. OR-1] because the ORIGEN2 data are of a later version than that of Ref. GE-1 (see Ref. SNL-5 for ORIGEN2 values).]

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(d) Total inventory (curie) data taken from Ref. CCA-2. Values correspond to a "WIPP-Scale" design basis.

(e) Transuranic inventory data corresponds to the activity (curie) data only for radionuclides that are "transuranic waste" per definitions in 40CFR191 Inventory data in bold corresponds to those data incorporated into the WIPP PA database (see Ref. SNL-4).

(f) Isotope with dominate curie load for CH-TRU wastes.

(g) Isotope with dominate curie load for RH-TRU wastes.

(h) Note, the total CH-TRU curie load is 6.42 MCi (also, 86.3 % of the total curie load in WIPP). The average CH-TRU volumetric total curie load is 6.42E+06/5.95E+06 = 1.08 (Ci/cu. ft.) = **38.1 (Ci/cu. m.)**. [See discussion note on Ref. LWA-1 for volumes -- CH→5.95E+06 cu. ft. Also note that the 5.95E+06 volume number is a volume limit, stored waste and projected waste volumes sum up to a volume less than this volume. The summed up volume is then "scaled" to yield a total volume of 5.95E+06, likewise the curie loads are also "scaled" by the same factor. Thus ratios of curie loads (or heat loads) to volume yield values are applicable to expected waste at WIPP (see Ref. BIR-2d).]

(i) Note, the total RH-TRU curie load is only 1.02 MCi (also, only 13.7 % of the total curie load in WIPP). This curie load is much less than the RH-TRU limit of 5.1 MCi [Ref. LWA-1]. The average RH-TRU volumetric total curie load is 1.02E+06/0.25E+06 = 4.08 (Ci/cu. ft.) = **144. (Ci/cu. m.)**. [See discussion note on Ref. LWA-1 for volumes -- RH→0.25E+06 cu. ft.]

(j) Note, there are only 15 radionuclides that comprise the "transuranic waste" (see footnote e above). Eleven of these radionuclides are included in the WIPP PA data base and correspond to 99.99999% of the total CH "transuranic" inventory. The average CH-TRU volumetric "transuranic" curie load is 4.048E+06/5.95E+06 = **0.680 (TRU-Ci/cu. ft.)** = **24.0 (TRU-Ci/cu. m.)**.

(k) Note, there are only 15 radionuclides that comprise the "transuranic waste" (see footnote e above). Eleven of these radionuclides are included in the WIPP PA data base and correspond to 99.99998% of the total RH "transuranic" inventory. The average RH-TRU volumetric "transuranic" curie load is 2.283E+04/0.25E+06 = **0.0913 (TRU-Ci/cu. ft.)** = **3.22 (TRU-Ci/cu. m.)**. [The RH contribution to the WIPP-scale inventory of transuranic curie load is 2.283E+04*100%/(2.283E+04 + 4.048E+06)=**0.561% (very small)**.] Note, this value is an order of magnitude less than that presented for the CH-TRU wastes -- since the majority of the curie content of the RH-TRU waste is due to shorter-lived non-transuranic radionuclides, this means that as the shorter-lived components decay away the remaining RH-TRU waste will have a lesser curie content than CH-TRU waste (i.e., as the RH-TRU waste decays, it becomes "wimpier" than CH-TRU waste). This is evident from the RH Study (Ref. DOE-1) which showed that after about 150 → 250 years that CH-TRU waste has a higher specific activity than that of RH-TRU waste.

(l) It is interesting to know that the Yucca Mountain Project (YMP) has approximately 12.4 billion curies of inventory (spent fuel -- 63,000 MTU [YMP-1b] × 1.57E+05 Ci/MTU [YMP-1c] + vitrified high-level waste -- 2.47E+09 Ci [YMP-1d]). Thus YMP is equivalent to 1660 WIPPs as far as curie load is concerned. Even though WIPP is less than one part in a thousand in comparison to YMP it still requires the same amount of work (with the exception of thermal effects) to demonstrate compliance for WIPP as it does for YMP because the EPA compliance requirements are based on a normalized basis (i.e., whether a repository has a radionuclide inventory on the order of millicuries, curies, millions of curies (like WIPP), or billions of curies (like YMP), the amount of work (with the exception of thermal effects) to show compliance is the same).

(m) Note, the unit of waste (UW, calculated to three significant figures) is the same whether the UW is calculated using all available information in the TWBID (Ref. CCA-2) or using the limited data within the WIPP PA database. [Also, only 4 radionuclides (Am241, Pu238, Pu239, and Pu240) make up 99.96% of the Unit of Waste value [see Ref. EPA-1b] -- using 5 radionuclides (adding Pu242) makes up 99.9936% of the Unit of Waste value].

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Table 4.
40CFR191 Release Limits for WIPP TRU Waste (a)

Nuclide			WIPP TRU Waste				
ID (b)	Decay Mode (c)	Half-Life (c)	Total Inventory [Curies] (d)		Release Limits Inventory [α-Curies] (e)		EPA Unit
			CH	RH	(Ci./UW)	(Ci)	
Ac225	α,γ	10.0 d	2.88E+00	1.17E-01			
Ac227	α,β⁻,γ	21.77 a	6.08E-01	7.57E-04	100.	407.	1.50E-03
Ac228	α,β⁻,γ	6.15 h	7.46E-01	7.77E-02			
Ag109m	*ITe⁻*	39.8 s	1.57E+01	NR			
Ag110	β⁻,γ,ε	24.6 s	7.07E-09	1.74E-09			
Ag110m	β⁻,γ,*ITe⁻*	249.8 d	5.31E-07	1.31E-07			
Am241	α,γ,*SF*	432.7 a	4.42E+05	5.96E+03	**100.**	**407.**	**1101.**
Am242	β,γ,ε*e⁻*	16.02 h	1.75E+00	NR			
Am242m	α,*ITe⁻*	141. h	1.75E+00	NR			
Am243	α,β⁻,γ	7.37E+03 a	3.26E+01	2.28E-04	**100.**	**407.**	**8.01E-02**
Am245	β⁻,γ	2.05 h	1.33E-09	2.87E-16			
At217	α,β⁻,γ	32 ms	2.88E+00	1.17E-01			
Ba137m	*IT*	2.552 m	7.63E+03	2.04E+05			
Bi210	α,β⁻,γ	5.01 d	2.55E+00	7.16E-06			
Bi211	α,β⁻,γ	2.14 m	6.09E-01	7.58E-04			
Bi212	α,β⁻,γ	1.009 h	2.71E+01	7.36E-02			
Bi213	α,β⁻,γ	45.6 m	2.88E+00	1.17E-01			
Bi214	α,β⁻,γ	19.9 m	1.16E+01	3.58E-05			
Bk249	α,β⁻,γ	3.2E+02 d	9.16E-05	1.98E-11			
Bk250	β⁻,γ	3.217 h	4.37E-11	NR			
C14	β⁻	5730 a	1.08E+01	2.05E+00	100.	407.	3.16E-02
Cd109	γ,ε	462.0 d	1.57E+01	NR			
Cd113m	β⁻,*IT*	14.1 a	1.82E-06	5.46E-07			
Ce144	β⁻,γ	284.6 d	6.26E-02	5.13E+00			
Cf249	α,γ,*SF*	351 a	6.42E-02	4.47E-03	100.	407.	1.69E-04
Cf250	α,γ,*SF*	13.1 a	3.30E-01	NR			
Cf251	α,γ	9.0E+02 a	3.78E-03	NR	100.	407.	9.29E-06
Cf252	α,γ,*SF*	2.638 a	2.39E+02	1.29E+00			
Cm242	α,γ,*SF*	162.8 d	1.14E+00	NR			
Cm243	α,γ,*SF*,ε	29.1 a	2.72E+00	4.95E+01	**100.**	**407.**	**0.128**
Cm244	α,γ,*SF*	18.1 a	3.15E+04	3.15E+02			
Cm245	α,γ,*SF*	8.5E+03 a	1.15E+02	1.46E-06	**100.**	**407.**	**0.283**
Cm246	α,γ,*SF*	4.76E+03 a	1.02E-01	NR	100.	407.	2.51E-04
Cm247	α,γ	1.56E+07 a	3.21E-09	NR	100.	407.	7.89E-12
Cm248	α,*SF*	3.48E+05 a	8.95E-02	2.05E-04	**100.**	**407.**	**2.20E-04**
Co58	β⁺,γ,ε	70.88 d	3.05E-13	1.24E-11			
Co60	β⁻,γ	5.271 a	6.46E+01	1.04E+04			
Cr51	εγ	27.70 d	NR	3.04E-06			
Cs134	β⁻,γ,ε	2.065 a	1.34E-02	1.84E+01			
Cs135	β⁻	2.3E+06 a	5.02E-04	1.17E-04	1000.	4070.	1.52E-07
Cs137	β⁻,γ	30.17 a	8.06E+03	**2.16E+05 (g)**	**1000.**	**4070.**	**55.1**
Es254	α,γ	276 d	4.24E-11	NR			

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Table 4 Continued.
40CFR191 Release Limits for WIPP TRU Waste (a)

