559257

Sandia National Laboratories
Waste Isolation Pilot Plant

# Radionuclide Inventory Screening Analysis for the 2014 Compliance Recertification Application Performance Assessment (CRA-2014 PA)

Revision 0

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# ACRONYMS

| | |
|---|---|
| CCA | Compliance Certification Application |
| CFR | Code of Federal Regulations |
| CH | contact handled |
| CRA | Compliance Recertification Application |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| LANL | Los Alamos National Laboratory |
| PA | performance assessment |
| PABC | Performance Assessment Baseline Calculation |
| PAIR | Performance Assessment Inventory Report |
| PAVT | Performance Assessment Verification Test |
| RH | remote handled |
| SNL | Sandia National Laboratories |
| TRU | transuranic |
| WIPP | Waste Isolation Pilot Plant |
| WUF | waste unit factor |

# 1. INTRODUCTION

The Waste Isolation Pilot Plant (WIPP), located in southeastern New Mexico, has been developed by the U.S. Department of Energy (DOE) for the geologic (deep underground) disposal of transuranic (TRU) waste. Containment of TRU waste at the WIPP is regulated by the U.S. Environmental Protection Agency (EPA) according to the regulations set forth in Title 40 of the Code of Federal Regulations (CFR), Part 191. The DOE demonstrates compliance with the containment requirements according to the Certification Criteria in Title 40 CFR Part 194 by means of performance assessment (PA) calculations performed by Sandia National Laboratories (SNL). WIPP PA calculations estimate the probability and consequence of potential radionuclide releases from the repository to the accessible environment for a regulatory period of 10,000 years after facility closure. The models used in PA are maintained and updated with new information as part of a recertification process that occurs at five-year intervals following the receipt of the first waste shipment at the site in 1999.

PA calculations were included in the 1996 Compliance Certification Application (CCA) (U.S. DOE 1996), and in a subsequent Performance Assessment Verification Test (PAVT) (MacKinnon and Freeze 1997a, 1997b and 1997c). Based in part on the CCA and PAVT PA calculations, the EPA certified that the WIPP met the regulatory containment criteria. The facility was approved for disposal of TRU waste in May 1998 (U.S. EPA 1998). PA calculations were an integral part of the 2004 Compliance Recertification Application (CRA-2004) (U.S. DOE 2004). During their review of the CRA-2004, the EPA requested an additional PA calculation, referred to as the CRA-2004 Performance Assessment Baseline Calculation (PABC) (Leigh et al. 2005), be conducted with modified assumptions and parameter values (Cotsworth 2005). Following review of the CRA-2004 and the CRA-2004 PABC, the EPA recertified the WIPP in March 2006 (U.S. EPA 2006).

PA calculations were completed for the second WIPP recertification and documented in the 2009 Compliance Recertification Application (CRA-2009). The CRA-2009 PA resulted from continued review of the CRA-2004 PABC, including a number of technical changes and corrections, as well as updates to parameters and improvements to the PA computer codes (Clayton et al. 2008). To incorporate additional information which was received after the CRA-2009 PA was completed, but before the submittal of the CRA-2009, the EPA has requested an additional PA calculation, referred to as the 2009 Compliance Recertification Application Performance Assessment Baseline Calculation (PABC-2009), be undertaken which included updated information (Cotsworth 2009). Following the completion and submission of the PABC-2009, the WIPP was recertified in 2010 (U.S. EPA 2010).

The Land Withdrawal Act (U.S. Congress 1992) requires that the DOE apply for WIPP recertification every five years following the initial 1999 waste shipment. The results of the analysis described herein will be included in the 2014 Compliance Recertification Application (CRA-2014) to demonstrate regulatory compliance with the containment requirements according to the Certification Criteria in Title 40 CFR Part 194.

The Performance Assessment Inventory Report (PAIR) – 2012 (Van Soest 2012) was released on November 29, 2012. The PAIR – 2012 contains updated estimates to the radionuclide content and waste material parameters, scaled to a full repository, based on inventory information collected up to December 31, 2011. This inventory update is the basis for the PA inventory for CRA-2014.

This analysis is governed by AP-164, *Analysis Plan for the 2014 WIPP Compliance Recertification Application Performance Assessment*, which discusses the methodology that will be used by Sandia National Laboratories to determine the WIPP repository radionuclide inventory information for use in the PA calculation for the CRA-2014.

This calculation was performed in accordance with the SNL Quality Assurance Program and was prepared as prescribed by the SNL NWMP Procedure, NP 9-1, *Analyses*, Section 2.2, "Routine Calculations."

Appendix A contains radionuclide inventories and potential releases (in EPA units) at six times. Appendix B contains radionuclide release limits and a calculation of the unit of waste. Appendix C presents the parameter values to be included in the CRA-2014 PA calculations based on the PAIR 2012 (Van Soest 2012). Appendix D explains how the EPAUNI input files are generated from the inventory database. Appendix E explains how the tables of this report are generated from the inventory database.

# 2. CALCULATION OF WASTE UNIT FACTOR

## 2.1 PROBLEM DESCRIPTION

The waste unit factor (WUF), also referred to as the "unit of waste," is defined in the CCA as the number of millions of curies of alpha-emitting TRU radionuclides with half-lives longer than 20 years destined for disposal in the WIPP repository (U.S. DOE 1996). Computation of a new waste unit factor based on the updated inventory information provided by Van Soest (2012), is required for the CRA-2014 PA. This computation is performed using the following equation (Sanchez et al.1997):

$$f_w = \frac{\sum W_i}{10^6\ Ci} \qquad (1)$$

where $f_w$ is the waste unit factor, and
$W_i$ is the WIPP-scale activity in curies (Ci) for alpha-emitting TRU repository wastes having half-lives greater than 20 years.

This calculation uses the WIPP-scale inventory provided by Van Soest (2012) at the following years: 2033, 2133, 2383, 3033, 7033, and 12,033.

## 2.2 ANALYSIS

To determine the radionuclides that are important with respect to WIPP PA, the release limits per 40 CFR 191 must be considered (see Appendix B, Table B-1). These release limits are normalized to a "unit of waste" (also called a "waste unit factor," $f_w$). For the TRU waste to be disposed of in the WIPP, the unit of waste is "an amount of TRU wastes containing one million curies of alpha-emitting transuranic radionuclides with half-lives greater than 20 years" (40 CFR

191, Appendix A, Table 1). The unit of waste is determined in Table B-2 in Appendix B and summarized in Table 1. From these tables it can be seen that of the 179 radionuclides in the current inventory report (Van Soest 2012, Tables 5-3 and 5-4), there are reported data for 17 TRU waste radionuclides that contribute to the unit of waste. The overall quantity of TRU waste radionuclides from Table B-2 that apply to the unit of waste at 2033 is 2.06E+06 curies, thus the value for the unit of waste is **2.06**. From Table 1 it is easily identified that the plutonium and americium radionuclides dominate the unit of waste.

For release to the accessible environment that involves a mix of radionuclides, the release limits in Tables A-1 through A-6 are used to define maximum potential normalized releases for comparison with the release limits. Now the unit of waste and the radionuclide-specific release limits are used to determine cumulative normalized release limits for the radionuclides specified in 40 CFR 191.13 (Table B-1). To help describe the 40 CFR 191 containment requirements, the following paragraphs were taken from *An Introduction to the Mechanics of Performance Assessment Using Examples of Calculations Done for the Waste Isolation Pilot Plant Between 1990 and 1992* (Rechard 1996, Section 6.1.2), which provides a very thorough introduction to the mechanics of the WIPP PA process:

> Containment Requirements in 40 CFR 191.13 specify general limits on the release of transuranic (TRU) waste, high-level waste, or spent nuclear fuel (SNF) from a geological 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 B-1). According to the Containment Requirements, there must be a reasonable expectation, based on a performance assessment that includes all significant processes and events, that the cumulative release of any one radionuclide over 10,000 years to the accessible environment shall have (these two points alone determine the EPA limits drawn on all WIPP Complimentary Cumulative Distribution Function codes:
>
> - less than 1 chance in 10 of exceeding the promulgated EPA radionuclides 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:

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

where:

$f_w$ = waste unit factor = $\frac{\sum W_i}{10^6\,Ci}$

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

$L_i$ = the EPA release limit for radionuclide $i$ (see Table 1 for examples of units) in curies (Ci)

$nR$ = number of radionuclides contributing to the release

$R_j$ = total normalized release (EPA unit) for the $j^{th}$ scenario

$Q_{ij}$ = cumulative release for radionuclide $q_{ij}$ beyond a specified boundary, $\int_0^{10,000\,yr} q_{ij}dt$

$q_{ij}$ = release rate into accessible environment at time $t$ for radionuclide $i$ and scenario $j$ calculated from consequence model(s) (see Chapter 5.0 of Rechard 1996).

**Table 1. Radionuclide Inventory Activities at 2033 that Contribute to Waste Unit Factor**

| Radionuclide | Activity |
|---|---|
| Am-241 | 7.05E+05 Ci |
| Am-242m | 2.25E+01 Ci |
| Am-243 | 5.13E+01 Ci |
| Cf-249 | 2.41E+01 Ci |
| Cf-251 | 4.86E-02 Ci |
| Cm-243 | 2.34E+02 Ci |
| Cm-245 | 1.23E+00 Ci |
| Cm-246 | 7.46E+01 Ci |
| Cm-247 | 1.12E-02 Ci |
| Cm-248 | 1.19E-01 Ci |
| Cm-250 | 5.91E-03 Ci |
| Np-237 | 2.32E+01 Ci |
| Pu-238 | 6.01E+05 Ci |
| Pu-239 | 5.74E+05 Ci |
| Pu-240 | 1.75E+05 Ci |
| Pu-242 | 8.09E+03 Ci |
| Pu-244 | 1.02E-02 Ci |
| Total | 2.06E+06 Ci |
| **WUF** | **2.06** |

# 3. RADIONUCLIDES EXPECTED TO DOMINATE POTENTIAL RELEASES

## 3.1 PROBLEM DESCRIPTION

Each potential radionuclide release mechanism modeled in PA has as its source an inventory of radionuclides that (1) the DOE expects will be disposed in WIPP and (2) analysts believe will be prevalent in a release via the individual release mechanism. For the CRA-2014, the DOE through its contractor, Los Alamos National Laboratory (LANL), has documented a radionuclide inventory that it expected would be disposed in the WIPP (Van Soest 2012). The radionuclide inventory contains 179 radioisotopes. However, not all of the 179 radioisotopes are important to track in a PA for the WIPP repository. Many of the isotopes have low concentrations or are short lived (short half-lives) and would not impact the releases calculated by PA simulations. In addition, tracking of all 179 radioisotopes is not practical since WIPP PA involves a suite of computationally intensive codes. Therefore, the number of isotopes tracked in the WIPP PA codes is reduced.

Three of the WIPP codes have radionuclide inventories as direct inputs: PANEL, NUTS, and CCDFGF. The three codes are used in calculations of releases via individual release mechanisms that are modeled in WIPP PA. PANEL provides the radionuclide source for direct brine release to the surface via a borehole (a potential short-term release mechanism), and it provides the radionuclide source for releases via a borehole to the Culebra member of the Rustler formation (a potential long-term release mechanism). NUTS calculates radionuclide releases via Salado formation to the accessible boundary (a potential long-term release mechanism). The inventory information is used in CCDFGF to calculate direct solid releases to the surface due to drilling activities (a potential short-term release mechanism). The criteria for selecting important radionuclides for each of these codes (and release mechanisms) vary slightly for each code.

## 3.2 ANALYSIS

The first criterion applied to the selection of important radionuclides for inclusion in PA calculations is based on the regulatory framework provided by the EPA in 40 CFR 191 (U.S. DOE 1996). Of the 179 radionuclides reported in the PAIR-2012 (Van Soest 2012), not all are regulated by 40 CFR 191—the regulations are identified in Table B-1 of Appendix B. The tables in Appendix A show the projected WIPP inventory of these isotopes as potential releases in EPA units. An EPA unit is defined as the inventory of that isotope in curies divided by the EPA release limit for that isotope in curies as specified in 40 CFR 191 (reproduced here in Table B-1). The repository is considered to comply with the EPA regulations if there is a less than 0.1 calculated probability (based on PA calculations) that the cumulative release to the accessible environment is greater than 1 EPA unit and a less than 0.001 probability that the cumulative release is greater than 10 EPA units.

Table 2 shows the radionuclide inventory in terms of EPA units at 0 years (2033), 100 years (2133), 350 years (2383), 1000 years (3033), 5000 years (7033), and 10,000 years (12033) for radionuclides that have an activity of at least 0.001 EPA units at some point from 2033 to 12033. Of the 179 isotopes given in the PAIR-2012 (Van Soest 2012), only 36 have more than 0.001 EPA units of inventory at any time within the 10,000-year regulatory period. These are $^{227}$Ac, $^{241}$Am, $^{242m}$Am, $^{243}$Am, $^{14}$C, $^{249}$Cf, $^{243}$Cm, $^{245}$Cm, $^{246}$Cm, $^{135}$Cs, $^{137}$Cs, $^{129}$I, $^{94}$Nb, $^{59}$Ni, $^{63}$Ni, $^{237}$Np, $^{231}$Pa, $^{210}$Pb, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{242}$Pu, $^{226}$Ra, $^{151}$Sm, $^{126}$Sn, $^{90}$Sr, $^{99}$Tc, $^{229}$Th, $^{230}$Th, $^{232}$Th, $^{232}$U, $^{233}$U, $^{234}$U, $^{235}$U, $^{236}$U, $^{238}$U. Additional isotopes are included in Table 2 which have short half-lives and are not regulated by the EPA, but have significant activities and/or are the parents of regulated isotopes, and are therefore included in some PA calculations. These are: $^{252}$Cf, $^{244}$Cm, $^{248}$Cm, $^{147}$Pm, $^{241}$Pu $^{244}$Pu, $^{228}$Ra and $^{147}$Sm.

The contribution of each radionuclide to the overall potential release changes as the radionuclides decay or build-up over time. For example, the relatively short-lived isotope $^{238}$Pu decays from a potential release of 2910 EPA units at closure to 1.08 EPA units by 1000 years. An example of an isotope that increases in activity with time is $^{230}$Th, which initially has less than one EPA unit of potential release that grows to two EPA units after 10,000 years.

**Table 2. Radionuclide Inventory Sorted by Maximum Potential Release During the Regulatory Period**

| Radionuclide | Half-Life[a] (yr) | Potential Release[b] (EPA Units) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 Years | 100 Years | 350 Years | 1000 Years | 5000 Years | 10000 Years | Maximum |
| Am-241 | 432.7 a | 3.42E+03 | 3.00E+03 | 2.01E+03 | 7.10E+02 | 1.17E+00 | 5.25E-03 | 3.42E+03 |
| Pu-238 | 87.7 a | 2.91E+03 | 1.32E+03 | 1.83E+02 | 1.08E+00 | 5.08E-12 | 1.07E-22 | 2.91E+03 |
| Pu-239 | 2.41E+04 a | 2.78E+03 | 2.77E+03 | 2.76E+03 | 2.70E+03 | 2.41E+03 | 2.09E+03 | 2.78E+03 |
| Pu-240 | 6.56E+03 a | 8.49E+02 | 8.41E+02 | 8.19E+02 | 7.64E+02 | 5.01E+02 | 2.95E+02 | 8.49E+02 |
| Cs-137 | 30.17 a | 1.14E+02 | 1.13E+01 | 3.50E-02 | 1.05E-08 | --- | --- | 1.14E+02 |
| Sr-90 | 29.1 a | 1.01E+02 | 8.62E+00 | 1.83E-02 | 2.04E-09 | --- | --- | 1.01E+02 |
| Pu-242 | 3.75E+05 a | 3.92E+01 | 3.92E+01 | 3.92E+01 | 3.91E+01 | 3.89E+01 | 3.85E+01 | 3.92E+01 |
| U-234 | 2.46E+05 a | 1.17E+00 | 1.74E+00 | 2.15E+00 | 2.21E+00 | 2.19E+00 | 2.16E+00 | 2.21E+00 |
| Th-230 | 7.54e+04 a | 2.00E-01 | 2.14E-01 | 2.60E-01 | 3.89E-01 | 1.17E+00 | 2.09E+00 | 2.09E+00 |
| Ni-63 | 100 a | 1.19E+00 | 5.93E-01 | 1.05E-01 | 1.17E-03 | 1.09E-15 | 9.99E-31 | 1.19E+00 |
| Cm-243 | 29.1 a | 1.14E+00 | 9.98E-02 | 2.28E-04 | 3.10E-11 | --- | --- | 1.14E+00 |
| C-14 | 5730 a | 1.05E+00 | 1.04E+00 | 1.01E+00 | 9.34E-01 | 5.76E-01 | 3.14E-01 | 1.05E+00 |
| Ni-59 | 7.6E+04 a | 1.03E+00 | 1.03E+00 | 1.03E+00 | 1.02E+00 | 9.86E-01 | 9.41E-01 | 1.03E+00 |
| Np-237 | 2.14E+06 a | 1.12E-01 | 2.17E-01 | 4.18E-01 | 6.81E-01 | 8.23E-01 | 8.22E-01 | 8.23E-01 |
| U-233 | 1.592E+05 a | 6.72E-01 | 6.72E-01 | 6.71E-01 | 6.71E-01 | 6.73E-01 | 6.77E-01 | 6.77E-01 |
| Th-229 | 7.3E+03 a | 6.78E-03 | 1.26E-02 | 2.69E-02 | 6.27E-02 | 2.44E-01 | 3.97E-01 | 3.97E-01 |
| U-235 | 7.04E+08 a | 3.70E-01 | 3.70E-01 | 3.71E-01 | 3.73E-01 | 3.83E-01 | 3.94E-01 | 3.94E-01 |
| Cm-246 | 4.76E+03 a | 3.62E-01 | 3.56E-01 | 3.44E-01 | 3.12E-01 | 1.74E-01 | 8.35E-02 | 3.62E-01 |
| U-238 | 4.47E+09 a | 3.14E-01 | 3.14E-01 | 3.14E-01 | 3.14E-01 | 3.14E-01 | 3.14E-01 | 3.14E-01 |
| Am-243 | 7.37E+03 a | 2.48E-01 | 2.46E-01 | 2.40E-01 | 2.26E-01 | 1.55E-01 | 9.70E-02 | 2.48E-01 |
| U-236 | 2.342E+07 a | 2.64E-02 | 2.89E-02 | 3.50E-02 | 5.02E-02 | 1.24E-01 | 1.82E-01 | 1.82E-01 |
| Ra-226 | 1.60E+03 a | 8.31E-02 | 8.05E-02 | 7.46E-02 | 6.43E-02 | 8.46E-02 | 1.68E-01 | 1.68E-01 |
| Pb-210 | 22.3 a | 6.91E-02 | 8.06E-02 | 7.46E-02 | 6.43E-02 | 8.45E-02 | 1.68E-01 | 1.68E-01 |
| Cf-249 | 351 a | 1.17E-01 | 9.60E-02 | 5.85E-02 | 1.62E-02 | 5.93E-06 | 3.01E-10 | 1.17E-01 |
| Am-242m | 141.0 a | 1.09E-01 | 6.66E-02 | 1.95E-02 | 7.99E-04 | 2.30E-12 | 4.87E-23 | 1.09E-01 |
| Ac-227 | 21.77 a | 1.31E-02 | 4.04E-03 | 5.80E-03 | 1.08E-02 | 4.06E-02 | 7.55E-02 | 7.55E-02 |
| Pa-231 | 3.28E+04 a | 3.09E-03 | 3.86E-03 | 5.80E-03 | 1.08E-02 | 4.06E-02 | 7.55E-02 | 7.55E-02 |
| Th-232 | 1.4E+10 a | 7.27E-02 | 7.27E-02 | 7.27E-02 | 7.27E-02 | 7.27E-02 | 7.27E-02 | 7.27E-02 |
| U-232 | 70 a | 7.04E-02 | 2.61E-02 | 2.18E-03 | 3.43E-06 | 1.93E-23 | --- | 7.04E-02 |
| Tc-99 | 2.13E+05 a | 3.88E-03 | 3.88E-03 | 3.88E-03 | 3.87E-03 | 3.82E-03 | 3.76E-03 | 3.88E-03 |

**Table 2. Radionuclide Inventory Sorted by Maximum Potential Release During the Regulatory Period (continued)**

| Radionuclide | Half-Life[a] (yr) | Potential Release[b] (EPA Units) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 0 Years | 100 Years | 350 Years | 1000 Years | 5000 Years | 10000 Years | Maximum |
| Cs-135 | 2.3E+06 a | 2.93E-02 | 2.93E-02 | 2.93E-02 | 2.93E-02 | 2.93E-02 | 2.92E-02 | 2.93E-02 |
| Sm-151 | 90 a | 2.55E-02 | 1.18E-02 | 1.72E-03 | 1.15E-05 | 4.79E-19 | 9.00E-36 | 2.55E-02 |
| Cm-245 | 8.5E+03 a | 5.94E-03 | 6.75E-03 | 8.14E-03 | 9.41E-03 | 7.29E-03 | 4.85E-03 | 9.41E-03 |
| I-129 | 1.57E+07 a | 1.83E-03 | 1.83E-03 | 1.83E-03 | 1.83E-03 | 1.83E-03 | 1.83E-03 | 1.83E-03 |
| Sn-126 | 1.0E+05 a | 1.16E-03 | 1.16E-03 | 1.15E-03 | 1.15E-03 | 1.12E-03 | 1.08E-03 | 1.16E-03 |
| Nb-94 | 2.0E+04 a | 1.01E-03 | 1.01E-03 | 9.97E-04 | 9.76E-04 | 8.51E-04 | 7.17E-04 | 1.01E-03 |
| Cm-248 | 3.48E+05 a | 5.77E-04 | 5.77E-04 | 5.76E-04 | 5.76E-04 | 5.71E-04 | 5.65E-04 | 5.77E-04 |
| Pu-244 | 8.0E+07 a | 4.92E-05 | 4.92E-05 | 4.92E-05 | 4.92E-05 | 4.92E-05 | 4.92E-05 | 4.92E-05 |
| Sm-147 | 1.06E+11 a | 8.44E-11 | 8.45E-11 | 8.45E-11 | 8.45E-11 | 8.45E-11 | 8.45E-11 | 8.45E-11 |
| Pm-147 | 2.6234 a | --- | --- | --- | --- | --- | --- | --- |
| Cm-244 | 18.1 a | --- | --- | --- | --- | --- | --- | --- |
| Cf-252 | 2.638 a | --- | --- | --- | --- | --- | --- | --- |
| Ra-228 | 5.76 a | --- | --- | --- | --- | --- | --- | --- |
| Pu-241 | 14.4 a | --- | --- | --- | --- | --- | --- | --- |

(a) Half-life information taken from *Nuclides and Isotopes* (also called the "Chart of the Nuclides"), 16th Ed. (Lockheed Martin 2002)
(b) Potential releases taken from Tables A-1 through A-6 in Appendix A.

Traditionally, 30 radioisotopes have been modeled in PANEL decay calculations. Those radioisotopes are: $^{241}$Am, $^{243}$Am, $^{252}$Cf, $^{243}$Cm, $^{244}$Cm, $^{245}$Cm, $^{248}$Cm, $^{137}$Cs, $^{237}$Np, $^{231}$Pa, $^{210}$Pb, $^{147}$Pm, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{242}$Pu, $^{244}$Pu, $^{226}$Ra, $^{228}$Ra, $^{147}$Sm, $^{90}$Sr, $^{229}$Th, $^{230}$Th, $^{232}$Th, $^{233}$U, $^{234}$U, $^{235}$U, $^{236}$U and $^{238}$U. Of these 30 radioisotopes, seven ($^{252}$Cf, $^{231}$Pa, $^{210}$Pb, $^{147}$Pm, $^{226}$Ra, $^{228}$Ra and $^{147}$Sm) are only included in the decay calculations, while the remaining 23 are used in both the decay calculations and the actinide mobilization calculations. The 23 radioisotopes modeled in PANEL actinide mobilization calculations encompass 99.96% of the potential releases (in EPA units) at the time of repository closure based on the CRA-2014 inventory (see Table 3). Therefore, there are sufficient radionuclides modeled in the PANEL calculations to capture the dominant releases.

**Table 3. Contribution to Potential Release at 2033 for Isotopes Modeled in PANEL**

| Radionuclide | Total Inventory[a] (Ci) | | | Potential Release[b] (EPA Units) | | | |
|---|---|---|---|---|---|---|---|
| | CH | RH | Total | CH | RH | Total | Cum. % |
| Am-241 | 6.97E+05 | 8.06E+03 | 7.05E+05 | 3.38E+03 | 3.91E+01 | 3.42E+03 | 33.41% |
| Pu-238 | 5.95E+05 | 5.80E+03 | 6.01E+05 | 2.88E+03 | 2.81E+01 | 2.91E+03 | 61.89% |
| Pu-239 | 5.67E+05 | 7.27E+03 | 5.74E+05 | 2.75E+03 | 3.52E+01 | 2.78E+03 | 89.12% |

**Table 3. Contribution to Potential Release at 2033 for Isotopes Modeled in PANEL (continued)**

| Radionuclide | Total Inventory[a] (Ci) | | | Potential Release[b] (EPA Units) | | | |
|---|---|---|---|---|---|---|---|
| | CH | RH | Total | CH | RH | Total | Cum. % |
| Pu-240 | 1.67E+05 | 7.94E+03 | 1.75E+05 | 8.11E+02 | 3.85E+01 | 8.49E+02 | 97.43% |
| Cs-137 | 2.31E+03 | 2.33E+05 | 2.35E+05 | 1.12E+00 | 1.13E+02 | 1.14E+02 | 98.54% |
| Sr-90 | 2.31E+03 | 2.07E+05 | 2.09E+05 | 1.12E+00 | 1.00E+02 | 1.01E+02 | 99.53% |
| Pu-242 | 1.66E+03 | 6.44E+03 | 8.09E+03 | 8.03E+00 | 3.12E+01 | 3.92E+01 | 99.92% |
| U-234 | 2.10E+02 | 3.23E+01 | 2.42E+02 | 1.02E+00 | 1.57E-01 | 1.17E+00 | 99.93% |
| Cm-243 | 2.16E+02 | 1.81E+01 | 2.34E+02 | 1.05E+00 | 8.76E-02 | 1.14E+00 | 99.94% |
| U-233 | 9.82E+01 | 4.04E+01 | 1.39E+02 | 4.76E-01 | 1.96E-01 | 6.72E-01 | 99.95% |
| U-235 | 8.66E+00 | 6.77E+01 | 7.64E+01 | 4.19E-02 | 3.28E-01 | 3.70E-01 | 99.95% |
| U-238 | 3.51E+01 | 2.97E+01 | 6.48E+01 | 1.70E-01 | 1.44E-01 | 3.14E-01 | 99.95% |
| Am-243 | 2.18E+01 | 2.95E+01 | 5.12E+01 | 1.05E-01 | 1.43E-01 | 2.48E-01 | 99.95% |
| Th-230 | 4.13E+00 | 1.02E-02 | 4.14E+00 | 2.00E-01 | 4.93E-04 | 2.00E-01 | 99.96% |
| Np-237 | 2.04E+01 | 2.84E+00 | 2.32E+01 | 9.86E-02 | 1.38E-02 | 1.12E-01 | 99.96% |
| Th-232 | 1.48E+00 | 1.46E-02 | 1.50E+00 | 7.19E-02 | 7.10E-04 | 7.27E-02 | 99.96% |
| U-236 | 5.08E+00 | 3.65E-01 | 5.44E+00 | 2.46E-02 | 1.77E-03 | 2.64E-02 | 99.96% |
| Th-229 | 4.19E-01 | 9.81E-01 | 1.40E+00 | 2.03E-03 | 4.75E-03 | 6.78E-03 | 99.96% |
| Cm-245 | 3.70E-01 | 8.55E-01 | 1.23E+00 | 1.79E-03 | 4.14E-03 | 5.94E-03 | 99.96% |
| Cm-248 | 1.03E-01 | 1.62E-02 | 1.19E-01 | 4.98E-04 | 7.87E-05 | 5.77E-04 | 99.96% |
| Pu-244 | 1.01E-02 | 7.38E-06 | 1.01E-02 | 4.91E-05 | 3.58E-08 | 4.92E-05 | 99.96% |
| Pu-241 | 6.48E+05 | 1.49E+04 | 6.63E+05 | N/A[c] | N/A[c] | N/A[c] | 99.96% |
| Cm-244 | 5.24E+03 | 4.73E+03 | 9.97E+03 | N/A[c] | N/A[c] | N/A[c] | 99.96% |

(a) Decayed radionuclide data taken from Van Soest 2012.
(b) CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Table A-1). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table A-1 in Appendix A. The total potential release for all radionuclides is 10,222 EPA units.
(c) Cm-244 and Pu-241 are not regulated isotopes and have no release limits (See Appendix B, Table B-1). Therefore, potential release in EPA units cannot be calculated.

For NUTS, the selection of the dominant radionuclides was previously based on those radionuclides that had a potential release greater than 1.0 EPA units during the 10,000 year regulatory period, and which for PABC-2009 resulted in the following list of eight isotopes: $^{241}$Am, $^{137}$Cs, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{90}$Sr, $^{230}$Th and $^{234}$U. Following the same criterion, the current list would include five additional isotopes: $^{14}$C, $^{243}$Cm, $^{59}$Ni, $^{63}$Ni, and $^{242}$Pu. A typical NUTS calculation includes the 10 isotopes shown in Table 4: $^{241}$Am, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{242}$Pu, $^{229}$Th, $^{230}$Th, $^{233}$U and $^{234}$U.

The isotopes $^{137}$Cs and $^{90}$Sr are excluded from the NUTS calculation because they are short-lived radionuclides that will no longer be contributors to the release by the time radioactive material is transported via the Salado transport pathway to the accessible boundary—the isotope $^{243}$Cm from the new list can also be excluded for this reason. In addition, $^{241}$Pu is added to the list of radionuclides to be modeled with NUTS since it is a parent isotope for $^{241}$Am and has a significant inventory at the start of the calculation. In the NUTS calculations, $^{229}$Th and $^{233}$U are also included, as they have potential releases close to 1.0 EPA units and were included previously (the isotope $^{242}$Pu was previously included using this rationale). Although the isotopes $^{14}$C, $^{243}$Cm, $^{59}$Ni, and $^{63}$Ni fulfill the initial criterion of having a potential release greater than 1.0 EPA units, their contribution to the overall potential release is miniscule and they are not included in the NUTS calculation.

Including the traditional list of $^{241}$Am, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{242}$Pu, $^{229}$Th, $^{230}$Th, $^{233}$U and $^{234}$U accounts for 97.83% of the potential releases (in EPA units) at the time of repository closure in the CRA-2014 inventory (see Table 4). An additional 2.1% of the potential releases at 2033 would be represented by $^{137}$Cs and $^{90}$Sr—this is a much higher contribution than in previous years; however, these two isotopes are relatively short-lived and by the end of the 10,000 year regulatory period, the traditional list of 10 isotopes represent 99.8% of the potential releases, so it is reasonable to exclude $^{137}$Cs and $^{90}$Sr from the NUTS calculation. In sum, there are sufficient radionuclides modeled in the NUTS calculations to capture the dominant releases.

**Table 4. Contribution to Potential Release at 2033 for Isotopes Modeled in NUTS**

| Radionuclide | Total Inventory[a] (Ci) | | | Potential Release[b] (EPA Units) | | | |
|---|---|---|---|---|---|---|---|
| | CH | RH | Total | CH | RH | Total | Cum. % |
| Am-241 | 6.97E+05 | 8.06E+03 | 7.05E+05 | 3.38E+03 | 3.91E+01 | 3.42E+03 | 33.41% |
| Pu-238 | 5.95E+05 | 5.80E+03 | 6.01E+05 | 2.88E+03 | 2.81E+01 | 2.91E+03 | 61.89% |
| Pu-239 | 5.67E+05 | 7.27E+03 | 5.74E+05 | 2.75E+03 | 3.52E+01 | 2.78E+03 | 89.12% |
| Pu-240 | 1.67E+05 | 7.94E+03 | 1.75E+05 | 8.11E+02 | 3.85E+01 | 8.49E+02 | 97.43% |
| Pu-242 | 1.66E+03 | 6.44E+03 | 8.09E+03 | 8.03E+00 | 3.12E+01 | 3.92E+01 | 97.81% |
| U-234 | 2.10E+02 | 3.23E+01 | 2.42E+02 | 1.02E+00 | 1.57E-01 | 1.17E+00 | 97.82% |
| U-233 | 9.82E+01 | 4.04E+01 | 1.39E+02 | 4.76E-01 | 1.96E-01 | 6.72E-01 | 97.83% |
| Th-230 | 4.13E+00 | 1.02E-02 | 4.14E+00 | 2.00E-01 | 4.93E-04 | 2.00E-01 | 97.83% |
| Th-229 | 4.19E-01 | 9.81E-01 | 1.40E+00 | 2.03E-03 | 4.75E-03 | 6.78E-03 | 97.83% |
| Pu-241 | 6.48E+05 | 1.49E+04 | 6.63E+05 | --- | --- | --- | 97.83% |

(a) Decayed radionuclide data taken from Van Soest 2012.
(b) CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Table A-1). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table A-1 in Appendix A. The total potential release for all radionuclides is 10,222 EPA units.
(c) Pu-241 is not a regulated isotope and has no release limit (See Appendix B, Table B-1). Therefore, potential release EPA units cannot be calculated.

The radionuclides that are important for modeling the direct solid release pathway (included in CCDFGF) are also based on those that have a potential release greater than 1.0 EPA units during the 10,000 year regulatory period, which resulted in the following list: $^{241}$Am, $^{14}$C, $^{243}$Cm, $^{137}$Cs, $^{59}$Ni, $^{63}$Ni, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{242}$Pu, $^{90}$Sr, $^{230}$Th and $^{234}$U. In contrast to the NUTS calculation, the isotopes $^{137}$Cs and $^{90}$Sr are maintained for this pathway even though they have relatively short half-lives, because a human intrusion event can occur as early as 100 years after repository closure. The PABC-2009 excluded $^{230}$Th from the calculations as it is less than 0.1% of the total initial activity and was not included previously—the isotopes $^{14}$C, $^{243}$Cm, $^{59}$Ni, $^{63}$Ni, and $^{242}$Pu can be excluded here for the same reasons.

The isotope $^{241}$Pu is added to the list of radionuclides to be modeled with CCDFGF since it is a parent isotope for $^{241}$Am and has a significant inventory at the start of the calculation. The isotope $^{233}$U is included in the CCDFGF calculations as it has a potential EPA unit release close to 1.0 and was included previously. The isotope $^{244}$Cm is included because it has a high initial inventory and was included previously. The direct solid release pathway is modeled using 10 radionuclides: $^{241}$Am, $^{244}$Cm, $^{137}$Cs, $^{238}$Pu, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{90}$Sr, $^{233}$U, and $^{234}$U. These 10 radionuclides accounted for 99.55% of the EPA units at the time of repository closure in the CRA-2014 inventory (see Table 5). Therefore, there are sufficient radionuclides modeled in the CCDFGF calculations to capture the dominant releases.

**Table 5. Contribution to Potential Release at 2033 for Isotopes Modeled in CCDFGF**

| Radionuclide | Total Inventory[a] (Ci) | | | Potential Release[b] (EPA Units) | | | |
|---|---|---|---|---|---|---|---|
| | CH | RH | Total | CH | RH | Total | Cum. % |
| Am-241 | 6.97E+05 | 8.06E+03 | 7.05E+05 | 3.38E+03 | 3.91E+01 | 3.42E+03 | 33.41% |
| Pu-238 | 5.95E+05 | 5.80E+03 | 6.01E+05 | 2.88E+03 | 2.81E+01 | 2.91E+03 | 61.89% |
| Pu-239 | 5.67E+05 | 7.27E+03 | 5.74E+05 | 2.75E+03 | 3.52E+01 | 2.78E+03 | 89.12% |
| Pu-240 | 1.67E+05 | 7.94E+03 | 1.75E+05 | 8.11E+02 | 3.85E+01 | 8.49E+02 | 97.43% |
| Cs-137 | 2.31E+03 | 2.33E+05 | 2.35E+05 | 1.12E+00 | 1.13E+02 | 1.14E+02 | 98.54% |
| Sr-90 | 2.31E+03 | 2.07E+05 | 2.09E+05 | 1.12E+00 | 1.00E+02 | 1.01E+02 | 99.53% |
| U-234 | 2.10E+02 | 3.23E+01 | 2.42E+02 | 1.02E+00 | 1.57E-01 | 1.17E+00 | 99.54% |
| U-233 | 9.82E+01 | 4.04E+01 | 1.39E+02 | 4.76E-01 | 1.96E-01 | 6.72E-01 | 99.55% |
| Pu-241 | 6.48E+05 | 1.49E+04 | 6.63E+05 | --- | --- | --- | 99.55% |
| Cm-244 | 5.24E+03 | 4.73E+03 | 9.97E+03 | --- | --- | --- | 99.55% |

(a) Decayed radionuclide data taken from Van Soest 2012.

(b) CH potential release is defined as the total CH inventory in Ci divided by the release limit in Ci (see Table A-1). Similarly, RH potential release is defined as the total RH inventory in Ci divided by the release limit in Ci. Total potential releases taken from Table A-1 in Appendix A. The total potential release for all radionuclides is 10,222 EPA units.

(c) Cm-244 and Pu-241 are not regulated isotopes and have no release limits (See Appendix B, Table B-1). Therefore, potential release in EPA units cannot be calculated.

# 4. CALCULATION OF RADIONUCLIDE INVENTORIES FOR USE IN NUTS

## 4.1 PROBLEM DESCRIPTION

Van Soest (2012, Tables 5-3 and 5-4) reports that the DOE waste generator sites are expected to dispose of TRU waste containing 179 different radionuclides in the WIPP. Not all of these radionuclides have significant inventories for disposal and not all of these radionuclides contribute to potential releases from the WIPP repository over the 10,000 year regulatory period. Section 3 identifies which radionuclides contribute to potential releases from the repository for the individual transport pathways modeled in performance assessment. For transport through the Salado to the accessible boundary and transport through the Salado to the Culebra which is modeled using the NUTS code in performance assessment, the important radionuclides are shown in Table 4 of Section 3.

The radionuclides in Table 4 are important contributors to potential releases and they have half-lives that are long enough to contribute to potential releases via the Salado. In addition, Section 3 identifies $^{241}$Pu as being important because it is the parent isotope for $^{241}$Am and it has a significant initial inventory. The inventory for $^{241}$Pu at the time of repository closure (2033) is 6.48E+05 curies in contact handled (CH) TRU waste and 1.49E+04 curies in remote handled (RH) TRU waste (Table A-1 in Appendix A).

Because NUTS is a computationally intensive code, minimizing the number of radionuclides that NUTS must track in a calculation is beneficial. Therefore, inventories for the uranium, plutonium, americium and thorium isotopes can be combined into "lumped" inventories to facilitate the NUTS calculations for performance assessment. Technical justification for lumping is provided below (see Table 6 for lumped values).

