Argonne NATIONAL LABORATORY

ANL/EVS/R-10/1

Supplement to Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste Inventory Reports

Environmental Science Division

ANL/EVS/R-10/1

Supplement to Greater-Than-Class C (GTCC) Low-Level Radioactive Waste and GTCC-Like Waste Inventory Reports

by
Environmental Science Division, Argonne National Laboratory

Work sponsored by U.S. Department of Energy,
Office of Environmental Management

October 2010

This page is intentionally left blank.

CONTENTS

CONTENTS (Cont.)

TABLES

NOTATION

ACRONYMS AND ABBREVIATIONS

B&W	Babcock & Wilcox Company
BWR	boiling water reactor
CFR	*Code of Federal Regulations*
CH	contact-handled
DOE	U.S. Department of Energy
EIA	Energy Information Administration
EIS	environmental impact statement
GTCC	greater-than-Class C
GTRI/OSRP	Global Threat Reduction Initiative/Off-Site Source Recovery Project
IAEA	International Atomic Energy Agency
INL	Idaho National Laboratory
ISSD	Interim Sealed Source Database (NRC)
LANL	Los Alamos National Laboratory
LEU	low-enriched uranium
LLRW	low-level radioactive waste
LWA	Land Withdrawal Act
MIPS	Medical Isotope Production System
MPPB	Main Plant Process Building (West Valley)
MURR	Missouri University Research Reactor
NDA	NRC-licensed disposal area (West Valley)
NFS	Nuclear Fuel Services
NOI	Notice of Intent
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
P.L.	Public Law
PWR	pressurized water reactor
RCRA	Resource Conservation and Recovery Act
REDC	Radiochemical Engineering Development Center (ORNL)
RH	remote-handled
RPS	Radioisotope Power Systems
RSRT	Radiological Source Registry and Tracking (System Database) (DOE)
SDA	state-licensed disposal area (West Valley)
SNAP	Systems for Nuclear Auxiliary Power
TRU	transuranic
WIPP	Waste Isolation Pilot Plant
WTF	Waste Tank Farm (West Valley)
WVDP	West Valley Demonstration Project

ELEMENTS

Am	americium
C	carbon
Cm	curium
Co	cobalt
Cs	cesium
Eu	europium
Fe	iron
H-3	hydrogen-3 or tritium
I	iodine
Mn	manganese
Mo	molybdenum
Nb	niobium
Ni	nickel
Np	neptunium
Pu	plutonium
Sr	strontium
Tc	technetium

SUPPLEMENT TO GREATER-THAN-CLASS C (GTCC) LOW-LEVEL RADIOACTIVE WASTE AND GTCC-LIKE WASTE INVENTORY REPORTS

by

Environmental Science Division
Argonne National Laboratory

SUMMARY

This report supplements the waste inventory information provided in two documents that were published to support the environmental impact statement (EIS) being prepared by the U.S. Department of Energy (DOE) to evaluate disposal alternatives for greater-than-Class C (GTCC) low-level radioactive waste (LLRW) and GTCC-like waste. Preliminary inventories were provided in the July 23, 2007, Notice of Intent (NOI) to prepare the EIS, and the bases of these estimates are described in a report prepared by Sandia National Laboratories (Sandia) entitled *Greater-Than-Class C Low-Level Radioactive Waste and DOE Greater-Than-Class C-Like Waste Inventory Estimates.* This report was issued in July 2007. Additional details on this inventory are provided in a subsequent report prepared by Sandia entitled *Basis Inventory for Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement Evaluations,* Revision 1, which was issued in May 2008. This supplement does not replace the information contained in these two documents; instead, it updates the estimates of the waste volumes and radionuclide activities to incorporate additional information.

Since the NOI and these two reports were issued, additional wastes were identified for inclusion in the EIS, and updated estimates were developed for certain wastes. To aid in the presentation of this waste information, the updated inventory that is evaluated in the GTCC EIS and in this supplement is considered to be in one of two groups. Group 1 wastes are wastes that were already generated and are in storage or that are projected to be generated by facilities currently in operation. Group 2 wastes are wastes that might be generated as a result of proposed future activities, including several DOE projects, molybdenum-99 (Mo-99) production activities, and the operation of new nuclear power plants that have not yet been licensed by the U.S. Nuclear Regulatory Commission (NRC) or constructed.

Table S-1 provides updated estimates of the packaged volumes and total radionuclide activities of the wastes that make up Groups 1 and 2. It is estimated that the total waste volume in Group 1 is 5,300 m^3 (190,000 ft^3) and contains 110 megacuries (MCi) of activity. This waste volume is 300 m^3 (11,000 ft^3) less than the amount identified in the NOI, and the total activity is 30 MCi lower. The decrease in the volume of Group 1 wastes is due to the cancellation of the proposed Radioisotope Power Systems (RPS) consolidation project, a revision in the volume of sealed sources that need to be disposed of to account for a longer generation time, the reassignment of some wastes from Group 1 to Group 2, and updated volume estimates for several types of wastes. The radionuclide activity in the Group 1 wastes is mainly from the decommissioning of commercial nuclear power reactors currently in operation.

TABLE S-1 Summary of Group 1 and Group 2 GTCC LLRW and GTCC-Like Waste Estimates[a]

Waste Type	In Storage		Projected		Total Stored and Projected	
	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Group 1 GTCC LLRW						
Activated metals	59	1.4	820	110	880	110
Sealed sources	–[c]	–	2,800	2.0	2,800	2.0
Other Waste	75	0.0042	1.0	0.00013	76	0.0043
Total	130	1.4	3,700	110	3,800	110
Group 1 GTCC-like waste						
Activated metals	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste	950	0.11	510	0.17	1,500	0.28
Total	960	0.34	510	0.18	1,500	0.52
Total Group 1	1,100	1.7	4,200	110	5,300	110
Group 2 GTCC LLRW						
Activated metals	–	–	1,100	48	1,100	48
Sealed sources	–	–	23	0.000020	23	0.000020
Other Waste	–	–	3,900	0.54	3,900	0.54
Total	–	–	5,000	49	5,000	49
Group 2 GTCC-like waste						
Activated metals	–	–	–	–	–	–
Sealed sources	–	–	–	–	–	–
Other Waste	–	–	1,400	0.49	1,400	0.49
Total	–	–	1,400	0.49	1,400	0.49
Total Group 2	–	–	6,400	49	6,400	49
Groups 1 plus 2 GTCC LLRW						
Activated metals	59	1.4	1,900	160	2,000	160
Sealed sources	–	–	2,900	2.0	2,900	2.0
Other Waste	75	0.0042	3,900	0.54	3,900	0.54
Total	130	1.4	8,700	160	8,800	160
Groups 1 plus 2 GTCC-like waste						
Activated metals	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste	950	0.11	1,900	0.67	2,800	0.78
Total	960	0.34	1,900	0.67	2,800	1.0
Total Groups 1 plus 2	1,100	1.7	11,000	160	12,000	160

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. The radionuclide activities given in this table represent those at the time that it is assumed that the waste would be available for disposal.

[b] MCi means megacurie or a million curies.

[c] A dash means that there is no value for that entry.

It had previously been estimated that the proposed RPS consolidation project would generate about 1,300 m^3 (46,000 ft^3) of GTCC-like wastes and contain a total activity of 16 MCi. These values were used to develop the estimates given in the NOI. The volume decrease associated with the cancellation of this project was largely offset by an increase in the volume of GTCC LLRW associated with the disposal of commercial sealed sources. The volume estimate for these sealed sources increased from 1,700 m^3 (60,000 ft^3) in the NOI to 2,800 m^3 (99,000 ft^3) because the time period over which it is assumed that the sources would become available for disposal was extended from year 2035 to year 2083. The total activity in these sealed sources is about 2.0 MCi.

The GTCC wastes associated with decontamination and decommissioning of the West Valley Site are in both Group 1 and Group 2. Group 1 wastes are all GTCC-like wastes and result from past and ongoing decontamination activities at the site. Some of the wastes are already in storage, and others are being generated during decontamination of the Main Plant Process Building (MPPB) to make it ready for demolition. Group 2 wastes are all projected wastes from potential future decommissioning activities. These wastes include GTCC-like wastes from decommissioning of the MPPB and the Waste Tank Farm (WTF). Group 2 GTCC wastes would also be generated if a decision is made to exhume the wastes from the NRC-licensed disposal area (NDA) and state-licensed disposal area (SDA) as part of future decommissioning activities. Most of the GTCC waste from these two disposal areas would be GTCC LLRW, with 31 m^3 (1,100 ft^3) from the NDA being GTCC-like waste. This 31 m^3 (1,100 ft^3) of GTCC-like waste is included with the volume of GTCC LLRW from the NDA and SDA for purposes of analysis in the EIS.

The volume of GTCC-like waste associated with the West Valley Site from waste already in storage, the ongoing decontamination of the MPPB, and the future decommissioning of the MPPB and WTF was reported to be about 1,430 m^3 (50,500 ft^3) in the report prepared by Sandia in 2007, and this value was used in developing the GTCC waste volume estimates for the NOI. After the NOI was issued, the DOE West Valley Site Office provided an updated estimate; the volume provided was about 2,240 m^3 (79,100 ft^3). This updated volume was used for analyses in the EIS. About 980 m^3 (35,000 ft^3) of the GTCC-like waste are associated with future potential decommissioning actions and, as such, are assigned to Group 2. Hence, the volume of Group 1 GTCC waste associated with these activities is 1,260 m^3 (44,500 ft^3). In addition, the estimated radionuclide activity of this GTCC waste decreased from about 15 MCi to less than 1 MCi as a result of more complete characterization information.

There were a few additional minor changes to the original inventory presented in the NOI, and the overall impact was a decrease in the total volume of Group 1 waste of about 300 m^3 (11,000 ft^3). The total radionuclide activity for Group 1 decreased by about 30 MCi. The decrease in radionuclide activity for the Group 1 wastes was due to the cancellation of the RPS project, the use of updated values for the West Valley Site (which were significantly lower than the values used to develop estimates for the NOI because there was more complete characterization information), and the reassignment of some wastes from Group 1 to Group 2.

Group 2 waste has an estimated volume of 6,400 m^3 (230,000 ft^3) and contains a total activity of 49 MCi. Much of this waste volume is associated with the West Valley Site. About 980 m^3 (35,000 ft^3) of GTCC-like waste are associated with decommissioning the MPPB and WTF; an additional 4,300 m^3 (150,000 ft^3) of GTCC LLRW and GTCC-like waste could be generated should a decision be made to exhume the NDA and SDA at that site. The radionuclide activity in the Group 2 wastes results mainly from the decommissioning of new commercial nuclear power reactors.