Nuclide			WIPP TRU Waste				
ID (b)	Decay Mode (c)	Half-Life (c)	Total Inventory [Curies] (d)		Release Limits Inventory [α-Curies] (e)		EPA Unit
			CH	RH	(Ci./UW)	(Ci)	
Eu150	γ,ε	36 a	3.51E-05	NR			
Eu152	β^-,γ,εβ^+	13.48 a	1.26E+00	1.22E+03			
Eu154	β^-,γ,εγ	8.59 a	1.15E+00	5.91E+02			
Eu155	β^-,γ	4.71 a	9.46E-01	1.18E+02			
Fe55	ε	2.73 a	1.91E-05	1.69E-01			
Fe59	β^-,γ	44.51 d	2.64E-07	NR			
Fr221	α,γ	4.8 m	2.88E+00	1.17E-01			
Fr223	α,β^-,γ	21.8 m	8.39E-03	1.04E-05			
H3	β^-	12.3 a	8.69E-01	6.60E-02			
I129	β^-,γ	1.57E+07 a	7.05E-07	NR	100.	407.	1.73E-09
Kr85	β^-,γ	10.73 a	2.02E-01	1.68E+00			
Mn54	εγ	312.2 d	8.51E-04	2.35E-02			
Nb95	β^-,γ	34.97 d	2.54E-09	6.69E-01			
Nb95m	β^-,γ,*IT*	3.61 d	8.50E-12	2.24E-03			
Ni59	ε	7.6E+04 a	7.52E-03	NR	1000.	4070.	1.85E-06
Ni63	β^-	100. a	9.19E-01	9.88E-01	1000.	4070.	4.69E-04
Np237	α,γ	2.14E+06 a	5.61E+01	2.85E+00	**100.**	**407.**	**1.45E-01**
Np238	β,γ	2.117 d	8.77E-03	NR			
Np239	β^-,γ	2.355 d	3.26E+01	2.28E-04			
Np240‡	β,γ	1.032 h	NR	NR			
Np240m	β^-,γ,*IT*	7.22 m	1.50E-06	2.21E-11			
Pa231	α,γ	3.28E+04 a	4.51E-01	1.91E-03	**100.**	**407.**	**1.11E-03**
Pa233	β^-,γ	27.0 d	5.61E+01	2.85E+00			
Pa234	β^-,γ	6.69 h	5.14E-02	1.36E-02			
Pa234m	β^-,γ,*IT*	1.17 m	3.96E+01	1.05E+01			
Pb209	β^-	3.25 h	2.88E+00	1.17E-01			
Pb210	α,β^-,γ	22.3 a	2.55E+00	7.16E-06	**100.**	**407.**	**6.27E-03**
Pb211	β^-,γ	36.1 m	6.09E-01	7.58E-04			
Pb212	β^-,γ	10.64 hr	2.71E+01	7.36E-02			
Pb214	β^-,γ	27 m	1.16E+01	3.58E-05			
Pd107	β^-,γ	6.5E+06 a	7.41E-05	1.73E-05	1000.	4070.	2.25E-08
Pm147	β^-,γ	2.6234 a	7.87E+00	1.07E+01			
Po210	α,γ	138.38 d	2.55E+00	7.16E-06			
Po211	α,γ	0.516 s	1.71E-03	2.12E-06			
Po212	α	0.298 μs	1.73E+01	4.72E-02			
Po213	α	4 μs	2.82E+00	1.15E-01			
Po214	α,γ	163.7 μs	1.16E+01	3.57E-05			
Po215	α,β^-,γ	1.780 ms	6.09E-01	7.58E-04			
Po216	α,γ	0.145 s	2.71E+01	7.36E-02			
Po218	α,β^-,γ	3.10 m	1.16E+01	3.58E-05			
Pr144	β^-,γ	17.28 m	6.18E-02	5.07E+00			
Pu236	α,γ,*SF*	2.87 a	1.04E-02	NR			

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Table 4 Continued.
40CFR191 Release Limits for WIPP TRU Waste (a)

Nuclide			WIPP TRU Waste				
ID (b)	Decay Mode (c)	Half-Life (c)	Total Inventory [Curies] (d)		Release Limits Inventory [α-Curies] (e)		EPA Unit
			CH	RH	(Ci./UW)	(Ci)	
Pu238	α,γ,*SF*	87.7 a	**2.61E+06 (f)**	1.45E+03	**100.**	**407.**	**6416.**
Pu239	α,γ,*SF*	2.410E+04 a	7.85E+05	1.03E+04	**100.**	**407.**	**1954.**
Pu240	α,γ,*SF*	6.56E+03 a	2.10E+05	5.07E+03	**100.**	**407.**	**528.**
Pu241	α,β⁻,γ	14.4 a	2.31E+06	1.42E+05			
Pu242	α,γ,*SF*	3.75E+05 a	1.17E+03	1.50E-01	**100.**	**407.**	**2.88**
Pu243	β⁻,γ	4.956 h	3.21E-09	NR			
Pu244	α,*SF*	8.0E+07 a	1.50E-06	2.21E-11	**100.**	**407.**	**3.69E-09**
Ra223	α,γ	11.435 d	6.09E-01	7.58E-04			
Ra224	α,γ	3.66 d	2.71E+01	7.36E-02			
Ra225	β⁻,γ	14.9 d	2.88E+00	1.17E-01			
Ra226	α,γ	1.60E+03 a	1.16E+01	3.58E-05	**100.**	**407.**	**2.85E-02**
Ra228	β⁻,γ	5.76 a	7.47E-01	7.77E-02			
Rh106	β⁻,γ	29.9 s	2.90E-02	1.09E+01			
Rn219	α,γ	3.96 s	6.09E-01	7.58E-04			
Rn220	α,γ	55.6 s	2.71E+01	7.36E-02			
Rn222	α,γ	3.8235 d	1.16E+01	3.58E-05			
Ru106	β⁻	1.02 a	2.90E-02	1.09E+01			
Sb125	β⁻,γ	2.758 a	1.21E-01	1.89E+00			
Sb126	β⁻,γ	12.4 d	1.35E-04	3.16E-05			
Sb126m	γ,*εe*⁻	19.0 m	9.65E-04	2.25E-04			
Se79	β⁻	6.5E+04 a	4.35E-04	1.02E-04	1000.	4070.	1.32E-07
Sm151	β⁻,γ	90 a	1.47E+00	3.57E-01	1000.	4070.	4.49E-04
Sn119m	γ,*ITe*⁻	293 d	4.14E-06	9.59E-07			
Sn121m	β⁻,γ,*ITe*⁻	55 a	2.66E-02	6.69E-03	1000.	4070.	8.18E-06
Sn126	β⁻,γ	1.0E+05 a	9.65E-04	2.25E-04	1000.	4070.	2.92E-07
Sr89†	β⁻,γ	50.52 d	NR	NR			
Sr90	β⁻	29.1 a	6.85E+03	2.09E+05	**1000.**	**4070.**	**53.0**
Ta182	β⁻,γ	114.43 d	NR	4.21E-08			
Tc99	β⁻,γ	2.13E+05 a	2.52E+01	5.85E-03	10000.	40700.	6.19E-04
Te125m	γ,*ITe*⁻	58 d	2.95E-02	4.65E-01			
Te127	β⁻,γ	9.4 h	1.30E-07	1.71E-09			
Te127m	β⁻,γ,*ITe*⁻	109 d	1.33E-07	1.75E-09			
Th227	α,γ	18.72 d	6.01E-01	7.47E-04			
Th228	α,γ	1.913 a	2.71E+01	7.36E-02			
Th229	α,γ	7.3E+03 a	2.88E+00	1.17E-01	**100.**	**407.**	**7.36E-03**
Th230	α,γ	7.54E+04 a	8.06E-02	7.56E-03	**10.**	**40.7**	**2.17E-03**
Th231	β⁻,γ	1.063 d	1.28E+01	4.63E+00			
Th232	α,γ	1.4E+10 a	9.13E-01	9.25E-02	**10.**	**40.7**	**2.48E-02**
Th234	β⁻,γ	24.10 m	3.96E+01	1.05E+01			
Tl207	β⁻,γ	4.77 m	6.07E-01	7.56E-04			
Tl208	β⁻,γ	3.053 m	9.73E+00	2.65E-02			

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Table 4 Continued.
40CFR191 Release Limits for WIPP TRU Waste (a)

