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Rev. 1

River Corridor
Closure Contract

Inventory Data Package for ERDF Waste Disposal

August 2013

For Public Release

Washington Closure Hanford

Prepared for the U.S. Department of Energy, Richland Operations Office
Office of Assistant Manager for River Corridor

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EXECUTIVE SUMMARY

This data package provides inventory estimates for specific radionuclides that are currently disposed at the Environmental Restoration and Disposal Facility (ERDF). In addition, bounding estimates of curies of specific radionuclides and volumes of waste are provided for waste that could be disposed at ERDF prior to closure. The waste sources containing these inventories have been and will continue to be generated by remediation of *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) waste sites on the Hanford Site. This information will be used to complete an update of the ERDF long-term post-closure Performance Assessment (PA) analysis. The PA analysis is required by DOE O 435.1, *Radioactive Waste Management,* and evaluates near-field environmental impacts and associated human health effects that may be caused by the release of radionuclides from ERDF.

Between June 1996 and August 2010, over 6 million m^3 of waste was disposed at ERDF. Over 3 million m^3 of waste is currently forecast to be disposed at ERDF. This would fill newly constructed ERDF super cells 9 and 10. An estimated additional 4 million m^3 could potentially be disposed at ERDF pending cleanup decisions over the next few decades. This would require up to three new super cells. At closure (approximately two decades), a bounding estimate of 13 million m^3 of waste could be disposed at ERDF. The majority of secondary waste generated from the Hanford Tank Waste Treatment and Immobilization Plant (Waste Treatment Plant) operations and tank farm operations are assumed to be disposed at the Integrated Disposal Facility.

Table ES-1 provides the current ERDF inventory as of August 2010, the sum of the current inventory and current forecast waste that is expected to be disposed at ERDF, and a bounding estimate of the ERDF inventory at closure for specific radionuclides. Appendices A and B provide charts that summarize the information for the specific radionuclides provided in Table ES-1. The specific radionuclides were selected based on their anticipated impact to the ERDF PA analysis. Additional radionuclides are also discussed in this report.

Table ES-1. ERDF Inventory for Specific Radionuclides.

Radionuclide	Current ERDF Inventory (Decayed to 2035)	Current ERDF Inventory + Currently Forecast Waste (Decayed to 2035)	Bounding ERDF Inventory Estimate at Closure (Decayed to 2035)
Carbon-14	**1,900** Ci	2,400 Ci	<45,000 Ci
Cesium-137	8,400 Ci	260,000 Ci	<1,200,000 Ci
Chlorine-36	0 Ci	0.02 Ci	300 Ci
Iodine-129	0.02 Ci	0.02 Ci	<10 Ci
Nickel-63	**12,000** Ci	13,000 Ci	<95,000 Ci
Plutonium Total	0.0048 metric tons	0.025 metric tons	<0.060 metric tons
Strontium-90	6,400 Ci	120,000 Ci	<690,000 Ci
Technetium-99	**21** Ci	53 Ci	<860 Ci
Tritium (H-3)	2,000 Ci	8,000 Ci	<40,000 Ci
Uranium Total	**202** metric tons	260 metric tons	<870 metric tons

Adjusted inventories resulting from review of the recorded inventory estimates in the WMIS are in **bolded text.**
ERDF = Environmental Restoration Disposal Facility
WMIS = Waste Management Inventory System

An assessment of the current ERDF inventory of specific radionuclides in the Waste Management Information System (WMIS) database was conducted to evaluate the credibility of recorded large increases in disposed quantities. The evaluation process included reviews of initial waste site characterization data for specific waste sites and independent estimates of disposed inventories for comparison with the WMIS record. Based on the results of this assessment, adjustments (shown in **bolded text**) are recommended to the ERDF inventory of carbon-14, calcium-41, nickel-59, nickel-59 activated metal (AM), nickel-63, nickel-63AM, selenium-79, molybdenum-93, niobium-93m (metastable), zirconium-93, niobium-94, niobium-94AM, technetium-99, silver-108m, barium-133, and uranium total.

The ERDF waste inventory increases (Table ES-1) in cesium-137 and strontium-90 (columns 2 and 3) are from forecasted cleanup of soils beneath the 324 facility B-Cell. The ERDF waste inventory increases (Table ES-1) in carbon-14 and chlorine-36 (column 3) are from potential receipt of 100 Area reactor cores, a waste stream pending cleanup decisions. The bounding ERDF inventory increase in iodine-129 (column 3) is from potential waste pending cleanup decisions of the 200 Area low-level waste burial grounds (LLBGs), 200 Area CERCLA waste sites, and canyon equipment and near surface waste (e.g., Plutonium/Uranium Extraction tunnels). Bounding ERDF inventory increases of total plutonium, technetium-99, and total uranium (column 3) are primarily from potential waste pending cleanup decisions of 200 Area

CERCLA waste sites (for technetium-99 approximately 100 ft or more below ground surface in the intermediate vadose zone) and the 200 Area LLBG. Bounding ERDF inventory increases of nickel-63 and tritium are from potential cleanup decisions of the 200 Area LLBG.

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REVISION HISTORY

Revision	Date	Reason for revision	Revision initiator
1	August 2013	Revised to add new Appendix B and minor corrections	C. Stroup
0	March 2013	Initial issuance	NA

ACRONYMS

ALE	Arid Lands Ecology
AM	activated metal
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CH	contact-handled
Ci	curie
CSB	Canister Storage Building
CWC	Central Waste Complex
D&D	decontamination and decommissioning
D4	deactivation, decommissioning, decontamination, and demolition
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility
FFTF	Fast Flux Test Facility
FMEF	Fuels and Materials Examination Facility
FY	fiscal year
IDF	Integrated Disposal Facility
LLBG	low-level burial ground
MUF	material unaccounted for
MWDT	Mixed Waste Disposal Trench
PA	Performance Assessment
PFP	Plutonium Finishing Plant
ppm	parts per million
PUREX	Plutonium/Uranium Extraction
RCRA	*Resource Conservation and Recovery Act of 1976*
REDOX	Reduction-Oxidation
RH	remote-handled
ROD	record of decision
RTD	retrieval, treatment, and disposal
SWITS	Solid Waste Information Tracking System
SWOC	Solid Waste Operations Complex
TC&WM	Tank Closure & Waste Management
TRU	transuranic
TRUM	mixed transuranic
TWINS	Tank Waste Information Systems
WESF	Waste Encapsulation and Storage Facility
WMIS	Waste Management Information System
WRAP	Waste Receiving and Processing
WTP	Waste Treatment Plant

1.0 INTRODUCTION

An update of the Environmental Restoration and Disposal Facility (ERDF) long-term post-closure Performance Assessment (PA) analysis is planned. The PA analysis is required by DOE O 435.1, *Radioactive Waste Management*, and evaluates near-field environmental impacts and associated human health effects that may be caused by the release of radionuclides from ERDF. This data package provides estimates of specific radionuclides that could be disposed in ERDF at closure. Also included is a bounding estimate of the volume of waste that could be disposed in ERDF.

1.1 BACKGROUND

The ERDF was constructed to dispose of waste generated by *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) waste site remediation efforts at the Hanford Site. It is not permitted to receive offsite waste. Since startup in June 1996, approximately 10 million metric tons or 6.3 million m^3 of waste has been disposed at ERDF. The 6.3 million m^3 of waste has completely filled ERDF cells 1 through 6 and partly filled cells 7 and 8. ERDF has two newly constructed super cells, 9 and 10.

The processes that generated Hanford Site remediation waste, that is or will be disposed at ERDF, were the irradiation of uranium fuel in nine production reactors and chemical treatment of irradiated fuel to separate and purify plutonium and other important isotopes. These processes occurred during the Hanford operations period between the mid-1940s and mid-1980s, and caused a residual distribution radionuclide inventory across many facilities and associated waste sites at Hanford.

The resulting waste sites and facilities are generally clustered in three geographic groups, the 100, 200, and 300/600 Areas. The 100 Area at the north end of the Hanford Site along the Columbia River contained the nine nuclear reactors that irradiated uranium fuel to produce plutonium. The 200 Area in the center of the Hanford Site on the Central Plateau contained the chemical processing facilities (T Plant, B Plant, U Plant, the Reduction-Oxidation [REDOX] facility, and the Plutonium/Uranium Extraction [PUREX] facility) used to extract plutonium and uranium from the irradiated fuel; tank farms to store separated fission product waste (e.g., cesium and strontium); facilities for purification, isolation, storage, and shipment of plutonium and uranium (231-Z, the Plutonium Finishing Plant and Uranium Trioxide Plant); cesium and strontium recovery, encapsulation, and storage facilities (B Plant and the Waste Encapsulation and Storage Facility [WESF]); storage of irradiated fuels (Canister Storage Building [CSB]); and support facilities (e.g., laboratories, evaporators). The 300/600 Areas contained facilities for fabricating fuel to be irradiated in the 100 Area reactors and support laboratories. At all three areas, numerous liquid waste discharge and solid waste facilities were developed.

Overall, facilities and waste discharge sites are the primary types of CERCLA sites being remediated along with some treatment of contamination plumes in groundwater underlying these areas. Waste materials typically disposed at ERDF include soils, facility rubble (e.g., concrete and wood), and metals (e.g., reactor parts). The ERDF is intended to continue operations until the remediation efforts are completed per the record of decision (ROD) approved in 1995. Because numerous CERCLA remediation decisions have not been finalized,

a closure date has not been determined. However, at least another two decades of waste receipt is expected. The majority of secondary waste generated from Hanford Tank Waste Treatment and Immobilization Plant Waste Treatment Plant (WTP) and tank farm operations are assumed to be disposed at the Integrated Disposal Facility (IDF).

1.2 PURPOSE AND SCOPE

Estimates of radionuclide inventories that are and will be disposed in ERDF are needed to complete a long-term post-closure PA analysis. The PA analysis is required by DOE O 435.1 and evaluates near-field environmental impacts and associated human health effects that may be caused by the release of radionuclides from ERDF. Numerous previous analyses have shown that radionuclide inventories are critical input parameters because the estimated environmental effects are generally proportional to radionuclide-specific inventory (activity or mass) and average concentrations (average concentrations per waste volume). This data package provides quantitative estimates of radionuclide inventories that could be disposed in the ERDF at closure. In addition, a brief discussion of potential waste volumes that may be disposed at ERDF by closure is discussed.

This data package considers inventory in chronological order, addressing currently disposed waste first, followed by future waste sources. We assess the current ERDF Waste Management Information System (WMIS) inventory of specific radionuclides, recommend adjustments to the current record where justified for input to the PA analysis, quantify current waste forecasts for ERDF, and estimate potential quantities of waste where no remediation decisions have been made that potentially could be disposed at ERDF. This sum of the parts provides a bounding quantity of radionuclide inventories to be disposed at ERDF closure.

1.3 APPROACH

The August 2010 ERDF WMIS inventory was used as the basis for estimating the current quantities of specific radionuclides disposed. The general processes and information used to develop and track inventory estimates are provided and sources of uncertainty are developed in Section 2.0. To address the accuracy of the WMIS inventory, inventory estimates for specific radionuclides at specific waste sites were generated from pre remediation waste site data (e.g., field data and historical records). These estimates were then compared with the WMIS information. Where warranted, adjustments to the current ERDF inventory are provided and will be the current inventory input to the PA analysis. The rationale for these adjustments is provided.

Future waste inventory estimates are made for specific radionuclides using a three-part calculation that ultimately provides a bounding estimate of waste that could be disposed at ERDF. First, the total radionuclide-specific inventories on the Hanford Site for abundant or known environmental contaminants are estimated from historical documents, ongoing databases, and knowledge of Hanford Site operations (provided in Section 3.0). The primary data in this step are Hanford production records that quantify the amount of fuel irradiated and fission products produced. Reactor operations are the primary source of inventory on site. Other wastes are also present at the Hanford Site such as naval reactor compartment waste in a dedicated trench (Trench 94 in low-level burial ground [LLBG] 218-E12B) and commercial waste disposed at the US Ecology site adjacent to the 200 Area.

Second, waste inventories associated with each major waste management process at the Hanford Site area is estimated from the individual waste management process documentation (Section 3.0). In this exercise, the gross distributions of specific radionuclide inventories across the Hanford Site are recreated as fuel processing and waste generation evolve. For example, the largest fraction of the initial inventory is stored in underground tanks in the 200 Area. Tank wastes are solids and sludges generated by fuel dissolution and processing to extract plutonium and uranium. These wastes will be vitrified and disposed in the IDF or sent off site to a high-level waste repository. Other wastes include cesium and strontium capsules that contain a portion of the initial tank waste and irradiated fuel elements that were not processed and are stored in the CSB in the 200 Area. Inventories associated with these processes will not be going to ERDF. By summing these inventories and comparing the sum with the total site estimate derived in step one, an "order of magnitude," or better estimate of inventory that is available for disposal at ERDF can be calculated.

Third, and finally, the estimated available inventory is broken down into two pieces from this total (Section 4.0). The first piece is the inventory present in waste from sites where well established remediation decisions have been made or are imminent. Some prominent waste sites include the following:

- 100 Area (i.e., 100-K)
- 200 Area (i.e., nontransuranic [non-TRU] residual waste from the Plutonium Finishing Plant [PFP], contaminated soil from the 200-PW-1/3/6 liquid waste sites, liquid waste from the 200 Area Effluent Treatment Facility [ETF])
- 300 Area (e.g., 324 Facility waste and contaminated soils)
- 600 Area (solid waste in the 618-10 and 618-11 Burial Grounds).

The second piece is the inventory in waste from sites where remediation decisions are not yet well established. These waste sites include the 100 Area (i.e., reactor cores) and 200 Area (i.e., solid waste in the 200-SW-2 Burial Grounds, residual waste in canyons and tunnels). Some quantity of waste will be generated by remediation of the 200 Area sites, but accurate projection of radionuclide inventories and waste volumes are highly uncertain because remediation decisions are not well formed. Consequently, expert judgment is used to estimate maximum reasonable amounts. By combining the information presented in Sections 2.0, 3.0, and 4.0, a total bounding estimate of the ERDF life-cycle inventory is made (Section 5.0).

Section 6.0 estimates additional waste volumes that will be disposed in ERDF prior to closure. Again, waste volumes are considered in terms of well-established versus to-be-established remediation decisions.

2.0 CURRENT ERDF INVENTORY

In this section the current disposed inventory in ERDF is described. Quantitative estimates of specific radionuclide inventories (in curies or metric tons) are taken from an August 2010 ERDF WMIS summary. To thoroughly describe the inventory, the estimating methodology was reviewed (Section 2.1) to establish the basis for quantifying inventory estimates. As discussed below, a conservative or bounding bias is built into the estimating process, generally resulting in larger than likely inventory estimates. To better understand this bias, additional reviews of waste sources were also conducted and alternative specific radionuclide estimates were developed where warranted. Field characterization data and historical records describing processes that generated these waste inventories provide the basis for these alternative estimates. These comparisons are discussed below and recommendations are made for adjusting the WMIS inventories of particular radionuclides for purposes of the PA analysis (Section 2.2).

The radionuclides have been divided into three groups with inventory estimates listed in Tables 2-1, 2-2, and 2-3. Alternative inventory quantities are shown in **bolded text** and discussed in Section 2.2. All radionuclide quantities have been decayed to 2011 and an inventory of zero is assumed for all recorded inventories less than 10^{-6} Ci. The groupings reflect general differences in the expected inventory levels of radionuclides over the analysis time frame, approximately 1,000 to 10,000 years after closure. In the first group radionuclides have relatively long half-lives (greater than 6 years) and potentially non-negligible inventories at facility closure (greater than one curie). Any radionuclides that are known to be important to PA analysis dose estimates are included in this group regardless of inventory (e.g., radium-226, which is the parent of radon-222 and iodine-129, a long-lived and mobile contaminant in the subsurface). Typically, more data is available that quantifies inventory levels in this group compared to the other groups. The second two groups include radionuclides that are not expected to be present in large quantities at closure. In the second group radionuclides have half-lives less than 6 years and will have decayed to levels substantially below current levels at closure. Although not firmly established, facility closure is assumed to be 2035 for analysis purposes. Given this closure date, approximately 5 half-lives will have happened for the longest half-life contaminant in this group (i.e., the half-life of cobalt-60 is 5.3 years), reducing expected inventories by more than an order of magnitude. In the third group, the radionuclide half-life is greater than 6 years and the expected inventory level is low (less than one curie) for one or more reasons. Typically, these radionuclides were not produced in large quantities by uranium fuel irradiation or are not expected to be available for disposal in ERDF.

Table 2-1. Current ERDF Inventory for Radionuclides with Half-Lives Greater than 6 Years and/or Inventories Greater than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Waste Form	ERDF Inventory in Curies (Exceptions are in Metric Tons)	Half-Life in Years	Specific Activity (Ci/g)
Silver-108m	Untreated	**248**	418.0	7.926
Americium-241	Untreated	545	432.9	3.427
Barium-133	Untreated	**5.0**	10.6	254.4
Carbon-14	Untreated	**35**	5,729.2	4.455
Carbon-14	Activated Metal	**98**	5,729.2	4.455
Carbon-14	Insoluble	**1755**	5,729.2	4.455
Calcium-41	Untreated	**0.3**	102,954.6	0.08500
Cadmium-113m	Untreated	3.0	13.7	231.1
Chlorine-36	Untreated	0	301,987.5	0.03291
Curium-244	Untreated	1.6	18.1	80.93
Cesium-137	Untreated	14,600	30.2	86.55
Europium-152	Untreated	4,840	13.5	174.0
Europium-154	Untreated	1,350	8.6	270.3
Tritium	Untreated	7,790	12.3	9,613
Iodine-129	Untreated	0.019	15,688,772.3	0.0001768
Potassium-40	Untreated	0	1,279,881,866.8	0.000006989
Molybdenum-93	Untreated	**0.5**	3,011.6	1.278
Niobium-93m	Untreated	**4.8**	16.1	238.6
Niobium-94	Untreated	**0.2**	19,985.7	0.1905
Niobium-94	Activated Metal	**0.1**	19,985.7	0.1905
Nickel-59	Untreated	**125**	75,988.0	0.07982
Nickel-59	Activated Metal	**65**	75,988.0	0.07982
Nickel-63	Untreated	**10,600**	99.0	57.38
Nickel-63	Activated Metal	**3,860**	99.0	57.38
Neptunium-237	Untreated	0.4	2,139,896.6	0.0007047
Plutonium-238	Untreated	42	87.7	17.12
Plutonium-239	Untreated	260	24,111.5	0.06202
Plutonium-240	Untreated	120	6,562.6	0.2269
Plutonium-241	Untreated	5,100	14.4	103.0
Plutonium-242	Untreated	0.7	373,602.6	0.003954
Plutonium Total	Untreated	0.00477 MT		
Radium-226	Untreated	0.9	1,599.9	0.9885
Selenium-79	Untreated	**0.1**	64,992.3	0.06969
Samarium-151	Untreated	259	90.0	26.32

Table 2-1. Current ERDF Inventory for Radionuclides with Half-Lives Greater than 6 Years and/or Inventories Greater than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Waste Form	ERDF Inventory in Curies (Exceptions are in Metric Tons)	Half-Life in Years	Specific Activity (Ci/g)
Tin-121m	Untreated	17.0	55.0	53.76
Strontium-90	Untreated	11,400	28.6	138.8
Technetium-99	Untreated	**21.0**	211,296.2	0.01711
Thorium-232	Untreated	1.1	14,050,498,136.7	0.0000001097
Uranium-233	Untreated	**14.6**	159,264.3	0.009633
Uranium-234	Untreated	**13.5**	245,709.4	0.006217
Uranium-235	Untreated	**7.6**	703,792,430.4	0.000002161
Uranium-236	Untreated	**0.4**	23,417,496.9	0.00006468
Uranium-238	Untreated	**67.5**	4,468,020,381.8	0.0000003361
Uranium Total	Untreated	**202 MT**		
Zirconium-93	Untreated	**16.0**	1,529,900.9	0.002515

Adjusted inventories are shown in **bolded text.**
ERDF = Environmental Restoration Disposal Facility
MT = metric tons

Table 2-2. Current ERDF Inventory for Radionuclides with Half-Lives Less than 6 Years (Decayed to 2011). (2 Pages)

Radionuclide	Waste Form	ERDF Inventory in Curies (Exceptions are in Metric Tons)	Half-Life in Years	Specific Activity (Ci/g)
Beryllium-7	Untreated	0	0.1	349,100
Cerium-144	Untreated	0.00006	0.8	3,185
Californium-252	Untreated	0	2.6	536.2
Cesium-134	Untreated	3.9	2.1	1,293
Cobalt-58	Untreated	0	0.2	31,810
Cobalt-60	Untreated	5,450	5.3	1,131
Curium-242	Untreated	0.0002	0.5	3,311
Europium-155	Untreated	120	4.8	476.2
Iron-55	Untreated	8.1	2.7	2,379
Iron-59	Untreated	0	0.1	49,790
Manganese-54	Untreated	0.001	0.9	7,751
Sodium-22	Untreated	0.000006	2.6	6,244
Promethium-147	Untreated	32.8	2.6	927.7
Radium-228	Untreated	0.2	5.8	272.7
Ruthenium-103	Untreated	0	0.1	32,320
Ruthenium-106	Untreated	0.001	1.0	3,349

Table 2-2. Current ERDF Inventory for Radionuclides with Half-Lives Less than 6 Years (Decayed to 2011). (2 Pages)

Radionuclide	Waste Form	ERDF Inventory in Curies (Exceptions are in Metric Tons)	Half-Life in Years	Specific Activity (Ci/g)
Antimony-125	Untreated	14.8	2.8	1,037
Antimony-126	Untreated	0	0.034	83,630
Tin-113	Untreated	0	0.3	10,050
Thorium-228	Untreated	0.2	1.9	819.5
Thorium-234	Untreated	0	0.1	23,150
Zinc-65	Untreated	0.000001	0.7	8,233

Adjusted inventories are shown in **bolded text.**
ERDF = Environmental Restoration Disposal Facility

Table 2-3. Current ERDF Inventory for Radionuclides with Half-Lives Greater than 6 Years and Current Inventories Less than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Waste Form	ERDF Inventory in Curies (Exceptions are in Metric Tons)	Half-Life in Years	Specific Activity (Ci/g)
Actinium-227	Untreated	0.000005	21.7	72.32
Americium-242m	Untreated	0.1	141.0	10.47
Americium-243	Untreated	0.6	7,364.3	0.1997
Bismuth-207	Untreated	0	31.8	54.38
Californium-249	Untreated	0.0009	351.1	4.089
Cesium-135	Untreated	0.1	2,400,055.8	0.001104
Curium-243	Untreated	0.1	30.0	49.03
Curium-245	Untreated	0	8,498.7	0.1716
Curium-246	Untreated	0	4,731.0	0.3072
Curium-247	Untreated	0	15,999,315.5	0.00009043
Curium-248	Untreated	0	340,013.2	0.004239
Europium-150	Untreated	0.0002	34.2	69.77
Krypton-85	Untreated	0.4	10.7	392.7
Lead-210	Untreated	0.01	22.3	76.34
Proactinium-231	Untreated	0	32,765.5	0.04723
Palladium-107	Untreated	0.02	6,496,058.0	0.0005148
Polonium-209	Untreated	0	102.1	17
Plutonium-244	Untreated	0	80,012,421.7	0.00001831
Rhenium-187	Untreated	0	49,972,114,482.7	0.00000003827
Tin-126	Untreated	0.2	100,007.6	0.02839
Titanium-44	Untreated	0.00002	47.2	172.2

Table 2-3. Current ERDF Inventory for Radionuclides with Half-Lives Greater than 6 Years and Current Inventories Less than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Waste Form	ERDF Inventory in Curies (Exceptions are in Metric Tons)	Half-Life in Years	Specific Activity (Ci/g)
Thorium-229	Untreated	0	7,339.0	0.2127
Thorium-230	Untreated	0.02	75,386.0	0.02061
Uranium-232	Untreated	0	69.8	22.07

Adjusted inventories are shown in **bolded text.**
ERDF = Environmental Restoration Disposal Facility

2.1 ERDF INVENTORY ESTIMATION AND TRACKING METHODOLOGY

Given the high rates of waste flow between the waste sites and ERDF and cost considerations, detailed characterization of waste has not been possible. To facilitate waste acceptance, a method was devised to accept waste in a timely fashion and provide real time conservative (e.g., bounding) inventory estimates that could be compared against disposal limits defined by ERDF waste acceptance criteria. This approach is functional and adequate as long as limiting disposal criteria are not exceeded or likely to be exceeded if projected wastes contained too much contamination. Thus far, this has proven to be the case.

The initial component of the waste acceptance process is a waste profile that describes the characteristics of waste from one or more contiguous sites that are being remediated simultaneously or sequentially. The waste profile describes the waste site being remediated, the nature of the waste material (e.g., soil, rubble, and fraction of each), and expected maximum radionuclide or chemical-specific concentrations in that waste. Concentrations for radionuclides are expressed as picocuries per gram (pCi/g) or curies per cubic meter (Ci/m^3). The maximum concentration estimates are based on a combination of available field characterization data and historical knowledge. Field characterization data are typically chemical analysis of waste materials to quantify specific radionuclide concentrations and/or measurements of radiation generated by radioactive decay (e.g., gamma and alpha emissions). Because the total suite of radionuclides present in a given waste material cannot be measured conveniently, scaling factors are frequently used to estimate concentrations of radionuclides not directly measured. The waste profile also includes references to relevant characterization data and historical processes that support the maximum concentration assumptions. Both electronic and paper files of waste profiles are kept in the official record.

Once the waste profile is accepted, waste materials that fit the profile can be accepted. To demonstrate that newly generated wastes fit the profile, visual observations are used to compare against the assumed material properties. A limited number of confirmation measurements are completed as the waste is generated. In this way, all waste that is shipped to ERDF can be associated with a contaminant measurement. These types of confirmatory observations can be done quickly, allowing waste shipments to occur in a timely fashion. For each shipment, an Onsite Waste Transfer Form is generated with pertinent information and kept in the official record. Each Onsite Waste Transfer Form identifies the associated waste profile, the radionuclide-specific concentrations as a fraction of the waste profile and the weight of the shipment. Given this information, total inventory estimates can be derived from concentration

and weight data. In 2005 an electronic database, WMIS, was developed to store this information. WMIS output is the source of inventory estimates described below.

Over time both revisions to existing waste profiles and generation of new waste profiles have been required. Revisions of waste profiles have frequently been required as remediation at the associated waste sites proceeds. Common reasons for revisions are changes in the types of waste materials being generated and contaminant measurements that exceed the initial or current maximum concentration estimates. New waste profiles have been required as new waste sites in different locations go through the remediation process. Since ERDF operations began, a combined total of more than 1,200 waste profiles and waste profile revisions have been developed.

To date, disposed wastes at ERDF have come primarily from remediation activities at waste sites along the Columbia River in the 100 and 300 Areas. These activities are well more than halfway completed and are planned to be largely finished by 2015. In the 200 Area, limited waste site remediation has been completed, which has provided mostly facility rubble to ERDF and some soils from waste sites. Also, pump-and-treat systems have removed parts of radioactive contamination in Central Plateau groundwater (e.g., uranium and small quantities of technetium-99).

The primary sources of uncertainty associated with quantification of currently disposed radionuclides are the limited characterization data for waste materials and the estimating methodology. Several aspects of the waste inventory estimating process lend themselves to inventory overestimation. Typically, large waste volumes are characterized by a small number of characterization analyses. To avoid underestimating radionuclide specific concentrations, waste shippers tend to select the maximum inventory concentrations that can be supported by the limited database. Because radionuclide concentrations are not homogeneously distributed at waste sites, selection of maximum values tends to represent the more concentrated waste zones rather than a true average value. Thus, the overall inventory estimate derived from the product of the selected radionuclide concentration and the waste weight ultimately overestimates the total inventory of a given waste load. The degree of overestimation tends to increase with the amount of waste associated with a given profile or waste profile revision. Secondly, since inventory estimates are identified as a fraction of the waste profile concentration, estimation of one radionuclide concentration may be greater than it should be because the fraction of another radionuclide is the basis for the entire profile.

The degree of conservatism that is imbedded in the inventory estimates is generally qualitative at best, but can be most easily addressed for radionuclides that are relatively abundant and known to be mobile in the environment. Historically, these radionuclides have been the focus of field investigations and historical process reviews. Consequently, sufficient information is available to make independent estimates of inventories from waste sites that have been remediated. Comparison of these independent estimates, with the estimated disposal inventory in WMIS, provides a numerical indication of inventory over estimates. Two prominent radionuclides that are addressed in this fashion are uranium and technetium-99 (Section 2.2).

This process becomes increasingly difficult for less abundant radionuclides and those radionuclides that are not routinely measured in field characterization studies. For these radionuclides, the assumption is made that ERDF estimates represent bounding inventories. Additional efforts will not be made to better understand uncertainty surrounding inventory estimates for low-inventory radionuclides unless they are projected to be significant contributors

to environmental risks. Where significant reductions in specific radionuclide inventories can be justified, the adjusted values will be the basis for reference case PA analyses.

In the next section, more detail about specific radionuclide inventory estimates are provided and, where alternative inventory estimates are proposed, the rationale for proposing alternative values is described.

2.2 ADDITIONAL DESCRIPTION OF RADIONUCLIDE INVENTORIES

In this section, the characteristics and inventory basis for specific radionuclides are described. The information provided includes a summarization of radioactive properties and description of primary waste site sources (e.g., processes that generated the wastes and the types of waste materials). Alternative inventory estimates and a rationale for recommending these values are provided. These discussions are provided for contaminants in Table 2-1 because these are expected to be present at closure in non-negligible quantities.

2.2.1 Technetium-99

Technetium-99 has a half-life of 211,000 years and a specific activity of 0.01711 Ci/g.

2.2.1.1 ERDF Inventory. Twenty-one curies (decayed to 2011) of technetium-99 was disposed in ERDF inventory as of August 2010. Major technetium-99 waste sources to ERDF include the 200 Area ETF (6 Ci), 183-H Evaporation Solar Basins solids and seepage liquid (3.5 Ci), and 300-FF-1 Trench soil (2 Ci). These estimates represent alternative inventory estimates to those provided in the WMIS output for wastes disposed as of August 2010. The rationale for developing alternative inventory estimates is provided below and provided in more detail in Appendix C.

A summary of the curies (can be related to mass by dividing the number of curies by the specific activity [see Table 2-1]) of technetium-99 that have been disposed at ERDF to date is summarized in Table 2-4. Inventory estimates in Column 2 are those recorded in the WMIS. In the WMIS inventory approximately 60% of the inventory has been sent to ERDF from the ETF. The ETF is an intermediate generator that has received liquid waste from numerous waste sites including 100 Area fuel storage and water retention basins, contaminated groundwater in the 200 Area, and leachate from lined solid waste disposal trenches. At the ETF, contaminated fluids were treated to remove contaminants and a residual powder was produced. The powders were packaged in drums and shipped to ERDF. Other significant sources include contaminated liquids and sludge/soil mixtures that built up in the 183-H solar evaporation basins, the 316-5 liquid disposal trench in the 300 Area, and contaminated soils and debris around a contaminated pipeline in the 200 Area. These waste sources illustrate two types of processes that underlie release of technetium-99 into the environment during operations, one relating to reactor operations in the 100 Area and the other relating to uranium fabrication and processing in the 300 and 200 Areas, respectively.

Table 2-4. Summary of Technetium-99 Sources and Quantities (Curies) Currently Disposed in ERDF (as of August 2010).

Waste Source	Disposed Technetium-99 (Ci)	
	WMIS	Adjusted
ETF	57.2	6
200 Area Waste Sites		
UP-1 Pump & Treat Operations	5.9	2
200-W-42 Pipeline Soils	3.6	1.1
300 Area Waste Sites		
316-5 Liquid Waste Disposal Trench	10.7	2
303-M Building Debris	1.7	0.2
100 Area Waste Sites		
183-H Solar Evaporation Basin	7.3	3.5
118 Burial Grounds (B, C, D, and K)	2.5	0.025
Miscellaneous Waste	6	6
Total	**94**	**21**

ERDF = Environmental Restoration Disposal Facility
ETF = Effluent Treatment Facility
WMIS = Waste Management Inventory System

In the 100 Area, reactor coolants, by far the largest volume of discharged fluid, were periodically contaminated by exposure to ruptured fuel elements in the reactors which allowed a small amount of dissolution. More concentrated contamination also occurred with lower volume fuel storage basin water where more prolonged contact with fuel elements occurred. In these waters, both dissolved technetium-99 and entrained technetium-99 bearing particulates were present in the water. Because waste site cleanup at liquid discharge locations in the 100 Area sites is largely complete, no substantial additions of technetium-99 waste to ERDF from 100 Area sources is expected (see Section 4.11).