## 4.2 COMPUTATIONAL METHODOLOGY

### 4.2.1 Theory

The theory behind combining radionuclide inventories into "lumped" inventories for transport calculations is that radionuclides of the same elemental form will transport at the same rate (Leigh and Trone 2005). Therefore, the inventories for isotopes of uranium can be combined. Additionally, inventories for isotopes of plutonium can be combined, and inventories for isotopes of thorium can be combined. Using the isotopes identified in Table 4 as important: (1) the activity of $^{234}$U and $^{233}$U will be combined to produce values for the material U234L (the lumped uranium inventory) for the NUTS calculation, (2) the activity of $^{239}$Pu, $^{240}$Pu and $^{242}$Pu will be combined to produce values for the material PU239L for the NUTS calculation, and (3) the activity of $^{230}$Th and $^{229}$Th will be combined to produce values for the material TH230L in the NUTS calculation.

In Table 4, $^{238}$Pu is also listed as an important radionuclide for the NUTS calculation. The inventory of $^{238}$Pu is not combined with the other plutonium isotopes because of its relatively short half-life.

Finally, the inventory of $^{241}$Pu is combined with the inventory of $^{241}$Am because $^{241}$Pu is a parent isotope to $^{241}$Am and $^{241}$Pu has a relatively short half-life when compared to $^{241}$Am. Combining the inventories for $^{241}$Am and $^{241}$Pu produces the inventory value for the material AM241L in the NUTS calculation.

The resulting decay chains for the NUTS calculations are:

$$^{238}\text{Pu} \rightarrow {}^{234}\text{U} \rightarrow {}^{230}\text{Th} \quad (3)$$

$$^{239}\text{Pu} \quad (4)$$

$$^{241}\text{Am} \quad (5)$$

### 4.2.2 Implementation

One can either add the activities (in curies) of two isotopes to get a combined inventory or one can add the molar amounts (in moles). Depending on the half-lives of the isotopes that are being combined, one method will result in a larger combined activity than the other. If for example, isotope A has a longer half-life than isotope B and the inventory of isotope B is to be combined with the inventory of isotope A, the method that results in the largest combined activity for isotope A is to add the activity of isotope B to the activity of isotope A. If on the other hand, the half-life of isotope A is shorter than the half-life of isotope B, the method that results in the largest combined activity for isotope A is to add the molar amount of isotope B to the molar amount of isotope A. Therefore, when combining the plutonium isotopes, $^{242}$Pu, $^{240}$Pu, and $^{239}$Pu, the activity of $^{240}$Pu is added to the activity of $^{239}$Pu but the molar amount of $^{242}$Pu is added to the molar amount of $^{239}$Pu. When combining the thorium isotopes, the activity of $^{229}$Th is added to the activity of $^{230}$Th. When combining the uranium isotopes, the activity of $^{233}$U is added to the activity of $^{234}$U.

### 4.2.3 Equations

Equations 6 through 15 show the computational methodology for combining radionuclide activities into lumped activity values.

$$A_L(\text{Pu238})_{CH} = A(\text{Pu238})_{CH} \quad (6)$$

$$A_L(\text{Pu238})_{RH} = A(\text{Pu238})_{RH} \quad (7)$$

where:

| | |
|---|---|
| $A_L(\text{Pu238})_{CH}$ | activity value for the property INVCHD for the material PU238L |
| $A(\text{Pu238})_{CH}$ | activity value for $^{238}$Pu from Table 3 for CH-TRU |
| $A_L(\text{Pu238})_{RH}$ | activity value for the property INVRHD for the material PU238L |
| $A(\text{Pu238})_{RH}$ | activity value for $^{238}$PU from Table 3 for RH-TRU |

$$A_L(\text{Am241})_{CH} = A(\text{Am241})_{CH} + A(\text{Pu241})_{CH} * \tau_{1/2}(\text{Pu241}) / \tau_{1/2}(\text{Am241}) \quad (8)$$

$$A_L(\text{Am241})_{RH} = A(\text{Am241})_{RH} + A(\text{Pu241})_{RH} * \tau_{1/2}(\text{Pu241}) / \tau_{1/2}(\text{Am241}) \quad (9)$$

where:

| | |
|---|---|
| $A_L(Am241)_{CH}$ | activity value for the property INVCHD for the material AM241L |
| $A(Am241)_{CH}$ | activity value for $^{241}$Am from Table 3for CH-TRU |
| $A(Pu241)_{CH}$ | activity value for $^{241}$Pu from Table 3 for CH-TRU |
| $A_L(Am241)_{RH}$ | activity value for the property INVRHD for the material AM241L |
| $A(Am241)_{RH}$ | activity value for $^{241}$Am from Table 3 for RH-TRU |
| $A(Pu241)_{RH}$ | activity value for $^{241}$Pu from Table 3 for RH-TRU |
| $\tau_{1/2}$ (Am241) | half-life of $^{241}$Am from Table 2 |
| $\tau_{1/2}$ (Pu241) | half-life of $^{241}$Pu from Table 2 |

$$A_L(Pu239)_{CH} = A(Pu239)_{CH} + A(Pu240)_{CH} + A(Pu242)_{CH} * \tau_{1/2}(Pu242)/\tau_{1/2}(Pu239) \quad (10)$$

$$A_L(Pu239)_{RH} = A(Pu239)_{RH} + A(Pu240)_{RH} + A(Pu242)_{RH} * \tau_{1/2}(Pu242)/\tau_{1/2}(Pu239) \quad (11)$$

where:

| | |
|---|---|
| $A_L(Pu239)_{CH}$ | activity value for the property INVCHD for the material PU239L |
| $A(Pu239)_{CH}$ | activity value for $^{239}$Pu from Table 3 for CH-TRU |
| $A(Pu240)_{CH}$ | activity value for $^{240}$Pu from Table 3 for CH-TRU |
| $A(Pu242)_{CH}$ | activity value for $^{242}$Pu from Table 3 for CH-TRU |
| $A_L(Pu239)_{RH}$ | activity value for the property INVRHD for the material PU239L |
| $A(Pu239)_{RH}$ | activity value for $^{239}$Pu from Table 3 for RH-TRU |
| $A(Pu240)_{RH}$ | activity value for $^{240}$Pu from Table 3 for RH-TRU |
| $A(Pu242)_{RH}$ | activity value for $^{242}$Pu from Table 3 for RH-TRU |
| $\tau_{1/2}$(Pu239) | half-life of $^{239}$Pu from Table 2 |
| $\tau_{1/2}$(Pu242) | half-life of $^{242}$Pu from Table 2 |

$$A_L(U234)_{CH} = A(U234)_{CH} + A(U233)_{CH} \quad (12)$$

$$A_L(U234)_{RH} = A(U234)_{RH} + A(U233)_{RH} \quad (13)$$

where:

| | |
|---|---|
| $A_L(U234)_{CH}$ | activity value for the property INVCHD for the material U234L |
| $A(U234)_{CH}$ | activity value for $^{234}$U from Table 3 for CH-TRU |
| $A(U233)_{CH}$ | activity value for $^{233}$U from Table 3 for CH-TRU |
| $A_L(U234)_{RH}$ | activity value for the property INVRHD for the material U234L |
| $A(U234)_{RH}$ | activity value for $^{234}$U from Table 3 for RH-TRU |
| $A(U233)_{RH}$ | activity value for $^{233}$U from Table 3 for RH-TRU |

$$A_L(Th230)_{CH} = A(Th230)_{CH} + A(Th229)_{CH} \quad (14)$$

$$A_L(Th230)_{RH} = A(Th230)_{RH} + A(Th229)_{RH} \quad (15)$$

where:

| | |
|---|---|
| $A_L(Th230)_{CH}$ | activity value for the property INVCHD for the material TH230L |
| $A(Th230)_{CH}$ | activity value for $^{230}$Th from Table 3 for CH-TRU |
| $A(Th229)_{CH}$ | activity value for $^{229}$Th from Table 3 for CH-TRU |
| $A_L(Th230)_{RH}$ | activity value for the property INVRHD for the material TH230L |
| $A(Th230)_{RH}$ | activity value for $^{230}$Th from Table 3 for RH-TRU |
| $A(Th229)_{RH}$ | activity value for $^{229}$Th from Table 3 for RH-TRU |

## 4.3 RESULTS

Using the radionuclide activity values from Table A-1 and the equations from Section 4.2 gives the values in Table 6 for the lumped radionuclide inventories at the end of 2033.

**Table 6. Lumped Radionuclide Inventory Values As of 12/31/2033**

| Material | INVCHD (Total Curies) | INVRHD (Total Curies) |
|---|---|---|
| AM241L | 7.18E+05 | 8.56E+03 |
| PU238L | 5.95E+05 | 5.80E+03 |
| PU239L | 7.60E+05 | 1.15E+05 |
| TH230L | 4.54E+00 | 9.91E-01 |
| U234L | 3.08E+02 | 7.28E+01 |

# 5. OXYANION MOLES

LANL provided masses of sulfate and nitrate in waste coming to the WIPP in the *Performance Assessment Inventory Report – 2012* (Van Soest 2012, Table 5-8). The values are 1.70E+06 kg of nitrate and 4.72E+05 kg of sulfate. A conversion to moles is needed for input to the CRA-2014. The molecular weights for nitrate and sulfate are given in Tierney (1996). The molecular weight of nitrate used in Tierney (1996) is 6.20E-02 kg/mole. The molecular weight of sulfate used in Tierney (1996) is 9.606E-02 kg/mole. The conversion is as follows:

$$M_{waste}^{NO_3^-} = \left[\frac{1.70\text{E+06 kg}}{6.20\text{E-02 kg/mole}}\right] = 2.74\text{E+07 moles } NO_3^- \qquad (16)$$

$$M_{waste}^{SO_4^{-2}} = \left[\frac{4.72\text{E+05 kg}}{9.606\text{E-02 kg/mole}}\right] = 4.91\text{E+06 moles } SO_4^{-2} \qquad (17)$$

# 6. RELEVANT PROCEDURES AND REFERENCES

## 6.1 PROCEDURES

AP-164, *Analysis Plan for the 2014 Compliance Recertification Application Performance Assessment.* Sandia National Laboratories, Carlsbad, NM.

NP 9-1, *Analyses.* Sandia National Laboratories Nuclear Waste Management Program Procedure, Revision 9.

NP 9-2, *Parameters.* Sandia National Laboratories Nuclear Waste Management Program Procedure, Revision 1.

## 6.2 REFERENCES

Cotsworth, E. 2005. *EPA Letter on Conducting the Performance Assessment Baseline Change (PABC) Verification Test*. ERMS 538858. Sandia National Laboratories, Carlsbad, NM.

Cotsworth, E. 2009. *EPA Letter on CRA-2009 First Set of Completeness Comments*. ERMS 551444. Sandia National Laboratories, Carlsbad, NM.

Clayton, D.J., S. Dunagan, J.W. Garner, A.E. Ismail, T.B. Kirchner, G.R. Kirkes, M.B. Nemer. 2008. Summary Report of the 2009 Compliance Recertification Application Performance Assessment. Sandia National Laboratories, Carlsbad, NM. ERMS 548862.

Fox, B., D. Clayton, T. Kirchner. 2009. Radionuclide Inventory Screening Analysis Report for the PABC-2009. Sandia National Laboratories, Carlsbad, NM. ERMS 551679.

Lockheed Martin (KAPL, Inc.). 2002. *Nuclides and Isotopes*, Sixteenth Edition.

Leigh, C.D., J.F. Kanney, L.H. Brush, J.W. Garner, G.R. Kirkes, T. Lowry, M.B. Nemer, J.S. Stein, E.D. Vugrin, S. Wagner, and T.B. Kirchner. 2005. 2004 Compliance Recertification Application Performance Assessment Baseline Calculation, Revision 0. Sandia National Laboratories, Carlsbad, NM. ERMS 541521.

Leigh, C. and Trone, J. 2005. *Calculation of Radionuclide Inventories for Use in NUTS in the Performance Assessment Baseline Calculation Revision 0*. ERMS# 539644. Sandia National Laboratories. Carlsbad, NM.

MacKinnon, R.J. and G. Freeze 1997a. *Summary of EPA-Mandated Performance Assessment Verification Test (Replicate 1) and Comparison With the Compliance Certification Application Calculations*. Revision 1. Carlsbad, NM: Sandia National Laboratories. ERMS 422595.

MacKinnon, R.J. and G. Freeze 1997b. *Summary of Uncertainty and Sensitivity Analysis Results for the EPA-Mandated Performance Assessment Verification Test*. Revision 1. Carlsbad, NM: Sandia National Laboratories. ERMS 420669.

MacKinnon, R.J. and G. Freeze 1997c. *Supplemental Summary of EPA-Mandated Performance Assessment Verification Test (All Replicates) and Comparison With the Compliance Certification Application Calculations*. Revision 1. Carlsbad, NM: Sandia National Laboratories. ERMS 414880.

Rechard, R.P 1996. *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 Revised, UC-721. Sandia National Laboratories. Albuquerque, New Mexico.

Sanchez, L.C., Liscum-Powell, J., Rath, J.S., and Trellue, H.R. 1997. *WIPP PA Analysis Report for EPAUNI: Estimating Probability Distribution of EPA Unit Loading in the WIPP Repository* *for Performance Assessment Calculations, Version 1.01. WBS 1.2.07.1.1.* ERMS # 243843. Sandia National Laboratories. Albuquerque, NM.

Tierney, M. 1996. Form 464. *ID 2906, IDMTRL NITRATE, IDPRAM QINIT, IMPT 1.* Sandia National Laboratories. Carlsbad, NM. ERMS #232335.

U.S. Congress 1992. WIPP Land Withdrawal Act, Public Law 102-579, 106 Stat. 4777, 1992; as amended by Public Law 104-201, 110 Stat. 2422, 1996.

U.S. DOE 1996. Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. DOE/CAO-1996-2184. U.S. Department of Energy. Carlsbad, NM

U.S. DOE 2004. *Title 40 CFR 191 Subparts B and C Compliance Recertification Application 2004.* DOE/WIPP 2004-3231. U.S. Department of Energy. Carlsbad, NM.

U.S. EPA 1998. *40 CFR 194, Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the Disposal Regulations: Certification Decision: Final Rule, Federal Register.* Vol. 63, 27354-27406.

U.S. EPA 2006. *40 CFR 194, Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the Disposal Regulations: Certification Decision: Final Rule, Federal Register.* Vol. 71, 18010-18021.

U.S. EPA 2010. *40 CFR 194 Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the Disposal Regulations: Recertification Decision, Federal Register* No. 222, Vol. 75, pp. 70584-70595, November 18, 2010.

Van Soest, G.D. 2012. *Performance Assessment Inventory Report – 2012.* INV-PA-12, Revision 0. Los Alamos National Laboratory, Carlsbad, NM. LA-UR-12-26643.

# APPENDIX A – Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste

**Table A-1. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2033)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Ac-225 | α, γ | 10.0 d | 4.19E-01 | 9.81E-01 | --- | --- | --- |
| Ac-227 | α, β-, γ | 21.77 a | 2.41E+00 | 2.91E-01 | 1.00E+02 | 2.06E+02 | 1.31E-02 |
| Ac-228 | α, β-, γ | 6.15 h | 1.45E+00 | 1.76E-02 | --- | --- | --- |
| Ag-108 | β-, γ, ε, β+ | 2.39 m | 1.76E-04 | 2.21E-03 | --- | --- | --- |
| Ag-108m | ε, β+ , γ, IT | 420 m | 2.02E-03 | 2.54E-02 | --- | --- | --- |
| Ag-109m | ITe- | 39.8 s | 2.86E-02 | 2.11E-06 | --- | --- | --- |
| Ag-110 | β-, γ, ε | 24.6 s | 4.22E-12 | 7.40E-14 | --- | --- | --- |
| Ag-110m | β-, γ, ITe- | 249.8 d | 3.10E-10 | 5.44E-12 | --- | --- | --- |
| Am-241 | α, γ, SF | 432.7 a | 6.97E+05 | 8.06E+03 | 1.00E+02 | 2.06E+02 | 3.42E+03 |
| Am-242 | β-, γ, ε e- | 16.02 h | 2.00E+01 | 2.39E+00 | --- | --- | --- |
| Am-242m | α, ITe-, γ, SF | 141.0 a | 2.01E+01 | 2.40E+00 | 1.00E+02 | 2.06E+02 | 1.09E-01 |
| Am-243 | α, γ, SF | 7.37E+03 a | 2.18E+01 | 2.95E+01 | 1.00E+02 | 2.06E+02 | 2.48E-01 |
| Am-245 | β-, γ | 2.05 h | 7.97E-12 | 3.85E-20 | --- | --- | --- |
| Ar-39 | β- | 269 a | --- | 1.89E-02 | 1.00E+03 | 2.06E+03 | 9.14E-06 |
| Ar-42 | β- | 33 a | --- | 3.22E-02 | 1.00E+03 | 2.06E+03 | 1.56E-05 |
| At-217 | α, β-, γ | 32 ms | 4.19E-01 | 9.81E-01 | --- | --- | --- |
| Ba-133 | ε, γ | 10.53 a | 1.95E-03 | 9.11E-01 | --- | --- | --- |
| Ba-137m | IT | 2.552 m | 2.18E+03 | 2.20E+05 | --- | --- | --- |
| Bi-210 | α, β-, γ | 5.01 d | 4.53E-01 | 1.38E+01 | --- | --- | --- |
| Bi-211 | α, β-, γ | 2.14 m | 2.41E+00 | 2.91E-01 | --- | --- | --- |
| Bi-212 | α, β-, γ | 1.009 h | 1.19E+01 | 4.47E+00 | --- | --- | --- |
| Bi-213 | α, β-, γ | 45.6 m | 4.19E-01 | 9.81E-01 | --- | --- | --- |
| Bi-214 | α, β-, γ | 19.9 m | 6.19E-01 | 1.65E+01 | --- | --- | --- |
| Bk-249 | α, β-, γ, SF | 3.2E+02 d | 5.50E-07 | 2.66E-15 | --- | --- | --- |
| Bk-250 | β-, γ | 3.217 h | 8.28E-04 | 7.59E-09 | --- | --- | --- |
| C-14 | β- | 5730 a | 1.04E-02 | 2.17E+02 | 1.00E+02 | 2.06E+02 | 1.05E+00 |
| Ca-45 | β- | 162.61 d | 9.02E-21 | 9.21E-19 | --- | --- | --- |
| Cd-109 | γ, ε | 462.0 d | 2.86E-02 | 2.11E-06 | --- | --- | --- |
| Cd-113 | β- | 7.7E+15 a | 1.51E-03 | 6.02E-18 | 1.00E+03 | 2.06E+03 | 7.33E-07 |
| Cd-113m | β-, IT | 14.1 a | 2.84E-04 | 1.21E+00 | --- | --- | --- |
| Ce-139 | γ, ε | 137.64 d | 2.12E-22 | 4.75E-21 | --- | --- | --- |
| Ce-144 | β-, γ | 284.6 d | 8.76E-07 | 3.31E-07 | --- | --- | --- |
| Cf-249 | α, γ, SF | 351 a | 2.25E+01 | 1.68E+00 | 1.00E+02 | 2.06E+02 | 1.17E-01 |
| Cf-250 | α, γ, SF | 13.1 a | 1.25E-01 | 2.83E-01 | --- | --- | --- |

**Table A-1. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Cf-251 | α, γ | 9.0E+02 a | 8.20E-03 | 4.04E-02 | 1.00E+02 | 2.06E+02 | 2.35E-04 |
| Cf-252 | α, γ, SF | 2.638 a | 7.62E-01 | 9.26E-04 | --- | --- | --- |
| Cl-36 | β-, ε, β+ | 3.01E+01 a | 4.07E-03 | --- | 1.00E+03 | 2.06E+03 | 1.97E-06 |
| Cm-242 | α, γ, SF | 162.8 d | 1.65E+01 | 1.98E+00 | --- | --- | --- |
| Cm-243 | α, γ, SF, ε | 29.1 a | 2.16E+02 | 1.81E+01 | 1.00E+02 | 2.06E+02 | 1.14E+00 |
| Cm-244 | α, γ, SF | 18.1 a | 5.24E+03 | 4.73E+03 | --- | --- | --- |
| Cm-245 | α, γ, SF | 8.5E+03 a | 3.70E-01 | 8.55E-01 | 1.00E+02 | 2.06E+02 | 5.94E-03 |
| Cm-246 | α, γ, SF | 4.76E+03 a | 6.73E+00 | 6.79E+01 | 1.00E+02 | 2.06E+02 | 3.62E-01 |
| Cm-247 | α, γ | 1.56E+07 a | 1.12E-02 | 4.10E-07 | 1.00E+02 | 2.06E+02 | 5.43E-05 |
| Cm-248 | α, SF | 3.48E+05 a | 1.03E-01 | 1.62E-02 | 1.00E+02 | 2.06E+02 | 5.77E-04 |
| Cm-250 | α, β-, SF | 9700 a | 5.91E-03 | 5.42E-08 | 1.00E+02 | 2.06E+02 | 2.86E-05 |
| Co-60 | β-, γ | 5.271 a | 3.98E-02 | 7.72E+03 | --- | --- | --- |
| Cs-134 | β-, γ, ε | 2.065 a | 4.62E-03 | 8.76E-01 | --- | --- | --- |
| Cs-135 | β- | 2.3E+06 a | 3.45E-07 | 6.05E+01 | 1.00E+03 | 2.06E+03 | 2.93E-02 |
| Cs-137 | β-, γ | 30.17 a | 2.31E+03 | 2.33E+05 | 1.00E+03 | 2.06E+03 | 1.14E+02 |
| Dy-159 | γ, ε | 144.4 d | --- | 5.10E-21 | --- | --- | --- |
| Es-254 | α, γ | 276 d | 7.50E-13 | 7.22E-23 | --- | --- | --- |
| Eu-152 | β-, γ, εβ+ | 13.48 a | 6.33E-01 | 3.29E+01 | --- | --- | --- |
| Eu-154 | β-, γ, εγ | 8.59 a | 1.54E+00 | 2.26E+02 | --- | --- | --- |
| Eu-155 | β-, γ | 4.71 a | 1.15E-01 | 3.07E+01 | --- | --- | --- |
| Fe-55 | ε | 2.73 a | 1.82E-04 | 1.49E+02 | --- | --- | --- |
| Fr-221 | α, γ | 4.8 m | 4.19E-01 | 9.81E-01 | --- | --- | --- |
| Fr-223 | α, β-, γ | 21.8 m | 3.32E-02 | 4.01E-03 | --- | --- | --- |
| Gd-152 | α | 1.1E+14 a | 4.87E-14 | 4.64E-12 | 1.00E+02 | 2.06E+02 | 2.27E-14 |
| Gd-153 | γ, ε - | 240.4 d | --- | 9.89E-13 | --- | --- | --- |
| H-3 | β- | 12.3 a | 5.53E+03 | 3.76E+02 | --- | --- | --- |
| Ho-166m | β-, γ | 1.2E+03 a | 1.82E-05 | 5.19E-10 | 1.00E+03 | 2.06E+03 | 8.81E-09 |
| I-129 | β-, γ | 1.57E+07 a | 3.94E-03 | 3.73E-01 | 1.00E+02 | 2.06E+02 | 1.83E-03 |
| In-113m | γ, ε | 1.6582 h | --- | 6.36E-26 | --- | --- | --- |
| In-115 | β- | 4.4E+15 a | --- | 6.05E-17 | 1.00E+03 | 2.06E+03 | 2.93E-20 |
| Ir-194 | β-,γ, ε - | 19.28 h | --- | 1.46E-03 | --- | --- | --- |
| K-40 | β-, γ, β+ | 1.27E+09 a | 6.05E-03 | --- | 1.00E+03 | 2.06E+03 | 2.93E-06 |
| K-42 | β-,γ | 12.36 h | --- | 3.22E-02 | --- | --- | --- |
| Kr-85 | β-, γ | 10.73 a | 8.13E-01 | 1.94E+02 | --- | --- | --- |
| Lu-177m | β-, α | 160.4 d | --- | 8.05E-21 | --- | --- | --- |
| Mn-54 | ε, γ | 312.2 d | 2.15E-11 | 2.17E-04 | --- | --- | --- |

**Table A-1. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Mo-93 | ε, γ | 3.5E+03 a | --- | 2.12E-02 | 1.00E+03 | 2.06E+03 | 1.02E-05 |
| Na-22 | ε | 2.6019 a | 6.36E-03 | 8.19E-05 | --- | --- | --- |
| Nb-91 | γ | 680 a | --- | 3.20E-02 | 1.00E+03 | 2.06E+03 | 1.55E-05 |
| Nb-93m | ITe- | 16.1 a | 2.14E-03 | 4.21E-01 | --- | --- | --- |
| Nb-94 | β-, γ | 2.0E+04 a | 1.23E-03 | 2.08E+00 | 1.00E+03 | 2.06E+03 | 1.01E-03 |
| Nd-144 | α | 2.29E+15 a | 7.28E-16 | 3.68E-11 | 1.00E+02 | 2.06E+02 | 1.78E-13 |
| Ni-59 | ε | 7.6E+04 a | 1.32E-05 | 2.13E+03 | 1.00E+03 | 2.06E+03 | 1.03E+00 |
| Ni-63 | β- | 100 a | 2.58E-01 | 2.45E+03 | 1.00E+03 | 2.06E+03 | 1.19E+00 |
| Np-235 | ε | 396.2 d | --- | 1.96E-07 | --- | --- | --- |
| Np-237 | α, γ | 2.14E+06 a | 2.04E+01 | 2.84E+00 | 1.00E+02 | 2.06E+02 | 1.12E-01 |
| Np-238 | β-, γ | 2.117 d | 9.04E-02 | 1.08E-02 | --- | --- | --- |
| Np-239 | β-, γ | 2.355 d | 2.18E+01 | 2.95E+01 | --- | --- | --- |
| Np-240 | β- | 61.9 m | 1.22E-05 | 8.85E-09 | --- | --- | --- |
| Np-240m | β-, γ, IT | 7.22 m | 1.01E-02 | 7.37E-06 | --- | --- | --- |
| Os-194 | β- | 6.0 a | --- | 1.45E-03 | --- | --- | --- |
| Pa-231 | α, γ | 3.28E+04 a | 5.88E-01 | 4.92E-02 | 1.00E+02 | 2.06E+02 | 3.09E-03 |
| Pa-233 | β-, γ | 27.0 d | 2.04E+01 | 2.84E+00 | --- | --- | --- |
| Pa-234 | β-, γ | 6.69 h | 4.56E-02 | 3.86E-02 | --- | --- | --- |
| Pa-234m | β-, γ, IT | 1.17 m | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Pb-209 | β- | 3.25 h | 4.19E-01 | 9.81E-01 | --- | --- | --- |
| Pb-210 | α, β-, γ | 22.3 a | 4.53E-01 | 1.38E+01 | 1.00E+02 | 2.06E+02 | 6.91E-02 |
| Pb-211 | β-, γ | 36.1 m | 2.41E+00 | 2.91E-01 | --- | --- | --- |
| Pb-212 | β-, γ | 10.64 h | 1.19E+01 | 4.47E+00 | --- | --- | --- |
| Pb-214 | β-, γ | 27 m | 6.19E-01 | 1.65E+01 | --- | --- | --- |
| Pd-107 | β- | 6.5E+06 a | 2.22E-05 | 9.53E-05 | 1.00E+03 | 2.06E+03 | 5.70E-08 |
| Pm-145 | ε | 17.7 a | --- | 4.95E-01 | --- | --- | --- |
| Pm-146 | ε, γ, β- | 5.53 a | 4.92E-07 | 6.78E-02 | --- | --- | --- |
| Pm-147 | β-, γ | 2.6234 a | 1.00E-01 | 4.53E-01 | --- | --- | --- |
| Po-210 | α, γ | 138.38 d | 4.53E-01 | 1.38E+01 | --- | --- | --- |
| Po-211 | α, γ | 0.516 s | 6.63E-03 | 8.01E-04 | --- | --- | --- |
| Po-212 | α | 0.298 ms | 7.65E+00 | 2.86E+00 | --- | --- | --- |
| Po-213 | α | 4 ms | 4.10E-01 | 9.60E-01 | --- | --- | --- |
| Po-214 | α, γ | 163.7 ms | 6.19E-01 | 1.65E+01 | --- | --- | --- |
| Po-215 | α, β-, γ | 1.780 ms | 2.41E+00 | 2.91E-01 | --- | --- | --- |
| Po-216 | α, γ | 0.145 s | 1.19E+01 | 4.47E+00 | --- | --- | --- |
| Po-218 | α, β-, γ | 3.10 m | 6.19E-01 | 1.65E+01 | --- | --- | --- |

**Table A-1. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Pr-144 | β-, γ | 17.28 m | 8.77E-07 | 3.31E-07 | --- | --- | --- |
| Pr-144m | β-, α | 7.2 m | 1.23E-08 | 4.64E-09 | --- | --- | --- |
| Pu-236 | α, γ, SF | 2.87 a | 4.22E-08 | 2.69E-03 | --- | --- | --- |
| Pu-238 | α, γ, SF | 87.7 a | 5.95E+05 | 5.80E+03 | 1.00E+02 | 2.06E+02 | 2.91E+03 |
| Pu-239 | α, γ, SF | 2.41E+04 a | 5.67E+05 | 7.27E+03 | 1.00E+02 | 2.06E+02 | 2.78E+03 |
| Pu-240 | α, γ, SF | 6.56E+03 a | 1.67E+05 | 7.94E+03 | 1.00E+02 | 2.06E+02 | 8.49E+02 |
| Pu-241 | α, β-, γ | 14.4 a | 6.48E+05 | 1.49E+04 | --- | --- | --- |
| Pu-242 | α, γ, SF | 3.75E+05 a | 1.66E+03 | 6.44E+03 | 1.00E+02 | 2.06E+02 | 3.92E+01 |
| Pu-243 | β-, γ | 4.956 h | 1.12E-02 | 4.10E-07 | --- | --- | --- |
| Pu-244 | α, SF | 8.0E+07 a | 1.01E-02 | 7.38E-06 | 1.00E+02 | 2.06E+02 | 4.92E-05 |
| Ra-223 | α, γ | 11.435 d | 2.41E+00 | 2.91E-01 | --- | --- | --- |
| Ra-224 | α, γ | 3.66 d | 1.19E+01 | 4.47E+00 | --- | --- | --- |
| Ra-225 | β-, γ | 14.9 d | 4.19E-01 | 9.81E-01 | --- | --- | --- |
| Ra-226 | α, γ | 1.60E+03 a | 6.19E-01 | 1.65E+01 | 1.00E+02 | 2.06E+02 | 8.31E-02 |
| Ra-228 | β-, γ | 5.76 a | 1.45E+00 | 1.76E-02 | --- | --- | --- |
| Rb-87 | β- | 4.88E+10 a | 1.24E-10 | 2.49E-09 | 1.00E+03 | 2.06E+03 | 1.27E-12 |
| Rh-102 | β-, γ | 2.9 a | --- | 2.91E-14 | --- | --- | --- |
| Rh-106 | β-, γ | 29.9 s | 1.59E-04 | 1.06E-05 | --- | --- | --- |
| Rn-219 | α, γ | 3.96 s | 2.41E+00 | 2.91E-01 | --- | --- | --- |
| Rn-220 | α, γ | 55.6 s | 1.19E+01 | 4.47E+00 | --- | --- | --- |
| Rn-222 | α, γ | 3.8235 d | 6.19E-01 | 1.65E+01 | --- | --- | --- |
| Ru-106 | β- | 1.02 a | 1.59E-04 | 1.06E-05 | --- | --- | --- |
| Sb-125 | β-, γ | 2.758 a | 1.58E-02 | 1.28E+00 | --- | --- | --- |
| Sb-126 | β-, γ | 12.4 d | 2.00E-01 | 1.34E-01 | --- | --- | --- |
| Sb-126m | γ, ITe- | 11.0 s | 1.43E+00 | 9.58E-01 | --- | --- | --- |
| Se-75 | ε | 119.79 d | 1.74E-34 | 3.16E-25 | --- | --- | --- |
| Se-79 | β- | 6.5E+04 a | 2.45E-05 | 1.40E-01 | 1.00E+03 | 2.06E+03 | 6.78E-05 |
| Sm-145 | ε | 340 d | --- | 2.87E-09 | --- | --- | --- |
| Sm-146 | α | 1.03E+08 a | 1.73E-13 | 3.09E-08 | 1.00E+02 | 2.06E+02 | 1.50E-10 |
| Sm-147 | α | 1.06E+11 a | 1.31E-09 | 1.61E-08 | 1.00E+02 | 2.06E+02 | 8.44E-11 |
| Sm-148 | α | 7E+15 a | 6.09E-29 | 2.29E-19 | 1.00E+02 | 2.06E+02 | 1.11E-21 |
| Sm-151 | β-, γ | 90 a | 6.64E+00 | 4.60E+01 | 1.00E+03 | 2.06E+03 | 2.55E-02 |
| Sn-113 | ε | 115.09 d | --- | 6.36E-26 | --- | --- | --- |
| Sn-119m | IT | 293.1 d | --- | 4.39E-10 | --- | --- | --- |
| Sn-121 | β- | 27.06 h | 6.62E-04 | 9.78E-01 | --- | --- | --- |
| Sn-121m | β-, γ, ITe- | 55 a | 8.53E-04 | 1.26E+00 | 1.00E+03 | 2.06E+03 | 6.11E-04 |

**Table A-1. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Sn-123 | β- | 129.2 d | --- | 1.92E-22 | --- | --- | --- |
| Sn-126 | β-, γ | 1.0E+05 a | 1.43E+00 | 9.58E-01 | 1.00E+03 | 2.06E+03 | 1.16E-03 |
| Sr-90 | β- | 29.1 a | 2.31E+03 | 2.07E+05 | 1.00E+03 | 2.06E+03 | 1.01E+02 |
| Ta-182 | β- | 114.43 d | --- | 1.13E-22 | --- | --- | --- |
| Tb-157 | ε | 71 a | --- | 8.00E-02 | 1.00E+03 | 2.06E+03 | 3.88E-05 |
| Tc-99 | β-, γ | 2.13E+05 a | 6.69E+01 | 1.32E+01 | 1.00E+04 | 2.06E+04 | 3.88E-03 |
| Te-121 | ε | 16.87 d | --- | 1.33E-19 | --- | --- | --- |
| Te-121m | β-, α | 154 d | --- | 1.34E-19 | --- | --- | --- |
| Te-123 | ε | 1.0E+13 a | 1.26E-03 | 1.55E-14 | 1.00E+03 | 2.06E+03 | 6.10E-07 |
| Te-123m | IT | 119.7 d | 4.19E-24 | 7.58E-25 | --- | --- | --- |
| Te-125m | γ, ITe- | 58 d | 3.87E-03 | 3.12E-01 | --- | --- | --- |
| Th-227 | α, γ | 18.72 d | 2.38E+00 | 2.87E-01 | --- | --- | --- |
| Th-228 | α, γ | 1.913 a | 1.19E+01 | 4.47E+00 | --- | --- | --- |
| Th-229 | α, γ | 7.3E+03 a | 4.19E-01 | 9.81E-01 | 1.00E+02 | 2.06E+02 | 6.78E-03 |
| Th-230 | α, γ | 7.54e+04 a | 4.13E+00 | 1.02E-02 | 1.00E+01 | 2.06E+01 | 2.00E-01 |
| Th-231 | β-, γ | 1.063 d | 8.66E+00 | 6.77E+01 | --- | --- | --- |
| Th-232 | α, γ | 1.4E+10 a | 1.48E+00 | 1.46E-02 | 1.00E+01 | 2.06E+01 | 7.27E-02 |
| Th-234 | β-, γ | 24.10 d | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Tl-204 | β-, ε | 3.78 a | 2.52E-06 | --- | --- | --- | --- |
| Tl-207 | β-, γ | 4.77 m | 2.40E+00 | 2.91E-01 | --- | --- | --- |
| Tl-208 | β-, γ | 3.053 m | 4.29E+00 | 1.61E+00 | --- | --- | --- |
| Tl-209 | β-, γ | 2.2 m | 8.80E-03 | 2.06E-02 | --- | --- | --- |
| Tm-170 | β-, α | 128.6 d | --- | 5.09E-24 | --- | --- | --- |
| Tm-171 | β- | 1.92 a | 3.45E-07 | 9.06E-05 | --- | --- | --- |
| U-232 | α, γ, SF | 70 a | 1.02E+01 | 4.33E+00 | 1.00E+02 | 2.06E+02 | 7.04E-02 |
| U-233 | α, γ, SF | 1.592E+05 a | 9.82E+01 | 4.04E+01 | 1.00E+02 | 2.06E+02 | 6.72E-01 |
| U-234 | α, γ, SF | 2.46E+05 a | 2.10E+02 | 3.23E+01 | 1.00E+02 | 2.06E+02 | 1.17E+00 |
| U-235 | α, γ, SF | 7.04E+08 a | 8.66E+00 | 6.77E+01 | 1.00E+02 | 2.06E+02 | 3.70E-01 |
| U-236 | α, γ, SF | 2.342E+07 a | 5.08E+00 | 3.65E-01 | 1.00E+02 | 2.06E+02 | 2.64E-02 |
| U-237 | β-, γ | 6.75 d | 1.55E+01 | 3.57E-01 | --- | --- | --- |
| U-238 | α, γ, SF | 4.47E+09 a | 3.51E+01 | 2.97E+01 | 1.00E+02 | 2.06E+02 | 3.14E-01 |
| U-240 | β-, γ | 14.1 h | 1.01E-02 | 7.37E-06 | --- | --- | --- |
| V-49 | ε | 330 d | --- | 3.19E-08 | --- | --- | --- |
| W-181 | ε | 121.2 d | --- | 6.80E-26 | --- | --- | --- |
| Y-90 | β-, γ | 2.67 d | 2.31E+03 | 2.07E+05 | --- | --- | --- |

**Table A-1. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Zn-65 | β+, γ, ε | 243.8 d | 3.76E-16 | 1.61E-12 | --- | --- | --- |
| Zr-93 | β-, γ | 1.5E+06 a | 2.46E-05 | 4.24E-02 | 1.00E+03 | 2.06E+03 | 2.06E-05 |

(a) Decay mode and half-life information taken from *Nuclides and Isotopes* (also called the "Chart of the Nuclides"), 16th Ed. (Lockheed Martin 2002).
(b) Decayed radionuclide inventory information taken from Van Soest (2012).
(c) Release limits are determined in accordance with 40 CFR 191 (Appendix B, Table B-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, 40 CFR 191). Right column corresponds to release limit obtained for 2.06 Units of Waste. The 2.06 value for the Unit of Waste corresponds to the Units of Waste present at repository closure in 2033.
(d) Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