Nuclide			WIPP TRU Waste				
ID (b)	Decay Mode (c)	Half-Life (c)	Total Inventory [Curies] (d)		Release Limits Inventory [α-Curies] (e)		EPA Unit
			CH	RH	(Ci./UW)	(Ci)	
Tl209	β^-,γ	2.2 m	6.22E-02	2.53E-03			
Tl210‡	β,γ	1.30 m	NR	NR			
U232	α,γ,SF	70 a	2.58E+01	NR	100.	407.	6.34E-02
U233	α,γ,SF	1.592E+05 a	1.79E+03	1.58E+02	**100.**	**407.**	**4.79**
U234	α,γ,SF	2.46E+05 a	4.65E+02	4.27E+01	**100.**	**407.**	**1.25**
U235	α,γ,SF	7.04E+08 a	1.28E+01	4.63E+00	**100.**	**407.**	**4.28E-02**
U236	α,γ,SF	2.342E+07 a	3.33E-01	9.68E-02	100.	407.	1.06E-03
U237	β^-,γ	6.75 d	5.66E+01	3.48E+00			
U238	α,γ,SF	4.47E+09 a	3.96E+01	1.05E+01	**100.**	**407.**	**1.23E-01**
U240	β^-,γ	14.1 h	1.50E-06	2.21E-11			
Y90	β^-,γ	2.67 d	6.85E+03	2.09E+05			
Zn65†	$\beta^+,\gamma,\varepsilon$	243.8 d	NR	NR			
Zr93	β^-,γ	1.5E+06 a	5.63E-03	1.32E-03	1000.	4070.	1.71E-06
Zr95	β^-,γ	64.02 d	1.15E-09	3.02E-01			
		Sum =	6.42E+06 **(h)**	1.02E+06 **(i)**			(1.012E+04) **1.012E+04 (j)**
		Sum =	7.44E+06				

Top 10 Radionuclides (k)

ID (b)	Total Inventory			EPA Unit			
	CH	RH	Total	CH	RH	Total	Cumulative
Pu238	**2.61E+06 (l)**	1.45E+03	2.61E+06	6413.	3.56	6416.	0.63418
Pu239	7.85E+05	1.03E+04	7.95E+05	1929.	25.3	1954.	0.82732
Am241	4.42E+05	5.96E+03	4.48E+05	1086.	14.6	1101.	0.93611
Pu240	2.10E+05	5.07E+03	2.15E+05	516.	12.5	528.	0.98834
Cs137	8.06E+03	**2.16E+05 (g)**	2.24E+05	1.98	53.1	55.1	0.99378
Sr90	6.85E+03	2.09E+05	2.16E+05	1.68	51.4	53.0	0.99902
U233	1.79E+03	1.58E+02	1.95E+03	4.40	0.39	4.79	0.99950
Pu242	1.17E+03	1.50E-01	1.17E+03	2.87	3.69E-04	2.88	0.99978
U234	4.65E+02	4.27E+01	5.08E+02	1.14	0.10	1.25	0.99990
Cm245	1.15E+02	1.46E-06	1.15E+02	0.283	3.59E-09	0.283	0.99993

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NR Not Reported by sites (see Ref. CCA-2).

‡ Data values for radionuclides were previously reported in Rev. 1 of WTWBIR (Ref. BIR-1).

† Data values for radionuclides were previously reported in Rev. 2 of TWBIR (Ref. BIR-2).

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(a) Radionuclide inventory information taken from Transuranic Waste Baseline Inventory Database (TWBID), Ref. CCA-2. (in total, 135 radionuclides are inventoried in the TWBID)

(b) Radionuclides in bold are those 29 incorporated into the WIPP PA database, Ref. SNL-4.

(c) Decay mode and half-life information taken from the Chart of the Nuclides, 14th Ed. Ref. GE-1. [It is better for technical calculations, to use halflives that are extracted from the databases of ORIGEN2 [Ref. OR-1] because the ORIGEN2 data are of a later version than that of Ref. GE-1 (see Ref. SNL-5 for ORIGEN2 values).]

(d) Total inventory (curie) data taken from Ref. CCA-2. Values correspond to a "WIPP-Scale" design basis.

(e) Release limits are determined in accordance with 40CFR191 (Appendix A, Table 1) [Ref. EPA-1]. Left column corresponds to specific release limits (cumulative releases to the accessible environment for 10,000 years after disposal per "unit of waste" identified in Note 1(e) of Table 1, Appendix A, 40CFR191). Right column corresponds to release limit obtained for 4.07 Units of Waste (see Table 2 for calculation of the Unit of Waste) determined from data in the Transuranic Waste Baseline Inventory Database (BID) [Ref. CCA-2].

(f) Isotope with dominate curie load for CH-TRU wastes.

(g) Isotope with dominate curie load for RH-TRU wastes.

(h) Note, the total CH-TRU curie load is 6.42 MCi (also, 86.3 % of the total curie load in WIPP). The average CH-TRU volumetric total curie load is 6.42E+06/5.95E+06 = 1.08 (Ci/cu. ft.) = **38.1 (Ci/cu. m.)**. [See discussion note on Ref. LWA-1 for volumes -- CH→5.95E+06 cu. ft. Also note that the 5.95E+06 volume number is a volume limit, stored waste and projected waste volumes sum up to a volume less than this volume. The summed up volume is then "scaled" to yield a total volume of 5.95E+06, likewise the curie loads are also "scaled" by the same factor. Thus ratios of curie loads (or heat loads) to volume yield values are applicable to expected waste at WIPP (see Ref. BIR-2d).]

(i) Note, the total RH-TRU curie load is only 1.02 MCi (also, only 13.7 % of the total curie load in WIPP). This curie load is much less than the RH-TRU limit of 5.1 MCi [Ref. LWA-1]. The average RH-TRU volumetric total curie load is 1.02E+06/0.25E+06 = 4.08 (Ci/cu. ft.) = **144. (Ci/cu. m.)**. [See discussion note on Ref. LWA-1 for volumes -- RH→0.25E+06 cu. ft.]

(j) Note, there are 42 radionuclides that comprise the "EPA Unit" (see footnote e above). 25 of these radionuclides are included in the WIPP PA data base and correspond to 99.99903% of the total CH- and RH-TRU "EPA Unit" inventory. The average CH-TRU volumetric "EPA Unit" load is 9.956E+03/5.95E+06 = **1.67E-03 (EPA Unit/cu. ft.) = 5.91E-02 (EPA Unit/cu. m.)**. The average RH-TRU volumetric "EPA Unit" load is 1.611E+02/0.25E+06 = **6.44E-04 (EPA Unit/cu. ft.) = 2.28E-02 (EPA Unit/cu. m.)**. [The RH contribution to the WIPP-scale inventory of transuranic curie load is 1.611E+02*100%/(1.611E+02 + 9.956E+03)=**1.592% (very small)**.] Note, this value is about two orders of magnitude less than that presented for the CH-TRU wastes -- since the majority of the curie content of the RH-TRU waste is due to shorter-lived non-transuranic radionuclides, this means that as the shorter-lived components decay away the remaining RH-TRU waste will have a lesser curie content than CH-TRU waste (i.e., as the RH-TRU waste decays, it becomes "wimpier" than CH-TRU waste). This is evident from the RH Study (Ref. DOE-1) which showed that after about 150 → 250 years that CH-TRU waste has a higher specific activity than that of RH-TRU waste.

(k) Note, the EPA Unit (calculated to four significant figures) is the same whether the EPA Unit is calculated using all available information in the TWBID (Ref. CCA-2) or using the limited data within the WIPP PA database. [Also, only 4 radionuclides (Pu238, Pu239, Am241, and Pu240) make up 98.83% of the EPA Unit (see Ref. EPA-1b) -- using 6 radionuclides (adding Cs137 & Sr90) makes up 99.9023% -- using the top 10 radionuclides makes up 99.9932% of the EPA Unit].

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Table 5.
Radionuclides Applicable to 40CFR191
But Not Reported in TWBIR (a)

Any other alpha-emitting radionuclide with a half-life > 20 yr		
Ac-227	Gd-150	Po-209
Am-242m	Gd-152	Pt-190
Bi-210m	Hf-174	Sm-146
Bk-247	Nd-144	Sm-147
Dy-154	Np-235	Sm-148
Gd-148	Os-186	

Any other radionuclide with a half-life > 20 yr that does not emit alpha particles		
Ag-108m	Ho-166m	Pt-193
Al-26	In-115	Rb-87
Ar-39	Ir-192m	Re-186m
Ar-42	K-40	Re-187
Be-10	Kr-81	Se-82
Bi-207	La-137	Si-32
Bi-208	La-138	Ta-180m
Ca-41	Lu-176	Tb-157
Cd-113	Mn-53	Tb-158
Cl-36	Mo-93	Tc-97
Cm-250 **(b)**	Nb-91	Tc-98
Fe-60	Nb-92	Te-123
Hf-178m	Nb-94	Te-130
Hf-182	Np-236	Ti-44
Hg-194	Pb-202	V-50
Ho-163	Pb-205	

(a) See Refs. BIR-2b & EPA-1.
(b) It has not yet been proven that Cm-250 decays by anything other than spontaneous fission (since Cm-250 is very neutron rich, it is very difficult to generate it [GE-1b]).