In the 300 and 200 Areas, technetium-99 releases to the environment at CERCLA waste sites are largely associated with operations involving uranium. During operations uranium was extensively recycled in the DOE complex. To accomplish recycling, the uranium component of spent fuel was separated from plutonium and other fission products at the chemical processing facilities and Uranium Trioxide Plant in the 200 Area and then sent off site for additional treatment (e.g., the Fernald Site). This material was then returned to the Hanford Site for fabrication into fuel elements in the 300 Area and shipped to the 100 Area reactors for another irradiation campaign. Because of the nature of the uranium separations process, trace quantities of technetium-99 were always present in the separated and recycled uranium materials. Various measurements over time put trace concentration levels between 3 and 12 parts per million (ppm) (WHC-SD-WM-RPT-16).

In the 300 Area, waste liquids disposed to the liquid disposal trenches from fuel fabrication processes and burial grounds containing uranium metal and uranium oxides contained technetium-99 (e.g., 316-5 Trench). Because all of the primary liquid waste discharge facilities have been remediated, additional inventory is not expected from these sites. Most solid waste sites have also been remediated. However, additional technetium-99 is expected from future

remediation of two large burial grounds, 618-10 and 618-11 (see Section 4.11). In the 200 Area, numerous discharges of waste liquids derived from uranium separations (e.g., around U Plant) contained technetium-99. A limited number of remediation efforts for near-surface soils has been completed (e.g., the 200-W-42 pipeline), as well as removal of contaminated groundwater (e.g., the 200-UP-1 pump-and-treat operations). Additional near-surface sites and groundwater remediation efforts are expected to provide additional technetium-99 to ERDF (see Section 4.11).

In the third column of Table 2-5, adjusted inventory estimates are provided for the waste sites that have contributed large fractions of technetium-99 to ERDF during remediation and also do not agree well with site specific and/or historical data. Appendix C provides additional details. Overall, the adjusted inventory estimate for total disposed technetium-99 is about four times lower than the WMIS record. The adjusted inventory estimates are derived from several sources of information. This review supports the expectation that inventory estimates are bounding, as intended by the waste estimating process used at ERDF. The purpose of this exercise was to gain a better understanding of the accuracy and uncertainty associated with the technetium-99 inventory estimates generated by the standard waste acceptance procedures used at ERDF. A brief summary of the review that resulted in the adjusted inventory values is provided below for each site. Table 2-5 provides a summary of WMIS versus adjusted inventory estimates for the major contributing waste sites, pertinent data, and source documents that support the adjusted inventory estimates.

Table 2-5. Summary Information Used to Estimate Adjusted Technetium-99 Inventories at Major Waste Sites.

Waste Sources	Disposed Technetium-99 (Ci)		Basis for Adjustment	Source Documents
	WMIS	Adjusted		
ETF	57.2	6	Waste water analyses prior to treatment	ETF records
183-H	7.3	3.5	Documented estimate	WHC-SD-W100-TP-007, WHC-SD-WM-TRP-243
118-B, C, D, and K	2.5	0.025	Historical use; null set soils data	WHC-EP-0087
200-W-42	3.6	1.1	Soils data	BHI-00033
UP-1	5.9	2	Pump and treat project data	DOE/RL-2006-73
316-5	10.7	2	Soils data and ratio to uranium	DOE/RL-92-32

ETF = Effluent Treatment Facility
WMIS = Waste Management Inventory System

At the ETF, technetium-99 inventory in the residual powders was based on chemical analyses of stored fluids and conservatively estimated concentrating factors caused by the treatment and residual powder production processes. As part of this effort, ETF staff reviewed liquid waste sampling data for measured technetium-99 concentrations and volumes treated to derive a pretreatment inventory. The results of that analysis are that about 6 Ci of technetium-99 have been shipped to ERDF to date. Additional details are presented in Appendix C.

Adjustment of the 183-H Solar Evaporation Basin waste is based on an extensive sampling database summarized in the listed documents. Different waste types are identified including solidified liquids, sand blast grit, and sludge/sand materials. Debris and chemical analyses were completed for each material type. By taking the product of the average technetium-99 concentration and waste weight, a total inventory of 3.5 Ci is estimated, about half of the WMIS record. The 100 Area solid waste burial grounds received failed metallic pieces of equipment from reactors during operations and occasional building or construction debris. None of these materials would have contained, other than incidental technetium-99, contamination and no technetium-99 measurements have been recorded at these sites in preremediation characterization efforts. Thus, no reasonable basis for the recorded technetium-99 estimate exists. To come up with an adjusted conservative estimate of technetium-99 in these waste sites, a nominal value of 0.025 Ci has been selected (e.g., 1% of the WMIS value).

The remaining sites in Table 2-5 received uranium-bearing waste with few other contaminants other than technetium-99. Field characterization data around the 200-W-42 provided near-surface technetium-99 concentrations in soil between 1 and 300 pCi/g (with an average value of about 40 pCi/g) reflecting a small hot spot area surrounded by areas of much lower concentrations. Assuming this average concentration and the disposed waste weight of 2.83E10 g, a technetium-99 estimate of 1.1 Ci is determined, about three times less the WMIS value. The pump-and-treat operations began in 1994 and continued through 2005. Treatment consisted of groundwater filtration through resins that were then sent to ERDF. Project records of contaminants removed (DOE/RL-2006-73, *Fiscal Year 2006 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*) show that a total of 2 Ci of technetium-99 have been removed.

At the 316-5 site, which received uranium fabrication waste water, soil data were collected along one of the two liquid disposal trenches prior to the dredging of the soil (see discussion in Section 2.2.2). Like uranium, the limited soil characterization database indicates that technetium-99 inventory in the collected soil was unevenly distributed with maximum values measured about 20 m down from the inlet pipe. Concentrations ranging from 1 to 3,600 pCi/g were measured. Using as simple calculation like the one used for the adjusted uranium estimate, a technetium-99 inventory of 2.4 Ci was determined. The 316-5 site is one site both uranium and technetium-99 data are available. The ratios of uranium to technetium-99, suggested by the historical estimates for 3 to 12 ppm, match well with the data from this site. Inventories of 2.4 Ci (141 g) of technetium-99 and 24 metric tons of uranium convert to about 6 ppm. A roundup value of 3 Ci is proposed, about three times less than the WMIS record.

2.2.1.2 Uncertainty. The best, minimum and maximum quantities for technetium-99 in the ERDF inventory are as follows:

- Best: 21 Ci –the adjusted quantity.
- Minimum: 17 Ci – 20% less than the Best quantity.
- Maximum: 32 Ci – 50% more than the Best quantity to account for measurement uncertainty.

2.2.2 Uranium

The uranium inventory is composed of several isotopes including uranium-232, uranium-233, uranium-234, uranium-235, uranium-236, and uranium-238 with half-lives ranging from 159,000 to 4.5 billion years and specific activities between 3.36E-7 and 9,633 curies per gram. Of these, uranium-238 typically makes up 99.3% of the total uranium mass.

2.2.2.1 ERDF Inventory. 202 metric tons of uranium-total was disposed in ERDF inventory as of August 2010. Major uranium-total waste sources to ERDF include 300-FF-2 (62 metric tons), 316 North and South Ponds (45 metric tons), and 300 Laboratories soil and concrete (35 metric tons). These estimates represent alternative inventory estimates to those provided in the WMIS output for wastes disposed as of August 2010. The rationale for developing alternative inventory estimates is provided below and in more detail in Appendix C.

A summary of the uranium mass that has been disposed at ERDF to date is summarized in Table 2-6. Inventory estimates in column 2 are those recorded in the WMIS. Approximately 90% of the disposed waste (i.e., by mass) has been generated by remediation of waste sites in the 300 and 600 Areas where unirradiated fuel was designed and manufactured for the 100 Area reactors. Among the 300/600 Area waste sites, contamination has been predominantly distributed in the liquid waste discharge facilities and solid waste burial grounds. The liquid waste, a byproduct of fuel fabrication and various laboratory tests, contained both dissolved uranium and uranium metal particulates. The total amount of uranium estimated for a given waste site was largely a function of waste material discharged to that site. Uranium in solid waste consisted of uranium metal chips, shavings, and turnings. Additionally, soils, operational debris, and building debris are contaminated with small concentrations of uranium. With the exception of the 618-10 and 618-11 Burial Grounds (see Section 4.13), all large 300/600 Area sites have been remediated to interim closure status.

In the 100 Area, uranium was far less mobile because operational processes typically caused releases of uranium to the environment in trace quantities. Liquid waste waters exposed to radionuclides included reactor coolant, fuel storage basin water, and miscellaneous fluids (e.g., laboratory and decontamination waste waters). Reactor coolants, by far the largest volume of discharged fluid, became contaminated by exposure to ruptured fuel elements, which allowed a small amount of dissolution. More concentrated contamination occurred with lower-volume fuel storage basin water where more prolonged contact with fuel elements occurred. In these waters, both dissolved-uranium and entrained-uranium particulates were present in the water. In the solid waste sites miscellaneous particulates were produced from a variety of activities. However, deliberate discharge of uranium in solid waste facilities was incidental. Because waste site cleanup at the 100 Area sites is largely complete, no substantial additions of uranium waste to ERDF from 100 Area sources is expected (see Section 4.13).

The small quantity of uranium generated in the 200 Area is partly due to the limited amount of CERCLA remediation that has been completed. Waste sources include groundwater extracted by pump-and-treat operations and filtered at the ETF, laboratory and facility waste, and building demolition waste. Potentially large uranium sources are present in the 200 Area that could contribute to the final uranium inventory (see Section 4.13).

In the third column of Table 2-6, alternate inventory estimates are provided for the waste sites that have contributed large fractions of uranium to ERDF during remediation. These include waste sites in the 300, 600, and 100 Areas. The adjusted inventory estimates were derived from a review of historical operational information and field characterization studies conducted prior to remediation for each of the major waste sites (see Appendix C for additional details). Overall, the adjusted inventory estimate for total disposed uranium is about three times lower than the WMIS record. This review supports the expectation that inventory estimates are bounding, as intended by the waste estimating process used at ERDF. The purpose of this exercise was to gain a better understanding of the uncertainty associated with the uranium inventory estimates generated by the standard waste acceptance procedures used at ERDF. A brief summary of the review that resulted in the adjusted inventory values is provided below for each site. Table 2-6 provides a summary of WMIS versus adjusted inventory estimates for the major contributing waste sites, pertinent data, and source documents that support the adjusted inventory estimates.

Table 2-6. Summary of Uranium Waste Sources and Quantities (Metric Tons) Currently Disposed in ERDF (as of August 2010).

Disposal Area	Disposed Uranium (Metric Tons)	
	Disposed Uranium (Metric Tons)	Adjusted
300/600 Area	**604**	**167**
North and South Pond (316-1 & 2)	*216*	*44*
Liquid disposal trenches (316-4 & 5)	*27*	*26*
Burial Grounds (618-1, 2, 3, 4, 5, 7,& 8)	*226*	*61*
Unknown (ponds or burial grounds)	*100*	*1*
Other (building debris and adjacent soils)	*35*	*35*
100 Area Liquid Waste Sites	**38**	**18**
107-C (116-C-1) Liquid Disposal Trench	*20*	*1*
Other	*17*	*17*
100 Area Solid Waste Site	**3**	**3**
100 Area Facility Waste	**8**	**8**
200 Area Waste	**4**	**4**
Miscellaneous Waste	**2**	**2**
Total	**659**	**202**

Numbers shown in bold are used in the total mass calculation, while the unbolded numbers provide additional subtotal detail and have been rounded off.

The North (316-2) and South (316-1) Ponds were the primary liquid discharge facilities used in the 300 Area during the fuel fabrication period and received waste from fuel fabrication facilities and various laboratories. North Pond was used between 1948 and 1974 and the South Pond was used between 1943 and 1975. Combined liquid discharge volumes ranged between 1.5 million and 11.4 million L/day. Waste weight estimates removed during remediation are provided in the WMIS and in the work plan summary (DOE/RL-2009-30, *300 Area Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable*

Units) and are in good agreement, each estimating removal of about 140,000 metric tons from North Pond and 234,000 metric tons from South Pond. Limited soil characterization at these two sites (DOE/RL-92-43, *Phase I Remedial Investigation Report for the 300-FF-1 Operable Unit*) show the average soil contamination values listed in Table 2-7. By multiplying these values by waste weight removed, adjusted inventories of 18 and 26 metric tons for North and South Ponds, respectively, are calculated. These values are assumed to be a more accurate estimate of disposed inventory and are about five times less than the WMIS record.

Table 2-7. Summary Information Used to Estimate Adjusted Uranium Inventories at Major Waste Sites.

Waste Sites	Disposed Uranium (Metric Tons)		Basis for adjustment	Average U Concentrations (g U/g soil)	Source Documents
	WMIS	Adjusted			
300 Area (Liquid Waste Disposal)					
316-1	91	26	Soils data & documented estimate	1.1E-04	DOE/RL-92-43, PNNL-17034
316-2	125	18	Soils data & documented estimate	1.3E-04	DOE/RL-92-43, PNNL-17034
316-4	17	1	Historical use; Documented estimate		DOE/RL-2009-30
316-5	10	25	Soils data	1.8E-2 and 2.2E-4	DOE/RL-93-06
600 Area (Solid Waste Disposal)					
618-1	172	14.5	Documented estimate		DOE/RL-2009-30
618-2		14.5	Documented estimate		DOE/RL-2009-30
618-3		1	Historical use		DOE/RL-2009-30
618-7		1	Historical use		DOE/RL-2009-30
618-8		1	Historical use		DOE/RL-2009-30
618-4	25	25	None	3.4E-04	DOE/RL-92-43, DOE/RL-2009-30
618-5	29	2	Soils data	3.8E-05	DOE/RL-92-43, DOE/RL-2009-30
100 Area (Liquid Waste Disposal)					
116-C-1	20	1	Soils data	4.6E-06	DOE/RL-93-06

WMIS = Waste Management Inventory System

Disposal trench 316-4 was a small trench that received hexone-bearing uranium waste between 1948 and 1956. Historical estimates of 550 kg of uranium were discharged to this site (DOE/RL-2009-30). No field characterization data were found prior to remediation. This contrasts with the WMIS record of 17 metric tons. An adjusted estimate of 1 metric ton is based on the historical record suggesting a substantial overestimate in the WMIS record.

Disposal trench 316-5 was constructed to receive liquid waste late in the fuel fabrication period as the effectiveness of North and South Pond diminished. The 316-5 Trench operated between 1975 and 1994 and consisted of two long trenches that received process sewer water from numerous facilities. Because of sludge and contamination level buildup, an Expedited Response Action was undertaken to dredge most of the trench and place the materials (about 5,400 metric tons/trench) into a spoils pile at the north end of the facility. This material and less contaminated trench material were ultimately disposed in ERDF. Prior to the Expedited Response Action, several samples were taken along the trenches showing very high uranium concentrations near the waste entry points at the south end (about 15,000 pCi/g) for about 20 m and much lower concentrations (about 200 pCi/g) along the remainder of the trenches. Using these values and the dredged waste weight a total uranium inventory of 24 metric tons was calculated. In the adjusted estimate, an extra 1 metric ton is added for contiguous materials removed along with the spoil pile, about 29 metric tons of additional soil. For this waste site, the historical and field data indicate that the WMIS record underestimated disposed inventory by a factor of two and a half times. This is the only waste site where the WMIS estimate is lower than the adjusted value.

Solid waste sites in the 300 and 600 Areas, which have contributed the majority of uranium to ERDF, include seven facilities. In the WMIS record burial grounds 618-1, -2, -3, -7, and -8 are lumped together providing a uranium estimate of 172 metric tons. For these facilities preremediation field characterization data were not found. However, historical estimates (DOE/RL-2009-30) suggest that the actual uranium inventory is substantially smaller. The largest reported estimate is 14.5 metric tons disposed and 618-1, the first burial ground put into use between 1945 and 1951. Burial ground 618-2 followed and operated between 1951 and 1954. For purposes of estimating an adjusted inventory estimate, the same amount of uranium disposal in 618-2 is assumed. During these early periods it is reasonable to expect that more uranium waste was disposed, but over time more care would have been taken to minimize uranium disposal. Burial ground 618-3 was used in 1954 and 1955 and received primarily building waste. Burial ground 618-7 operated between 1960 and 1973, receiving contaminated equipment and hundreds of 114-L drums containing uranium-contaminated zircaloy chips. Burial ground 618-8 operated between 1943 and 1954 and received uranium-contaminated construction debris. These descriptions suggest the disposal of less contaminated materials compared to 618-1 and 618-2 (e.g., building materials versus fuel fabrication waste) and an adjusted inventory of 1 metric ton at each site. Altogether, the adjusted uranium quantity is 32 metric tons, a little more than a five-fold reduction relative to the WMIS record.

In the WMIS record, waste from burial ground 618-4 is disposed with three other small landfills. In addition to contaminated soil and debris, the notable waste material in 618-4 was drummed uranium chips and uranium oxide stored in oil because of their pyrophoric characteristics. A total of 768 drums containing about 2 metric tons of uranium were ultimately grouted and disposed. An additional 23 metric tons of uranium are also provided in the WMIS record. Preremediation soil sample data (DOE/RL-92-43) show average soil concentration data that when multiplied by the waste weight (about 105,000 metric tons) yields a uranium inventory estimate that is in reasonable agreement with the WMIS record. Therefore, the adjusted value shows no change.

Waste from burial ground 618-5 contains about 29 metric tons according to the WMIS record. Burial ground 618-5 operated from 1945 through 1962, primarily as a burn pit for uranium-bearing trash. Materials removed from the pit included lead bricks, steel pipes, wood fragments, and other garbage. Preremediation soil analyses showed an average uranium concentration of approximately 15 pCi/g (about 3.6E-5 g of uranium per g of waste in Table 2-7). This average is lower than the other sites discussed above and expected given the historical description of waste materials. Using this average and an assumed total waste mass of about 47,000 metric tons, a uranium mass of about 2 metric tons is estimated, about 15 times lower than the WMIS record.

The final quantity in the WMIS record is labeled as unknown and assumes a substantial disposed uranium mass inventory of 100 metric tons. The record shows the only other contaminants in this material as small amounts of cesium-137 and strontium-90. Therefore, a 300 Area waste site source is clearly indicated. However, the site or sites involved are highly uncertain. Furthermore, several observations suggest that this is a largely fictitious waste stream. First, the very high inventory to waste mass ratio (100 metric tons of uranium in 73,000 metric tons of waste) is nearly an order of magnitude higher than the same ratio for any other 300 Area site, assuming adjusted inventory values. Second, comparison of estimated waste masses for the various sites between the WMIS record and work plan estimates (DOE/RL-2009-30) are in relatively good agreement where available. Consequently, a discrepancy of 73,000 metric tons is not obvious. Given these observations, an adjusted inventory of 1 metric ton is assumed (Table 2-6) to approximate inventory in miscellaneous waste.

Finally, one waste site in the 100 Area provides a significant contribution to the disposed uranium inventory in ERDF, almost half of all 100 Area sites. Liquid disposal trench 107-C (116-C-1) was a process effluent trench in the 100-C Area that received 700 million L of reactor coolant water from the 100-BC Area Retention Basins. These fluids were radioactively contaminated by exposure to ruptured fuel elements. Such waters are not expected to contain high uranium concentrations as uranium metal was not highly soluble in the reactor. Preremediation soil samples at the trench (DOE/RL-93-06) confirm this expectation, showing uranium concentration less than 2 pCi/g (i.e., about 5E-6 g of uranium per g of soil in Table 2-7). Using these estimates, about 2 metric tons of uranium are projected in the 115,000 metric tons of waste sent to ERDF from the 116-C-1 waste site. This estimate is twenty times lower than the WMIS record.

2.2.2.2 Uncertainty. The best, minimum and maximum quantities for uranium-total in the ERDF inventory are as follows:

- Best: 202 MT – The adjusted quantity.
- Minimum: 160 MT – 20% less than the Best quantity.
- Maximum: 260 MT – 30% more than the Best quantity to account for limitations of historical characterization data.

2.2.3 Carbon-14

Carbon-14 has a half-life of 5.73 thousand years and a specific activity of 4.455 Ci/g.

2.2.3.1 ERDF Inventory. Carbon-14 is identified in three waste groups in ERDF: untreated (soluble), activated metal, and insoluble. A total of 1,888 Ci (decayed to 2011) of carbon-14 was disposed in ERDF inventory as of August 2010. Of the 1,888 Ci, 35 Ci (2%) was untreated waste, 98 Ci (5%) was activated metal, and 1,755 Ci (93%) was insoluble waste. These estimates represent alternative inventory estimates to those provided in the WMIS output for wastes disposed as of August 2010. The rationale for developing alternative inventory estimates is provided below.

In all cases carbon-14 is derived from two waste material types, graphite blocks in the reactors that housed the uranium fuel rods and steel reactor parts containing trace amounts of carbon impurities. These materials make up the bulk of inventory identified as insoluble or activated metal waste. With irradiation a fraction of the local carbon was activated to form carbon-14. Waste materials were generated by replacement of metal parts in the reactors and machining or incidental removal of the graphite block materials. These waste materials were mostly deposited in reactor site-specific burial grounds dedicated to the receipt of used reactor parts. Major carbon-14 waste sources to ERDF include the 118-B/C Burial Grounds (669 Ci), 118-K-1 Burial Ground (560 Ci), and 1706-KE waste treatment plant materials (328 Ci in concrete and steel). Much smaller quantities of carbon-14 were either dissolved or carried as particulate matter in liquid discharges. The major liquid discharge waste site source for carbon-14 has been the 116-N-1 Trench in the 100 Area (9 Ci).

These values are recommended alternatives to those listed in the WMIS but differ largely in the assumed distribution of the inventory among the three categories rather than a total inventory change. These changes have resulted from a review of records by staff personnel at ERDF and reflect inconsistencies in the use of the definitions of the three groups. The biggest change is a reduction in the quantity assigned to the untreated carbon-14 group from 527 to 35 Ci (not decayed values) by shifting the 1706-KE inventory from untreated to insoluble waste. This waste was primarily piping material through which waste water flowed. The project engineer argued that a soluble contaminant could not have remained in the piping during operations and must, therefore, be fairly soluble.

2.2.3.2 Uncertainty. The best, minimum, and maximum quantities for carbon-14 in the ERDF inventory are as follows:

- Best: 1,888 Ci – The adjusted quantity.
- Minimum: 1,500 Ci – 20% less than the Best quantity.
- Maximum: 2,500 Ci – 30% more than the Best quantity to account for measurement uncertainty (assume same percent distribution for waste forms).

2.2.4 Calcium-41, Nickel-59, Nickel-63, Molybdenum-93, Niobium-93m, Niobium-94, Zirconium-93, Silver-108m, and Barium-133

Calcium-41 has a half-life of 103,000 years and a specific activity of 0.085 Ci/g. Nickel-59 has a half-life of 76,000 years and a specific activity of 0.07982 Ci/g. Nickel-63 has a half-life of 99.0 years and a specific activity of 57.38 Ci/g. Molybdenum-93 has a half-life of 3,000 years and a specific activity of 1.28 Ci/g. Niobium-93m has a half-life of 16.1 years and a specific activity of 238.6 Ci/g. Zirconium-93 has a half-life of 1.53 million years and a specific activity of 0.0025 Ci/g. Niobium-94 has a half-life of 20,000 years and a specific activity of 0.19 Ci/g.

Silver-108m has a half-life of 418 years and a specific activity of 7.9 Ci/g. Barium-133 has a half-life of 10.6 years and a specific activity of 254 Ci/g.

2.2.4.1 ERDF Inventory. These radionuclides are discussed together because they were primarily produced by activation of trace elements in metals (primarily aluminum and steel) present and irradiated in the reactors. These materials were then disposed in the major burial grounds at each reactor site. Alternative inventory estimates are proposed for these radionuclides and are shown in Table 2-8 along with the WMIS values as of August 2010. The rationale for changing these inventories is provided below.

Alternative inventory estimates for the activation products are shown in the far right column of Table 2-8 and range from 0.1 to 11,000 Ci. The WMIS inventory estimates are broken down by burial ground and other waste sites. Note that at least 50% of the WMIS inventory for each isotope came from these burial grounds. Other notable waste materials for nickel-59 and nickel-63 are soil and debris around reactor buildings. Alternative inventories for the activation products are based on a comprehensive review of metallic waste produced reactor operations (WHC-EP-0087, *Estimates of Solid Waste Buried in the 100 Area Burial Grounds*).

In 1987, a detailed discussion of waste materials produced during the 100 Area operations and disposed in the burial grounds was developed. The quantities and contamination levels of activation products were estimated. This information is summarized in Table 2-9. Two large waste streams by weight are aluminum tubing and spacers, and lead cadmium poison splines. Fuel elements were inserted and removed from the tubing in the reactor block and spacers kept the fuel elements centered. The tubing contained small nickel impurities, thereby, providing the largest inventory estimates for the nickel isotopes. Lead cadmium splines were used to control reactor fission rates and contained trace quantities of barium and silver, which when activated produced silver-108m and barium-133. Smaller quantities of zirconium cladding and silica gel desiccant were also disposed. Zirconium disposal is limited because aluminum was the primary material used to clad the fuel elements in reactors providing waste to these burial grounds. Niobium isotopes were created by decay of zirconium-93 and activation niobium metal, which is present at trace levels in zirconium metal. Finally, some calcium-41 is associated with the silica gel desiccant material.

In the last column the WMIS inventory estimates for these radionuclides is compared to the 1987 estimates. With the exception of barium-133, the WMIS inventories are more than 10 times higher. This comparison shows the bounding nature of the waste contamination level estimating process used to determine waste acceptance at ERDF.

The explanation for the higher values is assumed to occur because average concentration values used for all of the waste were more representative of the metallic waste while the majority of the waste (e.g., trash, soil and debris) was far less contaminated by these radionuclides. The total estimated amount of metallic waste was about 2,300 metric tons, compared to an estimated 1.2 million metric tons that have been removed from the burial grounds and disposed in ERDF. Given this difference, overestimates are expected. Adjusted values are proposed that allow no more than five times the original estimate plus contributions from the other sources that are left unchanged.

Table 2-8. Summary of Waste Sources and Quantities (Undecayed Curies) Currently Disposed in ERDF (as of August 2010).

	Burial Ground Inventory (Ci)						Other Waste Sites (Ci)	Disposed Inventory (Ci)	
	118-K-1	118-B/C-1	118-D-2	118-F-1	118-H-1	Burial Ground Total		WMIS total	Adjusted
Calcium-41	6	3	0.5			9.4	0.3	9.7	0.3
Nickel-59	67	90	20	1.6	1.4	180	108	288	125
Nickel-59 AM	555	250	148	109		1,062	5	1,067	65
Nickel-63	29	69	13,300		134	13,532	5,549	19,081	11,000
Nickel-63 AM	3,873	2,259	4,411	3,804	119	14,466	37	14,503	4,000
Molybdenum-93	0.9		0.9			1.7	0.4	2.1	0.5
Niobium-93m	1.3		0.4	17		19.0	4.9	23.9	6
Zirconium-93	0.1		39	26		64.9	5.8	70.8	16
Niobium-94	3		3.1			6.4	0.2	6.6	0.2
Niobium-94 AM	0.2		0.4	1.6		2.2	0.0	2.2	0.1
Silver-108m	388	134	72	1.2	38	632	4	636	250
Barium-133	5	0.9	0.2		0.6	6.3	0.7	7.1	7

AM = activated metal
ERDF = Environmental Restoration Disposal Facility
WMIS = Waste Management Inventory System

Table 2-9. Summary Information Used to Estimate Adjusted Activation Product Inventories at Major Waste Sites.

Radionuclide	WHC-EP-0087 data			WMIS Inventory (Ci)	Inventory Ratio (WMIS/ WHC-EP-0087)
	Waste Type	Waste Weight (Metric Tons)	Inventory (Ci)		
Calcium-41	Desiccant	6	0.06	10	161
Nickel-59	Aluminum tubing and miscellaneous waste	1,989	15	288	90
Nickel-59 AM				1,067	
Nickel-63			1,898	19,081	18
Nickel-63 AM				14,503	
Molybdenum-93	Zirconium cladding	45	0.03	2.1	70
Niobium-93m				24	
Niobium-94			0.07	6.6	126
Niobium-94 AM				2.2	
Zirconium-93			2.1	71	34
Silver-108m	Lead cadmium poison pieces	1,828	48	636	13
Barium-133			3	7.1	2

AM = activated metal
WMIS = Waste Management Inventory System

2.2.4.2 Uncertainty. The best, minimum and maximum quantities for nickel-63 in the ERDF inventory are as follows:

1. Best: 15,000 Ci – The adjusted quantities (see Table 2-8 for waste form distribution).

2. Minimum: 12,000 Ci – 20% less than the Best quantity (scale waste forms).

3. Maximum: 20,000 Ci – 30% more than the Best quantity to account for measurement uncertainty.

2.2.5 Cesium-137 and Strontium-90

Cesium-137 has a half-life of 30.2 years and an activity of 86.55 Ci/g. Strontium-90 has a half-life of 28.6 years and an activity of 138.8 Ci/g.

2.2.5.1 ERDF Inventory. A total of 14,600 Ci (decayed to 2011) of cesium-137 was disposed in ERDF inventory as of August 2010. Major cesium-137 waste sources to ERDF include K Basin concrete and steel (6,036 Ci), K Basin ion-exchange modules (3,344 Ci), and 116-N-1 soil and concrete (2,024 Ci). A total of 11,400 Ci of strontium-90 was disposed in ERDF inventory as of August 2010. Major strontium-90 waste sources to ERDF include K Basins ion-exchange modules (4,205 Ci), K Basin concrete and steel (4,107 Ci), ETF (613 Ci), and 118-B/C burial grounds (391 Ci). Cesium-137 and strontium-90 are grouped together because both are relatively abundant and soluble fission products that have entered numerous waste streams from contact between water or other fluids with ruptured and dissolved

fuel elements. Currently, most of the ERDF waste has come from the 100 Area where ruptured fuel and water came into contact, either in the reactor or fuel storage basins. The contaminated reactor coolant water was less contaminated than fuel storage basin water but much more abundant. Highly contaminated particulates also formed in the storage basins that could have been entrained in the water. Both types of water were routinely discharged into various nearby trenches and water retention basins during operations. These processes are clearly indicated by the fact that the major waste site contributors to the current inventory are liquid disposal facilities. No more than 10% of the waste is associated with solid waste sites.

2.2.5.2 Uncertainty. The best, minimum and maximum quantities for cesium-137 in the ERDF inventory are as follows:

- Best: 14,600 Ci – The WMIS quantity.
- Minimum: 12,000 Ci – 20% less than the Best quantity.
- Maximum: 19,000 Ci – 30% more than the Best quantity to account for measurement uncertainty.

2.2.5.3 Uncertainty. The best, minimum and maximum quantities for strontium-90 in the ERDF inventory are as follows:

- Best: 11,400 Ci – The WMIS quantity.
- Minimum: 9,000 Ci – 20% less than the Best quantity.
- Maximum: 15,000 Ci – 30% more than the Best quantity to account for measurement uncertainty.

2.2.6 Chlorine-36

Chlorine-36 has a half-life of 302,000 years and a specific activity of 0.03291 Ci/g.

2.2.6.1 ERDF Inventory. No chlorine-36 was disposed in ERDF inventory as of August 2010. Very few waste materials are expected to contain more than negligible amounts of chlorine-36. The one source that will contain significant quantities is the reactor graphite cores (see Section 3.0), which have not been disposed.

2.2.6.2 Uncertainty. The best, minimum and maximum quantities for chlorine-36 in the ERDF inventory are as follows:

- Best: 0 Ci – The WMIS quantity.
- Minimum: 0 Ci – The WMIS quantity.
- Maximum: 0 Ci – The WMIS quantity.

2.2.7 Iodine-129

Iodine-129 has a half-life of 15.7 million years and a specific activity of 0.0001768 Ci/g.

2.2.7.1 ERDF Inventory. A total of 0.019 Ci (decayed to 2011) of iodine-129 was disposed in ERDF inventory as of August 2010. Major iodine-129 waste sources to ERDF include 200-BC cribs, trenches, and control area (0.016 metric tons) and the 327 Building (0.002 Ci). Iodine-129 is readily soluble and likely to be found in any liquid waste stream, at least at low concentrations. Iodine-129 would have entered numerous waste streams from contact between water or other fluids such as processing fluid with ruptured and dissolved fuel elements. Concentrated amounts of iodine are unlikely to be present in most waste streams except for fluids generated during the refurbishment of silver saddle filters used in the processing facilities to prevent airborne release of iodine. None of these fluids or silver saddles is disposed at ERDF.

2.2.7.2 Uncertainty. The best, minimum, and maximum quantities for iodine-129 in the ERDF inventory are as follows:

- Best: 0.019 Ci – The WMIS quantity.
- Minimum: 0,015 Ci – 20% less than the Best quantity.
- Maximum: 0.03 Ci – 50% more than the Best quantity to account for measurement uncertainty.