**Table A-2. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2133)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Ac-225 | α, γ | 10.0 d | 1.28E+00 | 1.33E+00 | --- | --- | --- |
| Ac-227 | α, β-, γ | 21.77 a | 6.75E-01 | 1.59E-01 | 1.00E+02 | 2.06E+02 | 4.04E-03 |
| Ac-228 | α, β-, γ | 6.15 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Ag-108 | β-, γ, ε, β+ | 2.39 m | 1.02E-04 | 1.28E-03 | --- | --- | --- |
| Ag-108m | ε, β+ , γ, IT | 420 m | 1.17E-03 | 1.47E-02 | --- | --- | --- |
| Ag-109m | ITe- | 39.8 s | --- | --- | --- | --- | --- |
| Ag-110 | β-, γ, ε | 24.6 s | --- | --- | --- | --- | --- |
| Ag-110m | β-, γ, ITe- | 249.8 d | --- | --- | --- | --- | --- |
| Am-241 | α, γ, SF | 432.7 a | 6.12E+05 | 7.30E+03 | 1.00E+02 | 2.06E+02 | 3.00E+03 |
| Am-242 | β-, γ, ε e- | 16.02 h | 1.22E+01 | 1.46E+00 | --- | --- | --- |
| Am-242m | α, ITe-, γ, SF | 141.0 a | 1.23E+01 | 1.47E+00 | 1.00E+02 | 2.06E+02 | 6.66E-02 |
| Am-243 | α, γ, SF | 7.37E+03 a | 2.16E+01 | 2.92E+01 | 1.00E+02 | 2.06E+02 | 2.46E-01 |
| Am-245 | β-, γ | 2.05 h | --- | --- | --- | --- | --- |
| Ar-39 | β- | 269 a | --- | 1.46E-02 | 1.00E+03 | 2.06E+03 | 7.06E-06 |
| Ar-42 | β- | 33 a | --- | 3.91E-03 | 1.00E+03 | 2.06E+03 | 1.90E-06 |
| At-217 | α, β-, γ | 32 ms | 1.28E+00 | 1.33E+00 | --- | --- | --- |
| Ba-133 | ε, γ | 10.53 a | 2.68E-06 | 1.25E-03 | --- | --- | --- |
| Ba-137m | IT | 2.552 m | 2.17E+02 | 2.18E+04 | --- | --- | --- |
| Bi-210 | α, β-, γ | 5.01 d | 7.18E-01 | 1.59E+01 | --- | --- | --- |
| Bi-211 | α, β-, γ | 2.14 m | 6.75E-01 | 1.59E-01 | --- | --- | --- |
| Bi-212 | α, β-, γ | 1.009 h | 5.37E+00 | 1.66E+00 | --- | --- | --- |
| Bi-213 | α, β-, γ | 45.6 m | 1.28E+00 | 1.33E+00 | --- | --- | --- |
| Bi-214 | α, β-, γ | 19.9 m | 7.73E-01 | 1.58E+01 | --- | --- | --- |
| Bk-249 | α, β-, γ, SF | 3.2E+02 d | --- | --- | --- | --- | --- |
| Bk-250 | β-, γ | 3.217 h | 8.24E-04 | 7.56E-09 | --- | --- | --- |
| C-14 | β- | 5730 a | 1.03E-02 | 2.15E+02 | 1.00E+02 | 2.06E+02 | 1.04E+00 |
| Ca-45 | β- | 162.61 d | --- | --- | --- | --- | --- |
| Cd-109 | γ, ε | 462.0 d | --- | --- | --- | --- | --- |
| Cd-113 | β- | 7.7E+15 a | 1.51E-03 | 8.56E-18 | 1.00E+03 | 2.06E+03 | 7.33E-07 |
| Cd-113m | β-, IT | 14.1 a | 2.08E-06 | 8.83E-03 | --- | --- | --- |
| Ce-139 | γ, ε | 137.64 d | --- | --- | --- | --- | --- |
| Ce-144 | β-, γ | 284.6 d | --- | --- | --- | --- | --- |
| Cf-249 | α, γ, SF | 351 a | 1.84E+01 | 1.38E+00 | 1.00E+02 | 2.06E+02 | 9.60E-02 |
| Cf-250 | α, γ, SF | 13.1 a | 1.45E-03 | 1.41E-03 | --- | --- | --- |
| Cf-251 | α, γ | 9.0E+02 a | 7.59E-03 | 3.74E-02 | 1.00E+02 | 2.06E+02 | 2.18E-04 |
| Cf-252 | α, γ, SF | 2.638 a | 3.16E-12 | 3.84E-15 | --- | --- | --- |

**Table A-2. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2133) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Cl-36 | β-, ε, β+ | 3.01E+01 a | 4.07E-03 | --- | 1.00E+03 | 2.06E+03 | 1.97E-06 |
| Cm-242 | α, γ, SF | 162.8 d | 1.01E+01 | 1.21E+00 | --- | --- | --- |
| Cm-243 | α, γ, SF, ε | 29.1 a | 1.90E+01 | 1.59E+00 | 1.00E+02 | 2.06E+02 | 9.98E-02 |
| Cm-244 | α, γ, SF | 18.1 a | 1.14E+02 | 1.03E+02 | --- | --- | --- |
| Cm-245 | α, γ, SF | 8.5E+03 a | 5.32E-01 | 8.61E-01 | 1.00E+02 | 2.06E+02 | 6.75E-03 |
| Cm-246 | α, γ, SF | 4.76E+03 a | 6.63E+00 | 6.69E+01 | 1.00E+02 | 2.06E+02 | 3.56E-01 |
| Cm-247 | α, γ | 1.56E+07 a | 1.12E-02 | 5.79E-07 | 1.00E+02 | 2.06E+02 | 5.43E-05 |
| Cm-248 | α, SF | 3.48E+05 a | 1.03E-01 | 1.62E-02 | 1.00E+02 | 2.06E+02 | 5.77E-04 |
| Cm-250 | α, β-, SF | 9700 a | 5.89E-03 | 5.40E-08 | 1.00E+02 | 2.06E+02 | 2.85E-05 |
| Co-60 | β-, γ | 5.271 a | 7.72E-08 | 1.50E-02 | --- | --- | --- |
| Cs-134 | β-, γ, ε | 2.065 a | 1.16E-17 | 2.20E-15 | --- | --- | --- |
| Cs-135 | β- | 2.3E+06 a | 3.45E-07 | 6.05E+01 | 1.00E+03 | 2.06E+03 | 2.93E-02 |
| Cs-137 | β-, γ | 30.17 a | 2.29E+02 | 2.31E+04 | 1.00E+03 | 2.06E+03 | 1.13E+01 |
| Dy-159 | γ, ε | 144.4 d | --- | --- | --- | --- | --- |
| Es-254 | α, γ | 276 d | --- | --- | --- | --- | --- |
| Eu-152 | β-, γ, εβ+ | 13.48 a | 3.49E-03 | 1.81E-01 | --- | --- | --- |
| Eu-154 | β-, γ, εγ | 8.59 a | 4.82E-04 | 7.07E-02 | --- | --- | --- |
| Eu-155 | β-, γ | 4.71 a | 4.27E-08 | 1.13E-05 | --- | --- | --- |
| Fe-55 | ε | 2.73 a | 1.70E-15 | 1.40E-09 | --- | --- | --- |
| Fr-221 | α, γ | 4.8 m | 1.28E+00 | 1.33E+00 | --- | --- | --- |
| Fr-223 | α, β-, γ | 21.8 m | 9.32E-03 | 2.20E-03 | --- | --- | --- |
| Gd-152 | α | 1.1E+14 a | 7.04E-14 | 5.77E-12 | 1.00E+02 | 2.06E+02 | 2.83E-14 |
| Gd-153 | γ, ε - | 240.4 d | --- | --- | --- | --- | --- |
| H-3 | β- | 12.3 a | 2.00E+01 | 1.36E+00 | --- | --- | --- |
| Ho-166m | β-, γ | 1.2E+03 a | 1.72E-05 | 4.90E-10 | 1.00E+03 | 2.06E+03 | 8.32E-09 |
| I-129 | β-, γ | 1.57E+07 a | 3.94E-03 | 3.73E-01 | 1.00E+02 | 2.06E+02 | 1.83E-03 |
| In-113m | γ, ε | 1.6582 h | --- | --- | --- | --- | --- |
| In-115 | β- | 4.4E+15 a | --- | 6.05E-17 | 1.00E+03 | 2.06E+03 | 2.93E-20 |
| Ir-194 | β-,γ, ε - | 19.28 h | --- | 1.39E-08 | --- | --- | --- |
| K-40 | β-, γ, β+ | 1.27E+09 a | 6.05E-03 | --- | 1.00E+03 | 2.06E+03 | 2.93E-06 |
| K-42 | β-,γ | 12.36 h | --- | 3.91E-03 | --- | --- | --- |
| Kr-85 | β-, γ | 10.73 a | 1.26E-03 | 3.02E-01 | --- | --- | --- |
| Lu-177m | β-, α | 160.4 d | --- | --- | --- | --- | --- |
| Mn-54 | ε, γ | 312.2 d | --- | --- | --- | --- | --- |
| Mo-93 | ε, γ | 3.5E+03 a | --- | 2.07E-02 | 1.00E+03 | 2.06E+03 | 1.00E-05 |

**Table A-2. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2133) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Na-22 | ε | 2.6019 a | 1.71E-14 | 2.20E-16 | --- | --- | --- |
| Nb-91 | γ | 680 a | --- | 2.89E-02 | 1.00E+03 | 2.06E+03 | 1.40E-05 |
| Nb-93m | ITe- | 16.1 a | 5.34E-05 | 6.44E-02 | --- | --- | --- |
| Nb-94 | β-, γ | 2.0E+04 a | 1.22E-03 | 2.07E+00 | 1.00E+03 | 2.06E+03 | 1.01E-03 |
| Nd-144 | α | 2.29E+15 a | 7.28E-16 | 3.68E-11 | 1.00E+02 | 2.06E+02 | 1.78E-13 |
| Ni-59 | ε | 7.6E+04 a | 1.31E-05 | 2.13E+03 | 1.00E+03 | 2.06E+03 | 1.03E+00 |
| Ni-63 | β- | 100 a | 1.29E-01 | 1.22E+03 | 1.00E+03 | 2.06E+03 | 5.93E-01 |
| Np-235 | ε | 396.2 d | --- | --- | --- | --- | --- |
| Np-237 | α, γ | 2.14E+06 a | 4.17E+01 | 3.10E+00 | 1.00E+02 | 2.06E+02 | 2.17E-01 |
| Np-238 | β-, γ | 2.117 d | 5.53E-02 | 6.61E-03 | --- | --- | --- |
| Np-239 | β-, γ | 2.355 d | 2.16E+01 | 2.92E+01 | --- | --- | --- |
| Np-240 | β- | 61.9 m | 1.22E-05 | 8.87E-09 | --- | --- | --- |
| Np-240m | β-, γ, IT | 7.22 m | 1.01E-02 | 7.39E-06 | --- | --- | --- |
| Os-194 | β- | 6.0 a | --- | 1.39E-08 | --- | --- | --- |
| Pa-231 | α, γ | 3.28E+04 a | 6.05E-01 | 1.92E-01 | 1.00E+02 | 2.06E+02 | 3.86E-03 |
| Pa-233 | β-, γ | 27.0 d | 4.17E+01 | 3.10E+00 | --- | --- | --- |
| Pa-234 | β-, γ | 6.69 h | 4.56E-02 | 3.86E-02 | --- | --- | --- |
| Pa-234m | β-, γ, IT | 1.17 m | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Pb-209 | β- | 3.25 h | 1.28E+00 | 1.33E+00 | --- | --- | --- |
| Pb-210 | α, β-, γ | 22.3 a | 7.18E-01 | 1.59E+01 | 1.00E+02 | 2.06E+02 | 8.06E-02 |
| Pb-211 | β-, γ | 36.1 m | 6.75E-01 | 1.59E-01 | --- | --- | --- |
| Pb-212 | β-, γ | 10.64 h | 5.37E+00 | 1.66E+00 | --- | --- | --- |
| Pb-214 | β-, γ | 27 m | 7.73E-01 | 1.58E+01 | --- | --- | --- |
| Pd-107 | β- | 6.5E+06 a | 2.22E-05 | 9.53E-05 | 1.00E+03 | 2.06E+03 | 5.70E-08 |
| Pm-145 | ε | 17.7 a | --- | 9.86E-03 | --- | --- | --- |
| Pm-146 | ε, γ, β- | 5.53 a | 1.77E-12 | 2.44E-07 | --- | --- | --- |
| Pm-147 | β-, γ | 2.6234 a | 3.35E-13 | 1.52E-12 | --- | --- | --- |
| Po-210 | α, γ | 138.38 d | 7.18E-01 | 1.59E+01 | --- | --- | --- |
| Po-211 | α, γ | 0.516 s | 1.86E-03 | 4.38E-04 | --- | --- | --- |
| Po-212 | α | 0.298 ms | 3.44E+00 | 1.07E+00 | --- | --- | --- |
| Po-213 | α | 4 ms | 1.25E+00 | 1.30E+00 | --- | --- | --- |
| Po-214 | α, γ | 163.7 ms | 7.73E-01 | 1.58E+01 | --- | --- | --- |
| Po-215 | α, β-, γ | 1.780 ms | 6.75E-01 | 1.59E-01 | --- | --- | --- |
| Po-216 | α, γ | 0.145 s | 5.37E+00 | 1.66E+00 | --- | --- | --- |
| Po-218 | α, β-, γ | 3.10 m | 7.73E-01 | 1.58E+01 | --- | --- | --- |

**Table A-2. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2133) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Pr-144 | β-, γ | 17.28 m | --- | --- | --- | --- | --- |
| Pr-144m | β-, α | 7.2 m | --- | --- | --- | --- | --- |
| Pu-236 | α, γ, SF | 2.87 a | 1.76E-18 | 1.12E-13 | --- | --- | --- |
| Pu-238 | α, γ, SF | 87.7 a | 2.70E+05 | 2.63E+03 | 1.00E+02 | 2.06E+02 | 1.32E+03 |
| Pu-239 | α, γ, SF | 2.41E+04 a | 5.65E+05 | 7.25E+03 | 1.00E+02 | 2.06E+02 | 2.77E+03 |
| Pu-240 | α, γ, SF | 6.56E+03 a | 1.66E+05 | 7.87E+03 | 1.00E+02 | 2.06E+02 | 8.41E+02 |
| Pu-241 | α, β-, γ | 14.4 a | 5.17E+03 | 1.20E+02 | --- | --- | --- |
| Pu-242 | α, γ, SF | 3.75E+05 a | 1.66E+03 | 6.44E+03 | 1.00E+02 | 2.06E+02 | 3.92E+01 |
| Pu-243 | β-, γ | 4.956 h | 1.12E-02 | 5.79E-07 | --- | --- | --- |
| Pu-244 | α, SF | 8.0E+07 a | 1.01E-02 | 7.40E-06 | 1.00E+02 | 2.06E+02 | 4.92E-05 |
| Ra-223 | α, γ | 11.435 d | 6.75E-01 | 1.59E-01 | --- | --- | --- |
| Ra-224 | α, γ | 3.66 d | 5.37E+00 | 1.66E+00 | --- | --- | --- |
| Ra-225 | β-, γ | 14.9 d | 1.28E+00 | 1.33E+00 | --- | --- | --- |
| Ra-226 | α, γ | 1.60E+03 a | 7.73E-01 | 1.58E+01 | 1.00E+02 | 2.06E+02 | 8.05E-02 |
| Ra-228 | β-, γ | 5.76 a | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Rb-87 | β- | 4.88E+10 a | 1.24E-10 | 2.49E-09 | 1.00E+03 | 2.06E+03 | 1.27E-12 |
| Rh-102 | β-, γ | 2.9 a | --- | --- | --- | --- | --- |
| Rh-106 | β-, γ | 29.9 s | --- | --- | --- | --- | --- |
| Rn-219 | α, γ | 3.96 s | 6.75E-01 | 1.59E-01 | --- | --- | --- |
| Rn-220 | α, γ | 55.6 s | 5.37E+00 | 1.66E+00 | --- | --- | --- |
| Rn-222 | α, γ | 3.8235 d | 7.73E-01 | 1.58E+01 | --- | --- | --- |
| Ru-106 | β- | 1.02 a | --- | --- | --- | --- | --- |
| Sb-125 | β-, γ | 2.758 a | 1.49E-13 | 1.20E-11 | --- | --- | --- |
| Sb-126 | β-, γ | 12.4 d | 2.00E-01 | 1.34E-01 | --- | --- | --- |
| Sb-126m | γ, ITe- | 11.0 s | 1.43E+00 | 9.57E-01 | --- | --- | --- |
| Se-75 | ε | 119.79 d | --- | --- | --- | --- | --- |
| Se-79 | β- | 6.5E+04 a | 2.45E-05 | 1.40E-01 | 1.00E+03 | 2.06E+03 | 6.78E-05 |
| Sm-145 | ε | 340 d | --- | --- | --- | --- | --- |
| Sm-146 | α | 1.03E+08 a | 1.81E-13 | 3.21E-08 | 1.00E+02 | 2.06E+02 | 1.56E-10 |
| Sm-147 | α | 1.06E+11 a | 1.31E-09 | 1.61E-08 | 1.00E+02 | 2.06E+02 | 8.45E-11 |
| Sm-148 | α | 7E+15 a | 6.41E-28 | 2.29E-19 | 1.00E+02 | 2.06E+02 | 1.11E-21 |
| Sm-151 | β-, γ | 90 a | 3.07E+00 | 2.13E+01 | 1.00E+03 | 2.06E+03 | 1.18E-02 |
| Sn-113 | ε | 115.09 d | --- | --- | --- | --- | --- |
| Sn-119m | IT | 293.1 d | --- | --- | --- | --- | --- |
| Sn-121 | β- | 27.06 h | 1.88E-04 | 2.77E-01 | --- | --- | --- |
| Sn-121m | β-, γ, ITe- | 55 a | 2.42E-04 | 3.57E-01 | 1.00E+03 | 2.06E+03 | 1.73E-04 |

**Table A-2. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2133) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Sn-123 | β- | 129.2 d | --- | --- | --- | --- | --- |
| Sn-126 | β-, γ | 1.0E+05 a | 1.43E+00 | 9.57E-01 | 1.00E+03 | 2.06E+03 | 1.16E-03 |
| Sr-90 | β- | 29.1 a | 1.97E+02 | 1.76E+04 | 1.00E+03 | 2.06E+03 | 8.62E+00 |
| Ta-182 | β- | 114.43 d | --- | --- | --- | --- | --- |
| Tb-157 | ε | 71 a | --- | 5.04E-02 | 1.00E+03 | 2.06E+03 | 2.44E-05 |
| Tc-99 | β-, γ | 2.13E+05 a | 6.69E+01 | 1.32E+01 | 1.00E+04 | 2.06E+04 | 3.88E-03 |
| Te-121 | ε | 16.87 d | --- | --- | --- | --- | --- |
| Te-121m | β-, α | 154 d | --- | --- | --- | --- | --- |
| Te-123 | ε | 1.0E+13 a | 1.26E-03 | 1.55E-14 | 1.00E+03 | 2.06E+03 | 6.10E-07 |
| Te-123m | IT | 119.7 d | --- | --- | --- | --- | --- |
| Te-125m | γ, ITe- | 58 d | 3.63E-14 | 2.93E-12 | --- | --- | --- |
| Th-227 | α, γ | 18.72 d | 6.66E-01 | 1.57E-01 | --- | --- | --- |
| Th-228 | α, γ | 1.913 a | 5.37E+00 | 1.66E+00 | --- | --- | --- |
| Th-229 | α, γ | 7.3E+03 a | 1.28E+00 | 1.33E+00 | 1.00E+02 | 2.06E+02 | 1.26E-02 |
| Th-230 | α, γ | 7.54E+04 a | 4.38E+00 | 4.05E-02 | 1.00E+01 | 2.06E+01 | 2.14E-01 |
| Th-231 | β-, γ | 1.063 d | 8.71E+00 | 6.77E+01 | --- | --- | --- |
| Th-232 | α, γ | 1.4E+10 a | 1.48E+00 | 1.46E-02 | 1.00E+01 | 2.06E+01 | 7.27E-02 |
| Th-234 | β-, γ | 24.10 d | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Tl-204 | β-, ε | 3.78 a | 2.74E-14 | --- | --- | --- | --- |
| Tl-207 | β-, γ | 4.77 m | 6.74E-01 | 1.59E-01 | --- | --- | --- |
| Tl-208 | β-, γ | 3.053 m | 1.93E+00 | 5.98E-01 | --- | --- | --- |
| Tl-209 | β-, γ | 2.2 m | 2.68E-02 | 2.79E-02 | --- | --- | --- |
| Tm-170 | β-, α | 128.6 d | --- | --- | --- | --- | --- |
| Tm-171 | β- | 1.92 a | 7.26E-23 | 1.90E-20 | --- | --- | --- |
| U-232 | α, γ, SF | 70 a | 3.78E+00 | 1.60E+00 | 1.00E+02 | 2.06E+02 | 2.61E-02 |
| U-233 | α, γ, SF | 1.592E+05 a | 9.82E+01 | 4.04E+01 | 1.00E+02 | 2.06E+02 | 6.72E-01 |
| U-234 | α, γ, SF | 2.46E+05 a | 3.26E+02 | 3.35E+01 | 1.00E+02 | 2.06E+02 | 1.74E+00 |
| U-235 | α, γ, SF | 7.04E+08 a | 8.71E+00 | 6.77E+01 | 1.00E+02 | 2.06E+02 | 3.70E-01 |
| U-236 | α, γ, SF | 2.342E+07 a | 5.57E+00 | 3.88E-01 | 1.00E+02 | 2.06E+02 | 2.89E-02 |
| U-237 | β-, γ | 6.75 d | 1.24E-01 | 2.87E-03 | --- | --- | --- |
| U-238 | α, γ, SF | 4.47E+09 a | 3.51E+01 | 2.97E+01 | 1.00E+02 | 2.06E+02 | 3.14E-01 |
| U-240 | β-, γ | 14.1 h | 1.01E-02 | 7.39E-06 | --- | --- | --- |
| V-49 | ε | 330 d | --- | --- | --- | --- | --- |
| W-181 | ε | 121.2 d | --- | --- | --- | --- | --- |
| Y-90 | β-, γ | 2.67 d | 1.97E+02 | 1.76E+04 | --- | --- | --- |

**Table A-2. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2133) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Zn-65 | β+, γ, ε | 243.8 d | --- | --- | --- | --- | --- |
| Zr-93 | β-, γ | 1.5E+06 a | 2.46E-05 | 4.24E-02 | 1.00E+03 | 2.06E+03 | 2.06E-05 |

(a) Decay mode and half-life information taken from *Nuclides and Isotopes* (also called the "Chart of the Nuclides"), 16th Ed. (Lockheed Martin 2002).
(b) Decayed radionuclide inventory information taken from Van Soest (2012).
(c) Release limits are determined in accordance with 40 CFR 191 (Appendix B, Table B-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, 40 CFR 191). Right column corresponds to release limit obtained for 2.06 Units of Waste. The 2.06 value for the Unit of Waste corresponds to the Units of Waste present at repository closure in 2033.
(d) Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

**Table A-3. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2383)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Ac-225 | α, γ | 10.0 d | 3.38E+00 | 2.18E+00 | --- | --- | --- |
| Ac-227 | α, β-, γ | 21.77 a | 6.49E-01 | 5.49E-01 | 1.00E+02 | 2.06E+02 | 5.80E-03 |
| Ac-228 | α, β-, γ | 6.15 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Ag-108 | β-, γ, ε, β+ | 2.39 m | 2.60E-05 | 3.27E-04 | --- | --- | --- |
| Ag-108m | ε, β+ , γ, IT | 420 m | 2.99E-04 | 3.75E-03 | --- | --- | --- |
| Ag-109m | ITe- | 39.8 s | --- | --- | --- | --- | --- |
| Ag-110 | β-, γ, ε | 24.6 s | --- | --- | --- | --- | --- |
| Ag-110m | β-, γ, ITe- | 249.8 d | --- | --- | --- | --- | --- |
| Am-241 | α, γ, SF | 432.7 a | 4.10E+05 | 4.89E+03 | 1.00E+02 | 2.06E+02 | 2.01E+03 |
| Am-242 | β-, γ, ε e- | 16.02 h | 3.58E+00 | 4.28E-01 | --- | --- | --- |
| Am-242m | α, ITe-, γ, SF | 141.0 a | 3.59E+00 | 4.30E-01 | 1.00E+02 | 2.06E+02 | 1.95E-02 |
| Am-243 | α, γ, SF | 7.37E+03 a | 2.11E+01 | 2.85E+01 | 1.00E+02 | 2.06E+02 | 2.40E-01 |
| Am-245 | β-, γ | 2.05 h | --- | --- | --- | --- | --- |
| Ar-39 | β- | 269 a | --- | 7.65E-03 | 1.00E+03 | 2.06E+03 | 3.71E-06 |
| Ar-42 | β- | 33 a | --- | 2.02E-05 | 1.00E+03 | 2.06E+03 | 9.77E-09 |
| At-217 | α, β-, γ | 32 ms | 3.38E+00 | 2.18E+00 | --- | --- | --- |
| Ba-133 | ε, γ | 10.53 a | 1.88E-13 | 8.79E-11 | --- | --- | --- |
| Ba-137m | IT | 2.552 m | 6.71E-01 | 6.76E+01 | --- | --- | --- |
| Bi-210 | α, β-, γ | 5.01 d | 1.19E+00 | 1.42E+01 | --- | --- | --- |
| Bi-211 | α, β-, γ | 2.14 m | 6.49E-01 | 5.49E-01 | --- | --- | --- |
| Bi-212 | α, β-, γ | 1.009 h | 1.81E+00 | 1.52E-01 | --- | --- | --- |
| Bi-213 | α, β-, γ | 45.6 m | 3.38E+00 | 2.18E+00 | --- | --- | --- |
| Bi-214 | α, β-, γ | 19.9 m | 1.19E+00 | 1.42E+01 | --- | --- | --- |
| Bk-249 | α, β-, γ, SF | 3.2E+02 d | --- | --- | --- | --- | --- |
| Bk-250 | β-, γ | 3.217 h | 8.16E-04 | 7.48E-09 | --- | --- | --- |
| C-14 | β- | 5730 a | 1.00E-02 | 2.08E+02 | 1.00E+02 | 2.06E+02 | 1.01E+00 |
| Ca-45 | β- | 162.61 d | --- | --- | --- | --- | --- |
| Cd-109 | γ, ε | 462.0 d | --- | --- | --- | --- | --- |
| Cd-113 | β- | 7.7E+15 a | 1.51E-03 | 8.58E-18 | 1.00E+03 | 2.06E+03 | 7.33E-07 |
| Cd-113m | β-, IT | 14.1 a | 9.57E-12 | 4.06E-08 | --- | --- | --- |
| Ce-139 | γ, ε | 137.64 d | --- | --- | --- | --- | --- |
| Ce-144 | β-, γ | 284.6 d | --- | --- | --- | --- | --- |
| Cf-249 | α, γ, SF | 351 a | 1.12E+01 | 8.42E-01 | 1.00E+02 | 2.06E+02 | 5.85E-02 |
| Cf-250 | α, γ, SF | 13.1 a | 8.16E-04 | 9.97E-09 | --- | --- | --- |
| Cf-251 | α, γ | 9.0E+02 a | 6.26E-03 | 3.08E-02 | 1.00E+02 | 2.06E+02 | 1.80E-04 |

**Table A-3. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2383) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Cf-252 | α, γ, SF | 2.638 a | --- | --- | --- | --- | --- |
| Cl-36 | β-, ε, β+ | 3.01E+01 a | 4.07E-03 | --- | 1.00E+03 | 2.06E+03 | 1.97E-06 |
| Cm-242 | α, γ, SF | 162.8 d | 2.96E+00 | 3.54E-01 | --- | --- | --- |
| Cm-243 | α, γ, SF, ε | 29.1 a | 4.34E-02 | 3.63E-03 | 1.00E+02 | 2.06E+02 | 2.28E-04 |
| Cm-244 | α, γ, SF | 18.1 a | 7.91E-03 | 7.13E-03 | --- | --- | --- |
| Cm-245 | α, γ, SF | 8.5E+03 a | 8.15E-01 | 8.65E-01 | 1.00E+02 | 2.06E+02 | 8.14E-03 |
| Cm-246 | α, γ, SF | 4.76E+03 a | 6.39E+00 | 6.45E+01 | 1.00E+02 | 2.06E+02 | 3.44E-01 |
| Cm-247 | α, γ | 1.56E+07 a | 1.12E-02 | 9.47E-07 | 1.00E+02 | 2.06E+02 | 5.43E-05 |
| Cm-248 | α, SF | 3.48E+05 a | 1.03E-01 | 1.62E-02 | 1.00E+02 | 2.06E+02 | 5.76E-04 |
| Cm-250 | α, β-, SF | 9700 a | 5.83E-03 | 5.34E-08 | 1.00E+02 | 2.06E+02 | 2.82E-05 |
| Co-60 | β-, γ | 5.271 a | 4.03E-22 | 7.81E-17 | --- | --- | --- |
| Cs-134 | β-, γ, ε | 2.065 a | --- | --- | --- | --- | --- |
| Cs-135 | β- | 2.3E+06 a | 3.45E-07 | 6.05E+01 | 1.00E+03 | 2.06E+03 | 2.93E-02 |
| Cs-137 | β-, γ | 30.17 a | 7.11E-01 | 7.16E+01 | 1.00E+03 | 2.06E+03 | 3.50E-02 |
| Dy-159 | γ, ε | 144.4 d | --- | --- | --- | --- | --- |
| Es-254 | α, γ | 276 d | --- | --- | --- | --- | --- |
| Eu-152 | β-, γ, εβ+ | 13.48 a | 7.86E-09 | 4.09E-07 | --- | --- | --- |
| Eu-154 | β-, γ, εγ | 8.59 a | 8.36E-13 | 1.23E-10 | --- | --- | --- |
| Eu-155 | β-, γ | 4.71 a | 3.54E-24 | 9.41E-22 | --- | --- | --- |
| Fe-55 | ε | 2.73 a | --- | --- | --- | --- | --- |
| Fr-221 | α, γ | 4.8 m | 3.38E+00 | 2.18E+00 | --- | --- | --- |
| Fr-223 | α, β-, γ | 21.8 m | 8.95E-03 | 7.57E-03 | --- | --- | --- |
| Gd-152 | α | 1.1E+14 a | 7.05E-14 | 5.78E-12 | 1.00E+02 | 2.06E+02 | 2.83E-14 |
| Gd-153 | γ, ε - | 240.4 d | --- | --- | --- | --- | --- |
| H-3 | β- | 12.3 a | 1.57E-05 | 1.07E-06 | --- | --- | --- |
| Ho-166m | β-, γ | 1.2E+03 a | 1.49E-05 | 4.24E-10 | 1.00E+03 | 2.06E+03 | 7.20E-09 |
| I-129 | β-, γ | 1.57E+07 a | 3.94E-03 | 3.73E-01 | 1.00E+02 | 2.06E+02 | 1.83E-03 |
| In-113m | γ, ε | 1.6582 h | --- | --- | --- | --- | --- |
| In-115 | β- | 4.4E+15 a | --- | 6.05E-17 | 1.00E+03 | 2.06E+03 | 2.93E-20 |
| Ir-194 | β-,γ, ε - | 19.28 h | --- | 3.96E-21 | --- | --- | --- |
| K-40 | β-, γ, β+ | 1.27E+09 a | 6.05E-03 | --- | 1.00E+03 | 2.06E+03 | 2.93E-06 |
| K-42 | β-,γ | 12.36 h | --- | 2.02E-05 | --- | --- | --- |
| Kr-85 | β-, γ | 10.73 a | 1.20E-10 | 2.88E-08 | --- | --- | --- |
| Lu-177m | β-, α | 160.4 d | --- | --- | --- | --- | --- |
| Mn-54 | ε, γ | 312.2 d | --- | --- | --- | --- | --- |

**Table A-3. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2383) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Mo-93 | ε, γ | 3.5E+03 a | --- | 1.97E-02 | 1.00E+03 | 2.06E+03 | 9.56E-06 |
| Na-22 | ε | 2.6019 a | --- | --- | --- | --- | --- |
| Nb-91 | γ | 680 a | --- | 2.24E-02 | 1.00E+03 | 2.06E+03 | 1.09E-05 |
| Nb-93m | ITe- | 16.1 a | 2.46E-05 | 5.86E-02 | --- | --- | --- |
| Nb-94 | β-, γ | 2.0E+04 a | 1.21E-03 | 2.06E+00 | 1.00E+03 | 2.06E+03 | 9.97E-04 |
| Nd-144 | α | 2.29E+15 a | 7.28E-16 | 3.68E-11 | 1.00E+02 | 2.06E+02 | 1.78E-13 |
| Ni-59 | ε | 7.6E+04 a | 1.31E-05 | 2.12E+03 | 1.00E+03 | 2.06E+03 | 1.03E+00 |
| Ni-63 | β- | 100 a | 2.29E-02 | 2.17E+02 | 1.00E+03 | 2.06E+03 | 1.05E-01 |
| Np-235 | ε | 396.2 d | --- | --- | --- | --- | --- |
| Np-237 | α, γ | 2.14E+06 a | 8.26E+01 | 3.58E+00 | 1.00E+02 | 2.06E+02 | 4.18E-01 |
| Np-238 | β-, γ | 2.117 d | 1.62E-02 | 1.94E-03 | --- | --- | --- |
| Np-239 | β-, γ | 2.355 d | 2.11E+01 | 2.85E+01 | --- | --- | --- |
| Np-240 | β- | 61.9 m | 1.22E-05 | 8.90E-09 | --- | --- | --- |
| Np-240m | β-, γ, IT | 7.22 m | 1.01E-02 | 7.42E-06 | --- | --- | --- |
| Os-194 | β- | 6.0 a | --- | 3.95E-21 | --- | --- | --- |
| Pa-231 | α, γ | 3.28E+04 a | 6.48E-01 | 5.48E-01 | 1.00E+02 | 2.06E+02 | 5.80E-03 |
| Pa-233 | β-, γ | 27.0 d | 8.26E+01 | 3.58E+00 | --- | --- | --- |
| Pa-234 | β-, γ | 6.69 h | 4.56E-02 | 3.86E-02 | --- | --- | --- |
| Pa-234m | β-, γ, IT | 1.17 m | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Pb-209 | β- | 3.25 h | 3.38E+00 | 2.18E+00 | --- | --- | --- |
| Pb-210 | α, β-, γ | 22.3 a | 1.19E+00 | 1.42E+01 | 1.00E+02 | 2.06E+02 | 7.46E-02 |
| Pb-211 | β-, γ | 36.1 m | 6.49E-01 | 5.49E-01 | --- | --- | --- |
| Pb-212 | β-, γ | 10.64 h | 1.81E+00 | 1.52E-01 | --- | --- | --- |
| Pb-214 | β-, γ | 27 m | 1.19E+00 | 1.42E+01 | --- | --- | --- |
| Pd-107 | β- | 6.5E+06 a | 2.22E-05 | 9.53E-05 | 1.00E+03 | 2.06E+03 | 5.70E-08 |
| Pm-145 | ε | 17.7 a | --- | 5.52E-07 | --- | --- | --- |
| Pm-146 | ε, γ, β- | 5.53 a | 4.34E-26 | 5.99E-21 | --- | --- | --- |
| Pm-147 | β-, γ | 2.6234 a | --- | --- | --- | --- | --- |
| Po-210 | α, γ | 138.38 d | 1.19E+00 | 1.42E+01 | --- | --- | --- |
| Po-211 | α, γ | 0.516 s | 1.78E-03 | 1.51E-03 | --- | --- | --- |
| Po-212 | α | 0.298 ms | 1.16E+00 | 9.76E-02 | --- | --- | --- |
| Po-213 | α | 4 ms | 3.31E+00 | 2.13E+00 | --- | --- | --- |
| Po-214 | α, γ | 163.7 ms | 1.19E+00 | 1.42E+01 | --- | --- | --- |
| Po-215 | α, β-, γ | 1.780 ms | 6.49E-01 | 5.49E-01 | --- | --- | --- |
| Po-216 | α, γ | 0.145 s | 1.81E+00 | 1.52E-01 | --- | --- | --- |

**Table A-3. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2383) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Po-218 | α, β-, γ | 3.10 m | 1.19E+00 | 1.42E+01 | --- | --- | --- |
| Pr-144 | β-, γ | 17.28 m | --- | --- | --- | --- | --- |
| Pr-144m | β-, α | 7.2 m | --- | --- | --- | --- | --- |
| Pu-236 | α, γ, SF | 2.87 a | --- | --- | --- | --- | --- |
| Pu-238 | α, γ, SF | 87.7 a | 3.74E+04 | 3.65E+02 | 1.00E+02 | 2.06E+02 | 1.83E+02 |
| Pu-239 | α, γ, SF | 2.41E+04 a | 5.61E+05 | 7.19E+03 | 1.00E+02 | 2.06E+02 | 2.76E+03 |
| Pu-240 | α, γ, SF | 6.56E+03 a | 1.61E+05 | 7.67E+03 | 1.00E+02 | 2.06E+02 | 8.19E+02 |
| Pu-241 | α, β-, γ | 14.4 a | 8.45E-01 | 8.68E-01 | --- | --- | --- |
| Pu-242 | α, γ, SF | 3.75E+05 a | 1.66E+03 | 6.43E+03 | 1.00E+02 | 2.06E+02 | 3.92E+01 |
| Pu-243 | β-, γ | 4.956 h | 1.12E-02 | 9.47E-07 | --- | --- | --- |
| Pu-244 | α, SF | 8.0E+07 a | 1.01E-02 | 7.43E-06 | 1.00E+02 | 2.06E+02 | 4.92E-05 |
| Ra-223 | α, γ | 11.435 d | 6.49E-01 | 5.49E-01 | --- | --- | --- |
| Ra-224 | α, γ | 3.66 d | 1.81E+00 | 1.52E-01 | --- | --- | --- |
| Ra-225 | β-, γ | 14.9 d | 3.38E+00 | 2.18E+00 | --- | --- | --- |
| Ra-226 | α, γ | 1.60E+03 a | 1.19E+00 | 1.42E+01 | 1.00E+02 | 2.06E+02 | 7.46E-02 |
| Ra-228 | β-, γ | 5.76 a | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Rb-87 | β- | 4.88E+10 a | 1.24E-10 | 2.49E-09 | 1.00E+03 | 2.06E+03 | 1.27E-12 |
| Rh-102 | β-, γ | 2.9 a | --- | --- | --- | --- | --- |
| Rh-106 | β-, γ | 29.9 s | --- | --- | --- | --- | --- |
| Rn-219 | α, γ | 3.96 s | 6.49E-01 | 5.49E-01 | --- | --- | --- |
| Rn-220 | α, γ | 55.6 s | 1.81E+00 | 1.52E-01 | --- | --- | --- |
| Rn-222 | α, γ | 3.8235 d | 1.19E+00 | 1.42E+01 | --- | --- | --- |
| Ru-106 | β- | 1.02 a | --- | --- | --- | --- | --- |
| Sb-125 | β-, γ | 2.758 a | --- | --- | --- | --- | --- |
| Sb-126 | β-, γ | 12.4 d | 2.00E-01 | 1.34E-01 | --- | --- | --- |
| Sb-126m | γ, ITe- | 11.0 s | 1.43E+00 | 9.56E-01 | --- | --- | --- |
| Se-75 | ε | 119.79 d | --- | --- | --- | --- | --- |
| Se-79 | β- | 6.5E+04 a | 2.45E-05 | 1.40E-01 | 1.00E+03 | 2.06E+03 | 6.77E-05 |
| Sm-145 | ε | 340 d | --- | --- | --- | --- | --- |
| Sm-146 | α | 1.03E+08 a | 1.81E-13 | 3.21E-08 | 1.00E+02 | 2.06E+02 | 1.56E-10 |
| Sm-147 | α | 1.06E+11 a | 1.31E-09 | 1.61E-08 | 1.00E+02 | 2.06E+02 | 8.45E-11 |
| Sm-148 | α | 7E+15 a | 2.18E-27 | 2.29E-19 | 1.00E+02 | 2.06E+02 | 1.11E-21 |
| Sm-151 | β-, γ | 90 a | 4.48E-01 | 3.11E+00 | 1.00E+03 | 2.06E+03 | 1.72E-03 |
| Sn-113 | ε | 115.09 d | --- | --- | --- | --- | --- |
| Sn-119m | IT | 293.1 d | --- | --- | --- | --- | --- |
| Sn-121 | β- | 27.06 h | 8.04E-06 | 1.19E-02 | --- | --- | --- |

