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Predominant Radionuclides in Hanford Site Waste Tanks

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Abstract: Predominant radionuclides in Hanford Site waste tanks are determined. Predominant radionuclides are defined as those radionuclides presenting over 99 percent of the long-term or short-term risk to workers or members of the public. Predominant radionuclides are those for which best estimates of inventory are needed on a tank-by-tank basis.

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PREDOMINANT RADIONUCLIDES IN HANFORD SITE WASTE TANKS

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January 1996

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LIST OF TERMS

ALI	Annual limit on intake
ASA	Accelerated Safety Analysis
EPA	Environmental Protection Agency
HEPA	High-efficiency particulate air
ORIGEN	Oak Ridge Isotope Generation
PUREX	Plutonium-Uranium Extraction
TE	Tin equivalent
TRAC	Track radioactive components

CONTENTS

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PREDOMINANT RADIONUCLIDES IN HANFORD SITE WASTE TANKS

1.0 INTRODUCTION

The radionuclide inventories of single-shell and double-shell tanks include over 100 isotopes. It is not feasible to sample, analyze, or account for all these isotopes, nor is it necessary, because most of them occur in relatively insignificant fractions. A long-standing issue has been which isotopes must be tracked and which isotopes can be ignored. This issue is especially important in the development of the new database to replace the current Track Radioactive Components (TRAC) database. The new radiological database is to consist of best estimates of radionuclide inventories derived from sampling data and process knowledge. The methodology for obtaining best estimates will be described in subsequent reports.

1.1 PURPOSE OF DOCUMENT

The purpose of this document is to re-examine the issue of which radionuclides should be tracked and to make sure that the new database being developed for the Hanford Site waste tanks includes the appropriate radionuclides.

1.2 SCOPE OF DOCUMENT

By appropriate radionuclides, it is meant those radionuclides that present significant radiological risk. There are other reasons for tracking a radionuclide, such as waste acceptance criteria, air permits, other regulatory issues, etc. Although these other reasons are dealt with in this document, the focus here is radiological risk. As used in this document, radiological risk includes both long-term risk to members of the public and short-term risk to both workers and the public. These types of risks and their relationship to radionuclide inventories are discussed below.

This document has been extensively reviewed to ensure that radionuclides important to users of the new database are included. Westinghouse Hanford Company (WHC) organizations involved with nuclear safety, environmental protection, performance assessment, safety analysis, and waste disposal engineering have approved this document.

1.2.1 Long-Term Public Risk

Radionuclide inventories are used to calculate long-term, public radiation doses and risks from potential leakage out of the tank farm disposal system, or from other waste form disposal systems such as low-level glass. Dose calculations and risks are documented in Performance

Assessments and other documentation (e.g., Environmental Impact Statements). Public doses are incurred primarily by the following:

- Inhalation of radioactive materials
- Ingestion of contaminated groundwater
- External radiation exposure from surface contamination.

There are other routes of public exposure to radiation, but these result in a small fraction of the dose incurred from the three primary routes listed above.

It is assumed for performance assessment purposes, that using the radionuclides responsible for the majority of the potential dose (e.g., 99 percent) would be adequate and that the other radionuclides could be ignored. The radionuclides giving the majority of the annual public dose are time-dependent because of radioactive decay. For radioactive materials leaking from the Hanford Site waste tanks 20 years from now, the radionuclides ^{137}Cs and ^{90}Sr would vastly dominate the public dose, due to their prevalence and radiotoxicity. For radioactive materials leaking from Hanford Site tanks several million years from now, the predominate radionuclides would be ^{238}U and a few other very long-lived isotopes. However, the annual public dose from ^{238}U and the very long-lived radionuclides would be many orders of magnitude smaller than the annual public dose from earlier, comparable leakage of shorter-lived radionuclides.

It appears reasonable and conservative from a risk standpoint to use 300 years when determining which radionuclides are responsible for the majority of potential public dose, relative to performance assessment work. In about 300 years the shorter-lived radionuclides (half-lives less than 10 years) have essentially decayed to zero. The curie quantities of the prevalent ^{137}Cs and ^{90}Sr (half-lives of about 30 years) have decayed to about 0.1 percent of their current levels, while the curie quantities of the prevalent and longer-lived radionuclides such as ^{239}Pu, ^{240}Pu, ^{241}Am, ^{99}Tc, ^{129}I, and ^{126}Sn have not appreciably changed, nor will they change much for several thousand or hundred-thousand years.

1.2.2 Short-Term Occupational Risk From Routine Operations

Occupational radiation doses will be incurred as tank waste is stored, retrieved, processed, and finally disposed. These doses must be assessed for planning and design purposes. The primary routes for occupational dose include the following:

- Inhalation of radioactive particulate
- Inhalation of volatile radioactive materials (volatility is a special concern under melter conditions)

- External radiation exposure (the concern in shielding design).

The radionuclides presenting occupational particulate inhalation hazards are the same radionuclides presenting inhalation hazards with respect to performance assessment. Volatile radionuclides are a special occupational concern because of the difficulty in containment and confinement, and because they may concentrate in process areas. Certain radionuclides present shielding concerns because of differentiation in waste processing. For example, ion exchange columns for ^{137}Cs removal will have very high external radiation levels, while predominant gamma emitting radionuclides in treated waste may be ^{126}Sn, ^{60}Co, etc.

1.2.3 Short-Term Occupational and Public Risks From Accidents

Safety Analysis Reports and other documentation include calculation of doses to onsite workers and offsite members of the public from accidents. The routes of accidental exposure include the following:

- Inhalation of radioactive particulate
- Inhalation of volatile radioactive materials
- External radiation from radioactive materials release and deposition.

1.3 CATEGORIZATION OF RADIONUCLIDES BY RISK

From the risks discussed above, it appears that radionuclides can be placed into the five following risk categories.

1. Long-term or short-term inhalation hazards
2. Long-term groundwater hazards
3. Long-term external radiation hazards
4. Short-term shielding concerns
5. Short-term volatile hazards.

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2.0 METHODOLOGY

Predominant radionuclides, as used in this document, are defined as radionuclides that are estimated to present over 99 percent of the inherent risks in each of the five categories in Section 1.3. In determining the 99 percentile inherent risks, potential chemical or physical differentiation by waste processing or waste handling must be considered. Differentiation in the environment must also be considered. The predominant radionuclides are those for which best estimates are needed. The other radionuclides can be ignored because their risk contribution is estimated to be less than 1 percent.

There are several ways to rank the importance of radionuclides relative to internal dose risk and to determine those that present over 99 percent of the total internal risk. One way is to divide the inventory of each radionuclide (curies) by the Annual Limit on Intake (ALI), which is the amount of radionuclide inhaled or ingested that results in a dose of 5 rem. By dividing inventories by ALIs inherent risks are normalized and those radionuclides presenting over 99 percent of the risk can be determined from the total number of ALIs.

For gamma emitters, the external radiation hazards can be normalized to a single radionuclide. The radionuclides presenting 99 percent of the risk can be determined from total normalized curies. The radionuclide used here for normalization is ^{126}Sn because it has a high dose factor and a long half-life (100,000 years). If one curie of ^{126}Sn is deposited on each square meter of surface soil, the external dose rate above background is 5.71 rem/h (Rittmann 1994). The 5.71 rem-m^2/Ci-h is an external dose factor. The tin equivalent (TE) curies is defined as the inventory of a radionuclide (curies) multiplied by the radionuclide external dose factor divided by 5.71. The TE curies facilitates estimating external dose from wide-spread surface contamination using just the areal contamination (TE curies/m^2).

Another way to rank the importance of radionuclides is to multiply inventories (curies) by a dose conversion factor (e.g., rem/year per curie released). This method takes environmental dispersion and differentiation into account, although these factors can vary among calculational techniques or computer codes. The radionuclides giving over 99 percent of the annual dose can be determined from the total annual dose.

All the methods described above are employed here to determine the predominant radionuclides.

There are two major sources for radionuclide inventory data: (1) the TRAC database (Shelton 1995), and (2) the database derived from the Oak Ridge Isotope Generation (ORIGEN) code as given by Schmittroth et al. (1995). Both databases have their deficiencies and advantages. Both databases are employed in this document to determine predominant radionuclides.

2.1 PREDOMINANT LONG-TERM OR SHORT-TERM INHALATION RISKS

Radionuclides are ranked in accordance with the number of inhalation ALIs in the TRAC database and in the ORIGEN database. All ALIs in this document were taken from a U.S. Environmental Protection Agency report (EPA 1988). Besides the current inventories, inventories 300 years from now are considered. A decay time of 300 years is used to allow the longer-lived radionuclides to come into dominance. Daughters that ingrow from longer-lived radionuclides are also considered. The radionuclides presenting 99 percent of the inherent risks for inhalation are determined in Attachments 1 through 6 of this document.

2.2 PREDOMINANT LONG-TERM GROUNDWATER RISKS

Mobile radionuclides are ranked in accordance with the number of ingestion ALIs in the TRAC database and in the ORIGEN database. By mobile radionuclides, it is meant those radionuclide chemical species with half-lives greater than 10 years that would migrate to the groundwater unretarded by ion exchange properties of the soil. The 10-year half-life criteria are applied because it is assumed that travel time to the groundwater is over 100 years and in 10 half-lives the radionuclide would essentially be decayed away. Mobile radionuclide chemical species are those assumed to have K_d values of zero (Schmittroth, et al. 1995). The K_d is a measure of retardation of migration through a soil column. Besides the current inventories, inventories 300 years from now are considered. Daughters that ingrow from longer-lived radionuclides are also considered. The mobile radionuclides presenting 99 percent of the inherent risks for ingestion are determined in Attachments 1 through 6 of this document.

2.3 PREDOMINANT EXTERNAL RADIATION RISKS

Gamma-emitting radionuclides are ranked in accordance with the number of TE curies in the TRAC database and in the ORIGEN-derived database. Besides the current inventories, inventories 300 years from now are considered. Daughters that ingrow from longer-lived radionuclides are also considered. The radionuclides presenting 99 percent of the external radiation risks are determined in Attachments 1 through 6 of this document.