2.2.8 Transuranic Isotopes (Plutonium-Total and Americium-241)

Plutonium-total includes plutonium-238, plutonium-239, plutonium-240, plutonium-241 (not a TRU isotope), and plutonium-242. Plutonium-239 has a half-life of 24,000 years and a specific activity of 0.062 Ci/g. An average of 99.8 weight percent of the plutonium isotopic ratio is plutonium-239 (94.6%) and plutonium-240 (5.2%). The isotopic ratio will change based on weapons grade, fuels grade, or commercial grade material. ERDF WMIS records show an average of 84.4% plutonium-239 and 10.9% plutonium-240. These isotopic percentages reflect ERDF's receipt of fuels grade waste from the K Basin.

Other TRU isotopes that are recorded as present in the ERDF waste inventory include americium-241 (half-life of 433 years and specific activity of 3.427 Ci/g), americium-242m (141-year half-life), americium-243 (7,370-year half-life), neptunium-237 (2.14-million year half-life), curium-243 (30-year half-life), curium-245 (half-life of 8,500 years) and curium-246 (half-life of 4,700 years).

2.2.8.1 ERDF Inventory. A total of 0.00477 metric tons of plutonium-total was disposed in ERDF inventory as of August 2010. Major plutonium-total waste sources to ERDF include 100-K Basin concrete and steel (0.0013 metric tons), soils from the primary liquid disposal trenches at 100-N Area (0.0010 metric tons from 116-N-1 and 166-N-3), and 116-C trench soils (0.0008 metric tons). Similarly, over 60% of the disposed americium-241 came from the 100-K Basin (316 Ci) and 14% from 116-N trench soils (70.7 Ci). Curium-244 is more evenly distributed with 26% (0.42 Ci) in 100-K Basin concrete and steel, 18% in the 116-N-1 soil, and 13% (0.21 Ci) in 118-K-1 Burial Ground debris. Because none of these isotopes are soluble, it is likely that particulates from rupture fuel elements entrained in liquid discharges were the primary waste stream source, particularly fluids that covered spent fuel in the fuel storage basin. Plutonium-total in debris disposed in ERDF from cleanup of the 327 Radiometallurgy Facility and PFP are 0.00003 metric tons and 0.00002 metric tons, respectively. The average waste received from PFP is less than 1 nCi of TRU constituents per gram of waste.

Inventories for the remainder of the TRU radionuclides are all less than 1 Ci as expected given the relative abundances produced by fission the 100 Area reactors. None of these radionuclides, plutonium, or americium-241 are disposed at concentrations above the TRU shallow burial disposal limit of 100 nCi of transuranics per gram of waste.

2.2.8.2 Uncertainty. The best, minimum, and maximum quantities for plutonium-total in the ERDF inventory are as follows:

- Best: 0.00477 MT – The WMIS quantity.
- Minimum: 0.0038 MT – 20% less than the Best quantity.
- Maximum: 0.0062 MT – 30% more than the Best quantity to account for measurement uncertainty.

2.2.9 Tritium (H-3)

Tritium (H-3) has a half-life of 12.3 years and an activity of 9,613 Ci/g.

2.2.9.1 ERDF Inventory. A total of 7,790 Ci (decayed to 2011) of tritium was disposed in ERDF inventory as of August 2010. Major tritium waste sources to ERDF include the 325 Facility (2,258 Ci), 118-B/C Burial Ground (1,051 Ci), and 100-N Area (861 Ci). Like cesium and strontium, tritium is an abundant fission product that has been found in essentially all waste materials. The inventory estimates suggest that tritium has frequently been trapped in solid materials. Also, numerous controlled laboratory experiments in the 300 Area have been done with tritium creating waste subsequently disposed in ERDF.

2.2.9.2 Uncertainty. The best, minimum, and maximum quantities for tritium in the ERDF inventory are as follows:

- Best: 7,790 Ci – The WMIS quantity.
- Minimum: 6,200 Ci – 20% less than the Best quantity.
- Maximum: 10,000 Ci – 30% more than the Best quantity to account for measurement uncertainty.

2.2.10 Potassium-40 (K-40)

Potassium-40 has a half-life of 1.28 billion years and an activity of 0.000007 Ci/g.

2.2.10.1 ERDF Inventory. Potassium-40 is a naturally occurring radioactive isotope of potassium. The inventory presented in Table 2-1 represents that no significant quantity of potassium-40 beyond that occurring naturally is disposed in ERDF. Potassium-40 was not generated during Hanford reactor operations.

2.2.10.2 The best, minimum, and maximum quantities for potassium-40 in the ERDF inventory are as follows:

- Best: 0 Ci – The amount above natural occurring K-40 is insignificant.
- Minimum: 0 Ci – Same as the Best quantity.
- Maximum: 1 Ci – Assumes that significantly higher quantities of potassium in small sources (i.e., glass bottles) from non-Hanford reactor-generated material are disposed in ERDF.

2.2.11 Miscellaneous Radionuclides

Other radionuclides identified in Table 3-1 include europium-152 (half-life of 13.5 years and specific activity of 174 Ci/g), europium-154 (half-life of 8.6 years and specific activity of 270 Ci/g), samarium-151 (half-life of 90 years and specific activity of 26.3 Ci/g), cadmium-113m (half-life of 13.7 years and specific activity of 231 Ci/g), thorium-232 (half-life of 14 billion years and specific activity of 1.1E-7 Ci/g), radium-226 (half-life of 1,600 years and specific activity of 0.99 Ci/g), selenium-79 (half-life of 650,000 years and a specific activity of 0.07 Ci/g) and tin-121m (half-life of 55 years and specific activity of 53.8 Ci/g).

2.2.11.1 ERDF Inventory. A total of 0.9 Ci of radium-226 was disposed in ERDF with the primary waste sources being solid wastes from various locations. The primary waste sites are 300 Area burial grounds (38%) and a 100 Area burn pit (14%). Europium-152 and europium-154 have recorded inventories of 6,250 and 2,030, respectively. Waste site sources are mostly soils contaminated by liquid discharges in the 100 Area (about 80% to 90%), with most of the remainder present in 100 Area burial ground waste. Samarium-151 and cadmium-113m have recorded inventories of 269 and 3.9 Ci, respectively. The common primary waste site for these radionuclides are steel and lead casks from the 327 Building (35% to 51%) followed by solid waste from the 100-K Basin. Waste sources for thorium-232 (1.1 Ci) are solid waste sites, with the 300 Area burial grounds (40%) being the dominant source.

Inventory distributions among waste profiles for two radionuclides, selenium-79 and tin-121m indicate that inventory estimates have been calculated incorrectly. For each radionuclide the inventory in one waste profile is at least one order of magnitude greater than the next highest waste profile value and comparison of the average concentration in waste (Ci/kg) are similarly large. To correct these discrepancies, the lower average waste concentrations from similar waste profiles are applied to the outstanding waste profile value, thereby reducing the estimated inventory.

For selenium-79, 35 out of 35.1 total curies are recorded in three waste profiles for the 100-D burial grounds with an average concentration of about 10^{-7} Ci/kg of waste. Other waste profiles for waste in this burial ground record an average concentration of 10^{-12} Ci/kg of waste. Therefore, the inventories for these profiles are dropped by a factor of 10,000 for a total inventory of 0.07 Ci in the 100-D burial grounds. For tin-121m, 18 out of 18.1 total curies are recorded for debris wastes in one waste profile from the 1706-KE waste treatment facility. The waste concentration in this waste profile is about 10^{-5} versus 10^{-7} Ci/kg in other wastes from this facility. To correct this discrepancy, the 18 Ci estimate is reduced by a factor of a hundred, leaving a total estimated inventory of 0.3 Ci.

3.0 HANFORD SITE INVENTORY TOTALS AND DISTRIBUTIONS FOR KEY RADIONUCLIDES

In this section, radionuclide-specific inventories on and shipped off the Hanford Site are estimated from historical documents, ongoing databases, and knowledge of Site operations. ORIGEN runs and material processed through T Plant, B Plant, REDOX, and PUREX history (HNF-SD-WM-TI-794, *Activity of Fuel Batches Processed through Hanford Separations Plants, 1944 Through 1989*) were used to compare Hanford inventories with radionuclides generated from 100 Area reactor operations and irradiated fuel processed. Key radionuclides are those that are relatively abundant and/or environmentally mobile. Sources of radionuclide inventories include the following:

- Stored waste and fuels (i.e., irradiated fuel stored at the CSB [ISA is not included], high-level waste in tank farms, cesium and strontium in capsules at WESF, German logs stored at 2420-W, TRU waste stored at the Solid Waste Operating Complex [SWOC] including the Central Waste Complex [CWC], Waste Receiving and Processing Facility [WRAP] and T Plant, retrievably stored waste in the 200 Area burial grounds), K Basin sludge

- Disposed waste (i.e., *Resource Conservation and Recovery Act of 1976* [RCRA] wastes in the 218-W-5 mixed waste disposal trenches (MWDTs) 31 and 34, defuel naval reactor cores in the 218-E-12B Trench 94, commercial waste in the US Ecology facility, CERCLA waste in ERDF)

- Liquid waste sites (e.g., 200-PW-1/3/6)

- Groundwater

- Solid waste sites (i.e., 200-SW-2 Burial Grounds, 618-10 and 618-11 Burial Grounds, 100-K Burial Grounds)

- Residual waste in facilities (i.e., 324 Facility, PFP, 100 Area reactor cores, specific equipment in canyons and tunnels, filters; the Fast Flux Test Facility [FFTF] is not included)

- Shipped material (e.g., uranium shipped off site).

The quantity (curies or metric tons) of the specific radionuclide at Hanford and in material shipped off site is provided in this section and in Appendices A and B. Uncertainty inherent in the quantities is discussed. The bases for information are provided in Section 7.2. All radionuclide quantities have been decayed to 2011. The approximate quantities have been rounded to two significant figures.

Tables 3-1, 3-2, and 3-3 provide estimates of Hanford Site-specific radionuclides consistent with tables in Section 2.0.

Table 3-1. Estimated Hanford Radionuclides with Half-Lives Greater than 6 Years and/or Current ERDF Inventories Greater than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Estimated Hanford Curies (Exceptions are in Metric Tons)	Comments
Silver-108m	250	
Americium-241	570,000	Shipped material and stored plutonium-241 that has decayed to americium-241 (as a product or fuel) is not included. 370,000 Ci at CSB
Barium-133	38	27 Ci on 100 Area reactor graphite and bio-shields
Carbon-14	54,000	See Section 3.1
Calcium-41	700	690 Ci on 100 Area reactor graphite and bio-shields
Cadmium-113m	5,500	3,300 Ci in tank waste
Chlorine-36	310	See Section 3.3
Cesium-137	91,000,000	See Section 3.2
Curium-244	2,000	980 Ci at CSB
Europium-152	8,300	4,800 Ci at ERDF
Europium-154	93,000	48,000 Ci at CSB
Tritium	780,000	See Section 3.9
Iodine-129	56	See Section 3.4
Potassium-40	0	0 Ci at ERDF
Molybdenum-93	0.5	0.5 Ci at ERDF
Niobium-93m	3,000	2,800 Ci in tank waste
Niobium-94	23	15 Ci in 200 West Area LLBG
Nickel-59	9,000	5,100 Ci in 200 East LLBG 218-E-12B Trench 94 reactor cores
Nickel-63	2,100,000	See Section 3.5
Neptunium-237	230	120 Ci in tank waste
Plutonium-238	7,100	Shipped and stored plutonium (as a product or fuel) is not included
Plutonium-239	150,000	Shipped and stored plutonium (as a product or fuel) is not included
Plutonium-240	33,000	Shipped and stored plutonium (as a product or fuel) is not included
Plutonium-241	250,000	Shipped and stored plutonium (as a product or fuel) is not included
Plutonium-242	240	Shipped and stored plutonium (as a product or fuel) is not included. Nearly all plutonium-242 is at US Ecology.
Plutonium Total	2.6 MT	See Section 3.6. Shipped and stored plutonium (as a product or fuel) is not included

Table 3-1. Estimated Hanford Radionuclides with Half-Lives Greater than 6 Years and/or Current ERDF Inventories Greater than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Estimated Hanford Curies (Exceptions are in Metric Tons)	Comments
Radium-226	240	230 Ci at US Ecology
Selenium-79	240	150 Ci in tank waste
Samarium-151	4,100,000	3,900,000 Ci in tank waste
Tin-121m	140	70 Ci at CSB
Strontium-90	74,000,000	See Section 3.7
Technetium-99	35,000	See Section 3.8
Thorium-232	48	28 Ci in 200 West Area LLBG
Uranium-233	14,000	
Uranium-234	43,000	
Uranium-235	1,800	
Uranium-236	1,400	
Uranium-238	40,000	
Uranium Total	120,000 MT	See Section 3.10
Zirconium-93	4,200	3,700 Ci in tank waste

CSB = Canister Storage Building
ERDF = Environmental Restoration Disposal Facility
LLBG = low-level burial ground
MT = metric tons

Table 3-2. Estimated Hanford Radionuclides with Half-Lives Less than 6 Years (Decayed to 2011). (2 Pages)

Radionuclide	Estimated Hanford Curies (Exceptions are in Metric Tons)	Comments
Beryllium-7	0	
Cesium-144	0.2	0.1 Ci at CSB
Californium-252	0	
Cesium-134	1,900	780 Ci at US Ecology
Cobalt-58	0	
Cobalt-60	810,000	470,000 Ci at US Ecology
Curium-242	1.2	1.2 Ci in tank waste
Europium-155	22,000	17,000 Ci in tank waste
Iron-55	110,000	80,000 Ci in trench 94 reactor cores
Iron-59	0	
Manganese-54	0.2	0.2 Ci in the MWDTs
Sodium-22	3.2	3.2 Ci at US Ecology
Promethium-147	120,000	61,000 Ci in tank waste
Radium-228	5.2	4.8 Ci in tank waste

Table 3-2. Estimated Hanford Radionuclides with Half-Lives Less than 6 Years (Decayed to 2011). (2 Pages)

Radionuclide	Estimated Hanford Curies (Exceptions are in Metric Tons)	Comments
Ruthenium-103	0	
Ruthenium-106	3.4	1.9 Ci at CSB
Antimony-125	6,700	2,700 Ci at CSB
Antimony-126	0.01	0.01 Ci in 118-K-1 Burial Ground
Tin-113	0	
Thorium-228	0.7	0.3 Ci in tank waste
Thorium-234	20	618-10 Burial Ground
Zinc-65	0.000001	0.000001 Ci at ERDF

CSB = Canister Storage Building
ERDF = Environmental Restoration Disposal Facility
MWDT = mixed waste disposal trench

Table 3-3. Estimated Hanford Radionuclides with Half-Lives Greater than 6 Years and Current Inventories Less than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Estimated Hanford Curies (Exceptions are in Metric Tons)	Comments
Actinum-227	3.9	3.8 Ci in tank waste
Americium-242m	360	190 Ci at CSB
Americium-243	210	120 Ci at CSB
Bismuth-207	0	
Californium-249	0.0009	0.0009 Ci at ERDF
Cesium-135	1,200	1,100 Ci in tank waste
Curium-243	23	21 Ci at CWC
Curium-245	0.1	0.1 Ci in tank waste
Curium-246	0.002	0.002 Ci in tank waste
Curium-247	0	
Curium-248	0	
Europium-150	0.004	0.004 Ci in tank waste
Krypton-85	340,000	310,000 Ci at CSB
Proactinium-231	150	150 Ci in tank waste
Lead-210	15	15 Ci at US Ecology
Palladium-107	16	16 Ci at CSB
Polonium-209	0	
Plutonium-244	0	
Rhenium-187	0.000009	0.000009 Ci in tank waste
Tin-126	520	420 Ci in tank waste

Table 3-3. Estimated Hanford Radionuclides with Half-Lives Greater than 6 Years and Current Inventories Less than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Estimated Hanford Curies (Exceptions are in Metric Tons)	Comments
Titanium-44	0.00002	0.00002 Ci at ERDF
Thorium-229	0.9	0.9 Ci in tank waste
Thorium-230	2.0	1.9 Ci at US Ecology
Uranium-232	2,900	

CSB = Canister Storage Building
CWC = Central Waste Complex
ERDF = Environmental Restoration Disposal Facility

3.1 CARBON-14

Of the approximately 54,000 Ci of carbon-14 about 50,000 Ci is at the Hanford Site and 3,900 Ci is in product that has been shipped off site. The major components (~99.9%) of the 50,000 Ci include the following:

- 100 Area reactors graphite (~42,000 Ci)
- US Ecology (~4,000 Ci)
- ERDF (~1,900 Ci)
- CSB (~690 Ci)
- Tank waste (~560 Ci)
- Trench 94 reactor cores (~350 Ci)
- Waste in the 200 Area LLBG (SW-2 Operable Unit) (~240 Ci)
- 200 Area CERCLA liquid waste sites and tank leaks (~200 Ci).

The process that has produced well over 90% of the carbon-14 has been irradiation of the graphite blocks in the 100 Area reactors. The secondary process has been activation of trace carbon constituents in metals within the 100 Area reactor radiation field, and to a lesser degree in other radiation fields (e.g., defueled naval reactor compartments in 218-E-12B Trench 94).

Uncertainties: Estimates from year 1985 of the 100 Area reactors graphite inventory have the greatest uncertainty. Given the large fraction of the graphite core source term total inventory, estimate uncertainty is likely associated with extrapolation of the core inventories from the limited sampling information extrapolated over large material volumes. Authors of the characterization study (UNI-3714, *Radionuclide Inventory and Source Terms for the Surplus Production Reactors at Hanford*) for these materials indicate that the estimates were meant to be conservatively high. Thus, the listed values are assumed maximum values.

3.2 CESIUM-137

Of the approximately 91 million Ci (decayed) of cesium-137 about 89 million Ci (decayed) is at the Hanford Site and 1.5 million Ci (decayed) is in material that has been shipped offsite. The major components (~99%) of the 89 million Ci include the following:

- WESF cesium capsules (~37 million Ci)
- Tank waste (~36 million Ci)
- CSB (~10 million Ci)
- German logs (~3.0 million Ci)
- SWOC (i.e., CWC, WRAP, and T Plant) and 218-W-3AE (considered above ground storage) (~ 0.9 million Ci)
- Waste in the 200 Area LLBG (SW-2 Operable Unit) (~0.7 million Ci)
- 324 Building/Soil (~0.4 million Ci)
- PUREX tunnels (~0.4 million Ci)
- 200 Area CERCLA liquid waste sites and tank leaks (~0.2 million Ci)
- B-Plant filters (~0.1 million Ci)
- WESF cells and ventilation ductwork (~0.1 million Ci)
- US Ecology (~0.1 million Ci).

Cesium-137 is an abundant fission product in irradiated fuel that was separated in the 200 Area reprocessing plants and sent to tank farms. The three major sources are cesium chloride capsules at WESF, tank waste from the 1980 PUREX campaigns, and unprocessed fuel at CSB. The remainder of the inventory is in various solid wastes, liquid wastes, and facility ventilation systems.

Uncertainties: Knowledge of cesium-137 inventories is very good.

3.3 CHLORINE-36

Approximately 310 Ci (decayed to 2011) of chlorine-36 is at the Hanford Site. The major components (almost 100%) of the 310 Ci include the following:

- 100 Area reactor graphite (~300 Ci)
- US Ecology (~0.14 metric tons).

The only known significant source of chlorine-36 is the 100 Area reactor cores where chlorine impurities in the graphite cores were irradiated to produce the isotope.

Uncertainties: Estimates from 1985 of the 100 Area reactors graphite inventory (UNI-3714) were considered by the investigators to be conservative. Assuming this to be correct, the expected value is likely less than 300 Ci.

3.4 IODINE-129

Approximately 56 Ci of iodine-129 is at the Hanford Site or was in gaseous discharges from past operations. The major components (~75%) of the 55 Ci include the following:

- Tank waste (~25 Ci)
- CSB (~6.4 Ci)
- US Ecology (~5.6 Ci)
- 200 Area CERCLA liquid waste sites and tank leaks (~3.7 Ci)
- 200 Area groundwater (~1 Ci).

The remaining 13.8 Ci is in gaseous discharges, on silver reactors in canyons, in the 200 Area LLBG, and in PUREX tunnel #2.

Iodine-129 is a soluble and volatile fission product whose inventory generation estimates varies over time. Iodine-129 was generated by 100 Area reactors and distributed in liquid waste (tank waste and some crib waste), solid waste (silver reactors in the low-level burial grounds, tunnels, and canyons), and gaseous discharges. Given this estimate of 55 Ci is considered a bounding value, and tank waste is expected to contain the majority of the inventory.

Uncertainties: Both the accuracy of the fission product inventory and the fraction that escaped into the atmosphere are uncertain. Furthermore, the fraction that remained in dissolved fluids versus capture in processing plant silver reactors is problematic. The fraction of iodine-129 in gaseous discharges, on silver reactors in canyons, in the 200 Area LLBG, and in PUREX tunnels is not well known. Sampling and characterization capabilities to detect the small quantities of iodine-129 in waste and equipment make obtaining better information unlikely.

3.5 NICKEL-63

Approximately 2.1 million Ci of nickel-63 is at the Hanford Site. The major components (~99%) of the 2.1 million Ci include the following:

- Trench 94 reactor cores (~1.7 million Ci)
- US Ecology (~190,000 Ci)
- Tank waste (~140,000 Ci)
- Waste in the 200 Area LLBG (SW-2 Operable Unit) (~88,000 Ci).

Nickel-63 is an activation product produced by irradiation of fuel cladding metals and other reactor facility metal parts containing nickel as an impurity. The majority of these materials were dissolved as part of the plutonium separation process and nickel separated into liquid waste, which was discharged to the tank system. Note that offsite waste was generated by the U.S. Navy (e.g., all of Trench 94 inventory and majority of the 200 Area LLBG inventory) and makes up the majority of nickel-63 present onsite.

Uncertainties: Unknown.

3.6 PLUTONIUM TOTAL

Of the approximately 2.6 metric tons of plutonium-total about 2.1 metric tons is at the Hanford Site and 0.5 metric tons is in material that has been shipped to the Waste Isolation Pilot Plant. The quantity of plutonium-total does not include plutonium in product or fuel that is stored, or has been shipped off site. The major components (~94%) of the 2.1 metric tons include the following:

- Tank waste (~0.84 metric tons)
- Waste in the 200 Area LLBG (SW-2 Operable Unit) (~0.36 metric tons)
- SWOC (including CWC, WRAP, and T Plant) and 218-W-3AE (considered above-ground storage) (~0.32 metric tons)
- 200 Area CERCLA liquid waste sites and tank leaks (~0.23 metric tons)
- US Ecology (~0.14 metric tons) (the average waste received from off site is nearly 10 nCi of TRU constituents per gram)
- Retrievably stored waste in the 200 Area LLBG (~0.09 metric tons).

The majority of plutonium was separated and shipped off site as product. However, tank waste from processing of irradiated reactor fuel, solid waste from 200 Area processing and finishing facilities (e.g., gloveboxes, filters), stored TRU waste (e.g., at CWC), and liquid wastes discharged to ground (e.g., cribs) from early plutonium purification facilities contain the most of the current Hanford inventory.

Uncertainties: Characterization of the 618-11 Burial Ground is planned to be completed in the next few years. Per discussion with WCH personnel, estimates of the 618-11 inventory were made by doubling the draft 618-10 characterization information. The 618-10 characterization report is planned to be completed during the next few months.

Before 1978, inventory differences were identified as "material unaccounted for" (MUF). MUF has at various times included the fractional amounts of nuclear materials lost in day-to-day operations and accumulated and accounted for as normal operating losses, accidental losses, and materials removed from a facility for quality control and safeguards analysis. Hanford's MUF in 1994 was 1.3 metric tons. Hanford cleanup efforts have reduced this MUF to 0.84 metric tons (2011 estimate). Potential sources of this MUF are additional plutonium-total in the 200 Area LLBG (218-W-1, 218-W-2, and 218-W-3), 200 Area CERCLA liquid waste sites (PW-1, PW-3, and PW-6 associated with Z Plant [now PFP] operations), and, to a lesser extent, holdup in canyon facilities.

3.7 STRONTIUM-90

Of the approximately 74 million Ci (decayed) of strontium-90 about 73 million Ci is at the Hanford Site and 1.4 million Ci is in material that has been shipped off site. The major components (~ 99%) of the 73 million Ci include the following:

- Tank waste (~44 million Ci)
- WESF strontium capsules (~16 million Ci)
- CSB (~8.0 million Ci)
- German logs (~2.2 million Ci)
- SWOC (including CWC, WRAP, and T Plant) and 218-W-3AE (considered above-ground storage) (~0.8 million Ci)
- Waste in the 200 Area LLBG (SW-2 Operable Unit) (~0.5 million Ci)
- 324 Building/Soil (~0.2 million Ci)
- PUREX tunnels (~0.2 million Ci)
- WESF cells and ventilation ductwork (~0.2 million Ci)
- MWDTs (~0.1 million Ci).

Uncertainties: Knowledge of strontium-90 inventories is very good.

3.8 TECHNETIUM-99

Of the approximately 35,000 Ci of technetium-99 about 30,000 Ci is at the Hanford Site and 5,200 Ci is in uranium that has been shipped off site. The major components (~99.8%) of the 30,000 Ci include the following

- Tank waste (~26,000 Ci)
- CSB (~2,900 Ci)
- 200 Area CERCLA liquid waste sites and tank leaks (~670 Ci)
- MWDTs (~140 Ci)
- Waste in the 200 Area LLBG (200-SW-2 Operable Unit) (~130 Ci)
- US Ecology (~50 Ci).

Technetium-99 is a readily soluble fission product that was separated from irradiated fuel in the 200 Area processing plants and is stored in tank waste. A portion of the technetium from processing fuel and the recovery of uranium from tank waste in the U Plant (from initial T Plant and B Plant irradiated fuel processing operations waste sent to tank waste) was sent to liquid waste sites. Irradiated fuel that has not been processed is stored at CSB. A significant part of the technetium-99 was also sequestered with uranium (and retained in recycled uranium),

separated as a product in the 200 Area processing plants. Technetium-99 in solid waste (e.g., MWDTs, 200-SW-2) is primarily associated with uranium inventories.

Uncertainties: The 5,200 Ci of technetium-99 in uranium shipped off site was obtained by the difference of technetium produced in the reactors minus the inventories of waste onsite.

3.9 TRITIUM (H-3)

Approximately 780,000 Ci (decayed to 2011) of tritium is at the Hanford Site. The major components (~91%) of the 870,000 Ci include the following:

- US Ecology (~480,000 Ci)
- Waste in the 200 Area LLBG (SW-2 Operable Unit) (~100,000 Ci)
- 200 Area CERCLA liquid waste sites and tank leaks (~100,000 Ci).

Tritium is a readily soluble fission product that dissolved in fuel processing fluids in the 200 Area plants. The relatively large inventories in the 200 Area LLBG and MWDTs were not produced at Hanford but supplied by two offsite contractors, Brookhaven National Laboratory and Princeton Gamma Tech. Tritium from these sources is on filter material.

Uncertainties: None.

3.10 URANIUM TOTAL

Of the approximately 120,000 metric tons of uranium-total about 9,000 metric tons is at the Hanford Site and over 110,000 metric tons of uranium-total has been shipped off-site as product. Approximately 110,000 metric tons of the 120,000 metric tons that Hanford processed through the reactors was recycled uranium. Uranium started processing recycled uranium in July 1952. The major components (~98%) of the 9,000 metric tons include the following:

- US Ecology (~4,500 metric tons)
- CSB (~2,000 metric tons)
- MWDTs (~820 metric tons)
- Tank waste (~640 metric tons)
- Waste in the 200 Area LLBG (SW-2 Operable Unit) (~460 metric tons)
- ERDF (~200 metric tons)
- 200 Area CERCLA liquid waste sites and tank leaks (~160 metric tons).

The majority of the uranium inventory at Hanford is disposed as solid waste at US Ecology, irradiated fuel is stored at CSB, solid waste in the MWDTs, and in tank waste.

Uncertainties: Disposed uranium metal and stored fuel estimates are well quantified by weight. Characterization of the 618-11 Burial Ground is planned to be completed in a couple of years. Per discussion with WCH personnel, estimates of the 618-11 inventory were considered equal to the draft 618-10 characterization information. The 618-10 characterization report is planned to be completed during the next few months.

4.0 POTENTIAL SOURCES OF WASTE TO ERDF

4.1 CURRENTLY FORECAST WASTE

These sources have cleanup waste that is currently forecast to be complete from fiscal year (FY) 2011 through FY 2018, or is planned to be completed in the out-years. Remaining waste in the 100 Area are the reactor buildings and small-volume waste sites that include pipelines with associated soils, small solid waste sites, and building debris. The largest remaining solid waste site is the 118-K-1 Burial Ground, which was the main disposal facility for reactor waste in the 100-K Area. In the 300 Area, the remaining waste sites to be remediated are buildings that will provide debris. Two major solid waste sites, 618-10 and 618-11, remain and contain uranium metals, plutonium-contaminated metals, and research waste. The majority of the waste will be sent to ERDF for disposal from the following sources:

- 100-B/C Waste Area
  - 100-C-7 waste site is planned to be completed in FY 2012
  - Deactivation, decommissioning, decontamination, and demolition (D4) of facilities (116-B, 119-B and 1608-B) are planned to be completed in FY 2012.
- 100-D Area
  - 100-D-8, 100-D-28:1, 100-D-50:1, 100-D-50:4, 100-50:6, 100-D-50:7, 100-D-50:8, 100-D-62, 100-D-65, 100-D-66, 100-D-78, 132-D-1, 1607-D-1, 1607-D-5, 100-DR-3, and 100-DR-13 waste sites are planned to be completed in FY 2011
  - D4 of the 1902-D Facility is planned to be completed in FY 2011
  - 100-D-14, 100-D-50:2, 100-D-50:3, 100-D-69, 100-D-71, 100-D-72, 100-D-75, 100-D-80, 100-D-81, 100-D-83:1, 100-D-83:2, 100-D-83:3, 100-D-83:5, 100-D-84:2, 100-D-85:2, 100-D-86:1, 100-D-86:3, 100-D-93, 100-D-95, 100-D-96, 100-D-98, 100-D-99, 100-D-100, 100-D-101, 100-D-102, 100-D-103, and 100-D-104 waste sites are planned to be completed in FY 2012
  - D4 of facilities (151-D and 1606-D) are planned to be completed in FY 2012
  - 100-D-73 and 100-D-77 waste sites are planned to be completed in FY 2013
  - D4 of facilities (MO-561, MO-829, and MO-980) are planned to be completed in FY 2014
  - D4 of MO-889 Facility is planned to be completed in FY 2015.
- 100-F
  - 100-F-8, 100-F-26:4, 100-F-26:7, 100-F-44:8, 100-F-44:9, 100-F-45, 100-F-47, 100-F-48, 100-F-49, 100-F-51, 100-F-55, 100-F-56, 100-F-57, 100-F-58, 100-F-60, 100-F-61, 100-F-62, and 100-F-63 waste sites are planned to be completed in FY 2011.

- 100-H
  - 100-H-33, 118-H-3, 100-H-4, 100-H-36, 100-H-42, 100-H-43, 100-H-44, 100-H-46, 100-H-48, 100-H-52, 118-H-4, 128-H-1, 132-H-3, 600-151, and 1607-H3 waste sites are planned to be completed in FY 2011
  - 100-H-28:2, 100-H-28:3, 100-H-28:4, 100-H-28:5, 100-H-35, 100-H-38, 100-H-49, 100-H-50, 100-H-51:1, and 100-H-52 waste sites are planned to be completed in FY 2012
  - D4 of MO-229 facility is planned to be completed in FY 2013.
- 100-K
  - 100-K-84, 100-K-87, 100-K-91, 100-K-93, 100-K-95, 100-K-78, 118-K-1, and 600-29 waste sites are planned to be completed in FY 2011
  - 100-K-85, 100-K-86, 100-K-88, 100-K-89, 100-K-90, 100-K-92, and 128-K-2 waste sites are planned to be completed in FY 2012
  - 100-K-1, 100-K-3, 100-K-4, 100-K-14, 100-K-18, 100-K-27, 100-K-34, 100-K-42, 100-K-43, 100-K-47 Pt 1-3, 100-K-50, 100-K-53, 100-K-54, 100-K-55, 100-K-56 Pt 1-3, 100-K-57, 100-K-63, 100-K-68, 100-K-69, 100-K-70, 100-K-71, 100-K-72, 100-K-73, 100-K-74, 100-K-75, 100-K-77, 100-K-80, 100-K-81, 100-K-101, 100-K-102, 100-K-109, 116-K-3, 116-KE-2, 116-KE-3, 116-KW-1, 116-KW-2, 120-KE-1, 120-KE-2, 120-KE-4, 120-KE-5, 120-KE-9, 120-KW-1, 120-KW-2, 126-KE-2, and 1607-K3.
- 100-N
  - 100-N-13, 100-N-18, 100-N-22, 100-N-23, 100-N-25, 100-N-26, 100-N-33, 100-N-34, 100-N-36, 100-N-47, 100-N-57, 100-N-60, 100-N-61, 100-N-63, 116-N-2, 116-N-3, 116-N-4, 118-N-1, 124-N-2, 124-N-4, 128-N-1, 600-35, UPR-100-N-4, UPR-100-N-14, UPR-100-N-18, UPR-100-N-19, UPR-100-N-20, UPR-100-N-24, UPR-100-N-31, UPR-100-N-35, UPR-100-N-36, and UPR-100-N-43 waste sites are planned to be completed in FY 2011
  - D4 of 105-NE, 107-N, 116-N, 117-N, 117-NVH, 181-NA, 181-NB, 182-N, 186-N, 1112-N, 1120-N, 1143-N, 1310-N, 1332-N, 1607-N3, 1607-N9, 1614-N, 1903-N, 1904-NA, 1904-NB, 1904-NC, 1909-N, 1926-N, HS0007, HS0008, MO-100, MO-403, MO-425, MO-426, MO-427, MO-561, and MO-765 facilities are planned to be completed in FY 2011
  - 100-N-28, 100-N-35, 100-N-53, 100-N-54, 100-N-55, 100-N-62, 100-N-66, 100-N-68, 100-N-79, 100-N-81, 100-N-83, 100-N-84:2, 100-N-84:3, 100-N-84:4, 100-N-85, 100-N-86, 100-N-87, 100-N-88, 100-N-89, 100-N-90, 100-N-91, 100-N-94, 100-N-95, 100-N-96, 100-N-97, 100-N-98, 100-N-99, 100-N-100, 100-N-101, 100-N-102, 100-N-103, 120-N-4, 600-340, and 628-2 waste sites are planned to be completed in FY 2012
  - D4 of 181-N, 181-NE, and MO-415 facilities are planned to be completed in FY 2012

- 100-N-84:1, 100-N-84:5, 100-N-84:6, and 100-N-84:7 waste sites are planned to be completed in FY 2013

- D4 of MO-767 and MO-827 facilities are planned to be completed in FY 2013.