**Table A-3. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2383) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Sn-121m | β-, γ, ITe- | 55 a | 1.04E-05 | 1.53E-02 | 1.00E+03 | 2.06E+03 | 7.42E-06 |
| Sn-123 | β- | 129.2 d | --- | --- | --- | --- | --- |
| Sn-126 | β-, γ | 1.0E+05 a | 1.43E+00 | 9.56E-01 | 1.00E+03 | 2.06E+03 | 1.15E-03 |
| Sr-90 | β- | 29.1 a | 4.17E-01 | 3.73E+01 | 1.00E+03 | 2.06E+03 | 1.83E-02 |
| Ta-182 | β- | 114.43 d | --- | --- | --- | --- | --- |
| Tb-157 | ε | 71 a | --- | 1.59E-02 | 1.00E+03 | 2.06E+03 | 7.69E-06 |
| Tc-99 | β-, γ | 2.13E+05 a | 6.68E+01 | 1.32E+01 | 1.00E+04 | 2.06E+04 | 3.88E-03 |
| Te-121 | ε | 16.87 d | --- | --- | --- | --- | --- |
| Te-121m | β-, α | 154 d | --- | --- | --- | --- | --- |
| Te-123 | ε | 1.0E+13 a | 1.26E-03 | 1.55E-14 | 1.00E+03 | 2.06E+03 | 6.10E-07 |
| Te-123m | IT | 119.7 d | --- | --- | --- | --- | --- |
| Te-125m | γ, ITe- | 58 d | --- | --- | --- | --- | --- |
| Th-227 | α, γ | 18.72 d | 6.40E-01 | 5.41E-01 | --- | --- | --- |
| Th-228 | α, γ | 1.913 a | 1.81E+00 | 1.52E-01 | --- | --- | --- |
| Th-229 | α, γ | 7.3E+03 a | 3.38E+00 | 2.18E+00 | 1.00E+02 | 2.06E+02 | 2.69E-02 |
| Th-230 | α, γ | 7.54E+04 a | 5.24E+00 | 1.18E-01 | 1.00E+01 | 2.06E+01 | 2.60E-01 |
| Th-231 | β-, γ | 1.063 d | 8.85E+00 | 6.77E+01 | --- | --- | --- |
| Th-232 | α, γ | 1.4E+10 a | 1.48E+00 | 1.46E-02 | 1.00E+01 | 2.06E+01 | 7.27E-02 |
| Th-234 | β-, γ | 24.10 d | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Tl-204 | β-, ε | 3.78 a | 3.38E-34 | --- | --- | --- | --- |
| Tl-207 | β-, γ | 4.77 m | 6.47E-01 | 5.47E-01 | --- | --- | --- |
| Tl-208 | β-, γ | 3.053 m | 6.50E-01 | 5.48E-02 | --- | --- | --- |
| Tl-209 | β-, γ | 2.2 m | 7.10E-02 | 4.57E-02 | --- | --- | --- |
| Tm-170 | β-, α | 128.6 d | --- | --- | --- | --- | --- |
| Tm-171 | β- | 1.92 a | --- | --- | --- | --- | --- |
| U-232 | α, γ, SF | 70 a | 3.15E-01 | 1.34E-01 | 1.00E+02 | 2.06E+02 | 2.18E-03 |
| U-233 | α, γ, SF | 1.592E+05 a | 9.82E+01 | 4.04E+01 | 1.00E+02 | 2.06E+02 | 6.71E-01 |
| U-234 | α, γ, SF | 2.46E+05 a | 4.09E+02 | 3.43E+01 | 1.00E+02 | 2.06E+02 | 2.15E+00 |
| U-235 | α, γ, SF | 7.04E+08 a | 8.85E+00 | 6.77E+01 | 1.00E+02 | 2.06E+02 | 3.71E-01 |
| U-236 | α, γ, SF | 2.342E+07 a | 6.78E+00 | 4.46E-01 | 1.00E+02 | 2.06E+02 | 3.50E-02 |
| U-237 | β-, γ | 6.75 d | 2.02E-05 | 2.07E-05 | --- | --- | --- |
| U-238 | α, γ, SF | 4.47E+09 a | 3.51E+01 | 2.97E+01 | 1.00E+02 | 2.06E+02 | 3.14E-01 |
| U-240 | β-, γ | 14.1 h | 1.01E-02 | 7.42E-06 | --- | --- | --- |
| V-49 | ε | 330 d | --- | --- | --- | --- | --- |
| W-181 | ε | 121.2 d | --- | --- | --- | --- | --- |
| Y-90 | β-, γ | 2.67 d | 4.18E-01 | 3.73E+01 | --- | --- | --- |

**Table A-3. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 2383) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Zn-65 | β+, γ, ε | 243.8 d | --- | --- | --- | --- | --- |
| Zr-93 | β-, γ | 1.5E+06 a | 2.46E-05 | 4.24E-02 | 1.00E+03 | 2.06E+03 | 2.06E-05 |

(a) Decay mode and half-life information taken from *Nuclides and Isotopes* (also called the "Chart of the Nuclides"), 16th Ed. (Lockheed Martin 2002).
(b) Decayed radionuclide inventory information taken from Van Soest (2012).
(c) Release limits are determined in accordance with 40 CFR 191 (Appendix B, Table B-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, 40 CFR 191). Right column corresponds to release limit obtained for 2.06 Units of Waste. The 2.06 value for the Unit of Waste corresponds to the Units of Waste present at repository closure in 2033.
(d) Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

**Table A-4. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 3033)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Ac-225 | α, γ | 10.0 d | 8.65E+00 | 4.30E+00 | --- | --- | --- |
| Ac-227 | α, β-, γ | 21.77 a | 7.63E-01 | 1.47E+00 | 1.00E+02 | 2.06E+02 | 1.08E-02 |
| Ac-228 | α, β-, γ | 6.15 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Ag-108 | β-, γ, ε, β+ | 2.39 m | 7.48E-07 | 9.40E-06 | --- | --- | --- |
| Ag-108m | ε, β+ , γ, IT | 420 m | 8.60E-06 | 1.08E-04 | --- | --- | --- |
| Ag-109m | ITe- | 39.8 s | --- | --- | --- | --- | --- |
| Ag-110 | β-, γ, ε | 24.6 s | --- | --- | --- | --- | --- |
| Ag-110m | β-, γ, ITe- | 249.8 d | --- | --- | --- | --- | --- |
| Am-241 | α, γ, SF | 432.7 a | 1.45E+05 | 1.73E+03 | 1.00E+02 | 2.06E+02 | 7.10E+02 |
| Am-242 | β-, γ, ε e- | 16.02 h | 1.47E-01 | 1.75E-02 | --- | --- | --- |
| Am-242m | α, ITe-, γ, SF | 141.0 a | 1.47E-01 | 1.76E-02 | 1.00E+02 | 2.06E+02 | 7.99E-04 |
| Am-243 | α, γ, SF | 7.37E+03 a | 1.98E+01 | 2.68E+01 | 1.00E+02 | 2.06E+02 | 2.26E-01 |
| Am-245 | β-, γ | 2.05 h | --- | --- | --- | --- | --- |
| Ar-39 | β- | 269 a | --- | 1.43E-03 | 1.00E+03 | 2.06E+03 | 6.94E-07 |
| Ar-42 | β- | 33 a | --- | 2.27E-11 | 1.00E+03 | 2.06E+03 | 1.10E-14 |
| At-217 | α, β-, γ | 32 ms | 8.65E+00 | 4.30E+00 | --- | --- | --- |
| Ba-133 | ε, γ | 10.53 a | 4.71E-32 | 2.20E-29 | --- | --- | --- |
| Ba-137m | IT | 2.552 m | 2.01E-07 | 2.03E-05 | --- | --- | --- |
| Bi-210 | α, β-, γ | 5.01 d | 2.50E+00 | 1.08E+01 | --- | --- | --- |
| Bi-211 | α, β-, γ | 2.14 m | 7.63E-01 | 1.47E+00 | --- | --- | --- |
| Bi-212 | α, β-, γ | 1.009 h | 1.49E+00 | 1.49E-02 | --- | --- | --- |
| Bi-213 | α, β-, γ | 45.6 m | 8.65E+00 | 4.30E+00 | --- | --- | --- |
| Bi-214 | α, β-, γ | 19.9 m | 2.50E+00 | 1.08E+01 | --- | --- | --- |
| Bk-249 | α, β-, γ, SF | 3.2E+02 d | --- | --- | --- | --- | --- |
| Bk-250 | β-, γ | 3.217 h | 7.95E-04 | 7.29E-09 | --- | --- | --- |
| C-14 | β- | 5730 a | 9.25E-03 | 1.93E+02 | 1.00E+02 | 2.06E+02 | 9.34E-01 |
| Ca-45 | β- | 162.61 d | --- | --- | --- | --- | --- |
| Cd-109 | γ, ε | 462.0 d | --- | --- | --- | --- | --- |
| Cd-113 | β- | 7.7E+15 a | 1.51E-03 | 8.58E-18 | 1.00E+03 | 2.06E+03 | 7.33E-07 |
| Cd-113m | β-, IT | 14.1 a | 1.27E-25 | 5.37E-22 | --- | --- | --- |
| Ce-139 | γ, ε | 137.64 d | --- | --- | --- | --- | --- |
| Ce-144 | β-, γ | 284.6 d | --- | --- | --- | --- | --- |
| Cf-249 | α, γ, SF | 351 a | 3.11E+00 | 2.33E-01 | 1.00E+02 | 2.06E+02 | 1.62E-02 |
| Cf-250 | α, γ, SF | 13.1 a | 7.95E-04 | 7.29E-09 | --- | --- | --- |
| Cf-251 | α, γ | 9.0E+02 a | 3.79E-03 | 1.87E-02 | 1.00E+02 | 2.06E+02 | 1.09E-04 |
| Cf-252 | α, γ, SF | 2.638 a | --- | --- | --- | --- | --- |

**Table A-4. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 3033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Cl-36 | β-, ε, β+ | 3.01E+01 a | 4.06E-03 | --- | 1.00E+03 | 2.06E+03 | 1.97E-06 |
| Cm-242 | α, γ, SF | 162.8 d | 1.21E-01 | 1.45E-02 | --- | --- | --- |
| Cm-243 | α, γ, SF, ε | 29.1 a | 5.91E-09 | 4.94E-10 | 1.00E+02 | 2.06E+02 | 3.10E-11 |
| Cm-244 | α, γ, SF | 18.1 a | 1.22E-13 | 1.10E-13 | --- | --- | --- |
| Cm-245 | α, γ, SF | 8.5E+03 a | 1.10E+00 | 8.45E-01 | 1.00E+02 | 2.06E+02 | 9.41E-03 |
| Cm-246 | α, γ, SF | 4.76E+03 a | 5.81E+00 | 5.86E+01 | 1.00E+02 | 2.06E+02 | 3.12E-01 |
| Cm-247 | α, γ | 1.56E+07 a | 1.12E-02 | 1.63E-06 | 1.00E+02 | 2.06E+02 | 5.43E-05 |
| Cm-248 | α, SF | 3.48E+05 a | 1.03E-01 | 1.62E-02 | 1.00E+02 | 2.06E+02 | 5.76E-04 |
| Cm-250 | α, β-, SF | 9700 a | 5.68E-03 | 5.21E-08 | 1.00E+02 | 2.06E+02 | 2.75E-05 |
| Co-60 | β-, γ | 5.271 a | --- | --- | --- | --- | --- |
| Cs-134 | β-, γ, ε | 2.065 a | --- | --- | --- | --- | --- |
| Cs-135 | β- | 2.3E+06 a | 3.45E-07 | 6.05E+01 | 1.00E+03 | 2.06E+03 | 2.93E-02 |
| Cs-137 | β-, γ | 30.17 a | 2.13E-07 | 2.15E-05 | 1.00E+03 | 2.06E+03 | 1.05E-08 |
| Dy-159 | γ, ε | 144.4 d | --- | --- | --- | --- | --- |
| Es-254 | α, γ | 276 d | --- | --- | --- | --- | --- |
| Eu-152 | β-, γ, εβ+ | 13.48 a | 1.63E-23 | 8.49E-22 | --- | --- | --- |
| Eu-154 | β-, γ, εγ | 8.59 a | --- | --- | --- | --- | --- |
| Eu-155 | β-, γ | 4.71 a | --- | --- | --- | --- | --- |
| Fe-55 | ε | 2.73 a | --- | --- | --- | --- | --- |
| Fr-221 | α, γ | 4.8 m | 8.65E+00 | 4.30E+00 | --- | --- | --- |
| Fr-223 | α, β-, γ | 21.8 m | 1.05E-02 | 2.02E-02 | --- | --- | --- |
| Gd-152 | α | 1.1E+14 a | 7.05E-14 | 5.78E-12 | 1.00E+02 | 2.06E+02 | 2.83E-14 |
| Gd-153 | γ, ε - | 240.4 d | --- | --- | --- | --- | --- |
| H-3 | β- | 12.3 a | 2.12E-21 | 1.44E-22 | --- | --- | --- |
| Ho-166m | β-, γ | 1.2E+03 a | 1.02E-05 | 2.91E-10 | 1.00E+03 | 2.06E+03 | 4.95E-09 |
| I-129 | β-, γ | 1.57E+07 a | 3.94E-03 | 3.73E-01 | 1.00E+02 | 2.06E+02 | 1.83E-03 |
| In-113m | γ, ε | 1.6582 h | --- | --- | --- | --- | --- |
| In-115 | β- | 4.4E+15 a | --- | 6.05E-17 | 1.00E+03 | 2.06E+03 | 2.93E-20 |
| Ir-194 | β-,γ, ε - | 19.28 h | --- | --- | --- | --- | --- |
| K-40 | β-, γ, β+ | 1.27E+09 a | 6.05E-03 | --- | 1.00E+03 | 2.06E+03 | 2.93E-06 |
| K-42 | β-,γ | 12.36 h | --- | 2.27E-11 | --- | --- | --- |
| Kr-85 | β-, γ | 10.73 a | 6.71E-29 | 1.60E-26 | --- | --- | --- |
| Lu-177m | β-, α | 160.4 d | --- | --- | --- | --- | --- |
| Mn-54 | ε, γ | 312.2 d | --- | --- | --- | --- | --- |
| Mo-93 | ε, γ | 3.5E+03 a | --- | 1.73E-02 | 1.00E+03 | 2.06E+03 | 8.41E-06 |

**Table A-4. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 3033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Na-22 | ε | 2.6019 a | --- | --- | --- | --- | --- |
| Nb-91 | γ | 680 a | --- | 1.16E-02 | 1.00E+03 | 2.06E+03 | 5.60E-06 |
| Nb-93m | ITe- | 16.1 a | 2.46E-05 | 5.67E-02 | --- | --- | --- |
| Nb-94 | β-, γ | 2.0E+04 a | 1.18E-03 | 2.01E+00 | 1.00E+03 | 2.06E+03 | 9.76E-04 |
| Nd-144 | α | 2.29E+15 a | 7.28E-16 | 3.68E-11 | 1.00E+02 | 2.06E+02 | 1.78E-13 |
| Ni-59 | ε | 7.6E+04 a | 1.30E-05 | 2.11E+03 | 1.00E+03 | 2.06E+03 | 1.02E+00 |
| Ni-63 | β- | 100 a | 2.54E-04 | 2.40E+00 | 1.00E+03 | 2.06E+03 | 1.17E-03 |
| Np-235 | ε | 396.2 d | --- | --- | --- | --- | --- |
| Np-237 | α, γ | 2.14E+06 a | 1.36E+02 | 4.22E+00 | 1.00E+02 | 2.06E+02 | 6.81E-01 |
| Np-238 | β-, γ | 2.117 d | 6.62E-04 | 7.92E-05 | --- | --- | --- |
| Np-239 | β-, γ | 2.355 d | 1.98E+01 | 2.68E+01 | --- | --- | --- |
| Np-240 | β- | 61.9 m | 1.22E-05 | 9.00E-09 | --- | --- | --- |
| Np-240m | β-, γ, IT | 7.22 m | 1.01E-02 | 7.50E-06 | --- | --- | --- |
| Os-194 | β- | 6.0 a | --- | --- | --- | --- | --- |
| Pa-231 | α, γ | 3.28E+04 a | 7.63E-01 | 1.47E+00 | 1.00E+02 | 2.06E+02 | 1.08E-02 |
| Pa-233 | β-, γ | 27.0 d | 1.36E+02 | 4.22E+00 | --- | --- | --- |
| Pa-234 | β-, γ | 6.69 h | 4.56E-02 | 3.86E-02 | --- | --- | --- |
| Pa-234m | β-, γ, IT | 1.17 m | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Pb-209 | β- | 3.25 h | 8.65E+00 | 4.30E+00 | --- | --- | --- |
| Pb-210 | α, β-, γ | 22.3 a | 2.50E+00 | 1.08E+01 | 1.00E+02 | 2.06E+02 | 6.43E-02 |
| Pb-211 | β-, γ | 36.1 m | 7.63E-01 | 1.47E+00 | --- | --- | --- |
| Pb-212 | β-, γ | 10.64 h | 1.49E+00 | 1.49E-02 | --- | --- | --- |
| Pb-214 | β-, γ | 27 m | 2.50E+00 | 1.08E+01 | --- | --- | --- |
| Pd-107 | β- | 6.5E+06 a | 2.22E-05 | 9.53E-05 | 1.00E+03 | 2.06E+03 | 5.69E-08 |
| Pm-145 | ε | 17.7 a | --- | 4.86E-18 | --- | --- | --- |
| Pm-146 | ε, γ, β- | 5.53 a | --- | --- | --- | --- | --- |
| Pm-147 | β-, γ | 2.6234 a | --- | --- | --- | --- | --- |
| Po-210 | α, γ | 138.38 d | 2.50E+00 | 1.08E+01 | --- | --- | --- |
| Po-211 | α, γ | 0.516 s | 2.10E-03 | 4.03E-03 | --- | --- | --- |
| Po-212 | α | 0.298 ms | 9.51E-01 | 9.52E-03 | --- | --- | --- |
| Po-213 | α | 4 ms | 8.47E+00 | 4.21E+00 | --- | --- | --- |
| Po-214 | α, γ | 163.7 ms | 2.50E+00 | 1.08E+01 | --- | --- | --- |
| Po-215 | α, β-, γ | 1.780 ms | 7.63E-01 | 1.47E+00 | --- | --- | --- |
| Po-216 | α, γ | 0.145 s | 1.49E+00 | 1.49E-02 | --- | --- | --- |
| Po-218 | α, β-, γ | 3.10 m | 2.50E+00 | 1.08E+01 | --- | --- | --- |

**Table A-4. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 3033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Pr-144 | β-, γ | 17.28 m | --- | --- | --- | --- | --- |
| Pr-144m | β-, α | 7.2 m | --- | --- | --- | --- | --- |
| Pu-236 | α, γ, SF | 2.87 a | --- | --- | --- | --- | --- |
| Pu-238 | α, γ, SF | 87.7 a | 2.20E+02 | 2.18E+00 | 1.00E+02 | 2.06E+02 | 1.08E+00 |
| Pu-239 | α, γ, SF | 2.41E+04 a | 5.51E+05 | 7.06E+03 | 1.00E+02 | 2.06E+02 | 2.70E+03 |
| Pu-240 | α, γ, SF | 6.56E+03 a | 1.51E+05 | 7.16E+03 | 1.00E+02 | 2.06E+02 | 7.64E+02 |
| Pu-241 | α, β-, γ | 14.4 a | 1.10E+00 | 8.46E-01 | --- | --- | --- |
| Pu-242 | α, γ, SF | 3.75E+05 a | 1.65E+03 | 6.43E+03 | 1.00E+02 | 2.06E+02 | 3.91E+01 |
| Pu-243 | β-, γ | 4.956 h | 1.12E-02 | 1.63E-06 | --- | --- | --- |
| Pu-244 | α, SF | 8.0E+07 a | 1.01E-02 | 7.51E-06 | 1.00E+02 | 2.06E+02 | 4.92E-05 |
| Ra-223 | α, γ | 11.435 d | 7.63E-01 | 1.47E+00 | --- | --- | --- |
| Ra-224 | α, γ | 3.66 d | 1.49E+00 | 1.49E-02 | --- | --- | --- |
| Ra-225 | β-, γ | 14.9 d | 8.65E+00 | 4.30E+00 | --- | --- | --- |
| Ra-226 | α, γ | 1.60E+03 a | 2.50E+00 | 1.08E+01 | 1.00E+02 | 2.06E+02 | 6.43E-02 |
| Ra-228 | β-, γ | 5.76 a | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Rb-87 | β- | 4.88E+10 a | 1.24E-10 | 2.49E-09 | 1.00E+03 | 2.06E+03 | 1.27E-12 |
| Rh-102 | β-, γ | 2.9 a | --- | --- | --- | --- | --- |
| Rh-106 | β-, γ | 29.9 s | --- | --- | --- | --- | --- |
| Rn-219 | α, γ | 3.96 s | 7.63E-01 | 1.47E+00 | --- | --- | --- |
| Rn-220 | α, γ | 55.6 s | 1.49E+00 | 1.49E-02 | --- | --- | --- |
| Rn-222 | α, γ | 3.8235 d | 2.50E+00 | 1.08E+01 | --- | --- | --- |
| Ru-106 | β- | 1.02 a | --- | --- | --- | --- | --- |
| Sb-125 | β-, γ | 2.758 a | --- | --- | --- | --- | --- |
| Sb-126 | β-, γ | 12.4 d | 1.99E-01 | 1.33E-01 | --- | --- | --- |
| Sb-126m | γ, ITe- | 11.0 s | 1.42E+00 | 9.52E-01 | --- | --- | --- |
| Se-75 | ε | 119.79 d | --- | --- | --- | --- | --- |
| Se-79 | β- | 6.5E+04 a | 2.45E-05 | 1.40E-01 | 1.00E+03 | 2.06E+03 | 6.76E-05 |
| Sm-145 | ε | 340 d | --- | --- | --- | --- | --- |
| Sm-146 | α | 1.03E+08 a | 1.81E-13 | 3.21E-08 | 1.00E+02 | 2.06E+02 | 1.56E-10 |
| Sm-147 | α | 1.06E+11 a | 1.31E-09 | 1.61E-08 | 1.00E+02 | 2.06E+02 | 8.45E-11 |
| Sm-148 | α | 7E+15 a | 6.19E-27 | 2.29E-19 | 1.00E+02 | 2.06E+02 | 1.11E-21 |
| Sm-151 | β-, γ | 90 a | 3.00E-03 | 2.08E-02 | 1.00E+03 | 2.06E+03 | 1.15E-05 |
| Sn-113 | ε | 115.09 d | --- | --- | --- | --- | --- |
| Sn-119m | IT | 293.1 d | --- | --- | --- | --- | --- |
| Sn-121 | β- | 27.06 h | 2.23E-09 | 3.29E-06 | --- | --- | --- |
| Sn-121m | β-, γ, ITe- | 55 a | 2.87E-09 | 4.24E-06 | 1.00E+03 | 2.06E+03 | 2.06E-09 |

**Table A-4. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 3033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Sn-123 | β- | 129.2 d | --- | --- | --- | --- | --- |
| Sn-126 | β-, γ | 1.0E+05 a | 1.42E+00 | 9.52E-01 | 1.00E+03 | 2.06E+03 | 1.15E-03 |
| Sr-90 | β- | 29.1 a | 4.66E-08 | 4.17E-06 | 1.00E+03 | 2.06E+03 | 2.04E-09 |
| Ta-182 | β- | 114.43 d | --- | --- | --- | --- | --- |
| Tb-157 | ε | 71 a | --- | 7.88E-04 | 1.00E+03 | 2.06E+03 | 3.82E-07 |
| Tc-99 | β-, γ | 2.13E+05 a | 6.67E+01 | 1.32E+01 | 1.00E+04 | 2.06E+04 | 3.87E-03 |
| Te-121 | ε | 16.87 d | --- | --- | --- | --- | --- |
| Te-121m | β-, α | 154 d | --- | --- | --- | --- | --- |
| Te-123 | ε | 1.0E+13 a | 1.26E-03 | 1.55E-14 | 1.00E+03 | 2.06E+03 | 6.10E-07 |
| Te-123m | IT | 119.7 d | --- | --- | --- | --- | --- |
| Te-125m | γ, ITe- | 58 d | --- | --- | --- | --- | --- |
| Th-227 | α, γ | 18.72 d | 7.53E-01 | 1.45E+00 | --- | --- | --- |
| Th-228 | α, γ | 1.913 a | 1.49E+00 | 1.49E-02 | --- | --- | --- |
| Th-229 | α, γ | 7.3E+03 a | 8.65E+00 | 4.30E+00 | 1.00E+02 | 2.06E+02 | 6.27E-02 |
| Th-230 | α, γ | 7.54E+04 a | 7.70E+00 | 3.23E-01 | 1.00E+01 | 2.06E+01 | 3.89E-01 |
| Th-231 | β-, γ | 1.063 d | 9.21E+00 | 6.77E+01 | --- | --- | --- |
| Th-232 | α, γ | 1.4E+10 a | 1.48E+00 | 1.46E-02 | 1.00E+01 | 2.06E+01 | 7.27E-02 |
| Th-234 | β-, γ | 24.10 d | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Tl-204 | β-, ε | 3.78 a | --- | --- | --- | --- | --- |
| Tl-207 | β-, γ | 4.77 m | 7.61E-01 | 1.46E+00 | --- | --- | --- |
| Tl-208 | β-, γ | 3.053 m | 5.34E-01 | 5.34E-03 | --- | --- | --- |
| Tl-209 | β-, γ | 2.2 m | 1.82E-01 | 9.02E-02 | --- | --- | --- |
| Tm-170 | β-, α | 128.6 d | --- | --- | --- | --- | --- |
| Tm-171 | β- | 1.92 a | --- | --- | --- | --- | --- |
| U-232 | α, γ, SF | 70 a | 4.96E-04 | 2.11E-04 | 1.00E+02 | 2.06E+02 | 3.43E-06 |
| U-233 | α, γ, SF | 1.592E+05 a | 9.82E+01 | 4.03E+01 | 1.00E+02 | 2.06E+02 | 6.71E-01 |
| U-234 | α, γ, SF | 2.46E+05 a | 4.21E+02 | 3.44E+01 | 1.00E+02 | 2.06E+02 | 2.21E+00 |
| U-235 | α, γ, SF | 7.04E+08 a | 9.21E+00 | 6.77E+01 | 1.00E+02 | 2.06E+02 | 3.73E-01 |
| U-236 | α, γ, SF | 2.342E+07 a | 9.78E+00 | 5.88E-01 | 1.00E+02 | 2.06E+02 | 5.02E-02 |
| U-237 | β-, γ | 6.75 d | 2.63E-05 | 2.02E-05 | --- | --- | --- |
| U-238 | α, γ, SF | 4.47E+09 a | 3.51E+01 | 2.97E+01 | 1.00E+02 | 2.06E+02 | 3.14E-01 |
| U-240 | β-, γ | 14.1 h | 1.01E-02 | 7.50E-06 | --- | --- | --- |
| V-49 | ε | 330 d | --- | --- | --- | --- | --- |
| W-181 | ε | 121.2 d | --- | --- | --- | --- | --- |
| Y-90 | β-, γ | 2.67 d | 4.66E-08 | 4.17E-06 | --- | --- | --- |

**Table A-4. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 3033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Zn-65 | β+, γ, ε | 243.8 d | --- | --- | --- | --- | --- |
| Zr-93 | β-, γ | 1.5E+06 a | 2.46E-05 | 4.24E-02 | 1.00E+03 | 2.06E+03 | 2.05E-05 |

(a) Decay mode and half-life information taken from *Nuclides and Isotopes* (also called the "Chart of the Nuclides"), 16th Ed. (Lockheed Martin 2002).
(b) Decayed radionuclide inventory information taken from Van Soest (2012).
(c) Release limits are determined in accordance with 40 CFR 191 (Appendix B, Table B-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, 40 CFR 191). Right column corresponds to release limit obtained for 2.06 Units of Waste. The 2.06 value for the Unit of Waste corresponds to the Units of Waste present at repository closure in 2033.
(d) Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

**Table A-5. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 7033)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Ac-225 | α, γ | 10.0 d | 3.54E+01 | 1.49E+01 | --- | --- | --- |
| Ac-227 | α, β-, γ | 21.77 a | 1.53E+00 | 6.84E+00 | 1.00E+02 | 2.06E+02 | 4.06E-02 |
| Ac-228 | α, β-, γ | 6.15 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Ag-108 | β-, γ, ε, β+ | 2.39 m | 2.47E-16 | 3.10E-15 | --- | --- | --- |
| Ag-108m | ε, β+ , γ, IT | 420 m | 2.84E-15 | 3.57E-14 | --- | --- | --- |
| Ag-109m | ITe- | 39.8 s | --- | --- | --- | --- | --- |
| Ag-110 | β-, γ, ε | 24.6 s | --- | --- | --- | --- | --- |
| Ag-110m | β-, γ, ITe- | 249.8 d | --- | --- | --- | --- | --- |
| Am-241 | α, γ, SF | 432.7 a | 2.39E+02 | 3.49E+00 | 1.00E+02 | 2.06E+02 | 1.17E+00 |
| Am-242 | β-, γ, ε e- | 16.02 h | 4.23E-10 | 5.06E-11 | --- | --- | --- |
| Am-242m | α, ITe-, γ, SF | 141.0 a | 4.25E-10 | 5.08E-11 | 1.00E+02 | 2.06E+02 | 2.30E-12 |
| Am-243 | α, γ, SF | 7.37E+03 a | 1.36E+01 | 1.84E+01 | 1.00E+02 | 2.06E+02 | 1.55E-01 |
| Am-245 | β-, γ | 2.05 h | --- | --- | --- | --- | --- |
| Ar-39 | β- | 269 a | --- | 4.78E-08 | 1.00E+03 | 2.06E+03 | 2.32E-11 |
| Ar-42 | β- | 33 a | --- | --- | 1.00E+03 | 2.06E+03 | --- |
| At-217 | α, β-, γ | 32 ms | 3.54E+01 | 1.49E+01 | --- | --- | --- |
| Ba-133 | ε, γ | 10.53 a | --- | --- | --- | --- | --- |
| Ba-137m | IT | 2.552 m | --- | --- | --- | --- | --- |
| Bi-210 | α, β-, γ | 5.01 d | 1.46E+01 | 2.82E+00 | --- | --- | --- |
| Bi-211 | α, β-, γ | 2.14 m | 1.53E+00 | 6.84E+00 | --- | --- | --- |
| Bi-212 | α, β-, γ | 1.009 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Bi-213 | α, β-, γ | 45.6 m | 3.54E+01 | 1.49E+01 | --- | --- | --- |
| Bi-214 | α, β-, γ | 19.9 m | 1.46E+01 | 2.82E+00 | --- | --- | --- |
| Bk-249 | α, β-, γ, SF | 3.2E+02 d | --- | --- | --- | --- | --- |
| Bk-250 | β-, γ | 3.217 h | 6.78E-04 | 6.22E-09 | --- | --- | --- |
| C-14 | β- | 5730 a | 5.70E-03 | 1.19E+02 | 1.00E+02 | 2.06E+02 | 5.76E-01 |
| Ca-45 | β- | 162.61 d | --- | --- | --- | --- | --- |
| Cd-109 | γ, ε | 462.0 d | --- | --- | --- | --- | --- |
| Cd-113 | β- | 7.7E+15 a | 1.51E-03 | 8.58E-18 | 1.00E+03 | 2.06E+03 | 7.33E-07 |
| Cd-113m | β-, IT | 14.1 a | --- | --- | --- | --- | --- |
| Ce-139 | γ, ε | 137.64 d | --- | --- | --- | --- | --- |
| Ce-144 | β-, γ | 284.6 d | --- | --- | --- | --- | --- |
| Cf-249 | α, γ, SF | 351 a | 1.14E-03 | 8.53E-05 | 1.00E+02 | 2.06E+02 | 5.93E-06 |
| Cf-250 | α, γ, SF | 13.1 a | 6.78E-04 | 6.22E-09 | --- | --- | --- |
| Cf-251 | α, γ | 9.0E+02 a | 1.73E-04 | 8.51E-04 | 1.00E+02 | 2.06E+02 | 4.96E-06 |
| Cf-252 | α, γ, SF | 2.638 a | --- | --- | --- | --- | --- |

**Table A-5. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 7033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Cl-36 | β-, ε, β+ | 3.01E+01 a | 4.02E-03 | --- | 1.00E+03 | 2.06E+03 | 1.95E-06 |
| Cm-242 | α, γ, SF | 162.8 d | 3.51E-10 | 4.20E-11 | --- | --- | --- |
| Cm-243 | α, γ, SF, ε | 29.1 a | --- | --- | 1.00E+02 | 2.06E+02 | --- |
| Cm-244 | α, γ, SF | 18.1 a | --- | --- | --- | --- | --- |
| Cm-245 | α, γ, SF | 8.5E+03 a | 8.88E-01 | 6.17E-01 | 1.00E+02 | 2.06E+02 | 7.29E-03 |
| Cm-246 | α, γ, SF | 4.76E+03 a | 3.23E+00 | 3.26E+01 | 1.00E+02 | 2.06E+02 | 1.74E-01 |
| Cm-247 | α, γ | 1.56E+07 a | 1.12E-02 | 2.63E-06 | 1.00E+02 | 2.06E+02 | 5.43E-05 |
| Cm-248 | α, SF | 3.48E+05 a | 1.02E-01 | 1.61E-02 | 1.00E+02 | 2.06E+02 | 5.71E-04 |
| Cm-250 | α, β-, SF | 9700 a | 4.84E-03 | 4.44E-08 | 1.00E+02 | 2.06E+02 | 2.35E-05 |
| Co-60 | β-, γ | 5.271 a | --- | --- | --- | --- | --- |
| Cs-134 | β-, γ, ε | 2.065 a | --- | --- | --- | --- | --- |
| Cs-135 | β- | 2.3E+06 a | 3.45E-07 | 6.04E+01 | 1.00E+03 | 2.06E+03 | 2.93E-02 |
| Cs-137 | β-, γ | 30.17 a | --- | --- | 1.00E+03 | 2.06E+03 | --- |
| Dy-159 | γ, ε | 144.4 d | --- | --- | --- | --- | --- |
| Es-254 | α, γ | 276 d | --- | --- | --- | --- | --- |
| Eu-152 | β-, γ, εβ+ | 13.48 a | --- | --- | --- | --- | --- |
| Eu-154 | β-, γ, εγ | 8.59 a | --- | --- | --- | --- | --- |
| Eu-155 | β-, γ | 4.71 a | --- | --- | --- | --- | --- |
| Fe-55 | ε | 2.73 a | --- | --- | --- | --- | --- |
| Fr-221 | α, γ | 4.8 m | 3.54E+01 | 1.49E+01 | --- | --- | --- |
| Fr-223 | α, β-, γ | 21.8 m | 2.12E-02 | 9.44E-02 | --- | --- | --- |
| Gd-152 | α | 1.1E+14 a | 7.05E-14 | 5.78E-12 | 1.00E+02 | 2.06E+02 | 2.83E-14 |
| Gd-153 | γ, ε - | 240.4 d | --- | --- | --- | --- | --- |
| H-3 | β- | 12.3 a | --- | --- | --- | --- | --- |
| Ho-166m | β-, γ | 1.2E+03 a | 1.01E-06 | 2.89E-11 | 1.00E+03 | 2.06E+03 | 4.91E-10 |
| I-129 | β-, γ | 1.57E+07 a | 3.94E-03 | 3.73E-01 | 1.00E+02 | 2.06E+02 | 1.83E-03 |
| In-113m | γ, ε | 1.6582 h | --- | --- | --- | --- | --- |
| In-115 | β- | 4.4E+15 a | --- | 6.05E-17 | 1.00E+03 | 2.06E+03 | 2.93E-20 |
| Ir-194 | β-,γ, ε - | 19.28 h | --- | --- | --- | --- | --- |
| K-40 | β-, γ, β+ | 1.27E+09 a | 6.05E-03 | --- | 1.00E+03 | 2.06E+03 | 2.93E-06 |
| K-42 | β-,γ | 12.36 h | --- | --- | --- | --- | --- |
| Kr-85 | β-, γ | 10.73 a | --- | --- | --- | --- | --- |
| Lu-177m | β-, α | 160.4 d | --- | --- | --- | --- | --- |
| Mn-54 | ε, γ | 312.2 d | --- | --- | --- | --- | --- |
| Mo-93 | ε, γ | 3.5E+03 a | --- | 7.85E-03 | 1.00E+03 | 2.06E+03 | 3.81E-06 |