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Table 6. Disposal Radionuclide Inventory

Nuclide ID	WIPP TRU Waste							
	Total Inventory [Curies] (a)		Mass Load [Kg] (b)			Moles Load [Moles] (c)		
	CH	RH	CH	RH	Total	CH	RH	Total
Ac225	2.88E+00	1.17E-01	4.96E-08	2.02E-09	5.16E-08	2.21E-07	8.96E-09	2.30E-07
Ac227	6.08E-01	7.57E-04	8.41E-06	1.05E-08	8.42E-06	3.70E-05	4.61E-08	3.71E-05
Ac228	7.46E-01	7.77E-02	3.33E-10	3.47E-11	3.67E-10	1.46E-09	1.52E-10	1.61E-09
Ag109m	1.57E+01	NR	6.00E-12	--	6.00E-12	5.51E-11	--	5.51E-11
Ag110	7.07E-09	1.74E-09	1.69E-21	4.17E-22	2.11E-21	1.54E-20	3.79E-21	1.92E-20
Ag110m	5.31E-07	1.31E-07	1.12E-13	2.76E-14	1.39E-13	1.02E-12	2.51E-13	1.27E-12
Am241	4.42E+05	5.96E+03	1.29E+02	1.74E+00	1.31E+02	5.34E+02	7.21E+00	5.42E+02
Am242	1.75E+00	NR	2.17E-09	--	2.17E-09	8.95E-09	--	8.95E-09
Am242m	1.75E+00	NR	1.80E-04	--	1.80E-04	7.44E-04	--	7.44E-04
Am243	3.26E+01	2.28E-04	1.64E-01	1.14E-06	1.64E-01	6.73E-01	4.71E-06	6.73E-01
Am245	1.33E-09	2.87E-16	2.15E-19	4.65E-26	2.15E-19	8.79E-19	1.90E-25	8.79E-19
At217	2.88E+00	1.17E-01	1.79E-15	7.27E-17	1.86E-15	8.25E-15	3.35E-16	8.58E-15
Ba137m	7.63E+03	2.04E+05	1.42E-08	3.79E-07	3.93E-07	1.04E-07	2.77E-06	2.87E-06
Bi210	2.55E+00	7.16E-06	2.06E-08	5.77E-14	2.06E-08	9.79E-08	2.75E-13	9.79E-08
Bi211	6.09E-01	7.58E-04	1.46E-12	1.81E-15	1.46E-12	6.90E-12	8.59E-15	6.91E-12
Bi212	2.71E+01	7.36E-02	1.85E-09	5.02E-12	1.86E-09	8.73E-09	2.37E-11	8.75E-09
Bi213	2.88E+00	1.17E-01	1.49E-10	6.05E-12	1.55E-10	6.99E-10	2.84E-11	7.28E-10
Bi214	1.16E+01	3.58E-05	2.63E-10	8.11E-16	2.63E-10	1.23E-09	3.79E-15	1.23E-09
Bk249	9.16E-05	1.98E-11	5.59E-11	1.21E-17	5.59E-11	2.25E-10	4.85E-17	2.25E-10
BK250	4.37E-11	NR	1.12E-20	--	1.12E-20	4.49E-20	--	4.49E-20
C14		1.08E+01	2.05E+00	2.42E-03	4.60E-04	2.88E-03	1.73E-01	3.29E-02
Cd109	1.57E+01	NR	6.08E-06	--	6.08E-06	5.58E-05	--	5.58E-05
Cd113m	1.84E-06	5.46E-07	8.48E-12	2.52E-12	1.10E-11	7.51E-11	2.23E-11	9.74E-11
Ce144	6.26E-02	5.13E+00	1.96E-08	1.61E-06	1.63E-06	1.36E-07	1.12E-05	1.13E-05
Cf249	6.42E-02	4.47E-03	1.57E-05	1.09E-06	1.68E-05	6.29E-05	4.38E-06	6.73E-05
Cf250	3.30E-01	NR	3.02E-06	--	3.02E-06	1.21E-05	--	1.21E-05
Cf251	3.78E-03	NR	2.38E-06	--	2.38E-06	9.50E-06	--	9.50E-06
Cf252	2.39E+02	1.29E+00	4.45E-04	2.40E-06	4.47E-04	1.76E-03	9.52E-06	1.77E-03
Cm242	1.14E+00	NR	3.45E-07	--	3.45E-07	1.42E-06	--	1.42E-06
Cm243	2.72E+00	4.95E+01	5.27E-05	9.59E-04	1.01E-03	2.17E-04	3.95E-03	4.16E-03
Cm244	3.15E+04	3.15E+02	3.89E-01	3.89E-03	3.93E-01	1.60E+00	1.60E-02	1.61E+00
Cm245	1.15E+02	1.46E-06	6.70E-01	8.51E-09	6.70E-01	2.73E+00	3.47E-08	2.73E+00
Cm246	1.02E-01	NR	3.32E-04	--	3.32E-04	1.35E-03	--	1.35E-03
Cm247	3.21E-09	NR	3.46E-08	--	3.46E-08	1.40E-07	--	1.40E-07
Cm248	8.95E-02	2.05E-04	2.11E-02	4.82E-05	2.11E-02	8.49E-02	1.94E-04	8.51E-02
Co58	3.05E-13	1.24E-11	9.58E-21	3.89E-19	3.99E-19	1.65E-19	6.72E-18	6.89E-18
Co60	6.46E+01	1.04E+04	5.71E-05	9.19E-03	9.25E-03	9.52E-04	1.53E-01	1.54E-01
Cr51	NR	3.04E-06	--	3.29E-14	3.29E-14	--	6.45E-13	6.45E-13
Cs134	1.34E-02	1.84E+01	1.03E-08	1.42E-05	1.42E-05	7.73E-08	1.06E-04	1.06E-04
Cs135	5.02E-04	1.17E-04	4.36E-04	1.02E-04	5.37E-04	3.23E-03	7.53E-04	3.98E-03
Cs137	8.06E+03	**2.16E+05 (f)**	9.26E-02	2.48E+00	2.57E+00	6.76E-01	1.81E+01	1.88E+01

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Table 6 Continued. Disposal Radionuclide Inventory

Nuclide	WIPP TRU Waste							
ID	Total Inventory [Curies] (a)		Mass Load [Kg] (b)			Moles Load [Moles] (c)		
	CH	RH	CH	RH	Total	CH	RH	Total
Es254	4.24E-11	NR	2.27E-17	--	2.27E-17	8.95E-17	--	8.95E-17
Eu150	3.51E-05	NR	5.30E-10	--	5.30E-10	3.53E-09	--	3.53E-09
Eu152	1.26E+00	1.22E+03	7.28E-06	7.05E-03	7.06E-03	4.79E-05	4.64E-02	4.65E-02
Eu154	1.15E+00	5.91E+02	4.26E-06	2.19E-03	2.19E-03	2.77E-05	1.42E-02	1.42E-02
Eu155	9.46E-01	1.18E+02	2.03E-06	2.54E-04	2.56E-04	1.31E-05	1.64E-03	1.65E-03
Fe55	1.91E-05	1.69E-01	7.63E-12	6.75E-08	6.75E-08	1.39E-10	1.23E-06	1.23E-06
Fe59	2.64E-07	NR	5.36E-15	--	5.36E-15	9.10E-14	--	9.10E-14
Fr221	2.88E+00	1.17E-01	1.62E-11	6.60E-13	1.69E-11	7.35E-11	2.99E-12	7.65E-11
Fr223	8.39E-03	1.04E-05	2.17E-13	2.69E-16	2.17E-13	9.73E-13	1.21E-15	9.74E-13
H3	8.69E-01	6.60E-02	9.05E-08	6.88E-09	9.74E-08	3.00E-05	2.28E-06	3.23E-05
I129	7.05E-07	NR	3.99E-06	--	3.99E-06	3.10E-05	--	3.10E-05
Kr85	2.02E-01	1.68E+00	5.14E-07	4.28E-06	4.79E-06	6.06E-06	5.04E-05	5.64E-05
Mn54	8.51E-04	2.35E-02	1.10E-10	3.03E-09	3.14E-09	2.04E-09	5.62E-08	5.83E-08
Nb95	2.54E-09	6.69E-01	6.49E-17	1.71E-08	1.71E-08	6.84E-16	1.80E-07	1.80E-07
Nb95m	8.50E-12	2.24E-03	2.23E-20	5.88E-12	5.88E-12	2.35E-19	6.19E-11	6.19E-11
Ni59	7.52E-03	NR	9.92E-05	--	9.92E-05	1.68E-03	--	1.68E-03
Ni63	9.19E-01	9.88E-01	1.49E-05	1.60E-05	3.09E-05	2.36E-04	2.54E-04	4.91E-04
Np237	5.61E+01	2.85E+00	7.96E+01	4.04E+00	8.36E+01	3.36E+02	1.71E+01	3.53E+02
Np238	8.77E-03	NR	3.38E-11	--	3.38E-11	1.42E-10	--	1.42E-10
Np239	3.26E+01	2.28E-04	1.41E-07	9.83E-13	1.41E-07	5.88E-07	4.11E-12	5.88E-07
Np240m	1.50E-06	2.21E-11	1.42E-17	2.09E-22	1.42E-17	5.90E-17	8.70E-22	5.90E-17
Pa231	4.51E-01	1.91E-03	9.55E-03	4.04E-05	9.59E-03	4.13E-02	1.75E-04	4.15E-02
Pa233	5.61E+01	2.85E+00	2.70E-06	1.37E-07	2.84E-06	1.16E-05	5.89E-07	1.22E-05
Pa234	5.14E-02	1.36E-02	2.57E-11	6.81E-12	3.25E-11	1.10E-10	2.91E-11	1.39E-10
Pa234m	3.96E+01	1.05E+01	5.77E-11	1.53E-11	7.30E-11	2.46E-10	6.53E-11	3.12E-10
Pb209	2.88E+00	1.17E-01	6.34E-10	2.57E-11	6.60E-10	3.03E-09	1.23E-10	3.16E-09
Pb210	2.55E+00	7.16E-06	3.34E-05	9.38E-11	3.34E-05	1.59E-04	4.47E-10	1.59E-04
Pb211	6.09E-01	7.58E-04	2.47E-11	3.07E-14	2.47E-11	1.17E-10	1.46E-13	1.17E-10
Pb212	2.71E+01	7.36E-02	1.95E-08	5.30E-11	1.96E-08	9.20E-08	2.50E-10	9.23E-08
Pb214	1.16E+01	3.58E-05	3.54E-10	1.09E-15	3.54E-10	1.65E-09	5.10E-15	1.65E-09
Pd107	7.41E-05	1.73E-05	1.44E-04	3.36E-05	1.78E-04	1.35E-03	3.14E-04	1.66E-03
Pm147	7.87E+00	1.07E+01	8.48E-06	1.15E-05	2.00E-05	5.78E-05	7.85E-05	1.36E-04
Po210	2.55E+00	7.16E-06	5.68E-07	1.59E-12	5.68E-07	2.70E-06	7.59E-12	2.70E-06
Po211	1.71E-03	2.12E-06	1.79E-17	2.22E-20	1.79E-17	8.49E-17	1.05E-19	8.50E-17
Po212	1.73E+01	4.72E-02	9.75E-20	2.66E-22	9.78E-20	4.60E-19	1.26E-21	4.61E-19
Po213	2.82E+00	1.15E-01	2.24E-19	9.12E-21	2.33E-19	1.05E-18	4.28E-20	1.09E-18
Po214	1.16E+01	3.57E-05	3.62E-17	1.11E-22	3.62E-17	1.69E-16	5.20E-22	1.69E-16
Po215	6.09E-01	7.58E-04	2.07E-17	2.57E-20	2.07E-17	9.61E-17	1.20E-19	9.62E-17
Po216	2.71E+01	7.36E-02	7.78E-14	2.11E-16	7.80E-14	3.60E-13	9.79E-16	3.61E-13
Po218	1.16E+01	3.58E-05	4.10E-11	1.27E-16	4.10E-11	1.88E-10	5.81E-16	1.88E-10
Pr144	6.18E-02	5.07E+00	8.18E-13	6.71E-11	6.79E-11	5.68E-12	4.66E-10	4.72E-10
Pu236	1.04E-02	NR	1.96E-08	--	1.96E-08	8.29E-08	--	8.29E-08