- IU-2/6

  - 600-100, 600-109, 600-124, 600-125, 600-127, 600-182, 600-188, 600-202, 600-108, 600-146, 600-178, 600-205, 600-213, 600-280, 600-341, 600-342, 600-343, 600-344, 600-345, and 600-346 waste sites are planned to be completed in FY 2011

  - 600-186, 600-293, 600-294, 600-296, 600-298, 600-299, 600-300, 600-301, 600-302, 600-303, 600-305, 600-306, 600-307, 600-308, 600-309, 600-310, 600-311, 600-312, 600-313, 600-314, 600-315, 600-316, 600-317, 600-318, 600-319, 600-320, 600-321, 600-322, 600-323, 600-324, 600-325, 600-326, 600-327, 600-328, 600-329, 600-330, 600-331, 600-332, 600-333, 600-334, and 600-335 waste sites are planned to be completed in FY 2012.

- 200 Area

  - PFP, 200 East Industrial facilities, 200 ETF, 209-E, 212 Railcars, CSB operations, 200 West Area Pump and Treat Facility, PUREX D4, PUREX Zone remediation, Solid Waste Zone remediation, T Plant operation, T Plant Zone remediation, Tank Closure, U Plant Ancillary facilities, U Plant Zone remediation, WESF operations, WRAP operations, Waste Sampling and Characterization Facility operations.

  - Liquid Waste Sites: Liquid wastes were mainly disposed in cribs and ditches around PFP and are contaminated with TRU constituents where recent cleanup decisions (200-PW-1/3/6 and 200-CW-5) have been made.

- 300 Area

  - 300-28, 300-40, 300-46, 300-224, 313 ESSP, 3712-USSA, UPR-300-4, UPR-300-38, UPR-300-40, UPR-300-45, and 300-276 waste sites are planned to be completed in FY 2011

  - D4 of 308, 310, 315C, 315D, 324B (including contaminated soils under B-Cell), 335, 337, 337BA, 337B, 352E, 3506A, 3506B, 3621BC, 3621D, 3704, 3706, 3706A, 3707F, 3714, 3717C, 3718E, 3718G, 3718P, 3727, MO-270, and MO-271 facilities are planned to be completed in FY 2011

  - 300-5, 300-7, 300-9, 300-11, 300-22, 300-39, 300-95, 300-121, 300-255, 300-257, 300-263, 300-264, 309-TW-1, 309-TW-2, 309-TW-3, 309-WS-1, 309-WS-2, 309-WS-3, 316-3, 340 Complex, 600-58, 600-59, 600-60, 600-62, 600-276, UPR-300-1, UPR-300-5, and UPR-300-11 waste sites are planned to be completed in FY 2012

  - D4 of 300-279, 300-280, 300-281, 300-282, 300-283, 300-284, 303A, 303B, 303C, 303E, 303F, 303G, 303J, 304, 304A, 305A, 308, 308A, 309, 310-T7B, 313, 314, 320, 320-BA, 321, 321B, 321C, 321D, 323 below-grade structures, 323 Tank 1, 323 Tank 2, 323 Tank 3, 323 Tank 4, 340A, 340B, 342C, 382, 382B, 382-BA, 382C, 382D, 3229,

366A, 3128, 3231, 3232, 3503A, 3503B, 3506C, 3701U, 3705-BA, 3706-BA, 3707D, 3707E, 3707H, 3709, 3713, 3715, 3719, 3720-BA, 3722, 3730, 3731, 3731A, 3745, 3745A, 3745B, 3746, 3746A, 3763, 3766, 3802A, 3906, and MO-265 facilities (including slabs, tanks, etc.) are planned to be completed in FY 2012

- 300-2, 300-32, 300-265, 300-293, UPR-300-2, and 600-63 waste sites are planned to be completed in FY 2013
- D4 of 300-286, 300-287, 300-288, 300-289, 300-290, 300-291, 300-294, 323-BA, 324, 331C, 331D, 331G, 331H, 340, 600-290, 3760, and MO-059 facilities are planned to be completed in FY 2013
- 300 RLWS, 300 RRLWS, 300-93, 300-94, 300-15, 300-214, 300-293, and UPR-300-5 waste sites are planned to be completed in FY 2014
- 316-4 waste site is planned to be completed in FY 2016.

- 400 Area
  - D4 of 4701B, 4701C, 4702, 4706, 4719, 4722B, 4726, 4727, 4734D, 4760, 4790, 4791TC, 4802, and 4831 facilities are planned to be completed in FY 2011.
- 600 Area
  - 618-10 Burial Ground is planned to be completed in FY 2012
  - 618-11 Burial Ground is planned to be completed in FY 2016.
- Other
  - Arid Lands Ecology (ALE), surveillance and maintenance of balance of site, site infrastructure and utilities, and well drilling.

4.2 WASTES WHERE NO REMEDIATION DECISIONS HAVE BEEN MADE

These sources have cleanup waste where no remediation decisions have been made. If it is decided to remove this waste, a portion of this waste (using the assumptions in Section 7.1) could be sent to ERDF for disposal.

- 100 Area reactor cores.
- Central Plateau Burial Grounds: Solid wastes have been disposed in a variety of burial grounds since the 1940s. Most of the waste volume has been disposed in trenches, in various containers (e.g., boxes, drums). Some wastes have been disposed in caissons, high-integrity containers, or grouted in monoliths. Selected burial grounds contain post-1970 suspect TRU waste that is being retrieved for treatment and disposal. The MWDTs in the 200 West LLBG will be closed under the RCRA permit. Waste sites in the 200-SW-1 Operable Unit (NRDWL and SWL) are assumed to be closed in place and capped. Pre-1970 wastes likely contain spent fuel and TRU materials that would not be disposed at ERDF.

- Liquid Waste Sites: Liquid wastes were mainly disposed in cribs, ditches, and ponds. The remaining liquid disposal waste sites will be included in the 200-WA-1 and 200-EA-1 Operable Units. Ponds (Gable, B Pond, S Pond, Westlake) are located in the Outer Area Operable Unit where the final cleanup decision will established.

- Outer Area Waste Sites: Waste sites in the Outer Area consist mainly of ponds (see previous bullet), pipelines to those ponds, and a number of small and shallow waste sites where interim actions are well underway for RTD or confirmatory sampling/no action. The final cleanup decision will be documented in with the 200-OA-1 Operable Unit. One waste site not considered is the cross-site transfer line and the related active cross-site transfer line, which are mainly located in the outer area.

- 200 Area Groundwater: Groundwater beneath and adjacent to the Central Plateau is contaminated with several constituents (carbon tetrachloride, technetium-99, iodine-129, uranium) above permitted levels. Interim actions are underway, mainly pump-and-treat operations. Plans include continuation of interim actions until contamination levels are reduced and long-term groundwater monitoring. Small volumes of secondary solid wastes from these interim actions may continue to be disposed at ERDF.

- Deep Vadose Zone and Tank Leaks: Deep contamination is present in the vadose zone from a variety of sources including tank leaks and migration of contamination from waste sites on the Central Plateau. Interim actions are underway and include soil vapor extraction, new technology evaluation and testing for characterization, remediation and monitoring, and testing of interim surface barriers. Final cleanup decisions will be established with the 200-DV-1 Operable Unit.

- 200 Area Canyon Facilities: Five large canyon facilities were constructed in the 200 Areas for processing in support of the defense mission. An ROD is in place for the U Canyon, where the site will be capped after ancillary facilities are removed, the canyon facility stabilized, and the upper structure demolished. Decisions on the remaining canyons (PUREX, REDOX, B Plant, and T Plant) have not been made but are expected to follow the U Canyon approach. PUREX tunnels #1 and #2 contain highly radioactive waste and TRU wastes that are stored near the surface. The tunnels will be included in the PUREX decision.

- Plateau Pipelines: This includes more than 300 waste sites associated with inactive, buried process waste transfer pipeline systems. These waste sites include pipelines and pipeline components (e.g., diversion boxes, catch tanks, valve pits, vaults, and control structures). Also included are associated waste sites that are the result of unplanned leaks and spills likely originating from pipeline systems. Not included are noncontaminated utilities such as raw/potable water lines, utility lines, inert gas lines, sanitary sewer, stormwater, or aboveground and active pipelines. Pipelines located near facilities and tank farms that are planned to be capped will likely be transferred to those areas for a final decision. Some pipelines cross into the outer area and those portions will likely transfer to the 200-OA-1 Operable Unit for a final decision.

- 300 Area Facilities: In 2007, DOE's Office of Science elected to retain four facility complexes in the 300 Area (325, 331, 318, and 350 Buildings) for up to 20 years. These facilities will continue to support the Office of Science missions implemented through the

Pacific Northwest National Laboratory. When these facilities are determined to be excess to these missions, they will be returned to DOE-RL for final removal and remediation of any associated waste sites. The 300 Area ROD will identify mitigation actions needed to address waste sites associated with these buildings. Selected waste and demolition debris from the 325 Laboratory, a nuclear facility with significant radiological contamination, may be disposed at ERDF.

- Fast Flux Test Facility/400 Area: DOE is currently evaluating decommissioning and final disposition options for FFTF through the Tank Closure and Waste Management (TC&WM) Environmental Impact Statement (EIS) (DOE 2009e). The EIS ROD will identify the final disposition approach. The current draft recommends capping.

4.3 POTENTIAL ERDF WASTE SOURCES OF SPECIFIC RADIONUCLIDES

The estimated quantities (curies or metric tons) of specific radionuclides at the Hanford Site that will be disposed in ERDF at closure are provided in this section and Appendices A and B. These inventories are a subset of those described in Section 3.0. Potential waste sources are divided into two categories. The first category includes currently forecast waste inventories from waste sites where remediation decisions have been made or are expected. The second category includes waste sites for which no remediation decisions have been made. Inventories in each category are provided in Tables 4-1 through 4-3, maintaining the radionuclide characteristics described in previous chapters. Uncertainty inherent in the estimated quantities is discussed for those waste sources in the first category. All radionuclide quantities have been decayed to 2011 and the approximate quantities have been rounded to two significant figures.

Table 4-1. Estimated Potential Radionuclides with Half-Lives Greater than 6 Years and/or Current Inventories Greater than 1 Ci for Disposal at ERDF (Decayed to 2011). (2 Pages)

Radionuclide	Currently Forecast Waste in Curies (Exceptions are in Metric Tons)	Estimated Potential Waste in Curies (Exceptions are in Metric Tons) Where No Remediation Decisions Have Been Made
Silver-108m	0.8	0
Americium-241	330	<2,100
Barium-133	0	27
Carbon-14	460	<43,000
Calcium-41	0	690
Cadmium-113m	1.6	<43
Chlorine-36	0.02	300
Curium-244	28	<1.8
Cesium-137	430,000	<1,500,000
Europium-152	20	<380
Europium-154	170	<490
Tritium	23,000	<130,000
Iodine-129	0	<10

Table 4-1. Estimated Potential Radionuclides with Half-Lives Greater than 6 Years and/or Current Inventories Greater than 1 Ci for Disposal at ERDF (Decayed to 2011). (2 Pages)

Radionuclide	Currently Forecast Waste in Curies (Exceptions are in Metric Tons)	Estimated Potential Waste in Curies (Exceptions are in Metric Tons) Where No Remediation Decisions Have Been Made
Potassium-40	0	0
Molybdenum-93	0.03	0
Niobium-93m	0.2	<58
Niobium-94	0.08	<15
Nickel-59	22	<990
Nickel-63	550	98,000
Neptunium-237	0.03	<12
Plutonium-238	50	95
Plutonium-239	1,200	2,000
Plutonium-240	300	510
Plutonium-241	800	1,400
Plutonium-242	0.02	0.02
Plutonium Total	0.020 MT	<0.035 MT
Radium-226	0.8	<6.7
Selenium-79	0.05	<1.9
Samarium-151	62	<79,000
Tin-121m	0.04	0
Strontium-90	200,000	<1,000,000
Technetium-99	32	<810
Thorium-232	0.2	<28
Uranium-233	0.006	26
Uranium-234	4	140
Uranium-235	0.3	7
Uranium-236	0.1	10
Uranium-238	20	210
Uranium Total	60 MT	<610 MT
Zirconium-93	2	<95

ERDF = Environmental Restoration Disposal Facility
MT = metric tons

Table 4-2. Estimated Potential Radionuclides with Half-Lives Less than 6 Years for Disposal at ERDF (Decayed to 2011).

Radionuclide	Currently Forecast Waste in Curies (Exceptions are in Metric Tons)	Estimated Potential Waste in Curies (Exceptions are in Metric Tons) Where No Remediation Decisions Have Been Made
Beryllium-7	0	0
Cerium-144	0	0
Californium-252	0	0
Cesium-134	4	<0.8
Cobalt-58	0	0
Cobalt-60	30,000	<27,000
Curium-242	0	<1
Europium-155	72	<170
Iron-55	18	<31
Iron-59	0	0
Manganese-54	0.0001	0
Sodium-22	0	0
Promethium-147	62	<4
Radium-228	0.2	0
Ruthenium-103	0	0
Ruthenium-106	0.01	0
Antimony-125	0.3	<12
Antimony-126	0.01	0
Tin-113	0	0
Thorium-228	0.2	0
Thorium-234	20	0
Zinc-65	0	0

ERDF = Environmental Restoration Disposal Facility

Table 4-3. Estimated Potential Radionuclide with Half-Lives Greater than 6 Years and Current Inventories Less than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Currently Forecast Waste in Curies (Exceptions are in Metric Tons)	Estimated Potential Waste in Curies (Exceptions are in Metric Tons) Where No Remediation Decisions Have Been Made
Actinium-227	0	<0.1
Americium-242m	0.2	0
Americium-243	0.2	<0.5
Bismuth-207	0	0
Californium-249	0	0

Table 4-3. Estimated Potential Radionuclide with Half-Lives Greater than 6 Years and Current Inventories Less than 1 Ci (Decayed to 2011). (2 Pages)

Radionuclide	Currently Forecast Waste in Curies (Exceptions are in Metric Tons)	Estimated Potential Waste in Curies (Exceptions are in Metric Tons) Where No Remediation Decisions Have Been Made
Cesium-135	0.03	0
Curium-243	0.8	0.1
Curium-245	0	0
Curium-246	0	0
Curium-247	0	0
Curium-248	0	0
Europium-150	0	0
Krypton-85	0	<3
Proactinium-231	0	<0.1
Lead-210	0	0
Palladium-107	0.009	0
Polonium-209	0	0
Plutonium-244	0	0
Radium-228	0.2	0
Rhenium-187	0	0
Tin-126	0.07	<7
Titanium-44	0	0
Thorium-229	0	0
Thorium-230	0	0
Uranium-232	0	<53

4.4 CARBON-14

A total of 43,000 Ci of carbon-14 has the potential of being sent to ERDF. The prime source of carbon-14 to ERDF is the graphite from the 100 Area reactors. Almost all of the carbon-14 that could be sent to ERDF is from sources where no remediation decisions have been made.

Uncertainties: Estimates from year 1985 of the 100 Area reactors graphite inventory are the greatest uncertainty. Given the large fraction of the graphite core source term inventory estimate, uncertainty is likely associated with extrapolation of core inventories from limited sampling information extrapolated over large material volumes. Authors of the characterization study for these materials (UNI-3714) indicate that the estimates are meant to be conservatively high. Thus, the listed values are assumed to be maximum values. The best, minimum, and maximum quantities for carbon-14 in the current ERDF waste forecast are as follows:

- Best: 460 Ci –The best quantity is the current forecast quantity. Assume waste form distribution is the same as currently disposed carbon-14 in ERDF (see Section 2.2.3).

- Minimum: 460 Ci - Recent information on condensate cribs 116-KE-1 and 116-KW-1 characterizations are that approximately 460 Ci of carbon-14 will be sent to ERDF for disposal.

- Maximum: 920 Ci – The maximum quantity includes an increase of 100% above the minimum. Almost all of the 1,900 Ci in ERDF are from cleanup in the 100 Areas. Recent information on condensate cribs 116-KE-1 and 116-KW-1 indicate approximately 460 Ci of carbon-14 will be sent to ERDF for disposal. With the exception of reactor core removal (a major potential carbon-14 source) the majority of the 100 Areas cleanup is complete. The remaining waste sites and structures in the 100 Area other Hanford Areas are thought to contain small quantities.

4.5 CESIUM-137

Less than 2.0 million Ci of cesium-137 has the potential of being sent to ERDF. Current waste sources of cesium-137 (~430,000 Ci) that will be sent to ERDF include the 324 Building and soils, 118-K-1 Burial Ground, 618-10/11 Burial Grounds, and other miscellaneous sites. Less than 1.5 million Ci of cesium-137 could be sent to ERDF from sources where no remediation decisions have been made.

Uncertainties: The characterization methods discussed in Section 2.0 that have been applied to 100 and 300 Area wastes suggest that the cesium-137 inventory estimates will be conservatively high. The 430,000 Ci of cesium-137 in the soil underneath the 324 Building B cell is based on sampling and radiological calculations (characterization studies are ongoing). The best, minimum, and maximum quantities for cesium-137 in the current ERDF waste forecast are as follows (Note: all assume that the 324 soil is the major source [over 98%], and that the soil will be excavated and disposed in ERDF):

- Best: 430,000 Ci – The best quantity is the current forecast quantity.

- Minimum: 310,000 Ci – Assumes 324 Building soil radiological measurements are 100% over stated. 310,000 Ci is the difference between: the sum of the quantity of cesium in the capsules cut-up to make the German Logs and other waste forecast for ERDF, and 2) the sum of quantity in the German Logs and in the solid waste from processing (i.e., PUREX tunnel waste from 324). Other cesium-137 losses from other B-Cell activities are not well known.

- Maximum: 520,000 Ci – Assumes quantity 20% more than the 324 Building soil radiological calculations.

4.6 CHLORINE-36

A total of 300 Ci of chlorine-36 from the 100 Area reactors graphite has the potential of being sent to ERDF.

Uncertainties: Estimates from year 1985 of the 100 Area reactors graphite inventory are the greatest uncertainty. Given the large fraction of the graphite core source-term total inventory estimate, uncertainty is likely associated with extrapolation of core inventories from limited

sampling information extrapolated over large material volumes. Authors of the characterization study for these materials (UNI-3714) indicate that the estimates are meant to be conservatively high. Thus, the listed values are assumed to be maximum values.

The best, minimum, and maximum quantities for chlorine-36 in the current ERDF waste forecast are as follows:

- Best: 0.02 Ci – Current waste forecast.
- Minimum: 0.01 Ci – Assumes quantity 50% less than the Best quantity.
- Maximum: 0.04 Ci – Assumes quantity 100% more than the Best quantity.

4.7 IODINE-129

Less than 10 Ci of iodine-129 has the potential of being sent to ERDF. No current waste sources for iodine-129 being sent to ERDF exist. Less than 10 Ci of iodine-129 could be sent to ERDF from sources where no remediation decisions have been made.

Uncertainties: The best, minimum, and maximum quantities for iodine-129 in the current ERDF waste forecast are as follows:

- Best: 0 Ci – The current waste forecast quantity.
- Minimum: 0 Ci – The current waste forecast quantity.
- Maximum: 0.01Ci – 50% of the current disposed quantity of iodine-129 in ERDF.

4.8 NICKEL-63

Less than 110,000 Ci of nickel-63 has the potential of being sent to ERDF. Current waste sources of nickel-63 (~550 Ci) that will be sent to ERDF include the 118-K-1 Burial Ground and other miscellaneous sites. Approximately 87,000 Ci of nickel-63 that could be sent to ERDF is from sources where no remediation decisions have been made. Approximately 80,000 Ci in the 200 Area LLBG is from core-basket thermal shields and related hardware.

Uncertainties: The best, minimum, and maximum quantities for nickel-63 in the current ERDF waste forecast are as follows:

- Best: 550 Ci – The current forecast quantity.
- Minimum: 390 Ci – 30% less than the Best quantity.
- Maximum: 1,100 Ci – 100% more than the Best quantity.

4.9 PLUTONIUM TOTAL

Less than 0.066 metric tons of plutonium-total has the potential of being sent to ERDF. Current waste sources where the non-TRU portion (~0.026 metric tons) will be sent to ERDF include PFP Zone PW-1, -3, -5 cribs/trench and the Z ditches, PFP, 618-10/11 Burial Grounds, and other miscellaneous sites (i.e., 325 Facility, 340 Facility, 118-K-1 Burial Grounds). Less than 0.035 metric tons of plutonium-total could be sent to ERDF from the non-TRU waste portion of sources where no remediation decisions have been made.

Uncertainties: The amount of blending of the TRU waste and clean soils, or monolithing waste to achieve non-TRU quantities could cause these estimates to change. The best, minimum, and maximum quantities for plutonium-total in the current ERDF waste forecast are as follows:

- Best: 0.020 MT – This quantity is primarily for disposal of less than 100 nCi per gram waste from PFP Zone PW-1, -3, -5 cribs/trench and the Z ditches. The best quantity is based a small amount mixing, during retrieval, of high TRU concentration material with soils that can be disposed at ERDF.

- Minimum: 0.016 MT – Assumes 20% less than the best quantity. The minimum quantity assumes no mixing, during retrieval, of high TRU concentration material with soils that can be disposed at ERDF.

- Maximum: 0.030 MT – Assumes 50% higher than the best quantity. The maximum quantity assumes a greater quantity of mixing, during retrieval, of high TRU concentration material with soils that can be disposed at ERDF.

4.10 STRONTIUM-90

Less than 1.2 million Ci (decayed to 2011) of strontium-90 has the potential of being sent to ERDF. Current waste sources of strontium-90 (~200,000 Ci) that will be sent to ERDF include 324 Building and soil, 118-K-1 Burial Ground, 618-10/11 Burial Grounds, and other miscellaneous sites. Less than 1 million Ci of strontium-90 could be sent to ERDF from sources where no remediation decisions have been made.

Uncertainties: The 190,000 Ci of strontium-90 in the soil underneath the 324 Building B cell is based on sampling and radiological calculations (Characterization studies are ongoing). The best, minimum, and maximum quantities for strontium-90 in the current ERDF waste forecast are as follows (Note – all assume that the 324 soil is the major source [over 97%], and that the soil will be excavated and disposed in ERDF):

- Best: 200,000 Ci – The difference between: 1) the sum of the strontium used to make the German Logs and other waste forecast for ERDF, and 2) the sum of quantity in the German Logs and in the solid waste from processing (i.e., PUREX tunnel waste from 324). Other strontium-90 losses from other B-Cell activities are not well known.

- Minimum: 100,000 Ci – Assumes radiological measurements are 50% over stated.

- Maximum: 240,000 Ci – Assumes value 20% higher than the radiological calculations.

4.11 TECHNETIUM-99

Less than 840 Ci of technetium-99 has the potential of being sent to ERDF. Current waste sources where technetium-99 (~32 Ci) will be sent to ERDF include the 618-10/11 Burial Grounds, 200 West Area groundwater, and other miscellaneous sites. Less than 810 Ci of technetium-99 could be sent to ERDF from sources where no remediation decisions have been made.

Uncertainties: 618-10/11 characterization efforts are not planned to be complete until next year Ten curies are estimated to be in the groundwater in 200 West Area (this is a calculated quantity and the actual amount may be from 5 Ci to 20 Ci). The best, minimum, and maximum quantities for technetium-99 in the current ERDF waste forecast are as follows:

- Best: 32 Ci – The Best quantity is the same as the current forecast.
- Minimum: 22 Ci – Assumes 30% less than the Best quantity.
- Maximum: 64 Ci – Assumes 100% more than the Best quantity.

4.12 TRITIUM (H-3)

Less than 150,000 Ci (decayed to 2011) of tritium has the potential of being sent to ERDF. Current waste sources that will be sent to ERDF include the 118-K-1 Burial Ground, 105-N, the 340 Facility, and other miscellaneous sites. Less than 100,000 Ci of tritium could be sent to ERDF from sources where no remediation decisions have been made.

Uncertainties: The best, minimum, and maximum quantities for tritium in the current ERDF waste forecast are as follows:

- Best: 23,000 Ci – The Best quantity is the same as the current forecast.
- Minimum: 16,000 Ci – Assumes 30% less than the Best quantity.
- Maximum: 35,000 Ci – Assumes 50% more than the Best quantity.

4.13 URANIUM TOTAL

Less than 670 metric tons of uranium-total has the potential of being sent to ERDF. Current waste sources where the uranium-total (approximately 60 metric tons) will be sent to ERDF include the 618-10/11 Burial Grounds and other miscellaneous sites. Less than 610 metric tons of uranium-total could be sent to ERDF from sources where no remediation decisions have been made.

Uncertainties: The best, minimum, and maximum quantities for uranium-total in the current ERDF waste forecast are as follows:

- Best: 60 MT – The Best quantity is based on recent characterization efforts of 618-10/11.
- Minimum: 42 MT – Assumes 30% less than the Best quantity.
- Maximum: 120 MT – Assumes 100% higher than the Best quantity. 618-10/11 characterization efforts are not planned to be complete until next year.

5.0 SUMMARY OF POTENTIAL ERDF INVENTORY AT CLOSURE FOR SPECIFIC RADIONUCLIDES

The estimated quantities (curies or metric tons) of specific radionuclides at the Hanford Site that could be disposed in ERDF at closure are provided in Tables 5-1 through 5-3 and Appendices A and B. These potential ERDF inventories are the sum of the current ERDF inventory (from Section 2.0), the currently forecast waste that is expected to be disposed at ERDF (from Section 4), and maximum estimates of waste that could be disposed at ERDF from sources where no remediation decisions have been made (from Section 4.0). These potential or bounding estimates are in curies or metric tons. The approximate quantities have been rounded to two significant figures. For bounding the uncertainty in radionuclide inventory at ERDF, use the suggested uncertainty ranges for specific radionuclides provided in Sections 2.0 and 4.0. For all other radionuclides, assume uncertainties of 30% less for minimum and 50% more for maximum from the best estimate value.

Table 5-1. Estimated Potential ERDF Inventory at Closure for Radionuclides with Half-Lives Greater than 6 Years and/or Current Inventories Greater than 1 Ci. (2 Pages)

Radionuclide	Current ERDF Inventory + Currently Forecast Waste (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2035)
Silver-108m	250	250	<240
Americium-241	870	<2,900	<3,100
Barium-133	5	32	<7
Carbon-14	2,400	<45,000	<45,000
Calcium-41	0.3	690	690
Cadmium-113m	5	<48	<14
Chlorine-36	0.02	300	300
Curium-244	29	<31	<12
Cesium-137	450,000	<2,000,000	<1,200,000
Europium-152	4,900	<5,400	<1,600
Europium-154	1,500	<2,000	<290
Tritium	31,000	160,000	40,000
Iodine-129	0.02	<10	<10
Potassium-40	0	0	0
Molybdenum-93	0.5	0.5	0.5
Niobium-93m	5	<63	<23
Niobium-94	0.4	<16	<16
Nickel-59	210	<1,200	<1,200
Nickel-63	15,000	110,000	95,000
Neptunium-237	0.4	<12	<12
Plutonium-238	92	190	190

Table 5-1. Estimated Potential ERDF Inventory at Closure for Radionuclides with Half-Lives Greater than 6 Years and/or Current Inventories Greater than 1 Ci. (2 Pages)

Radionuclide	Current ERDF Inventory + Currently Forecast Waste (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2035)
Plutonium-239	1,500	3,500	3,500
Plutonium-240	420	930	930
Plutonium-241	5,900	7,300	2,400
Plutonium-242	0.7	0.7	0.7
Plutonium Total	0.025 MT	<0.060 MT	<0.060 MT
Radium-226	1.7	<8.5	<8.4
Selenium-79	0.2	<2	<2
Samarium-151	320	<79,000	<66,000
Tin-121m	17	17	13
Strontium-90	210,000	<1,200,000	<690,000
Technetium-99	53	<860	<860
Thorium-232	1.3	<29	<29
Uranium-233	15	41	41
Uranium-234	17	160	160
Uranium-235	8	15	15
Uranium-236	0.5	11	11
Uranium-238	88	300	300
Uranium Total	260 MT	<870 MT	<870 MT
Zr-93	18	<110	<110

ERDF = Environmental Restoration Disposal Facility
MT = metric tons

Table 5-2. Estimated Potential ERDF Inventory at Closure for Radionuclides with Half-Lives Less than 6 Years. (2 Pages)

Radionuclide	Current ERDF Inventory + Currently Forecast Waste (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2035)
Beryllium-7	0	0	0
Cerium-144	0	0	0
Californium-252	0	0	0
Curium-242	0.0002	<1	0

Table 5-2. Estimated Potential ERDF Inventory at Closure for Radionuclides with Half-Lives Less than 6 Years. (2 Pages)

Radionuclide	Current ERDF Inventory + Currently Forecast Waste (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2035)
Cesium-134	7.9	<8.7	<0.003
Cobalt-58	0	0	0
Cobalt-60	35,000	<62,000	<2,600
Europium-155	190	<360	<12
Iron-55	18	<49	<0.1
Iron-59	0	0	0
Manganese-54	0.0001	0.0001	0
Sodium-22	0	<0.005	<0.000009
Promethium-147	62	<66	<0.1
Radium-228	0.4	0.4	0.02
Ruthenium-103	0	0	0
Ruthenium-106	0.02	<0.05	0
Antimony-125	15	<27	<0.07
Antimony-126	0.01	0.01	0
Tin-113	0	0	0
Thorium-228	0.2	0.2	0.00003
Thorium-234	20	20	0
Zinc-65	0	0	0

ERDF = Environmental Restoration Disposal Facility

Table 5-3. Estimated Potential ERDF Inventory at Closure for Radionuclides with Half-Lives Greater than 6 Years and Current Inventories Less than 1 Ci. (2 Pages)

Radionuclide	Current ERDF Inventory + Currently Forecast Waste (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2035)
Actinium-227	0	<0.08	<0.04
Americium-242m	0.3	0.3	0.3
Americium-243	0.8	<1.3	<1.3
Bismuth-207	0	0	0
Californium-249	0.0009	0.0009	0.0008
Cesium-135	0.03	0.03	0.03
Curium-243	0.9	0.9	0.5

Table 5-3. Estimated Potential ERDF Inventory at Closure for Radionuclides with Half-Lives Greater than 6 Years and Current Inventories Less than 1 Ci. (2 Pages)

Radionuclide	Current ERDF Inventory + Currently Forecast Waste (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2011)	Bounding ERDF Inventory Estimate at Closure (Curies Decayed to 2035)
Curium-245	0	0	0
Curium-246	0	0	0
Curium-247	0	0	0
Curium-248	0	0	0
Europium-150	0.0002	0.0002	0.0001
Krypton-85	0.4	0.4	0.09
Proactinium-231	0.000001	<0.09	<0.09
Lead-210	0	0	0
Palladium-107	0.009	0.009	0.009
Polonium-209	0	0	0
Plutonium-244	0	0	0
Rhenium-187	0	0	0
Tin-126	0.3	<7	<7
Titanium-44	0.00002	0.00002	0.00002
Thorium-229	0.000001	<0.0004	<0.0004
Thorium-230	0.02	0.02	0.02
Uranium-232	0	<53	<42

ERDF = Environmental Restoration Disposal Facility

6.0 POTENTIAL ERDF VOLUMES OF WASTE

This section discusses potential volumes of waste that may be disposed at ERDF. The purpose of this section is to give perspective on ERDF waste volumes, considering the volumes already disposed at ERDF and the magnitude of potential waste volumes. Because the additional waste volumes to be disposed are dependent on CERCLA waste site remediation decisions and not all decisions have been made, the potential waste volume estimates are divided into two groups. Current waste volume forecasts are based on those waste sites where the remediation actions are planned, and in some cases approved and are being completed. Those waste sites are primarily the remaining shallow land waste sites in the 100, 300, and 600 Areas (e.g., the River Corridor Project). Future waste volume forecasts are informal estimates completed for the Performance Assessment analysis involving sites where remediation decisions have yet to be made. These waste sites are primarily 200 Area Central Plateau sites. The key cleanup projects that drive ERDF waste volumes are identified for both current and future estimates. The estimated quantities have been rounded to two significant figures.