A planned DOE project for the production of plutonium-238 (Pu-238) is estimated to produce 380 m^3 (13,000 ft^3) of Group 2 GTCC-like wastes with a total activity of 0.094 MCi. Many of the radionuclides in these wastes have short half-lives (three years or less) that do not have an impact on long-term management decisions. For purposes of analysis in the EIS, it is assumed that the wastes from the Pu-238 production project would be stored for three years at the facility that generates these wastes before being shipped to the disposal site. The total activity in these wastes given here includes radioactive decay for three years.

An additional type of Group 2 GTCC LLRW was identified for inclusion in the EIS after the NOI was issued. This waste is associated with the future production of Mo-99 for medical uses. Two organizations are planning to begin producing Mo-99 in the near future, and it is estimated that the annual volume of GTCC LLRW associated with these activities would be about 5.5 m^3 (190 ft^3) and contain a total of 6,800 Ci. For purposes of analysis in the EIS, it is assumed that these two processes would begin operation in the next few years and operate for 71 years (to 2083). It is estimated that the total volume of GTCC LLRW produced over this time frame for these two Mo-99 production projects would be about 390 m^3 (14,000 ft^3) and contain 0.48 MCi of activity. It is assumed that before being shipped to the disposal site, these wastes would also be stored at the generating facilities for three years to allow for the decay of the short-lived radionuclides, and the total activity given here reflects this decay.

In addition to presenting details of the additional waste being considered for the EIS, this report reviews and expands the information provided in the two inventory reports prepared by Sandia cited above in order to provide sufficient details for use in preparing the EIS. In particular, the list of radionuclides was expanded to include those that might occur in some wastes at lower concentrations but could still present a long-term management concern because of their long half-lives or greater mobility in the environment. The radionuclides in these two reports generally focused on those most prevalent in the wastes to allow for the development of estimates of the total activities associated with these wastes.

In summary, this supplement has been prepared to:

- Organize the waste inventory information into two groups for use in the EIS analyses;

- Update the volumes and radionuclide activities of the wastes in these two groups for use in preparing the EIS;

- Provide a list of radionuclides that represent the full spectrum of those that might be present in these wastes by expanding the list given in previous reports, as appropriate;

- Develop estimates of the activities of these additional radionuclides; and

- Provide this updated information in a systematic format to facilitate reviews and further updates, as indicated.

The two reports noted above contain detailed information on the approaches used to estimate the volumes and radionuclide activities of these wastes, and this information is not repeated here. This report is intended to supplement the previously developed information to allow for detailed analyses of the alternatives for managing these wastes in the EIS. In addition, these two reports provide detailed information on various approaches for packaging the wastes to meet the constraints of various disposal concepts and to facilitate the handling and transportation of these wastes from the point of generation to the reference disposal locations being considered in the EIS. Supplements to this information, where necessary, are presented in a separate report entitled *Conceptual Designs for Greater-Than-Class C Low-Level Radioactive Waste Land Disposal Facilities* prepared by Argonne National Laboratory, which was completed in August 2010.

This page is intentionally left blank.

1 INTRODUCTION

1.1 PURPOSE

The U.S. Department of Energy (DOE) is preparing an environmental impact statement (EIS) to evaluate alternatives for the development, operation, and long-term management of a disposal facility for greater-than-Class C (GTCC) low-level radioactive waste (LLRW). GTCC LLRW is radioactive waste that has concentrations of radionuclides exceeding the limits for Class C LLRW established by the U.S. Nuclear Regulatory Commission (NRC) in Title 10, Part 61 of the *Code of Federal Regulations* (10 CFR Part 61). A Notice of Intent (NOI) to prepare the EIS was issued by DOE on July 23, 2007, with a printing correction issued on July 31, 2007.

The NRC LLRW classification system does not apply to radioactive wastes generated and owned by DOE and their disposal in DOE facilities. However, DOE owns and generates both LLRW and transuranic (TRU) radioactive waste, which have characteristics similar to GTCC LLRW and for which there may be no path to disposal. DOE is including these wastes in the EIS evaluations, as the disposal options for them are expected to be comparable to those for GTCC LLRW. For purposes of the EIS, these wastes are referred to as “GTCC-like” wastes. The use of the term “GTCC-like” is not intended to and does not create a new DOE classification of radioactive waste.

This supplement was prepared to update the inventory information that is presented in the *Greater-Than-Class C Low-Level Radioactive Waste and DOE Greater-Than-Class C-Like Waste Inventory Estimates* prepared by Sandia National Laboratories (Sandia 2007) and the additional details on this waste inventory that are presented in the *Basis Inventory for Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement Evaluations,* Revision 1 (Sandia 2008). This supplement summarizes key information from these two reports for use in the EIS evaluations, and it provides data on additional wastes that were subsequently identified for inclusion in the EIS. These estimates update those previously issued by DOE for GTCC LLRW in 1994 (DOE 1994). The inventory estimates reported in 1994 were limited to GTCC LLRW and did not consider GTCC-like wastes.

The first report cited above (Sandia 2007) provides summary-level inventory information and was prepared to support the issuance of the NOI for the EIS and the public scoping process. That report presents data on the volumes and total activities of the various types of GTCC LLRW and GTCC-like wastes that were expected to be addressed in the EIS at that time. The second report (Sandia 2008) presents more detailed information on the inventory of radionuclides expected to be present in these wastes. The second report also provides minor modifications in the volume estimates for some waste streams on the basis of the previously developed information.

Since issuance of the NOI and these two reports, updated information has been developed for the volume and activity estimates for certain wastes, and additional wastes have been identified for inclusion in the EIS. This supplement provides information about these changes to the information included in the NOI and about the additional wastes at the level of detail necessary for evaluation in the EIS.

In addition to providing information about the additional wastes and thus supplementing the Sandia (2007) report, this report also expands on the list of radionuclides discussed in Sandia (2008) for some waste types to address the full spectrum of radionuclides that could be present in these materials. The information provided in the two reports prepared by Sandia (2007, 2008) focused on those radionuclides most prevalent in the various types of wastes at the time the wastes would be available for disposal. Some additional radionuclides that may be present in lower concentrations could present a long-term management concern because of their very long half-lives or greater mobility in the environment. Estimates of the inventories of such radionuclides were obtained from using published information and updates to the data call responses, and these were added to the information provided in Sandia (2008) for input into the evaluations for the EIS.

To facilitate presentation of this waste information, the updated inventory is presented in this supplement as being in two groups. Group 1 wastes are comparable to the inventory presented in the NOI and consist of wastes that were already generated and in storage or projected to be generated by facilities currently in operation. Group 2 wastes largely consist of wastes that were identified for inclusion in the EIS after the NOI was published, and they includes wastes that may be generated from proposed future activities, including several DOE projects, two planned molybdenum-99 (Mo-99) production projects, and new nuclear power plants that have not yet been licensed by NRC or constructed. An additional discussion of the two groups is presented in Section 2 of this supplement.

Sandia (2008) includes information on various approaches to package the wastes to meet the constraints of potential disposal facilities. Some of these wastes have very high gamma exposure rates; such rates create additional challenges for safely handling and transporting these wastes from their generation points to the potential disposal sites being addressed in the EIS. This information is not repeated here but is used in the evaluations when appropriate with regard to the various alternatives addressed in the EIS. In addition, Sandia (2008) contains detailed information on the approaches used to estimate the volumes and radionuclide activities of these wastes.

The packaging assumptions used in the EIS analyses are provided in a report prepared by Argonne National Laboratory (Argonne 2010) and were based in part on the information contained in Sandia (2008). This information is also not repeated here. This report is simply a supplement to the previously developed information on the volumes, radionuclide activities, and physical characteristics of the GTCC LLRW and GTCC-like wastes to allow for detailed analyses of the alternatives for managing these wastes in the EIS.

The GTCC waste volumes and radionuclide activities are generally presented to two significant figures in this supplement. In compiling the GTCC waste inventory, additional significant figures were used for the volumes and activities of individual waste streams to minimize the impact of round-off errors. The resulting totals (volumes and activities) were determined and then rounded to two significant figures. Because of this approach, there are instances where the totals in tables may not exactly equal the sum of the individual components. This approach was used to report the inventory information as accurately as possible.

1.2 ORGANIZATION

The remainder of this supplement is organized as follows. A description of the GTCC LLRW and GTCC-like wastes included in the inventory for evaluation in the GTCC EIS is provided in Section 2. Section 3 summarizes the volumes and radionuclide activities of the wastes included in Group 1, with a focus on the rationale and approach for including additional radionuclides in the inventory. Section 4 provides estimates of the volumes and radionuclide activities of the new wastes added to the inventory (Group 2 wastes) since issuance of the NOI. A list of references used in the supplement is given in Section 5.

This page is intentionally left blank.

2 GTCC LLRW AND GTCC-LIKE WASTE INVENTORY

For purposes of analysis in the EIS, GTCC LLRW and GTCC-like wastes are considered to be in one of three waste types as presented in the NOI: activated metals, sealed sources, or Other Waste. The waste inventory includes wastes already generated and in storage (stored inventory) as well as those wastes estimated to be generated in the future (projected inventory). Wastes from all three types (activated metals, sealed sources, and Other Waste) are currently in storage at sites licensed by the NRC and Agreement States and at certain DOE sites.

Inventory estimates are presented in this supplement as being in one of two groups. Group 1 wastes are either already in storage or are expected to be generated from facilities (such as commercial nuclear power plants) already in operation. All stored GTCC LLRW and GTCC-like wastes are included in Group 1. Group 2 consists of wastes that may be generated through future planned actions, including two commercial Mo-99 production projects and a planned DOE plutonium-238 (Pu-238) production project. Group 2 also includes (1) the wastes associated with the decommissioning of the NRC-licensed disposal area (NDA) and the state-licensed disposal area (SDA) at the West Valley Site in the state of New York (if such an activity is included in the remaining West Valley Demolition Project [WVDP] decommissioning decision-making, with its Phase 2 decision to be made within 10 years of the ROD that was issued in 2010) and (2) the wastes that could be generated in the future from an assumed number of new commercial nuclear power plants that are not yet licensed or constructed. There are no stored GTCC LLRW and GTCC-like wastes included in Group 2.

The estimated packaged volumes and radionuclide activities for the wastes being addressed in the EIS are given in Table 2-1. Some of the Group 1 wastes have already been generated and are in storage; the rest would be generated in the future. All Group 2 wastes would be generated in the future. Table 2-2 identifies the locations where GTCC LLRW and GTCC-like wastes are currently being stored or would be generated in the future. Additional information for GTCC-like wastes is presented in Table 2-3.