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Table 6 Continued. Disposal Radionuclide Inventory

Nuclide	WIPP TRU Waste							
ID	Total Inventory [Curies] (a)		Mass Load [Kg] (b)			Moles Load [Moles] (c)		
	CH	RH	CH	RH	Total	CH	RH	Total
Pu238	**2.61E+06** (e)	1.45E+03	1.52E+02	8.47E-02	1.53E+02	6.41E+02	3.56E-01	6.41E+02
Pu239	7.85E+05	1.03E+04	1.26E+04	1.66E+02	1.28E+04	5.28E+04	6.93E+02	5.35E+04
Pu240	2.10E+05	5.07E+03	9.22E+02	2.23E+01	9.44E+02	3.84E+03	9.27E+01	3.93E+03
Pu241	2.31E+06	1.42E+05	2.24E+01	1.38E+00	2.38E+01	9.30E+01	5.72E+00	9.88E+01
Pu242	1.17E+03	1.50E-01	3.07E+02	3.93E-02	3.07E+02	1.27E+03	1.62E-01	1.27E+03
Pu243	3.21E-09	NR	1.23E-18	--	1.23E-18	5.08E-18	--	5.08E-18
Pu244	1.50E-06	2.21E-11	8.46E-05	1.25E-09	8.46E-05	3.47E-04	5.11E-09	3.47E-04
Ra223	6.09E-01	7.58E-04	1.19E-08	1.48E-11	1.19E-08	5.33E-08	6.64E-11	5.34E-08
Ra224	2.71E+01	7.36E-02	1.70E-07	4.62E-10	1.71E-07	7.60E-07	2.06E-09	7.62E-07
Ra225	2.88E+00	1.17E-01	7.35E-08	2.98E-09	7.65E-08	3.27E-07	1.33E-08	3.40E-07
Ra226	1.16E+01	3.58E-05	1.17E-02	3.62E-08	1.17E-02	5.19E-02	1.60E-07	5.19E-02
Ra228	7.47E-01	7.77E-02	3.19E-06	3.32E-07	3.52E-06	1.40E-05	1.46E-06	1.55E-05
Rh106	2.90E-02	1.09E+01	8.14E-15	3.06E-12	3.07E-12	7.69E-14	2.89E-11	2.90E-11
Rn219	6.09E-01	7.58E-04	4.68E-14	5.83E-17	4.69E-14	2.14E-13	2.66E-16	2.14E-13
Rn220	2.71E+01	7.36E-02	2.94E-11	7.98E-14	2.95E-11	1.34E-10	3.63E-13	1.34E-10
Rn222	1.16E+01	3.58E-05	7.54E-08	2.33E-13	7.54E-08	3.40E-07	1.05E-12	3.40E-07
Ru106	2.90E-02	1.09E+01	8.66E-09	3.25E-06	3.26E-06	8.18E-08	3.07E-05	3.08E-05
Sb125	1.21E-01	1.89E+00	1.17E-07	1.83E-06	1.95E-06	9.38E-07	1.46E-05	1.56E-05
Sb126	1.35E-04	3.16E-05	1.61E-12	3.78E-13	1.99E-12	1.28E-11	3.00E-12	1.58E-11
Sb126m	9.65E-04	2.25E-04	1.23E-14	2.86E-15	1.51E-14	9.75E-14	2.27E-14	1.20E-13
Se79	4.35E-04	1.02E-04	6.24E-06	1.46E-06	7.70E-06	7.90E-05	1.85E-05	9.76E-05
Sm151	1.47E+00	3.57E-01	5.58E-05	1.36E-05	6.94E-05	3.70E-04	8.99E-05	4.60E-04
Sn119m	4.14E-06	9.59E-07	9.24E-13	2.14E-13	1.14E-12	7.77E-12	1.80E-12	9.57E-12
Sn121m	2.66E-02	6.69E-03	4.50E-07	1.13E-07	5.63E-07	3.72E-06	9.35E-07	4.65E-06
Sn126	9.65E-04	2.25E-04	3.40E-05	7.93E-06	4.19E-05	2.70E-04	6.29E-05	3.33E-04
Sr89†	NR	NR	--	--	--	--	--	--
Sr90	6.85E+03	2.09E+05	5.02E-02	1.53E+00	1.58E+00	5.58E-01	1.70E+01	1.76E+01
Ta182	NR	4.21E-08	--	6.75E-15	6.75E-15	--	3.71E-14	3.71E-14
Tc99	2.52E+01	5.85E-03	1.49E+00	3.45E-04	1.49E+00	1.50E+01	3.49E-03	1.50E+01
Te125m	2.95E-02	4.65E-01	1.64E-09	2.58E-08	2.74E-08	1.31E-08	2.07E-07	2.20E-07
Te127	1.30E-07	1.71E-09	4.92E-17	6.47E-19	4.99E-17	3.88E-16	5.10E-18	3.93E-16
Te127m	1.33E-07	1.75E-09	1.41E-14	1.85E-16	1.43E-14	1.11E-13	1.46E-15	1.12E-13
Th227	6.01E-01	7.47E-04	1.96E-08	2.43E-11	1.96E-08	8.61E-08	1.07E-10	8.62E-08
Th228	2.71E+01	7.36E-02	3.31E-05	8.98E-08	3.32E-05	1.45E-04	3.94E-07	1.45E-04
Th229	2.88E+00	1.17E-01	1.35E-02	5.50E-04	1.41E-02	5.91E-02	2.40E-03	6.15E-02
Th230	8.06E-02	7.56E-03	3.99E-03	3.75E-04	4.37E-03	1.74E-02	1.63E-03	1.90E-02
Th231	1.28E+01	4.63E+00	2.41E-08	8.71E-09	3.28E-08	1.04E-07	3.77E-08	1.42E-07
Th232	9.13E-01	9.25E-02	8.33E+03	8.44E+02	9.17E+03	3.59E+04	3.64E+03	3.95E+04
Th234	3.96E+01	1.05E+01	1.71E-06	4.54E-07	2.16E-06	7.31E-06	1.94E-06	9.25E-06
Tl207	6.07E-01	7.56E-04	3.19E-12	3.97E-15	3.19E-12	1.54E-11	1.92E-14	1.54E-11
Tl208	9.73E+00	2.65E-02	3.30E-11	9.00E-14	3.31E-11	1.59E-10	4.33E-13	1.59E-10

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Table 6 Continued. Disposal Radionuclide Inventory