6.1 CURRENT VOLUME OF WASTE DISPOSED AT ERDF

Approximately 10 million metric tons of waste is disposed at ERDF (Section 2.0). This represents approximately 6.3 million m^3. This waste volume is disposed in ERDF cells 1 through 8.

6.2 VOLUMES OF CURRENTLY FORECAST WASTE

A total of 3.4 million m^3 of waste is currently forecast waste for disposal at ERDF. Forecast waste is waste that is expected to be disposed at ERDF. Disposal plans are at various stages of completion. Estimates of volumes of currently forecast waste for disposal at ERDF are based on existing estimates, estimates based on previous studies, and estimates based on process knowledge. Expert judgment was applied to complete the estimates. Estimates of the volumes of currently forecast waste that could be disposed at ERDF are provided in Table 6-1. Cells 7 and 8 and newly constructed super cells 9 and 10 should have available volume for disposal of this waste. The majority of the currently forecast volume is from completion of the River Corridor cleanup and includes 100 Area waste site remediation, disposal of the reactor cores to ERDF, all waste and overburden at the 618-10/11 Burial Grounds (except TRU waste [e.g., caisson waste]), and removal of PFP to "slab-on-grade." Liquid waste sites in the 200-PW-1/3/6 operable unit will be remediated by selected removal of TRU soils (greater than 100 nCi of transuranics per gram of soil). Note that the 400 Area forecast does not include FFTF/Fuels and Materials Examination Facility (FMEF) as no remediation decision has been made. Also not included are facilities remaining in the 300 Area (i.e., 325 Building) that await final cleanup decisions.

Table 6-1. Estimated Volumes of Currently Forecast Waste That Could Be Disposed at ERDF. (2 Pages)

Waste Source	m^3	Comments	Source Reference
100-B/C	320,000	FY 2011 - FY 2016. Includes remaining waste sites and buildings.	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
100-D	510,000	FY 2011 - FY 2016. Includes remaining waste sites and buildings.	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
100-F	45,000	FY 2011 - FY 2016. Includes remaining waste sites and buildings.	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
100-H	100,000	FY 2011 - FY 2016. Includes remaining waste sites and buildings.	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
100-K	570,000	FY 2011 - FY 2016. Includes remaining waste sites and buildings.	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
100-N	270,000	FY 2011 - FY 2016. Includes remaining waste sites and buildings.	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
IU-2/6	79,000	FY 2011 - FY 2016. Includes remaining waste sites and buildings.	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
200-PW-1/3/6	150,000	Selected removal of soils greater than 100 nCi of transuranics per gram of soil	DOE/RL-2007-27 (200-PW-1/3/6 FS)
200-CW-5	18,000	Assumed 4.5 m deep, average 4.5 m wide and 842.7 m long. No adjustments made in volume changes from retrieval operations and packaging.	DOE/RL-2004-24 (200-CW-5 FS), DOE/RL-2009-117 (PP for 200-CW-5 200-PW-1 200-PW-3 AND 200-PW-6)
200 Area	450,000	Scaled for 15 years based on 2010 and 2011 average of 30,000 m^3/yr. Includes Plutonium Finishing Plant cleanup with 50% contingency.	E-mail from J. Jacobs to C. Stroup, ERDF FY2010-2011 Comparison, January 5, 2011
300 Area	490,000	FY 2011-FY2016. Includes remaining waste sites, buildings, slabs, pipelines. Includes 309, and associated below-grade structures. Includes 17,700 m^3 of 324 (9,700 m^3 counted in FY 2011).	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
400 Area	8,100	FY 2011-FY2016. Waste Site 400-37 (Building 4732B).	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011
600 Area	280,000	FY 2011-FY2016. Includes remaining waste sites (618-10 and 618-11).	E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011

Table 6-1. Estimated Volumes of Currently Forecast Waste That Could Be Disposed at ERDF. (2 Pages)

Waste Source	m^3	Comments	Source Reference
Other	150,000	ALE, surveillance and maintenance of balance of site, site infrastructure and utilities, well drilling. Scaled for 15 years based on 2010 and 2011 average of 10,000 m^3/yr.	E-mail from J. Jacobs to C. Stroup, ERDF FY2010-2011 Comparison, January 5, 2011
TOTAL	3,400,000 (rounded)		

ALE = Arid Lands Ecology
ERDF = Environmental Restoration Disposal Facility
FY = fiscal year

6.3 ESTIMATED VOLUMES FROM SOURCES WHERE NO REMEDIATION DECISIONS HAVE BEEN MADE

The estimated maximum potential volume of waste from sources where no remediation decisions have been made for disposal at ERDF is 3.7 million m^3. This waste may or may not be disposed at ERDF. Remediation decisions are at various stages of completion. Estimates of volumes of waste from these sources of waste that could be disposed at ERDF are based on existing estimates, estimates based on previous studies, and estimates based on process knowledge. Expert judgment was applied to complete the estimates. Estimates of the volumes from sources where no remediation decisions have been made are provided in Table 6-2. Up to three additional ERDF super cells could be required for disposal of the waste from these sources.

Several assumptions were required to estimate these volumes, since there are information and decision gaps that can strongly influence the waste volume ultimately generated such as waste characteristics, amounts and methods used for waste removal and/or treatment, and interfaces with adjacent waste sites (i.e., caps on tank farm and canyon facilities). Obviously, estimated waste volume quantities in this group are more uncertain than those for current waste volume forecasts where at least interim decisions have been made and similar previous remediation actions provide precedence. Expert judgment has been used to generate waste volume estimates that are meant to be conservatively high. Assumptions are also made to reasonably envelop the life-cycle volume ERDF may need to support. Key assumptions include the following:

- 100 Area reactor cores.

- Pre-1970 burial grounds were split into two groups. The first group includes those burial grounds that contain higher quantities of TRU constituents that may drive a remediation decision to partial or full retrieval. The second group includes burial grounds that contain lower levels of TRU constituents and hence will be less likely retrieved. The complete RTD case for both groups assumes all the overburden material, as well as all the waste, will be disposed at ERDF. The partial removal case assumes only the waste volumes and associated contaminated soils in the trenches are disposed at ERDF. Some material will likely assay as TRU or spent fuel and will not be disposed at ERDF; that volume is ignored. Volume changes from waste retrieval, processing, and packaging for transportation are unknown and not considered.

- Decisions for remediation of pipelines on the Central Plateau have not been made. Based on preliminary work in the draft RI/FS work plan, remediation of all pipelines shallower than 3 m has been proposed by DOE. Given that assumption, waste volumes were estimated. There is substantial uncertainty in this estimate as the depth of many pipelines is not known, and it is unclear whether all types of pipelines (i.e., high-level waste lines versus cooling-water discharge lines) pose risk levels warranting RTD. In addition, underground catch tanks and diverter boxes were ignored as the volumes are assumed to be small compared to pipeline RTD volumes. Finally, the portion of pipelines adjacent to tank farm or canyon facilities that will end up under a cap will likely not be remediated; however, this volume is included in the estimate.

- Facilities associated with tank farms and WTP will likely operate well beyond the planned life of ERDF. Potential remediation wastes are assumed to be disposed at the IDF. This includes potential wastes from WTP, the ETF, and the CSB.

- Potential wastes from office and support buildings on the Central Plateau are assumed to be disposed at ERDF. This excludes facilities near canyon facilities that are under presumed caps, facilities that support tank waste processing and disposal (WTP, ETF), and the CSB, which will operate after ERDF closure.

- The 309 and 324 Facilities are included in current forecasts. The 325 Building and associated below-grade structures are assumed to be demolished and disposed at ERDF.

- The draft TC&WM EIS assumes capping the facilities in the 400 Area (i.e., FFTF, FMEF); hence, no volumes of waste are assumed for ERDF.

Table 6-2. Potential Waste Volumes to ERDF. (2 Pages)

Waste Source	Partial Removal (m^3)	Complete RTD (m^3)	Comments	Source Reference
100 Area reactor cores	--	11,000	Includes the "Entire Stack." Assume N Reactor ~ K Reactor. No adjustments made in volume changes from dismantling operations and packaging. Volumes from the remaining facility are not considered.	UNI-3714
200 Area Burial Grounds with higher TRU inventories	100,000	300,000	W-1/2/3/4A&B, E-1/5A/12B contain the majority of pre-1970 buried waste with TRU constituents. 98,000 m^3 waste/soil volume and 207,000 m^3 overburden volume. Partial removal case assumes overburden material used to refill the burial trenches.	RHO-RE-ST-30 P

Table 6-2. Potential Waste Volumes to ERDF. (2 Pages)

Waste Source	Partial Removal (m^3)	Complete RTD (m^3)	Comments	Source Reference
200 Area Burial Grounds with lower TRU inventories	300,000	620,000	W-1A/2A/5/6/11 and remaining non-TRU in 3A/3AE and 4C. E-2/2A/4/5/8/9/10/12A/C9. Assumed the same ratio of overburden volume as above. 295,000 m^3 waste/soil volume and 620,000 m^3 overburden volume. Partial removal case assumes overburden material used to refill the burial trenches.	SWITS. 200-SW-2 briefing materials
200 Area Plateau Pipelines		1,200,000	128.7 km of pipeline, assumed 3 m wide by 3 m deep to retrieve. Worst case as some lines may be deeper than 3 m and some will remain under a tank farm or canyon cap. Pipes deeper than 3 m not included. Diversion boxes/misc. tanks not included.	DOE/RL-2010-114 (RFI/CMS RI/FS Work Plan for 200-IS-1)
200 Area Canyons and Tunnels		200,000	Removal of selected equipment and RTD of filters	
200 Area Facilities		1,300,000	Excludes facilities near canyon facilities that are under presumed caps. Excludes CSB, WTP, and ETF where waste is assumed to be disposed at the IDF. Includes 1 million m^3 from miscellaneous facilities and operations waste over the next 30 years.	CP-22319 DEL (Plan for Central Plateau Closure). Scale-up of E-mail from J. Jacobs to C. Stroup, ERDF FY2010-2011 Comparison, January 5, 2011
300 Area Facilities		50,000	Assumes demolition of 325 and associated below-grade structures for disposal at ERDF.	Volume of 325 waste estimated to be between 324 volume of 48,000 m^3 and PFP volume of 72,000 m^3
400 Area			Assume FFTF/FMEF, etc., disposal in place	EIS-0391 (Draft TC&WM EIS)
TOTAL	400,000	3,700,000 (rounded)		

CSB = Canister Storage Building
EIS = Environmental Impact Statement
ERDF = Environmental Restoration Disposal Facility
ETF = Effluent Treatment Facility
FFTF = Fast Flux Test Facility
FMEF = Fuels and Materials Examination Facility
IDF = Integrated Disposal Facility
PFP = Plutonium Finishing Plant
RTD = retrieval, treatment, and disposal
SWITS = Solid Waste Information Tracking System
TC&WM = Tank Closure & Waste Management
TRU = transuranic
WTP = Waste Treatment Plant

6.4 POTENTIAL ERDF VOLUME OF WASTE AT CLOSURE

Nearly 13 million m^3 of waste could potentially be disposed in ERDF at closure. This is the sum of the current volume of waste disposed at ERDF, the volume of currently forecast waste, and the volumes from sources where no remediation decisions have been made.

7.0 BASES OF INFORMATION

This section provides a listing of assumptions and sources of information used to prepare the information in this data package.

7.1 ASSUMPTIONS

- No transuranic waste will be disposed at ERDF. Transuranic waste is waste that meets the definition in subsection 180, Section 2 of the Waste Isolation Pilot Plant Land Withdrawal Act. Transuranic waste includes both mixed transuranic (TRUM) waste and nonmixed transuranic (TRU) waste, and comprises the following categories: contact-handled (CH) TRU, CH TRUM, remote-handled (RH) TRU, and RH TRUM. CH waste is a waste package with a surface dose rate of less than or equal to 200 mrem/hr. RH waste is a waste package with a surface dose rate greater than or equal to 200 mrem/hr.
- No offsite waste will be disposed at ERDF.
- No tank waste (high-level waste) will be disposed at ERDF.
- No spent fuel will be disposed at ERDF.
- The cesium and strontium capsules will not be disposed at ERDF.
- The German logs will not be disposed at ERDF.
- Waste Greater-Than-Nuclear Regulatory Commission-Class C will not be disposed at ERDF.
- The 618-10 Burial Ground preliminary characterization data is representative (the final report has not been issued).
- Waste that will be disposed at ERDF from the 618-11 Burial Ground has the same radionuclide quantities as the 618-10 Burial Ground (characterization of the 618-11 Burial Ground is not planned for a couple of years).
- The 618-10 vertical pipe units are non-TRU and can be disposed at ERDF.
- Technetium-99 in uranium shipped off site was obtained by difference (total technetium-99 produced in the reactors minus technetium-99 in waste onsite [except US Ecology waste]) is representative. NOTE: The recorded technetium-99 in uranium shipped was much greater, but over 90% of Hanford uranium was recycled with technetium-99 already in it (only small technetium-99 was removed from uranium in the gaseous diffusion plants).
- Irradiated lithium target cores in the 200 Area LLBG could be disposed at ERDF. No remediation decisions have been made for this waste.
- Core basket thermal shield and related hardware in the 200 Area LLBG could be disposed at ERDF. No remediation decisions have been made for this waste.

- Less than 0.004 metric tons of plutonium total would be obtained in nontransuranic waste from canyons, PUREX tunnels, and filters. No remediation decisions have been made for this waste.

- Less than 0.013 metric tons of plutonium total would be obtained from nontransuranic waste in 200 Area CERCLA liquid sites/tank leaks and nontransuranic waste in the 200 Area LLBG (SW-2 Operable Unit). No remediation decisions have been made for these wastes.

- Less than 0.0005 metric tons of plutonium total would be obtained from nontransuranic waste in the 618-10/11 Burial Grounds.

- An average of 0.25 Ci of iodine-129 per silver reactor is assumed.

- The majority of secondary waste generated from WTP operations and tank farm operations are assumed to be disposed at IDF.

- Average times are acceptable to estimate radionuclide quantities. Average times were used to decay inventories of the various sources (i.e., an average of 30 years was used to decay the waste in the 200 Area LLBG [SW-2 Operable Unit]). A 40-year decay period was used for the tritium in the irradiated lithium target cores to provide a better estimate of the tritium inventory.

- At least another two decades of waste receipt at ERDF is expected.

7.2 SOURCES OF INFORMATION

The quantities of radionuclides for the following activities and information required to understand waste flow and characterization were obtained from the following sources.

- **Radionuclides Produced in Hanford Reactors**

  - Material processed through T Plant, B Plant, REDOX, and PUREX was obtained from HNF-SD-WM-TI-794, *Activity of Fuel Batches Processed through Hanford Separations Plants*

  - Waste in storage at the CSB and in K-Basin sludge were obtained from HNF-SD-SNF-TI-015, *Spent Nuclear Fuel Project Technical Datebook*

  - Uranium processing history at the Hanford Site was obtained from DOE/RL-2000-43, *Review of Generation and Flow of Recycled Uranium at Hanford*

  - Tritium produced at the Hanford Site was obtained from UNI-1993, *Hanford Production Levels From 1945 to Present*

  - Plutonium and tritium produced at the Hanford Site were obtained from WHC-SD-CP-RPT-014, *Plutonium and Tritium Produced in the Hanford Site Production Reactors*

  - Information on 300 Area test reactors was obtained from ORAUT-TKBS-0006-2, *ORAU Team NIOSH Dose Reconstruction Project.*

- **Waste Stored in High-Level Waste Tanks**
  - Tank Waste Information System (TWINS) Best Basis Inventory
  - Information on tank waste histories in WHC-SD-WM-RPT-164, *Inventories for Low-Level Waste Tank Waste*
  - Waste inventories listed in EIS-0391, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington.*
- **Waste in Storage or Disposed**
  - An August 2010 WMIS EXCEL data file listing all waste profiles associated radionuclide quantities was obtained from G. Loading
  - A listing of ERDF waste received by origin (WMIS1002) was received from G. Loehding (E-mail G. Loehding to C. Stroup, ERDF PA WMIS data, August 24, 2010)
  - Inventory in cesium and strontium capsules from REG-0275, *Waste Encapsulation and Storage Facility Fact Sheet*
  - Inventory in the 200 Area LLBG from the Solid Waste Information Tracking System (SWITS), numerous data runs for various sorts from R. Barco
  - Inventories at US Ecology in *Appendix IV Groundwater Concentrations and Drinking Water Doses with Uncertainty Commercial Low-Level Radioactive Waste Disposal Site Richland Washington* (WDOH 2004)
  - Inventory estimates of solid waste that were buried in the 100 Area burial grounds from WHC-EP-0087, *Estimates of Solid Waste Buried in the 100 Area Burial Grounds*
  - Waste inventories of the vessel in U Plant Cell 30 from D&D-33135, *Disposition of Waste From Process Vessel in Cell 30 of 221-U*
  - 618-10/11 characterization information and assumptions from discus*sions with S. Khabir on Characterization Data for 618-10/11* Burial Grounds
  - Calculation 0600X-CA-N0060, *Radiological Inventory in the 618-10 Burial Ground Trenches*
  - Estimates of radionuclides in the 100 Areas from UNI-946, *Radiological Characterization of the Retired 100 Areas*
  - Present radionuclide inventories in T Plant from Bryan Crume
  - Radionuclide inventories of PUREX tunnels #1 and #2 from HNF-2545, *Plutonium-Uranium Extraction Facility (PUREX) Plutonium and Fission Product Residual Estimates*
  - Additional information on the 618-10 Burial Ground from *Final Hazard Categorization for the 618-10 Burial Ground Remediation*

- Radionuclide information on the 218-W-4B alpha caissons from CHPRC-00585, *218-W-4B Alpha Caissons Technical Information Report*
- Information on 200 Area silver reactors from an excel file from J. Jensen
- Additional information on 200 Area silver reactors from HW-63703, *Disposition of Contaminated Processing Equipment at Hanford Atomic Products Operation 1958 – 1959*
- Additional information on 300-FF-1 from DOE/RL-92-43, *Phase I Remedial Investigation Report for the 300-FF-1 Operable Unit*
- Information on uranium in soils in the 300 Area from PNNL-17034, *Uranium Contamination in the Subsurface Beneath the 300 Area, Hanford Site*
- Additional information on 300-FF-1, 300-FF-2, and 300-FF-5 from DOE/RL-2009-30, *300 Area Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*
- Additional information on 100-BC-1 from DOE/RL-93-06, *Limited Field Investigation Report for the 100-BC-1 Operable Unit*
- ARH-2762, *Input and Decayed Values of Radioactive Solid Wastes Buried in the 200 Areas through 1971*
- ARH-231, *Hanford Low Level Waste Management Reevaluation Study*
- DOE/DP-0137, *Plutonium: The First 50 Years*
- Preliminary Hanford information prepared by C. R. Stroup, S. M. Joyce, and G. Konzek to revised DOE/DP-0137, *Plutonium: The First 50 Years*
- RHO-RE-ST-30 P, *Hanford Defense Waste Disposal Alternatives: Engineering Support Data for the Hanford Defense Waste-Environmental Impact Statement*
- WHC-MR-0521, *The Plutonium Production Story at the Hanford Site: Processes and Facilities History*
- WHC-SD-TP-PDC-033, *GNS-12 Packaging Design Criteria*
- DOE/RL-98-28, *200 Area Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*
- HNF-8069, *Nuclear Material Mass Flow and Accountability on the Hanford Site*
- PWM-530, *Hanford Radioactive Waste Management Plans*
- 200-SW-2, Public Meeting Presentation
- WHC-SD-WM-TRP-243, *Physical Property Characterization of 183-H Sludge Basin*

- WHC-SD-W100-TP-007, *183-H Basin Mixed Waste Analysis and Testing Report*
- BHI-00033, *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit*
- DOE/RL-92-32, *Expedited Response Action Assessment for 316-5 Process Trenches*
- E-mail from M. Casbon to C. Stroup, *Inventory Reconciliations*, January 13, 2011.

- **Facility Residual Waste**
  - Estimates of radionuclides in the WESF cells and ventilation system (K-3) ductwork from HNF-8556, *Estimate of WESF Hot Cell Inventory*
  - Estimates of radionuclides in the 100 Area reactors from UNI-3714, *Radionuclide Inventory and Source Terms for the Surplus Production Reactors at Hanford*
  - Waste inventories for REDOX from DOE-RL Correspondence 0301503, Approval of *REDOX Documented Safety Analysis*
  - Residual radionuclide inventories in Hanford facilities estimates from RHO-SD-DD-FL-001, *Rockwell Retired Contaminated Facility Listing and Description*
  - Residual radionuclide inventory on the REDOX sand filter from Calculation 0200W-CA-N0007, *291-S Sand Filter Loading Estimate*
  - Radionuclide inventory on the PUREX deep-bed filters from HNF-2545
  - Radionuclide inventories of PUREX from HNF-2545 and CP-14977, *Plutonium Uranium Extraction Facility Documented Safety Analysis*
  - Information from W. Josephson that 120,000 Ci of German Log solution spilled in the 324 Facility B-Cell
  - CP-22319, *Plan for Central Plateau Closure*
  - WHC-IP-0977, *Estimation of PUREX Equipment and Materials that are Candidates for Removal and Waste Processing during PUREX Plant Closure.*

- **Waste Shipped Offsite**
  - Waste in cesium and strontium capsule that is offsite from HNF-21462, *WESF Capsule Families*
  - Uranium processing history from DOE/SO-0003, *Recycled Uranium United States Production, Enrichment, and Utilization.*

- **Waste in CERCLA Liquid Waste Sites and Tank Leaks**
  - Waste in CERCLA liquid waste sites and tank leaks from RPP-26744, *Hanford Soil Inventory Model*
  - DOE/RL-2007-27, *Feasibility Study for the Plutonium/Organic-Rich Process Waste Group Operable Unit: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*
  - RHO-ST-17, *Distribution of Plutonium and Americium beneath the 216-Z-1A Crib: A Status Report*
  - RHO-LD-114, Informal Report, *Existing Data on the 216-Z Liquid Waste Sites*
  - West and East Area technetium-99 in groundwater estimates from S. Mehta (in e-mail), November 2010
  - DOE/RL-2004-24, *Feasibility Study for the 200-CW-5 Cooling Water Operable Unit*
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  - Casbon e-mail January 20, 2011 (ERDF Forecast).
- **Waste Forecasts**
  - Radionuclide quantities from key remaining Washington Closure Hanford waste sites and facilities from M. F. Maxson of Washington Closure Hanford. M. F. Maxson sent an e-mail message with attached estimates.
  - Estimates from the 200 West Pump and Treat Facility design from SGW-46244, *Source Term Calculation for the 200 West Pump and Treat Facility.*
  - Waste forecast for ERDF from FY 2011 through 2018 from HNF-EP-0918, *Solid Waste Integrated Forecast Technical (SWIFT) Report.*
  - Waste half-life and specific activities from HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria.*
  - The ERDF waste acceptance criteria from WCH-191, *Environmental Restoration Disposal Facility Waste Acceptance Criteria.*
  - E-mail from M. Casbon to C. Stroup, *2015 Waste Sites*, January 20, 2011.
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- **Waste Characterization, Uncertainties, and Process Flow Discussions**
  - Numerous discussions were held to better understand waste characterization, uncertainties, and process flow. Information was exchanged from M. Casbon, G. Loading, K. Lueck, G. Millward, R. Gana, D. Teachout, N. Little, R. Hynes, M. Maxson, S. Khabir, and J. Ludowise.
  - A process flowchart of waste characterization, designation, transportation and disposal at ERDF, and closeout was obtained from M. Casbon.
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APPENDIX A

SPECIFIC RADIONUCLIDE CHARTS

APPENDIX A

SPECIFIC RADIONUCLIDE CHARTS

This appendix provides a consolidated overview of the quantities of specific radionuclides in the Executive Summary of this report that are or could be disposed in the Environmental Restoration Disposal Facility (ERDF). Figure A-1 provides a template for the specific radionuclide charts. Figures A-2 through A-11 provide specific radionuclide charts for carbon-14, cesium-137, chlorine-36, iodine-129, nickel-63, plutonium total, strontium-90, technetium-99, tritium (H-3), and uranium total.

Figure A-1. Template for Specific Radionuclide Charts.

The specific radionuclide is identified here. Red indicates a groundwater contributor (to satisfy the 4 mrem/yr performance objective) and blue indicates only an intruder concentration limitation.

The half-life of the radionuclide is provided in years

Quantities shown on this chart have been decayed to 2011

The inventory of the specific radionuclide disposed in ERDF is provided in this section.

The WMIS Inventory (rounded) as of August 2010 of the specific radionuclide disposed in ERDF is provided here in curies or metric tons. An adjusted inventory from analysis of available information may be provided in red.

The sum of the major sources of the WMIS Inventory of the specific radionuclide disposed in ERDF is provided here in curies or metric tons, and as a percent of the total.

The major sources (in order - greatest first) of the WMIS inventory of the specific radionuclide disposed in ERDF is provided here in curies or metric tons, and as a percent of the total. If no additional waste is planned to be disposed in ERDF from this source it is labeled *Complete*. *Ongoing* is used for sources were additional waste is planned to be disposed in ERDF. An adjusted inventory from analysis of available information may be provided in red.

The waste forms of the WMIS inventory of the specific radionuclide disposed in ERDF is provided here in curies or metric tons, and as a percent of the total. Types of waste forms include untreated waste, activated metal waste, and insoluble (i.e., grouted) waste.

The potential inventory at closure of the specific radionuclide disposed in ERDF is provided in this section.

The estimated inventory at closure of the specific radionuclide disposed in ERDF is provided here in curies or metric tons.

The quantity of the specific radionuclide at Hanford and in material shipped off-site is provided in this section.

The approximately quantity (rounded to two significant figures) of the specific radionuclide at Hanford and in material shipped off-site (exceptions are noted in this section) is provided here in curies or metric tons.

A pie chart is provided here showing the relationship of the quantities by major source (in order – greatest first) of the specific radionuclide at Hanford and in material shipped off-site.

An indicator of the potential sources in the pie chart that could be sent to ERDF is provided if it can be easily displayed.

Template for Specific Radionuclide Charts

A note of significance or an omission from the pie chart is included here.

The quantity of the specific radionuclide at Hanford that is a potential source of waste for disposal in ERDF.

A less-than or approximate quantity (rounded to two significant figures) of the specific radionuclide that could be disposed in ERDF is provided here in curies or metric tons.

A pie chart is provided here showing the relationship of the quantities by major source (in order – greatest first for expected [currently forecast] waste and then for waste where no remediation decisions have been made) of the specific radionuclide that could be disposed in ERDF.

Less-than or approximate quantities (rounded to two significant figures) in the pie chart are provided here (in order – greatest first for currently forecasted waste and then for waste where no remediation decisions have been made) of the specific radionuclide that could be disposed in ERDF.

A note of significance or an omission from the pie chart is included here.

A note for waste where no remediation decisions have been made.

Figure A-2. Carbon-14.

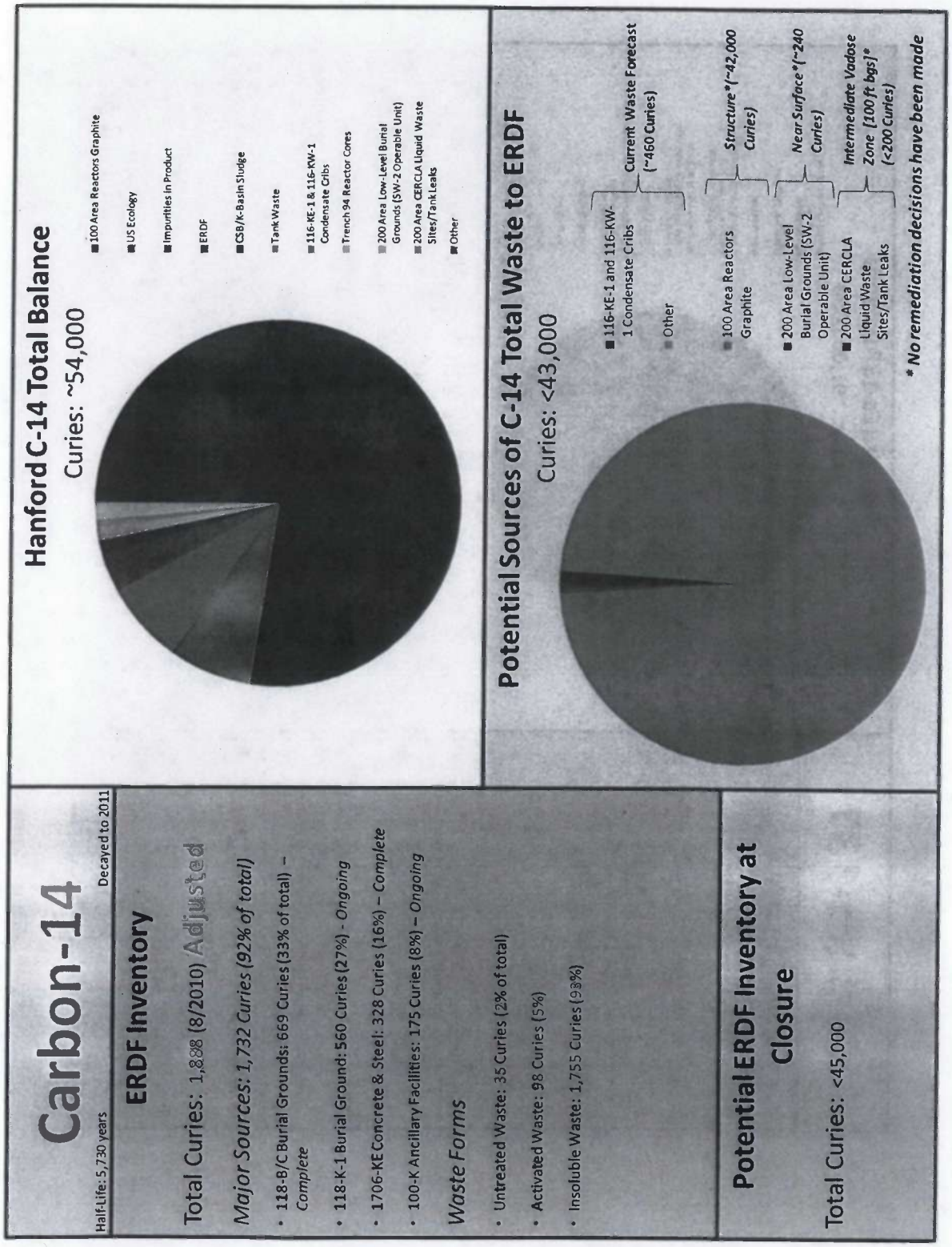


Figure A-3. Cesium-137.