**Table A-5. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 7033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Na-22 | ε | 2.6019 a | --- | --- | --- | --- | --- |
| Nb-91 | γ | 680 a | --- | 1.96E-04 | 1.00E+03 | 2.06E+03 | 9.49E-08 |
| Nb-93m | ITe- | 16.1 a | 2.45E-05 | 4.88E-02 | --- | --- | --- |
| Nb-94 | β-, γ | 2.0E+04 a | 1.03E-03 | 1.76E+00 | 1.00E+03 | 2.06E+03 | 8.51E-04 |
| Nd-144 | α | 2.29E+15 a | 7.28E-16 | 3.68E-11 | 1.00E+02 | 2.06E+02 | 1.78E-13 |
| Ni-59 | ε | 7.6E+04 a | 1.26E-05 | 2.03E+03 | 1.00E+03 | 2.06E+03 | 9.86E-01 |
| Ni-63 | β- | 100 a | 2.37E-16 | 2.25E-12 | 1.00E+03 | 2.06E+03 | 1.09E-15 |
| Np-235 | ε | 396.2 d | --- | --- | --- | --- | --- |
| Np-237 | α, γ | 2.14E+06 a | 1.65E+02 | 4.57E+00 | 1.00E+02 | 2.06E+02 | 8.23E-01 |
| Np-238 | β-, γ | 2.117 d | 1.91E-12 | 2.29E-13 | --- | --- | --- |
| Np-239 | β-, γ | 2.355 d | 1.36E+01 | 1.84E+01 | --- | --- | --- |
| Np-240 | β- | 61.9 m | 1.22E-05 | 9.62E-09 | --- | --- | --- |
| Np-240m | β-, γ, IT | 7.22 m | 1.01E-02 | 8.02E-06 | --- | --- | --- |
| Os-194 | β- | 6.0 a | --- | --- | --- | --- | --- |
| Pa-231 | α, γ | 3.28E+04 a | 1.53E+00 | 6.84E+00 | 1.00E+02 | 2.06E+02 | 4.06E-02 |
| Pa-233 | β-, γ | 27.0 d | 1.65E+02 | 4.57E+00 | --- | --- | --- |
| Pa-234 | β-, γ | 6.69 h | 4.56E-02 | 3.86E-02 | --- | --- | --- |
| Pa-234m | β-, γ, IT | 1.17 m | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Pb-209 | β- | 3.25 h | 3.54E+01 | 1.49E+01 | --- | --- | --- |
| Pb-210 | α, β-, γ | 22.3 a | 1.46E+01 | 2.82E+00 | 1.00E+02 | 2.06E+02 | 8.45E-02 |
| Pb-211 | β-, γ | 36.1 m | 1.53E+00 | 6.84E+00 | --- | --- | --- |
| Pb-212 | β-, γ | 10.64 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Pb-214 | β-, γ | 27 m | 1.46E+01 | 2.82E+00 | --- | --- | --- |
| Pd-107 | β- | 6.5E+06 a | 2.22E-05 | 9.53E-05 | 1.00E+03 | 2.06E+03 | 5.69E-08 |
| Pm-145 | ε | 17.7 a | --- | --- | --- | --- | --- |
| Pm-146 | ε, γ, β- | 5.53 a | --- | --- | --- | --- | --- |
| Pm-147 | β-, γ | 2.6234 a | --- | --- | --- | --- | --- |
| Po-210 | α, γ | 138.38 d | 1.46E+01 | 2.82E+00 | --- | --- | --- |
| Po-211 | α, γ | 0.516 s | 4.22E-03 | 1.88E-02 | --- | --- | --- |
| Po-212 | α | 0.298 ms | 9.51E-01 | 9.38E-03 | --- | --- | --- |
| Po-213 | α | 4 ms | 3.46E+01 | 1.46E+01 | --- | --- | --- |
| Po-214 | α, γ | 163.7 ms | 1.46E+01 | 2.82E+00 | --- | --- | --- |
| Po-215 | α, β-, γ | 1.780 ms | 1.53E+00 | 6.84E+00 | --- | --- | --- |
| Po-216 | α, γ | 0.145 s | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Po-218 | α, β-, γ | 3.10 m | 1.46E+01 | 2.82E+00 | --- | --- | --- |

**Table A-5. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 7033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Pr-144 | β-, γ | 17.28 m | --- | --- | --- | --- | --- |
| Pr-144m | β-, α | 7.2 m | --- | --- | --- | --- | --- |
| Pu-236 | α, γ, SF | 2.87 a | --- | --- | --- | --- | --- |
| Pu-238 | α, γ, SF | 87.7 a | 9.37E-10 | 1.12E-10 | 1.00E+02 | 2.06E+02 | 5.08E-12 |
| Pu-239 | α, γ, SF | 2.41E+04 a | 4.91E+05 | 6.30E+03 | 1.00E+02 | 2.06E+02 | 2.41E+03 |
| Pu-240 | α, γ, SF | 6.56E+03 a | 9.87E+04 | 4.69E+03 | 1.00E+02 | 2.06E+02 | 5.01E+02 |
| Pu-241 | α, β-, γ | 14.4 a | 8.90E-01 | 6.18E-01 | --- | --- | --- |
| Pu-242 | α, γ, SF | 3.75E+05 a | 1.64E+03 | 6.38E+03 | 1.00E+02 | 2.06E+02 | 3.89E+01 |
| Pu-243 | β-, γ | 4.956 h | 1.12E-02 | 2.63E-06 | --- | --- | --- |
| Pu-244 | α, SF | 8.0E+07 a | 1.01E-02 | 8.03E-06 | 1.00E+02 | 2.06E+02 | 4.92E-05 |
| Ra-223 | α, γ | 11.435 d | 1.53E+00 | 6.84E+00 | --- | --- | --- |
| Ra-224 | α, γ | 3.66 d | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Ra-225 | β-, γ | 14.9 d | 3.54E+01 | 1.49E+01 | --- | --- | --- |
| Ra-226 | α, γ | 1.60E+03 a | 1.46E+01 | 2.82E+00 | 1.00E+02 | 2.06E+02 | 8.46E-02 |
| Ra-228 | β-, γ | 5.76 a | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Rb-87 | β- | 4.88E+10 a | 1.24E-10 | 2.49E-09 | 1.00E+03 | 2.06E+03 | 1.27E-12 |
| Rh-102 | β-, γ | 2.9 a | --- | --- | --- | --- | --- |
| Rh-106 | β-, γ | 29.9 s | --- | --- | --- | --- | --- |
| Rn-219 | α, γ | 3.96 s | 1.53E+00 | 6.84E+00 | --- | --- | --- |
| Rn-220 | α, γ | 55.6 s | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Rn-222 | α, γ | 3.8235 d | 1.46E+01 | 2.82E+00 | --- | --- | --- |
| Ru-106 | β- | 1.02 a | --- | --- | --- | --- | --- |
| Sb-125 | β-, γ | 2.758 a | --- | --- | --- | --- | --- |
| Sb-126 | β-, γ | 12.4 d | 1.93E-01 | 1.30E-01 | --- | --- | --- |
| Sb-126m | γ, ITe- | 11.0 s | 1.38E+00 | 9.25E-01 | --- | --- | --- |
| Se-75 | ε | 119.79 d | --- | --- | --- | --- | --- |
| Se-79 | β- | 6.5E+04 a | 2.42E-05 | 1.38E-01 | 1.00E+03 | 2.06E+03 | 6.70E-05 |
| Sm-145 | ε | 340 d | --- | --- | --- | --- | --- |
| Sm-146 | α | 1.03E+08 a | 1.81E-13 | 3.21E-08 | 1.00E+02 | 2.06E+02 | 1.56E-10 |
| Sm-147 | α | 1.06E+11 a | 1.31E-09 | 1.61E-08 | 1.00E+02 | 2.06E+02 | 8.45E-11 |
| Sm-148 | α | 7E+15 a | 3.09E-26 | 2.29E-19 | 1.00E+02 | 2.06E+02 | 1.11E-21 |
| Sm-151 | β-, γ | 90 a | 1.25E-16 | 8.64E-16 | 1.00E+03 | 2.06E+03 | 4.79E-19 |
| Sn-113 | ε | 115.09 d | --- | --- | --- | --- | --- |
| Sn-119m | IT | 293.1 d | --- | --- | --- | --- | --- |
| Sn-121 | β- | 27.06 h | --- | --- | --- | --- | --- |
| Sn-121m | β-, γ, ITe- | 55 a | --- | --- | 1.00E+03 | 2.06E+03 | --- |

**Table A-5. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 7033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Sn-123 | β- | 129.2 d | --- | --- | --- | --- | --- |
| Sn-126 | β-, γ | 1.0E+05 a | 1.38E+00 | 9.25E-01 | 1.00E+03 | 2.06E+03 | 1.12E-03 |
| Sr-90 | β- | 29.1 a | --- | --- | 1.00E+03 | 2.06E+03 | --- |
| Ta-182 | β- | 114.43 d | --- | --- | --- | --- | --- |
| Tb-157 | ε | 71 a | --- | 7.39E-12 | 1.00E+03 | 2.06E+03 | 3.58E-15 |
| Tc-99 | β-, γ | 2.13E+05 a | 6.58E+01 | 1.30E+01 | 1.00E+04 | 2.06E+04 | 3.82E-03 |
| Te-121 | ε | 16.87 d | --- | --- | --- | --- | --- |
| Te-121m | β-, α | 154 d | --- | --- | --- | --- | --- |
| Te-123 | ε | 1.0E+13 a | 1.26E-03 | 1.55E-14 | 1.00E+03 | 2.06E+03 | 6.10E-07 |
| Te-123m | IT | 119.7 d | --- | --- | --- | --- | --- |
| Te-125m | γ, ITe- | 58 d | --- | --- | --- | --- | --- |
| Th-227 | α, γ | 18.72 d | 1.51E+00 | 6.75E+00 | --- | --- | --- |
| Th-228 | α, γ | 1.913 a | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Th-229 | α, γ | 7.3E+03 a | 3.54E+01 | 1.49E+01 | 1.00E+02 | 2.06E+02 | 2.44E-01 |
| Th-230 | α, γ | 7.54E+04 a | 2.26E+01 | 1.55E+00 | 1.00E+01 | 2.06E+01 | 1.17E+00 |
| Th-231 | β-, γ | 1.063 d | 1.13E+01 | 6.77E+01 | --- | --- | --- |
| Th-232 | α, γ | 1.4E+10 a | 1.48E+00 | 1.46E-02 | 1.00E+01 | 2.06E+01 | 7.27E-02 |
| Th-234 | β-, γ | 24.10 d | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Tl-204 | β-, ε | 3.78 a | --- | --- | --- | --- | --- |
| Tl-207 | β-, γ | 4.77 m | 1.53E+00 | 6.82E+00 | --- | --- | --- |
| Tl-208 | β-, γ | 3.053 m | 5.34E-01 | 5.26E-03 | --- | --- | --- |
| Tl-209 | β-, γ | 2.2 m | 7.43E-01 | 3.12E-01 | --- | --- | --- |
| Tm-170 | β-, α | 128.6 d | --- | --- | --- | --- | --- |
| Tm-171 | β- | 1.92 a | --- | --- | --- | --- | --- |
| U-232 | α, γ, SF | 70 a | 2.79E-21 | 1.19E-21 | 1.00E+02 | 2.06E+02 | 1.93E-23 |
| U-233 | α, γ, SF | 1.592E+05 a | 9.93E+01 | 3.97E+01 | 1.00E+02 | 2.06E+02 | 6.73E-01 |
| U-234 | α, γ, SF | 2.46E+05 a | 4.17E+02 | 3.44E+01 | 1.00E+02 | 2.06E+02 | 2.19E+00 |
| U-235 | α, γ, SF | 7.04E+08 a | 1.13E+01 | 6.77E+01 | 1.00E+02 | 2.06E+02 | 3.83E-01 |
| U-236 | α, γ, SF | 2.342E+07 a | 2.43E+01 | 1.28E+00 | 1.00E+02 | 2.06E+02 | 1.24E-01 |
| U-237 | β-, γ | 6.75 d | 2.13E-05 | 1.48E-05 | --- | --- | --- |
| U-238 | α, γ, SF | 4.47E+09 a | 3.51E+01 | 2.97E+01 | 1.00E+02 | 2.06E+02 | 3.14E-01 |
| U-240 | β-, γ | 14.1 h | 1.01E-02 | 8.02E-06 | --- | --- | --- |
| V-49 | ε | 330 d | --- | --- | --- | --- | --- |
| W-181 | ε | 121.2 d | --- | --- | --- | --- | --- |
| Y-90 | β-, γ | 2.67 d | --- | --- | --- | --- | --- |

**Table A-5. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 7033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Zn-65 | β+, γ, ε | 243.8 d | --- | --- | --- | --- | --- |
| Zr-93 | β-, γ | 1.5E+06 a | 2.45E-05 | 4.23E-02 | 1.00E+03 | 2.06E+03 | 2.05E-05 |

(a) Decay mode and half-life information taken from *Nuclides and Isotopes* (also called the "Chart of the Nuclides"), 16th Ed. (Lockheed Martin 2002).
(b) Decayed radionuclide inventory information taken from Van Soest (2012).
(c) Release limits are determined in accordance with 40 CFR 191 (Appendix B, Table B-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, 40 CFR 191). Right column corresponds to release limit obtained for 2.06 Units of Waste. The 2.06 value for the Unit of Waste corresponds to the Units of Waste present at repository closure in 2033.
(d) Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

**Table A-6. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 12,033)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Ac-225 | α, γ | 10.0 d | 5.84E+01 | 2.35E+01 | --- | --- | --- |
| Ac-227 | α, β-, γ | 21.77 a | 2.63E+00 | 1.30E+01 | 1.00E+02 | 2.06E+02 | 7.55E-02 |
| Ac-228 | α, β-, γ | 6.15 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Ag-108 | β-, γ, ε, β+ | 2.39 m | 3.47E-28 | 4.36E-27 | --- | --- | --- |
| Ag-108m | ε, β+ , γ, IT | 420 m | 3.99E-27 | 5.01E-26 | --- | --- | --- |
| Ag-109m | ITe- | 39.8 s | --- | --- | --- | --- | --- |
| Ag-110 | β-, γ, ε | 24.6 s | --- | --- | --- | --- | --- |
| Ag-110m | β-, γ, ITe- | 249.8 d | --- | --- | --- | --- | --- |
| Am-241 | α, γ, SF | 432.7 a | 6.71E-01 | 4.12E-01 | 1.00E+02 | 2.06E+02 | 5.25E-03 |
| Am-242 | β-, γ, ε e- | 16.02 h | 8.94E-21 | 1.07E-21 | --- | --- | --- |
| Am-242m | α, ITe-, γ, SF | 141.0 a | 8.98E-21 | 1.07E-21 | 1.00E+02 | 2.06E+02 | 4.87E-23 |
| Am-243 | α, γ, SF | 7.37E+03 a | 8.50E+00 | 1.15E+01 | 1.00E+02 | 2.06E+02 | 9.70E-02 |
| Am-245 | β-, γ | 2.05 h | --- | --- | --- | --- | --- |
| Ar-39 | β- | 269 a | --- | 1.21E-13 | 1.00E+03 | 2.06E+03 | 5.88E-17 |
| Ar-42 | β- | 33 a | --- | --- | 1.00E+03 | 2.06E+03 | --- |
| At-217 | α, β-, γ | 32 ms | 5.84E+01 | 2.35E+01 | --- | --- | --- |
| Ba-133 | ε, γ | 10.53 a | --- | --- | --- | --- | --- |
| Ba-137m | IT | 2.552 m | --- | --- | --- | --- | --- |
| Bi-210 | α, β-, γ | 5.01 d | 3.21E+01 | 2.57E+00 | --- | --- | --- |
| Bi-211 | α, β-, γ | 2.14 m | 2.63E+00 | 1.30E+01 | --- | --- | --- |
| Bi-212 | α, β-, γ | 1.009 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Bi-213 | α, β-, γ | 45.6 m | 5.84E+01 | 2.35E+01 | --- | --- | --- |
| Bi-214 | α, β-, γ | 19.9 m | 3.21E+01 | 2.57E+00 | --- | --- | --- |
| Bk-249 | α, β-, γ, SF | 3.2E+02 d | --- | --- | --- | --- | --- |
| Bk-250 | β-, γ | 3.217 h | 5.56E-04 | 5.09E-09 | --- | --- | --- |
| C-14 | β- | 5730 a | 3.11E-03 | 6.49E+01 | 1.00E+02 | 2.06E+02 | 3.14E-01 |
| Ca-45 | β- | 162.61 d | --- | --- | --- | --- | --- |
| Cd-109 | γ, ε | 462.0 d | --- | --- | --- | --- | --- |
| Cd-113 | β- | 7.7E+15 a | 1.51E-03 | 8.58E-18 | 1.00E+03 | 2.06E+03 | 7.33E-07 |
| Cd-113m | β-, IT | 14.1 a | --- | --- | --- | --- | --- |
| Ce-139 | γ, ε | 137.64 d | --- | --- | --- | --- | --- |
| Ce-144 | β-, γ | 284.6 d | --- | --- | --- | --- | --- |
| Cf-249 | α, γ, SF | 351 a | 5.77E-08 | 4.33E-09 | 1.00E+02 | 2.06E+02 | 3.01E-10 |
| Cf-250 | α, γ, SF | 13.1 a | 5.56E-04 | 5.09E-09 | --- | --- | --- |
| Cf-251 | α, γ | 9.0E+02 a | 3.64E-06 | 1.79E-05 | 1.00E+02 | 2.06E+02 | 1.05E-07 |
| Cf-252 | α, γ, SF | 2.638 a | --- | --- | --- | --- | --- |

**Table A-6. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 12,033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Cl-36 | β-, ε, β+ | 3.01E+01 a | 3.98E-03 | --- | 1.00E+03 | 2.06E+03 | 1.93E-06 |
| Cm-242 | α, γ, SF | 162.8 d | 7.42E-21 | 8.87E-22 | --- | --- | --- |
| Cm-243 | α, γ, SF, ε | 29.1 a | --- | --- | 1.00E+02 | 2.06E+02 | --- |
| Cm-244 | α, γ, SF | 18.1 a | --- | --- | --- | --- | --- |
| Cm-245 | α, γ, SF | 8.5E+03 a | 5.91E-01 | 4.10E-01 | 1.00E+02 | 2.06E+02 | 4.85E-03 |
| Cm-246 | α, γ, SF | 4.76E+03 a | 1.56E+00 | 1.57E+01 | 1.00E+02 | 2.06E+02 | 8.35E-02 |
| Cm-247 | α, γ | 1.56E+07 a | 1.12E-02 | 2.67E-06 | 1.00E+02 | 2.06E+02 | 5.43E-05 |
| Cm-248 | α, SF | 3.48E+05 a | 1.01E-01 | 1.59E-02 | 1.00E+02 | 2.06E+02 | 5.65E-04 |
| Cm-250 | α, β-, SF | 9700 a | 3.97E-03 | 3.64E-08 | 1.00E+02 | 2.06E+02 | 1.92E-05 |
| Co-60 | β-, γ | 5.271 a | --- | --- | --- | --- | --- |
| Cs-134 | β-, γ, ε | 2.065 a | --- | --- | --- | --- | --- |
| Cs-135 | β- | 2.3E+06 a | 3.44E-07 | 6.03E+01 | 1.00E+03 | 2.06E+03 | 2.92E-02 |
| Cs-137 | β-, γ | 30.17 a | --- | --- | 1.00E+03 | 2.06E+03 | --- |
| Dy-159 | γ, ε | 144.4 d | --- | --- | --- | --- | --- |
| Es-254 | α, γ | 276 d | --- | --- | --- | --- | --- |
| Eu-152 | β-, γ, εβ+ | 13.48 a | --- | --- | --- | --- | --- |
| Eu-154 | β-, γ, εγ | 8.59 a | --- | --- | --- | --- | --- |
| Eu-155 | β-, γ | 4.71 a | --- | --- | --- | --- | --- |
| Fe-55 | ε | 2.73 a | --- | --- | --- | --- | --- |
| Fr-221 | α, γ | 4.8 m | 5.84E+01 | 2.35E+01 | --- | --- | --- |
| Fr-223 | α, β-, γ | 21.8 m | 3.63E-02 | 1.79E-01 | --- | --- | --- |
| Gd-152 | α | 1.1E+14 a | 7.05E-14 | 5.78E-12 | 1.00E+02 | 2.06E+02 | 2.83E-14 |
| Gd-153 | γ, ε - | 240.4 d | --- | --- | --- | --- | --- |
| H-3 | β- | 12.3 a | --- | --- | --- | --- | --- |
| Ho-166m | β-, γ | 1.2E+03 a | 5.64E-08 | 1.61E-12 | 1.00E+03 | 2.06E+03 | 2.73E-11 |
| I-129 | β-, γ | 1.57E+07 a | 3.94E-03 | 3.73E-01 | 1.00E+02 | 2.06E+02 | 1.83E-03 |
| In-113m | γ, ε | 1.6582 h | --- | --- | --- | --- | --- |
| In-115 | β- | 4.4E+15 a | --- | 6.05E-17 | 1.00E+03 | 2.06E+03 | 2.93E-20 |
| Ir-194 | β-,γ, ε - | 19.28 h | --- | --- | --- | --- | --- |
| K-40 | β-, γ, β+ | 1.27E+09 a | 6.05E-03 | --- | 1.00E+03 | 2.06E+03 | 2.93E-06 |
| K-42 | β-,γ | 12.36 h | --- | --- | --- | --- | --- |
| Kr-85 | β-, γ | 10.73 a | --- | --- | --- | --- | --- |
| Lu-177m | β-, α | 160.4 d | --- | --- | --- | --- | --- |
| Mn-54 | ε, γ | 312.2 d | --- | --- | --- | --- | --- |
| Mo-93 | ε, γ | 3.5E+03 a | --- | 2.92E-03 | 1.00E+03 | 2.06E+03 | 1.41E-06 |

**Table A-6. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 12,033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Na-22 | ε | 2.6019 a | --- | --- | --- | --- | --- |
| Nb-91 | γ | 680 a | --- | 1.20E-06 | 1.00E+03 | 2.06E+03 | 5.81E-10 |
| Nb-93m | ITe- | 16.1 a | 2.45E-05 | 4.46E-02 | --- | --- | --- |
| Nb-94 | β-, γ | 2.0E+04 a | 8.71E-04 | 1.48E+00 | 1.00E+03 | 2.06E+03 | 7.17E-04 |
| Nd-144 | α | 2.29E+15 a | 7.28E-16 | 3.68E-11 | 1.00E+02 | 2.06E+02 | 1.78E-13 |
| Ni-59 | ε | 7.6E+04 a | 1.20E-05 | 1.94E+03 | 1.00E+03 | 2.06E+03 | 9.41E-01 |
| Ni-63 | β- | 100 a | 2.17E-31 | 2.06E-27 | 1.00E+03 | 2.06E+03 | 9.99E-31 |
| Np-235 | ε | 396.2 d | --- | --- | --- | --- | --- |
| Np-237 | α, γ | 2.14E+06 a | 1.65E+02 | 4.56E+00 | 1.00E+02 | 2.06E+02 | 8.22E-01 |
| Np-238 | β-, γ | 2.117 d | 4.04E-23 | 4.84E-24 | --- | --- | --- |
| Np-239 | β-, γ | 2.355 d | 8.50E+00 | 1.15E+01 | --- | --- | --- |
| Np-240 | β- | 61.9 m | 1.22E-05 | 1.04E-08 | --- | --- | --- |
| Np-240m | β-, γ, IT | 7.22 m | 1.01E-02 | 8.65E-06 | --- | --- | --- |
| Os-194 | β- | 6.0 a | --- | --- | --- | --- | --- |
| Pa-231 | α, γ | 3.28E+04 a | 2.63E+00 | 1.30E+01 | 1.00E+02 | 2.06E+02 | 7.55E-02 |
| Pa-233 | β-, γ | 27.0 d | 1.65E+02 | 4.56E+00 | --- | --- | --- |
| Pa-234 | β-, γ | 6.69 h | 4.56E-02 | 3.86E-02 | --- | --- | --- |
| Pa-234m | β-, γ, IT | 1.17 m | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Pb-209 | β- | 3.25 h | 5.84E+01 | 2.35E+01 | --- | --- | --- |
| Pb-210 | α, β-, γ | 22.3 a | 3.21E+01 | 2.57E+00 | 1.00E+02 | 2.06E+02 | 1.68E-01 |
| Pb-211 | β-, γ | 36.1 m | 2.63E+00 | 1.30E+01 | --- | --- | --- |
| Pb-212 | β-, γ | 10.64 h | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Pb-214 | β-, γ | 27 m | 3.21E+01 | 2.57E+00 | --- | --- | --- |
| Pd-107 | β- | 6.5E+06 a | 2.22E-05 | 9.52E-05 | 1.00E+03 | 2.06E+03 | 5.69E-08 |
| Pm-145 | ε | 17.7 a | --- | --- | --- | --- | --- |
| Pm-146 | ε, γ, β- | 5.53 a | --- | --- | --- | --- | --- |
| Pm-147 | β-, γ | 2.6234 a | --- | --- | --- | --- | --- |
| Po-210 | α, γ | 138.38 d | 3.21E+01 | 2.57E+00 | --- | --- | --- |
| Po-211 | α, γ | 0.516 s | 7.23E-03 | 3.56E-02 | --- | --- | --- |
| Po-212 | α | 0.298 ms | 9.51E-01 | 9.38E-03 | --- | --- | --- |
| Po-213 | α | 4 ms | 5.72E+01 | 2.31E+01 | --- | --- | --- |
| Po-214 | α, γ | 163.7 ms | 3.21E+01 | 2.57E+00 | --- | --- | --- |
| Po-215 | α, β-, γ | 1.780 ms | 2.63E+00 | 1.30E+01 | --- | --- | --- |
| Po-216 | α, γ | 0.145 s | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Po-218 | α, β-, γ | 3.10 m | 3.21E+01 | 2.57E+00 | --- | --- | --- |

**Table A-6. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 12,033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Pr-144 | β-, γ | 17.28 m | --- | --- | --- | --- | --- |
| Pr-144m | β-, α | 7.2 m | --- | --- | --- | --- | --- |
| Pu-236 | α, γ, SF | 2.87 a | --- | --- | --- | --- | --- |
| Pu-238 | α, γ, SF | 87.7 a | 1.97E-20 | 2.36E-21 | 1.00E+02 | 2.06E+02 | 1.07E-22 |
| Pu-239 | α, γ, SF | 2.41E+04 a | 4.25E+05 | 5.46E+03 | 1.00E+02 | 2.06E+02 | 2.09E+03 |
| Pu-240 | α, γ, SF | 6.56E+03 a | 5.82E+04 | 2.77E+03 | 1.00E+02 | 2.06E+02 | 2.95E+02 |
| Pu-241 | α, β-, γ | 14.4 a | 5.92E-01 | 4.11E-01 | --- | --- | --- |
| Pu-242 | α, γ, SF | 3.75E+05 a | 1.63E+03 | 6.32E+03 | 1.00E+02 | 2.06E+02 | 3.85E+01 |
| Pu-243 | β-, γ | 4.956 h | 1.12E-02 | 2.67E-06 | --- | --- | --- |
| Pu-244 | α, SF | 8.0E+07 a | 1.01E-02 | 8.66E-06 | 1.00E+02 | 2.06E+02 | 4.92E-05 |
| Ra-223 | α, γ | 11.435 d | 2.63E+00 | 1.30E+01 | --- | --- | --- |
| Ra-224 | α, γ | 3.66 d | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Ra-225 | β-, γ | 14.9 d | 5.84E+01 | 2.35E+01 | --- | --- | --- |
| Ra-226 | α, γ | 1.60E+03 a | 3.21E+01 | 2.57E+00 | 1.00E+02 | 2.06E+02 | 1.68E-01 |
| Ra-228 | β-, γ | 5.76 a | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Rb-87 | β- | 4.88E+10 a | 1.24E-10 | 2.49E-09 | 1.00E+03 | 2.06E+03 | 1.27E-12 |
| Rh-102 | β-, γ | 2.9 a | --- | --- | --- | --- | --- |
| Rh-106 | β-, γ | 29.9 s | --- | --- | --- | --- | --- |
| Rn-219 | α, γ | 3.96 s | 2.63E+00 | 1.30E+01 | --- | --- | --- |
| Rn-220 | α, γ | 55.6 s | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Rn-222 | α, γ | 3.8235 d | 3.21E+01 | 2.57E+00 | --- | --- | --- |
| Ru-106 | β- | 1.02 a | --- | --- | --- | --- | --- |
| Sb-125 | β-, γ | 2.758 a | --- | --- | --- | --- | --- |
| Sb-126 | β-, γ | 12.4 d | 1.87E-01 | 1.25E-01 | --- | --- | --- |
| Sb-126m | γ, ITe- | 11.0 s | 1.33E+00 | 8.94E-01 | --- | --- | --- |
| Se-75 | ε | 119.79 d | --- | --- | --- | --- | --- |
| Se-79 | β- | 6.5E+04 a | 2.39E-05 | 1.37E-01 | 1.00E+03 | 2.06E+03 | 6.62E-05 |
| Sm-145 | ε | 340 d | --- | --- | --- | --- | --- |
| Sm-146 | α | 1.03E+08 a | 1.81E-13 | 3.21E-08 | 1.00E+02 | 2.06E+02 | 1.56E-10 |
| Sm-147 | α | 1.06E+11 a | 1.31E-09 | 1.61E-08 | 1.00E+02 | 2.06E+02 | 8.45E-11 |
| Sm-148 | α | 7E+15 a | 6.17E-26 | 2.29E-19 | 1.00E+02 | 2.06E+02 | 1.11E-21 |
| Sm-151 | β-, γ | 90 a | 2.34E-33 | 1.62E-32 | 1.00E+03 | 2.06E+03 | 9.00E-36 |
| Sn-113 | ε | 115.09 d | --- | --- | --- | --- | --- |
| Sn-119m | IT | 293.1 d | --- | --- | --- | --- | --- |
| Sn-121 | β- | 27.06 h | --- | --- | --- | --- | --- |
| Sn-121m | β-, γ, ITe- | 55 a | --- | --- | 1.00E+03 | 2.06E+03 | --- |

**Table A-6. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 12,033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Sn-123 | β- | 129.2 d | --- | --- | --- | --- | --- |
| Sn-126 | β-, γ | 1.0E+05 a | 1.33E+00 | 8.94E-01 | 1.00E+03 | 2.06E+03 | 1.08E-03 |
| Sr-90 | β- | 29.1 a | --- | --- | 1.00E+03 | 2.06E+03 | --- |
| Ta-182 | β- | 114.43 d | --- | --- | --- | --- | --- |
| Tb-157 | ε | 71 a | --- | 6.83E-22 | 1.00E+03 | 2.06E+03 | 3.31E-25 |
| Tc-99 | β-, γ | 2.13E+05 a | 6.47E+01 | 1.28E+01 | 1.00E+04 | 2.06E+04 | 3.76E-03 |
| Te-121 | ε | 16.87 d | --- | --- | --- | --- | --- |
| Te-121m | β-, α | 154 d | --- | --- | --- | --- | --- |
| Te-123 | ε | 1.0E+13 a | 1.26E-03 | 1.55E-14 | 1.00E+03 | 2.06E+03 | 6.10E-07 |
| Te-123m | IT | 119.7 d | --- | --- | --- | --- | --- |
| Te-125m | γ, ITe- | 58 d | --- | --- | --- | --- | --- |
| Th-227 | α, γ | 18.72 d | 2.59E+00 | 1.28E+01 | --- | --- | --- |
| Th-228 | α, γ | 1.913 a | 1.48E+00 | 1.46E-02 | --- | --- | --- |
| Th-229 | α, γ | 7.3E+03 a | 5.84E+01 | 2.35E+01 | 1.00E+02 | 2.06E+02 | 3.97E-01 |
| Th-230 | α, γ | 7.54E+04 a | 4.02E+01 | 3.02E+00 | 1.00E+01 | 2.06E+01 | 2.09E+00 |
| Th-231 | β-, γ | 1.063 d | 1.35E+01 | 6.78E+01 | --- | --- | --- |
| Th-232 | α, γ | 1.4E+10 a | 1.48E+00 | 1.46E-02 | 1.00E+01 | 2.06E+01 | 7.27E-02 |
| Th-234 | β-, γ | 24.10 d | 3.51E+01 | 2.97E+01 | --- | --- | --- |
| Tl-204 | β-, ε | 3.78 a | --- | --- | --- | --- | --- |
| Tl-207 | β-, γ | 4.77 m | 2.62E+00 | 1.29E+01 | --- | --- | --- |
| Tl-208 | β-, γ | 3.053 m | 5.34E-01 | 5.26E-03 | --- | --- | --- |
| Tl-209 | β-, γ | 2.2 m | 1.23E+00 | 4.94E-01 | --- | --- | --- |
| Tm-170 | β-, α | 128.6 d | --- | --- | --- | --- | --- |
| Tm-171 | β- | 1.92 a | --- | --- | --- | --- | --- |
| U-232 | α, γ, SF | 70 a | --- | --- | 1.00E+02 | 2.06E+02 | --- |
| U-233 | α, γ, SF | 1.592E+05 a | 1.01E+02 | 3.89E+01 | 1.00E+02 | 2.06E+02 | 6.77E-01 |
| U-234 | α, γ, SF | 2.46E+05 a | 4.12E+02 | 3.43E+01 | 1.00E+02 | 2.06E+02 | 2.16E+00 |
| U-235 | α, γ, SF | 7.04E+08 a | 1.35E+01 | 6.78E+01 | 1.00E+02 | 2.06E+02 | 3.94E-01 |
| U-236 | α, γ, SF | 2.342E+07 a | 3.57E+01 | 1.82E+00 | 1.00E+02 | 2.06E+02 | 1.82E-01 |
| U-237 | β-, γ | 6.75 d | 1.41E-05 | 9.83E-06 | --- | --- | --- |
| U-238 | α, γ, SF | 4.47E+09 a | 3.51E+01 | 2.97E+01 | 1.00E+02 | 2.06E+02 | 3.14E-01 |
| U-240 | β-, γ | 14.1 h | 1.01E-02 | 8.65E-06 | --- | --- | --- |
| V-49 | ε | 330 d | --- | --- | --- | --- | --- |
| W-181 | ε | 121.2 d | --- | --- | --- | --- | --- |
| Y-90 | β-, γ | 2.67 d | --- | --- | --- | --- | --- |

**Table A-6. 40 CFR 191 Release Limits and Source Term EPA Units for WIPP-Scale TRU Waste (Calendar Year = 12,033) (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | |
|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | Release Limit[c] | | Potential Release[d] (EPA Units) |
| | | | CH | RH | (Ci/UW) | (Ci) | |
| Zn-65 | β+, γ, ε | 243.8 d | --- | --- | --- | --- | --- |
| Zr-93 | β-, γ | 1.5E+06 a | 2.45E-05 | 4.22E-02 | 1.00E+03 | 2.06E+03 | 2.05E-05 |

(a) Decay mode and half-life information taken from *Nuclides and Isotopes* (also called the "Chart of the Nuclides"), 16th Ed. (Lockheed Martin 2002).
(b) Decayed radionuclide inventory information taken from Van Soest (2012).
(c) Release limits are determined in accordance with 40 CFR 191 (Appendix B, Table B-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, 40 CFR 191). Right column corresponds to release limit obtained for 2.06 Units of Waste. The 2.06 value for the Unit of Waste corresponds to the Units of Waste present at repository closure in 2033.
(d) Potential release is defined as the total inventory (CH + RH) in Ci divided by the release limit in Ci. Those isotopes without defined release limits have no potential release.

# APPENDIX B – 40 CFR 191 Release Limits and Unit of Waste for WIPP-Scale TRU Waste

**Table B-1. 40 CFR 191 Release Limits for Containment Requirements[a]**

| [Cumulative releases to the accessible environment for 10,000 years after disposal] | |
|---|---|
| **Radionuclide** | **Release Limit per 1,000 metric tons of heavy metal or other unit of waste [(b)] (see notes) [(c)] (curies)** |
| Americium-241 or –243 | 100 |
| Carbon-14 | 100 |
| Cesium-135 or –137 | 1,000 |
| Iodine-129 | 100 |
| Neptunium-237 | 100 |
| Plutonium-238, -239, -240, or –242 | 100 |
| Radium-226 | 100 |
| Strontium-90 | 1,000 |
| Technetium-99 | 10,000 |
| Thorium-230 or –232 | 10 |
| Tin-126 | 1,000 |
| Uranium-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 |
| NOTE 1: *Units of Waste*. The Release Limits in Table 1 [of Appendix A of 40 CFR 191] apply to the amount of wastes in any one of the following: (e) An amount of transuranic wastes containing one million curies of alpha-emitting transuranic radionuclides with half-lives greater than 20 years. | |

(a) Based on Table 1 of Appendix A of 40 CFR 191.
(b) Notes 1(a) through 1(d) of Table 1 from Appendix A of 40 CFR 191 do not apply to TRU waste and are not shown here. Only TRU wastes are allowed in the WIPP facility, thus only Note 1(e) should be used for identification of the "unit of waste" value. Also, alpha, beta and gamma emitting radionuclides with half-lives greater than 20 years all contribute to the "release limits".
(c) Notes 2 through 6 of Table 1 from Appendix A of 40 CFR191 are not shown here.