For purposes of analysis in the EIS, the GTCC wastes are categorized as being either contact-handled (CH) or remote-handled (RH) wastes. CH waste is waste for which the dose rate on the surface of the package is less than 200 millirem/hour (mrem/h), and RH waste is waste for which the dose rate on the surface of the package is equal to or greater than 200 mrem/h. These definitions are consistent with the definitions of CH and RH waste given in the Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act (LWA) (Public Law [P.L.] 102-579). These designations are used for the various types of wastes listed in Table 2-1 and also in a number of additional tables in this supplement.

The total packaged volume of GTCC LLRW in Groups 1 and 2 is estimated to be about 8,800 m^3 (310,000 ft^3), and the total volume of GTCC-like wastes in these two groups is estimated to be about 2,800 m^3 (99,000 ft^3). The combined total volume of wastes in these two groups (to two significant figures) is about 12,000 m^3 (420,000 ft^3), and the total radionuclide activity in these wastes is estimated to be about 160 megacuries (MCi). The impacts associated

TABLE 2-1 Summary of Group 1 and Group 2 GTCC LLRW and GTCC-Like Waste Packaged Volumes and Radionuclide Activities[a]

Waste Type	In Storage		Projected		Total Stored and Projected	
	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Group 1						
GTCC LLRW						
Activated metals (BWRs)[c] - RH	7.1	0.22	200	30	210	31
Activated metals (PWRs) - RH	51	1.1	620	76	670	77
Sealed sources (Small)[d] - CH	–[e,f]	–	1,800	0.28	1,800	0.28
Sealed sources (Cs-137 irradiators) - CH	–	–	1,000	1.7	1,000	1.7
Other Waste[g] - CH	42	0.000011	–	–	42	0.000011
Other Waste - RH	33	0.0042	1.0	0.00013	34	0.0043
Total	130	1.4	3,700	110	3,800	110
GTCC-like waste						
Activated metals - RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources (Small) - CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste - CH	430	0.016	310	0.0062	740	0.022
Other Waste - RH	520	0.096	200	0.17	720	0.26
Total	960	0.34	510	0.18	1,500	0.52
Total Group 1	1,100	1.7	4,200	110	5,300	110
Group 2						
GTCC LLRW						
Activated metals (BWRs) - RH	–	–	73	11	73	11
Activated metals (PWRs) - RH	–	–	300	37	300	37
Activated metals (Other) - RH	–	–	740	0.14	740	0.14
Sealed sources - CH	–	–	23	0.000020	23	0.000020
Other Waste - CH	–	–	1,600	0.024	1,600	0.024
Other Waste - RH	–	–	2,300	0.51	2,300	0.51
Total	–	–	5,000	49	5,000	49
GTCC-like waste						
Activated metals - RH	–	–	–	–	–	–
Sealed sources - CH	–	–	–	–	–	–
Other Waste - CH	–	–	490	0.012	490	0.012
Other Waste - RH	–	–	870	0.48	870	0.48
Total	–	–	1,400	0.49	1,400	0.49
Total Group 2	–	–	6,400	49	6,400	49

TABLE 2-1 (Cont.)

Waste Type	In Storage		Projected		Total Stored and Projected	
	Volume (m^3)	Activity (MCi)[b]	Volume (m^3)	Activity (MCi)	Volume (m^3)	Activity (MCi)
Groups 1 and 2						
GTCC LLRW						
Activated metals - RH	59	1.4	1,900	160	2,000	160
Sealed sources - CH	–	–	2,900	2.0	2,900	2.0
Other Waste - CH	42	0.00091	1,600	0.024	1,600	0.024
Other Waste - RH	33	0.0042	2,300	0.51	2,300	0.51
Total	130	1.4	8,700	160	8,800	160
GTCC-like waste						
Activated metals - RH	6.2	0.23	6.6	0.0049	13	0.24
Sealed sources - CH	0.21	0.0000060	0.62	0.000071	0.83	0.000077
Other Waste - CH	430	0.016	800	0.02	1,200	0.036
Other Waste - RH	520	0.096	1,100	0.65	1,600	0.75
Total	960	0.34	1,900	0.67	2,800	1.0
Total Groups 1 and 2	1,100	1.7	11,000	160	12,000	160

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. BWR = boiling water reactor, CH = contact-handled (waste), PWR = pressurized water reactor, RH = remote-handled (waste).

[b] MCi means megacurie or 1 million curies.

[c] There are two types of commercial nuclear reactors in operation in the United States, BWRs and PWRs. Different factors were used to estimate the volumes and activities of activated metal wastes for these two types of reactors.

[d] Sealed sources may be physically small but have high concentration of radionuclides.

[e] There are sealed sources currently possessed by NRC licensees that may become GTCC LLRW when no longer needed by the licensee. Due to the lack of information on the current status of the sources (i.e., whether they are in use, waste, etc.), the estimated volume and activity of these sources are included in the projected inventory.

[f] A dash means that there is no value for that entry.

[g] Other Waste consists of those wastes that are not activated metals or sealed sources; it includes contaminated equipment, debris, scrap metals, filters, resins, soil, solidified sludges, and other materials.

TABLE 2-2 Storage and Generator Locations of the GTCC LLRW and GTCC-Like Waste[a]

Waste Type	GTCC LLRW	GTCC-Like
Group 1		
Activated metals (RH)	Various states	INL (Idaho) ORR (Tennessee)
Sealed sources (CH)	Various states	LANL (New Mexico)
Other Waste - CH	Virginia and Texas	West Valley Site (New York) INL (Idaho) Babcock and Wilcox (Virginia)
Other Waste - RH	Virginia and Texas	West Valley Site (New York) INL (Idaho) ORR (Tennessee) Babcock and Wilcox (Virginia)
Group 2		
Activated metals (RH)	Various states	–
Sealed sources (CH)	West Valley Site (New York)	–
Other Waste - CH	West Valley Site (New York)	West Valley Site (New York) ORR (Tennessee)
Other Waste - RH	West Valley Site (New York) Missouri and Virginia	West Valley Site (New York) ORR (Tennessee)

[a] Other Waste consists of those wastes that are not activated metals or sealed sources; it includes contaminated equipment, debris, scrap metal, filters, resins, soil, solidified sludges, and other materials. A dash means no volume for that waste type. INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, ORR = Oak Ridge Reservation.

with management of these Group 1 and Group 2 GTCC LLRW and GTCC-like wastes are addressed quantitatively in the EIS.

For comparison, the total volume of GTCC LLRW and GTCC-like wastes given in the NOI was 5,600 m^3 (200,000 ft^3), and the estimated total radionuclide activity was identified as 140 MCi. The changes in volume and radionuclide activities in the wastes being addressed in the EIS are discussed in more detail in Section 2.1.

2.1 SUMMARY OF CHANGES TO THE INVENTORY FROM VALUES GIVEN IN THE NOTICE OF INTENT

DOE issued the NOI for the EIS and initiated the scoping process in the summer of 2007. The NOI included a table that summarized the volumes and radionuclide activities of the GTCC LLRW and GTCC-like waste that were expected to be addressed in the EIS. This information is not repeated here but is available in the NOI. Since issuance of the NOI, updated information has been developed for the volume and activity estimates for certain wastes, and additional wastes have been identified for inclusion in the EIS. In addition, supplemental information on the

TABLE 2-3 Sources of GTCC-Like Waste[a]

Waste Type	Site[b]	Stored Volume (m^3)	Projected Volume (m^3)
Group 1			
Activated metals (RH)	INL	3.3	6.6
	ORR	2.9	–[c]
Sealed sources (CH)	LANL	0.21	0.62
Other Waste - CH	West Valley Site[d]	400	310
	INL	31	–
	B&W	3.4	–
Other Waste - RH	West Valley Site[d]	480	63
	INL	19	–
	ORR	4.0	130
	B&W	15	0.60
Total		960	510
Group 2			
Activated metals (RH)	–	–	–
Sealed sources (CH)	–	–	–
Other Waste - CH	West Valley Site	–	220
	ORR	–	260
Other Waste - RH	West Valley Site	–	760
	ORR	–	120
Total		–	1,400

[a] All values have been rounded to two significant figures. Some totals may not equal sum of individual components because of independent rounding. B&W = Babcock & Wilcox Company (Lynchburg, Va.), CH = contact-handled (waste), INL = Idaho National Laboratory, LANL = Los Alamos National Laboratory, ORR = Oak Ridge Reservation, RH = remote-handled (waste).

[b] These are the sites where the wastes are currently being stored or would be generated in the future.

[c] A dash means that there is no value for that entry.

[d] These volumes were provided by the DOE West Valley Site Office and were based on the assumption that waste repackaging with volume reduction occurred prior to disposal. These wastes are associated with decontamination activities at the West Valley Site. Because of the assumed reduction in volume, the volumes presented in the GTCC EIS are less than those presented in the Final EIS for the West Valley Site (DOE 2010).

radionuclide activities associated with these wastes has been developed. Table 2-1 summarizes data on the wastes that will be addressed in the EIS, including the wastes that were added after issuance of the NOI. This supplement identifies the sources of the additional wastes and provides information on the approach used to expand the list of radionuclides from the list used for the NOI.

The total waste volume in Group 1 is estimated to be about 5,300 m^3 (190,000 ft^3), and this waste contains a total of 110 MCi of activity. The radionuclide activity is mainly from the decommissioning of commercial nuclear power reactors currently in operation. This waste volume of 5,300 m^3 (190,000 ft^3) for Group 1 is 300 m^3 (11,000 ft^3) lower than the volume identified in the NOI, and the total activity is 30 MCi lower. This decrease in waste volume for Group 1 wastes results from the cancellation of the proposed Radioisotope Power Systems (RPS) consolidation project, a revision in the volume of sealed sources requiring disposal to account for a longer generation time, the reassignment of some wastes from Group 1 to Group 2, and updates in the estimates of the volume of several types of wastes, as discussed below.

The proposed RPS consolidation project was previously estimated to generate about 1,300 m^3 (46,000 ft^3) of GTCC-like wastes containing a total of 16 MCi of activity (Sandia 2007). These values were used to develop the estimates provided in the NOI. The volume decrease associated with the cancellation of this project is largely offset by an increase in the volume of GTCC LLRW associated with disposal of sealed sources. The estimated volume of these sealed sources increased from 1,700 m^3 (60,000 ft^3) in the NOI to 2,800 m^3 (99,000 ft^3) because the period over which it was assumed that the sources would become available for disposal was extended from 2035 to 2083. It is estimated that the total activity in these sealed sources would be about 2.0 MCi (see Table 2-1), which is comparable to the value given in the NOI (2.4 MCi).