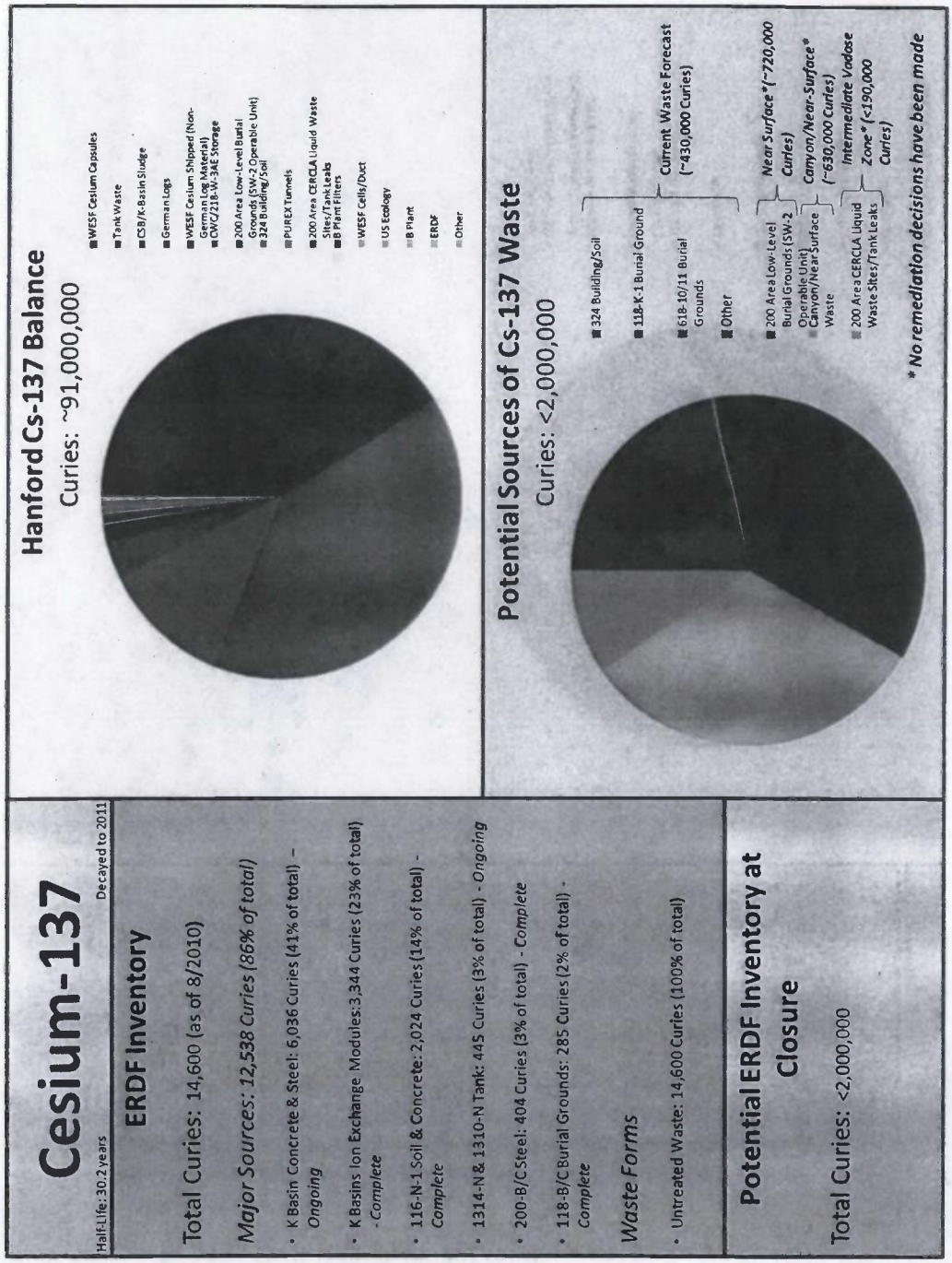


Figure A-4. Chlorine-36.

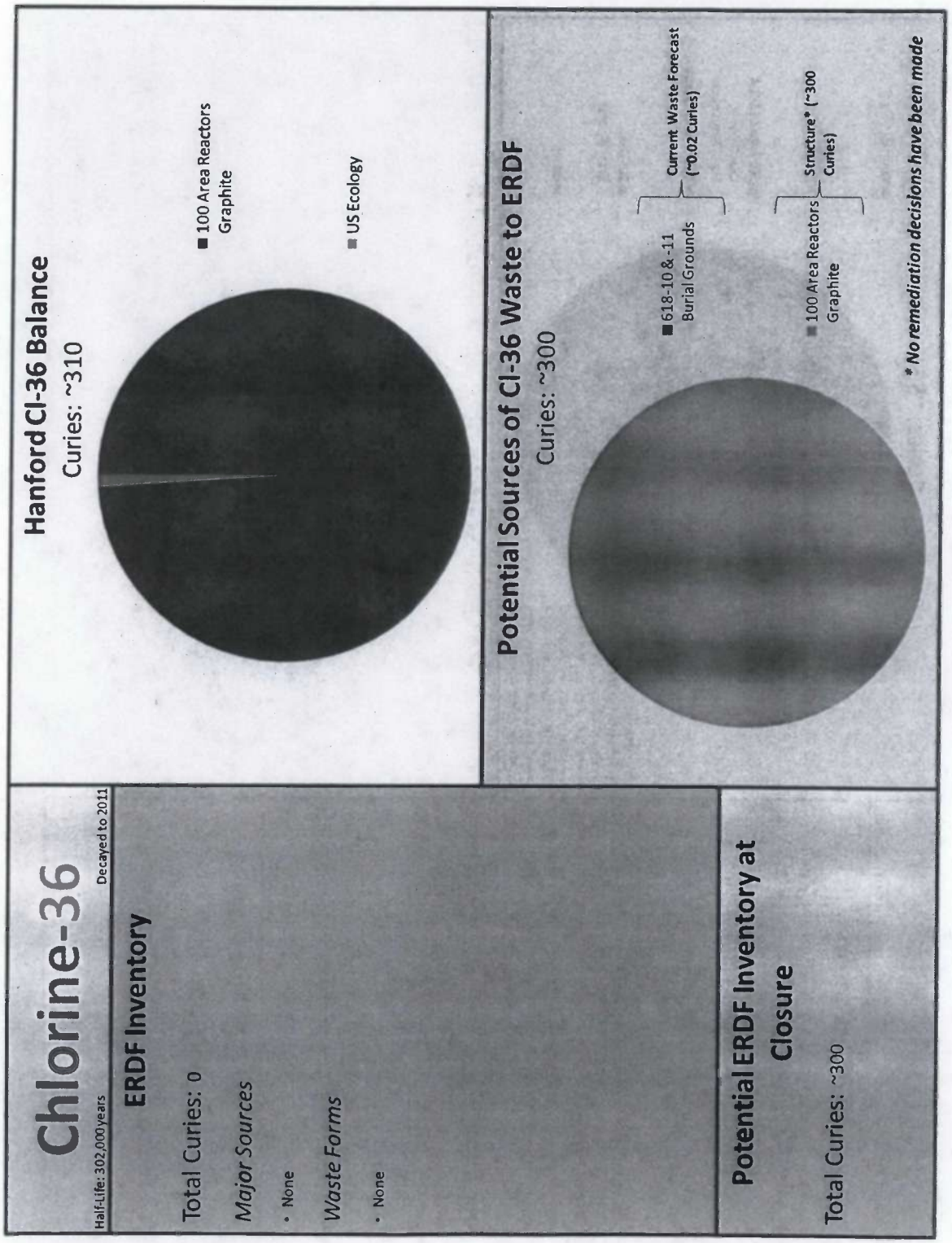


Figure A-5. Iodine-129.

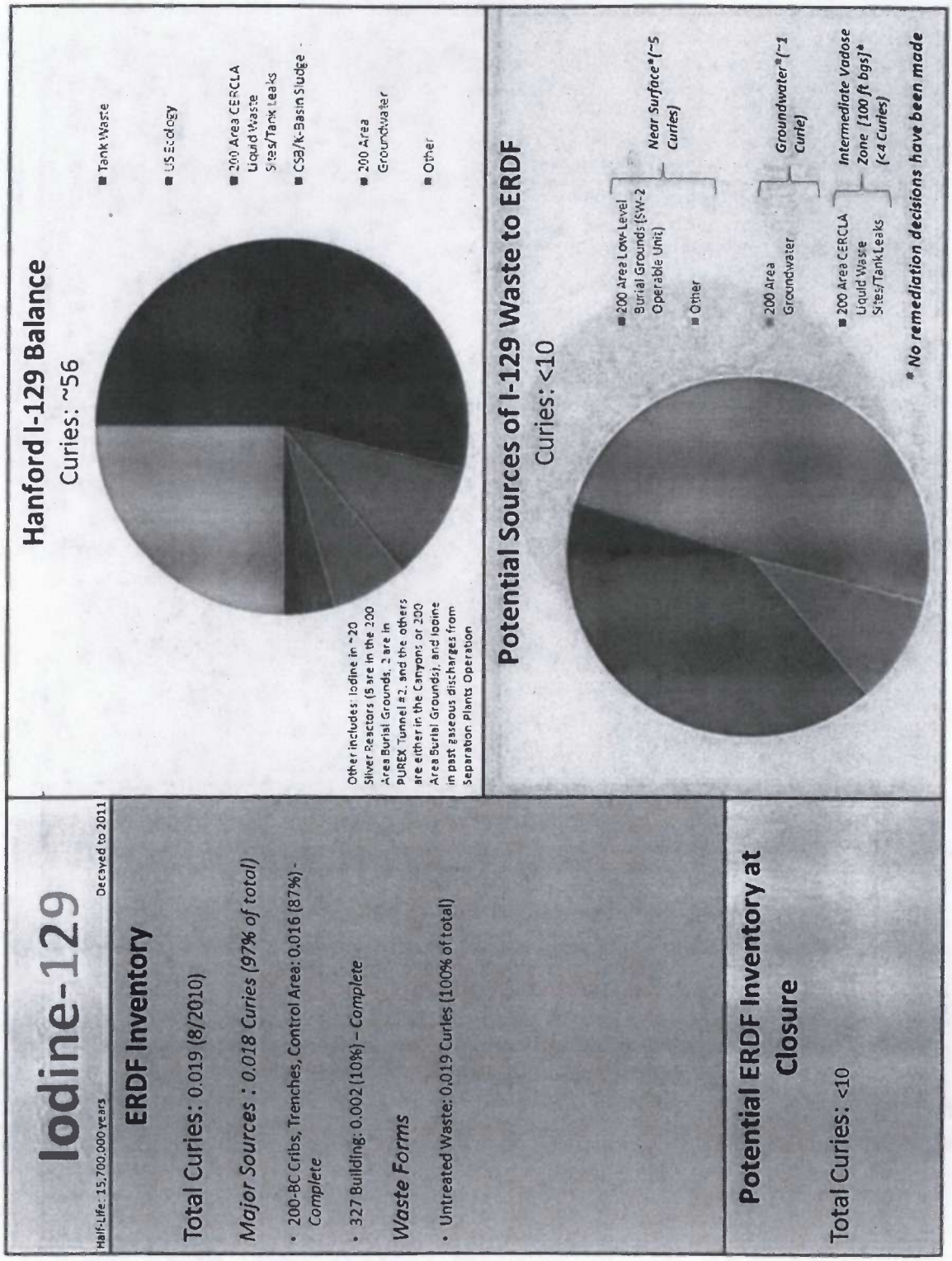


Figure A-6. Nickel-63.

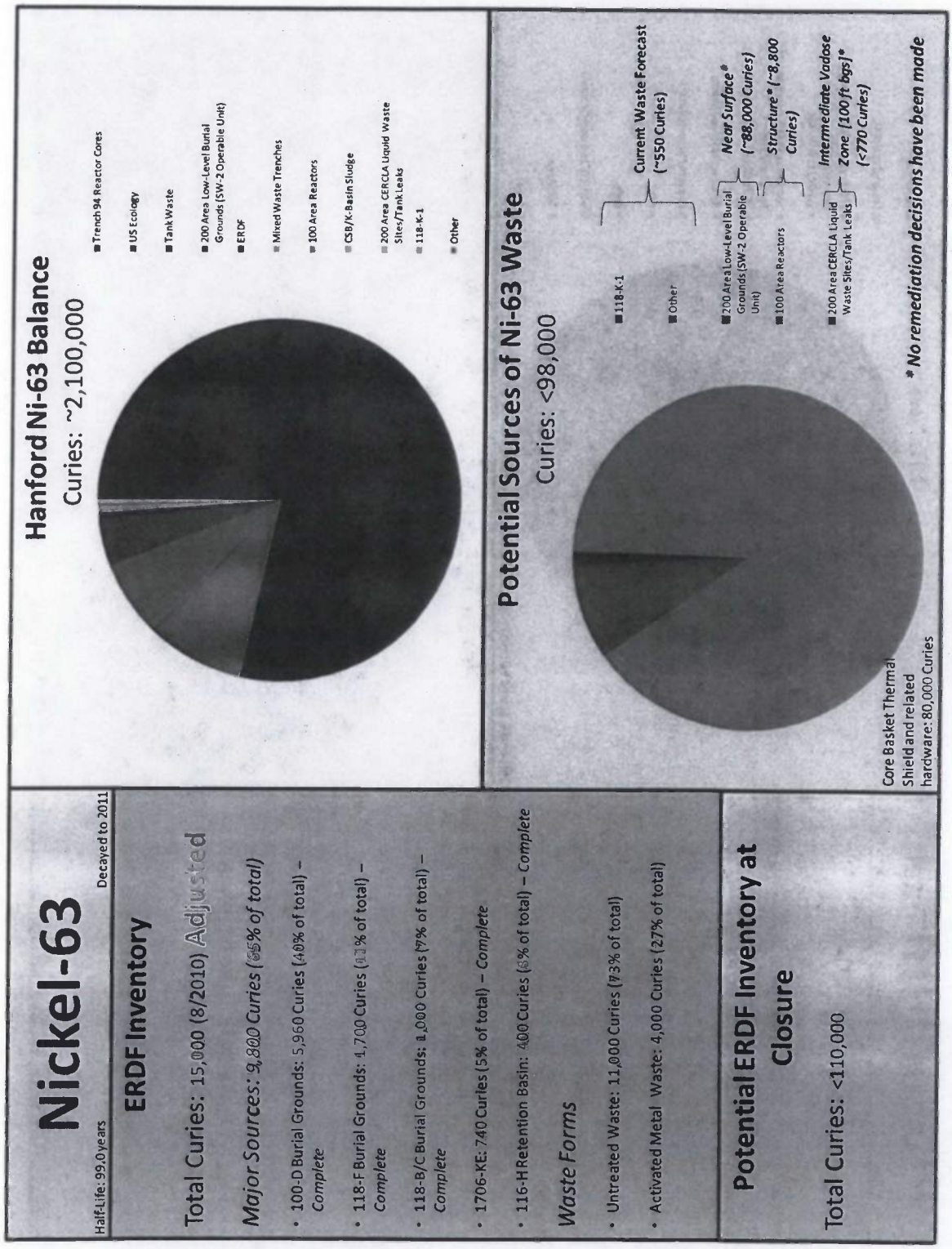


Figure A-7. Total Plutonium.

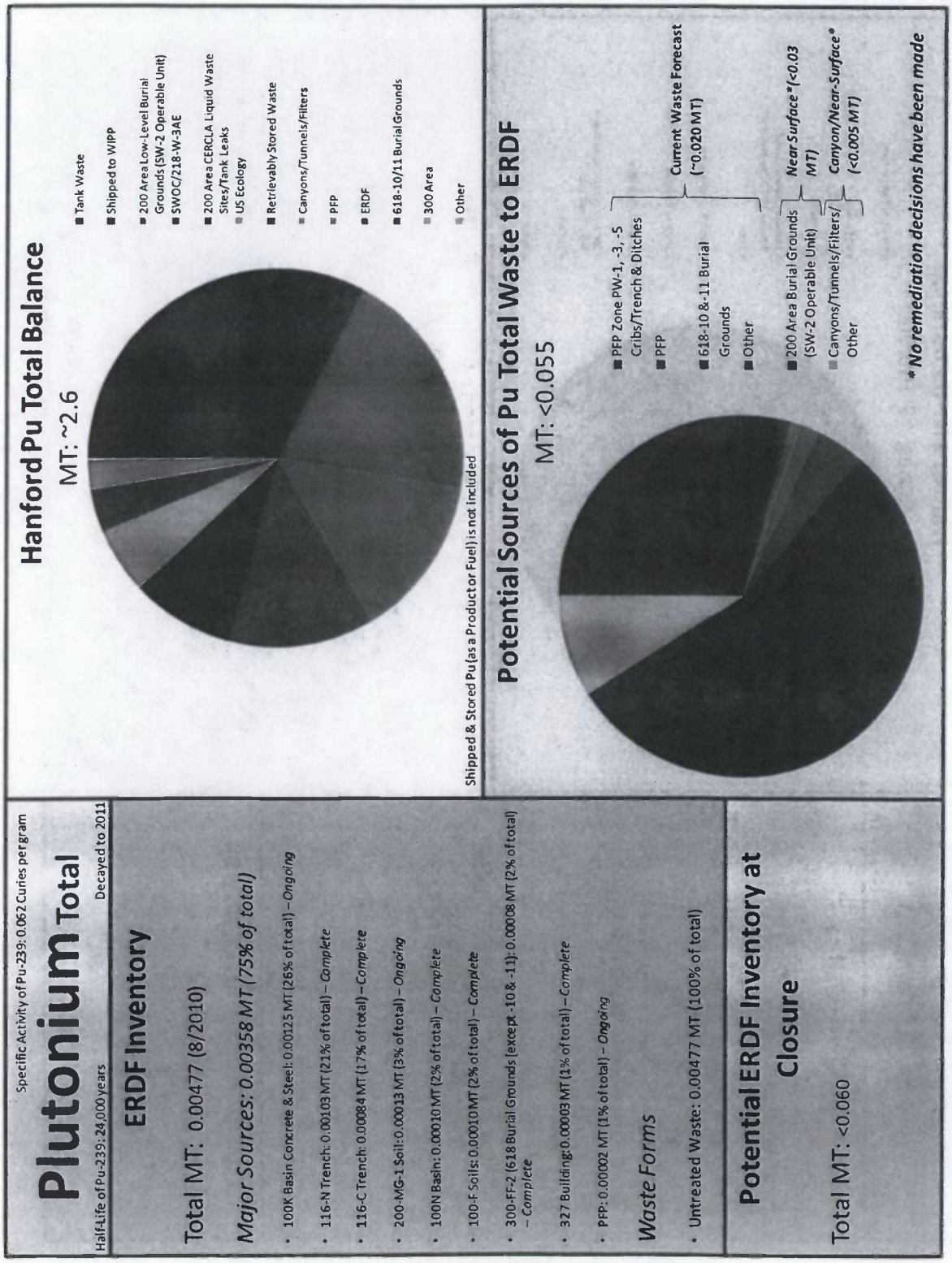


Figure A-8. Strontium-90.

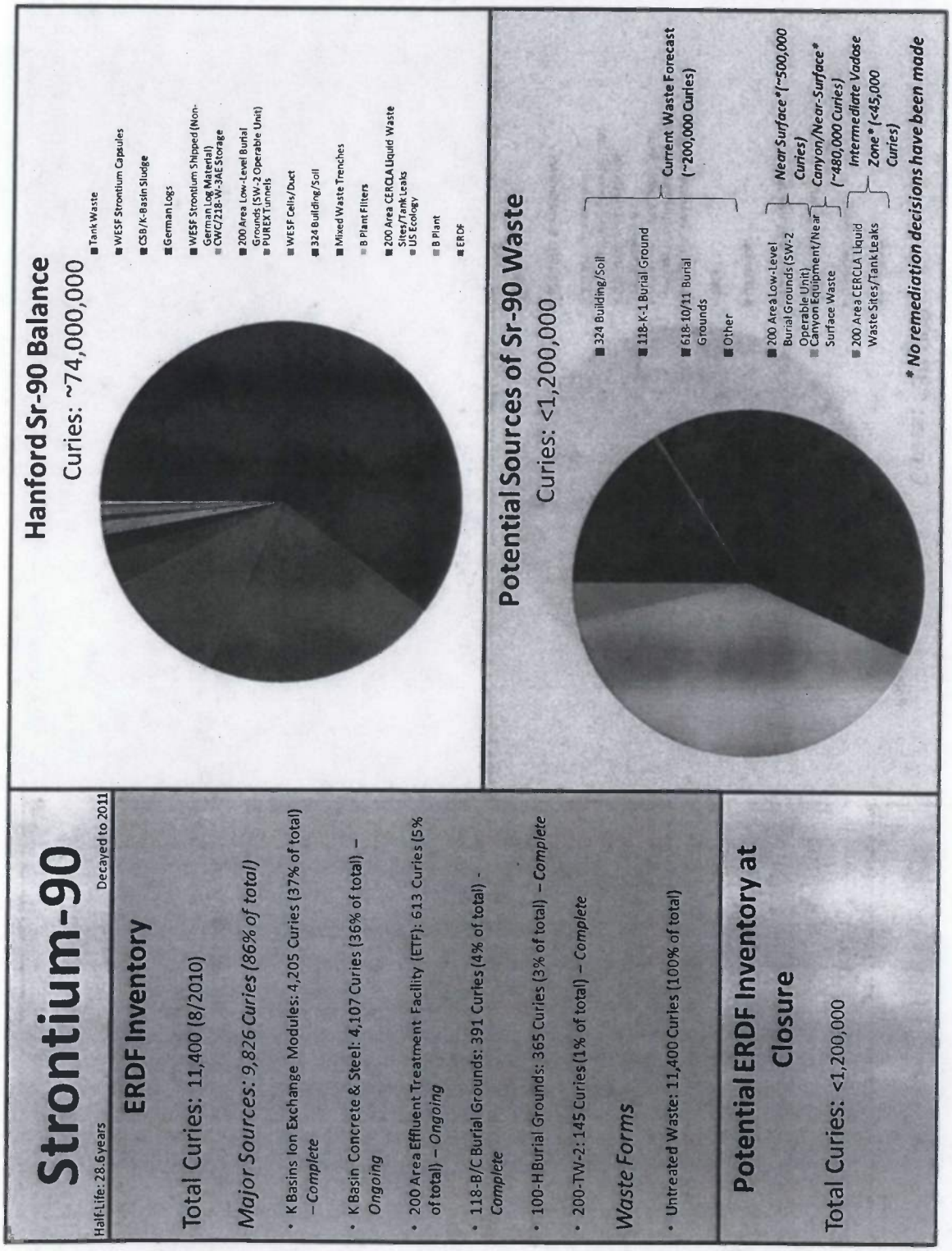


Figure A-9. Technetium-99.

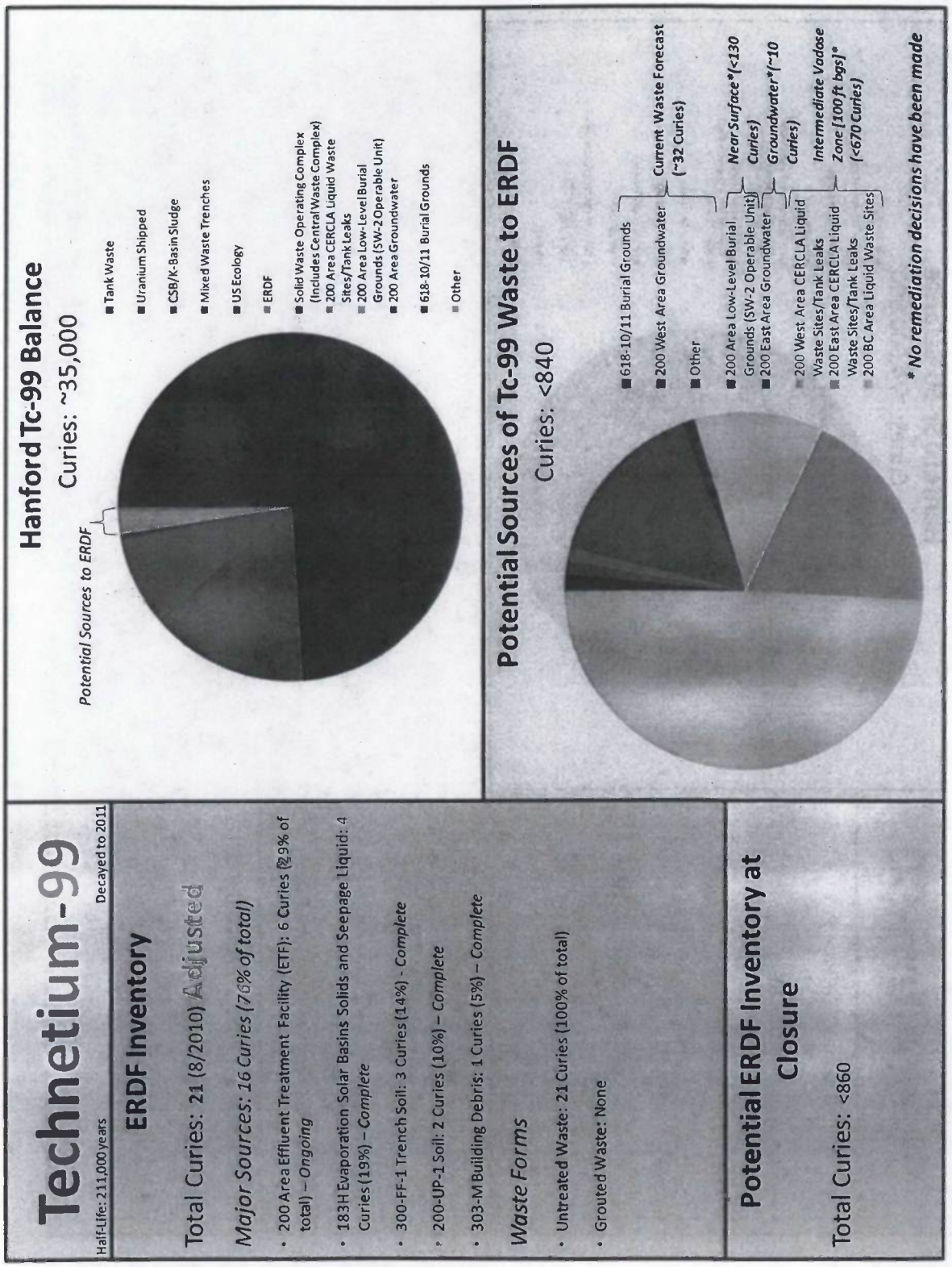
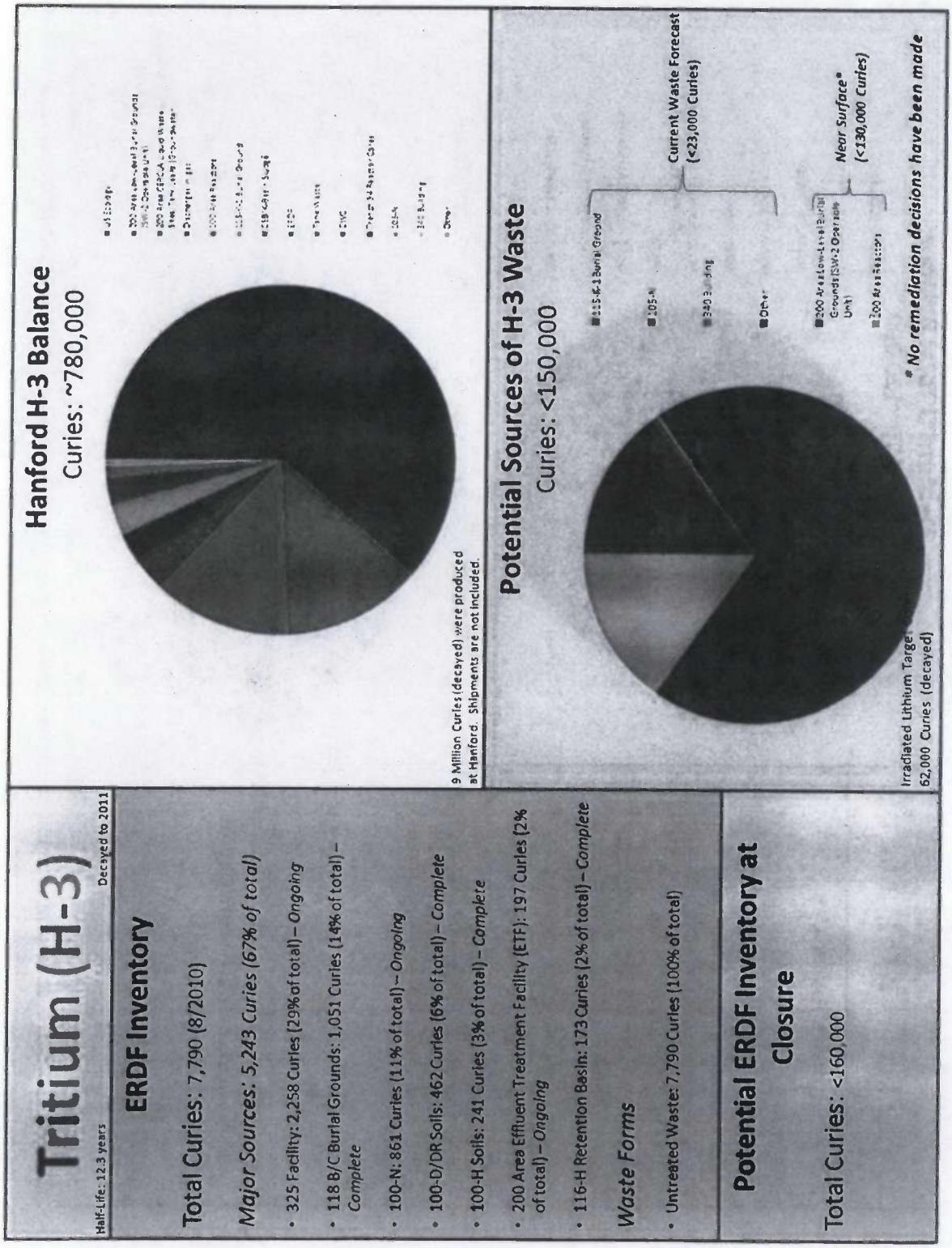


Figure A-10. Tritium (H-3).



Specific Activity of U-238: 0.00000034 Curies per gram

Uranium Total

Half-Life of U-238: 4.5 billion years

Decayed to 2011

ERDF Inventory

Total MT: 202 (8/2010) Adjusted

Major Sources: 186 MT (92% of total)

- 300-FF-2 Burial Grounds (618-1, -2, -3, -7 & -8): 62 MT (31% of total) – *Complete*
- 316 North & South Ponds: 45 MT (22%) – *Complete*
- 300 Labs Soil & Concrete: 35 MT (17%) – *Ongoing*
- 316-4 & 316-5 Trenches: 26 MT (13%) – *Complete*
- 100 Area Liquid Waste Sites: 18 MT (9%) – *Complete*

Waste Forms

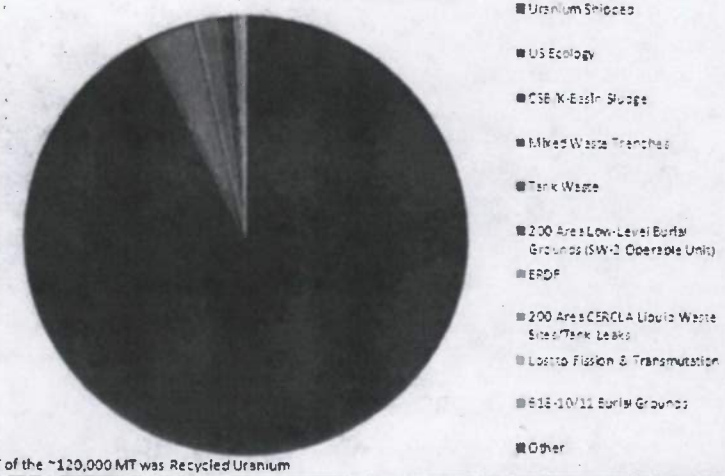
- Untreated Waste: 202 MT (100% of total)
- Grouted Waste: None

Potential ERDF Inventory at Closure

Total MT: <870

Hanford U Total Balance

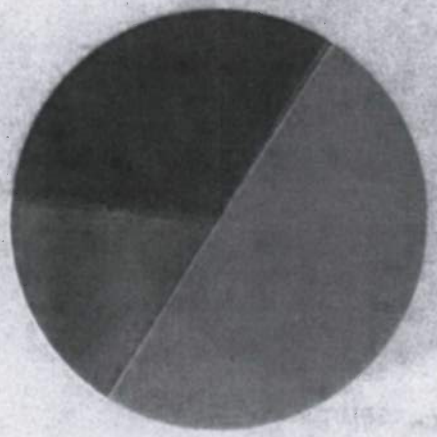
MT: ~120,000



~110,000 MT of the ~120,000 MT was Recycled Uranium

Potential Sources of U Total Waste to ERDF

MT: <670



- 618-10 &-11 Burial Grounds
- Other

Current Waste Forecast (~60 MT)

- 200 Area Burial Grounds (SW-2 Operable Unit)
- 200 Area Burial Grounds (SW-2 Operable Unit) Grouted in Monolith

Near Surface* (~450 MT)

- 200 Area CERCLA Liquid Waste Sites/Tank Leaks

Intermediate Vadose Zone* (<160 MT)

**** No remediation decisions have been made***

Figure A-11. Total Uranium.

APPENDIX B

ADDITIONAL RADIONUCLIDE INFORMATION

APPENDIX B

ADDITIONAL RADIONUCLIDE INFORMATION

The following charts have activities, rounded quantities (in curies or metric tons), and primary information references for 10 key radionuclides to the Environmental Restoration Disposal Facility (ERDF) performance assessment. Radionuclide quantities are for source activities ("inputs"), removals from Hanford ("outputs"), and existing "on-site" accumulations.

Examples of "inputs" include fuels processed through T, B, REDOX and PUREX; inventory of spent fuel in the Canister Storage Building (CSB); US Ecology; existing 100 Area waste sites that have not been remediated; 100 Area reactors; Trench 94 reactor cores; Hanford burial of off-site waste; disposal of waste from reactor operations in ERDF; and 610-10/11 Burial Grounds. Inputs for plutonium and most products and fuels (i.e., Fast Flux Test Facility [FFTF]) activities are not included.

Examples of "outputs" include capsule material that will not be returned to the Hanford Site, radionuclides (i.e., iodine and tritium) in past gaseous discharges, uranium shipped off site, and technetium in uranium shipped off site.