**Table B-2. 40 CFR 191 Unit of Waste for WIPP-Scale TRU Waste**

| Radionuclide | | | WIPP TRU Waste | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | | | | | Transuranic Inventory[c] (Ci) | % of Unit of Waste |
| | | | 2033 | 2133 | 2383 | 3033 | 7033 | 12033 | 2033 | 2033 |
| Ac-225 | α, γ | 10.0 d | 1.40E+00 | 2.60E+00 | 5.56E+00 | 1.29E+01 | 5.03E+01 | 8.19E+01 | --- | --- |
| Ac-227 | α, β-, γ | 21.77 a | 2.70E+00 | 8.34E-01 | 1.20E+00 | 2.23E+00 | 8.38E+00 | 1.56E+01 | --- | --- |
| Ac-228 | α, β-, γ | 6.15 h | 1.47E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Ag-108 | β-, γ, ε, β+ | 2.39 m | 2.38E-03 | 1.38E-03 | 3.53E-04 | 1.02E-05 | 3.35E-15 | 4.71E-27 | --- | --- |
| Ag-108m | ε, β+ , γ, IT | 420 m | 2.74E-02 | 1.59E-02 | 4.05E-03 | 1.17E-04 | 3.85E-14 | 5.41E-26 | --- | --- |
| Ag-109m | ITe- | 39.8 s | 2.86E-02 | --- | --- | --- | --- | --- | --- | --- |
| Ag-110 | β-, γ, ε | 24.6 s | 4.29E-12 | --- | --- | --- | --- | --- | --- | --- |
| Ag-110m | β-, γ, ITe- | 249.8 d | 3.16E-10 | --- | --- | --- | --- | --- | --- | --- |
| **Am-241** | **α, γ, SF** | **432.7 a** | **7.05E+05** | **6.20E+05** | **4.15E+05** | **1.46E+05** | **2.42E+02** | **1.08E+00** | **7.05E+05** | **34.15%** |
| Am-242 | β-, γ, ε e- | 16.02 h | 2.24E+01 | 1.37E+01 | 4.01E+00 | 1.64E-01 | 4.73E-10 | 1.00E-20 | --- | --- |
| **Am-242m** | **α, ITe-, γ, SF** | **141.0 a** | **2.25E+01** | **1.38E+01** | **4.02E+00** | **1.65E-01** | **4.76E-10** | **1.01E-20** | **2.25E+01** | **0.00%** |
| **Am-243** | **α, γ, SF** | **7.37E+03 a** | **5.12E+01** | **5.08E+01** | **4.96E+01** | **4.67E+01** | **3.20E+01** | **2.00E+01** | **5.12E+01** | **0.00%** |
| Am-245 | β-, γ | 2.05 h | 7.97E-12 | --- | --- | --- | --- | --- | --- | --- |
| Ar-39 | β- | 269 a | 1.89E-02 | 1.46E-02 | 7.65E-03 | 1.43E-03 | 4.78E-08 | 1.21E-13 | --- | --- |
| Ar-42 | β- | 33 a | 3.22E-02 | 3.91E-03 | 2.02E-05 | 2.27E-11 | --- | --- | --- | --- |
| At-217 | α, β-, γ | 32 ms | 1.40E+00 | 2.60E+00 | 5.56E+00 | 1.29E+01 | 5.03E+01 | 8.19E+01 | --- | --- |
| Ba-133 | ε, γ | 10.53 a | 9.13E-01 | 1.26E-03 | 8.80E-11 | 2.21E-29 | --- | --- | --- | --- |
| Ba-137m | IT | 2.552 m | 2.22E+05 | 2.20E+04 | 6.83E+01 | 2.05E-05 | --- | --- | --- | --- |
| Bi-210 | α, β-, γ | 5.01 d | 1.43E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.74E+01 | 3.47E+01 | --- | --- |
| Bi-211 | α, β-, γ | 2.14 m | 2.70E+00 | 8.35E-01 | 1.20E+00 | 2.23E+00 | 8.38E+00 | 1.56E+01 | --- | --- |
| Bi-212 | α, β-, γ | 1.009 h | 1.64E+01 | 7.03E+00 | 1.96E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Bi-213 | α, β-, γ | 45.6 m | 1.40E+00 | 2.60E+00 | 5.56E+00 | 1.29E+01 | 5.02E+01 | 8.19E+01 | --- | --- |
| Bi-214 | α, β-, γ | 19.9 m | 1.71E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.74E+01 | 3.47E+01 | --- | --- |
| Bk-249 | α, β-, γ, SF | 3.2E+02 d | 5.50E-07 | --- | --- | --- | --- | --- | --- | --- |
| Bk-250 | β-, γ | 3.217 h | 8.28E-04 | 8.24E-04 | 8.16E-04 | 7.95E-04 | 6.78E-04 | 5.56E-04 | --- | --- |
| C-14 | β- | 5730 a | 2.18E+02 | 2.15E+02 | 2.08E+02 | 1.93E+02 | 1.19E+02 | 6.49E+01 | --- | --- |
| Ca-45 | β- | 162.61 d | 9.30E-19 | --- | --- | --- | --- | --- | --- | --- |
| Cd-109 | γ, ε | 462.0 d | 2.86E-02 | --- | --- | --- | --- | --- | --- | --- |
| Cd-113 | β- | 7.7E+15 a | 1.51E-03 | 1.51E-03 | 1.51E-03 | 1.51E-03 | 1.51E-03 | 1.51E-03 | --- | --- |
| Cd-113m | β-, IT | 14.1 a | 1.21E+00 | 8.84E-03 | 4.06E-08 | 5.37E-22 | --- | --- | --- | --- |
| Ce-139 | γ, ε | 137.64 d | 4.96E-21 | --- | --- | --- | --- | --- | --- | --- |
| Ce-144 | β-, γ | 284.6 d | 1.21E-06 | --- | --- | --- | --- | --- | --- | --- |
| **Cf-249** | **α, γ, SF** | **351 a** | **2.41E+01** | **1.98E+01** | **1.21E+01** | **3.34E+00** | **1.22E-03** | **6.20E-08** | **2.41E+01** | **0.00%** |

**Table B-2. 40 CFR 191 Unit of Waste for WIPP-Scale TRU Waste (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | | | | | Transuranic Inventory[c] (Ci) | % of Unit of Waste |
| | | | 2033 | 2133 | 2383 | 3033 | 7033 | 12033 | 2033 | 2033 |
| Cf-250 | α, γ, SF | 13.1 a | 4.08E-01 | 2.86E-03 | 8.16E-04 | 7.95E-04 | 6.78E-04 | 5.56E-04 | --- | --- |
| **Cf-251** | **α, γ** | **9.0E+02 a** | **4.86E-02** | **4.50E-02** | **3.71E-02** | **2.24E-02** | **1.02E-03** | **2.16E-05** | **4.86E-02** | **0.00%** |
| Cf-252 | α, γ, SF | 2.638 a | 7.63E-01 | 3.17E-12 | --- | --- | --- | --- | --- | --- |
| Cl-36 | β-, ε, β+ | 3.01E+01 a | 4.07E-03 | 4.07E-03 | 4.07E-03 | 4.06E-03 | 4.02E-03 | 3.98E-03 | --- | --- |
| Cm-242 | α, γ, SF | 162.8 d | 1.85E+01 | 1.13E+01 | 3.31E+00 | 1.36E-01 | 3.93E-10 | 8.30E-21 | --- | --- |
| **Cm-243** | **α, γ, SF, ε** | **29.1 a** | **2.34E+02** | **2.06E+01** | **4.71E-02** | **6.41E-09** | --- | --- | **2.34E+02** | **0.01%** |
| Cm-244 | α, γ, SF | 18.1 a | 9.97E+03 | 2.16E+02 | 1.50E-02 | 2.32E-13 | --- | --- | --- | --- |
| **Cm-245** | **α, γ, SF** | **8.5E+03 a** | **1.23E+00** | **1.39E+00** | **1.68E+00** | **1.94E+00** | **1.51E+00** | **1.00E+00** | **1.23E+00** | **0.00%** |
| **Cm-246** | **α, γ, SF** | **4.76E+03 a** | **7.46E+01** | **7.35E+01** | **7.09E+01** | **6.44E+01** | **3.59E+01** | **1.72E+01** | **7.46E+01** | **0.00%** |
| **Cm-247** | **α, γ** | **1.56E+07 a** | **1.12E-02** | **1.12E-02** | **1.12E-02** | **1.12E-02** | **1.12E-02** | **1.12E-02** | **1.12E-02** | **0.00%** |
| **Cm-248** | **α, SF** | **3.48E+05 a** | **1.19E-01** | **1.19E-01** | **1.19E-01** | **1.19E-01** | **1.18E-01** | **1.17E-01** | **1.19E-01** | **0.00%** |
| **Cm-250** | **α, β-, SF** | **9700 a** | **5.91E-03** | **5.89E-03** | **5.83E-03** | **5.68E-03** | **4.84E-03** | **3.97E-03** | **5.91E-03** | **0.00%** |
| Co-60 | β-, γ | 5.271 a | 7.72E+03 | 1.50E-02 | 7.81E-17 | --- | --- | --- | --- | --- |
| Cs-134 | β-, γ, ε | 2.065 a | 8.81E-01 | 2.21E-15 | --- | --- | --- | --- | --- | --- |
| Cs-135 | β- | 2.3E+06 a | 6.05E+01 | 6.05E+01 | 6.05E+01 | 6.05E+01 | 6.04E+01 | 6.03E+01 | --- | --- |
| Cs-137 | β-, γ | 30.17 a | 2.35E+05 | 2.33E+04 | 7.23E+01 | 2.17E-05 | --- | --- | --- | --- |
| Dy-159 | γ, ε | 144.4 d | 5.10E-21 | --- | --- | --- | --- | --- | --- | --- |
| Es-254 | α, γ | 276 d | 7.50E-13 | --- | --- | --- | --- | --- | --- | --- |
| Eu-152 | β-, γ, εβ+ | 13.48 a | 3.35E+01 | 1.85E-01 | 4.16E-07 | 8.66E-22 | --- | --- | --- | --- |
| Eu-154 | β-, γ, εγ | 8.59 a | 2.27E+02 | 7.12E-02 | 1.23E-10 | --- | --- | --- | --- | --- |
| Eu-155 | β-, γ | 4.71 a | 3.08E+01 | 1.14E-05 | 9.44E-22 | --- | --- | --- | --- | --- |
| Fe-55 | ε | 2.73 a | 1.49E+02 | 1.40E-09 | --- | --- | --- | --- | --- | --- |
| Fr-221 | α, γ | 4.8 m | 1.40E+00 | 2.60E+00 | 5.56E+00 | 1.29E+01 | 5.03E+01 | 8.19E+01 | --- | --- |
| Fr-223 | α, β-, γ | 21.8 m | 3.72E-02 | 1.15E-02 | 1.65E-02 | 3.08E-02 | 1.16E-01 | 2.15E-01 | --- | --- |
| Gd-152 | α | 1.1E+14 a | 4.69E-12 | 5.84E-12 | 5.85E-12 | 5.85E-12 | 5.85E-12 | 5.85E-12 | --- | --- |
| Gd-153 | γ, ε - | 240.4 d | 9.89E-13 | --- | --- | --- | --- | --- | --- | --- |
| H-3 | β- | 12.3 a | 5.90E+03 | 2.13E+01 | 1.68E-05 | 2.26E-21 | --- | --- | --- | --- |
| Ho-166m | β-, γ | 1.2E+03 a | 1.82E-05 | 1.72E-05 | 1.49E-05 | 1.02E-05 | 1.01E-06 | 5.64E-08 | --- | --- |
| I-129 | β-, γ | 1.57E+07 a | 3.77E-01 | 3.77E-01 | 3.77E-01 | 3.77E-01 | 3.77E-01 | 3.77E-01 | --- | --- |
| In-113m | γ, ε | 1.6582 h | 6.36E-26 | --- | --- | --- | --- | --- | --- | --- |
| In-115 | β- | 4.4E+15 a | 6.05E-17 | 6.05E-17 | 6.05E-17 | 6.05E-17 | 6.05E-17 | 6.05E-17 | --- | --- |
| Ir-194 | β-,γ, ε - | 19.28 h | 1.46E-03 | 1.39E-08 | 3.96E-21 | --- | --- | --- | --- | --- |
| K-40 | β-, γ, β+ | 1.27E+09 a | 6.05E-03 | 6.05E-03 | 6.05E-03 | 6.05E-03 | 6.05E-03 | 6.05E-03 | --- | --- |
| K-42 | β-,γ | 12.36 h | 3.22E-02 | 3.91E-03 | 2.02E-05 | 2.27E-11 | --- | --- | --- | --- |
| Kr-85 | β-, γ | 10.73 a | 1.95E+02 | 3.03E-01 | 2.89E-08 | 1.61E-26 | --- | --- | --- | --- |

**Table B-2. 40 CFR 191 Unit of Waste for WIPP-Scale TRU Waste (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | | | | | Transuranic Inventory[c] (Ci) | % of Unit of Waste |
| | | | 2033 | 2133 | 2383 | 3033 | 7033 | 12033 | 2033 | 2033 |
| Lu-177m | β-, α | 160.4 d | 8.05E-21 | --- | --- | --- | --- | --- | --- | --- |
| Mn-54 | ε, γ | 312.2 d | 2.17E-04 | --- | --- | --- | --- | --- | --- | --- |
| Mo-93 | ε, γ | 3.5E+03 a | 2.12E-02 | 2.07E-02 | 1.97E-02 | 1.73E-02 | 7.85E-03 | 2.92E-03 | --- | --- |
| Na-22 | ε | 2.6019 a | 6.44E-03 | 1.73E-14 | --- | --- | --- | --- | --- | --- |
| Nb-91 | γ | 680 a | 3.20E-02 | 2.89E-02 | 2.24E-02 | 1.16E-02 | 1.96E-04 | 1.20E-06 | --- | --- |
| Nb-93m | ITe- | 16.1 a | 4.23E-01 | 6.44E-02 | 5.87E-02 | 5.67E-02 | 4.88E-02 | 4.46E-02 | --- | --- |
| Nb-94 | β-, γ | 2.0E+04 a | 2.08E+00 | 2.08E+00 | 2.06E+00 | 2.01E+00 | 1.76E+00 | 1.48E+00 | --- | --- |
| Nd-144 | α | 2.29E+15 a | 3.68E-11 | 3.68E-11 | 3.68E-11 | 3.68E-11 | 3.68E-11 | 3.68E-11 | --- | --- |
| Ni-59 | ε | 7.6E+04 a | 2.13E+03 | 2.13E+03 | 2.12E+03 | 2.11E+03 | 2.03E+03 | 1.94E+03 | --- | --- |
| Ni-63 | β- | 100 a | 2.45E+03 | 1.22E+03 | 2.17E+02 | 2.40E+00 | 2.25E-12 | 2.06E-27 | --- | --- |
| Np-235 | ε | 396.2 d | 1.96E-07 | --- | --- | --- | --- | --- | --- | --- |
| **Np-237** | **α, γ** | **2.14E+06 a** | **2.32E+01** | **4.48E+01** | **8.62E+01** | **1.40E+02** | **1.70E+02** | **1.70E+02** | **2.32E+01** | **0.00%** |
| Np-238 | β-, γ | 2.117 d | 1.01E-01 | 6.19E-02 | 1.81E-02 | 7.42E-04 | 2.14E-12 | 4.52E-23 | --- | --- |
| Np-239 | β-, γ | 2.355 d | 5.12E+01 | 5.08E+01 | 4.96E+01 | 4.67E+01 | 3.20E+01 | 2.00E+01 | --- | --- |
| Np-240 | β- | 61.9 m | 1.22E-05 | 1.22E-05 | 1.22E-05 | 1.22E-05 | 1.22E-05 | 1.22E-05 | --- | --- |
| Np-240m | β-, γ, IT | 7.22 m | 1.01E-02 | 1.01E-02 | 1.01E-02 | 1.01E-02 | 1.01E-02 | 1.01E-02 | --- | --- |
| Os-194 | β- | 6.0 a | 1.45E-03 | 1.39E-08 | 3.95E-21 | --- | --- | --- | --- | --- |
| Pa-231 | α, γ | 3.28E+04 a | 6.37E-01 | 7.97E-01 | 1.20E+00 | 2.23E+00 | 8.38E+00 | 1.56E+01 | --- | --- |
| Pa-233 | β-, γ | 27.0 d | 2.32E+01 | 4.48E+01 | 8.62E+01 | 1.40E+02 | 1.70E+02 | 1.70E+02 | --- | --- |
| Pa-234 | β-, γ | 6.69 h | 8.42E-02 | 8.42E-02 | 8.42E-02 | 8.42E-02 | 8.42E-02 | 8.42E-02 | --- | --- |
| Pa-234m | β-, γ, IT | 1.17 m | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | --- | --- |
| Pb-209 | β- | 3.25 h | 1.40E+00 | 2.60E+00 | 5.56E+00 | 1.29E+01 | 5.02E+01 | 8.19E+01 | --- | --- |
| Pb-210 | α, β-, γ | 22.3 a | 1.43E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.74E+01 | 3.47E+01 | --- | --- |
| Pb-211 | β-, γ | 36.1 m | 2.70E+00 | 8.35E-01 | 1.20E+00 | 2.23E+00 | 8.38E+00 | 1.56E+01 | --- | --- |
| Pb-212 | β-, γ | 10.64 h | 1.64E+01 | 7.03E+00 | 1.96E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Pb-214 | β-, γ | 27 m | 1.71E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.74E+01 | 3.47E+01 | --- | --- |
| Pd-107 | β- | 6.5E+06 a | 1.18E-04 | 1.18E-04 | 1.18E-04 | 1.18E-04 | 1.17E-04 | 1.17E-04 | --- | --- |
| Pm-145 | ε | 17.7 a | 4.95E-01 | 9.86E-03 | 5.52E-07 | 4.86E-18 | --- | --- | --- | --- |
| Pm-146 | ε, γ, β- | 5.53 a | 6.78E-02 | 2.44E-07 | 5.99E-21 | --- | --- | --- | --- | --- |
| Pm-147 | β-, γ | 2.6234 a | 5.53E-01 | 1.85E-12 | --- | --- | --- | --- | --- | --- |
| Po-210 | α, γ | 138.38 d | 1.43E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.74E+01 | 3.47E+01 | --- | --- |
| Po-211 | α, γ | 0.516 s | 7.43E-03 | 2.30E-03 | 3.29E-03 | 6.13E-03 | 2.30E-02 | 4.29E-02 | --- | --- |
| Po-212 | α | 0.298 ms | 1.05E+01 | 4.50E+00 | 1.26E+00 | 9.61E-01 | 9.61E-01 | 9.61E-01 | --- | --- |
| Po-213 | α | 4 ms | 1.37E+00 | 2.55E+00 | 5.44E+00 | 1.27E+01 | 4.92E+01 | 8.02E+01 | --- | --- |
| Po-214 | α, γ | 163.7 ms | 1.71E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.74E+01 | 3.47E+01 | --- | --- |
| Po-215 | α, β-, γ | 1.780 ms | 2.70E+00 | 8.35E-01 | 1.20E+00 | 2.23E+00 | 8.38E+00 | 1.56E+01 | --- | --- |

## Table B-2. 40 CFR 191 Unit of Waste for WIPP-Scale TRU Waste (continued)

| Radionuclide | | | WIPP TRU Waste | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | | | | | Transuranic Inventory[c] (Ci) | % of Unit of Waste |
| | | | 2033 | 2133 | 2383 | 3033 | 7033 | 12033 | 2033 | 2033 |
| Po-216 | α, γ | 0.145 s | 1.64E+01 | 7.03E+00 | 1.96E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Po-218 | α, β-, γ | 3.10 m | 1.72E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.75E+01 | 3.47E+01 | --- | --- |
| Pr-144 | β-, γ | 17.28 m | 1.21E-06 | --- | --- | --- | --- | --- | --- | --- |
| Pr-144m | β-, α | 7.2 m | 1.69E-08 | --- | --- | --- | --- | --- | --- | --- |
| Pu-236 | α, γ, SF | 2.87 a | 2.69E-03 | 1.12E-13 | --- | --- | --- | --- | --- | --- |
| **Pu-238** | **α, γ, SF** | **87.7 a** | **6.01E+05** | **2.73E+05** | **3.78E+04** | **2.22E+02** | **1.05E-09** | **2.21E-20** | **6.01E+05** | **29.11%** |
| **Pu-239** | **α, γ, SF** | **2.41E+04 a** | **5.74E+05** | **5.73E+05** | **5.69E+05** | **5.58E+05** | **4.97E+05** | **4.31E+05** | **5.74E+05** | **27.83%** |
| **Pu-240** | **α, γ, SF** | **6.56E+03 a** | **1.75E+05** | **1.73E+05** | **1.69E+05** | **1.58E+05** | **1.03E+05** | **6.10E+04** | **1.75E+05** | **8.49%** |
| Pu-241 | α, β-, γ | 14.4 a | 6.63E+05 | 5.29E+03 | 1.71E+00 | 1.94E+00 | 1.51E+00 | 1.00E+00 | --- | --- |
| **Pu-242** | **α, γ, SF** | **3.75E+05 a** | **8.09E+03** | **8.09E+03** | **8.09E+03** | **8.08E+03** | **8.02E+03** | **7.95E+03** | **8.09E+03** | **0.39%** |
| Pu-243 | β-, γ | 4.956 h | 1.12E-02 | 1.12E-02 | 1.12E-02 | 1.12E-02 | 1.12E-02 | 1.12E-02 | --- | --- |
| **Pu-244** | **α, SF** | **8.0E+07 a** | **1.01E-02** | **1.01E-02** | **1.01E-02** | **1.02E-02** | **1.02E-02** | **1.02E-02** | **1.01E-02** | **0.00%** |
| Ra-223 | α, γ | 11.435 d | 2.70E+00 | 8.35E-01 | 1.20E+00 | 2.23E+00 | 8.38E+00 | 1.56E+01 | --- | --- |
| Ra-224 | α, γ | 3.66 d | 1.64E+01 | 7.03E+00 | 1.96E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Ra-225 | β-, γ | 14.9 d | 1.40E+00 | 2.60E+00 | 5.56E+00 | 1.29E+01 | 5.03E+01 | 8.19E+01 | --- | --- |
| Ra-226 | α, γ | 1.60E+03 a | 1.72E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.75E+01 | 3.47E+01 | --- | --- |
| Ra-228 | β-, γ | 5.76 a | 1.47E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Rb-87 | β- | 4.88E+10 a | 2.61E-09 | 2.61E-09 | 2.61E-09 | 2.61E-09 | 2.61E-09 | 2.61E-09 | --- | --- |
| Rh-102 | β-, γ | 2.9 a | 2.91E-14 | --- | --- | --- | --- | --- | --- | --- |
| Rh-106 | β-, γ | 29.9 s | 1.69E-04 | --- | --- | --- | --- | --- | --- | --- |
| Rn-219 | α, γ | 3.96 s | 2.70E+00 | 8.35E-01 | 1.20E+00 | 2.23E+00 | 8.38E+00 | 1.56E+01 | --- | --- |
| Rn-220 | α, γ | 55.6 s | 1.64E+01 | 7.03E+00 | 1.96E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Rn-222 | α, γ | 3.8235 d | 1.72E+01 | 1.66E+01 | 1.54E+01 | 1.33E+01 | 1.75E+01 | 3.47E+01 | --- | --- |
| Ru-106 | β- | 1.02 a | 1.69E-04 | --- | --- | --- | --- | --- | --- | --- |
| Sb-125 | β-, γ | 2.758 a | 1.29E+00 | 1.21E-11 | --- | --- | --- | --- | --- | --- |
| Sb-126 | β-, γ | 12.4 d | 3.34E-01 | 3.34E-01 | 3.33E-01 | 3.32E-01 | 3.23E-01 | 3.12E-01 | --- | --- |
| Sb-126m | γ, ITe- | 11.0 s | 2.39E+00 | 2.39E+00 | 2.38E+00 | 2.37E+00 | 2.31E+00 | 2.23E+00 | --- | --- |
| Se-75 | ε | 119.79 d | 3.16E-25 | --- | --- | --- | --- | --- | --- | --- |
| Se-79 | β- | 6.5E+04 a | 1.40E-01 | 1.40E-01 | 1.40E-01 | 1.40E-01 | 1.38E-01 | 1.37E-01 | --- | --- |
| Sm-145 | ε | 340 d | 2.87E-09 | --- | --- | --- | --- | --- | --- | --- |
| Sm-146 | α | 1.03E+08 a | 3.09E-08 | 3.21E-08 | 3.21E-08 | 3.21E-08 | 3.21E-08 | 3.21E-08 | --- | --- |
| Sm-147 | α | 1.06E+11 a | 1.74E-08 | 1.74E-08 | 1.74E-08 | 1.74E-08 | 1.74E-08 | 1.74E-08 | --- | --- |
| Sm-148 | α | 7E+15 a | 2.29E-19 | 2.29E-19 | 2.29E-19 | 2.29E-19 | 2.29E-19 | 2.29E-19 | --- | --- |
| Sm-151 | β-, γ | 90 a | 5.27E+01 | 2.44E+01 | 3.55E+00 | 2.38E-02 | 9.89E-16 | 1.86E-32 | --- | --- |
| Sn-113 | ε | 115.09 d | 6.36E-26 | --- | --- | --- | --- | --- | --- | --- |
| Sn-119m | IT | 293.1 d | 4.39E-10 | --- | --- | --- | --- | --- | --- | --- |

**Table B-2. 40 CFR 191 Unit of Waste for WIPP-Scale TRU Waste (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | | | | | Transuranic Inventory[c] (Ci) | % of Unit of Waste |
| | | | 2033 | 2133 | 2383 | 3033 | 7033 | 12033 | 2033 | 2033 |
| Sn-121 | β- | 27.06 h | 9.79E-01 | 2.78E-01 | 1.19E-02 | 3.30E-06 | --- | --- | --- | --- |
| Sn-121m | β-, γ, ITe- | 55 a | 1.26E+00 | 3.58E-01 | 1.53E-02 | 4.25E-06 | --- | --- | --- | --- |
| Sn-123 | β- | 129.2 d | 1.92E-22 | --- | --- | --- | --- | --- | --- | --- |
| Sn-126 | β-, γ | 1.0E+05 a | 2.39E+00 | 2.39E+00 | 2.38E+00 | 2.37E+00 | 2.31E+00 | 2.23E+00 | --- | --- |
| Sr-90 | β- | 29.1 a | 2.09E+05 | 1.78E+04 | 3.77E+01 | 4.21E-06 | --- | --- | --- | --- |
| Ta-182 | β- | 114.43 d | 1.13E-22 | --- | --- | --- | --- | --- | --- | --- |
| Tb-157 | ε | 71 a | 8.00E-02 | 5.04E-02 | 1.59E-02 | 7.88E-04 | 7.39E-12 | 6.83E-22 | --- | --- |
| Tc-99 | β-, γ | 2.13E+05 a | 8.01E+01 | 8.01E+01 | 8.00E+01 | 7.98E+01 | 7.88E+01 | 7.75E+01 | --- | --- |
| Te-121 | ε | 16.87 d | 1.33E-19 | --- | --- | --- | --- | --- | --- | --- |
| Te-121m | β-, α | 154 d | 1.34E-19 | --- | --- | --- | --- | --- | --- | --- |
| Te-123 | ε | 1.0E+13 a | 1.26E-03 | 1.26E-03 | 1.26E-03 | 1.26E-03 | 1.26E-03 | 1.26E-03 | --- | --- |
| Te-123m | IT | 119.7 d | 4.95E-24 | --- | --- | --- | --- | --- | --- | --- |
| Te-125m | γ, ITe- | 58 d | 3.16E-01 | 2.96E-12 | --- | --- | --- | --- | --- | --- |
| Th-227 | α, γ | 18.72 d | 2.67E+00 | 8.23E-01 | 1.18E+00 | 2.20E+00 | 8.26E+00 | 1.54E+01 | --- | --- |
| Th-228 | α, γ | 1.913 a | 1.64E+01 | 7.03E+00 | 1.96E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Th-229 | α, γ | 7.3E+03 a | 1.40E+00 | 2.60E+00 | 5.56E+00 | 1.29E+01 | 5.03E+01 | 8.19E+01 | --- | --- |
| Th-230 | α, γ | 7.54E+04 a | 4.14E+00 | 4.42E+00 | 5.36E+00 | 8.03E+00 | 2.41E+01 | 4.32E+01 | --- | --- |
| Th-231 | β-, γ | 1.063 d | 7.64E+01 | 7.64E+01 | 7.66E+01 | 7.69E+01 | 7.90E+01 | 8.13E+01 | --- | --- |
| Th-232 | α, γ | 1.4E+10 a | 1.50E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | 1.50E+00 | --- | --- |
| Th-234 | β-, γ | 24.10 d | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | --- | --- |
| Tl-204 | β-, ε | 3.78 a | 2.52E-06 | 2.74E-14 | 3.38E-34 | --- | --- | --- | --- | --- |
| Tl-207 | β-, γ | 4.77 m | 2.70E+00 | 8.32E-01 | 1.19E+00 | 2.22E+00 | 8.35E+00 | 1.55E+01 | --- | --- |
| Tl-208 | β-, γ | 3.053 m | 5.90E+00 | 2.53E+00 | 7.05E-01 | 5.39E-01 | 5.39E-01 | 5.39E-01 | --- | --- |
| Tl-209 | β-, γ | 2.2 m | 2.94E-02 | 5.46E-02 | 1.17E-01 | 2.72E-01 | 1.06E+00 | 1.72E+00 | --- | --- |
| Tm-170 | β-, α | 128.6 d | 5.09E-24 | --- | --- | --- | --- | --- | --- | --- |
| Tm-171 | β- | 1.92 a | 9.09E-05 | 1.91E-20 | --- | --- | --- | --- | --- | --- |
| U-232 | α, γ, SF | 70 a | 1.45E+01 | 5.38E+00 | 4.49E-01 | 7.07E-04 | 3.97E-21 | --- | --- | --- |
| U-233 | α, γ, SF | 1.592E+05 a | 1.39E+02 | 1.39E+02 | 1.39E+02 | 1.38E+02 | 1.39E+02 | 1.40E+02 | --- | --- |
| U-234 | α, γ, SF | 2.46E+05 a | 2.42E+02 | 3.59E+02 | 4.43E+02 | 4.56E+02 | 4.51E+02 | 4.46E+02 | --- | --- |
| U-235 | α, γ, SF | 7.04E+08 a | 7.64E+01 | 7.64E+01 | 7.66E+01 | 7.69E+01 | 7.90E+01 | 8.13E+01 | --- | --- |
| U-236 | α, γ, SF | 2.342E+07 a | 5.44E+00 | 5.96E+00 | 7.23E+00 | 1.04E+01 | 2.56E+01 | 3.75E+01 | --- | --- |
| U-237 | β-, γ | 6.75 d | 1.59E+01 | 1.27E-01 | 4.09E-05 | 4.65E-05 | 3.60E-05 | 2.40E-05 | --- | --- |
| U-238 | α, γ, SF | 4.47E+09 a | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | 6.48E+01 | --- | --- |
| U-240 | β-, γ | 14.1 h | 1.01E-02 | 1.01E-02 | 1.01E-02 | 1.01E-02 | 1.01E-02 | 1.01E-02 | --- | --- |
| V-49 | ε | 330 d | 3.19E-08 | --- | --- | --- | --- | --- | --- | --- |

**Table B-2. 40 CFR 191 Unit of Waste for WIPP-Scale TRU Waste (continued)**

| Radionuclide | | | WIPP TRU Waste | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ID | Decay Mode[a] | Half-Life[a] | Total Inventory[b] (Ci) | | | | | | Transuranic Inventory[c] (Ci) | % of Unit of Waste |
| | | | 2033 | 2133 | 2383 | 3033 | 7033 | 12033 | 2033 | 2033 |
| W-181 | ε | 121.2 d | 6.80E-26 | --- | --- | --- | --- | --- | --- | --- |
| Y-90 | β-, γ | 2.67 d | 2.09E+05 | 1.78E+04 | 3.77E+01 | 4.21E-06 | --- | --- | --- | --- |
| Zn-65 | β+, γ, ε | 243.8 d | 1.61E-12 | --- | --- | --- | --- | --- | --- | --- |
| Zr-93 | β-, γ | 1.5E+06 a | 4.24E-02 | 4.24E-02 | 4.24E-02 | 4.24E-02 | 4.23E-02 | 4.22E-02 | --- | --- |
| **Total (Ci)** | | | 3.63E+06 | 1.74E+06 | 1.20E+06 | 8.75E+05 | 6.13E+05 | 5.04E+05 | **2.06E+06** | 100.00% |
| | | | | | | | | **WUF** | **2.06** | |

(a) Decay mode and half-life information taken from *Nuclides and Isotopes* (also called the "Chart of the Nuclides"), 16th Ed. (Lockheed Martin 2002).
(b) Decayed radionuclide inventory information taken from Van Soest (2012). The inventory information given has been decayed through 2033.
(c) Transuranic inventory data corresponds to the activity (Curie) data only for radionuclides that are categorized as "transuranic waste" per definitions in 40 CFR 191.

## APPENDIX C – Parameter Data Entry Tables

The following tables identify parameter value changes associated with the CRA-2014 PA. The data found in Tables C-1 through C-5 supports Parameter Data Entry form NP 9-2-1 for changing parameters affected by this document.

**Table C-1. Waste Unit Factor (WUF) Parameter Change**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| BOREHOLE | WUF | 2.06 | NONE | Constant | Appendix B, Table B-2 |

**Table C-2. Radionuclide Parameter Changes**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| AM241 | INVCHD | 6.97E+05 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| AM241 | INVRHD | 8.06E+03 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| AM243 | INVCHD | 2.18E+01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| AM243 | INVRHD | 2.95E+01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| CF252 | INVCHD | 7.62E-01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| CF252 | INVRHD | 9.26E-04 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| CM243 | INVCHD | 2.16E+02 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| CM243 | INVRHD | 1.81E+01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| CM244 | INVCHD | 5.24E+03 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |

**Table C-2. Radionuclide Parameter Changes (continued)**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| CM244 | INVRHD | 4.73E+03 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| CM245 | INVCHD | 3.70E-01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| CM245 | INVRHD | 8.55E-01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| CM248 | INVCHD | 1.03E-01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| CM248 | INVRHD | 1.62E-02 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| CS137 | INVCHD | 2.31E+03 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| CS137 | INVRHD | 2.33E+05 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| NP237 | INVCHD | 2.04E+01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| NP237 | INVRHD | 2.84E+00 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PA231 | INVCHD | 5.88E-01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| PA231 | INVRHD | 4.92E-02 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PB210 | INVCHD | 4.53E-01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| PB210 | INVRHD | 1.38E+01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PM147 | INVCHD | 1.00E-01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| PM147 | INVRHD | 4.53E-01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PU238 | INVCHD | 5.95E+05 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |

**Table C-2. Radionuclide Parameter Changes (continued)**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| PU238 | INVRHD | 5.80E+03 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PU239 | INVCHD | 5.67E+05 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| PU239 | INVRHD | 7.27E+03 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PU240 | INVCHD | 1.67E+05 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| PU240 | INVRHD | 7.94E+03 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PU241 | INVCHD | 6.48E+05 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| PU241 | INVRHD | 1.49E+04 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PU242 | INVCHD | 1.66E+03 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| PU242 | INVRHD | 6.44E+03 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| PU244 | INVCHD | 1.01E-02 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| PU244 | INVRHD | 7.38E-06 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| RA226 | INVCHD | 6.19E-01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| RA226 | INVRHD | 1.65E+01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| RA228 | INVCHD | 1.45E+00 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| RA228 | INVRHD | 1.76E-02 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| SR90 | INVCHD | 2.31E+03 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |

**Table C-2. Radionuclide Parameter Changes (continued)**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| SR90 | INVRHD | 2.07E+05 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| TH229 | INVCHD | 4.19E-01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| TH229 | INVRHD | 9.81E-01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| TH230 | INVCHD | 4.13E+00 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| TH230 | INVRHD | 1.02E-02 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| TH232 | INVCHD | 1.48E+00 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| TH232 | INVRHD | 1.46E-02 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| U233 | INVCHD | 9.82E+01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| U233 | INVRHD | 4.04E+01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| U234 | INVCHD | 2.10E+02 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| U234 | INVRHD | 3.23E+01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| U235 | INVCHD | 8.66E+00 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| U235 | INVRHD | 6.77E+01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| U236 | INVCHD | 5.08E+00 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |
| U236 | INVRHD | 3.65E-01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |
| U238 | INVCHD | 3.51E+01 | curies | Constant | Van Soest 2012, Table 5.3, year 2033 |

**Table C-2. Radionuclide Parameter Changes (continued)**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| U238 | INVRHD | 2.97E+01 | curies | Constant | Van Soest 2012, Table 5.4, year 2033 |

**Table C-3. Lumped Radionuclide Parameter Changes**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| AM241L | INVCHD | 7.18E+05 | curies | Constant | Section 4.3, Table 6 |
| AM241L | INVRHD | 8.56E+03 | curies | Constant | Section 4.3, Table 6 |
| TH230L | INVCHD | 4.54E+00 | curies | Constant | Section 4.3, Table 6 |
| TH230L | INVRHD | 9.91E-01 | curies | Constant | Section 4.3, Table 6 |
| PU238L | INVCHD | 5.95E+05 | curies | Constant | Section 4.3, Table 6 |
| PU238L | INVRHD | 5.80E+03 | curies | Constant | Section 4.3, Table 6 |
| U234L | INVCHD | 3.08E+02 | curies | Constant | Section 4.3, Table 6 |
| U234L | INVRHD | 7.28E+01 | curies | Constant | Section 4.3, Table 6 |
| PU239L | INVCHD | 7.60E+05 | curies | Constant | Section 4.3, Table 6 |
| PU239L | INVRHD | 1.15E+05 | curies | Constant | Section 4.3, Table 6 |

**Table C-4. Waste Material Parameter Changes**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| WAS_AREA | IRONCHW | 1.09E+07 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | IRONRHW | 1.35E+06 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | IRNCCHW | 3.00E+07 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | IRNCRHW | 6.86E+06 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | CELLCHW | 3.55E+06 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | CELLRHW | 1.18E+05 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | CELCCHW | 7.23E+05 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | CELCRHW | 0.00E+00 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | CELECHW | 2.60E+05 | kg | Constant | Van Soest 2012, Table 5.7 |
| WAS_AREA | CELERHW | 0.00E+00 [a] | kg | Constant | See Note a |
| WAS_AREA | PLASCHW | 5.20E+06 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | PLASRHW | 2.93E+05 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | PLSCCHW | 2.47E+06 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | PLSCRHW | 3.01E+05 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | PLSECHW | 1.25E+06 | kg | Constant | Van Soest 2012, Table 5.7 |
| WAS_AREA | PLSERHW | 0.00E+00 [a] | kg | Constant | See Note a |

**Table C-4. Waste Material Parameter Changes (continued)**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| WAS_AREA | RUBBCHW | 1.09E+06 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | RUBBRHW | 8.80E+04 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | RUBCCHW | 6.91E+04 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | RUBCRHW | 4.18E+03 | kg | Constant | Van Soest 2012, Table 5.5 |
| WAS_AREA | RUBECHW | 0.00E+00 [b] | kg | Constant | See Note b |
| WAS_AREA | RUBERHW | 0.00E+00 [a] | kg | Constant | See Note a |

NOTES: [a] The emplacement materials identified by Van Soest (2012, Table 5-7) are for CH waste only. Currently, no cellulosic, plastic, or rubber emplacement materials are used for RH waste emplacement.
[b] No rubber emplacement materials were identified by Van Soest (2012, Table 5-7).

**Table C-5. Oxyanion Parameter Changes**

| Material | Property | Value / Median | Units | Distribution | Source |
|---|---|---|---|---|---|
| NITRATE | QINIT | 2.74E+07 | moles | Constant | Section 5 |
| SULFATE | QINIT | 4.91E+06 | moles | Constant | Section 5 |

## APPENDIX D – Generation of the EPAUNI Input Files using the InventoryDB Database

This appendix provides information on the Microsoft® Office Excel® 2010 file and the Microsoft® Access® 2010 file used to generate EPAUNI input files. Both the Excel file, *PAIR-2012.xlsx*, and the Access file, *InventoryDB.mdb*, were developed on a PC workstation running Windows 7 Enterprise and are included as a machine readable (CD ROM) supplement to this report.

A Microsoft Access database called *InventoryDB* was created to select the radionuclides of interest from the inventory data provided by LANL and to export the data into ASCII files formatted for use by EPAUNI. The inventory data were imported from the Excel spreadsheet *PAIR-2012.xlsx* and placed into the table Inventory using the Access File/Get External Data/Import menu function and selecting the "2033 Normalized" sheet. Additionally, the same method was used to import the volume data for the CH waste streams from the sheet labeled "CH_Volumes" and the volume data for the RH waste streams from the sheet "RH_Volumes". These two sheets were created by cutting the data from the first three columns of the sheets "CH 2033" and "RH 2033", respectively. This operation was needed to remove the title line (row 1) on each sheet. The table RadsUsed was created to list the radionuclides to be included in each of the CH and RH input files for EPAUNI.