The GTCC wastes associated with decontamination and decommissioning of the West Valley Site are in both Group 1 and Group 2. All Group 1 wastes are GTCC-like waste and result from past and ongoing decontamination activities at the site. Some of the wastes are already in storage, and others are being generated by decontamination of the Main Plant Process Building (MPPB) to make it ready for demolition. All Group 2 wastes are projected wastes from potential future decommissioning activities. These wastes include GTCC-like wastes from decommissioning of the MPPB and the Waste Tank Farm (WTF). Group 2 GTCC wastes would also be generated if a decision was made to exhume the wastes from the NDA and SDA as part of future decommissioning activities. Most of the GTCC waste from these two disposal areas would be GTCC LLRW, with 31 m^3 (1,100 ft^3) from the NDA being GTCC-like waste. This 31 m^3 (1,100 ft^3) of GTCC-like waste is included with the volume of GTCC LLRW from the NDA and SDA for purposes of analysis in the EIS.

The volume of GTCC-like wastes associated with the West Valley Site from wastes already in storage, ongoing decontamination of the MPPB, and the future decommissioning of the MPPB and WTF was reported to be about 1,430 m^3 (50,500 ft^3) in Sandia (2007), and this value was used in developing the GTCC waste volume estimates for the NOI. After the NOI was issued, the DOE West Valley Site Office provided an updated estimate; the volume provided was about 2,240 m^3 (79,100 ft^3). This updated volume was used for analyses in the EIS. About

980 m^3 (35,000 ft^3) of the GTCC-like wastes are associated with future potential decommissioning actions and, as such, are assigned to Group 2. Hence, the volume of Group 1 GTCC wastes associated with these activities is 1,260 m^3 (44,500 ft^3). In addition, the estimated radionuclide activity of these GTCC wastes decreased from about 15 MCi to less than 1 MCi as a result of more complete characterization information.

Several additional minor changes were made to the original inventory to update the information for some specific waste streams. For example, some cesium-137 (Cs-137) irradiators and a relatively small volume of activated metal waste at Idaho National Laboratory (INL) previously identified as GTCC-like wastes were subsequently determined to be LLRW suitable for disposal at existing DOE LLRW facilities. In addition, the approach used to estimate the volumes of the individual waste streams included in the NOI was thoroughly reviewed and updated, as needed. For example, even though the waste volumes in the NOI were to have been packaged, they were actually unpackaged in a few cases. For these waste streams, the waste volumes were revised to reflect packaged waste volumes. With these changes, the total volume of the waste inventory that was presented in the NOI for GTCC LLRW and GTCC-like wastes was reduced by about 300 m^3 (11,000 ft^3).

The data on radionuclide activity given in Sandia (2008) and the original project submittals were reviewed to prepare this supplement and for use in the EIS analyses. The total activity reported in the NOI (140 MCi) is larger than the activity reported for the Group 1 wastes (110 MCi). The decrease in the radionuclide activity of the Group 1 wastes is a result of the following: cancellation of the RPS consolidation project; the use of updated values for the West Valley Site wastes, which were much lower than those used to develop estimates for the NOI; and the reassignment of some GTCC wastes from Group 1 to Group 2.

The radionuclide activities reported in the NOI were generally the total activities at the time of generation, except for those reported for activated metals for commercial nuclear reactors, for which a six-year decay period was assumed. The radionuclide activities given in this supplement for Group 1 wastes reflect the activities at the time that it is assumed the wastes would be available for disposal. Some of the total activities for some waste streams in this supplement differ from those given in Sandia (2007, 2008) as a result of this approach for reporting radionuclide activities. Additional information on the approach used to develop radionuclide activity estimates for Group 1 and Group 2 wastes is provided later in this section.

Group 2 wastes have an estimated volume of about 6,400 m^3 (230,000 ft^3) and contain a total activity of 49 MCi. Much of this waste volume is associated with the West Valley Site. A total of 980 m^3 (35,000 ft^3) of GTCC-like wastes are associated with decommissioning the MPPB and WTF, and an additional 4,300 m^3 (150,000 ft^3) of GTCC LLRW and GTCC-like wastes could be generated should a decision be made to exhume the NDA and SDA at that site. The radionuclide activity in the Group 2 wastes results mainly from the decommissioning of new commercial nuclear power reactors.

A planned DOE Pu-238 project is estimated to produce about 380 m^3 (13,000 ft^3) of Group 2 GTCC-like wastes with a total activity of 0.094 MCi. Many of the radionuclides in these wastes have short half-lives (three years or less) and thus would not have an impact on long-term management decisions. For purposes of analysis in the EIS, it is assumed that the Pu-238 production project wastes will be stored for three years at the facility that generated these wastes before they are shipped to the disposal site. The total activity in these wastes given here includes radioactive decay for three years.

An additional volume of GTCC LLRW was identified for inclusion in the EIS after the NOI was issued. This waste is associated with the future production of Mo-99. Two organizations are currently planning to produce Mo-99 for medical uses in the near future: Babcock & Wilcox Company (B&W) and the Missouri University Research Reactor (MURR). The B&W concept uses a homogenous solution reactor termed the Medical Isotope Production System (MIPS). The MIPS is estimated to produce an annual volume of about 5 m^3 (180 ft^3) of GTCC LLRW containing a total activity of 3,700 curies (Ci). As for the planned Pu-238 production wastes, it is assumed that the GTCC LLRW produced by MIPS would be stored at the generating site for three years before being shipped to the disposal facility to allow the short-lived radionuclides to decay. An annual activity of 3,700 Ci for MIPS reflects three years of radioactive decay.

Use of the MURR involves irradiating solid targets containing low-enriched uranium (LEU) with neutrons in the research reactor and processing the targets to extract Mo-99. This process is estimated to produce an annual volume of about 0.46 m^3 (16 ft^3) of GTCC LLRW containing a total activity of 3,100 Ci. As was the case for MIPS, it is assumed that these wastes would be stored at the generating site for three years before being shipped to the disposal facility, and the activity reported here reflects that decay. For purposes of analysis in the EIS, it is assumed that these two processes would begin operation in the next few years and operate for 71 years (to 2083). It is estimated that the total volume of GTCC LLRW produced over this time frame for these two Mo-99 production projects would be about 390 m^3 (14,000 ft^3) and contain 0.48 MCi of activity.

The activities for all Group 1 stored wastes and all of the Group 1 projected wastes for the West Valley Site were decay-corrected to 2019, the date when it is assumed that a GTCC waste disposal site would be available for the purposes of the EIS analysis. This correction is also consistent with the information provided in Sandia (2008). The activities for the other Group 1 projected wastes reflect the values at the time of generation but no earlier than 2019. In other words, all of the radionuclide activities used in the EIS analyses reflect radioactive decay until the time when the wastes are transported and placed into the disposal facility.

The radionuclide activities for Group 2 wastes reflect the activities at the time that the wastes are expected to be generated and available for disposal. The activities of the activated metal wastes from commercial nuclear reactors reflect a six-year radioactive decay period, as was the case for similar Group 1 wastes. All Group 2 GTCC LLRW and GTCC-like wastes associated with the West Valley Site represent values for the year 2019, because plans for the activities that could generate these wastes are very preliminary. If these wastes were actually generated in the future, it is very likely that they would be generated after 2019. So this approach is conservative in terms of analyzing impacts in the EIS. Finally, the activities for the two commercial Mo-99 production projects and the planned DOE Pu-238 production project have been subjected to three years of radioactive decay to reflect interim on-site storage, as noted above.

It is estimated that the total activity for the Group 2 wastes would be about 49 MCi. Thus, the total activity for the combined Group 1 and Group 2 wastes is about 160 MCi, which is about 20 MCi more than indicated in the NOI. This information is discussed in more detail in later sections of this supplement.

All of the GTCC waste inventory information has been compiled in a manner to support EIS analyses and to ensure that the radionuclide activities are evaluated on a common time basis (i.e., they are decay-corrected on a consistent time basis that is appropriate with regard to the assumptions used to define the alternatives). The results provided in this supplement were obtained from this compilation.

2.2 ASSUMED WASTE GENERATION TIMES

For the Group 1 wastes, future inventory estimates are projected to 2035 for Other Waste, 2062 for activated metals, and 2083 for sealed sources. The time period used for activated metal waste accounts for the decommissioning of all currently NRC-licensed commercial nuclear power plants, which will produce most of the radionuclide activity for Group 1 wastes. Many nuclear utilities are currently seeking and being granted extensions to their operating licenses from NRC. These extensions are generally for about 20 years. Assuming that all commercial nuclear power reactors receive 20-year license extensions, the last currently operating nuclear power plant will cease operation in 2050. It is assumed that a six-year cooling period occurs before decommissioning operations commence and these wastes become available for disposal. Hence all Group 1 activated metal wastes from commercial nuclear reactors will be disposed of by 2062 (Sandia 2008).

The time period for Group 1 Other Waste reflects a reasonable amount of time for addressing the indicated wastes. Many of these wastes are associated with the West Valley Site, and activities that could generate Group 1 wastes at this site are expected to be completed before 2035. The waste volumes and activities for the Other Waste generated by other sources are comparatively small and well defined. The time period for Group 1 sealed sources is consistent with the assumption used to address the future decommissioning of Group 2 commercial nuclear power reactors.

All of the wastes in Group 2 will be generated in the future. Some of these facilities may or may not be constructed and operated as currently envisioned, so these projections have a high degree of uncertainty associated with them. This situation contrasts with that of the Group 1 wastes, some of which are already in storage, and the rest of which are expected to be generated from currently operating facilities.

The same approach as that used for the Group 1 activated metal wastes from commercial nuclear reactors was used for comparable Group 2 wastes from proposed new reactors. Although the schedules for new commercial reactors are subject to change, it is projected that activated metal wastes from decommissioning these reactors would be generated to 2083. A total of 33 new reactors was assumed to estimate the volumes and radionuclide activities for these wastes, consistent with information provided by the NRC (NRC 2009). As was the case for the Group 1 activated metal wastes, it is assumed that a six-year cooling period would occur before decommissioning operations would commence and these wastes would become available for disposal.

All other GTCC LLRW and GTCC-like wastes in Group 2 are expected to be disposed of shortly after generation. Most of Group 2 GTCC LLRW is associated with the potential exhumation of the NDA and SDA at the West Valley Site. For purposes of analysis in the EIS, it is assumed that a decision to exhume these wastes would be made within 10 years of the *Record of Decision: Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center* (DOE 2010) and that these wastes would be generated from about 2020 to 2035. As noted previously, it is assumed that the interim on-site storage of wastes from the two planned commercial Mo-99 production projects and the planned DOE Pu-238 production project would allow for decay of the short-lived radionuclides in these wastes.