Examples of "on-site" accumulations include Waste Encapsulation Storage Facility (WESF) cesium and strontium capsules; tank waste; inventory of spent fuel in the CSB; US Ecology; existing 100 Area waste sites that have not been remediated; 100 Area reactors; Trench 94 reactor cores; German logs; 200 Area low-level burial grounds (SW-2 Operable Unit); PUREX tunnels; Separation and Finishing Plants; plant filters; ERDF; Central Waste Complex (CWC)/218-W-3AE storage; and mixed waste trenches.

Chart Information in green is in the current ERDF waste forecast. Information in dark red is potential waste (no remediation decisions have been made) for ERDF. Plus signs indicate that a portion of the activity may apply. Quantities are decayed to 2011.

Figure B-1. Carbon-14.

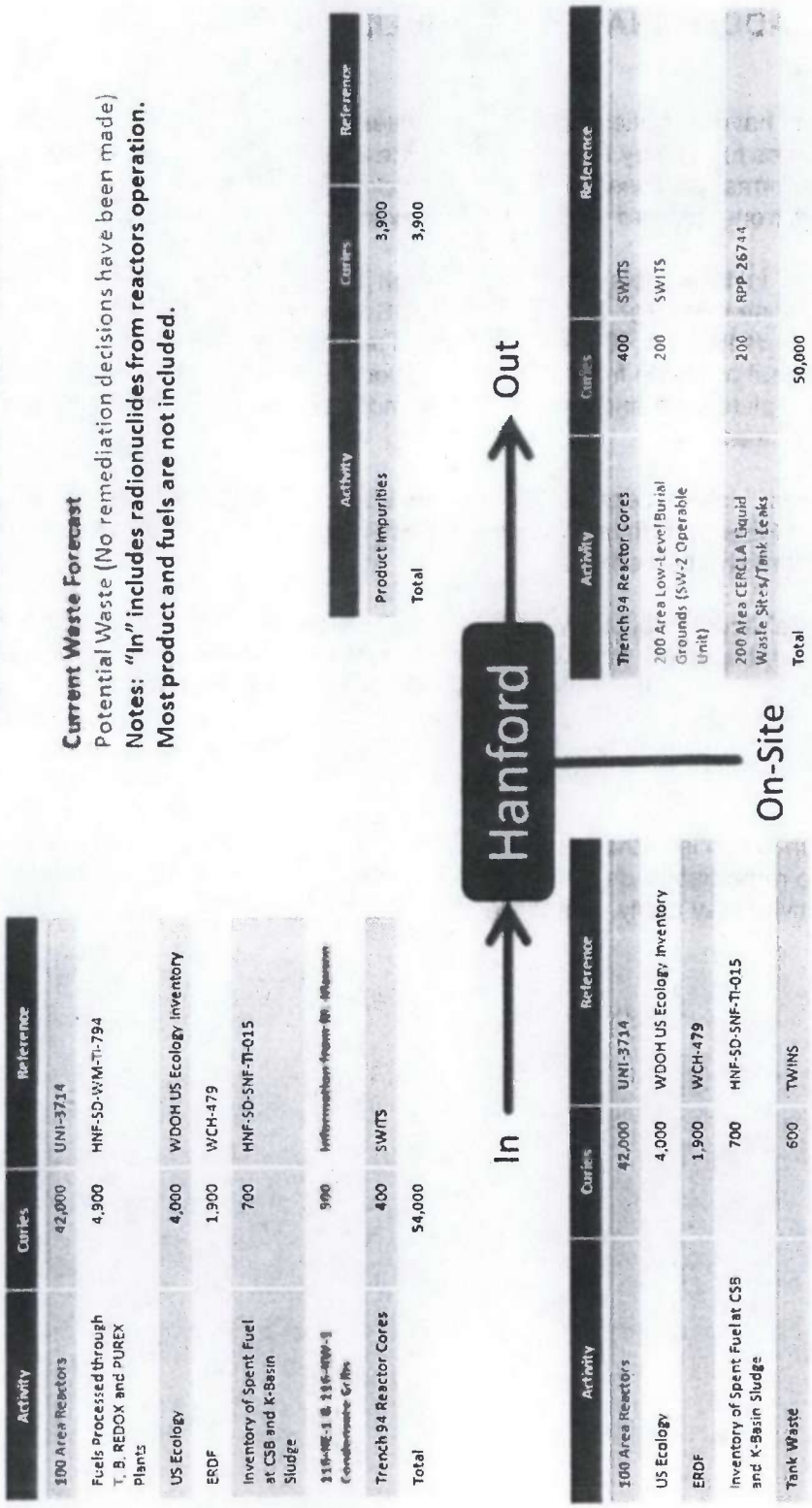


Figure B-2. Cesium-137.

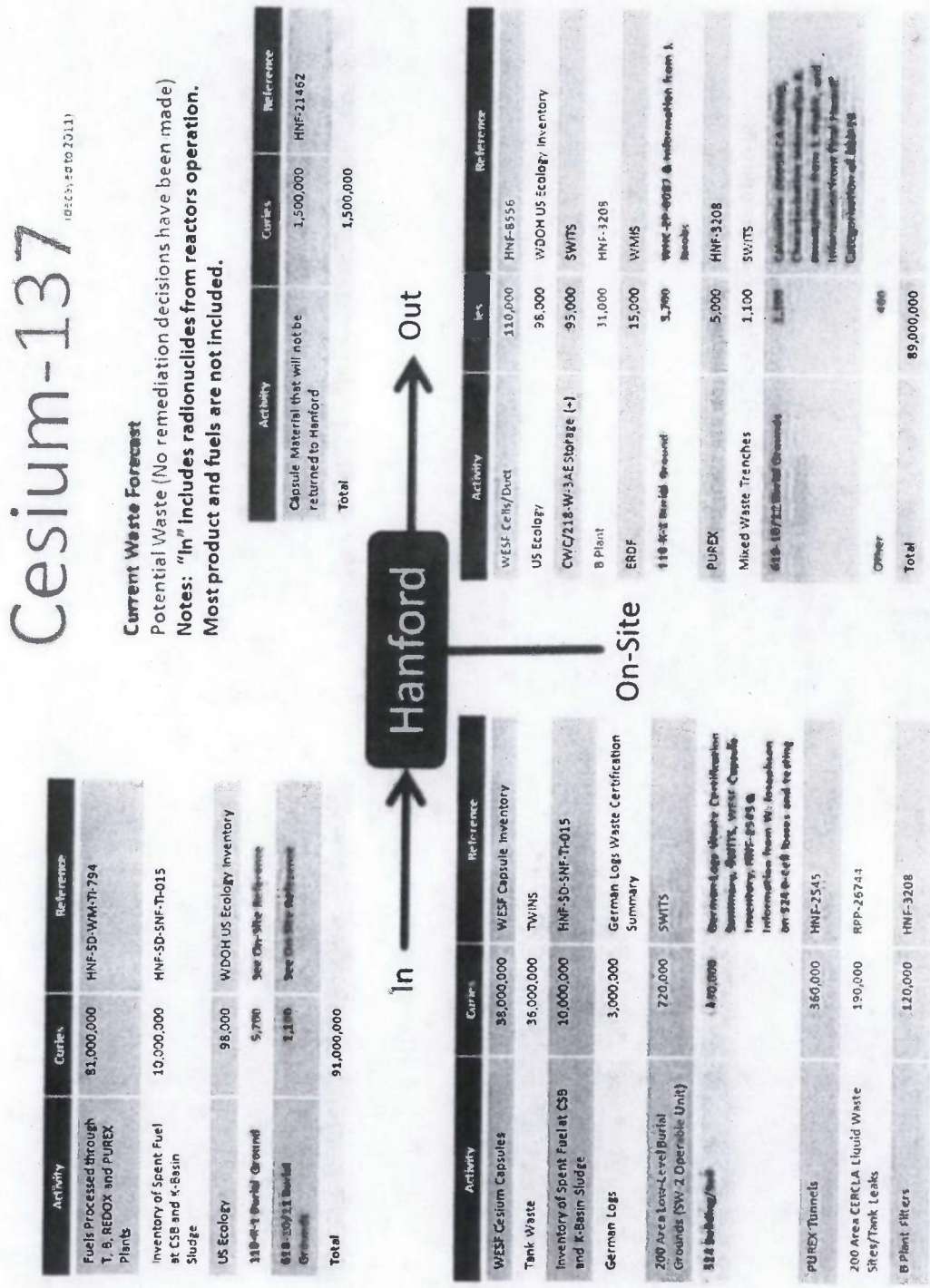


Figure B-3. Chlorine-36.

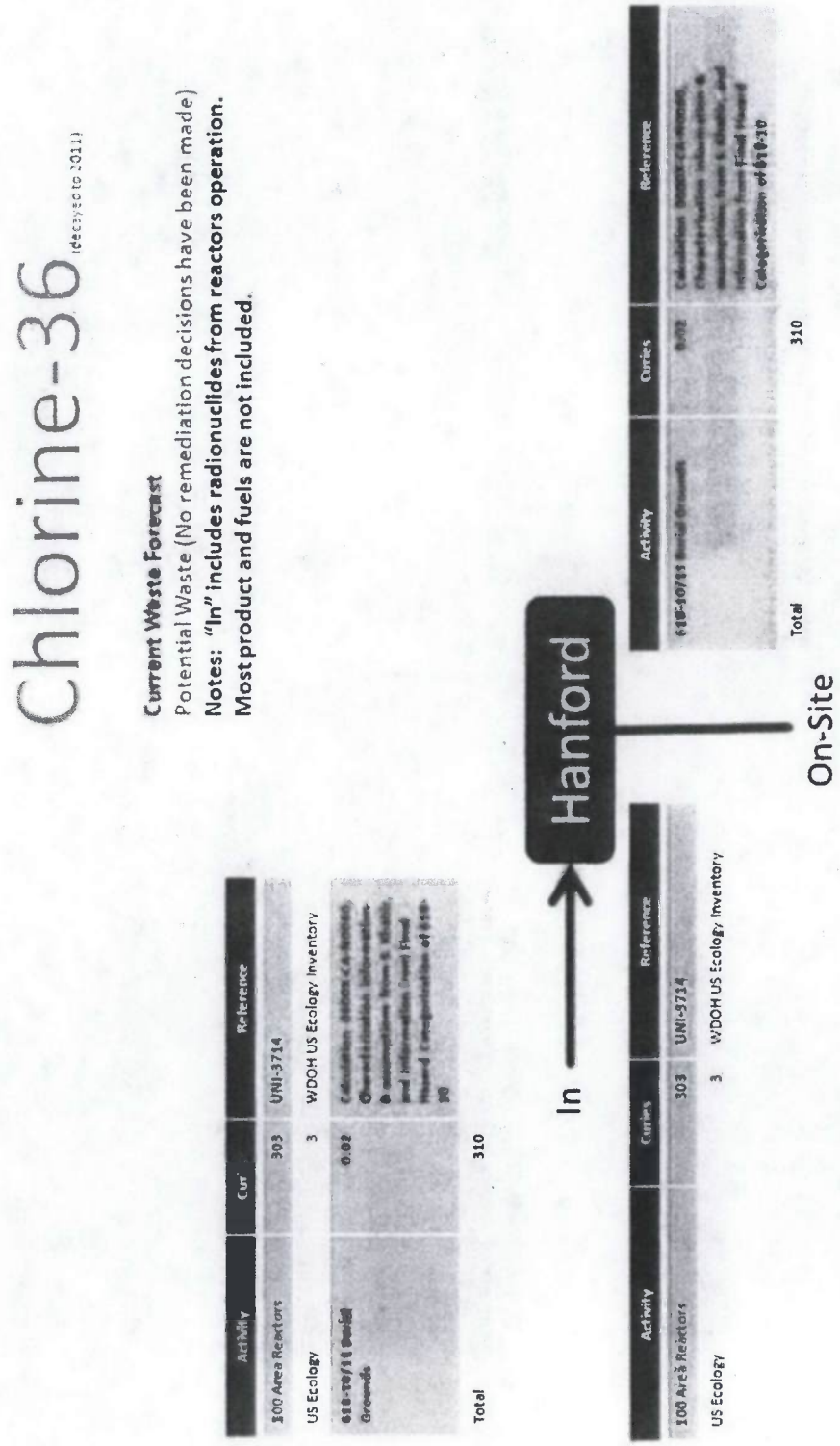
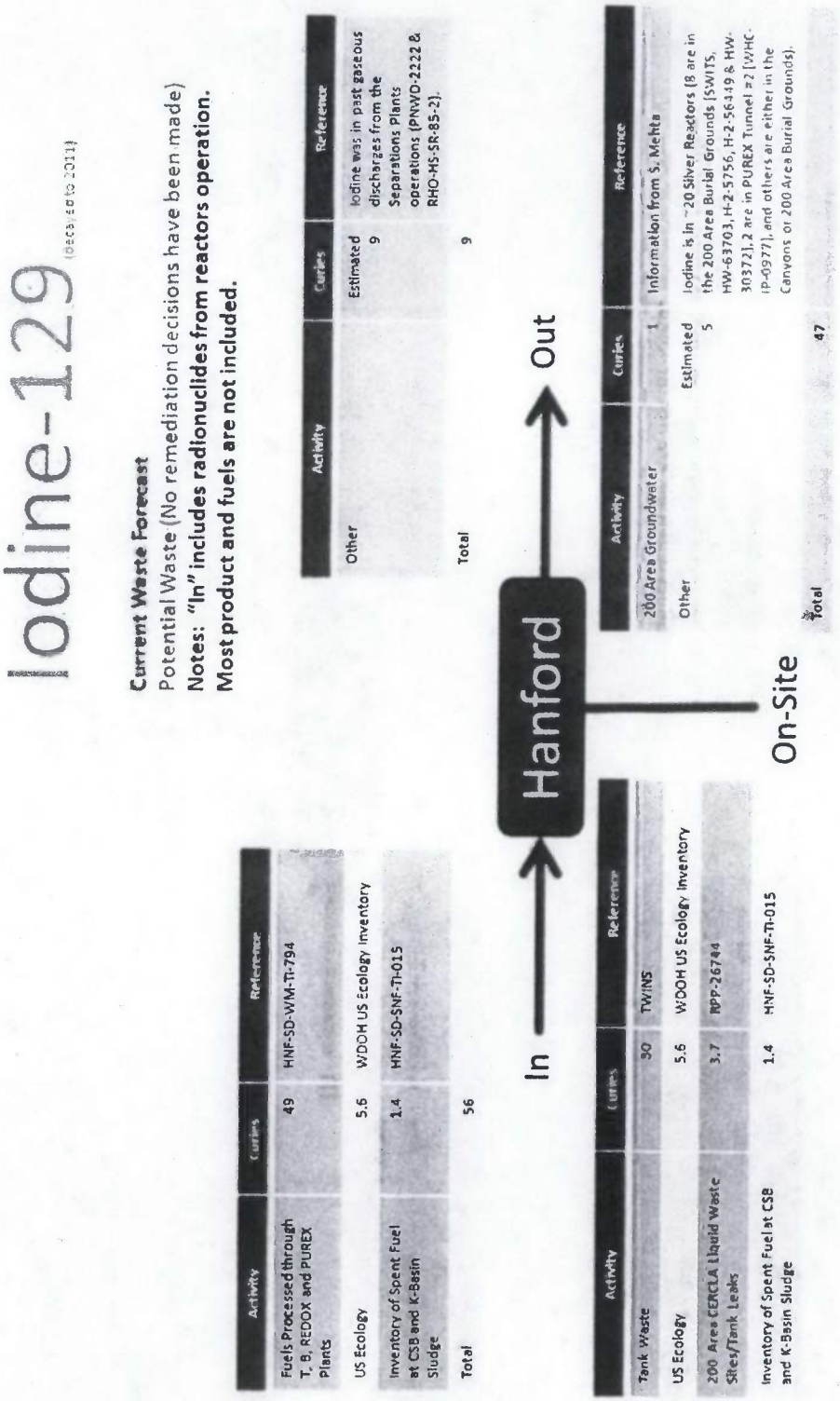


Figure B-4. Iodine-129.



Nickel-63 (decayed to 2011)

Current Waste Forecast

Potential Waste (No remediation decisions have been made)

Notes: "In" includes radionuclides from reactors operation. Most product and fuels are not included.

Activity	Curies	Reference
Trench 94 Reactor Cores	1,700,000	SWITS
US Ecology	190,000	WDOH US Ecology Inventory
Fuels Processed through T, B, REDOX and PUREX Plants	100,000	HNF-SD-WM-TI-794
200 Area Low-Level Burial Grounds Core-Basket Thermal Shield and related hardware (SW-2 Operable Unit)	80,000	SWITS
100 Area Reactors	8,800	UNI-3714
Inventory of Spent Fuel at CSB and K-Basin Sludge	4,400	HNF-SD-SNF-TI-015
110-K-1 Burial Ground	480	See On-Site Reference
Total	2,100,000	

In → Hanford

Activity	Curies	Reference
Trench 94 Reactor Cores	1,700,000	SWITS
US Ecology	190,000	WDOH US Ecology Inventory
Tank Waste	140,000	TWINS
200 Area Low-Level Burial Grounds (SW-2 Operable Unit)	88,000	SWITS
ERDF	15,000	WCH-479
Mixed Waste Trenches	9,700	SWITS
100 Area Reactors	8,800	UNI-3714

On-Site

Activity	Curies	Reference
Inventory of Spent Fuel at CSB and K-Basin Sludge	4,400	HNF-SD-SNF-TI-015
200 Area CERCLA Liquid Waste Sites/Tank Leaks	770	RPP-26744
110-K-1 Burial Ground	480	WHC-EP-0017 & Information from L. Hollis
Other	70	
Total	2,200,000	

Figure B-5. Nickel-63.

Plutonium (decayed to 2011)

Current Waste Forecast

Potential Waste (No remediation decisions have been made)

Notes: "In" includes radionuclides from reactors operation. Generated, shipped product and most fuels are not included.

Hanford

On-Site

Activity	MT	Reference
Tank Waste	0.84	TWINS
Shipped to WIPP	0.52	WIPP Shipment Records
200 Area Low-Level Burial Grounds (SW-2 Operable Unit)	0.33	SWITS
200 Area Low-Level Burial Grounds (SW-2 Operable Unit)	0.03	SWITS fractions assumption
SWOC/218-W-3AE	0.32	SWITS
200 Area CERCLA Liquid Waste Sites/Tank Leaks	0.21	RPP-26744
PFP Zone PW-1, -3, -5 Cribs/ Trench & Ditches	0.016	RPP 200-CW-5 and 200-PW-1, 200-PW-3, and 200-PW-4 Operable Units (including cost estimation analysis assumptions)
US Ecology	0.14	WDOH US Ecology Inventory
Retrievably Stored Waste	0.10	SWITS

Activity	MT	Reference
Canyons/Tunnels/Filters	0.04	WHC-IP-0977, HNF-2545, CP-14977, SD-DD-FL-001, Calculation 0200W-CA-N0007, HNF-3208, and T Plant & U Plant inventories)
Canyons/Tunnels/Filters	0.005	WHC-IP-0977, HNF-2545, CP-14977, SD-DD-FL-001, Calculation 0200W-CA-N0007, HNF-3208, and T Plant & U Plant inventories) fractions assumption
PFP (Waste Only)	0.02	SWIFT & information from J. Jacobs
PFP	0.001	SWIFT & information from J. Jacobs
ERDF	0.005	WMIS
618-10/11 Burial Grounds	0.001	Calculation 0600X-CA-N0008, Characterization information & assumptions from S. Khahir, and information from Final Hazard Categorization of 618-10
Other	0.004	
Other	0.002	
Total	2.6	

Figure B-6. Total Plutonium.

Strontium-90 (decayed to 2011)

Current Waste Forecast

Potential Waste (No remediation decisions have been made)

Notes: "In" includes radionuclides from reactors operation. Most product and fuels are not included.

In

Activity	Curies	Reference
Fuels Processed through T, B, REDOX and PUREX Plants	69,000,000	HNF-SD-WM-TI-794
Inventory of Spent Fuel at CSB and K-Basin Sludge	8,000,000	HNF-SD-SNF-TI-015
US Ecology	36,000	WDOH US Ecology Inventory
118-K-1 Burial Ground	4,100	See On-Site Reference
618-10/11 Burial Grounds	1,100	See On-Site Reference
Total	77,000,000	

Hanford

On-Site

Activity	Curies	Reference
Tank Waste	45,000,000	TWINS
WESF Strontium Capsules	16,000,000	WESF Capsule Inventory
Inventory of Spent Fuel at CSB and K-Basin Sludge	8,000,000	HNF-SD-SNF-TI-015
German Logs	2,200,000	German Logs Waste Certification Summary
CWC/218-W-3AE Storage (+)	810,000	SWITS
200 Area Low-Level Burial Grounds (SW-2 Operable Unit)	490,000	SWITS
PUREX Tunnels	200,000	HNF-2545
WESF Cells/Duct	190,000	HNF-8556
324 Building/Soil	190,000	German Logs Waste Certification Summary, SWITS, WESF Capsule Inventory, HNF-2545 & Information from W. Josephson on 324 BCAF Cases and testing
Mixed Waste Trenches	100,000	SWITS
B Plant Filters	54,000	HNF-3208

Out

Activity	Curies	Reference
Capsule Material that will not be returned to Hanford	1,400,000	HNF-21462
Total	1,400,000	

Activity	Curies	Reference
200 Area CERCLA Liquid Waste Sites/Tank Leaks	45,000	RPP-26744
US Ecology	36,000	WDOH US Ecology Inventory
B Plant	17,000	HNF-3208
ERDF	11,000	WMIS
REDOX Sand Filter	5,800	Calculation 0200W-CA-N0007
REDOX	5,000	Correspondence 0301503
PUREX	4,100	HNF-2545 & CP-14977
118-K-1 Burial Ground	4,100	WMC FP-0087 & Information from J. Jacobs
618-10/11 Burial Grounds	1,100	Calculation 0600X-CA-N0060, Characterization Information & Assumptions from S. Weller, and Information from Final Hanford Categorization of 618-10
Other	490	
Total	73,000,000	

Figure B-7. Strontium-90.

Technetium-99 (decayed to 2011)

Current Waste Forecast

Potential Waste (No remediation decisions have been made)

Notes: "In" includes radionuclides from reactors operation. Most product and fuels are not included.

Activity	Curies	Reference
Fuels Processed through T, B, REDOX and PUREX Plants	33,000	HNF-SD-WM-TI-794
Inventory of Spent Fuel at CSB and K-Basin Sludge	2,900	HNF-SD-SNF-TI-015
US Ecology	50	WDOH US Ecology Inventory
618-10/11 Burial Grounds	10	Calculation 0600X-CA-N0060, Characterization information & assumptions from S. Mehta, and information from Final Hazard Categorization of 618-10
Total	36,000	

Activity	Curies	Reference
Technetium-99 in Uranium Shipped	5,000	DOE/RL-2000-43
Total	5,000	

In → Hanford → Out

Hanford → On-Site

Activity	Curies	Reference
Tank Waste	26,000	TWINS
Inventory of Spent Fuel at CSB and K-Basin Sludge	2,900	HNF-SD-SNF-TI-015
200 BC Area CERCLA Liquid Waste Sites	410	RPP-26744
200 East Area CERCLA Liquid Waste Sites/Tank Leaks	160	RPP-26744
200 West Area CERCLA Liquid Waste Sites/Tank Leaks	100	RPP-26744
200 Area Low-Level Burial Grounds (SW-2 Operable Unit)	130	SWITS
Mixed Waste Trenches	100	SWITS
US Ecology	50	WDOH US Ecology Inventory

Activity	Curies	Reference
ERDF	20	WCH-479
618-10/11 Burial Grounds	33	Calculation 0600X-CA-N0060, Characterization information & assumptions from S. Mehta, and information from Final Hazard Categorization of 618-10
200 East Area Groundwater	10	Information from S. Mehta
200 West Area Groundwater	10	Information from S. Mehta
Solid Waste Operating Complex	7	SWITS
Other	9	
Total	30,000	

Figure B-8. Technetium-99.

Tritium (decayed to 2011)

Current Waste Forecast

Potential Waste (No remediation decisions have been made)

Notes: "In" includes radionuclides from reactors operation. Most product and fuels are not included. The majority of the 9 million curies (decayed) of tritium produced at Hanford (UNI-1993) are not included.

Activity	Curies	Reference
US Ecology	480,000	WDOH US Ecology Inventory
Activity in Fuels Processed through T, B, REDOX and PUREX Plants	91,000	HNF-SD-WM-TI-794
Majority of waste in 200 Area Low-Level Burial Grounds (i.e., Irradiated Lithium Target Cores)	100,000	SWITS
100 Area Reactors	23,000	UNI-3714
118-K-1 Burial Ground	22,000	See On-Site Reference
Inventory of Spent Fuel at CSB and K-Basin Sludge	21,000	HNF-SD-SNF-TI-015
Other	2,000	
Total	740,000	

Activity	Curies	Reference
Discharges in gas phase	23,000	HW-74536 & HW-SA-3303
Total	23,000	

In → Hanford → Out

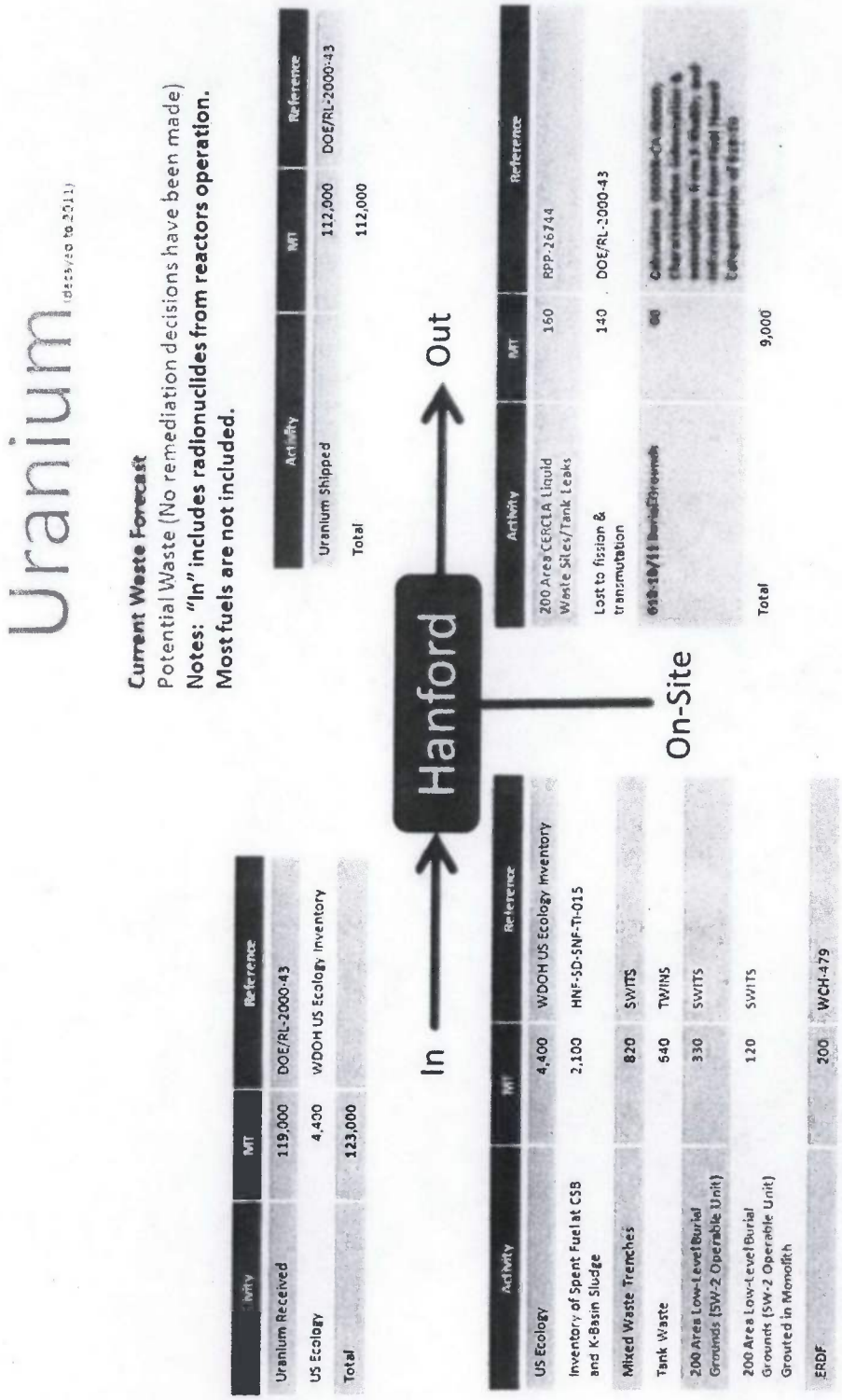
On-Site

Activity	Curies	Reference
US Ecology	480,000	WDOH US Ecology Inventory
200 Area Low-Level Burial Grounds (SW-2 Operable Unit)	100,000	SWITS
200 Area CERCLA Liquid Waste Sites/Tank Leaks	100,000	RPP-26744
100 Area Reactors	23,000	UNI-3714
118-K-1 Burial Ground	22,000	[illegible] & information from M. Mason
Inventory of Spent Fuel at CSB and K-Basin Sludge	21,000	HNF-SD-SNF-TI-015

Activity	Curies	Reference
ERDF	7,600	WMIS
Tank Waste	2,400	TWINS
CWC	800	SWITS
Trench 94 Reactor Cores	600	SWITS
105-N	600	Information from M. Mason
340 Building	300	WCH-427 & information from M. Mason
Other	100	
Total	760,000	

Figure B-9. Tritium (H-3).

Figure B-12. Total Uranium.



APPENDIX C

TECHNETIUM-99 AND TOTAL URANIUM INVENTORY ADJUSTMENT CALCULATION

APPENDIX C

TECHNETIUM-99 AND TOTAL URANIUM INVENTORY ADJUSTMENT CALCULATION

The purpose of this appendix is to document the assumption and data used to calculate the adjusted inventory values for both technetium-99 and total uranium, including isotope concentrations, as presented in Tables 2-4 and 2-5 for technetium-99 and Tables 2-6 and 2-7 for uranium. The following sections present both the equations and assumptions as well as the data used to generate the adjusted inventory values.

C.1 TECHNETIUM-99 ADJUSTED INVENTORY CALCULATIONS

Twenty-one curies (decayed to 2011) of technetium-99 were disposed in Environmental Restoration Disposal Facility (ERDF) inventory as of August 2010. As discussed in Section 2.2.1, major technetium-99 waste sources to ERDF include the 200 Area Effluent Treatment Facility (ETF) (6 Ci), 183-H Evaporation Solar Basins solids and seepage liquid (3.5 Ci), 300-FF-1 Trench soil (2 Ci), and others found in Tables 2-4 and 2-5. These estimates represent alternative inventory estimates to those provided in the Waste Management Inventory System (WMIS) output for wastes disposed as of August 2010. The following sections give a more detailed discussion as to how the adjusted inventory values were calculated.

C.1.1 ETF Inventory

The adjusted technetium-99 inventory for the ETF (presented in Tables 2-4 and 2-5) was calculated using data collected and maintained by the ETF staff and sample data from the Hanford Environmental Information System (HEIS). The ETF staff maintained spreadsheets that document the quantities and constituents of liquid sent to the Liquid Effluent Retention Facility (LERF)/ETF for treatment. The total volume of effluent received was determined for each year starting in 1997 categorized by the waste source type. This allows for a simple summation of the effluent volume received in gallons. Table C-1 provides a summary of the total volumes used to determine the adjusted technetium-99 value.

Table C-1. ETF Liquid Discharge Volume Summary. (2 Pages)

Year	Waste Types		
	Basin 44 (gal)	200-UP-1 Groundwater (gal)	TY/TX/UP-1 (gal)
1997		14,050,245	
1998		27,167,356	
1999	380,000	22,688,191	
2000		21,896,345	
2001		25,922,535	

Table C-1. ETF Liquid Discharge Volume Summary. (2 Pages)

Year	Waste Types		
	Basin 44 (gal)	200-UP-1 Groundwater (gal)	TY/TX/UP-1 (gal)
2002		20,599,144	
2003		23,085,447	
2004	927,062	27,326,679	
2005		4,951,479	
2006	1,865,372	2,926,168	
2007	3,333,854		5,352,389
2008			17,899,067
2009			21,156,218
2010	2,377,241		10,882,986

Next, data collected to characterize the effluent being received were used to determine an average technetium-99 concentration. Samples collected from LERF Basin 43 and Basin 44 are included in Tables C-2 and C-3, respectively. To determine the 2004 average concentration for Basin 44, an exception was made since no technetium-99 data were collected that year. To be conservative, the maximum concentration collected during 1999 was used. Table C-4 provide a summary of the average concentrations determined and used in the ETF adjusted inventory calculation.