2.4 PREDOMINANT SHIELDING RADIONUCLIDES

To perform adequate shielding design, accurate source terms for gamma emitters are needed. Generally, ^{137}Cs dominates all other gamma emitters on the short term, and ^{126}Sn dominates on the long term. However, there may be situations where ^{137}Cs is significantly reduced in the waste form, and other gamma emitters could be predominant, mainly ^{60}Co, ^{152}Eu, and ^{154}Eu. A ^{137}Cs to ^{60}Co comparison shows that ^{60}Co could be predominant in some of the tanks, at least according to TRAC and to the Accelerated Safety Analysis (ASA) tank concentrations (Brevick et al. 1995). Similarly, ^{152}Eu and ^{154}Eu could contribute significantly to external radiation in the absence of ^{137}Cs. In the interest of conservatism, these shorter-lived radionuclides are included in the list of predominant radionuclides because of shielding concerns.

2.5 PREDOMINANT VOLATILE RADIONUCLIDES

The volatility of radionuclide species is a primary concern, since volatile compounds may pass through high-efficiency particulate air (HEPA) filters and cause elevated airborne concentrations in stack emissions and working air. Volatile compounds may also concentrate in process areas and become predominant contamination concerns. For purposes of this document, volatile means a gaseous state capable of breaching confinement and containment systems (including HEPA filters) associated with tank waste storage, handling and processing. Waste processing includes adding the waste to a melter for purposes of making glass. The suspected volatile or potentially volatile radionuclides (elemental or compounds) at the elevated temperatures of a melter include the following:

^{3}H	^{14}C	^{60}Co	^{79}Se	^{87}Rb
^{93}Mo	^{98}Tc	^{99}Tc	^{102}Rh	^{106}Ru
^{108m}Ag	^{109}Cd	^{113m}Cd	^{125}Sb	^{123}Te
^{129}I	^{134}Cs	^{135}Cs	^{137}Cs	^{205}Pb

Although arsenic, fluorine, germanium, bromine, boron, chlorine, chromium, copper, vanadium, phosphorus, mercury, tungsten, thallium, potassium, sodium, zinc, and sulfur compounds are also potentially volatile or semi-volatile, there are no such radionuclides with half-lives greater than one year present in the waste. Furthermore, there are no significant volatile daughters from non-predominant radionuclides that could build up or cause an airborne concern. That is, daughters such as bismuth and lead ingrow from uranium, thorium or other decay chains, but these parents are included in the predominant radionuclides and the impact of the daughters are normally assessed. The volatile or semi-volatile components were taken from evaluations performed by Stegen (1994).

The above volatile or potentially volatile radionuclides are ranked in Attachment 7, using the number of inhalation ALIs and an estimated fraction of the material which would volatize under melter conditions (Stegen 1994). A 99 percentile ranking of volatiles may not be meaningful, since regardless of hazard, air permit requirements must be met. The ^{137}Cs tends to "wash out" all other radionuclides due to its extreme prevalence, yet it may be removed from some waste streams. Also, the ^{106}Ru inventory is very suspect due to significant discharges from the Plutonium-Uranium Extraction (PUREX) main stack.

Because of these factors, a conservative approach is used in that all volatiles over the 99.99 percentile with cesium and ruthenium removed are included in the predominant radionuclide list (see Attachment 7).

2.6 PROCESS DIFFERENTIATION OF RADIONUCLIDES

Besides volatility, another concern regarding differentiation of radionuclides is the potential concentration of an isotope somewhere in the process. For example, cesium will be concentrated in ion exchange columns, and there may be uranium and technetium removal. Also, some of the volatiles, like ^{129}I, may be captured on special filters. However, other than these purposeful concentrations and the differentiation due to volatility, there does not appear to be any additional differentiation of radionuclides that would impact the predominant list of radionuclides.

2.7 ENVIRONMENTAL DIFFERENTIATION OF RADIONUCLIDES

Dividing the radionuclide inventory by the ALI or using the TE curies normalizes the inherent inhalation, ingestion or external risks of the radionuclides. However, it does not account for possible differentiation or concentration in the environment. This differentiation is accounted for when doses are calculated using environmental dose conversion factors or appropriate computer codes. Schmittroth, et al. (1995) ranked radionuclides by multiplying dose consequence factors by low-level waste form inventories. Attachment 8 lists the radionuclides responsible for most of the dose relative to an intruder scenario (drilling into the waste and bringing radioactive materials to the surface) and drinking water scenarios. The drinking water scenarios consider cases where only the mobile radionuclide species reach the groundwater (retarded) and where any radionuclide may reach the groundwater (unretarded). The unretarded case was not used in determining predominant radionuclides. The 99 percentile radionuclides given in Attachment 8 are only approximately the 99 percentile, since the total dose from all radionuclides was not given by Schmittroth, et al. (1995).

3.0 TABLE OF PREDOMINANT RADIONUCLIDES

Table 3-1 below lists the predominant radionuclides as defined and determined in this document. The notes section of the table indicates what type of risks a radionuclide presents and the comments section explains why a radionuclide is predominant and why best estimates of inventory are needed. The comments section also provides information on performance assessment issues, regulatory issues, and other matters that relate to the importance of a radionuclide.

Table 3-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
^{3}H	2,4	Tritium is within the 99 percentile groundwater hazard in accordance with Oak Ridge Isotope Generation (ORIGEN) decayed to 1990, however, it drops out of the 99 percentile after less than 300 years decay. The half-life of tritium (12.3 years) is short compared with travel time to the groundwater, so most analysts exclude it in performance assessment work. However, there are about 275,000 Ci (as of 1990) of tritium in tanks (not counting indeterminate losses), and it is volatile as well as mobile. It may be an air permit issue for the melter, and it still may be a groundwater concern, at least on the short-term. Because of these concerns, it is included in the list of predominant radionuclides, although it should be excluded in long-term tank waste performance assessment work. Also, best estimates of this radionuclide are needed because it is a "radionuclide of interest" relative to the Nuclear Regulatory Commission's determination of low-level waste (Boldt et al. 1995)
^{14}C	2,4	The radionuclide is within the 99 percentile groundwater hazard in accordance with Track Radioactive Components (TRAC), but not ORIGEN. The radionuclide is also volatile, and therefore could be an airborne concern, both from an air permit and an occupational exposure standpoint. Also, best estimates of this radionuclide are needed because it is a "radionuclide of interest" relative to the U.S. Nuclear Regulatory Commission's (NRC) determination of low-level waste.

Table 3-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
^{59}Ni	2	This radionuclide is within the 99 percentile groundwater hazard in accordance with TRAC, but not ORIGEN. Best estimates are needed.
^{60}Co	4,5	Best estimates of this radionuclide are needed because of the short-term shielding concerns. It should not be included in tank performance assessment work.
^{63}Ni	2	This radionuclide is within the 99 percentile groundwater hazard in accordance with TRAC and ORIGEN but drops out of the ORIGEN 99 percentile after less than 300 years decay. Best estimates are needed because it is a short-term groundwater hazard. It should not be included in long-term tank performance assessment work. Best estimates of this radionuclide are also needed, because it is a "radionuclide of interest" relative to the NRC's determination of low-level waste.
^{79}Se	2,4,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with TRAC and ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{90}Sr	1,3,6	This radionuclide is within the 99 percentile inhalation hazard in accordance with TRAC and ORIGEN. It is also an external radiation hazard due to bremsstrahlung. Under some rare circumstances it could be a shielding concern. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{93}Zr	2,6	This nonmobile radionuclide is the parent of mobile ^{93m}Nb, and therefore best estimates of inventories are needed and it should be included in tank performance assessment work. It is within the 99 percentile groundwater hazard in accordance with ORIGEN and TRAC.

Table 3-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
^{93m}Nb	2,6	^{93m}Nb (half-life of 16.1 years) is the daughter of long-lived ^{93}Zr (half-life of 1.53E+6 years), so the ^{93}Zr requires best estimates. It could be argued that the half-life of ^{93m}Nb is short compared to travel time to the groundwater, and like tritium, it should be excluded from performance assessment work. However, the ALI of ^{93m}Nb is 80 times more restrictive than the ALI for tritium, and the ^{93m}Nb is continuously replenished from the decay of ^{93}Zr. Therefore, it is recommended for inclusion in tank waste performance assessment work.
^{99}Tc	2,4,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with TRAC and ORIGEN. Best estimates are needed and it should be included in tank performance assessment work.
^{106}Ru	4	With a half-life of only 368 days, ^{106}Ru is not a long-term environmental hazard. However, it can be very volatile and it is therefore a potential short-term airborne concern. The inventory (1990) according to ORIGEN is about 636,000 Ci. Best estimates are needed.
^{113m}Cd	4	This radionuclide is potentially volatile, posing a short-term airborne concern. It is not a long-term tank performance assessment concern but best estimates are needed.
^{125}Sb	4	Like ^{113m}Cd, this radionuclide is a potential short-term airborne concern because it is volatile, best estimates are needed.
^{126}Sn	3,5,6	This radionuclide, with its daughters, is the predominant gamma emitter on a long-term basis. Best estimates are needed and it should be included in tank performance assessment work. It could also be a shielding concern in highly differentiated waste from which the ^{137}Cs has been removed.
^{129}I	2,4,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with TRAC and ORIGEN. The radionuclide is one of the few that has a concentration factor in the food chain relative to the airborne pathway. Best estimates are needed and it should be included in tank performance assessment work.