2.3 RADIONUCLIDE PROFILES OF THE WASTES

Radionuclide profiles for the various Group 1 and Group 2 GTCC LLRW and GTCC-like wastes were developed by using information provided by the DOE project offices in response to a data call, information from databases, and data from a review of documents on GTCC LLRW and TRU waste prepared by DOE and the NRC. The radionuclides present in GTCC LLRW and GTCC-like waste can generally be placed in one of three categories: neutron activation products, radioactive fission products, or actinides (i.e., radionuclides higher than actinium in the Chart of the Nuclides). The main source of activity in activated metals is neutron activation products. Fission products and actinides are expected to be the main sources of radionuclide activity in sealed sources and Other Waste. Fission products and some actinides are also present in relatively low concentrations in activated metals. The actinides include TRU radionuclides, and many of these are present in GTCC-like wastes in the Other Waste type.

Radionuclide profiles were used to develop estimates of the activities of each radionuclide that would be present in the various waste streams. Then the individual waste streams were summed to obtain an estimate of the total radionuclide activity for the wastes that make up a category (such as those given in Table 2-1). These activities can be summed to obtain estimates of the total activities in the various GTCC LLRW and GTCC-like waste categories, as appropriate. This information was used to address the waste handling, transportation, and disposal impacts of these wastes in the EIS.

3 WASTES INCLUDED AS GROUP 1

A discussion of volume estimates and associated radionuclide activities for each of the three waste types (i.e., activated metals, sealed sources, and Other Waste) for Group 1 is presented in this section.

3.1 ACTIVATED METALS

The activated metal waste consists of steel, stainless steel, and a number of specialty alloys used in nuclear reactors. Portions of the reactor assembly and other components near the nuclear fuel are activated by high fluxes of neutrons during reactor operations for long periods of time, and high concentrations of some radionuclides result. Many of these have very short half-lives and decay rapidly, but others have longer half-lives and remain radioactive for an extended period of time. Most of the activated metal waste will be generated in the future from the decommissioning of commercial nuclear power reactors. The neutron activation products expected to be most prevalent in these wastes when they will be available for disposal are these eight: carbon-14 (C-14), manganese-54 (Mn-54), iron-55 (Fe-55), nickel-59 (Ni-59), cobalt-60 (Co-60), nickel-63 (Ni-63), molybdenum-93 (Mo-93), and niobium-94 (Nb-94). Somewhat lower concentrations of some fission products — including strontium-90 (Sr-90), technetium-99 (Tc-99), iodine-129 (I-129), and cesium-137 (Cs-137) — and actinides, such as various isotopes of plutonium, are also expected to be present on these materials as surface contamination.

Only a very small fraction of the activated metal waste generated from decommissioning commercial nuclear power plants will be GTCC LLRW. Most of the waste will be Class A, B, or C LLRW that can be disposed of at existing commercial radioactive waste disposal sites. For purposes of analysis in the EIS, all of the GTCC LLRW activated metal waste is assumed to be RH waste on the basis of the expected high concentrations of gamma-emitting radionuclides in this material. These wastes will need a significant amount of shielding to reduce the levels of radiation to acceptable levels and/or will have to be handled remotely. RH waste is defined to be radioactive waste for which the dose rate on the surface of the package is equal to or exceeds 200 mrem/h in the WIPP LWA (P.L.102-579), and this value is used in the EIS to define RH wastes. The physical form of this waste is solid metal, which is both physically and chemically inert.

3.1.1 Volume Estimates

Group 1 activated metal wastes are those associated with currently operating or decommissioned reactors. The GTCC LLRW associated with decommissioned reactors is generally being stored at the reactor site that generated the waste or at a nearby reactor site owned by the same utility. Essentially the entire volume of the Group 1 GTCC LLRW and GTCC-like activated metal waste results from the decommissioning of commercial nuclear power plants. Data on Group 1 activated metal waste volumes are provided in Sandia (2008), and these data and the approach used to develop the estimates from that report are summarized here.

GTCC-like activated metal wastes were identified at only two DOE sites (INL and Oak Ridge National Laboratory [ORNL]). The total volume of activated metal waste (stored and projected) at these two DOE sites was determined to be about 13 m^3 (460 ft^3); about half of this volume is currently in storage, and the other half is projected to be generated in the future. As described in Sandia (2007, 2008), this information was developed by examining DOE databases, other documented information sources, and results from a DOE-complex-wide data call performed in August 2005, which was updated in 2007. The information was compiled and sent to the DOE generator sites for verification and used for analysis in the EIS.

As noted above, most of the activated metal waste is associated with decommissioning commercial nuclear power plants. The Group 1 activated metal waste volume that is identified as being GTCC LLRW from these decommissioning activities is estimated to be about 880 m^3 (31,000 ft^3). While a small amount of GTCC LLRW metal waste is currently being stored at some reactor sites, more than 90% of this total will be generated in the future. There are 104 operating NRC-licensed commercial nuclear reactors used by the electric utility industry, and another 18 reactors have already been shut down. The waste volume associated with decommissioning the 18 shutdown reactors is estimated to be about 59 m^3 (2,100 ft^3); two of the reactors were decommissioned without generating any GTCC LLRW (Sandia 2007). The GTCC LLRW volume from decommissioning the 104 operating reactors is projected to be about 820 m^3 (29,000 ft^3).

Estimates of the volume of GTCC LLRW associated with decommissioning these commercial nuclear reactors were developed for the EIS by using volume scaling factors given in Appendix H of Sandia (2008). Separate scaling factors were used for pressurized water reactors (PWRs) and boiling water reactors (BWRs), and these factors give the volume of GTCC LLRW (in m^3) per megawatt of electrical energy output (MWe). The scaling factor for a PWR is 9.40×10^{-3} m^3/MWe, and the scaling factor for a BWR is 6.03×10^{-3} m^3/MWe. The operating capacities (in MWe) of the 104 operating nuclear power plants were obtained from the DOE Energy Information Administration (EIA) website and used to develop estimates for each individual reactor. This approach is described in detail in Sandia (2008).

The results from use of these scaling factors were compared with information developed by the Electric Power Research Institute and are considered to be reasonable estimates of the expected waste volumes. The operating licenses were assumed to be extended by 20 years beyond the original expiration date to be consistent with current utility operations and plans, and each reactor was assumed to be kept in safe storage for six years following shutdown prior to decommissioning. On the basis of these assumptions, estimates of GTCC LLRW activated metal waste requiring disposal were developed over time (through 2062). This information is presented in a number of tables in Sandia (2008). The waste generation rate for GTCC LLRW activated metal wastes is used to evaluate waste handling, transportation, and disposal impacts in the EIS.

3.1.2 Radionuclide Activity Estimates

An approach similar to that used to estimate the volumes of GTCC LLRW was used to calculate the total activities at the time of reactor shutdown. Rather than providing volumes (in m^3), these scaling factors give the total activity (in Ci). The scaling factor for a PWR is 3.65×10^3 Ci/MWe, and the scaling factor for a BWR is 5.97×10^3 Ci/MWe. As was the case for the volume estimates, these scaling factors, along with the operating capacities of the various power plants given on the EIA web site, were used to estimate the total activity at the time of shutdown for each individual reactor. Estimates were developed for all of the commercial reactors at shutdown and when they were available for disposal (assumed to be 2019 for shutdown reactors and after 60 years of operation and a six-year cooling period for operating reactors). These results are given in Sandia (2008).

To determine the activities of the individual radionuclides in the GTCC LLRW activated metal waste, information provided in two NRC documents that address the decommissioning of a reference PWR (NRC 1978) and a reference BWR (NRC 1980) was used. The PWR components considered to be GTCC LLRW were the core shroud, the lower 4.72 m (15.5 ft) of the core barrel, the thermal shields, and the upper and lower grid plates. On the basis of the information given in NRC (1978), it was determined that eight radionuclides were of significance with regard to determining the total radionuclide activity in these wastes. (These eight are listed in the first paragraph of Section 3.1.) Table C.1-3 in Appendix C of NRC (1978) identifies the activity concentrations of these eight radionuclides in various reactor components at the time of reactor shutdown. This information was used to apportion the total activity obtained from using the scaling factor above to these eight radionuclides for PWRs. Since the wastes will not become available for disposal until 2019 or six years after reactor shutdown (whichever occurs later), it was assumed that radioactive decay would occur from the time of reactor shutdown to the time when the waste would be available for disposal.

The same approach was used to determine the activities of individual radionuclides for BWRs. The main BWR component considered to be GTCC LLRW is the core shroud. The activity concentrations for the eight neutron activation products of concern are given in Table E.1-1 in Appendix E of NRC (1980) for the major activated reactor components. As was the case for the PWR analysis, this information was used to apportion the total activity to these eight radionuclides, and it was assumed that radioactive decay would occur from the time of reactor shutdown to the time the waste would be available for disposal. Activity estimates for these eight radionuclides for both PWRs and BWRs are given in Sandia (2008).

To determine if the list of radionuclides given in Sandia (2008) was comprehensive for use in the EIS analysis, several additional references were reviewed to identify other radionuclides that might be present in sufficient concentrations to warrant consideration in the EIS. Information on the radionuclides expected to be present in GTCC LLRW and GTCC-like waste is provided in DOE (2002). Two additional radionuclides are identified for activated metals in addition to the eight neutron activation products given in Sandia (2008): hydrogen-3 (H-3, tritium) and transuranics. No information was provided for specific TRU radionuclides. Other comparable wastes (in addition to activated metals) were identified as having fission products (principally Sr-90 and Cs-137), Tc-99, I-129, and several TRU radionuclides, including americium-241 (Am-241) and isotopes of plutonium (Pu).

On the basis of this information, nine radionuclides were added to the list provided in Sandia (2008) from information reported in Table 4-3 of Henry (1993) for activated metal wastes to better represent the full spectrum of radionuclides that could be present in these wastes. This addition was done to ensure that all significant potential contributors to human health and environmental impacts are accounted for in the EIS. Activity estimates were developed for these nine radionuclides (H-3, Sr-90, Tc-99, I-129, Cs-137, Pu-238, Pu-239, Pu-241, and Am-241), and these were added to the inventories of the eight radionuclides given in Sandia (2008).