Table C-2. ETF Basin 43 Sample Data. (4 Pages)

Sample ID	Sample Date	Constituent	Value	Units	LQ	Source
L03945	13-Jan-99	Technetium-99	1,600	pCi/L		UP-1
L03970	17-Feb-99	Technetium-99	1,600	pCi/L		UP-1
L04501	02-Jun-99	Technetium-99	1,400	pCi/L		UP-1
L04500	02-Jun-99	Technetium-99	1,400	pCi/L		UP-1
L04664	08-Sep-99	Technetium-99	1,400	pCi/L		UP-1
L04802	07-Dec-99	Technetium-99	1,500	pCi/L		UP-1
L04898	09-Feb-00	Technetium-99	1,500	pCi/L		UP-1
L05115	27-Jun-00	Technetium-99	1,500	pCi/L		UP-1

Table C-2. ETF Basin 43 Sample Data. (4 Pages)

Sample ID	Sample Date	Constituent	Value	Units	LQ	Source
L05204	16-Aug-00	Technetium-99	1,500	pCi/L		UP-1
L05344	07-Nov-00	Technetium-99	1,380	pCi/L		UP-1
L05439	19-Feb-01	Technetium-99	1,500	pCi/L		UP-1
L05509	23-May-01	Technetium-99	1,300	pCi/L		UP-1
L05562	11-Jul-01	Technetium-99	1,400	pCi/L		UP-1
L05741	10-Oct-01	Technetium-99	1, 600	pCi/L		UP-1
L05884	16-Jan-02	Technetium-99	3,200	pCi/L		UP-1
L05963	16-Apr-02	Technetium-99	3,300	pCi/L		UP-1
L06071	05-Aug-02	Technetium-99	2,500	pCi/L		UP-1
L06128	13-Oct-02	Technetium-99	2,300	pCi/L		UP-1
L06235	28-Jan-03	Technetium-99	1,900	pCi/L		UP-1
L06300	14-Apr-03	Technetium-99	2,000	pCi/L		UP-1
L06379	22-Jul-03	Technetium-99	1,700	pCi/L		UP-1
L06490	19-Jan-04	Technetium-99	4,300	pCi/L		UP-1
L06592	08-Feb-04	Technetium-99	1,800	pCi/L		UP-1
L06632	12-Apr-04	Technetium-99	2,100	pCi/L		UP-1
L06666	30-Jun-04	Technetium-99	1,700	pCi/L		UP-1
B1BJB7	19-Oct-04	Technetium-99	1,500	pCi/L		UP-1
B1NP95	10-Jun-07	Technetium-99	6,400	pCi/L		TX/TY/UP-1
B1PY21	16-Oct-07	Technetium-99	17,000	pCi/L		TX/TY/UP-1
B1TF75	02-Mar-08	Technetium-99	6,800	pCi/L		TX/TY/UP-1
B1W3H3	29-Jul-08	Technetium-99	5,800	pCi/L		TX/TY/UP-1
B1XXN4	31-Dec-08	Technetium-99	4,600	pCi/L		TX/TY/UP-1
B1YDC6	18-Feb-09	Technetium-99	4,600	pCi/L		TX/TY/UP-1
B209P1	25-May-09	Technetium-99	4,200	pCi/L		TX/TY/UP-1
B21729	26-Aug-09	Technetium-99	4,700	pCi/L		TX/TY/UP-1
B250V6	12-May-10	Technetium-99	4,400	pCi/L		TX/TY/UP-1

Table C-2. ETF Basin 43 Sample Data. (4 Pages)

Sample ID	Sample Date	Constituent	Value	Units	LQ	Source
B26LT5	01-Sep-10	Technetium-99	4,600	pCi/L		TX/TY/UP-1
L03970	17-Feb-99	Uranium	220	µg/L		UP-1
L04501	02-Jun-99	Uranium	230	µg/L		UP-1
L04500	02-Jun-99	Uranium	220	µg/L		UP-1
L04664	08-Sep-99	Uranium	218	µg/L		UP-1
L04664R	08-Sep-99	Uranium	250	µg/L		UP-1
L04802	07-Dec-99	Uranium	210	µg/L		UP-1
L04898	09-Feb-00	Uranium	220	µg/L		UP-1
L05115	27-Jun-00	Uranium	210	µg/L		UP-1
L05204	16-Aug-00	Uranium	180	µg/L		UP-1
L05341	07-Nov-00	Uranium	190	µg/L		UP-1
L05439	19-Feb-01	Uranium	170	µg/L		UP-1
L05439R	19-Feb-01	Uranium	190	µg/L		UP-1
L05509	23-May-01	Uranium	130	µg/L		UP-1
L05562	11-Jul-01	Uranium	150	µg/L		UP-1
L05741	10-Oct-01	Uranium	160	µg/L		UP-1
L05884	16-Jan-02	Uranium	510	µg/L		UP-1
L05963	16-Apr-02	Uranium	360	µg/L		UP-1
L06071	05-Aug-02	Uranium	290	µg/L		UP-1
L06128	13-Oct-02	Uranium	250	µg/L		UP-1
L06235	28-Jan-03	Uranium	200	µg/L		UP-1
L06300	14-Apr-03	Uranium	200	µg/L		UP-1
L06379	22-Jul-03	Uranium	180	µg/L		UP-1
L06490	19-Jan-04	Uranium	500	µg/L		UP-1
L06592	08-Feb-04	Uranium	230	µg/L		UP-1
L06632	12-Apr-04	Uranium	230	µg/L		UP-1
L06666	30-Jun-04	Uranium	190	µg/L		UP-1

Table C-2. ETF Basin 43 Sample Data. (4 Pages)

Sample ID	Sample Date	Constituent	Value	Units	LQ	Source
B1BJB7	19-Oct-04	Uranium	160	µg/L		UP-1
B1NP95	10-Jun-07	Uranium	450	µg/L		TX/TY/UP-1
B1PY23	16-Oct-07	Uranium	84	µg/L		TX/TY/UP-1
B1TF77	23-Mar-08	Uranium	52	µg/L		TX/TY/UP-1
B1W3H3	29-Jul-08	Uranium	46	µg/L		TX/TY/UP-1
B1XXN4	31-Dec-08	Uranium	47	µg/L		TX/TY/UP-1
B1YDC6	18-Feb-09	Uranium	33	µg/L		TX/TY/UP-1
B208X5	24-Apr-09	Uranium	0.65	µg/L		TX/TY/UP-1
B209P1	25-May-09	Uranium	31	µg/L		TX/TY/UP-1
B21729	26-Aug-09	Uranium	27	µg/L		TX/TY/UP-1
B250V6	12-May-10	Uranium	32	µg/L		TX/TY/UP-1
B26LT5	01-Sep-10	Uranium	2.8	µg/L		TX/TY/UP-1

Table C-3. ETF Basin 44 Sample Data. (2 Pages)

Sample Location	Sample Number	Sample Date	Uranium Total µg/L	Tc-99 pCi/L
LERF BASIN 44 – SAMPLE RISER 2	L03400	09/10/98	76	28,000
LERF BASIN 44 – SAMPLE RISER 2	L03400FIL	09/10/98	68	--
LERF BASIN 44 – SAMPLE RISER 4	L03401	09/10/98	750	340,000
LERF BASIN 44 – SAMPLE RISER 4	L03401FIL	09/10/98	710	--
LERF BASIN 44 – SAMPLE RISER 6	L03402	09/11/98	880	480,000
LERF BASIN 44 – SAMPLE RISER 6	L03402FIL	09/11/98	820	--
LERF BASIN 44 – SAMPLE RISER 7	L03403	09/11/98	920	760,000
LERF BASIN 44 – SAMPLE RISER 7	L03403FIL	09/11/98	890	--
LERF BASIN 44 – SAMPLE RISER 2	L06015	08/07/02	570	--
LERF BASIN 44 – SAMPLE RISER 4	L06016	08/12/02	560	--
LERF BASIN 44 – SAMPLE RISER 6	L06017	08/27/02	600	--

Table C-3. ETF Basin 44 Sample Data. (2 Pages)

Sample Location	Sample Number	Sample Date	Uranium Total µg/L	Tc-99 pCi/L
LERF BASIN 44 - SAMPLE RISER 7	L06018	08/27/02	580	--
Surge Inlet - Basin 44 Feed	B1HLJ6	02/22/06	670	4,700
Surge Inlet - Basin 44 Feed	B1HVP0	04/10/06	--	--
Surge Inlet - Basin 44 Feed	B1MBV6	03/14/07	--	--
Surge Inlet - Basin 44 Feed (rad only)	B1MWN2	03/16/07	--	--
Surge Inlet - Basin 44 Feed	B1N7C5	04/23/07	1,000	8,700

Table C-4. ETF Tc-99 Average Concentrations.

Waste Type	Tc-99 Average Concentration (pCi/L)
UP-1	1,900
TY/TX/UP-1	5,100
Basin 44 (1999)	4.0E+05
Basin 44 (2004)	7.6E+05
Basin 44 (2006-07)	6,700
Basin 44 (2010)	3,800

Next, the average concentrations presented in Table C-4 are multiplied by the total waste discharged presented in Table C-1 and converted using the following equation to determine the total number of curies disposed by waste type:

Total Discharge (gal) x Average Conc. (pCi/L) x (1000 L / 246.17 gal) x (1 Ci / 1.0E+12 pCi)

Table C-5 provides total technetium-99 curies based on the above calculation per year for each of the waste site types. The total Ci of technetium-99 disposed from the ETF is 5.8 Ci. The final value was rounded up to 6 for the ERDF PA evaluation.

Table C-5. ETF Tc-99 Total Curies Disposed.

Year	Waste Types		
	Basin 44 Tc-99 (Ci)	UP-1 Groundwater Tc-99 (Ci)	TX/TY/UP-1 Tc-99 (Ci)
1997		1.0E-01	
1998		1.9E-01	
1999	5.8E-01	1.6E-01	
2000		1.6E-01	
2001		1.8E-01	
2002		1.5E-01	
2003		1.6E-01	
2004	2.7E+00	1.9E-01	
2005		3.5E-02	
2006	4.7E-02	2.1E-02	
2007	8.5E-02		1.0E-01
2008			3.5E-01
2009			4.1E-01
2010	3.4E-02		2.1E-01
Totals	**3.4E+00**	**1.4E+00**	**1.1E+00**

C.1.2 200-UP-1 Pump-and-Treat Operations Inventory

The technetium-99 inventory from 200-UP-1 pump-and-treat operations was determined by referencing the *Fiscal Year 2006 Annual Summary Report for 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations* (DOE/RL-2006-73). Project records of contaminants removed show that a total of 2 Ci of technetium-99 has been removed from the pump-and-treat system.

C.1.3 200-W-42 Pipeline Soils

Information provided in *Surface and Near Surface Field Investigation Data Summary Report for the 200-UP-2 Operable Unit* (BHI-00033) field characterization data around the 200-W-42 provided near-surface technetium-99 concentrations in soil between 1 and 300 pCi/g (with an average value of about 40 pCi/g) reflecting a small hot spot area surrounded by areas of much lower concentrations. Assuming this average concentration and the disposed waste weight of 2.8E10 g, which was determined using the ERDF package WP200UW1001, a technetium-99 estimate of 1.1 Ci is determined.

C.1.3 316-5 Liquid Waste Disposal Trench

The information used to determine the adjusted technetium-99 value for 316-5 was taken from the *Expedited Response Action Assessment for 316-5 Process Trenches* (DOE/RL-92-32). As part of the expedited response action, the 316-5 Liquid Waste Disposal Trench was divided into two trenches, the east and west trench. Soil data were collected from the eastern trench and analyzed for technetium-99, and it was determined that there are two separate areas within the trench. Samples were collected at 0, 20, 100, and 400 m from the outfall structure, which showed the highest concentrations of technetium-99 within the first 20 m of the trench. To calculate the adjusted technetium-99 value, the trench was cut into two regions, the first 20 m and the remainder. The average technetium-99 was determined for each of the sample areas. The 0- and 20-m samples and the 100- and 400-m samples were then averaged together. Table C-6 contains the technetium-99 results from DOE/RL-92-32, Appendix C.

Table C-6. 316-5 Disposal Trench Technetium-99 Analytical Data.

Location – 0 m		Location – 20 m		Location – 100 m		Location – 400 m	
Sample ID	**Result (pCi/g)**	**Sample ID**	**Result (pCi/g)**	**Sample ID**	**Result (pCi/g)**	**Sample ID**	**Result (pCi/g)**
B01032	3.8	B01035	2,300	B01041	1.3	B01044	13
B01033	99	B01036	690	B01042	22	B01045	12
B01034	740	B01038	3,600	B01043	27	B01046	24
		B01040	3,500				
Average Conc.	**280**	**Average Conc.**	**2,500**	**Average Conc.**	**17**	**Average Conc.**	**16**

Table C-7 presents the remaining data and steps used to calculate the technetium-99 adjusted inventory value for the 316-5 Trench. For the west trench, the average concentration calculated for the east trench is assumed to be the same. The last step in calculating the 316-5 Liquid Disposal trench is to sum both the east and west 20 m and remainder of regions leading to 1.8E+12 pCi of technetium-99. Converting this from picocuries to curies gives a total of 1.8 Ci technetium-99. The final value is rounded to 2.

Table C-7. 316-5 Adjusted Tc-99 Inventory Inputs and Calculations. (2 Pages)

316-5 Trench	Total Volume Removed (m^3)[a]	Approx. Soil Mass (g)[b]	Excavation Length (m)	Mass per meter[c]	Tc-99 Conc. 1st 20 m (pCi/g)[d]	Tc-99 Conc. Remainder[e]	Tc-99 Total 20 m (pCi)[f]	Tc-99 total Remainder (pCi)[g]
West Trench	5,400	9.8E+09	368	2.64E+07	1,400	17	7.3E+11	1.5E+11

Table C-7. 316-5 Adjusted Tc-99 Inventory Inputs and Calculations. (2 Pages)

316-5 Trench	Total Volume Removed (m^3)[a]	Approx. Soil Mass (g)[b]	Excavation Length (m)	Mass per meter[c]	Tc-99 Conc. 1st 20 m (pCi/g)[d]	Tc-99 Conc. Remainder[e]	Tc-99 Total 20 m (pCi)[f]	Tc-99 total Remainder (pCi)[g]
East Trench	5,400	9.8E+09	348	2.79E+07	1,400	17	7.8E+11	1.5E+11
Total							1.5E+12	3.0E+11

[a] Total volume removed was document on page 5 of DOE/RL-92-32.
[b] A soil density of 1.8 g/cm^3 was assumed for this calculation as well as a conversion factor for converting m^3 to cm^3.
[c] Calculated value, where Approx. soil mass x Excavation Length = Mass per meter.
[d] Average concentration (280+2,500)/2.
[e] Average concentration (17+16)/2.
[f] Tc-99 total 20 m calculated by mass per meter x Tc-99 Conc. 1st 20 m X 20.
[g] Tc-99 total remainder calculated by Mass per meter x Tc-99 Conc. Remainder X (Excavation Length – 20 m).

C.1.4 303-M Building Debris

The 303-M Building was used to store uranium chips awaiting processing at the 303-M Uranium Oxide Facility. It is assumed that 1 MT of uranium-contaminated material was taken from the 303-M Building and disposed of at the 618-13 Burial Ground. Approximately 12 parts per million of technetium-99 is estimated as the trace quantity in this uranium. Using this estimate and specific activity, the following equation is used to determine the adjusted technetium-99 inventory:

$$12 \text{ g Tc-99} \times 0.017 \text{ Ci/g} = 0.2 \text{ Ci}$$

C.1.5 183-H Solar Evaporation Basin

The 183-H Solar Evaporation Basin adjusted value was calculated using values documented in *183-H Basin Mixed Waste Analysis and Testing Report* (WHC-SD-W100-TD-001), Rev. 1. Table C-8 contains relevant information pertaining to the calculation of the 183-H technetium-99 adjusted value.

Table C-8. 183-H Technetium-99 Adjusted Inventory Inputs. (2 Pages)

Waste Type	# of Drums[a]	Average Tc-99 Concentration (pCi/g)[b]
Basin #3 Solids	3,182	800
Basin #4 Solids	1,407	1,800
Solidified Evaporated Liquid	1,559	4,600

Table C-8. 183-H Technetium-99 Adjusted Inventory Inputs. (2 Pages)

Waste Type	# of Drums[a]	Average Tc-99 Concentration (pCi/g)[b]
Solidified Seepage Liquid	1,208	3,500
Precipitated Crystal	4,437	140
Sandblast Grit	189	6
Unknowns Basin #3 or #4	81	760

[a] Values taken from page 6 of WHC-SD-W100-TD-001.
[b] The average Tc-99 concentration values are presented in summary tables in WHC-SD-W100-TD-001 between pages 21 through 45.

The following conversion factors are used along with information presented in Table C-8:

- 1 55-gal drum = 208,000 cm^3 (drums assumed to be 55-gal drums)
- 1 cm^3 of water = 1 g of mass (uses the density of water to convert the total volume disposed to a mass with unit grams)
- 1 Ci = 10^{12} pCi.

The final calculation used to determine the adjusted technetium-99 value for 183-H Solar Evaporation Basin is the summation of the product of the average technetium-99 concentrations (presented in Table C-8), the mass, and the conversion factor of 1 Ci = 10^{12} pCi. Table C-9 presents the calculated values and the total technetium-99 in curies.

Table C-9. 183-H Tc-99 Adjusted Inventory Calculations.

Waste Type	Total Volume (cm^3)	Total Mass (g)	Total Tc-99 (Ci)
Basin #3 Solids	6.6E+08	6.6E+08	5.3E-01
Basin #4 Solids	2.9E+08	2.9E+08	5.1E-01
Solidified Evaporated Liquid	3.2E+08	3.2E+08	1.5E+00
Solidified Seepage Liquid	2.5E+08	2.5E+08	8.7E-01
Precipitated Crystal	9.2E+08	9.2E+08	1.3E-01
Sandblast Grit	3.9E+07	3.9E+07	2.4E-04
Unknowns Basin #3 or #4	1.7E+07	1.7E+07	1.3E-02
Total			**3.5E+00**

C.1.6 118 Burial Grounds (B, C, D, and K)

The 100 Area solid waste burial grounds received failed metallic pieces of equipment from reactors during operations and occasional building or construction debris. None of these materials would have contained, other than incidental technetium-99, contamination, and no technetium-99 measurements have been recorded at these sites during remedial characterization efforts. Thus, no reasonable basis for the recorded technetium-99 estimate exists. To come up with an adjusted conservative estimate of technetium-99 in these waste sites, a nominal value of 0.025 Ci has been selected (e.g., 1% of the WMIS value).

C.2 TOTAL URANIUM ADJUSTED INVENTORY CALCULATIONS

Major uranium waste sources to ERDF include 300-FF-2 (62 metric tons), 316 North and South Ponds (45 metric tons), 300 Laboratories soil and concrete (35 metric tons), and those indicated in Tables 2-6 and 2-7. These estimates represent alternative inventory estimates to those provided in the WMIS output for wastes disposed as of August 2010. The following sections give a more detailed discussion as to how the adjusted inventory values were calculated.

C.2.1 300/600 Area North and South Ponds (316-1 and 316-2)

The adjusted uranium inventory in Table 2-6 for the North and South Ponds (316-1 and 316-2) is a summation of two separate calculations using the average concentrations of uranium isotopes (U-234, U-235, and U-238) converted to total uranium using the specific activity of each isotope.

Data documented in *Phase I Remedial Investigation Report for the 300-FF-1 Operable Unit* (DOE/RL-92-43) and presented in Table C-10 were used to calculate the average concentration of each uranium isotope. The following equation uses the average concentration, specific activity, and the conversion factor of pCi to Ci to calculate the average total uranium value per gram of soil:

$$\text{Average Concentration } (pCi/g_{soil}) \times 1.0E\text{-}12\ (Ci/pCi) \,/\, \text{specific activity } (Ci/g_{U}) = g\ U/\ g\ soil$$

Table C-10. 316-1 and 316-2 Analytical Data. (3 Pages)

316-1 Sample Data				316-2 Sample Data			
Sample Number	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Sample Number	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
B00GY3	0.8	0.04	0.7	B00H81	1,100	110	900
B00GY6	20	1.8	16	B00H83	--	2.5	120
B00GY7	0.1	0.05	0.8	B00H85	42	--	--
B00GY8	1	0.06	0.9	B00H87	15	1.5	12
B00H44	3.6	0.3	2.9	B00H89	16	1.6	14
B00H49	0.6	0.07	0.6	B00H93	3	0.2	2.6

Table C-10. 316-1 and 316-2 Analytical Data. (3 Pages)

316-1 Sample Data				316-2 Sample Data			
Sample Number	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Sample Number	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
B00H50	0.8	0.08	0.8	B00H96	2.6	0.2	2.5
B00H52	1	0.07	1	B00H97	2.6	--	2.5
B00H53	3.2	0.3	2.7	B00H99	9.8	0.9	7.5
B00H54	1.6	--	1.4	B00HB3	130	--	--
B00H59	50	1.8	46	B00HB5	--	4.4	34
B00H62	62	2.4	56	B014H7	2.4	--	2.3
B00H64	46	--	43	B014M8	22	1.9	18
B00H65	41	--	34	B014M9	8.5	0.8	7.4
B00H66	2.6	0.22	2	B014N0	52	4.9	43
B00H67	1	0.08	1	B014N1	13	1.2	11
B00H68	1.7	0.14	1.5	B01GF4	36	--	43
B00H69	1.3	0.08	1.2	B01GF7	55	2.1	49
B00H70	1.7	0.1	1.6	B01GF8	3	0.3	2.8
B00H71	1	0.09	0.9	B01GF9	3.4	0.3	3.3
B00H76	3.2	0.3	2.9	B01GG0	2.3	0.2	2.2
B00H79	1,200	75	980	B01GG1	1.2	0.05	1.1
B00H80	8	0.8	6.7	B01GG2	0.8	0.04	0.9
B00H81	2.2	0.2	1.9	B01GG3	1	0.6	1
B00H82	2.5	0.2	2.7	B01GG9	8.6	0.7	7.4
B00H83	8.9	0.8	7.2	B01GH2	1	0.1	0.9
B00H84	32	2	26	B01GH3	1.1	0.09	1.1
B00H86	2	0.1	1.9	B01GJ4	0.9	0.04	0.7
B00H88	8.5	0.9	6.8	B01GJ5	0.8	0.8	0.7
B014L1	6.4	0.6	5.5	B01GJ6	1.3	0.09	1.2
B014L2	40	2	36	B01GJ7	2.4	0.2	2.1
B014L3	16	1.5	14	B01GJ8	2.5	0.2	2.2
B014L4	8	0.9	7.1				

Table C-10. 316-1 and 316-2 Analytical Data. (3 Pages)

316-1 Sample Data				316-2 Sample Data			
Sample Number	**U-234 (pCi/g)**	**U-235 (pCi/g)**	**U-238 (pCi/g)**	**Sample Number**	**U-234 (pCi/g)**	**U-235 (pCi/g)**	**U-238 (pCi/g)**
B014L9	2.6	0.2	2.6				
B014M1	2.6	0.2	2.7				
Average Concentration	**46**	**2.9**	**38**	**Average Concentration**	**51**	**5**	**43**
Specific Activity (Ci/g)	**6.2E-03**	**2.2E-06**	**3.4E-07**	**Specific Activity (Ci/g)**	**6.2E-03**	**2.2E-06**	**3.4E-07**
Total Uranium (g U/g Soil)	**7.4E-09**	**1.3E-06**	**1.1E-04**	**Total Uranium (g U/g Soil)**	**8.3E-09**	**2.3E-06**	**1.3E-04**

The final steps in calculating the adjusted total uranium inventory is multiplying the final concentration of uranium per gram of soil by the total amount of soil disposed of at ERDF. Table C-11 shows the inputs and the final steps taken. Final values used are rounded in Table 2-6.

Table C-11. 316-1 and 316-2 Total Uranium Adjusted Inventory Calculation.

	316-1	**316-2**
Total Uranium (g U/ g soil)	1.1E-04	1.3E-04
Total mass of waste disposed at ERDF in grams (Converted from metric tons to grams, 1 MT = 1.0E+06 g)	2.3E+11[a]	1.4E+11[b]
Total Uranium mass (in Metric Tons)	26	18

[a] Original value of 230,000 MT taken from *Cleanup Verification Package for South Process Pond (WIDS Site 316-1), the Retired Filter Backwash Pond (WIDS Site 300 RFBP), 300-262 Contaminated Soil, and Unplanned Releases Sites UPR-300-32, UPR-300-33, UPR-300-34, UPR-300-35, UPR-300-36, UPR-300-37, and UPR-300-FF-1* (CVP-2003-00002).

[b] Original value of 140,000 MT taken from 300-*FF-1 Operable Unit, North Process Pond/Scraping Disposal Area Verification Package* (BHI-01298).

C.2.2 300 Area Liquid Disposal Trenches (316-4 and 316-5)

Based on process knowledge of the 316-4 Liquid disposal trench, a total of 550 kg (1,230 lb) of uranium was discharged to the site. For a conservative estimate, the value was rounded to 1 metric ton.

The 316-5 Liquid Disposal trench total uranium adjusted inventory value was calculated using the same methodology as presented in Section B.1.3. An average concentration was calculated based on pre-excavation soil data and then multiplied by the total waste volume disposed. In this instance, uranium-234, uranium-235, and uranium-238 were analyzed in both the east and west trenches. However, the west trench was sampled only at the outfall structure or at 0 m distance. The average concentration is calculated for each of the east and west trenches separately and the higher of the two average values is used for both trenches. In this case the east trench average concentrations far exceeded that of the west. Tables C-12 and C-13 contain the original analytical data from DOE/RL-92-32. T able C-14 presents the remaining data and steps used to calculate the uranium adjusted inventory value for 316-5. The last step in calculating the 316-5 Liquid Disposal trench is to take the sum total for both the east and west 20 m and remainder regions. This gives a total of 2.4E+01 total uranium in MT. In the adjusted estimate, an extra 1 metric ton of uranium is added for contiguous materials removed along with the spoil pile, about 29 metric tons of additional soil.

Table C-12. 316-5 East Trench Pre-Excavation Soil Samples (Table 7 – DOE/RL-92-32).

Sample Location Distance (m)	0	20	100	400	1st 20 m Average Conc (pCi/g)	Remainder Average Conc (pCi/g)	Specific Activity (Ci/g)	1st 20 m (g U/g Soil)	Remainder (g U/g Soil)
Depth from Surface (m)	0	0	0	0	--	--	--	--	--
Uranium-234	3,900	11,900	110	87	7,900	99	6.2E-03	1.3E-06	1.6E-08
Uranium-235	320	1,600	10	4.2	960	7.1	2.2E-06	4.4E-04	3.3E-06
Uranium-238	2,900	9,100	77	69	6,000	73	3.4E-07	1.8E-02	2.2E-04
Totals								**1.8E-02**	**2.20E-04**

Table C-13. 316-5 West Trench Pre-Excavation Soil Samples (Table 7 – DOE/RL-92-32).

Sample Location Distance (m)	0	0	0	0	1st 20 m Average Conc (pCi/g)
Depth from Surface (m)	0	0	1	1.5	--
Uranium-234	350	2,700	130	22	1,500
Uranium-235	8	220	5	3	110
Uranium-238	200	1,800	93	15	990

Table C-14. 316-5 Total Uranium Adjusted Inventory Calculation.

316-5 Trench	Total Volume Removed (m^3)[a]	Approx. Soil Mass (g)[b]	Excavation Length (m)	Mass per meter[c]	Mass in 1st 20 m (MT)[d]	Mass in remainder (MT)[e]	1st 20 m Total Uranium (g U/g soil)[f]	Remainder Total Uranium (g U/g soil)[f]	1st 20 m U total (MT)[g]	Remainder U total (MT)[h]
West Trench	5,400	9.8E+09	368	2.6E+07	5.3E+02	9.2E+03	1.8E-02	2.2E-04	9.7E+00	2.0E+00
East Trench	5,400	9.8E+09	348	2.8E+07	5.6E+02	9.2E+03	1.8E-02	2.2E-04	1.0E+01	2.0E+00
Total									**1.2E+01**	**1.2E+01**

[a] Total volume removed was document on page 5 of DOE/RL-92-32.
[b] A soil density of 1.8 g/cm^3 was assumed for this calculation as well as a conversion factor for converting m^3 to cm^3.
[c] Calculated value, where Approx. soil mass x Excavation Length = Mass per meter.
[d] Calculated using (mass per meter x 20)/ conversion factor (1 MT = 1.0E+06 g).
[e] Calculated using (mass per meter x (Excavation length -20)/ conversion factor (1 MT = 1.0E+06 g).
[f] Value taken from Table J.
[g] Calculated using Mass in 1st 20 m x 1st 20 m Total Uranium.
[h] Calculated using Mass in Remainder X Remainder Total Uranium.

C.2.3 300 Area Burial Grounds (618-1, 2, 3, 4, 5, 7, & 8)

For the 618-1, 618-2, 618-3, 618-7, and 618-8 Burial Grounds, the adjusted values are documented estimated values from DOE/RL-2009-30, *300 Area Remedial Investigation/Feasibility Study Work Plan for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units*. Appendix A of DOE/RL-2009-30 contains table with summary information for every waste site and facility located within the 300 Area.

618-1 – The adjusted value for the 618-1 Burial Ground is assumed from DOE/RL-2009-30, Appendix A, p. B-69.

618-2 – The adjusted value for the 618-2 Burial Ground is assumed from 618-1 since they share a common history; however, there are no inventory records associated with 618-2.

618-3 – The value presented in Table 2-7 is an assumed value based on process history of the 618-3 Burial Ground. The site received uranium-contaminated building debris.

618-4 – The adjusted value for the 618-4 Burial Ground was determined to be adequate for this evaluation. No change was made to the adjusted inventory value.

618-5 – The adjusted value for total uranium in Table 2-6 for the 618-5 Burial Ground was calculated using the average concentrations of uranium isotopes (U-234, U-235, and U-238) converted to total uranium using the specific activity of each isotope. Data documented in *Phase I Remedial Investigation Report for the 300-FF-1 Operable Unit* (DOE/RL-92-43) and presented in Table C-15 was used to calculate the average concentration of each uranium isotope. The following equation uses the average concentration, specific activity, and the conversion factor of pCi to Ci to calculate the average total uranium value per gram of soil:

Average Concentration (pCi/g) x 1.0E-12 (Ci/pCi) / specific activity (Ci/g) = g U/ g soil

Table C-15. 618-5 Sample Data Summary. (2 Pages)

Sample Number	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
B01GK4	0.7	0.02	0.7 [a]
B01GK7	24	1.2	24
B01GK8	3	0.2	3
B01GM0	3.1	0.1	2.9
B01GM3	2.9	1.3	29
B01GM4	0.8	0.04	0.8 [a]
B01GM8	0.6	0.03	0.7 [a]
B01GM9	1.4	0.08	1.4

Table C-15. 618-5 Sample Data Summary. (2 Pages)

Sample Number	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
B01GN3	16	0.7	16
Average Concentration	5.8	0.4	13
Specific Activity	6.22E-03	2.16E-06	3.36E-07
Total Uranium (g U/g Soil)	9.4E-10	1.9E-07	3.8E-05

[a] Value excluded from the average concentration calculation because values are "U" flagged in original data set.

The final steps in calculating the adjusted uranium value is multiplying the final sum concentration of uranium per gram of soil by the total amount of soil disposed of at ERDF. The final calculation is as follows:

46,000 MT x 3.8E-05 g U/ g Soil = 1.8 MT Uranium

618-7 - Value presented in Table 2-7 is an assumed value based on process history of the 618-7 Burial Ground. The site received Zircaloy chips immersed in a water-soluble oil as well as aluminum turnings and solids containing lead.

618-8 – Value presented in Table 2-7 is an assumed values based on process history of the 618-8 Burial Ground. The best available information indicates that the site received contaminated construction debris from the 313 facility remodel in 1954 (CVP-2006-00006).

C.2.4 100 Area Liquid Waste Sites – 116-C-1

The adjusted uranium value was calculated using the average concentrations of uranium isotopes (U-234, U-235, and U-238) converted to total uranium using the specific activity of each isotope. Data documented in the *Limited Field Investigation Report for the 100-BC-1 Operable Unit* (DOE/RL-93-06) and presented in Table C-16 were used to calculate the average concentration of each uranium isotope. The following equation uses the average concentration, specific activity, and the conversion factor of picocuries to curies to calculate the average total uranium value per gram of soil:

Average Concentration (pCi/g) x 1.0E-12 (Ci/pCi) / specific activity (Ci/g) = g U/ g soil

Table C-16. 116-C-1 Sample Data Summary.

	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
	1.3	0.6	1.3
	1.2	0.6	1.2
	0.28		0.28
Average Concentration	**0.94**	**0.6**	**0.94**
Specific Activity	**6.22E-03**	**2.16E-06**	**3.36E-07**
Total Uranium (g U/g Soil)	**1.5E-10**	**2.8E-07**	**2.8E-06**

Notes:

Concentration values presented in this table at from Table 3-43 of DOE/RL-93-06.

The final steps in calculating the adjusted uranium value is multiplying the final sum concentration of uranium per gram of soil by the total amount of soil disposed of at ERDF.

The final calculation is as follows:

98,000 MT x 3.1E-06 g U/ g Soil = 0.3 MT Uranium

C.3 REFERENCES

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