Table 3-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
^{134}Cs	4	This isotope is not within the 99 percentile inhalation or groundwater hazard. However, since cesium is potentially volatile, it could be an air permit issue. It is within the 99.93 percentile with respect to volatility, although the ^{137}Cs would certainly "wash out" any dose or inhalation concerns. Best estimates are needed but it should not be included in tank performance assessment work.
^{137}Cs	1,3,4,5,6	This radionuclide is within the 99 percentile inhalation and long-term external radiation hazard (because of its prevalence) in accordance with TRAC and ORIGIN. Best estimates are needed and it should be included in tank performance assessment work.
^{151}Sm	0	As of 1990, the Curies of this radionuclide present 3.69E+6 Ci, but it is not within the 99 percentile hazard because of its high ALI (100 uCi inhalation and 10,000 uCi ingestion). It is ranked 13th in inhalation hazard according to ORIGEN, and is within the 99.43 percentile hazard. Although many analysts have considered this an important radionuclide, it is not recommended for inclusion in tank performance assessment work because it is insignificant compared to other radionuclides. One possible reason for tracking this radionuclide is that it could provide a good "finger print" for other radionuclides, due to its relatively long half-life (90 years) and its chemical inertness. Nevertheless, the need for best estimates of this radionuclide is questionable.
^{152}Eu and ^{154}Eu	5	These radionuclides are short-term shielding concerns. Best estimates are needed but they should not be included in long-term performance assessment work due to their short half-lives (13.33 and 8.8 years, respectively).
^{226}Ra and ^{228}Ra	2,6	These radionuclides are not within the 99 percentile inhalation or groundwater hazard in accordance with TRAC or ORIGEN decayed 300 years. However best estimates are needed because ^{228}Ra is within the 99 percentile groundwater hazard with no decay, and ^{226}Ra is within the 99.99 percentile after 300 years decay.

Table 3-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
^{227}Ac	1,6	This radionuclide is within the 99 percentile inhalation hazard in accordance with ORIGEN, but drops out of the 99 percentile after 300 years decay. Best estimates are needed.
^{229}Th	0	This radionuclide is not within the 99 percentile inhalation hazard in accordance with TRAC or ORIGEN. Assuming this radionuclide is not mobile it should not be included in tank performance assessment work. The need for best estimates is questionable.
^{231}Pa	1,6	This radionuclide is within the 99 percentile inhalation hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{232}Th	0	This radionuclide is not within the 99 percentile inhalation, groundwater or external radiation hazard in accordance with TRAC or ORIGEN. It should not be included in tank performance assessment work. The need for best estimates is questionable.
^{232}U	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{233}U	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{234}U	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{235}U	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.

Table 3-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
^{236}U	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{238}U	2,6	This radionuclide is within the 99 percentile groundwater hazard in accordance with ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{237}Np	1	This radionuclide is not within the 99 percentile inhalation or groundwater hazard in accordance with TRAC or ORIGEN. However, due to its long half-life (2.4E+6 years), it would eventually become predominant relative to inhalation risk after plutonium has decayed away sufficiently, and it should be included in tank performance assessment work. Best estimates of this radionuclide are needed also because it is a "radionuclide of interest" relative to the Nuclear Regulatory Commission's determination of low-level waste. This radionuclide was not included in the list of predominant radionuclides previously given by Boothe (1995).
^{238}Pu	1	This radionuclide is within the 99 percentile inhalation hazard in accordance with ORIGEN, but it drops out of the 99 percentile after less than 300 years decay. Therefore, it is a short-term environmental and occupational hazard. Best estimates are needed but it should not be included in long-term tank performance assessment work.
^{239}Pu	1,6	This radionuclide is within the 99 percentile inhalation hazard in accordance with TRAC and ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{240}Pu	1,6	This radionuclide is within the 99 percentile hazard in accordance with TRAC and ORIGEN. Best estimates are needed and the radionuclide should be considered in tank performance assessment work.

Table 3-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments
^{241}Pu	5	This radionuclide is within the 99 percentile inhalation hazard in accordance with TRAC, but drops out of the 99 percentile after less than 300 years decay. It does not appear within the 99 percentile in accordance with ORIGEN. It should not be considered in tank performance assessment work. However, best estimates of this radionuclide are needed because it is the parent of ^{241}Am. ^{241}Am is responsible for the external radiation from plutonium, and in some instances the isotope can be significant with respect to shielding.
^{241}Am	1,5	This radionuclide is within the 99 percentile inhalation hazard in accordance with TRAC and ORIGEN. Best estimates are needed and the radionuclide should be included in tank performance assessment work.
^{243}Am	0	This radionuclide is not within the 99 percentile inhalation or groundwater hazard in accordance with TRAC or ORIGEN. The radionuclide should not be included in tank performance assessment work. The need for best estimates for this radionuclide is questionable. This radionuclide is an alpha emitter, and is a transuranic. However, it is assumed that it is not prevalent enough to be a "radionuclide of interest" relative to the Nuclear Regulatory Commission's determination of low level waste. This assumption is also made for other alpha emitting transuranic radionuclides with half-lives greater than 20 years, including: ^{242m}Am and ^{243}Cm.
^{244}Cm	1	This radionuclide is within the 99 percentile inhalation hazard in accordance with ORIGEN, but drops out of the 99 percentile after less than 300 years decay. Best estimates are needed but this radionuclide should not be included in long-term tank performance assessment work.

Table 3-1. Predominant Radionuclides in Single-Shell and Double-Shell Tanks.

Isotope	Notes	Comments

NOTES:

[0] These radionuclides do not meet the criteria for predominant radionuclides given above, but are included here because they have been used in past performance assessment work. The need for best estimates of these radionuclides is questionable.

[1] Inhalation hazard. These radionuclides present either short-term or long-term hazards to either workers or the general public through the airborne pathway.

[2] Groundwater hazard. These radionuclides present either short-term hazards (e. g., leakage to the environment from sluicing leaker tanks) or long-term hazards (leakage from the disposal system) through the groundwater pathway.

[3] External radiation hazard. These radionuclides present long-term hazards to the public from external radiation. Occupational hazards and short-term shielding concerns are indicated by note 5.

[4] Volatile hazard. These radionuclides present short-term hazards to workers from airborne radioactivity. The radionuclides may concentrate in process areas. Air permit issues are also indicated.

[5] Shielding concern. These radionuclides present short-term occupational hazards from external radiation. Shielding design issues are indicated.

[6] These radionuclides should be included in tank waste performance assessment work (i.e., tank farm closure), but not necessarily the performance assessment work for low-level glass, high-level glass, or some other waste form.

4.0 REFERENCES

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ATTACHMENT 1

TRAC RADIONUCLIDES

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Attachment 1
TRAC Radionuclides (Sheet 1 of 3)

PARENT	ISOTOPE(1)	TOTAL SST & DST INVENTORY (CURIES)(1)	INHALATION ALI (uCi)(2)	INGESTION ALI (uCi)(2)	EXTERNAL DOSE CONVERSION FACTOR(2)	QUOTIENT: INVENTORY/ INHALATION ALI(3)	QUOTIENT: INVENTORY/ INGESTION ALI(3)	TIN EQUIVALENT CURIES(3)
Th-229	Ac-225(4)	1.98E-05	0.3	50		6.60E+01	3.96E-01	0.00E+00
	Ac-227	2.21E-02	0.0004	0.2	9.26E+02	5.53E+07	1.11E+05	3.58E-03
Ra-228	Ac-228(4)	7.42E-14	9	2000		8.24E-09	3.71E-11	0.00E+00
Pu-241	Am-241(5)	1.04E+05	0.006	0.8		1.73E+13	1.30E+11	0.00E+00
	Am-242	6.82E+01	80	4000		8.53E+05	1.71E+04	0.00E+00
	Am-242m	6.86E+01	0.006	0.8		1.14E+10	8.57E+07	0.00E+00
	Am-243	3.32E+01	0.006	0.8		5.53E+09	4.15E+07	0.00E+00
Pb-210	Bi-210(4)	7.17E-08	30	800		2.39E-03	8.96E-05	0.00E+00
Th-229	Bi-213(4)	1.98E-05	300	7000		6.60E-02	2.83E-03	0.00E+00
Ra-226	Bi-214(4)	2.70E-07	800	20000		3.38E-04	1.35E-05	0.00E+00
	C-14	5.34E+03	2000	2000		2.67E+06	2.67E+06	0.00E+00
	Cm-242	5.66E+01	0.3	30		1.89E+08	1.89E+06	0.00E+00
	Cm-244	1.18E+02	0.01	1		1.18E+10	1.18E+08	0.00E+00
	Cm-245	1.04E-02	0.006	0.7		1.74E+06	1.49E+04	0.00E+00
	Cs-135	1.45E+02	1000	700		1.45E+05	2.07E+05	0.00E+00
	Cs-137	3.49E+07	200	100	1.58E+03	1.75E+11	3.49E+11	9.66E+06
Ac-227(.014)	Fr-223(4)	3.09E-04	800	600		3.86E-01	5.15E-01	0.00E+00
	I-129	1.60E+01	9	5		1.78E+06	3.20E+06	0.00E+00
	Ni-59	5.03E+03	2000	20000		2.52E+06	2.52E+05	0.00E+00
	Ni-63	2.69E+05	800	9000		3.36E+08	2.99E+07	0.00E+00
	Np-237	6.97E+01	0.004	0.5		1.74E+10	1.39E+08	0.00E+00
	Np-238	3.26E-01	60	1000		5.44E+03	3.26E+02	0.00E+00
	Np-239	3.32E+01	2000	2000		1.66E+04	1.66E+04	0.00E+00
	Pa-231	3.80E-02	0.002	0.2		1.90E+07	1.90E+05	0.00E+00
Np-237	Pa-233(4)	6.97E+01	600	1000		1.16E+05	6.97E+04	0.00E+00
U-238(.0016)	Pa-234(4)	7.70E-01	7000	2000		1.10E+02	3.85E+02	0.00E+00
U-238	Pa-234m(4)	4.81E+02	200	90		2.40E+06	5.34E+06	0.00E+00
Th-229	Pb-209(4)	1.98E-05	60000	20000		3.30E-04	9.90E-04	0.00E+00
	Pb-210	7.17E-08	0.2	0.6		3.59E-01	1.20E-01	0.00E+00
Ac-227	Pb-211(4)	2.21E-02	600	10000		3.68E+01	2.21E+00	0.00E+00
Th-228	Pb-212(4)	3.72E-14	30	80		1.24E-09	4.65E-10	0.00E+00
Ra-226	Pb-214(4)	2.70E-07	800	9000		3.38E-04	3.00E-05	0.00E+00
	Pd-107	8.65E+01	400	30000		2.16E+05	2.88E+03	0.00E+00
Pb-210	Po-210(4)	7.17E-08	0.6	3		1.20E-01	2.39E-02	0.00E+00
	Pu-238	2.45E+03	0.007	0.9		3.51E+11	2.73E+09	0.00E+00
	Pu-239	2.64E+04	0.006	0.8		4.39E+12	3.30E+10	0.00E+00
	Pu-240	6.70E+03	0.006	0.8		1.12E+12	8.38E+09	0.00E+00
	Pu-241	7.49E+04	0.3	40		2.50E+11	1.87E+09	0.00E+00
	Pu-242	4.32E-04	0.007	0.8		6.17E+04	5.40E+02	0.00E+00
Ac-227	Ra-223(4)	2.21E-02	0.7	5		3.16E+04	4.42E+03	0.00E+00