Nuclide ID	WIPP TRU Waste							
	Total Inventory [Curies] (a)		Mass Load [Kg] (b)			Moles Load [Moles] (c)		
	CH	RH	CH	RH	Total	CH	RH	Total
Tl209	6.22E-02	2.53E-03	1.52E-13	6.19E-15	1.58E-13	7.28E-13	2.96E-14	7.57E-13
U232	2.58E+01	NR	1.21E-03	--	1.21E-03	5.20E-03	--	5.20E-03
U233	1.79E+03	1.58E+02	1.85E+02	1.63E+01	2.01E+02	7.94E+02	7.01E+01	8.64E+02
U234	4.65E+02	4.27E+01	7.44E+01	6.83E+00	8.13E+01	3.18E+02	2.92E+01	3.47E+02
U235	1.28E+01	4.63E+00	5.92E+03	2.14E+03	8.07E+03	2.52E+04	9.12E+03	3.43E+04
U236	3.33E-01	9.68E-02	5.15E+00	1.50E+00	6.64E+00	2.18E+01	6.34E+00	2.82E+01
U237	5.66E+01	3.48E+00	6.94E-07	4.26E-08	7.36E-07	2.93E-06	1.80E-07	3.11E-06
U238	3.96E+01	1.05E+01	**1.18E+05 (g)**	**3.12E+04 (h)**	**1.49E+05 (i)**	**4.95E+05 (j)**	**1.31E+05 (k)**	**6.26E+05 (l)**
U240	1.50E-06	2.21E-11	1.62E-15	2.39E-20	1.62E-15	6.75E-15	9.94E-20	6.75E-15
Y90	6.85E+03	2.09E+05	1.26E-05	3.84E-04	3.96E-04	1.40E-04	4.27E-03	4.41E-03
Zn65†	NR	NR	--	--	--	--	--	--
Zr93	5.63E-03	1.32E-03	2.24E-03	5.25E-04	2.76E-03	2.41E-02	5.65E-03	2.97E-02
Zr95	1.15E-09	3.02E-01	5.35E-17	1.40E-08	1.40E-08	5.64E-16	1.48E-07	1.48E-07
Total	6.42E+06	1.02E+06	1.47E+05	3.44E+04	1.81E+05	6.17E+05	1.45E+05	7.62E+05

-- Not calculated.

NR Not Reported by sites (see Ref. CCA-2).

† Data values for radionuclides were previously reported in Rev. 2 of TWBIR (Ref. BIR-2).

(a) Radionuclide inventory information taken from Transuranic Waste Baseline Inventory Database (TWBID), Ref. CCA-2. (in total, 135 radionuclides are inventoried in the TWBID) Values correspond to a "WIPP-Scale" design basis.

(b) Data calculated from the equation;

$$\text{Mass Load} = TOTAL\ ACTIVITY(Ci)\frac{3.7E+10(dis/sec)}{Ci}\ \frac{\tau_{1/2}}{ln(2)}\ \frac{AtWt}{Na}\ \frac{kg}{1000\,gm}$$

(c) Data calculated from the equation;

$$\text{Mole Load} = MassLoad\ \frac{1}{AtWt}\ \frac{1000\,gm}{kg}$$

(e) Isotope with dominate curie load for CH-TRU wastes.

(f) Isotope with dominate curie load for RH-TRU wastes.

(g) Isotope with dominate mass load for CH-TRU wastes.

(h) Isotope with dominate mass load for RH-TRU wastes.

(i) Isotope with dominate mass load for CH- & RH-TRU wastes.

(j) Isotope with dominate mole load for CH-TRU wastes.

(k) Isotope with dominate mole load for RH-TRU wastes.

(l) Isotope with dominate mole load for CH- & RH-TRU wastes.

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Table 7. Disposal Radionuclide Inventory

Nuclide			WIPP TRU Waste					
ID	Energy		Total Inventory [Curies] (b)		Heat Load [Watts] (c)		% Heat Load [%]	
	$\frac{MeV}{dis}$ (a)	$\frac{W}{Ci}$	CH	RH	CH	RH	CH	RH
Ac225	5.893	3.49E-02	2.88E+00	1.17E-01	1.01E-01	4.09E-03	7.56E-05	1.22E-04
Ac227	0.082	4.84E-04	6.08E-01	7.57E-04	2.94E-04	3.67E-07	2.21E-07	1.09E-08
Ac228	1.458	8.64E-03	7.46E-01	7.77E-02	6.45E-03	6.72E-04	4.85E-06	2.00E-05
Ag109m	0.087	5.15E-04	1.57E+01	NR	8.09E-03	--	6.08E-06	--
Ag110	1.212	7.18E-03	7.07E-09	1.74E-09	5.08E-11	1.25E-11	3.82E-14	3.72E-13
Ag110m	2.817	1.67E-02	5.31E-07	1.31E-07	8.87E-09	2.19E-09	6.67E-12	6.51E-11
Am241	5.604	3.32E-02	4.42E+05	5.96E+03	1.47E+04	1.98E+02	1.10E+01	5.89E+00
Am242	0.192	1.14E-03	1.75E+00	NR	1.99E-03	--	1.49E-06	--
Am242m	0.067	3.95E-04	1.75E+00	NR	6.91E-04	--	5.20E-07	--
Am243	5.423	3.21E-02	3.26E+01	2.28E-04	1.05E+00	7.33E-06	7.88E-04	2.18E-07
Am245	0.313	1.86E-03	1.33E-09	2.87E-16	2.47E-12	5.32E-19	1.86E-15	1.58E-20
At217	7.199	4.27E-02	2.88E+00	1.17E-01	1.23E-01	4.99E-03	9.24E-05	1.49E-04
Ba137m	0.662	3.93E-03	7.63E+03	2.04E+05	3.00E+01	8.01E+02	2.25E-02	2.38E+01
Bi210	0.389	2.31E-03	2.55E+00	7.16E-06	5.88E-03	1.65E-08	4.42E-06	4.91E-10
Bi211	6.729	3.99E-02	6.09E-01	7.58E-04	2.43E-02	3.02E-05	1.83E-05	9.00E-07
Bi212	2.869	1.70E-02	2.71E+01	7.36E-02	4.61E-01	1.25E-03	3.47E-04	3.73E-05
Bi213	0.709	4.20E-03	2.88E+00	1.17E-01	1.21E-02	4.92E-04	9.10E-06	1.46E-05
Bi214	2.162	1.28E-02	1.16E+01	3.58E-05	1.49E-01	4.59E-07	1.12E-04	1.37E-08
Bk249	0.125	7.41E-04	9.16E-05	1.98E-11	6.79E-08	1.47E-14	5.10E-11	4.37E-16
Bk250	1.172	6.95E-03	4.37E-11	NR	3.04E-13	--	2.28E-16	--
C14	0.049	2.93E-04	1.08E+01	2.05E+00	3.17E-03	6.01E-04	2.38E-06	1.79E-05
Cd109	0.020	1.16E-04	1.57E+01	NR	1.82E-03	--	1.37E-06	--
Cd113m	0.284	1.68E-03	1.84E-06	5.46E-07	3.10E-09	9.19E-10	2.33E-12	2.74E-11
Ce144	0.112	6.63E-04	6.26E-02	5.13E+00	4.15E-05	3.40E-03	3.12E-08	1.01E-04
Cf249	7.806	4.63E-02	6.42E-02	4.47E-03	2.97E-03	2.07E-04	2.23E-06	6.16E-06
Cf250	6.267	3.71E-02	3.30E-01	NR	1.23E-02	--	9.22E-06	--
Cf251	6.027	3.57E-02	3.78E-03	NR	1.35E-04	--	1.02E-07	--
Cf252	12.04	7.14E-02	2.39E+02	1.29E+00	1.71E+01	9.21E-02	1.28E-02	2.74E-03
Cm242	6.216	3.68E-02	1.14E+00	NR	4.20E-02	--	3.16E-05	--
Cm243	6.189	3.67E-02	2.72E+00	4.95E+01	9.98E-02	1.82E+00	7.50E-05	5.40E-02
Cm244	5.901	3.50E-02	3.15E+04	3.15E+02	1.10E+03	1.10E+01	8.28E-01	3.28E-01
Cm245	5.598	3.32E-02	1.15E+02	1.46E-06	3.82E+00	4.84E-08	2.87E-03	1.44E-09
Cm246	5.523	3.27E-02	1.02E-01	NR	3.34E-03	--	2.51E-06	--
Cm247	5.390	3.20E-02	3.21E-09	NR	1.03E-10	--	7.71E-14	--
Cm248	21.00	1.24E-01	8.95E-02	2.05E-04	1.11E-02	2.55E-05	8.38E-06	7.59E-07
Co58	1.009	5.98E-03	3.05E-13	1.24E-11	1.82E-15	7.42E-14	1.37E-18	2.21E-15
Co60	2.601	1.54E-02	6.46E+01	1.04E+04	9.96E-01	1.60E+02	7.49E-04	4.77E+00
Cr51	0.036	2.15E-04	NR	3.04E-06	--	6.52E-10	--	1.94E-11
Cs134	1.717	1.02E-02	1.34E-02	1.84E+01	1.36E-04	1.87E-01	1.03E-07	5.57E-03
Cs135	0.056	3.34E-04	5.02E-04	1.17E-04	1.68E-07	3.90E-08	1.26E-10	1.16E-09
Cs137	0.187	1.11E-03	8.06E+03	**2.16E+05** (f)	8.92E+00	2.39E+02	6.70E-03	7.11E+00
Es254	6.623	3.93E-02	4.24E-11	NR	1.66E-12	--	1.25E-15	--