Estimates of the inventories of these radionuclides were obtained by taking the ratio of the value reported for each of these nine radionuclides in Henry (1993) and dividing this by the value reported for Ni-63 in that report. This ratio was then multiplied by the reported value for Ni-63 for the activated metal wastes from decommissioning nuclear reactors in Sandia (2008) to get estimates for these nine radionuclides. Although the result is an approximation, it does provide better coverage for some radionuclides that move through the environment more quickly (such as H-3, Tc-99, and I-129) and also accounts for major fission products (Sr-90 and Cs-137) and TRU radionuclides (Pu-238, Pu-239, Pu-241, and Am-241) that may adhere to the activated metal items.

Nickel-63 was chosen as the basis for this scaling approach because of its high abundance in activated metal wastes, as identified in Table 4-3 of Henry (1993), and its relatively long half-life of 96 years. It has also been identified as being a major radionuclide affecting waste classification of activated metals in 10 CFR Part 61 (Bedore et al. 1987; Robertson et al. 2000).

These nine radionuclides were added only to the GTCC LLRW activated metal waste, and this approach was not used with the GTCC-like activated metal waste. The radionuclides in the GTCC-like activated metal waste used in the EIS analyses were those provided by INL and ORNL in response to the data call. The radionuclides in the data call response included seven of the eight given in Section 3.1 (no values were reported for Mo-93) as well as a few additional radionuclides, including H-3 and three isotopes of the fission product europium (Eu): Eu-152, Eu-154, and Eu-155. The activity concentrations of the seven neutron activation products reported by INL and ORNL were also included in Sandia (2008). As was the case for GTCC LLRW, it was assumed that radioactive decay would occur until the waste became available for disposal.

The radionuclide activity in GTCC LLRW activated metal waste (110 MCi) accounts for more than 97% of the total radionuclide activity in all Group 1 wastes (see Table 2-1). In contrast, the total activity in the GTCC-like activated metal waste is about 0.24 MCi. Not adding these nine radionuclides to GTCC-like activated metal waste will have no measurable impact on the radiological impacts analyses presented in the EIS. Also, the information in Henry (1993) was specifically developed for activated metal waste from commercial nuclear power plants and may not be appropriate for use with the GTCC-like activated metal waste, which is produced as a result of DOE activities.

Radionuclides in addition to those identified here have been reported to occur in various activated metal waste streams associated with commercial nuclear power plants. These radionuclides include beryllium-10, chlorine-36, silver-108m, silver-110m, cadmium-113m, tin-121m, and antimony-125 (Bedore et al. 1987; Robertson et al. 2000). (An “m” following the isotopic number indicates that this radionuclide is metastable and reaches a more stable energy configuration by isomeric transition, generally accompanied with one or more gamma rays.) A number of these radionuclides are associated with control rods (often containing boron-10 and silver-indium-cadmium alloys), which are not projected to be GTCC LLRW. In addition, either these radionuclides are expected to be present in other reactor components only in low concentrations or they have relatively short half-lives (the half-lives of tin-121m and antimony-125 are less than three years) and so would not have a major impact on long-term management concerns. Finally, these radionuclides are generally metals and would move through the environment in a manner comparable to that of other radioactive metals that are present in much greater concentrations in this inventory. On the basis of these considerations, these radionuclides were not added to the inventory for use in the EIS analyses.

The activities of the major radionuclides for the Group 1 activated metal wastes are given in Tables 3-1 through 3-3. The packaged waste volumes and total activities were given previously in Table 2-1. Table 3-1 presents the radionuclide inventories for all of the Group 1 GTCC LLRW and GTCC-like wastes, which are divided into stored wastes and projected wastes in Tables 3-2 and 3-3, respectively. The information on activated metal waste in these three tables was developed by using the approach summarized above. It is estimated that the total activity associated with Group 1 activated metal wastes at the time they would be available for disposal would be 110 MCi.

The values given in Tables 3-1 through 3-3 for the activated metal wastes from decommissioning commercial nuclear reactors differ slightly from values in tables and comparable information found in Sandia (2008). These differences are due to the number of significant figures used in the calculations, the specific half-lives used in addressing radioactive decay, and the subsequent rounding off of the results. These small differences are not of significance in terms of the EIS analyses.

The radionuclides listed in Tables 3-1 through 3-3 are those expected to be of most significance with regard to managing these wastes. Most of the activity in the activated metal wastes is associated with neutron activation products. Additional radionuclides were included in the information provided for the various projects, and data on all radionuclides provided in the data call responses and in other information sources are included in the EIS analyses.

3.2 SEALED SOURCES

Sealed sources typically consist of concentrated radioactive material encapsulated in relatively small containers made of titanium, stainless steel, or other metals. These sources are

TABLE 3-1 Radionuclide Activity (in curies) of Group 1 GTCC LLRW and GTCC-Like Waste[a]

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Hydrogen-3	6.8×10^{3}	–	–	–	–	2.3×10^{5}	–	–	1.7×10^{-1}	1.6×10^{1}
Carbon-14	2.3×10^{4}	–	–	–	5.8×10^{-3}	6.8×10^{2}	–	–	1.3×10^{1}	1.0×10^{2}
Manganese-54	4.9×10^{4}	–	–	–	9.6×10^{-3}	2.8×10^{-5}	–	–	4.7×10^{-3}	4.8×10^{1}
Iron-55	4.0×10^{7}	–	–	–	6.3×10^{-4}	1.7×10^{2}	–	–	5.7	8.2
Nickel-59	1.3×10^{5}	–	–	–	1.1×10^{-1}	3.1	–	–	7.6×10^{-2}	1.6×10^{2}
Cobalt-60	5.0×10^{7}	–	–	–	8.7	4.7×10^{3}	–	–	4.1×10^{-3}	1.2×10^{3}
Nickel-63	1.8×10^{7}	–	–	–	5.3	8.0×10^{2}	–	–	2.5×10^{-2}	9.4×10^{3}
Strontium-90	1.2×10^{4}	–	–	–	1.5×10^{3}	–	–	–	6.6×10^{1}	3.6×10^{4}
Molybdenum-93	1.1×10^{2}	–	–	–	–	–	–	–	–	–
Niobium-94	6.0×10^{2}	–	–	–	–	1.3×10^{-2}	–	–	5.2×10^{-5}	9.8×10^{-2}
Technetium-99	4.5×10^{3}	–	–	–	7.6×10^{-1}	–	–	–	3.2×10^{-1}	1.7×10^{2}
Iodine-129	1.9	–	–	–	–	–	–	–	9.7×10^{-5}	2.7
Cesium-137	1.3×10^{4}	–	1.7×10^{6}	5.7	2.0×10^{3}	–	–	–	6.5×10^{1}	3.9×10^{4}
Promethium-147	–	–	–	–	–	–	–	–	1.4×10^{-3}	5.6
Samarium-151	–	–	–	–	–	–	–	–	2.9×10^{-3}	1.7×10^{-1}
Europium-152	–	–	–	–	–	6.6×10^{2}	–	–	3.1×10^{-3}	6.8×10^{2}
Europium-154	–	–	–	–	–	6.0	–	–	1.9×10^{-1}	2.2×10^{2}
Europium-155	–	–	–	–	–	7.1×10^{-1}	–	–	3.1×10^{-4}	9.2×10^{1}
Lead-210	–	–	–	–	5.1×10^{-9}	–	–	–	3.6×10^{-6}	2.3×10^{-9}
Radium-226	–	–	–	–	–	–	–	–	4.3	–
Actinium-227	–	–	–	–	–	–	–	–	3.3×10^{-2}	1.6×10^{-9}
Radium-228	–	–	–	–	–	–	–	–	2.3×10^{-1}	–
Thorium-229	–	–	–	–	8.8×10^{-4}	–	–	–	2.2	7.4×10^{-2}
Thorium-230	–	–	–	–	8.9×10^{-6}	–	–	–	4.1×10^{-1}	2.7×10^{-2}
Protactinium-231	–	–	–	–	–	–	–	–	1.1×10^{-5}	1.3×10^{-8}
Thorium-232	–	–	–	–	–	–	–	–	2.8×10^{-1}	6.8×10^{-1}
Uranium-232	–	–	–	–	–	–	–	–	2.3×10^{1}	1.9
Uranium-233	–	–	–	–	6.0×10^{-1}	–	–	–	9.4	7.9×10^{2}
Uranium-234	–	–	–	–	–	–	–	–	4.4×10^{1}	1.6
Uranium-235	–	–	–	–	5.2×10^{-3}	–	–	–	1.6×10^{-1}	3.5×10^{-1}
Uranium-236	–	–	–	–	–	–	–	–	5.4×10^{-2}	7.9×10^{-1}
Neptunium-237	–	–	–	–	3.2×10^{-3}	–	–	–	1.1	1.5

TABLE 3-1 (Cont.)

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Uranium-238	–	–	–	–	–	–	–	–	9.1×10^{-2}	1.1×10^{1}
Plutonium-238	8.8×10^{-1}	1.2×10^{5}	–	–	1.8×10^{1}	–	–	–	1.3×10^{3}	1.5×10^{3}
Plutonium-239	4.5×10^{3}	8.4×10^{3}	–	–	2.5×10^{1}	–	–	–	9.0×10^{2}	2.9×10^{3}
Plutonium-240	–	–	–	–	7.5	–	2.2×10^{1}	–	7.1×10^{2}	1.8×10^{3}
Plutonium-241	2.5×10^{1}	–	–	–	6.2×10^{2}	–	–	–	1.4×10^{4}	1.7×10^{4}
Americium-241	6.4×10^{1}	1.5×10^{5}	–	5.0	6.6×10^{1}	–	–	–	4.4×10^{3}	5.3×10^{3}
Plutonium-242	–	–	–	–	2.3×10^{-3}	–	–	–	4.5	3.9
Americium-243	–	–	–	–	4.7×10^{-3}	–	3.5×10^{-1}	–	3.4×10^{1}	8.6×10^{1}
Curium-243	–	–	–	–	–	–	–	–	7.6×10^{-2}	2.2
Curium-244	–	2.2×10^{1}	–	–	5.2	–	5.4×10^{1}	–	1.8	1.1×10^{3}
Curium-245	–	–	–	–	–	–	–	–	2.0×10^{-9}	3.4×10^{2}
Curium-246	–	–	–	–	–	–	–	–	1.9×10^{-11}	5.4×10^{1}

[a] The activities represent values at the time the wastes are projected to be available for disposal and are given to two significant figures. Separate estimates were developed for GTCC LLRW and GTCC-like waste. A dash means there is no value for that entry. CH = contact-handled (waste), RH = remote-handled (waste).

[b] All of the activated metal wastes are expected to be RH waste.

[c] All of the sealed source wastes are expected to be CH waste, with the possible exception of two americium-241/beryllium sources.