Attachment 1
TRAC Radionuclides (Sheet 2 of 3)

PARENT	ISOTOPE(1)	TOTAL SST & DST INVENTORY (CURIES)(1)	INHALATION ALI (uCi)(2)	INGESTION ALI (uCi)(2)	EXTERNAL DOSE CONVERSION FACTOR(2)	QUOTIENT: INVENTORY/ INHALATION ALI(3)	QUOTIENT: INVENTORY/ INGESTION ALI(3)	TIN EQUIVALENT CURIES(3)
Th-228	Ra-224(4)	3.72E-14	2	8		1.86E-08	4.65E-09	0.00E+00
Th-229	Ra-225(4)	1.98E-05	0.7	8		2.83E+01	2.48E+00	0.00E+00
	Ra-226	2.70E-07	0.6	0.07	4.92E+03	4.50E-01	3.86E+00	2.33E-07
	Ra-228	7.42E-14	1	0.09	2.67E+03	7.42E-08	8.24E-07	3.47E-14
	Ru-106	3.79E-02	10	200		3.79E+03	1.90E+02	0.00E+00
	Se-79	9.11E+02	600	600		1.52E+06	1.52E+06	0.00E+00
	Sm-151	6.30E+05	100	10000		6.30E+09	6.30E+07	0.00E+00
	Sn-126	6.27E+02	60	300	5.71E+03	1.05E+07	2.09E+06	6.27E+02
	Sr-90	5.36E+07	4	30		1.34E+13	1.79E+12	0.00E+00
	Tc-99	3.21E+04	700	4000		4.59E+07	8.02E+06	0.00E+00
Ac-227	Th-227(4)	2.21E-02	0.3	100		7.37E+04	2.21E+02	0.00E+00
	Th-228	3.72E-14	0.01	6		3.72E-06	6.20E-09	0.00E+00
	Th-229	1.98E-05	0.0009	0.6		2.20E+04	3.30E+01	0.00E+00
	Th-230	3.90E-05	0.006	4		6.49E+03	9.74E+00	0.00E+00
U-235	Th-231(4)	2.06E+01	6000	4000		3.43E+03	5.15E+03	0.00E+00
	Th-232	6.42E-13	0.001	0.7		6.42E-04	9.18E-07	0.00E+00
U-238	Th-234(4)	4.81E+02	200	300		2.40E+06	1.60E+06	0.00E+00
	U-233	1.21E-02	0.04	10		3.01E+05	1.21E+03	0.00E+00
	U-234	2.12E-01	0.04	10		5.29E+06	2.12E+04	0.00E+00
	U-235	2.06E+01	0.04	10		5.15E+08	2.06E+06	0.00E+00
	U-236	2.88E-03	0.04	10		7.20E+04	2.88E+02	0.00E+00
Pu-241(2.5E-5)	U-237(4)	1.72E+00	2000	2000		8.60E+02	8.60E+02	0.00E+00
	U-238	4.81E+02	0.04	10		1.20E+10	4.81E+07	0.00E+00
	Zr-93	3.94E+03	6	1000		6.56E+08	3.94E+06	0.00E+00

Attachment 1
TRAC Radionuclides (Sheet 3 of 3)

PARENT	ISOTOPE(1)	TOTAL SST & DST INVENTORY (CURIES)(1)	INHALATION ALI (uCi)(2)	INGESTION ALI (uCi)(2)	EXTERNAL DOSE CONVERSION FACTOR(2)	QUOTIENT: INVENTORY/ INHALATION ALI(3)	QUOTIENT: INVENTORY/ INGESTION ALI(3)	TIN EQUIVALENT CURIES(3)

NOTES

(1) The isotopes and the curies are taken from re-normalized TRAC (L. W. Shelton, Internal Memo 71320-95-002, "Radionuclide Inventories for Single- and Double- Shell Tanks," 1995). Some isotopes have been omitted because they are daughters that are considered in the ALI determinations (e.g., Ba-135m, Ba-137m, Ni-93m, Rh-106, Sb-126, Sb-126m, Y-90, etc.). The curies are total curies in liquid and solid single-shell and double-shell tanks.

(2) The ALIs were taken from "Federal Guidance Report No. 11 - Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," EPA-570/1-88-020, 1988. The external dose factors (mrem-sq. m/hr-Ci) were taken from P. D. Rittmann, "Dose Estimates for the Solid Waste Performance Assessment," WHC-SD-WM-TI-616, 1994.

(3) The quotients give the number of ALIs in the tank for each radionuclide. The tin equivalent curies is simply curie inventory of the radionuclide multiplied by the ratio of the radionuclide dose factor to the Sn-126 dose factor. These parameters are measures of the significance of the radionuclide with respect to inherent hazard and risk relative to a given pathway.

(4) Many of the radionuclides given by TRAC are present only because they are daughters of longer-lived radionuclides. In all cases denoted with this footnote, it is conservatively assumed that the radionuclide is in equilibrium with its uranium, thorium, or other long-lived parent, even though equilibrium may not be achieved for a long time. The numbers in parentheses in the PARENT column is a fractional yield in the decay scheme.

(5) The relatively small ingrowth of Am-241 from Pu-241 is ignored.

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ATTACHMENT 2

TRAC RADIONUCLIDE RANK

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Attachment 2

TRAC Radionuclide Rank (Sheet 1 of 2)

TRAC RADIONUCLIDE RANK - INHALATION(1)			TRAC RADIONUCLIDE RANK - MOBILE(2)			TRAC RADIONUCLIDE RANK - GAMMA(3)		
ISOTOPE	QUOTIENT: INVENTORY/ INHALATION ALI	% CUMULATIVE	ISOTOPE	QUOTIENT: INVENTORY/ INGESTION ALI	% CUMULATIVE	ISOTOPE	TIN EQUIVALENT CURIES	% CUMULATIVE
Am-241	1.73E+13	46.73%	Ni-63	2.99E+07	57.92%	Cs-137	9.66E+06	99.99%
Sr-90	1.34E+13	82.88%	Tc-99	8.02E+06	73.49%	Sn-126	6.27E+02	100.00%
Pu-239	4.39E+12	94.72%	Zr-93(4)	3.94E+06	81.13%	Ac-227	3.58E-03	100.00%
Pu-240	1.12E+12	97.73%	I-129	3.20E+06	87.34%	Ra-226	2.33E-07	100.00%
Pu-238	3.51E+11	98.68%	C-14	2.67E+06	92.52%	Ra-228	3.47E-14	100.00%
Pu-241	2.50E+11	99.35%	U-235	2.06E+06	96.51%			
Cs-137	1.75E+11	99.82%	Se-79	1.52E+06	99.46%			
Np-237	1.74E+10	99.87%	Ni-59	2.52E+05	99.95%			
U-238	1.20E+10	99.90%	U-234	2.12E+04	99.99%			
Cm-244	1.18E+10	99.93%	Ra-223	4.42E+03	100.00%			
Am-242m	1.14E+10	99.96%	U-233	1.21E+03	100.00%			
Sm-151	6.30E+09	99.98%	U-237	8.60E+02	100.00%			
Am-243	5.53E+09	100.00%	U-236	2.88E+02	100.00%			
Zr-93	6.56E+08	100.00%	Ra-226	3.86E+00	100.00%			
U-235	5.15E+08	100.00%	Ra-225	2.48E+00	100.00%			
Ni-63	3.36E+08	100.00%	Ra-228	8.24E-07	100.00%			
Cm-242	1.89E+08	100.00%	Ra-224	4.65E-09	100.00%			
Ac-227	5.53E+07	100.00%						
Tc-99	4.59E+07	100.00%						
Pa-231	1.90E+07	100.00%						
Sn-126	1.05E+07	100.00%						
U-234	5.29E+06	100.00%						
C-14	2.67E+06	100.00%						
Ni-59	2.52E+06	100.00%						
Pa-234m	2.40E+06	100.00%						
Th-234	2.40E+06	100.00%						
I-129	1.78E+06	100.00%						
Cm-245	1.74E+06	100.00%						
Se-79	1.52E+06	100.00%						
Am-242	8.53E+05	100.00%						
U-233	3.01E+05	100.00%						
Pd-107	2.16E+05	100.00%						
Cs-135	1.45E+05	100.00%						
Pa-233	1.16E+05	100.00%						
Th-227	7.37E+04	100.00%						
U-236	7.20E+04	100.00%						
Pu-242	6.17E+04	100.00%						
Ra-223	3.16E+04	100.00%						
Th-229	2.20E+04	100.00%						
Np-239	1.66E+04	100.00%						

Attachment 2
TRAC Radionuclide Rank (Sheet 2 of 2)

TRAC RADIONUCLIDE RANK - INHALATION(1)			TRAC RADIONUCLIDE RANK - MOBILE(2)			TRAC RADIONUCLIDE RANK - GAMMA(3)		
	QUOTIENT: INVENTORY/	%		QUOTIENT: INVENTORY/	%		TIN EQUIVALENT	%
ISOTOPE	INHALATION ALI	CUMULATIVE	ISOTOPE	INGESTION ALI	CUMULATIVE	ISOTOPE	CURIES	CUMULATIVE
Th-230	6.49E+03	100.00%						
Np-238	5.44E+03	100.00%						
Ru-106	3.79E+03	100.00%						
Th-231	3.43E+03	100.00%						
U-237	8.60E+02	100.00%						
Pa-234	1.10E+02	100.00%						
Ac-225	6.60E+01	100.00%						
Pb-211	3.68E+01	100.00%						
Ra-225	2.83E+01	100.00%						
Ra-226	4.50E-01	100.00%						
Fr-223	3.86E-01	100.00%						
Pb-210	3.59E-01	100.00%						
Po-210	1.20E-01	100.00%						
Bi-213	6.60E-02	100.00%						
Bi-210	2.39E-03	100.00%						
Th-232	6.42E-04	100.00%						
Bi-214	3.38E-04	100.00%						
Pb-214	3.38E-04	100.00%						
Pb-209	3.30E-04	100.00%						
Th-228	3.72E-06	100.00%						
Ra-228	7.42E-08	100.00%						
Ra-224	1.86E-08	100.00%						
Ac-228	8.24E-09	100.00%						
Pb-212	1.24E-09	100.00%						
TOTAL	3.71E+13		TOTAL	5.15E+07		TOTAL	9.66E+06	

NOTES

1. All TRAC radionuclides are included in the ranking because all radionuclides have the potential to go airborne.
2. Only the mobile species are included (i.e., those radionuclides that have Kd values equal to zero).
3. Only those radionuclides giving significant external radiation dose are included.
4. The isotope Zr-93 is included because it is assumed to be in equilibrium with its daughter, Nb-93, which is mobile.