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Table 7 Continue. Disposal Radionuclide Inventory

Nuclide			WIPP TRU Waste					
ID	Energy		Total Inventory [Curies] (b)		Heat Load [Watts] (c)		% Heat Load [%]	
	$\frac{MeV}{dis}$ (a)	$\frac{W}{Ci}$	CH	RH	CH	RH	CH	RH
Eu150	1.540	9.13E-03	3.51E-05	NR	3.20E-07	--	2.41E-10	--
Eu152	1.276	7.56E-03	1.26E+00	1.22E+03	9.53E-03	9.23E+00	7.17E-06	2.75E-01
Eu154	1.509	8.95E-03	1.15E+00	5.91E+02	1.03E-02	5.29E+00	7.73E-06	1.57E-01
Eu155	0.123	7.27E-04	9.46E-01	1.18E+02	6.88E-04	8.58E-02	5.17E-07	2.55E-03
Fe55	0.006	3.38E-05	1.91E-05	1.69E-01	6.45E-10	5.71E-06	4.85E-13	1.70E-07
Fe59	1.306	7.74E-03	2.64E-07	NR	2.04E-09	--	1.54E-12	--
Fr221	6.511	3.86E-02	2.88E+00	1.17E-01	1.11E-01	4.52E-03	8.36E-05	1.34E-04
Fr223	0.438	2.60E-03	8.39E-03	1.04E-05	2.18E-05	2.70E-08	1.64E-08	8.04E-10
H3	0.006	3.37E-05	8.69E-01	6.60E-02	2.93E-05	2.22E-06	2.20E-08	6.61E-08
I129	0.078	4.63E-04	7.05E-07	NR	3.26E-10	--	2.45E-13	--
Kr85	0.253	1.50E-03	2.02E-01	1.68E+00	3.03E-04	2.52E-03	2.28E-07	7.49E-05
Mn54	0.840	4.98E-03	8.51E-04	2.35E-02	4.24E-06	1.17E-04	3.19E-09	3.48E-06
Nb95	0.809	4.80E-03	2.54E-09	6.69E-01	1.22E-11	3.21E-03	9.16E-15	9.55E-05
Nb95m	0.234	1.39E-03	8.50E-12	2.24E-03	1.18E-14	3.11E-06	8.88E-18	9.26E-08
Ni59	0.007	3.97E-05	7.52E-03	NR	2.99E-07	--	2.25E-10	--
Ni63	0.017	1.01E-04	9.19E-01	9.88E-01	9.26E-05	9.96E-05	6.96E-08	2.96E-06
Np237	5.156	3.06E-02	5.61E+01	2.85E+00	1.71E+00	8.71E-02	1.29E-03	2.59E-03
Np238	0.408	4.79E-03	8.77E-03	NR	4.20E-05	--	3.16E-08	--
Np239	1.788	2.42E-03	3.26E+01	2.28E-04	7.88E-02	5.51E-07	5.93E-05	1.64E-08
Np240m	0.978	5.80E-03	1.50E-06	2.21E-11	8.69E-09	1.28E-13	6.54E-12	3.81E-15
Pa231	5.083	3.01E-02	4.51E-01	1.91E-03	1.36E-02	5.76E-05	1.02E-05	1.71E-06
Pa233	0.383	2.27E-03	5.61E+01	2.85E+00	1.27E-01	6.47E-03	9.57E-05	1.93E-04
Pa234	2.423	1.44E-02	5.14E-02	1.36E-02	7.38E-04	1.95E-04	5.55E-07	5.81E-06
Pa234m	0.834	4.94E-03	3.96E+01	1.05E+01	1.96E-01	5.19E-02	1.47E-04	1.54E-03
Pb209	0.194	1.15E-03	2.88E+00	1.17E-01	3.31E-03	1.35E-04	2.49E-06	4.00E-06
Pb210	0.039	2.32E-04	2.55E+00	7.16E-06	5.91E-04	1.66E-09	4.44E-07	4.94E-11
Pb211	0.505	3.00E-03	6.09E-01	7.58E-04	1.82E-03	2.27E-06	1.37E-06	6.76E-08
Pb212	0.321	1.90E-03	2.71E+01	7.36E-02	5.16E-02	1.40E-04	3.88E-05	4.17E-06
Pb214	0.538	3.19E-03	1.16E+01	3.58E-05	3.70E-02	1.14E-07	2.78E-05	3.40E-09
Pd107	0.010	5.93E-05	7.41E-05	1.73E-05	4.39E-09	1.03E-09	3.30E-12	3.05E-11
Pm147	0.061	3.59E-04	7.87E+00	1.07E+01	2.82E-03	3.84E-03	2.12E-06	1.14E-04
Po210	5.408	3.21E-02	2.55E+00	7.16E-06	8.17E-02	2.30E-07	6.15E-05	6.83E-09
Po211	7.592	4.50E-02	1.71E-03	2.12E-06	7.70E-05	9.54E-08	5.79E-08	2.84E-09
Po212	8.940	5.30E-02	1.73E+01	4.72E-02	9.17E-01	2.50E-03	6.89E-04	7.44E-05
Po213	8.537	5.06E-02	2.82E+00	1.15E-01	1.43E-01	5.82E-03	1.07E-04	1.73E-04
Po214	7.833	4.64E-02	1.16E+01	3.57E-05	5.39E-01	1.66E-06	4.05E-04	4.93E-08
Po215	7.531	4.46E-02	6.09E-01	7.58E-04	2.72E-02	3.38E-05	2.04E-05	1.01E-06
Po216	6.906	4.09E-02	2.71E+01	7.36E-02	1.11E+00	3.01E-03	8.34E-04	8.97E-05
Po218	6.113	3.62E-02	1.16E+01	3.58E-05	4.20E-01	1.30E-06	3.16E-04	3.86E-08
Pr144	1.240	7.35E-03	6.18E-02	5.07E+00	4.54E-04	3.73E-02	3.42E-07	1.11E-03
Pu236	5.871	3.48E-02	1.04E-02	NR	3.62E-04	--	2.72E-07	--

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Table 7 Continue. Disposal Radionuclide Inventory

Nuclide			WIPP TRU Waste					
ID	Energy		Total Inventory [Curies] (b)		Heat Load [Watts] (c)		% Heat Load [%]	
	$\frac{MeV}{dis}$ (a)	$\frac{W}{Ci}$	CH	RH	CH	RH	CH	RH
Pu238	5.591	3.31E-02	**2.61E+06** (e)	1.45E+03	**8.65E+04** (g)	4.81E+01	**6.50E+01** (g)	1.43E+00
Pu239	5.199	3.08E-02	7.85E+05	1.03E+04	2.42E+04	3.17E+02	1.82E+01	9.45E+00
Pu240	5.253	3.11E-02	2.10E+05	5.07E+03	6.54E+03	1.58E+02	4.92E+00	4.70E+00
Pu241	0.005	3.10E-05	2.31E+06	1.42E+05	7.16E+01	4.40E+00	5.38E-02	1.31E-01
Pu242	4.982	2.95E-02	1.17E+03	1.50E-01	3.46E+01	4.43E-03	2.60E-02	1.32E-04
Pu243	0.195	1.15E-03	3.21E-09	NR	3.70E-12	--	2.79E-15	--
Pu244	4.892	2.90E-02	1.50E-06	2.21E-11	4.35E-08	6.41E-13	3.27E-11	1.91E-14
Ra223	6.007	3.56E-02	6.09E-01	7.58E-04	2.17E-02	2.70E-05	1.63E-05	8.03E-07
Ra224	5.790	3.43E-02	2.71E+01	7.36E-02	9.30E-01	2.53E-03	6.99E-04	7.52E-05
Ra225	0.118	7.01E-04	2.88E+00	1.17E-01	2.02E-03	8.20E-05	1.52E-06	2.44E-06
Ra226	4.871	2.89E-02	1.16E+01	3.58E-05	3.35E-01	1.03E-06	2.52E-04	3.08E-08
Ra228	0.013	7.71E-05	7.47E-01	7.77E-02	5.76E-05	5.99E-06	4.33E-08	1.78E-07
Rh106	1.618	9.59E-03	2.90E-02	1.09E+01	2.78E-04	1.05E-01	2.09E-07	3.11E-03
Rn219	7.000	4.15E-02	6.09E-01	7.58E-04	2.53E-02	3.15E-05	1.90E-05	9.36E-07
Rn220	6.405	3.80E-02	2.71E+01	7.36E-02	1.03E+00	2.79E-03	7.74E-04	8.32E-05
Rn222	5.590	3.31E-02	1.16E+01	3.58E-05	3.84E-01	1.19E-06	2.89E-04	3.53E-08
Ru106	0.010	5.95E-05	2.90E-02	1.09E+01	1.72E-06	6.48E-04	1.30E-09	1.93E-05
Sb125	0.527	3.13E-03	1.21E-01	1.89E+00	3.78E-04	5.91E-03	2.84E-07	1.76E-04
Sb126	3.117	1.85E-02	1.35E-04	3.16E-05	2.49E-06	5.84E-07	1.88E-09	1.74E-08
Sb126m	2.148	1.27E-02	9.65E-04	2.25E-04	1.23E-05	2.86E-06	9.24E-09	8.53E-08
Se79	0.042	2.49E-04	4.35E-04	1.02E-04	1.08E-07	2.54E-08	8.14E-11	7.56E-10
Sm151	0.020	1.17E-04	1.47E+00	3.57E-01	1.72E-04	4.19E-05	1.30E-07	1.25E-06
Sn119m	0.087	5.17E-04	4.14E-06	9.59E-07	2.14E-09	4.96E-10	1.61E-12	1.48E-11
Sn121m	0.338	2.00E-03	2.66E-02	6.69E-03	5.33E-05	1.34E-05	4.01E-08	3.99E-07
Sn126	0.210	1.25E-03	9.65E-04	2.25E-04	1.20E-06	2.81E-07	9.05E-10	8.35E-09
Sr89†	0.583	3.46E-03	NR	NR	--	--	--	--
Sr90	0.196	1.16E-03	6.85E+03	2.09E+05	7.95E+00	2.43E+02	5.98E-03	7.22E+00
Ta182	1.502	8.90E-03	NR	4.21E-08	--	3.75E-10	--	1.12E-11
Tc99	0.085	5.01E-04	2.52E+01	5.85E-03	1.26E-02	2.93E-06	9.50E-06	8.73E-08
Te125m	0.142	8.41E-04	2.95E-02	4.65E-01	2.48E-05	3.91E-04	1.86E-08	1.16E-05
Te127	0.228	1.35E-03	1.30E-07	1.71E-09	1.76E-10	2.31E-12	1.32E-13	6.87E-14
Te127m	0.091	5.38E-04	1.33E-07	1.75E-09	7.15E-11	9.41E-13	5.38E-14	2.80E-14
Th227	6.157	3.65E-02	6.01E-01	7.47E-04	2.19E-02	2.73E-05	1.65E-05	8.11E-07
Th228	5.517	3.27E-02	2.71E+01	7.36E-02	8.86E-01	2.41E-03	6.66E-04	7.16E-05
Th229	5.161	3.06E-02	2.88E+00	1.17E-01	8.81E-02	3.58E-03	6.62E-05	1.07E-04
Th230	4.774	2.83E-02	8.06E-02	7.56E-03	2.28E-03	2.14E-04	1.71E-06	6.37E-06
Th231	0.095	5.61E-04	1.28E+01	4.63E+00	7.18E-03	2.60E-03	5.40E-06	7.73E-05
Th232	4.084	2.42E-02	9.13E-01	9.25E-02	2.21E-02	2.24E-03	1.66E-05	6.66E-05
Th234	0.068	4.05E-04	3.96E+01	1.05E+01	1.61E-02	4.26E-03	1.21E-05	1.27E-04
Tl207	0.495	2.94E-03	6.07E-01	7.56E-04	1.78E-03	2.22E-06	1.34E-06	6.61E-08
Tl208	3.970	2.35E-02	9.73E+00	2.65E-02	2.29E-01	6.24E-04	1.72E-04	1.86E-05