The volume data for the CH waste was joined to the inventory data using the query CH_Inventory. The data were combined using the site and waste stream fields of the two tables to join the data appropriately. The table RadsUsed was then joined through the Radionuclide and Handling fields to select out the set of data to be included in the EPAUNI input files. The SQL for the query is:

```
SELECT Inventory.[Site Code], Inventory.[Waste Stream ID], Volumes.Volume,
Inventory.Type, Inventory.Radionuclide, Inventory.[Scld Activity Ci],
RadsUsed.Handling, RadsUsed.SortOrder
FROM (Inventory INNER JOIN Volumes ON (Inventory.[Waste Stream ID] = Volumes.[Waste
Stream ID]) AND (Inventory.[Site Code] = Volumes.[Site ID])) INNER JOIN RadsUsed ON
(Inventory.Radionuclide = RadsUsed.Radionuclide) AND (Inventory.Handling =
RadsUsed.Handling)
WHERE (((RadsUsed.Handling)="CH"))
ORDER BY Inventory.[Waste Stream ID], RadsUsed.SortOrder;
```

The volume data, inventory data and the RadsUsed data for the RH waste streams were joined in a similar manner:

```
SELECT Inventory.[Site Code], Inventory.[Waste Stream ID], Volumes_RH.Volume,
Inventory.Type, Inventory.Radionuclide, Inventory.[Scld Activity Ci],
RadsUsed.Handling, RadsUsed.SortOrder
FROM (Inventory INNER JOIN RadsUsed ON (Inventory.Radionuclide =
RadsUsed.Radionuclide) AND (Inventory.Handling = RadsUsed.Handling)) INNER JOIN
Volumes_RH ON (Inventory.[Site Code] = Volumes_RH.[Site ID]) AND (Inventory.[Waste
Stream ID] = Volumes_RH.[Waste Stream ID])
WHERE (((RadsUsed.Handling)="RH"))
ORDER BY Inventory.[Site Code], Inventory.[Waste Stream ID], RadsUsed.SortOrder;
```

Crosstab (pivot) queries were then used with each of these two queries to organize the data into tables having waste streams as rows and volumes and radionuclides as columns. The SQL for the CH query is:

```
TRANSFORM First(CH_Inventory.[Scld Activity Ci]) AS [FirstOfScld Activity Ci]
SELECT CH_Inventory.[Site Code], CH_Inventory.[Waste Stream ID], CH_Inventory.Volume
FROM CH_Inventory
GROUP BY CH_Inventory.[Site Code], CH_Inventory.[Waste Stream ID], CH_Inventory.Volume
PIVOT [SortOrder] & ":" & [Radionuclide];
```

The SQL for the RH query is:

```
TRANSFORM First(RH_Inventory.[Scld Activity Ci]) AS [FirstOfScld Activity Ci]
SELECT RH_Inventory.[Site Code], RH_Inventory.[Waste Stream ID], RH_Inventory.Volume
FROM RH_Inventory
GROUP BY RH_Inventory.[Site Code], RH_Inventory.[Waste Stream ID], RH_Inventory.Volume
PIVOT [SortOrder] & ":" & [Radionuclide];
```

The data from the two crosstab queries were written to ASCII files using the code:

```
Sub WriteFile(fName As String, sql As String, ch As Boolean)
'write a formatted file
Dim db As Database
Dim rec As Recordset

Open fName For Output As #1
Set db = CurrentDb
Set rec = db.OpenRecordset(sql)
If Not rec.BOF And Not rec.EOF Then
    rec.MoveFirst
    If ch Then
        Print #1, "StreamRH (Really CH) Volume(m3) Am-241 Cm-244 Pu-238 Pu-239 Pu-240
Pu-241 U-234"
    Else
        Print #1, "StreamRH Volume(m3) Am-241 Cm-244 Pu-238 Pu-239 Pu-240 Pu-241 U-
234"
    End If
    Print #1, "       Cs-137 Sr-90 U-233"
    While Not rec.EOF
        Print #1, rec.Fields("Waste Stream ID"); " ";
        Debug.Print rec.Fields("Waste Stream ID"); " ";
        For i = 2 To 9
            Print #1, Format(Nz(rec.Fields(i), 0#), "0.00E+00"); " ";
            Debug.Print Format(Nz(rec.Fields(i), 0#), "0.00E+00"); " ";
        Next
        Print #1, ""
        Debug.Print ""
        Print #1, "      ";
        For i = 10 To 12
            Print #1, Format(Nz(rec.Fields(i), 0#), "0.00E+00"); " ";
        Next
        Print #1, ""
        rec.MoveNext
    Wend
    Close #1
End If
rec.Close
Set rec = Nothing
db.Close
Set db = Nothing
End Sub
```

The subroutine takes as arguments the name of the file to be written, the dataset to be used, and a Boolean parameter which is used to identify the data as CH or RH. The subroutine is called once for each of the CH and RH datasets using the form CreateFilesForm (Figure D-1), which is used to export the inventory data to ASCII files for use by EPAUNI.

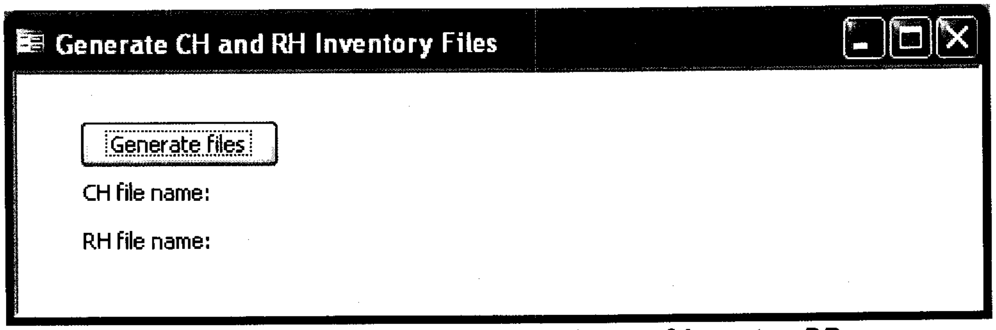



**Figure D-1. The CreateFilesForm of *InventoryDB***

The user selects the "Generate files" button to export the data. The code for this button then prompts the user for files names for the CH and RH files, via the standard Windows Common Dialog control, and calls the WriteFile subroutine for each:

```
Private Sub Command0_Click()
'get CH file name
Dim s As String, i As Integer
   'CancelError is True.
    CommCtrl.CancelError = True
    On Error GoTo ErrHandler
   ' Set filters.
    CommCtrl.Filter = "All Files (*.*)|*.*|Text Files (*.txt)|*.txt|Input files
(*.INP)|*.INP"
   ' Specify default filter.
    CommCtrl.FilterIndex = 3
    CommCtrl.DefaultExt = ".INP"
    CommCtrl.DialogTitle = "Save CH data as"
    CommCtrl.FileName = ""
   ' Display the Open dialog box.
    CommCtrl.ShowSave
    WriteFile CommCtrl.FileName, "CH_Inventory_Crosstab", True
    Me.CH_file.Caption = CommCtrl.FileName
    s = CommCtrl.FileName
    i = InStr(s, "\")
    While i > 0
        s = Mid(s, i + 1)
        i = InStr(s, "\")
    Wend
    i = InStr(s, "CH")
    If i > 0 Then
        Mid(s, i, 2) = "RH"
    End If
    CommCtrl.FileName = s
    CommCtrl.DialogTitle = "Save RH data as"
   ' Display the Open dialog box.
    CommCtrl.ShowSave
    WriteFile CommCtrl.FileName, "RH_Inventory_Crosstab", False
    Me.RH_file.Caption = CommCtrl.FileName

   Exit Sub
```

```
ErrHandler:
' User pressed Cancel button.
   Exit Sub

End Sub
```

The operation of the database in producing the files was verified by comparing selected values in the data in the files to the data in the spreadsheet and verifying that the files had the same number of records as in the spreadsheet. The sheets “CH 2033” and “RH 2033” were used for these comparisons. For example, the spreadsheet for CH waste is shown in Figure D-2.

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Site | Waste Stream ID | Scaled Vol ($m^3$) | Am-241 | Am-243 | Cm-244 | Cs-137 | Np-237 | Pu-238 | Pu-239 | Pu-240 | Pu-241 |
| 3 | AE | AE-T001 | 187.92 | 1.11E+01 | 2.74E+00 | 2.57E+02 | 4.68E+00 | 1.09E-01 | [illegible] | [illegible] | [illegible] | [illegible] |
| 4 | AE | AE-T003 | 3.12 | 1.27E+00 | 3.41E-02 | 4.38E-03 | 1.73E-01 | 1.86E-03 | 2.67E+00 | 1.59E+00 | 1.47E+00 | 4.92E+00 |
| 5 | AE | WP-AECHDM | 102.33 | 5.42E+01 | 1.88E+00 | 4.30E-02 | 9.74E-01 | 1.23E-01 | 5.20E+01 | 8.54E+01 | 6.45E+01 | 2.56E+01 |
| 6 | AE | WP-AECHHM | 13.95 | 1.41E+01 | 5.13E-03 | -- | 7.63E-04 | 1.83E-03 | 3.62E+00 | 4.13E+01 | 1.64E+01 | 2.96E-10 |
| 7 | AE | WP-MU-W002 | 4.50 | 6.72E+00 | 1.14E-03 | -- | 9.17E-07 | 3.91E-03 | -- | 2.27E-02 | -- | -- |
| 8 | AW | AW-5649N | 0.21 | 8.45E-04 | -- | -- | -- | 5.37E-09 | 5.98E-06 | 2.45E-03 | 1.22E-03 | 6.31E-03 |
| 9 | AW | AW-N027.531 | 13.62 | 2.33E+00 | 1.57E-14 | 1.53E-09 | 3.64E-02 | 3.96E-03 | 2.88E-01 | 5.92E+00 | 2.59E+00 | 4.58E+00 |
| 10 | AW | AW-T033.1325 | 75.67 | 2.52E+02 | 3.09E-01 | 9.50E-01 | 1.04E-02 | 1.37E-01 | 1.97E+00 | 5.16E+01 | 1.27E+01 | 9.02E+02 |
| 11 | IN | IN-AECHDM-PK | 0.21 | 6.75E+00 | 1.28E-04 | -- | 9.08E-03 | 4.45E-04 | 1.31E-01 | 1.93E+00 | 6.96E-01 | 2.08E+00 |
| 12 | IN | IN-BN004 | 548.10 | 2.91E+02 | -- | -- | 4.01E-06 | 1.26E-02 | 2.04E+01 | 6.32E+02 | 1.42E+02 | 3.18E+02 |

CH 2033 RH 2033 2033 Normalized CH_Volumes RH_Volumes

| | A | B | M | N | O | P | Q | R | S | T | U | V | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Site | Waste Stream ID | Pu-242 | Pu-244 | Sr-90 | Th-229 | Th-230 | Th-232 | U-233 | U-234 | U-235 | U-236 | U-238 |
| 3 | AE | AE-T001 | 1.74E-02 | 8.65E-06 | 3.90E+00 | 1.43E-05 | 8.89E-03 | 9.93E-06 | 6.93E-03 | 1.49E-02 | 2.03E-04 | 3.45E-05 | 1.33E-03 |
| 4 | AE | AE-T003 | 1.36E-02 | 1.36E-07 | 1.18E-01 | 2.43E-07 | 1.03E-04 | 1.14E-06 | 1.20E-04 | 2.71E-04 | 3.78E-06 | 3.61E-06 | 9.04E-05 |
| 5 | AE | WP-AECHDM | 2.62E-02 | 5.89E-16 | 9.71E-01 | 8.62E-03 | 2.23E-05 | 4.24E-14 | 4.20E-02 | 8.33E-02 | 1.50E-03 | 5.73E-05 | 4.41E-02 |
| 6 | AE | WP-AECHHM | 2.02E-03 | -- | 7.62E-04 | 3.21E-04 | 1.52E-06 | 1.08E-14 | 2.30E-07 | 5.67E-03 | 1.07E-04 | 1.46E-05 | 2.69E-03 |
| 7 | AE | WP-MU-W002 | -- | -- | 9.15E-07 | 1.09E-03 | 2.02E-13 | -- | 5.05E-07 | 1.46E-09 | 6.70E-10 | -- | 1.73E-05 |
| 8 | AW | AW-5649N | -- | -- | -- | 1.76E-16 | 5.54E-14 | 5.56E-19 | 2.58E-13 | 4.67E-10 | 6.03E-11 | 9.02E-10 | -- |
| 9 | AW | AW-N027.531 | 7.17E-04 | -- | 7.10E-02 | 4.37E-10 | 7.09E-06 | 7.68E-09 | 4.13E-07 | 1.32E-02 | 4.44E-04 | 4.95E-05 | 4.27E-06 |
| 10 | AW | AW-T033.1325 | 2.28E-03 | -- | 3.15E-02 | 1.50E-08 | 1.20E-05 | 6.57E-10 | 1.42E-05 | 2.26E-02 | 6.05E-04 | 1.35E-04 | 4.51E-05 |
| 11 | IN | IN-AECHDM-PK | 5.14E-05 | -- | 8.78E-03 | 3.80E-11 | 3.84E-08 | 2.46E-16 | 4.01E-08 | 1.94E-04 | 4.26E-06 | 4.54E-07 | 9.68E-04 |
| 12 | IN | IN-BN004 | 1.51E-02 | -- | 4.25E-06 | 1.23E-09 | 1.56E-06 | 5.98E-14 | 1.20E-06 | 7.83E-03 | 9.66E-04 | 1.01E-04 | 5.18E-02 |
| 13 | IN | IN-BN050 | -- | -- | -- | 2.55E-11 | -- | -- | 1.32E-08 | -- | 1.08E-09 | -- | -- |

CH 2033 RH 2033 2033 Normalized CH_Volumes RH_Volumes

**Figure D-2. Example CH Waste Data from Excel Spreadsheet *PAIR-2012.xlsx***

The corresponding data in the CH input file are highlighted:

**The CH input file:**

StreamRH (Really CH) Volume(m3) Am-241 Cm-244 Pu-238 Pu-239 Pu-240 Pu-241 U-234 Cs-137 Sr-90 U-233

**AE-T001 1.88E+02 1.11E+01 2.57E+02 3.34E+00 2.65E+01 1.93E+01 1.64E+01 1.49E-02 4.68E+00 3.90E+00 6.93E-03**

AE-T003 3.12E+00 1.27E+00 4.38E-03 2.67E+00 1.59E+00 1.47E+00 4.92E+00 2.71E-04 1.73E-01 1.18E-01 1.20E-04

WP-AECHDM 1.02E+02 5.42E+01 4.30E-02 5.20E+01 8.54E+01 6.45E+01 2.56E+01 8.33E-02 9.74E-01 9.71E-01 4.20E-02

WP-AECHHM 1.40E+01 1.41E+01 0.00E+00 3.62E+00 4.13E+01 1.64E+01 2.96E-10 5.67E-03 7.63E-04 7.62E-04 2.30E-07

WP-MU-W002 4.50E+00 6.72E+00 0.00E+00 0.00E+00 2.27E-02 0.00E+00 0.00E+00 1.46E-09 9.17E-07 9.15E-07 5.05E-07

AW-5649N 2.10E-01 8.45E-04 0.00E+00 5.98E-06 2.45E-03 1.22E-03 6.31E-03 4.67E-10 0.00E+00 0.00E+00 2.58E-13

AW-N027.531 1.36E+01 2.33E+00 1.53E-09 2.88E-01 5.92E+00 2.59E+00 4.58E+00 1.32E-02 3.64E-02 7.10E-02 4.13E-07

Note that the header specified the data as StreamRH (Really CH). The StreamRH title is used by EPAUNI to indicate that 10 radionuclides will be written into a logical record consisting of two physical records.

An example using the RH sheet shown in Figure D-3.

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Site | Waste Stream ID | Scaled Vol ($m^3$) | Am-241 | Am-243 | Cm-244 | Cs-137 | Np-237 | Pu-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | Pu-244 | Sr-90 |
| 3 | AE | **AE-T009** | **85.91** | **400.79897** | 6.89E+00 | **1.68E+02** | **4.26E+03** | 1.31E-02 | **2.70E+02** | **2.08E+02** | **1.34E+02** | **1.04E+03** | 1.62E-01 | 2.87E-15 | **3.12E+03** |
| 4 | AE | WP-AERHDM | 39.04 | 3.09E+02 | -- | 4.44E+02 | 2.94E+03 | 2.02E-03 | 4.63E+02 | 5.53E+01 | 6.56E+01 | 1.54E+03 | 2.29E-01 | -- | 1.67E+03 |
| 5 | AW | AW-5410N | 0.11 | 4.92E-02 | 1.96E-04 | 7.98E-07 | 1.66E-01 | 5.25E-06 | 1.85E-02 | 6.01E-03 | 9.03E-03 | 1.16E-01 | 2.45E-05 | -- | 3.39E-01 |
| 6 | AW | AW-5882N | 0.62 | 1.21E-01 | -- | -- | 1.33E-01 | 1.16E-06 | -- | -- | -- | -- | -- | -- | 1.27E-01 |
| 7 | AW | AW-T031 1322 | 309.50 | 7.73E+02 | 3.68E-08 | 3.66E-06 | 6.06E+04 | 3.54E-01 | 1.05E+01 | 2.98E+03 | 1.31E+03 | 2.00E+01 | 3.58E-02 | -- | 9.02E+04 |
| 8 | AW | AW-W020 13 | 51.69 | 6.27E+00 | -- | -- | 3.51E+03 | 1.00E-02 | 1.91E+01 | 8.89E+01 | 2.78E+01 | 1.92E+01 | 1.23E-03 | -- | 2.40E+03 |
| 9 | BT | BT-T001 | 18.34 | 3.79E-01 | 1.42E-03 | 6.55E-04 | 4.66E+02 | 2.03E-03 | 1.38E+01 | 1.36E-02 | 1.44E-03 | 9.86E-01 | 2.31E-04 | -- | 4.51E+02 |
| 10 | BT | WP-BT-T001 | 3.15 | 9.40E-02 | -- | 2.16E-02 | 7.78E+00 | 6.93E-07 | 1.01E+00 | 1.10E-02 | 1.55E-02 | 9.82E-02 | 6.56E-03 | -- | 1.10E+01 |
| 11 | IN | IN-AE-AGHC-02 | 156.00 | -- | -- | -- | 9.41E+03 | -- | -- | 4.25E+02 | 2.11E+02 | -- | -- | -- | 1.40E+04 |
| 12 | IN | IN-AE-AGHC-02T | 1.25 | -- | -- | -- | 9.80E+01 | -- | -- | 4.43E+00 | 2.20E+00 | -- | -- | -- | 1.46E+02 |
| 13 | IN | IN-ID-BTO-030 | 1.25 | 5.15E-03 | 6.88E-04 | -- | 2.52E+01 | 7.26E-04 | 4.71E+00 | 6.18E-03 | 6.22E-03 | -- | 6.02E-05 | -- | 2.32E+01 |
| 14 | IN | IN-ID-EBR-S5000 | 4.37 | -- | -- | -- | 1.26E-01 | -- | -- | 1.11E+00 | -- | -- | -- | -- | 1.31E-01 |

CH 2033 RH 2033 2033 Normalized CH_Volumes RH_Volumes

**Figure D-3. Example RH Waste Data from Excel Spreadsheet *PAIR-2012.xlsx***

The corresponding data from the RH input file are highlighted:

**The RH input file:**

```
StreamRH Volume(m3) Am-241 Cm-244 Pu-238 Pu-239 Pu-240 Pu-241 U-234
        Cs-137 Sr-90 U-233
AE-T009 8.59E+01 4.01E+02 1.68E+02 2.70E+02 2.08E+02 1.34E+02 1.04E+03 3.61E-02
       4.26E+03 3.12E+03 1.22E-02
WP-AERHDM 3.90E+01 3.09E+02 4.44E+02 4.63E+02 5.53E+01 6.56E+01 1.54E+03 2.66E-01
       2.94E+03 1.67E+03 5.52E-03
AW-5410N 1.13E-01 4.92E-02 7.98E-07 1.85E-02 6.01E-03 9.03E-03 1.16E-01 3.05E-06
       1.66E-01 3.39E-01 5.29E-10
AW-5882N 6.24E-01 1.21E-01 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
       1.33E-01 1.27E-01 7.37E-11
AW-T031.1322 3.09E+02 7.73E+02 3.66E-06 1.05E+01 2.98E+03 1.31E+03 2.00E+01
2.91E+01
       6.06E+04 9.02E+04 4.63E-05
AW-W020.13 5.17E+01 6.27E+00 0.00E+00 1.91E+01 8.89E+01 2.78E+01 1.92E+01 1.12E-01
       3.51E+03 2.40E+03 3.85E-05
BT-T001 1.83E+01 3.79E-01 6.55E-04 1.38E+01 1.36E-02 1.44E-03 9.86E-01 6.52E-03
       4.66E+02 4.51E+02 8.45E-02
```

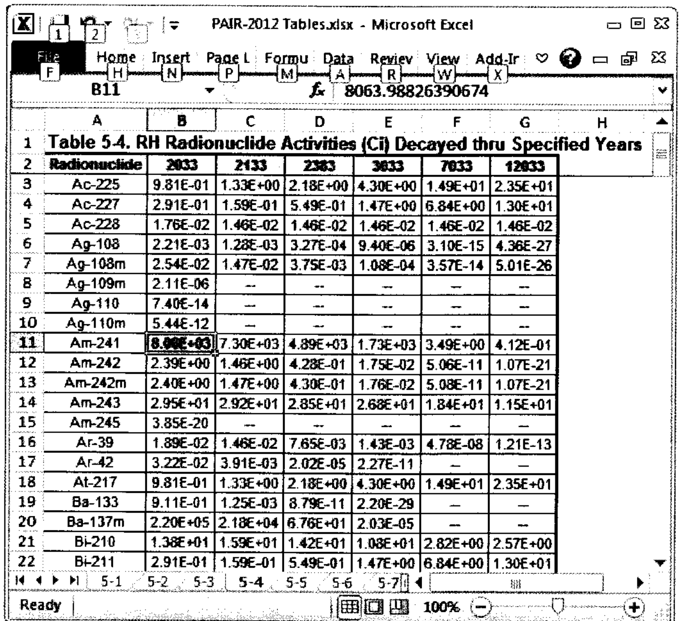
The data files were subsequently transferred to the VMS Alpha system using FTP using mib.Sandia.gov as an intermediate transfer location.

## APPENDIX E – Queries used to Produce the Tables of this Report

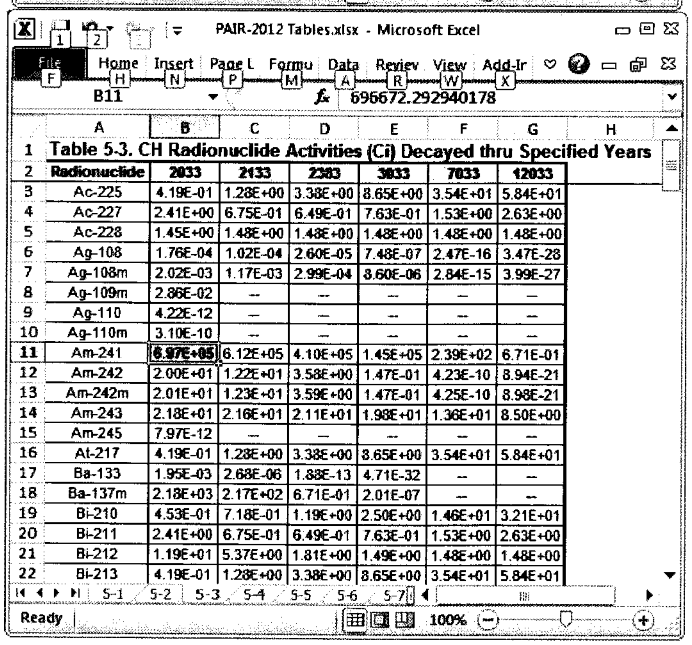
This appendix provides information on the Microsoft® Office Excel® 2010 file and the Microsoft® Access® 2010 file used to produce tables within this report. Both the Excel file, *PAIR-2012 Tables.xlsx*, and the Access file, *InventoryDB.mdb*, were developed on a PC workstation running Windows 7 Enterprise and are included as a machine readable (CD ROM) supplement to this report.

The CH and RH data were extracted from the spreadsheet *PAIR-2012 Tables.xlsx*, sheets "CH_Data" and "RH_Data", respectively. These two sheets were created from sheets "5-3" and "5-4" by eliminating the first and last rows (title and grand total rows). The data were then loaded into the CH_Data and RH_Data tables of the *InventoryDB.mdb* database using the Access File/Get External Data/Import menu function. Half-lives and decay modes for the radionuclides were extracted from the Fox et al. report from the PABC-2009 and expanded for the current set of radionuclides using data from the *Chart of the Radionuclides* (Lockheed Martin 2002). These data were inserted into the database tables HalfLife and DecayMode. Release limits for the radionuclides were obtained from 40 CFR 191 (see Table B-1) and inserted into table ReleaseLimit. The additional rules in Table B-1 for release limits on radionuclides not specified by name were implemented in the query NuclidesWithReleaseLimits. The lists of radionuclides used by the codes CCDFGF, PANEL and NUTS were taken from Fox et al. (2009) and inserted into CCDFGFNuclides, PanelNuclides and NutsNuclides, respectively.

Verification of the queries used to produce tables will be done by visual inspection. For Table 1, the Query WUF_byNuclide selects the radionuclides of interest using the HalfLife table. Radionuclides are restricted to transuranic Alpha emitters having half-lives greater than 20 years. The sum of the RH and CH values for these radionuclides are obtained from the query CH_and_RHData, which is simply a union of the CH_Data and RH_Data tables. Table 1 lists for AM-241 a value of 7.05E+05. This is equal to the sum of the values for AM-241 shown in sheet:cell 5-3:B11 and 5-4:B-11, i.e. 6.97E+05 and 8.06E+03 curies (Figure E-1).




| Table 5-4. RH Radionuclide Activities (Ci) Decayed thru Specified Years | | | | | | |
|---|---|---|---|---|---|---|
| Radionuclide | 2033 | 2133 | 2383 | 3033 | 7033 | 12033 |
| Ac-225 | 9.81E-01 | 1.33E+00 | 2.18E+00 | 4.30E+00 | 1.49E+01 | 2.35E+01 |
| Ac-227 | 2.91E-01 | 1.59E-01 | 5.49E-01 | 1.47E+00 | 6.84E+00 | 1.30E+01 |
| Ac-228 | 1.76E-02 | 1.46E-02 | 1.46E-02 | 1.46E-02 | 1.46E-02 | 1.46E-02 |
| Ag-108 | 2.21E-03 | 1.28E-03 | 3.27E-04 | 9.40E-06 | 3.10E-15 | 4.36E-27 |
| Ag-108m | 2.54E-02 | 1.47E-02 | 3.75E-03 | 1.08E-04 | 3.57E-14 | 5.01E-26 |
| Ag-109m | 2.11E-06 | -- | -- | -- | -- | -- |
| Ag-110 | 7.40E-14 | -- | -- | -- | -- | -- |
| Ag-110m | 5.44E-12 | -- | -- | -- | -- | -- |
| Am-241 | 8.06E+03 | 7.30E+03 | 4.89E+03 | 1.73E+03 | 3.49E+00 | 4.12E-01 |
| Am-242 | 2.39E+00 | 1.46E+00 | 4.28E-01 | 1.75E-02 | 5.06E-11 | 1.07E-21 |
| Am-242m | 2.40E+00 | 1.47E+00 | 4.30E-01 | 1.76E-02 | 5.08E-11 | 1.07E-21 |
| Am-243 | 2.95E+01 | 2.92E+01 | 2.85E+01 | 2.68E+01 | 1.84E+01 | 1.15E+01 |
| Am-245 | 3.85E-20 | -- | -- | -- | -- | -- |
| Ar-39 | 1.89E-02 | 1.46E-02 | 7.65E-03 | 1.43E-03 | 4.78E-08 | 1.21E-13 |
| Ar-42 | 3.22E-02 | 3.91E-03 | 2.02E-05 | 2.27E-11 | -- | -- |
| At-217 | 9.81E-01 | 1.33E+00 | 2.18E+00 | 4.30E+00 | 1.49E+01 | 2.35E+01 |
| Ba-133 | 9.11E-01 | 1.25E-03 | 8.79E-11 | 2.20E-29 | -- | -- |
| Ba-137m | 2.20E+05 | 2.18E+04 | 6.76E+01 | 2.03E-05 | -- | -- |
| Bi-210 | 1.38E+01 | 1.59E+01 | 1.42E+01 | 1.08E+01 | 2.82E+00 | 2.57E+00 |
| Bi-211 | 2.91E-01 | 1.59E-01 | 5.49E-01 | 1.47E+00 | 6.84E+00 | 1.30E+01 |




| Table 5-3. CH Radionuclide Activities (Ci) Decayed thru Specified Years | | | | | | |
|---|---|---|---|---|---|---|
| Radionuclide | 2033 | 2133 | 2383 | 3033 | 7033 | 12033 |
| Ac-225 | 4.19E-01 | 1.28E+00 | 3.38E+00 | 8.65E+00 | 3.54E+01 | 5.84E+01 |
| Ac-227 | 2.41E+00 | 6.75E-01 | 6.49E-01 | 7.63E-01 | 1.53E+00 | 2.63E+00 |
| Ac-228 | 1.45E+00 | 1.48E+00 | 1.48E+00 | 1.48E+00 | 1.48E+00 | 1.48E+00 |
| Ag-108 | 1.76E-04 | 1.02E-04 | 2.60E-05 | 7.48E-07 | 2.47E-16 | 3.47E-28 |
| Ag-108m | 2.02E-03 | 1.17E-03 | 2.99E-04 | 8.60E-06 | 2.84E-15 | 3.99E-27 |
| Ag-109m | 2.86E-02 | -- | -- | -- | -- | -- |
| Ag-110 | 4.22E-12 | -- | -- | -- | -- | -- |
| Ag-110m | 3.10E-10 | -- | -- | -- | -- | -- |
| Am-241 | 6.97E+05 | 6.12E+05 | 4.10E+05 | 1.45E+05 | 2.39E+02 | 6.71E-01 |
| Am-242 | 2.00E+01 | 1.22E+01 | 3.58E+00 | 1.47E-01 | 4.23E-10 | 8.94E-21 |
| Am-242m | 2.01E+01 | 1.23E+01 | 3.59E+00 | 1.47E-01 | 4.25E-10 | 8.98E-21 |
| Am-243 | 2.18E+01 | 2.16E+01 | 2.11E+01 | 1.98E+01 | 1.36E+01 | 8.50E+00 |
| Am-245 | 7.97E-12 | -- | -- | -- | -- | -- |
| At-217 | 4.19E-01 | 1.28E+00 | 3.38E+00 | 8.65E+00 | 3.54E+01 | 5.84E+01 |
| Ba-133 | 1.95E-03 | 2.68E-06 | 1.88E-13 | 4.71E-32 | -- | -- |
| Ba-137m | 2.18E+03 | 2.17E+02 | 6.71E-01 | 2.01E-07 | -- | -- |
| Bi-210 | 4.53E-01 | 7.18E-01 | 1.19E+00 | 2.50E+00 | 1.46E+01 | 3.21E+01 |
| Bi-211 | 2.41E+00 | 6.75E-01 | 6.49E-01 | 7.63E-01 | 1.53E+00 | 2.63E+00 |
| Bi-212 | 1.19E+01 | 5.37E+00 | 1.81E+00 | 1.49E+00 | 1.48E+00 | 1.48E+00 |
| Bi-213 | 4.19E-01 | 1.28E+00 | 3.38E+00 | 8.65E+00 | 3.54E+01 | 5.84E+01 |

**Figure E-1. Example CH and RH Waste Data from Excel Spreadsheet *PAIR-2012 Tables.xlsx***

For Table 2 release limits are associated with the data from tables CH_Data and RH_Data using query NuclidesWithReleaseLimits. The queries ReleaseLimitsAndSourceTerm_'year'_num, where 'year' is 2033, 2133, 2383, 3033, 7033 and 12033, compute the inventories for each year in EPA Units. These data are combined using the union query ReleaseLimitsAndSourceTerm_AllYears, the maximum across years by radionuclide appended using ReleaseEPA_Units_withMaximum, and organized into a table with years as columns using ReleasesEPA_Units_withMaximum_Crosstab. The specific radionuclides for the table are then filtered from the crosstab query using ReleasesEPAUnits_filtered. Again using the AM-241 data as an example, the inventory in EPA Units is 3.42E+03 = 7.05E+05/2.06/100 where 2.06 is the WUF and 100 the release limit for Am-241. This is equal to the value for AM-241 at 0 Years (i.e.. 2033) shown in Table 2.

Tables 3 to 5 simply show the inventory for radionuclides modeled in CCDFGF, PANEL and NUTS in terms of both their activities in curies and EPA Units. The Am-241 example can be used for all three of these tables. The RH and CH inventories in EPA units are 3.91E+01=8.06E+03/2.06/100 and 3.38E+03=6.97E+05/2.06/100.

Tables A1 to A6 are created using queries ReleaseLimitsAndSourceTerm_'year' , where 'year' is 2033, 2133, 2383, 3033, 7033 and 12033. These queries simply format the data in the matching queries ReleaseLimitsAndSourceTerm_'year'_num by replacing empty fields with the string "---". The AM-241 inventory data in table A-1 can be seen to be equal to the values descibed above for Tables 3 to 5.

Table B-2 lists the totals inventory across CH and RH waste in curies by year for the radionuclides, with those contributing to the WUF showing their percent contribution. The table is created using query AllNuclidesWithWUFPercentagesAndTotalFormatted, which is in turn derived from AllNuclidesWithWUFPercentagesAndTotal. AllNuclidesWithWUFPercentagesAndTotal is a union of data selected by ActivityAcrossAllNuclides and AllNuclidesWithWUFPercentages. ActivityAcrossAllNuclides computes the sum by radionuclide of the activities in CHandRH_Data, which in turn is a union of the data in the tables CH_Data and RH_Data. AllNuclidesWithWUFPercentages combines the data from ActivityAcrossAllNuclides with data from the HalfLife and DecayMode tables and data from the query WUFnuclideWithPercent. WUFnuclideWithPercent computes the percent contributions using the queries WUF_byNuclide, described above, and WUF. The WUF query selects the CH and RH values in year 2033 for transuranic radionuclides having long halflives and emitting alpha radiation, sums their activities and divides by 1,000,000 to compute the WUF The total activity for AM-241 listed in Table B-1 is 7.05E+05, matching the sum of the activities from the spreadsheet. The contribution to the WUF is 7.05E+05/2.06E+06=34.15% which matches the percentage listed in Table B-2.

The SQL statements of the queries referenced in this appendix are listed below.