ATTACHMENT 3

ORIGEN2 RADIONUCLIDES

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ORIGEN 2 RADIONUCLIDES

ISOTOPES(1) (FISSION PRODUCTS)	HALF-LIFE (YEARS)(2)	INVENTORY (Ci)(3)	INHALATION ALI (uCi)(4)	INGESTION ALI (uCi)(4)	QUOTIENT: INVENTORY/ INHALATION ALI	QUOTIENT: INVENTORY/ INGESTION ALI	TE CURIES(5)
Cs-137/Ba-137	30	1.30E+08	200	100	6.50E+11	1.30E+12	3.60E+07
Sr-90/Y-90	29.12	1.63E+07	4	30	4.08E+12	5.43E+11	4.85E+04
Sm-151	90	3.69E+06	100	10000	3.69E+10	3.69E+08	
H-3	12.35	2.75E+05	80000	80000	3.44E+06	3.44E+06	
Tc-99	2.13E+05	2.72E+04	700	4000	3.89E+07	6.80E+06	
Eu-154	8.8	2.32E+05	20	500	1.16E+10	4.64E+08	1.32E+05
Zr-93/Nb-93m	1.53E+06	4.86E+03	6	1000	8.10E+08	4.86E+06	
Cd-113m	13.6	2.61E+04	2	20	1.31E+10	1.31E+09	
Sn-126(6)	1.00E+05	1.58E+03	60	300	2.63E+07	5.27E+06	1.58E+03
Cs-135	2.30E+06	1.09E+03	1000	700	1.09E+06	1.56E+06	
Se-79	6.50E+04	1.03E+03	600	600	1.72E+06	1.72E+06	
Eu-155	4.96	1.98E+05	90	4000	2.20E+09	4.95E+07	
Eu-152	13.33	2.57E+03	20	800	1.29E+08	3.21E+06	1.42E+03
Pm-147	2.62	5.48E+06	100	4000	5.48E+10	1.37E+09	
Sn-121m/Sn-121	55	2.78E+02	500	3000	5.56E+05	9.27E+04	
Pd-107	6.50E+06	1.02E+02	400	30000	2.55E+05	3.40E+03	
I-129	1.57E+07	6.62E+01	9	5	7.36E+06	1.32E+07	
Sb-125	2.77	3.30E+05	500	2000	6.60E+08	1.65E+08	
Cs-134	2.06	2.54E+05	100	70	2.54E+09	3.63E+09	
Pm-146	5.53	4.41E+01	100	1000	4.41E+05	4.41E+04	
C-14	5.73E+03	7.75E+02	2000	2000	3.88E+05	3.88E+05	
Nb-94	2.03E+04	1.25E-01	20	900	6.25E+03	1.39E+02	8.93E-02
Ho-166m	1.20E+03	1.02E-01	7	600	1.46E+04	1.70E+02	
Rb-87	4.70E+10	6.12E-02	2000	1000	3.06E+01	6.12E+01	
Sm-147	1.06E+11	2.40E-02	0.04	20	6.00E+05	1.20E+03	
Ag-108m	127	1.41E-02	200	600	7.05E+01	2.35E+01	
Be-10	1.60E+06	6.83E-03	10	1000	6.83E+02	6.83E+00	
Tc-98	4.20E+04	5.25E-04	300	1000	1.75E+00	5.25E-01	
Rh-102	2.9	2.21E+00	60	600	3.68E+04	3.68E+03	
Sm-146	1.03E+08	2.13E-05	0.04	10	5.33E+02	2.13E+00	
Ru-106/Rh-106	1.008	6.36E+05	10	200	6.36E+10	3.18E+09	
La-138	1.35E+11	4.39E-07	4	900	1.10E-01	4.88E-04	
In-115	5.10E+15	1.22E-07	1	40	1.22E-01	3.05E-03	
Gd-152	1.08E+14	5.42E-10	0.04	20	1.36E-02	2.71E-05	
Te-123	1.00E+13	3.68E-11	200	500	1.84E-07	7.36E-08	
Tm-171	1.92	5.48E-06	300	10000	1.83E-02	5.48E-04	
Cd-109/Ag-109m	1.27	1.27E-01	40	300	3.18E+03	4.23E+02	
(ACTINIDES)							
Am-241	432.2	5.18E+04	0.006	0.8	8.63E+12	6.48E+10	9.99E+01
Pu-239	2.41E+04	3.71E+04	0.006	0.8	6.18E+12	4.64E+10	
Pu-241/U-237	14.4	1.48E+05	0.3	40	4.93E+11	3.70E+09	
Pu-240	6.54E+03	7.19E+03	0.006	0.8	1.20E+12	8.99E+09	
Pu-238	87.74	2.25E+03	0.007	0.9	3.21E+11	2.50E+09	
Cm-244	18.11	4.04E+03	0.01	1	4.04E+11	4.04E+09	
Am-242m(7)	152	1.86E+02	0.006	0.8	3.10E+10	2.33E+08	1.01E+00
Pa-231	3.28E+04	1.45E+02	0.002	0.2	7.25E+10	7.25E+08	1.99E+00
Ac-227(8)	21.773	7.52E+01	0.0004	0.2	1.88E+11	3.76E+08	1.22E+01
Np-237/Pa-233	2.14E+06	7.45E+01	0.004	0.5	1.86E+10	1.49E+08	8.03E+00
U-233	1.58E+05	4.30E+02	0.04	10	1.08E+10	4.30E+07	
U-234	2.44E+05	3.00E+02	0.04	10	7.50E+09	3.00E+07	
U-238(9)	4.47E+09	2.96E+02	0.04	10	7.40E+09	2.96E+07	3.26E+00
Th-228(10)	1.91	8.67E+00	0.01	6	8.67E+08	1.45E+06	6.60E+00
Cm-243	28.5	1.56E+01	0.009	1	1.73E+09	1.56E+07	6.72E-01
U-232	72	1.15E+02	0.008	10	1.44E+10	1.15E+07	
Ra-228/Ac-228	5.75	3.30E+00	1	0.09	3.30E+06	3.67E+07	1.54E+00
Th-232	1.40E+10	2.68E+00	0.001	0.7	2.68E+09	3.83E+06	
Th-229(11)	7.34E+03	9.33E-01	0.0009	0.6	1.04E+09	1.56E+06	1.27E-01

ORIGEN 2 RADIONUCLIDES

ISOTOPES(1) (FISSION PRODUCTS)	HALF-LIFE (YEARS)(2)	INVENTORY (CI)(3)	INHALATION ALI (uCi)(4)	INGESTION ALI (uCi)(4)	QUOTIENT: INVENTORY/ INHALATION ALI	QUOTIENT: INVENTORY/ INGESTION ALI	TE CURIES(5)
U-235/Th-231	7.04E+08	1.22E+01	0.04	10	3.05E+08	1.22E+06	4.55E-01
Pu-242	3.76E+05	6.02E-01	0.007	0.8	8.60E+07	7.53E+05	
U-236	2.34E+07	7.38E+00	0.04	10	1.85E+08	7.38E+05	
Th-230	7.70E+04	2.43E-08	0.006	4	4.05E+00	6.08E-03	
Cm-245	8500	1.03E-01	0.006	0.7	1.72E+07	1.47E+05	2.00E-03
Ra-226(12)	1600	2.61E-03	0.6	0.07	4.35E+03	3.73E+04	1.96E-03
Cm-246	4730	2.25E-03	0.006	0.7	3.75E+05	3.21E+03	
Np-236	1.55E+05	2.32E-04	0.02	3	1.16E+04	7.73E+01	
Pu-236	2.85	1.42E-02	0.02	2	7.10E+05	7.10E+03	
Pu-244(13)	8.26E+07	9.71E-09	0.02	0.8	4.86E-01	1.21E-02	1.73E-09
Cm-247/Pu-243	1.56E+07	7.22E-10	0.006	0.8	1.20E-01	9.03E-04	1.43E-10
Cf-249	350.6	2.94E-10	0.004	0.5	7.35E-02	5.88E-04	
Cm-248	3.39E+05	1.80E-10	0.002	0.2	9.00E-02	9.00E-04	
Cf-250	13.08	1.71E-10	0.001	1	1.71E-01	1.71E-04	
Cf-251	898	5.80E-13	0.004	0.5	1.45E-04	1.16E-06	
Np-235	1.085	6.20E-04	800	20000	7.75E-01	3.10E-02	
Bi-210m	3.00E+04	4.55E-16	0.7	40	6.50E-10	1.14E-11	
Cf-252	2.638	5.66E-13	0.02	2	2.83E-05	2.83E-07	
(ACTIVATION PRODUCTS ONLY)							
Ni-63	96	1.91E+04	800	9000	2.39E+07	2.12E+06	
Ni-59	7.50E+04	1.86E+02	2000	20000	9.30E+04	9.30E+03	
Co-60	5.27	9.24E+03	30	200	3.08E+08	4.62E+07	1.07E+04
Fe-55	2.7	1.89E+04	2000	9000	9.45E+06	2.10E+06	
Mo-93	3.50E+03	1.41E-01	200	4000	7.05E+02	3.53E+01	
Hf-182	9.00E+06	7.85E-05	3	200	2.62E+01	3.93E-01	
Re-187	5.00E+10	8.60E-06	100000	600000	8.60E-05	1.43E-05	
Pb-205	1.43E+07	8.09E-06	1000	4000	8.09E-03	2.02E-03	
Si-32	450	6.08E-06	5	2000	1.22E+00	3.04E-03	
Lu-176	3.60E+10	4.01E-09	5	700	8.02E-04	5.73E-06	
Ir-192m	241	4.92E-11	90	3000	5.47E-07	1.64E-08	
Pt-193	50	1.56E-11	20000	40000	7.80E-10	3.90E-10	
In-115	5.10E+15	2.66E-12	1	40	2.66E-06	6.65E-08	
Os-194	6	3.90E-15	8	400	4.88E-10	9.75E-12	

NOTES

1. The isotopes include ORIGEN 2 radionuclides with half-lives greater than one year. The isotopes in **bold** are both fission products and activation products. Where a parent is in equilibrium with a daughter, the daughter inventory is excluded since the ALI and dose factor considers the daughter. In cases of multiple daughters, the daughters are listed in the indicated footnote.