TABLE 3-2 Radionuclide Activity (in curies) of Stored Group 1 GTCC LLRW and GTCC-Like Waste[a]

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Hydrogen-3	1.6×10^{2}	–	–	–	–	2.3×10^{5}	–	–	1.1×10^{-1}	1.6×10^{1}
Carbon-14	1.4×10^{3}	–	–	–	5.6×10^{-3}	2.0×10^{2}	–	–	1.0×10^{1}	1.0×10^{2}
Manganese-54	9.2×10^{-3}	–	–	–	9.4×10^{-3}	2.8×10^{-5}	–	–	2.3×10^{-6}	4.2×10^{-3}
Iron-55	3.4×10^{4}	–	–	–	6.1×10^{-4}	1.7×10^{2}	–	–	9.9×10^{-1}	8.2
Nickel-59	7.8×10^{3}	–	–	–	1.1×10^{-1}	6.0×10^{-1}	–	–	5.9×10^{-2}	1.6×10^{2}
Cobalt-60	3.5×10^{5}	–	–	–	8.4	8.5×10^{2}	–	–	4.0×10^{-3}	3.1×10^{2}
Nickel-63	9.6×10^{5}	–	–	–	5.2	1.9×10^{2}	–	–	2.5×10^{-2}	9.4×10^{3}
Strontium-90	4.7×10^{2}	–	–	–	1.5×10^{3}	–	–	–	8.6	2.9×10^{4}
Molybdenum-93	7.4	–	–	–	–	–	–	–	–	–
Niobium-94	4.1×10^{1}	–	–	–	–	1.8×10^{-3}	–	–	5.2×10^{-5}	9.8×10^{-2}
Technetium-99	2.8×10^{2}	–	–	–	7.3×10^{-1}	–	–	–	2.4×10^{-1}	1.7×10^{2}
Iodine-129	1.2×10^{-1}	–	–	–	–	–	–	–	4.9×10^{-5}	2.7
Cesium-137	5.5×10^{2}	–	–	5.7	2.0×10^{3}	–	–	–	5.0	3.0×10^{4}
Promethium-147	–	–	–	–	–	–	–	–	1.4×10^{-3}	5.6
Samarium-151	–	–	–	–	–	–	–	–	2.9×10^{-3}	1.7×10^{-1}
Europium-152	–	–	–	–	–	6.6×10^{2}	–	–	3.1×10^{-3}	6.0×10^{-4}
Europium-154	–	–	–	–	–	6.0	–	–	1.1×10^{-1}	1.7×10^{1}
Europium-155	–	–	–	–	–	7.1×10^{-1}	–	–	3.1×10^{-4}	7.9×10^{-1}
Lead-210	–	–	–	–	4.9×10^{-9}	–	–	–	3.6×10^{-6}	2.2×10^{-9}
Radium-226	–	–	–	–	–	–	–	–	3.4	–
Actinium-227	–	–	–	–	–	–	–	–	2.4×10^{-2}	1.6×10^{-9}
Radium-228	–	–	–	–	–	–	–	–	1.1×10^{-1}	–
Thorium-229	–	–	–	–	8.5×10^{-4}	–	–	–	1.7	7.4×10^{-2}
Thorium-230	–	–	–	–	8.6×10^{-6}	–	–	–	3.2×10^{-1}	2.7×10^{-2}
Protactinium-231	–	–	–	–	–	–	–	–	1.1×10^{-5}	1.3×10^{-8}
Thorium-232	–	–	–	–	–	–	–	–	2.2×10^{-1}	6.8×10^{-1}
Uranium-232	–	–	–	–	–	–	–	–	1.8×10^{1}	1.9
Uranium-233	–	–	–	–	5.8×10^{-1}	–	–	–	7.3	1.7×10^{1}
Uranium-234	–	–	–	–	–	–	–	–	3.4×10^{1}	1.6
Uranium-235	–	–	–	–	5.0×10^{-3}	–	–	–	1.5×10^{-1}	3.5×10^{-1}
Uranium-236	–	–	–	–	–	–	–	–	4.2×10^{-2}	7.9×10^{-1}

TABLE 3-2 (Cont.)

Radionuclide	GTCC LLRW Activated Metals[b]	GTCC LLRW Sealed Sources[c] Actinides	GTCC LLRW Sealed Sources[c] Nonactinides	GTCC LLRW Other Waste CH	GTCC LLRW Other Waste RH	GTCC-Like Waste Activated Metals[b]	GTCC-Like Waste Sealed Sources[c] Actinides	GTCC-Like Waste Sealed Sources[c] Nonactinides	GTCC-Like Waste Other Waste CH	GTCC-Like Waste Other Waste RH
Neptunium-237	–	–	–	–	3.1×10^{-3}	–	–	–	1.0	1.5
Uranium-238	–	–	–	–	–	–	–	–	7.0×10^{-2}	1.8
Plutonium-238	4.7×10^{-2}	–	–	–	1.8×10^{1}	–	–	–	1.0×10^{3}	7.5×10^{2}
Plutonium-239	2.8×10^{2}	–	–	–	2.4×10^{1}	–	–	–	7.0×10^{2}	2.7×10^{3}
Plutonium-240	–	–	–	–	7.3	–	–	–	5.6×10^{2}	1.7×10^{3}
Plutonium-241	6.4×10^{-1}	–	–	–	6.0×10^{2}	–	–	–	9.6×10^{3}	1.6×10^{4}
Americium-241	3.8	–	–	5.0	6.4×10^{1}	–	–	–	3.6×10^{3}	5.3×10^{3}
Plutonium-242	–	–	–	–	2.2×10^{-3}	–	–	–	3.5	3.9
Americium-243	–	–	–	–	4.6×10^{-3}	–	–	–	2.7×10^{1}	8.6×10^{1}
Curium-243	–	–	–	–	–	–	–	–	5.3×10^{-2}	1.8
Curium-244	–	–	–	–	5.0	–	6.0	–	1.2	3.8×10^{1}
Curium-245	–	–	–	–	–	–	–	–	2.0×10^{-9}	3.4×10^{2}
Curium-246	–	–	–	–	–	–	–	–	1.9×10^{-11}	5.4×10^{1}

[a] The activities represent values at the time the wastes are projected to be available for disposal and are given to two significant figures. Separate estimates were developed for GTCC LLRW and GTCC-like waste. A dash means there are no values for that entry. CH = contact-handled (waste), RH = remote-handled (waste).

[b] All of the activated metal wastes are expected to be RH waste.

[c] All of the sealed source wastes are expected to be CH waste, with the possible exception of two americium-241/beryllium sources.

TABLE 3-3 Radionuclide Activity (in curies) of Projected Group 1 GTCC LLRW and GTCC-Like Waste[a]

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Hydrogen-3	6.7×10^{3}	–	–	–	–	–	–	–	5.7×10^{-2}	–
Carbon-14	2.1×10^{4}	–	–	–	1.7×10^{-4}	4.9×10^{2}	–	–	3.0	1.4×10^{-2}
Manganese-54	4.9×10^{4}	–	–	–	2.9×10^{-4}	–	–	–	4.7×10^{-3}	4.8×10^{1}
Iron-55	4.0×10^{7}	–	–	–	1.9×10^{-5}	–	–	–	4.7	1.1×10^{-5}
Nickel-59	1.2×10^{5}	–	–	–	3.3×10^{-3}	2.5	–	–	1.7×10^{-2}	2.0×10^{-3}
Cobalt-60	5.0×10^{7}	–	–	–	2.6×10^{-1}	3.8×10^{3}	–	–	9.8×10^{-5}	8.8×10^{2}
Nickel-63	1.7×10^{7}	–	–	–	1.6×10^{-1}	6.1×10^{2}	–	–	–	9.5×10^{-2}
Strontium-90	1.1×10^{4}	–	–	–	4.6×10^{1}	–	–	–	5.7×10^{1}	7.3×10^{3}
Molybdenum-93	1.0×10^{2}	–	–	–	–	–	–	–	–	–
Niobium-94	5.5×10^{2}	–	–	–	–	1.1×10^{-2}	–	–	–	–
Technetium-99	4.2×10^{3}	–	–	–	2.3×10^{-2}	–	–	–	8.7×10^{-2}	2.1
Iodine-129	1.8	–	–	–	–	–	–	–	4.8×10^{-5}	6.6×10^{-5}
Cesium-137	1.3×10^{4}	–	1.7×10^{6}	–	6.0×10^{1}	–	–	–	6.0×10^{1}	9.5×10^{3}
Promethium-147	–	–	–	–	–	–	–	–	–	–
Samarium-151	–	–	–	–	–	–	–	–	–	–
Europium-152	–	–	–	–	–	–	–	–	–	6.8×10^{2}
Europium-154	–	–	–	–	–	–	–	–	7.5×10^{-2}	2.0×10^{2}
Europium-155	–	–	–	–	–	–	–	–	–	9.1×10^{1}
Lead-210	–	–	–	–	1.5×10^{-10}	–	–	–	–	9.1×10^{-11}
Radium-226	–	–	–	–	–	–	–	–	9.5×10^{-1}	–
Actinium-227	–	–	–	–	–	–	–	–	9.5×10^{-3}	–
Radium-228	–	–	–	–	–	–	–	–	1.2×10^{-1}	–
Thorium-229	–	–	–	–	2.6×10^{-5}	–	–	–	4.9×10^{-1}	1.6×10^{-5}
Thorium-230	–	–	–	–	2.7×10^{-7}	–	–	–	8.8×10^{-2}	1.6×10^{-7}
Protactinium-231	–	–	–	–	–	–	–	–	–	–
Thorium-232	–	–	–	–	–	–	–	–	6.2×10^{-2}	–
Uranium-232	–	–	–	–	–	–	–	–	5.5	5.6×10^{-3}
Uranium-233	–	–	–	–	1.8×10^{-2}	–	–	–	2.1	7.8×10^{2}
Uranium-234	–	–	–	–	–	–	–	–	9.6	2.4×10^{-3}
Uranium-235	–	–	–	–	1.5×10^{-4}	–	–	–	4.1×10^{-3}	3.1×10^{-4}
Uranium-236	–	–	–	–	–	–	–	–	1.2×10^{-2}	–

TABLE 3-3 (Cont.)