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ActivityAcrossAllNuclides

**SQL**

```
SELECT CHandRH_Data.Radionuclide, Sum(CHandRH_Data.[2033]) AS SumOf2033, Sum(CHandRH_Data.[2133])
AS SumOf2133, Sum(CHandRH_Data.[2383]) AS SumOf2383, Sum(CHandRH_Data.[3033]) AS SumOf3033,
Sum(CHandRH_Data.[7033]) AS SumOf7033, Sum(CHandRH_Data.[12033]) AS SumOf12033
FROM CHandRH_Data
GROUP BY CHandRH_Data.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: AllNuclidesSumByYear

**SQL**

```
SELECT "Total" AS Radionuclide, " " AS [Decay Mode], " " AS HalfLife,
Sum(AllNuclidesWithWUFPercentages.[2033]) AS SumOf2033, Sum(AllNuclidesWithWUFPercentages.[2133]) AS
SumOf2133, Sum(AllNuclidesWithWUFPercentages.[2383]) AS SumOf2383,
```

```
Sum(AllNuclidesWithWUFPercentages.[3033]) AS SumOf3033, Sum(AllNuclidesWithWUFPercentages.[7033]) AS
SumOf7033, Sum(AllNuclidesWithWUFPercentages.[12033]) AS SumOf12033,
Sum(AllNuclidesWithWUFPercentages.[Transuranic Inventory]) AS [SumOfTransuranic Inventory],
Sum(AllNuclidesWithWUFPercentages.[% of Unit of Waste]) AS [SumOf% of Unit of Waste]
FROM AllNuclidesWithWUFPercentages;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: AllNuclidesWithWUFPercentages

**SQL**

```
SELECT ActivityAcrossAllNuclides.Radionuclide, DecayMode.[Decay Mode], HalfLife.[Half-life label] AS [Half-
Life], ActivityAcrossAllNuclides.SumOf2033 AS 2033, ActivityAcrossAllNuclides.SumOf2133 AS 2133,
ActivityAcrossAllNuclides.SumOf2383 AS 2383, ActivityAcrossAllNuclides.SumOf3033 AS 3033,
ActivityAcrossAllNuclides.SumOf7033 AS 7033, ActivityAcrossAllNuclides.SumOf12033 AS 12033,
WUFnuclideWithPercent.SumOf2033 AS [Transuranic Inventory], WUFnuclideWithPercent.Percent AS [% of Unit
of Waste]
FROM ((ActivityAcrossAllNuclides LEFT JOIN WUFnuclideWithPercent ON
ActivityAcrossAllNuclides.Radionuclide = WUFnuclideWithPercent.Nuclide) LEFT JOIN HalfLife ON
ActivityAcrossAllNuclides.Radionuclide = HalfLife.Nuclide) INNER JOIN DecayMode ON
ActivityAcrossAllNuclides.Radionuclide = DecayMode.Radionuclide
ORDER BY ActivityAcrossAllNuclides.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: AllNuclidesWithWUFPercentagesAndTotal

**SQL**

```
SELECT " "+[HalfLife]![Nuclide] AS Radionuc, DecayMode.[Decay Mode], HalfLife.[Half-life label] AS [Half-Life],
ActivityAcrossAllNuclides.SumOf2033 AS 2033, ActivityAcrossAllNuclides.SumOf2133 AS 2133,
ActivityAcrossAllNuclides.SumOf2383 AS 2383, ActivityAcrossAllNuclides.SumOf3033 AS 3033,
ActivityAcrossAllNuclides.SumOf7033 AS 7033, ActivityAcrossAllNuclides.SumOf12033 AS 12033,
WUFnuclideWithPercent.SumOf2033 AS [Transuranic Inventory], WUFnuclideWithPercent.Percent AS [% of Unit
of Waste]
FROM ((ActivityAcrossAllNuclides LEFT JOIN WUFnuclideWithPercent ON
ActivityAcrossAllNuclides.Radionuclide = WUFnuclideWithPercent.Nuclide) LEFT JOIN HalfLife ON
ActivityAcrossAllNuclides.Radionuclide = HalfLife.Nuclide) INNER JOIN DecayMode ON
ActivityAcrossAllNuclides.Radionuclide = DecayMode.Radionuclide
ORDER BY " "+[HalfLife]![Nuclide]
UNION SELECT "Total" AS Radionuclide, " " AS [Decay Mode], " " AS HalfLife,
Sum(AllNuclidesWithWUFPercentages.[2033]) AS SumOf2033, Sum(AllNuclidesWithWUFPercentages.[2133]) AS
SumOf2133, Sum(AllNuclidesWithWUFPercentages.[2383]) AS SumOf2383,
Sum(AllNuclidesWithWUFPercentages.[3033]) AS SumOf3033, Sum(AllNuclidesWithWUFPercentages.[7033]) AS
SumOf7033, Sum(AllNuclidesWithWUFPercentages.[12033]) AS SumOf12033,
Sum(AllNuclidesWithWUFPercentages.[Transuranic Inventory]) AS [SumOfTransuranic Inventory],
Sum(AllNuclidesWithWUFPercentages.[% of Unit of Waste]) AS [SumOf% of Unit of Waste]
FROM AllNuclidesWithWUFPercentages;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: AllNuclidesWithWUFPercentagesAndTotalFormatted

**SQL**

```
SELECT Trim([Radionuc]) AS RADIONUCLIDE, AllNuclidesWithWUFPercentagesAndTotal.[Decay Mode],
AllNuclidesWithWUFPercentagesAndTotal.[Half-Life], AllNuclidesWithWUFPercentagesAndTotal.[2033],
AllNuclidesWithWUFPercentagesAndTotal.[2133], AllNuclidesWithWUFPercentagesAndTotal.[2383],
AllNuclidesWithWUFPercentagesAndTotal.[3033], AllNuclidesWithWUFPercentagesAndTotal.[7033],
AllNuclidesWithWUFPercentagesAndTotal.[12033], AllNuclidesWithWUFPercentagesAndTotal.[Transuranic
Inventory], AllNuclidesWithWUFPercentagesAndTotal.[% of Unit of Waste]
FROM AllNuclidesWithWUFPercentagesAndTotal
ORDER BY AllNuclidesWithWUFPercentagesAndTotal.Radionuc;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: CCDFGFInventories

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_2033_num.Radionuclide, ReleaseLimitsAndSourceTerm_2033_num.CH AS
[CH (Ci)], ReleaseLimitsAndSourceTerm_2033_num.RH AS [RH (Ci)],
ReleaseLimitsAndSourceTerm_2033_num.Total AS [Total (Ci)], IIf(IsNull([CH_EPA_UNIT]),"---
",Format([CH_EPA_UNIT],"Scientific")) AS [CH (EPA Units)], IIf(IsNull([RH_EPA_UNIT]),"---
",Format([RH_EPA_UNIT],"Scientific")) AS [RH (EPA Units)], IIf(IsNull([Source EPA Unit]),"---",Format([Source
EPA Unit],"Scientific")) AS [Total (EPA Units)], [Source EPA Unit]/[TotalEPA_Units] AS Percentage
FROM TotalEPA, ReleaseLimitsAndSourceTerm_2033_num INNER JOIN CCDFGFNuclides ON
```

```
ReleaseLimitsAndSourceTerm_2033_num.Radionuclide = CCDFGFNuclides.Radionuclide
ORDER BY IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) DESC;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: CH_Inventory

**SQL**

```
SELECT Inventory.[Site Code], Inventory.[Waste Stream ID], Volumes_CH.Volume, Inventory.Type,
Inventory.Radionuclide, Inventory.[Scld Activity Ci], RadsUsed.Handling, RadsUsed.SortOrder
FROM (Inventory INNER JOIN Volumes_CH ON (Inventory.[Site Code] = Volumes_CH.[Site ID]) AND
(Inventory.[Waste Stream ID] = Volumes_CH.[Waste Stream ID])) INNER JOIN RadsUsed ON
(Inventory.Handling = RadsUsed.Handling) AND (Inventory.Radionuclide = RadsUsed.Radionuclide)
WHERE (((RadsUsed.Handling)="CH"))
ORDER BY Inventory.[Waste Stream ID], RadsUsed.SortOrder;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: CH_Inventory_Crosstab

**SQL**

```
TRANSFORM First(CH_Inventory.[Scld Activity Ci]) AS [FirstOfScld Activity Ci]
SELECT CH_Inventory.[Site Code], CH_Inventory.[Waste Stream ID], CH_Inventory.Volume
FROM CH_Inventory
GROUP BY CH_Inventory.[Site Code], CH_Inventory.[Waste Stream ID], CH_Inventory.Volume
PIVOT [SortOrder] & ":" & [Radionuclide];
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: CHandRH_Data

**SQL**

```
SELECT CH_Data.Radionuclide, CH_Data.[2033], CH_Data.[2133], CH_Data.[2383], CH_Data.[3033],
CH_Data.[7033], CH_Data.[12033]
FROM CH_Data
UNION SELECT RH_Data.Radionuclide, RH_Data.[2033], RH_Data.[2133], RH_Data.[2383],RH_Data.[3033],
RH_Data.[7033], RH_Data.[12033]
FROM RH_Data;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: CheckMissingData

**SQL**

```
SELECT CHandRH_Data.Radionuclide, DecayMode.[Decay Mode], HalfLife.Halflife
FROM (DecayMode RIGHT JOIN CHandRH_Data ON DecayMode.Radionuclide = CHandRH_Data.Radionuclide)
LEFT JOIN HalfLife ON CHandRH_Data.Radionuclide = HalfLife.Nuclide
WHERE (((DecayMode.[Decay Mode]) Is Null)) OR (((HalfLife.Halflife) Is Null));
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: CreateDataNeeded_Table

**SQL**

```
SELECT NuclidesWithReleaseLimits.Radionuclide, DecayMode.[Decay Mode], NuclidesWithReleaseLimits.[Half-
Life] INTO DataNeeded
FROM NuclidesWithReleaseLimits LEFT JOIN DecayMode ON NuclidesWithReleaseLimits.Radionuclide =
DecayMode.Radionuclide
WHERE (((DecayMode.[Decay Mode]) Is Null));
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: NuclidesWithReleaseLimits

**SQL**

```
SELECT SumCHandRHActivities.Radionuclide, SumCHandRHActivities.SumOf2033, CH_Data.[2033],
RH_Data.[2033], HalfLife.[Half-life label] AS [Half-Life], HalfLife.Alpha, IIf([alpha]=Yes And
IsNull([ReleaseLimit]) And [HalfLife]>20 And [Units]="a",100,IIf([alpha]=No And IsNull([ReleaseLimit]) And
[HalfLife]>20 And [Units]="a",1000,[ReleaseLimit])) AS RL, SumCHandRHActivities.SumOf2133,
CH_Data.[2133], RH_Data.[2133], SumCHandRHActivities.SumOf2383, CH_Data.[2383], RH_Data.[2383],
SumCHandRHActivities.SumOf3033, CH_Data.[3033], RH_Data.[3033], SumCHandRHActivities.SumOf7033,
CH_Data.[7033], RH_Data.[7033], SumCHandRHActivities.SumOf12033, CH_Data.[12033], RH_Data.[12033]
FROM (((SumCHandRHActivities LEFT JOIN ReleaseLimit ON SumCHandRHActivities.Radionuclide =
ReleaseLimit.Radionuclide) LEFT JOIN HalfLife ON SumCHandRHActivities.Radionuclide = HalfLife.Nuclide) LEFT
JOIN CH_Data ON SumCHandRHActivities.Radionuclide = CH_Data.Radionuclide) LEFT JOIN RH_Data ON
SumCHandRHActivities.Radionuclide = RH_Data.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: NutsInventories

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_2033_num.Radionuclide, ReleaseLimitsAndSourceTerm_2033_num.CH AS
[CH (Ci)], ReleaseLimitsAndSourceTerm_2033_num.RH AS [RH (Ci)],
ReleaseLimitsAndSourceTerm_2033_num.Total AS [Total (Ci)], IIf(IsNull([CH_EPA_UNIT]),"---
",Format([CH_EPA_UNIT],"Scientific")) AS [CH (EPA Units)], IIf(IsNull([RH_EPA_UNIT]),"---
",Format([RH_EPA_UNIT],"Scientific")) AS [RH (EPA Units)], IIf(IsNull([Source EPA Unit]),"---",Format([Source
EPA Unit],"Scientific")) AS [Total (EPA Units)], [Source EPA Unit]/[TotalEPA_Units] AS Percentage
FROM TotalEPA, NutsNuclides INNER JOIN ReleaseLimitsAndSourceTerm_2033_num ON
NutsNuclides.Radionuclide = ReleaseLimitsAndSourceTerm_2033_num.Radionuclide
ORDER BY IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) DESC;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: NutsInventories12033

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_12033_num.Radionuclide, ReleaseLimitsAndSourceTerm_12033_num.CH
AS [CH (Ci)], ReleaseLimitsAndSourceTerm_12033_num.RH AS [RH (Ci)],
ReleaseLimitsAndSourceTerm_12033_num.Total AS [Total (Ci)], IIf(IsNull([CH_EPA_UNIT]),"---
",Format([CH_EPA_UNIT],"Scientific")) AS [CH (EPA Units)], IIf(IsNull([RH_EPA_UNIT]),"---
",Format([RH_EPA_UNIT],"Scientific")) AS [RH (EPA Units)], IIf(IsNull([Source EPA Unit]),"---",Format([Source
EPA Unit],"Scientific")) AS [Total (EPA Units)], [Source EPA Unit]/[TotalEPA_Units] AS Percentage
FROM Total_12033, ReleaseLimitsAndSourceTerm_12033_num INNER JOIN NutsNuclides ON
ReleaseLimitsAndSourceTerm_12033_num.Radionuclide = NutsNuclides.Radionuclide
ORDER BY IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) DESC;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: PanelInventories

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_2033_num.Radionuclide, ReleaseLimitsAndSourceTerm_2033_num.CH AS
[CH (Ci)], ReleaseLimitsAndSourceTerm_2033_num.RH AS [RH (Ci)],
ReleaseLimitsAndSourceTerm_2033_num.Total AS [Total (Ci)], IIf(IsNull([CH_EPA_UNIT]),"---
",Format([CH_EPA_UNIT],"Scientific")) AS [CH (EPA Units)], IIf(IsNull([RH_EPA_UNIT]),"---
",Format([RH_EPA_UNIT],"Scientific")) AS [RH (EPA Units)], IIf(IsNull([Source EPA Unit]),"---",Format([Source
EPA Unit],"Scientific")) AS [Total (EPA Units)], [Source EPA Unit]/[TotalEPA_Units] AS Percentage
FROM TotalEPA, ReleaseLimitsAndSourceTerm_2033_num INNER JOIN PanelNuclides ON
ReleaseLimitsAndSourceTerm_2033_num.Radionuclide = PanelNuclides.Radionuclide
ORDER BY IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) DESC;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ParamDB_InputData

**SQL**

```
SELECT ParamDB_values_CH_Crosstab.[Am-241_CH], ParamDB_values_CH_Crosstab.[Pu-238_CH],
ParamDB_values_CH_Crosstab.[Pu-239_CH], ParamDB_values_CH_Crosstab.[Pu-240_CH],
ParamDB_values_CH_Crosstab.[Pu-241_CH], ParamDB_values_CH_Crosstab.[Pu-242_CH],
ParamDB_values_CH_Crosstab.[Th-229_CH], ParamDB_values_CH_Crosstab.[Th-230_CH],
ParamDB_values_CH_Crosstab.[U-233_CH], ParamDB_values_CH_Crosstab.[U-234_CH],
ParamDB_values_RH_Crosstab.[Am-241_RH], ParamDB_values_RH_Crosstab.[Pu-238_RH],
ParamDB_values_RH_Crosstab.[Pu-239_RH], ParamDB_values_RH_Crosstab.[Pu-240_RH],
ParamDB_values_RH_Crosstab.[Pu-241_RH], ParamDB_values_RH_Crosstab.[Pu-242_RH],
ParamDB_values_RH_Crosstab.[Th-229_RH], ParamDB_values_RH_Crosstab.[Th-230_RH],
ParamDB_values_RH_Crosstab.[U-233_RH], ParamDB_values_RH_Crosstab.[U-234_RH],
ParamDB_values_HalfLife_Crosstab.[HL_Am-241], ParamDB_values_HalfLife_Crosstab.[HL_Pu-238],
ParamDB_values_HalfLife_Crosstab.[HL_Pu-239], ParamDB_values_HalfLife_Crosstab.[HL_Pu-240],
ParamDB_values_HalfLife_Crosstab.[HL_Pu-241], ParamDB_values_HalfLife_Crosstab.[HL_Pu-242],
ParamDB_values_HalfLife_Crosstab.[HL_Th-229], ParamDB_values_HalfLife_Crosstab.[HL_Th-230],
ParamDB_values_HalfLife_Crosstab.[HL_U-233], ParamDB_values_HalfLife_Crosstab.[HL_U-234]
FROM (ParamDB_values_CH_Crosstab INNER JOIN ParamDB_values_HalfLife_Crosstab ON
ParamDB_values_CH_Crosstab.Total = ParamDB_values_HalfLife_Crosstab.Total) INNER JOIN
ParamDB_values_RH_Crosstab ON ParamDB_values_CH_Crosstab.Total = ParamDB_values_RH_Crosstab.Total;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ParamDB_LumpedInventoryValues

**SQL**

```
SELECT ParamDB_InputData.[Pu-238_CH] AS [Pu-238L_CH], [Am-241_CH]+[Pu-241_CH]*[HL_Pu-241]/[HL_Am-
```

```
241] AS [Am-241L_CH], [Pu-239_CH]+[Pu-240_CH]+[Pu-242_CH]*[HL_Pu-242]/[HL_Pu-239] AS [Pu-239L_CH],
[U-234_CH]+[U-233_CH] AS U234L_CH, [Th-230_CH]+[Th-229_CH] AS [Th-230L_CH], ParamDB_InputData.[Pu-
238_RH] AS [Pu-238L_RH], [Am-241_RH]+[Pu-241_RH]*[HL_Pu-241]/[HL_Am-241] AS [Am-241L_RH], [Pu-
239_RH]+[Pu-240_RH]+[Pu-242_RH]*[HL_Pu-242]/[HL_Pu-239] AS [Pu-239L_RH], [U-234_RH]+[U-233_RH] AS
U234L_RH, [Th-230_RH]+[Th-229_RH] AS [Th-230L_RH]
FROM ParamDB_InputData;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ParamDB_values_CH_Crosstab

**SQL**

```
TRANSFORM First(ParamDB_values_step1.CH) AS FirstOfCH
SELECT ParamDB_values_step1.Total, First("Link") AS Link
FROM ParamDB_values_step1
GROUP BY ParamDB_values_step1.Total
PIVOT ParamDB_values_step1.CH_label;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ParamDB_values_HalfLife_Crosstab

**SQL**

```
TRANSFORM First(ParamDB_values_step1.HLife) AS HalfLif
SELECT ParamDB_values_step1.Total
FROM ParamDB_values_step1
GROUP BY ParamDB_values_step1.Total
PIVOT "HL_"+[Radionuclide];
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ParamDB_values_RH_Crosstab

**SQL**

```
TRANSFORM First(ParamDB_values_step1.RH) AS FirstOfRH
SELECT ParamDB_values_step1.Total, First("Link") AS Link
FROM ParamDB_values_step1
GROUP BY ParamDB_values_step1.Total
PIVOT ParamDB_values_step1.RH_label;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ParamDB_values_step1

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_2033_num.Radionuclide, HalfLife.Halflife AS HLife, HalfLife.Units,
ReleaseLimitsAndSourceTerm_2033_num.CH, ReleaseLimitsAndSourceTerm_2033_num.RH, "Total" AS Total,
[PAPDB_Nuclides]![Radionuclide]+"_CH" AS CH_label, [PAPDB_Nuclides]![Radionuclide]+"_RH" AS RH_label,
[PAPDB_Nuclides]![Radionuclide]+"_HL" AS HL_label
FROM (ReleaseLimitsAndSourceTerm_2033_num INNER JOIN HalfLife ON
ReleaseLimitsAndSourceTerm_2033_num.Radionuclide = HalfLife.Nuclide) INNER JOIN PAPDB_Nuclides ON
ReleaseLimitsAndSourceTerm_2033_num.Radionuclide = PAPDB_Nuclides.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: RadInventorySortedByMax_Table1

**SQL**

```
SELECT ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide,
ReleasesEPA_Units_withMaximum_Crosstab.[Half-Life], ReleasesEPA_Units_withMaximum_Crosstab.[2033],
ReleasesEPA_Units_withMaximum_Crosstab.[2133], ReleasesEPA_Units_withMaximum_Crosstab.[2383],
ReleasesEPA_Units_withMaximum_Crosstab.[3033], ReleasesEPA_Units_withMaximum_Crosstab.[7033],
ReleasesEPA_Units_withMaximum_Crosstab.[12033], ReleasesEPA_Units_withMaximum_Crosstab.Maximum
FROM ReleasesEPA_Units_withMaximum_Crosstab
ORDER BY ReleasesEPA_Units_withMaximum_Crosstab.Maximum DESC;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_12033

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_12033_num.Year, ReleaseLimitsAndSourceTerm_12033_num.Radionuclide,
ReleaseLimitsAndSourceTerm_12033_num.[Decay Mode], ReleaseLimitsAndSourceTerm_12033_num.[Half-Life],
IIf(IsNull([CH]),"---",Format([ch],"Scientific")) AS [CH(Ci)], IIf(IsNull([RH]),"---",Format([RH],"Scientific")) AS
[RH(Ci)], IIf(IsNull([Release Limits (Ci/UW)]),"---",Format([Release Limits (Ci/UW)],"Scientific")) AS [Rel
Limit(Ci/UW)], IIf(IsNull([Release Limit (Ci)]),"---",Format([Release Limit (Ci)],"Scientific")) AS [Rel Limit
(Ci)], IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) AS [Source (EPA Unit)],
```

```
IIf(IsNull([CH_EPA_UNIT]),"---",Format([CH_EPA_UNIT],"Scientific")) AS [CH(EPA Unit)],
IIf(IsNull([RH_EPA_UNIT]),"---",Format([RH_EPA_UNIT],"Scientific")) AS [RH(EPA Unit)], IIf(IsNull([Total]),"---
",Format([Total],"Scientific")) AS [Total(Curies)]
FROM ReleaseLimitsAndSourceTerm_12033_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_12033_num

**SQL**

```
SELECT 12033 AS [Year], NuclidesWithReleaseLimits.Radionuclide, DecayMode.[Decay Mode],
NuclidesWithReleaseLimits.[Half-Life], NuclidesWithReleaseLimits.CH_Data.[12033] AS CH,
NuclidesWithReleaseLimits.RH_Data.[12033] AS RH, NuclidesWithReleaseLimits.RL AS [Release Limits
(Ci/UW)], [WUF]*[RL] AS [Release Limit (Ci)], [SumOf12033]/([WUF]*[RL]) AS [Source EPA Unit],
[NuclidesWithReleaseLimits]![CH_Data.12033]/([WUF]*[RL]) AS CH_EPA_UNIT,
[NuclidesWithReleaseLimits]![RH_Data.12033]/([WUF]*[RL]) AS RH_EPA_UNIT,
NuclidesWithReleaseLimits.SumOf12033 AS Total
FROM WUF, NuclidesWithReleaseLimits INNER JOIN DecayMode ON NuclidesWithReleaseLimits.Radionuclide =
DecayMode.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_2033

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_2033_num.Year, ReleaseLimitsAndSourceTerm_2033_num.Radionuclide,
ReleaseLimitsAndSourceTerm_2033_num.[Decay Mode], ReleaseLimitsAndSourceTerm_2033_num.[Half-Life],
IIf(IsNull([CH]),"---",Format([ch],"Scientific")) AS [CH(Ci)], IIf(IsNull([RH]),"---",Format([RH],"Scientific")) AS
[RH(Ci)], IIf(IsNull([Release Limits (Ci/UW)]),"---",Format([Release Limits (Ci/UW)],"Scientific")) AS [Rel
Limit(Ci/UW)], IIf(IsNull([Release Limit (Ci)]),"---",Format([Release Limit (Ci)],"Scientific")) AS [Rel Limit
(Ci)], IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) AS [Source (EPA Unit)],
IIf(IsNull([CH_EPA_UNIT]),"---",Format([CH_EPA_UNIT],"Scientific")) AS [CH(EPA Unit)],
IIf(IsNull([RH_EPA_UNIT]),"---",Format([RH_EPA_UNIT],"Scientific")) AS [RH(EPA Unit)], IIf(IsNull([Total]),"---
",Format([Total],"Scientific")) AS [Total(Curies)]
FROM ReleaseLimitsAndSourceTerm_2033_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_2033_num

**SQL**

```
SELECT 2033 AS [Year], NuclidesWithReleaseLimits.Radionuclide, DecayMode.[Decay Mode],
NuclidesWithReleaseLimits.[Half-Life], NuclidesWithReleaseLimits.CH_Data.[2033] AS CH,
NuclidesWithReleaseLimits.RH_Data.[2033] AS RH, NuclidesWithReleaseLimits.RL AS [Release Limits (Ci/UW)],
[WUF]*[RL] AS [Release Limit (Ci)], [SumOf2033]/([WUF]*[RL]) AS [Source EPA Unit],
[NuclidesWithReleaseLimits]![CH_Data.2033]/([WUF]*[RL]) AS CH_EPA_UNIT,
[NuclidesWithReleaseLimits]![RH_Data.2033]/([WUF]*[RL]) AS RH_EPA_UNIT,
NuclidesWithReleaseLimits.SumOf2033 AS Total
FROM WUF, NuclidesWithReleaseLimits INNER JOIN DecayMode ON NuclidesWithReleaseLimits.Radionuclide =
DecayMode.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_2133

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_2133_num.Year, ReleaseLimitsAndSourceTerm_2133_num.Radionuclide,
ReleaseLimitsAndSourceTerm_2133_num.[Decay Mode], ReleaseLimitsAndSourceTerm_2133_num.[Half-Life],
IIf(IsNull([CH]),"---",Format([ch],"Scientific")) AS [CH(Ci)], IIf(IsNull([RH]),"---",Format([RH],"Scientific")) AS
[RH(Ci)], IIf(IsNull([Release Limits (Ci/UW)]),"---",Format([Release Limits (Ci/UW)],"Scientific")) AS [Rel
Limit(Ci/UW)], IIf(IsNull([Release Limit (Ci)]),"---",Format([Release Limit (Ci)],"Scientific")) AS [Rel Limit
(Ci)], IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) AS [Source (EPA Unit)],
IIf(IsNull([CH_EPA_UNIT]),"---",Format([CH_EPA_UNIT],"Scientific")) AS [CH(EPA Unit)],
IIf(IsNull([RH_EPA_UNIT]),"---",Format([RH_EPA_UNIT],"Scientific")) AS [RH(EPA Unit)], IIf(IsNull([Total]),"---
",Format([Total],"Scientific")) AS [Total(Curies)]
FROM ReleaseLimitsAndSourceTerm_2133_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_2133_num

**SQL**

```
SELECT 2133 AS [Year], NuclidesWithReleaseLimits.Radionuclide, DecayMode.[Decay Mode],
NuclidesWithReleaseLimits.[Half-Life], NuclidesWithReleaseLimits.CH_Data.[2133] AS CH,
NuclidesWithReleaseLimits.RH_Data.[2133] AS RH, NuclidesWithReleaseLimits.RL AS [Release Limits (Ci/UW)],
```

```
[WUF]*[RL] AS [Release Limit (Ci)], [SumOf2133]/([WUF]*[RL]) AS [Source EPA Unit],
[NuclidesWithReleaseLimits]![CH_Data.2133]/([WUF]*[RL]) AS CH_EPA_UNIT,
[NuclidesWithReleaseLimits]![RH_Data.2133]/([WUF]*[RL]) AS RH_EPA_UNIT,
NuclidesWithReleaseLimits.SumOf2133 AS Total
FROM WUF, NuclidesWithReleaseLimits INNER JOIN DecayMode ON NuclidesWithReleaseLimits.Radionuclide =
DecayMode.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_2383

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_2383_num.Year, ReleaseLimitsAndSourceTerm_2383_num.Radionuclide,
ReleaseLimitsAndSourceTerm_2383_num.[Decay Mode], ReleaseLimitsAndSourceTerm_2383_num.[Half-Life],
IIf(IsNull([CH]),"---",Format([ch],"Scientific")) AS [CH(Ci)], IIf(IsNull([RH]),"---",Format([RH],"Scientific")) AS
[RH(Ci)], IIf(IsNull([Release Limits (Ci/UW)]),"---",Format([Release Limits (Ci/UW)],"Scientific")) AS [Rel
Limit(Ci/UW)], IIf(IsNull([Release Limit (Ci)]),"---",Format([Release Limit (Ci)],"Scientific")) AS [Rel Limit
(Ci)], IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) AS [Source (EPA Unit)],
IIf(IsNull([CH_EPA_UNIT]),"---",Format([CH_EPA_UNIT],"Scientific")) AS [CH(EPA Unit)],
IIf(IsNull([RH_EPA_UNIT]),"---",Format([RH_EPA_UNIT],"Scientific")) AS [RH(EPA Unit)], IIf(IsNull([Total]),"---
",Format([Total],"Scientific")) AS [Total(Curies)]
FROM ReleaseLimitsAndSourceTerm_2383_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_2383_num

**SQL**

```
SELECT 2383 AS [Year], NuclidesWithReleaseLimits.Radionuclide, DecayMode.[Decay Mode],
NuclidesWithReleaseLimits.[Half-Life], NuclidesWithReleaseLimits.CH_Data.[2383] AS CH,
NuclidesWithReleaseLimits.RH_Data.[2383] AS RH, NuclidesWithReleaseLimits.RL AS [Release Limits (Ci/UW)],
[WUF]*[RL] AS [Release Limit (Ci)], [SumOf2383]/([WUF]*[RL]) AS [Source EPA Unit],
[NuclidesWithReleaseLimits]![CH_Data.2383]/([WUF]*[RL]) AS CH_EPA_UNIT,
[NuclidesWithReleaseLimits]![RH_Data.2383]/([WUF]*[RL]) AS RH_EPA_UNIT,
NuclidesWithReleaseLimits.SumOf2383 AS Total
FROM WUF, NuclidesWithReleaseLimits INNER JOIN DecayMode ON NuclidesWithReleaseLimits.Radionuclide =
DecayMode.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_3033

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_3033_num.Year, ReleaseLimitsAndSourceTerm_3033_num.Radionuclide,
ReleaseLimitsAndSourceTerm_3033_num.[Decay Mode], ReleaseLimitsAndSourceTerm_3033_num.[Half-Life],
IIf(IsNull([CH]),"---",Format([ch],"Scientific")) AS [CH(Ci)], IIf(IsNull([RH]),"---",Format([RH],"Scientific")) AS
[RH(Ci)], IIf(IsNull([Release Limits (Ci/UW)]),"---",Format([Release Limits (Ci/UW)],"Scientific")) AS [Rel
Limit(Ci/UW)], IIf(IsNull([Release Limit (Ci)]),"---",Format([Release Limit (Ci)],"Scientific")) AS [Rel Limit
(Ci)], IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) AS [Source (EPA Unit)],
IIf(IsNull([CH_EPA_UNIT]),"---",Format([CH_EPA_UNIT],"Scientific")) AS [CH(EPA Unit)],
IIf(IsNull([RH_EPA_UNIT]),"---",Format([RH_EPA_UNIT],"Scientific")) AS [RH(EPA Unit)], IIf(IsNull([Total]),"---
",Format([Total],"Scientific")) AS [Total(Curies)]
FROM ReleaseLimitsAndSourceTerm_3033_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_3033_num

**SQL**

```
SELECT 3033 AS [Year], NuclidesWithReleaseLimits.Radionuclide, DecayMode.[Decay Mode],
NuclidesWithReleaseLimits.[Half-Life], NuclidesWithReleaseLimits.CH_Data.[3033] AS CH,
NuclidesWithReleaseLimits.RH_Data.[3033] AS RH, NuclidesWithReleaseLimits.RL AS [Release Limits (Ci/UW)],
[WUF]*[RL] AS [Release Limit (Ci)], [SumOf3033]/([WUF]*[RL]) AS [Source EPA Unit],
[NuclidesWithReleaseLimits]![CH_Data.3033]/([WUF]*[RL]) AS CH_EPA_UNIT,
[NuclidesWithReleaseLimits]![RH_Data.3033]/([WUF]*[RL]) AS RH_EPA_UNIT,
NuclidesWithReleaseLimits.SumOf3033 AS Total
FROM WUF, NuclidesWithReleaseLimits INNER JOIN DecayMode ON NuclidesWithReleaseLimits.Radionuclide =
DecayMode.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_7033

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_7033_num.Year, ReleaseLimitsAndSourceTerm_7033_num.Radionuclide,
```

```
ReleaseLimitsAndSourceTerm_7033_num.[Decay Mode], ReleaseLimitsAndSourceTerm_7033_num.[Half-Life],
IIf(IsNull([CH]),"---",Format([ch],"Scientific")) AS [CH(Ci)], IIf(IsNull([RH]),"---",Format([RH],"Scientific")) AS
[RH(Ci)], IIf(IsNull([Release Limits (Ci/UW)]),"---",Format([Release Limits (Ci/UW)],"Scientific")) AS [Rel
Limit(Ci/UW)], IIf(IsNull([Release Limit (Ci)]),"---",Format([Release Limit (Ci)],"Scientific")) AS [Rel Limit
(Ci)], IIf(IsNull([Source EPA Unit]),"---",Format([Source EPA Unit],"Scientific")) AS [Source (EPA Unit)],
IIf(IsNull([CH_EPA_UNIT]),"---",Format([CH_EPA_UNIT],"Scientific")) AS [CH(EPA Unit)],
IIf(IsNull([RH_EPA_UNIT]),"---",Format([RH_EPA_UNIT],"Scientific")) AS [RH(EPA Unit)], IIf(IsNull([Total]),"---
",Format([Total],"Scientific")) AS [Total(Curies)]
FROM ReleaseLimitsAndSourceTerm_7033_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_7033_num

**SQL**

```
SELECT 7033 AS [Year], NuclidesWithReleaseLimits.Radionuclide, DecayMode.[Decay Mode],
NuclidesWithReleaseLimits.[Half-Life], NuclidesWithReleaseLimits.CH_Data.[7033] AS CH,
NuclidesWithReleaseLimits.RH_Data.[7033] AS RH, NuclidesWithReleaseLimits.RL AS [Release Limits (Ci/UW)],
[WUF]*[RL] AS [Release Limit (Ci)], [SumOf7033]/([WUF]*[RL]) AS [Source EPA Unit],
[NuclidesWithReleaseLimits]![CH_Data.7033]/([WUF]*[RL]) AS CH_EPA_UNIT,
[NuclidesWithReleaseLimits]![RH_Data.7033]/([WUF]*[RL]) AS RH_EPA_UNIT,
NuclidesWithReleaseLimits.SumOf7033 AS Total
FROM WUF, NuclidesWithReleaseLimits INNER JOIN DecayMode ON NuclidesWithReleaseLimits.Radionuclide =
DecayMode.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleaseLimitsAndSourceTerm_AllYears

**SQL**

```
Select * from ReleaseLimitsAndSourceTerm_2033_num
Union
Select * from ReleaseLimitsAndSourceTerm_2133_num
union
Select * from ReleaseLimitsAndSourceTerm_2383_num
union
Select * from ReleaseLimitsAndSourceTerm_3033_num
union
Select * from ReleaseLimitsAndSourceTerm_7033_num
UNION Select * from ReleaseLimitsAndSourceTerm_12033_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleasesEPA_Units_withMaximum

**SQL**

```
Select * from ReleasesEPA_UnitsByYear
UNION select * from ReleasesEPA_UnitsMaxAcrossYears;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleasesEPA_Units_withMaximum_Crosstab

**SQL**

```
TRANSFORM First(ReleasesEPA_Units_withMaximum.[TotalEPA]) AS FirstOfTotalEPA
SELECT ReleasesEPA_Units_withMaximum.[Radionuclide], ReleasesEPA_Units_withMaximum.[Half-Life]
FROM ReleasesEPA_Units_withMaximum
GROUP BY ReleasesEPA_Units_withMaximum.[Radionuclide], ReleasesEPA_Units_withMaximum.[Half-Life]
PIVOT ReleasesEPA_Units_withMaximum.[Year];
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleasesEPA_UnitsByYear

**SQL**

```
SELECT ReleaseLimitsAndSourceTerm_AllYears.Year, ReleaseLimitsAndSourceTerm_AllYears.Radionuclide,
ReleaseLimitsAndSourceTerm_AllYears.[Half-Life], [CH_EPA_UNIT]+[RH_EPA_UNIT] AS TotalEPA
FROM ReleaseLimitsAndSourceTerm_AllYears;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleasesEPA_UnitsMaxAcrossYears

**SQL**

```
SELECT "Maximum" AS [Year], ReleasesEPA_UnitsByYear.Radionuclide, ReleasesEPA_UnitsByYear.[Half-Life],
Max(ReleasesEPA_UnitsByYear.TotalEPA) AS MaxOfTotalEPA
FROM ReleasesEPA_UnitsByYear
```

GROUP BY "Maximum", ReleasesEPA_UnitsByYear.Radionuclide, ReleasesEPA_UnitsByYear.[Half-Life];

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: ReleasesEPAUnits_filtered

**SQL**

```
SELECT ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide,
ReleasesEPA_Units_withMaximum_Crosstab.[Half-Life], IIf(IsNull([2033]),"---",Format([2033],"Scientific")) AS [0
 Years], IIf(IsNull([2133]),"---",Format([2133],"Scientific")) AS [100 Years], IIf(IsNull([2383]),"---
",Format([2383],"Scientific")) AS [350 Years], IIf(IsNull([3033]),"---",Format([3033],"Scientific")) AS [1000
Years], IIf(IsNull([7033]),"---",Format([7033],"Scientific")) AS [5000 Years], IIf(IsNull([12033]),"---
",Format([12033],"Scientific")) AS [10,000 Years], IIf(IsNull([Maximum]),"---",Format([Maximum],"Scientific"))
AS [Across-year Maximum], ReleasesEPA_Units_withMaximum_Crosstab.Maximum
FROM ReleasesEPA_Units_withMaximum_Crosstab
WHERE (((ReleasesEPA_Units_withMaximum_Crosstab.Maximum)>0.001)) OR
(((ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide)="CF-252")) OR
(((ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide)="Cm-244")) OR
(((ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide)="Cm-248")) OR
(((ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide)="Pm-147")) OR
(((ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide)="Pu-241")) OR
(((ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide)="Pu-244")) OR
(((ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide)="Ra-228")) OR
(((ReleasesEPA_Units_withMaximum_Crosstab.Radionuclide)="Sm-147"))
ORDER BY ReleasesEPA_Units_withMaximum_Crosstab.Maximum DESC;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: RH_Inventory

**SQL**

```
SELECT Inventory.[Site Code], Inventory.[Waste Stream ID], Volumes_RH.Volume, Inventory.Type,
Inventory.Radionuclide, Inventory.[Scld Activity Ci], RadsUsed.Handling, RadsUsed.SortOrder
FROM (Inventory INNER JOIN RadsUsed ON (Inventory.Radionuclide=RadsUsed.Radionuclide) AND
(Inventory.Handling=RadsUsed.Handling)) INNER JOIN Volumes_RH ON (Inventory.[Site
Code]=Volumes_RH.[Site ID]) AND (Inventory.[Waste Stream ID]=Volumes_RH.[Waste Stream ID])
WHERE (((RadsUsed.Handling)="RH"))
ORDER BY Inventory.[Site Code], Inventory.[Waste Stream ID], RadsUsed.SortOrder;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: RH_Inventory_Crosstab

**SQL**

```
TRANSFORM First(RH_Inventory.[Scld Activity Ci]) AS [FirstOfScld Activity Ci]
SELECT RH_Inventory.[Site Code], RH_Inventory.[Waste Stream ID], RH_Inventory.Volume
FROM RH_Inventory
GROUP BY RH_Inventory.[Site Code], RH_Inventory.[Waste Stream ID], RH_Inventory.Volume
PIVOT [SortOrder] & ":" & [Radionuclide];
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: SumCHandRHActivities

**SQL**

```
SELECT CHandRH_Data.Radionuclide, Sum(CHandRH_Data.[2033]) AS SumOf2033, Sum(CHandRH_Data.[2133])
AS SumOf2133, Sum(CHandRH_Data.[2383]) AS SumOf2383, Sum(CHandRH_Data.[3033]) AS SumOf3033,
Sum(CHandRH_Data.[7033]) AS SumOf7033, Sum(CHandRH_Data.[12033]) AS SumOf12033
FROM CHandRH_Data
GROUP BY CHandRH_Data.Radionuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: Total_12033

**SQL**

```
SELECT Sum(ReleaseLimitsAndSourceTerm_12033_num.[Source EPA Unit]) AS TotalEPA_Units
FROM ReleaseLimitsAndSourceTerm_12033_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: TotalEPA

**SQL**

```
SELECT Sum(ReleaseLimitsAndSourceTerm_2033_num.[Source EPA Unit]) AS TotalEPA_Units
FROM ReleaseLimitsAndSourceTerm_2033_num;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: WUF

**SQL**

```
SELECT Sum(CHandRH_Data.[2033])/1000000 AS WUF
FROM CHandRH_Data INNER JOIN HalfLife ON CHandRH_Data.Radionuclide = HalfLife.Nuclide
WHERE (((HalfLife.Transuranic)=Yes) AND ((HalfLife.Alpha)=Yes) AND ((HalfLife.LongLived)=Yes));
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: WUF_byNuclide

**SQL**

```
SELECT HalfLife.Nuclide, Sum(CHandRH_Data.[2033]) AS SumOf2033
FROM CHandRH_Data INNER JOIN HalfLife ON CHandRH_Data.Radionuclide = HalfLife.Nuclide
WHERE (((HalfLife.Transuranic)=Yes) AND ((HalfLife.Alpha)=Yes) AND ((HalfLife.LongLived)=Yes))
GROUP BY HalfLife.Nuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: WUFnuclides

**SQL**

```
SELECT HalfLife.Nuclide, DecayMode.[Decay Mode], HalfLife.Halflife, HalfLife.Units, HalfLife.LongLived,
HalfLife.Transuranic, HalfLife.Alpha
FROM HalfLife INNER JOIN DecayMode ON HalfLife.Nuclide = DecayMode.Radionuclide
WHERE (((HalfLife.LongLived)=Yes) AND ((HalfLife.Transuranic)=Yes) AND ((HalfLife.Alpha)=Yes))
ORDER BY HalfLife.Nuclide;
```

C:\Users\tbkirch\Documents\Projects\AP164\EPAUNI\InventoryDB_V4.mdb Friday, February 08, 2013
Query: WUFnuclideWithPercent

**SQL**

```
SELECT WUF_byNuclide.Nuclide, WUF_byNuclide.SumOf2033, [SumOf2033]/([WUF]*1000000) AS [Percent]
FROM WUF_byNuclide, WUF;
```