2. Half-lives were taken from "Federal Guidance Report No. 11 - Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion," EPA-520/1-88-020, 1988.

3. The inventories were taken from Schmittroth et. al. ("Inventories for Low-Level Waste Tank Waste," WHC-SD-WM-RPT-164, 1995). Inventories are composite, decayed through 1990, and include losses as discussed in Schmittroth et. al.

4. The ALIs were taken from EPA-520/1-88-020 (See note 2).

5. The tin-equivalent curies (TE) normalizes dose rates to Sn-126 using dose conversion factors (mrem-m^2/Ci-hr). The dose conversion factors were taken from Rittmann, "Dose Estimates for the Solid Waste Performance Assessment," WHC-SD-WM-TI-616, 1994.

6. Daughters include: Sb-126m(.86) and Sb-126(.14).

ISOTOPES(1) (FISSION PRODUCTS)	HALF-LIFE (YEARS)(2)	INVENTORY (CI)(3)	INHALATION ALI (uCi)(4)	INGESTION ALI (uCi)(4)	QUOTIENT: INVENTORY/ INHALATION ALI	QUOTIENT: INVENTORY/ INGESTION ALI	TE CURIES(5)

NOTES (continued)

7. Daughters include: Am-242(.99524), Cm-242(.827), Np-238(.00476)

8. Daughters include: Th-227(.9862), Fr-223(.0138), Ra-223, Rn-219, Po-215, Pb-211, Bi-211, Tl-207(.99727), Po-211(.00273).

9. Daughters include: Th-234, Pa-234m(.9987), Pa-234(.0016)

10. Daughters include: Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212(.6407), Tl-208(.3593).

11. Daughters include: Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Tl-209.

12. Daughters include: Rn-222, Po-218, Pb-214, Bi-214, Po-214.

13. Daughters include: U-240, Np-240m(.9989), Np-240(.0011)

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ATTACHMENT 4

ORIGEN RADIONUCLIDE RANK

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ORIGEN RADIONUCLIDE RANK

INHALATION ISOTOPES(1)	QUOTIENT: INVENTORY/ INHALATION ALI	% CUM.	MOBILE ISOTOPES(2)	QUOTIENT: INVENTORY/ INGESTION ALI	% CUM.	GAMMA ISOTOPES(3)	TE CURIES	% CUM.
Am-241	8.63E+12	38.37%	U-233	4.30E+07	23.20%	Cs-137/Ba-137	3.60E+07	98.28%
Pu-239	6.18E+12	65.84%	Ra-228/Ac-228	3.67E+07	42.98%	Eu-154	1.32E+05	98.64%
Sr-90/Y-90	4.08E+12	83.95%	U-234	3.00E+07	59.17%	Sr-90	4.85E+05	99.96%
Pu-240	1.20E+12	89.28%	U-238	2.96E+07	75.14%	Co-60	1.07E+04	99.99%
Cs-137/Ba-137	6.50E+11	92.17%	I-129	1.32E+07	82.29%	Sn-126	1.58E+03	100.00%
Pu-241/U-237	4.93E+11	94.36%	U-232	1.15E+07	88.49%	Eu-152	1.42E+03	100.00%
Cm-244	4.04E+11	96.16%	Tc-99	6.80E+06	92.16%	Am-241	9.99E+01	100.00%
Pu-238	3.21E+11	97.58%	Zr-93/Nb-93m	4.86E+06	94.78%	Ac-227	1.22E+01	100.00%
Ac-227	1.88E+11	98.42%	H-3	3.44E+06	96.64%	Np-237/Pa-233	8.03E+00	100.00%
Pa-231	7.25E+10	98.74%	Ni-63	2.12E+06	97.78%	Th-228	6.60E+00	100.00%
Ru-106/Rh-106	6.36E+10	99.02%	Se-79	1.72E+06	98.71%	U-238	3.26E+00	100.00%
Pm-147	5.48E+10	99.27%	U-235/Th-231	1.22E+06	99.37%	Pa-231	1.99E+00	100.00%
Sm-151	3.69E+10	99.43%	U-236	7.38E+05	99.77%	Ra-228/Ac-228	1.54E+00	100.00%
Am-242m	3.10E+10	99.57%	C-14	3.88E+05	99.97%	Am-242m	1.01E+00	100.00%
Np-237/Pa-233	1.86E+10	99.65%	Ra-226	3.73E+04	99.99%	Cm-243	6.72E-01	100.00%
U-232	1.44E+10	99.72%	Ni-59	9.30E+03	100.00%	U-235/Th-231	4.55E-01	100.00%
Cd-113m	1.31E+10	99.77%	Nb-94	1.39E+02	100.00%	Th-229	1.27E-01	100.00%
Eu-154	1.16E+10	99.83%	Tc-98	5.25E-01	100.00%	Nb-94	8.93E-02	100.00%
U-233	1.08E+10	99.87%	TOTAL	1.85E+08		Cm-245	2.00E-03	100.00%
U-234	7.50E+09	99.91%				Ra-226	1.96E-03	100.00%
U-238	7.40E+09	99.94%				Pu-244	1.73E-09	100.00%
Th-232	2.68E+09	99.95%				Cm-247/Pu-243	1.43E-10	100.00%
Cs-134	2.54E+09	99.96%				TOTAL	3.66E+07	
Eu-155	2.20E+09	99.97%						
Cm-243	1.73E+09	99.98%						
Th-229	1.04E+09	99.98%						
Th-228	8.67E+08	99.99%						
Zr-93/Nb-93m	8.10E+08	99.99%						
Sb-125	6.60E+08	99.99%						
Co-60	3.08E+08	100.00%						
U-235/Th-231	3.05E+08	100.00%						
U-236	1.85E+08	100.00%						
Eu-152	1.29E+08	100.00%						
Pu-242	8.60E+07	100.00%						
Tc-99	3.89E+07	100.00%						
Sn-126	2.63E+07	100.00%						
Ni-63	2.39E+07	100.00%						
Cm-245	1.72E+07	100.00%						
Fe-55	9.45E+06	100.00%						
I-129	7.36E+06	100.00%						
H-3	3.44E+06	100.00%						
Ra-228/Ac-228	3.30E+06	100.00%						
Se-79	1.72E+06	100.00%						
Cs-135	1.09E+06	100.00%						
Pu-236	7.10E+05	100.00%						
Sm-147	6.00E+05	100.00%						
Sn-121m/Sn-121	5.56E+05	100.00%						
Pm-146	4.41E+05	100.00%						
C-14	3.88E+05	100.00%						
Cm-246	3.75E+05	100.00%						
Pd-107	2.55E+05	100.00%						
Ni-59	9.30E+04	100.00%						
Rh-102	3.68E+04	100.00%						
Ho-166m	1.46E+04	100.00%						
Np-236	1.16E+04	100.00%						
Nb-94	6.25E+03	100.00%						
Ra-226	4.35E+03	100.00%						

ORIGEN RADIONUCLIDE RANK

INHALATION ISOTOPES(1)	QUOTIENT: INVENTORY/ INHALATION ALI	% CUM.	MOBILE ISOTOPES(2)	QUOTIENT: INVENTORY/ INGESTION ALI	% CUM.	GAMMA ISOTOPES(3)	TE CURIES	% CUM.
Cd-109/Ag-109m	3.18E+03	100.00%						
Mo-93	7.05E+02	100.00%						
Be-10	6.83E+02	100.00%						
Sm-146	5.33E+02	100.00%						
Ag-108m	7.05E+01	100.00%						
Rb-87	3.06E+01	100.00%						
Hf-182	2.62E+01	100.00%						
Th-230	4.05E+00	100.00%						
Tc-98	1.75E+00	100.00%						
Si-32	1.22E+00	100.00%						
Np-235	7.75E-01	100.00%						
Pu-244	4.86E-01	100.00%						
Cf-250	1.71E-01	100.00%						
In-115	1.22E-01	100.00%						
Cm-247/Pu-243	1.20E-01	100.00%						
La-138	1.10E-01	100.00%						
Cm-248	9.00E-02	100.00%						
Cf-249	7.35E-02	100.00%						
Tm-171	1.83E-02	100.00%						
Gd-152	1.36E-02	100.00%						
Pb-205	8.09E-03	100.00%						
Lu-176	8.02E-04	100.00%						
Cf-251	1.45E-04	100.00%						
Re-187	8.60E-05	100.00%						
Cf-252	2.83E-05	100.00%						
In-115	2.66E-06	100.00%						
Ir-192m	5.47E-07	100.00%						
Te-123	1.84E-07	100.00%						
Pt-193	7.80E-10	100.00%						
Bi-210m	6.50E-10	100.00%						
Os-194	4.88E-10	100.00%						
TOTAL	**2.25E+13**							

NOTES

1. Because all isotopes have the potential to go airborne, all are considered inhalation isotopes.
2. Only those radionuclides assumed to have a Kd of zero are considered mobile.
3. Those radionuclides with an external dose conversion factor greater than 1.0E+1mrem-m^2/Ci-hr are listed.