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Table 7 Continue. Disposal Radionuclide Inventory

Nuclide			WIPP TRU Waste					
ID	Energy		Total Inventory [Curies] (b)		Heat Load [Watts] (c)		% Heat Load [%]	
	$\frac{MeV}{dis}$ (a)	$\frac{W}{Ci}$	CH	RH	CH	RH	CH	RH
Tl209	2.803	1.66E-02	6.22E-02	2.53E-03	1.03E-03	4.20E-05	7.77E-07	1.25E-06
U232	5.416	3.21E-02	2.58E+01	NR	8.28E-01	--	6.23E-04	--
U233	4.904	2.91E-02	1.79E+03	1.58E+02	5.20E+01	4.59E+00	3.91E-02	1.37E-01
U234	4.859	2.88E-02	4.65E+02	4.27E+01	1.34E+01	1.23E+00	1.01E-02	3.66E-02
U235	4.418	2.62E-02	1.28E+01	4.63E+00	3.35E-01	1.21E-01	2.52E-04	3.61E-03
U236	4.570	2.71E-02	3.33E-01	9.68E-02	9.02E-03	2.62E-03	6.78E-06	7.80E-05
U237	0.319	1.89E-03	5.66E+01	3.48E+00	1.07E-01	6.58E-03	8.05E-05	1.96E-04
U238	4.279	2.54E-02	3.96E+01	1.05E+01	1.00E+00	2.66E-01	7.55E-04	7.93E-03
U240	0.138	8.20E-04	1.50E-06	2.21E-11	1.23E-09	1.81E-14	9.25E-13	5.40E-16
Y90	0.935	5.54E-03	6.85E+03	2.09E+05	3.80E+01	**1.16E+03** (h)	2.85E-02	**3.45E+01** (h)
Zn65†	0.590	3.50E-03	NR	NR	--	--	--	--
Zr93	0.020	1.16E-04	5.63E-03	1.32E-03	6.54E-07	1.53E-07	4.92E-10	4.56E-09
Zr95	0.855	5.07E-03	1.15E-09	3.02E-01	5.83E-12	1.53E-03	4.38E-15	4.55E-05
Sum=			**6.42E+06** (i)	**1.02E+06** (j)	**1.33E+05** (k)	**3.36E+03** (l)	1.00E+02	1.00E+02

-- Not calculated.

NR Not Reported by sites (see Ref. CCA-2).

† Data values for radionuclides were previously reported in Rev. 2 of TWBIR (Ref. BIR-2).

(a) Data from Ref OR-1.

(b) Radionuclide inventory information taken from Transuranic Waste Baseline Inventory Database (TWBID), Ref. CCA-2. (in total, 135 radionuclides are inventoried in the TWBID) Values correspond to a "WIPP-Scale" design basis.

(c) Data calculated from the equation;

$$\text{Heat Load} = TOTAL\ ACTIVITY(Ci)\frac{3.7E+10(dis/sec)}{Ci}\ ENERGY(MeV/dis)\ \frac{E+06\,eV}{MeV}\ \frac{1.60219E-19\,J}{eV}\ \frac{watt-sec}{J}$$

$$\text{Heat Load (watts)} = 0.005928103 \times TOTAL\ ACTIVITY(Ci) \times ENERGY(MeV/dis)$$

(e) Isotope with dominate curie load for CH-TRU wastes.

(f) Isotope with dominate curie load for RH-TRU wastes.

(g) Isotope with dominate heat load for CH-TRU wastes.

(h) Isotope with dominate heat load for RH-TRU wastes.

(i) Note, the total CH-TRU curie load is 6.42 MCi (also, 86.3 % of the total curie load in WIPP). The average CH-TRU volumetric total curie load is 6.42E+06/5.95E+06 = 1.079 (Ci/cu. ft.) = **38.10 (Ci/cu. m.)**. [See discussion note on Ref. LWA-1 for volumes -- CH→5.95E+06 cu. ft. Also note that the 5.95E+06 volume number is a volume limit, stored waste and projected waste volumes sum up to a volume less than this volume. The summed up volume is then "scaled" to yield a total volume of 5.95E+06, likewise the curie loads are also "scaled" by the same factor. Thus ratios of curie loads (or heat loads) to volume yield values applicable to expected waste at WIPP (See Ref. BIR-2d).]

(j) Note, the total RH-TRU curie load is only 1.02 MCi (also, 13.7 % of the total curie load in WIPP). This curie load is much less than the RH-TRU limit of 5.1 MCi [Ref. LWA-1]. The average RH-TRU volumetric total curie load is 1.02E+06/0.25E+06 = 4.08 (Ci/cu. ft.) = **144.1 (Ci/cu. m.)**. [See discussion note on Ref. LWA-1 for volumes -- RH→0.25E+06 cu. ft.]

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(k) Note, the total CH-TRU heat load is only **133. kW** (also, 97.5 % of the total heat load in WIPP). The ratio for CH-TRU of total heat load to total curie load is 133.E+03/6.42E+06 = **0.0207 W/Ci**. The average CH-TRU volumetric heat load is 133.E+03/5.95E+06 = 0.0224 (W/cu. ft.) = 0.7894 (W/cu. m.). The average CH-TRU drum heat load is 0.7894 (W/cu. m.)x 0.2082 (cu. m.) = **0.1644 W**. [The volume of a CH-TRU drum was set equal to the nominal volume of a 55-gal drum.]

(l) Note, the total RH-TRU heat load is only **3.36 kW** (also, 2.5 % of the total heat load in WIPP). The ratio for RH-TRU of total heat load to total curie load is 3.36E+03/1.02E+06 = **0.003294 W/Ci**. The average RH-TRU volumetric heat load is 3.36E+03/0.25E+06 = 0.0134 (W/cu. ft.) = 0.47 (W/cu. m.). The average RH-TRU canister heat load is 0.47 (W/cu. m.)x 0.6246 (cu. m.) = **0.2964 W** (this is about two times that of an average CH-TRU drum). [The volume of a RH-TRU canister was set equal to three times the nominal volume of a 55-gal drum. Even though the reported volume of a RH-TRU canister is 0.89 cu. m. (Ref. BIR-2e), these canisters are loaded with three 55-gal drums internally. Ref. DOE-1.]

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