(See Origen Radionuclides for parent/daughter assumptions)

ATTACHMENT 5

TRAC RANK DECAYED 300 YEARS

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TRAC RANK DECAYED 300 YEARS

TRAC RADIONUCLIDE RANK - INHALATIO			TRAC RADIONUCLIDE RANK - MOBIL			TRAC RADIONUCLIDE RANK - GAMMA		
	QUOTIENT:			QUOTIENT:			TIN	
	INVENTORY/	%		INVENTORY/			EQUIVALENT	
ISOTOPE	INHALATION AL	CUMULATIVE	ISOTOPE	INGESTION ALI		ISOTOPE	CURIES	
Am-241	1.07E+13	70.71%	Tc-99	8.02E+06	32.07%	Cs-137	9.43E+03	93.77%
Pu-239	4.36E+12	99.45%	Zr-93(4)	3.94E+06	47.82%	Sn-126	6.26E+02	100.00%
Pu-238	3.28E+10	99.67%	Ni-63	3.42E+06	61.51%	Ac-227	2.55E-07	100.00%
Np-237	1.74E+10	99.78%	I-129	3.20E+06	74.31%	Ra-226	2.04E-07	100.00%
U-238	1.20E+10	99.86%	C-14	2.57E+06	84.61%	Ra-228	6.83E-30	100.00%
Sr-90	1.06E+10	99.93%	U-235	2.06E+06	92.85%		1.01E+04	
Am-243	5.37E+09	99.97%	Se-79	1.51E+06	98.91%			
Am-242m	2.91E+09	99.99%	Ni-59	2.51E+05	99.91%			
Zr-93	6.56E+08	99.99%	U-234	2.11E+04	99.99%			
Sm-151	6.25E+08	99.99%	U-233	1.20E+03	100.00%			
U-235	5.15E+08	100.00%	U-236	2.88E+02	100.00%			
Cs-137	1.70E+08	100.00%	Ra-226	3.39E+00	100.00%			
Cm-242	5.26E+07	100.00%	Ra-228	1.62E-22	100.00%			
Tc-99	4.58E+07	100.00%	Ra-223	0.00E+00	100.00%			
Ni-63	3.85E+07	100.00%	U-237	0.00E+00	100.00%			
Pa-231	1.89E+07	100.00%	Ra-225	0.00E+00	100.00%			
Sn-126	1.04E+07	100.00%	Ra-224	0.00E+00	100.00%			
U-234	5.28E+06	100.00%		2.50E+07				
C-14	2.57E+06	100.00%						
Ni-59	2.51E+06	100.00%						
I-129	1.78E+06	100.00%						
Cm-245	1.69E+06	100.00%						
Se-79	1.51E+06	100.00%						
U-233	3.01E+05	100.00%						
Pd-107	2.16E+05	100.00%						
Cs-135	1.45E+05	100.00%						
Pu-241	1.34E+05	100.00%						
Cm-244	1.22E+05	100.00%						
U-236	7.20E+04	100.00%						
Pu-242	6.17E+04	100.00%						
Th-230	6.48E+03	100.00%						
Ac-227	3.93E+03	100.00%						
Ra-226	3.95E-01	100.00%						
Pu-240	1.71E-02	100.00%						
Bi-210	2.37E-03	100.00%						
Th-232	6.42E-04	100.00%						
Pb-210	3.20E-05	100.00%						
Th-229	1.09E-08	100.00%						
Ra-228	1.46E-23	100.00%						
Th-228	1.94E-53	100.00%						
Ru-106	1.19E-86	100.00%						
Po-210	6.22E-240	100.00%						
Pa-234m	0.00E+00	100.00%						
Th-234	0.00E+00	100.00%						
Am-242	0.00E+00	100.00%						
Pa-233	0.00E+00	100.00%						
Th-227	0.00E+00	100.00%						
Ra-223	0.00E+00	100.00%						
Np-239	0.00E+00	100.00%						
Np-238	0.00E+00	100.00%						
Th-231	0.00E+00	100.00%						
U-237	0.00E+00	100.00%						
Pa-234	0.00E+00	100.00%						
Ac-225	0.00E+00	100.00%						
Pb-211	0.00E+00	100.00%						
Ra-225	0.00E+00	100.00%						
Fr-223	0.00E+00	100.00%						

ATTACHMENT 5
WHC-SD-WM-TI-731 Rev 0
TRAC RANK DECAYED 300 YEARS

TRAC RADIONUCLIDE RANK - INHALATIO			TRAC RADIONUCLIDE RANK - MOBIL			TRAC RADIONUCLIDE RANK - GAMMA			
Bi-213	0.00E+00	100.00%							
Bi-214	0.00E+00	100.00%							
Pb-214	0.00E+00	100.00%							
Pb-209	0.00E+00	100.00%							
Ra-224	0.00E+00	100.00%							
Ac-228	0.00E+00	100.00%							
Pb-212	0.00E+00	100.00%							
	1.52E+13								

ATTACHMENT 6

ORIGEN DECAYED 300 YEARS

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ORIGEN DECAYED 300 YEARS

INHALATION ISOTOPES	QUOTIENT: INVENTORY/ INHALATION ALI	% CUM.	MOBILE ISOTOPES	QUOTIENT: INVENTORY/ INGESTION ALI	% CUM.	GAMMA ISOTOPES	TE CURIES	% CUM.
Pu-239	6.13E+12	47.91%	U-233	4.29E+07	32.44%	Cs-137/Ba-137	3.52E+04	95.41%
Am-241	5.34E+12	89.62%	U-234	3.00E+07	55.08%	Sn-126	1.58E+03	99.69%
Pu-240	1.16E+12	98.69%	U-238	2.96E+07	77.44%	Am-241	6.17E+01	99.86%
Pa-231	7.20E+10	99.25%	I-129	1.32E+07	87.44%	Sr-90	3.84E+01	99.96%
Pu-238	3.00E+10	99.49%	Tc-99	6.79E+06	92.58%	Np-237/Pa-233	8.03E+00	99.98%
Np-237/Pa-233	1.86E+10	99.63%	Zr-93/Nb-93m	4.86E+06	96.25%	U-238	3.26E+00	99.99%
U-233	1.07E+10	99.72%	Se-79	1.71E+06	97.54%	Pa-231	1.98E+00	100.00%
Am-242m	7.89E+09	99.78%	U-235/Th-231	1.22E+06	98.46%	U-235/Th-231	4.55E-01	100.00%
U-234	7.49E+09	99.84%	U-236	7.38E+05	99.02%	Am-242m	2.57E-01	100.00%
U-238	7.40E+09	99.89%	U-232	6.40E+05	99.50%	Th-229	1.23E-01	100.00%
Sm-151	3.66E+09	99.92%	C-14	3.74E+05	99.78%	Nb-94	8.84E-02	100.00%
Sr-90/Y-90	3.23E+09	99.95%	Ni-63	2.43E+05	99.97%	Cm-245	1.95E-03	100.00%
Th-232	2.68E+09	99.97%	Ra-226	3.27E+04	99.99%	Ra-226	1.72E-03	100.00%
Th-229	1.01E+09	99.98%	Ni-59	9.27E+03	100.00%	Ac-227	8.68E-04	100.00%
Zr-93/Nb-93m	8.10E+08	99.98%	Nb-94	1.37E+02	100.00%	Cm-243	4.56E-04	100.00%
U-232	8.00E+08	99.99%	Tc-98	5.22E-01	100.00%	Eu-152	2.38E-04	100.00%
Cs-137/Ba-137	6.35E+08	99.99%	H-3	1.67E-01	100.00%	Eu-154	7.21E-06	100.00%
U-235/Th-231	3.05E+08	100.00%	Ra-228/Ac-228	7.22E-09		Pu-244	1.73E-09	100.00%
U-236	1.84E+08	100.00%	TOTAL	1.32E+08		Cm-247/Pu-243	1.43E-10	100.00%
Pu-242	8.60E+07	100.00%				Co-60	7.81E-14	100.00%
Tc-99	3.88E+07	100.00%				Ra-228/Ac-228	3.03E-16	100.00%
Sn-126	2.63E+07	100.00%				Th-228	3.44E-47	100.00%
Cm-245	1.68E+07	100.00%				TOTAL	3.68E+04	
Ac-227	1.34E+07	100.00%						
I-129	7.36E+06	100.00%						
Cm-244	4.17E+06	100.00%						
Ni-63	2.74E+06	100.00%						
Se-79	1.71E+06	100.00%						
Cm-243	1.18E+06	100.00%						
Cs-135	1.09E+06	100.00%						
Sm-147	6.00E+05	100.00%						
C-14	3.74E+05	100.00%						
Cm-246	3.59E+05	100.00%						
Pu-241/U-237	2.64E+05	100.00%						
Pd-107	2.55E+05	100.00%						
Ni-59	9.27E+04	100.00%						
Sn-121m/Sn-121	1.27E+04	100.00%						
Ho-166m	1.23E+04	100.00%						
Np-236	1.16E+04	100.00%						
Nb-94	6.19E+03	100.00%						
Ra-226	3.82E+03	100.00%						
Cd-113m	2.99E+03	100.00%						
Be-10	6.83E+02	100.00%						
Mo-93	6.64E+02	100.00%						
Sm-146	5.32E+02	100.00%						
Rb-87	3.06E+01	100.00%						
Hf-182	2.62E+01	100.00%						
Eu-152	2.16E+01	100.00%						
Ag-108m	1.37E+01	100.00%						
Th-230	4.04E+00	100.00%						
Tc-98	1.74E+00	100.00%						
Si-32	7.66E-01	100.00%						
Eu-154	6.34E-01	100.00%						
Pu-244	4.85E-01	100.00%						
H-3	1.67E-01	100.00%						
In-115	1.22E-01	100.00%						
Cm-247/Pu-243	1.20E-01	100.00%						

La-138	1.10E-01	100.00%
Cm-248	8.99E-02	100.00%
Cf-249	4.06E-02	100.00%
Gd-152	1.35E-02	100.00%
Pb-205	8.09E-03	100.00%
Lu-176	8.02E-04	100.00%
Cf-251	1.15E-04	100.00%
Re-187	8.60E-05	100.00%
In-115	2.66E-06	100.00%
Ir-192m	2.31E-07	100.00%
Te-123	1.84E-07	100.00%
Cf-250	2.13E-08	100.00%
Co-60	2.25E-09	100.00%
Eu-155	1.36E-09	100.00%
Ra-228/Ac-228	6.49E-10	100.00%
Bi-210m	6.46E-10	100.00%
Pm-146	2.06E-11	100.00%
Pt-193	1.22E-11	100.00%
Pm-147	1.86E-24	100.00%
Sb-125	1.65E-24	100.00%
Os-194	4.33E-25	100.00%
Pu-236	1.46E-26	100.00%
Fe-55	3.37E-27	100.00%
Rh-102	2.66E-27	100.00%
Cs-134	3.68E-35	100.00%
Th-228	4.53E-39	100.00%
Cf-252	1.65E-39	100.00%
Tm-171	1.68E-49	100.00%
Cd-109/Ag-109m	2.47E-68	100.00%
Ru-106/Rh-106	1.62E-79	100.00%
Np-235	4.52E-84	100.00%
TOTAL	**1.28E+13**	

SEE ORIGEN INVENTORIES FOR PARENT/DAUGHTER ASSUMPTIONS

ATTACHMENT 7

VOLATILE RADIONUCLIDES

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VOLATILE RADIONUCLIDES

ISOTOPE	NUMBER OF INHALATION ALIs (ORIGEN)	VOLATILITY(1)	VOLATILE INDEX(2)	VOLATILES RANKED(3)	VOLATILE INDEX	% CUMULATIVE
H-3	3.44E+06	1	3.44E+06	Cs-137/Ba-137	3.25E+11	83.26%
Cs-137/Ba-137	6.50E+11	0.5	3.25E+11	Ru-106/Rh-106	5.72E+10	97.92%
Ru-106/Rh-106	6.36E+10	0.9	5.72E+10	Cd-113m	6.55E+09	99.60%
Cd-113m	1.31E+10	0.5	6.55E+09	Cs-134	1.27E+09	99.93%
Cs-134	2.54E+09	0.5	1.27E+09	Sb-125	1.65E+08	99.97%
Sb-125	6.60E+08	0.25	1.65E+08	Co-60	7.70E+07	99.99%
Co-60	3.08E+08	0.25	7.70E+07	Tc-99	3.50E+07	100.00%
Tc-99	3.89E+07	0.9	3.50E+07	I-129	7.36E+06	100.00%
I-129	7.36E+06	1	7.36E+06	H-3	3.44E+06	100.00%
Se-79	1.72E+06	1	1.72E+06	Se-79	1.72E+06	100.00%
Cs-135	1.09E+06	0.5	5.45E+05	Cs-135	5.45E+05	100.00%
C-14	3.88E+05	1	3.88E+05	C-14	3.88E+05	100.00%
Rh-102	3.68E+04	0.9	3.31E+04	Rh-102	3.31E+04	100.00%
Cd-109/Ag-109m	3.18E+03	0.5	1.59E+03	Cd-109/Ag-109m	1.59E+03	100.00%
Mo-93	7.05E+02	0.5	3.53E+02	Mo-93	3.53E+02	100.00%
Ag-108m	7.05E+01	0.25	1.76E+01	Ag-108m	1.76E+01	100.00%
Rb-87	3.06E+01	0.25	7.65E+00	Rb-87	7.65E+00	100.00%
Tc-98	1.75E+00	0.9	1.58E+00	Tc-98	1.58E+00	100.00%
Pb-205	8.09E-03	0.5	4.05E-03	Pb-205	4.05E-03	100.00%
Te-123	1.84E-07	0.9	1.66E-07	Te-123	1.66E-07	100.00%
					3.90E+11	

RANK OF VOLATILES WITH CESIUM(3) REMOVED:

ISOTOPE	VOLATILE INDEX	% CUMULATIVE
Ru-106/Rh-106	5.72E+10	8.93E-01
Cd-113m	6.55E+09	9.95E-01
Sb-125	1.65E+08	9.98E-01
Co-60	7.70E+07	9.99E-01
Tc-99	3.50E+07	1.00E+00
I-129	7.36E+06	1.00E+00
H-3	3.44E+06	1.00E+00
Se-79	1.72E+06	1.00E+00
C-14	3.88E+05	1.00E+00
Rh-102	3.31E+04	1.00E+00
Cd-109/Ag-109m	1.59E+03	1.00E+00
Mo-93	3.53E+02	1.00E+00
Ag-108m	1.76E+01	1.00E+00
Rb-87	7.65E+00	1.00E+00
Tc-98	157.50%	1.00E+00
Pb-205	0.40%	1.00E+00
Te-123	0.00%	1.00E+00
	6.41E+10	

RANK OF VOLATILES WITH RUTHENIUM (4) REMOVED:

ISOTOPE	VOLATILE INDEX	% CUMULATIVE
Cd-113m	6.55E+09	95.76%
Sb-125	1.65E+08	98.17%
Co-60	7.70E+07	99.30%
Tc-99	3.50E+07	99.81%
I-129	7.36E+06	99.92%
H-3	3.44E+06	99.97%
Se-79	1.72E+06	99.99%
C-14	3.88E+05	100.00%
Rh-102	3.31E+04	100.00%
Cd-109/Ag-109m	1.59E+03	100.00%
Mo-93	3.53E+02	100.00%
Ag-108m	1.76E+01	100.00%
Rb-87	7.65E+00	100.00%
Tc-98	157.50%	100.00%
Pb-205	0.40%	100.00%
Te-123	0.00%	100.00%
	6.84E+09	

NOTES

1. The estimated fractional airborne loss under melter conditions. Derived from Stegen, 1994.
2. This is the number of ALIs times the volatility.
3. Cesium is removed because it may be removed from melter feed.
4. Ruthenium is removed because of large losses out the PUREX main stack.

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ATTACHMENT 8

SCHMITTROTH DOSE RANK

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Attachment 8
Schmittroth Dose Rank

ISOTOPE	INTRUDER RANK(1)	% CUMULATIVE	ISOTOPE	RETARDED GROUNDWATER RANK(1)	% CUMULATIVE	ISOTOPE	UNRETARDED GROUNDWATER RANK(1)	% CUMULATIVE
Sr-90	4.89E+07	45.33%	Tc-99	2.09E+01	41.26%	Pu-239	6.05E+03	64.40%
Cs-137	4.45E+07	86.59%	Se-79	5.91E+00	52.93%	Ac-227	1.39E+03	79.19%
Sn-126	8.90E+06	94.84%	U-233	5.34E+00	63.47%	Pa-231	1.05E+03	90.37%
Am-241	2.27E+06	96.94%	U-234	3.58E+00	70.54%	Pu-240	7.95E+02	98.83%
Pu-239	1.31E+06	98.16%	U-238	3.14E+00	76.74%	Th-229	3.02E+01	99.15%
Ac-227	1.02E+06	99.10%	Ra-228	2.35E+00	81.38%	Tc-99	2.09E+01	99.37%
Tc-99	4.20E+05	99.49%	Nb-93m	1.79E+00	84.91%	Sn-126	2.05E+01	99.59%
Pu-240	2.52E+05	99.72%	I-129	1.35E+00	87.57%	Np-237	1.22E+01	99.72%
Pa-231	2.40E+05	99.95%	Ra-226	5.67E+00	98.77%	Se-79	5.91E+00	99.78%
Sm-151	5.81E+04	100.00%	U-236	2.33E-01	99.23%	Zr-93	5.67E+00	99.85%
TOTAL	1.08E+08		Cm-245	2.25E-01	99.67%	Am-243	3.47E+00	99.88%
			U-235	1.66E-01	100.00%	Th-232	5.48E+00	99.94%
			TOTAL	5.07E+01		U-233	5.59E+00	100.00%
						Am-241	1.35E-02	100.00%
						TOTAL	9.39E+03	

NOTES

1. The rankings are from F. A. Schmittroth, " Inventories for Low Level Waste Performance Assessment," WHC-SD-WM-RPT-164, 1995. The rankings are based on the product of the dose consequence factor and the waste form inventories, derived from ORIGEN 2 modeling.

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DISTRIBUTION SHEET

To	From	Page 1 of 1
Distribution	G. F. Boothe, 376-0158	Date 1/31/96
Project Title/Work Order		EDT No. 613845
WHC-SD-WM-TI-731, Revision 0, Predominant Radionuclides in Hanford Site Waste Tanks		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Central Files (2)	A3-88	X			
DOE Public Reading Room	A1-65	X			
S. K. Baker	H5-57	X			
D. E. Ball	H5-61	X			
J. A. Bates	H6-22	X			
A. L. Boldt	H5-49	X			
G. F. Boothe (10)	H5-27	X			
L. E. Bornemann	R2-06	X			
C. H. Brevick	S3-10	X			
N. R. Brown (2)	K6-51	X			
N. G. Colton	K2-40	X			
S. J. Eberlein	R2-12	X			
C. R. Eihutzer	H0-36	X			
E. A. Fredenburgh	H5-09	X			
D. W. Fritz	H6-22	X			
J. Greenborg	H0-35	X			
B. A. Higley	H5-27	X			
D. A. Himes	A3-34	X			
J. C. Van Keuren	A3-34	X			
N. W. Kirch	R2-11	X			
M. J. Kupfer	H5-49	X			
R. M. Mitchell	H6-30	X			
C. A. Petersen	H5-27	X			
J. B. Schaffer	R2-12	X			
F. A. Schmittroth	H0-35	X			
L. W. Shelton	H5-49	X			
B. C. Simpson	R2-12	X			
J. C. Sonnichsen	H6-23	X			
D. J. Washenfelder	H5-27	X			
R. A. Watrous	H5-27	X			
G. F. Williamson	H5-03	X			