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[c]		Other Waste			Sealed Sources[c]		Other Waste	
Radionuclide	Activated Metals[b]	Actinides	Nonactinides	CH	RH	Activated Metals[b]	Actinides	Nonactinides	CH	RH
Neptunium-237	–	–	–	–	9.5×10^{-5}	–	–	–	1.1×10^{-2}	3.1×10^{-2}
Uranium-238	–	–	–	–	–	–	–	–	2.2×10^{-2}	8.8
Plutonium-238	8.3×10^{-1}	1.2×10^{5}	–	–	5.4×10^{-1}	–	–	–	2.9×10^{2}	7.5×10^{2}
Plutonium-239	4.2×10^{3}	8.4×10^{3}	–	–	7.4×10^{-1}	–	–	–	2.0×10^{2}	2.0×10^{2}
Plutonium-240	–	–	–	–	2.2×10^{-1}	–	2.2×10^{1}	–	1.6×10^{2}	3.4×10^{1}
Plutonium-241	2.4×10^{1}	–	–	–	1.8×10^{1}	–	–	–	4.6×10^{3}	1.0×10^{2}
Americium-241	6.0×10^{1}	1.5×10^{5}	–	–	2.0	–	–	–	7.1×10^{2}	6.0×10^{1}
Plutonium-242	–	–	–	–	6.8×10^{-5}	–	–	–	9.8×10^{-1}	4.1×10^{-5}
Americium-243	–	–	–	–	1.4×10^{-4}	–	3.5×10^{-1}	–	7.5	8.4×10^{-5}
Curium-243	–	–	–	–	–	–	–	–	2.3×10^{-2}	3.4×10^{-1}
Curium-244	–	2.2×10^{1}	–	–	1.5×10^{-1}	–	4.8×10^{1}	–	5.9×10^{-1}	1.1×10^{3}
Curium-245	–	–	–	–	–	–	–	–	–	–
Curium-246	–	–	–	–	–	–	–	–	–	–

[a] The activities represent values at the time the wastes are projected to be available for disposal and are given to two significant figures. Separate estimates were developed for GTCC LLRW and GTCC-like waste. A dash means there are not values for that entry. CH = contact-handled (waste), RH = remote-handled (waste).

[b] All of the activated metal wastes are expected to be RH waste.

[c] All of the sealed source wastes are expected to be CH waste, with the possible exception of two americium-241/beryllium sources.

commonly used to sterilize medical products, detect flaws and failures in pipelines and metal welds, determine moisture content in soil and other materials, and diagnose and treat illnesses such as cancer. Only a small fraction of the sealed sources are GTCC LLRW, depending on the quantity (in Ci) and the half-life of the specific radionuclide in the source. Most sealed sources are Class A, B, or C LLRW and can be disposed of at existing LLRW disposal facilities. The sealed sources that are GTCC LLRW are those that represent a long-term hazard to human health and the environment and exceed the radionuclide concentrations for classification as Class C LLRW as given in 10 CFR 61.55.

Essentially all of the sealed sources being addressed in the GTCC EIS are in Group 1. For purposes of analysis in the EIS, it is assumed that GTCC LLRW sealed sources would be packaged in 55-gal (208-L) drums by radionuclide on the basis of packaging factor limits developed by the DOE Global Threat Reduction Initiative/Off-Site Source Recovery Project (GTRI/OSRP) at Los Alamos National Laboratory (LANL). These limits are provided in Table 3.3 of Sandia (2007) and are not repeated here. The radionuclides expected to be present in GTCC LLRW and GTCC-like sealed source wastes include Cs-137, Pu-238, Pu-239, Pu-240, Am-241, Am-243, and curium-244 (Cm-244).

In addition to these small sealed sources that would be packaged in 55-gal (208-L) drums, there are 1,481 large Cs-137 irradiators in the waste inventory. These irradiators cannot be packaged in 55-gal (208-L) drums; it is assumed they would be disposed of individually in their original shielded devices. For purposes of analysis in the EIS, each Cs-137 irradiator is assumed to have a packaged waste volume of 0.71 m^3 (25 ft^3). Of the 1,481 Cs-137 irradiators identified for consideration in the EIS, 1,435 are commercial sources, and 46 are owned by DOE (Sandia 2008).

It was initially assumed that all of the large Cs-137 irradiators would be addressed in the EIS, and the waste volumes and Cs-137 activities for all 1,481 irradiators were included in Sandia (2008) and used to develop estimates for the NOI. However, it was later determined that the DOE Cs-137 irradiators can be disposed of as LLRW at DOE's existing facilities, so the 46 DOE Cs-137 irradiators were removed from the waste inventory being addressed in the GTCC EIS. The information contained in this supplement for these large Cs-137 irradiators is limited to the 1,435 commercial sources that are being considered in the disposal alternatives in the EIS.

Sealed sources can encompass several physical forms, including ceramic oxides, salts, or metals. Cesium chloride salt was generally used in older Cs-137 sources, and newer sources typically have the radionuclide bonded in a ceramic. Of these two forms, cesium chloride salt is much more water soluble. For the EIS, it is assumed that all of the Cs-137 sources would be present as cesium chloride salt. For the rest of the sealed sources, it is assumed that the radionuclides would be in the form of oxides. These oxide sources are likely to be in the form of pellets (Sandia 2008). While there are some sealed sources currently in storage, most of this waste will be generated in the future.

Sealed sources generally have relatively low exposure rates when packaged for disposal. As noted in Sandia (2008), all of the packaged sealed sources are expected to be CH waste, except for two Am-241/beryllium sources. For purposes of analysis in the EIS, CH waste is defined as waste for which the dose rate on the surface of the package is less than 200 mrem/h, consistent with the definition of CH waste given in the WIPP LWA (P.L. 102-579). Should RH sealed source waste be generated, appropriate precautions would be taken in waste handling and disposal operations to protect workers.

Information on sealed sources was obtained from three sources: (1) the NRC Interim Sealed Source Database (ISSD), (2) the DOE Radiological Source Registry and Tracking (RSRT) System Database, and (3) forecasts of projected GTCC LLRW sealed sources based on the recovery rates from GTRI/OSRP at LANL. The NRC ISSD includes information on sealed sources from NRC and Agreement State licensees that possess aggregate quantities of radionuclides in excess of International Atomic Energy Agency (IAEA) Category 2 thresholds (IAEA 2003). This NRC database was used to estimate the inventory of commercial GTCC LLRW sources containing Cs-137 and Cm-244. The DOE RSRT System Database includes only DOE sealed sources and was used to estimate the stored and projected inventory of GTCC-like sealed sources. The GTRI/OSRP annual forecast of the recovery rate was used to estimate the projected inventory of GTCC LLRW sealed sources from commercial entities containing Pu-238, Pu-239, and Am-241. This approach is described in Sandia (2008).

3.2.1 Volume Estimates

The volume of sealed sources being addressed as GTCC LLRW and GTCC-like waste in the EIS was based on information provided in Table 12 of Sandia (2008), with several modifications. As noted above, the 46 DOE Cs-137 irradiators were removed from the waste inventory for EIS analyses. In addition, the time period for the projected inventory of commercial Pu-238, Pu-239, and Am-241 GTCC LLRW sealed sources was extended from 2035 as given in Sandia (2008) to 2083 to be consistent with the time frame used for the generation of Group 2 activated metal wastes (see Section 4.1.1). As a result of these changes, about 8,700 55-gal (208-L) drums and 1,435 self-contained Cs-137 irradiators would require disposal as GTCC LLRW, and four 55-gal (208-L) drums would require disposal as GTCC-like waste.

Essentially all of this waste type is associated with commercial users of radioactive sources and would be generated in the future. It is assumed that the sealed sources would be packaged in 55-gal (208-L) drums in accordance with GTRI/OSRP packaging limits, except for the Cs-137 irradiators, each of which is assumed to have a packaged volume of 0.71 m^3 (25 ft^3). In these Cs-137 irradiators, the Cs-137 source is contained within a very robust shielded device. The packaged volume of GTCC LLRW sealed sources is estimated to be about 2,800 m^3 (99,000 ft^3), and the packaged volume of GTCC-like sealed sources is estimated to be about 0.83 m^3 (29 ft^3). For purposes of analysis in the EIS, it is assumed that the waste volume of sealed sources would become available for disposal at a generally steady (linear) rate from 2019 to 2083. The sealed source waste volumes are summarized in Table 2-1. For conservatism, it is assumed that none of the sealed sources would be recycled.

3.2.2 Radionuclide Activity Estimates

The radionuclide activities of the individual sealed sources were obtained from the three information sources identified above. The total activity of the sealed sources is estimated to be 2.0 MCi, with Cs-137 accounting for about 86% of this total. The activity in the small volume of stored sealed source waste was subjected to radioactive decay until 2019. This is the earliest date at which it is assumed, for the purposes of the EIS analyses, that a disposal facility for GTCC LLRW and GTCC-like waste would be available. It is assumed that the projected sealed source wastes would be disposed of shortly after generation.

The data on the radionuclide activities for the sealed source wastes are given in Table 2-1 and Tables 3-1 through 3-3. They were obtained from the information given in Sandia (2008), with the noted modifications (i.e., deletion of 46 large DOE Cs-137 irradiators from the waste inventory and extension of the time period for the generation of commercial sealed source waste from 2035 to 2083).

3.3 OTHER WASTE

Other Waste consists of a wide variety of materials, including contaminated equipment, debris, scrap metals, filters, resins, soil, solidified sludges, and other materials. This category of waste includes those GTCC LLRW and GTCC-like wastes that do not fall into one of the other two categories (activated metals or sealed sources). These wastes can include a number of physical forms, and a range of radionuclides may be present.

Although some of this waste was produced in the commercial sector as a result of radionuclide manufacturing, research, and other activities (and is GTCC LLRW), about 95% of this waste in Group 1 is associated with DOE activities and considered to be GTCC-like waste. Much of this GTCC-like Other Waste is associated with the West Valley Site. It is assumed for purposes of analysis in the EIS that the radioactive contamination in these wastes could leach somewhat readily when exposed to water. As such, it is assumed that these wastes would be solidified (e.g., with grout or another matrix) before being shipped to the disposal facilities considered in this EIS. A wide spectrum of radionuclides is present in these wastes, with the isotopes of various actinides (uranium, neptunium, plutonium, americium, and curium) being of most concern with regard to long-term management.

About 67% of the Group 1 Other Waste has already been generated and is in storage; the remaining 33% is projected to be generated in the future. Most of the waste in this category is expected to meet the DOE definition for TRU waste given in Chapter III of the *Radioactive Waste Management Manual* (DOE 1999): It is waste containing more than 100 nanocuries (nCi) of alpha-emitting TRU radionuclides with half-lives greater than 20 years per gram of waste. This TRU waste might have originated from non-defense activities and therefore does not have a currently identified path to disposal. About half of the waste in this category is RH waste, and half is CH waste.

3.3.1 Volume Estimates

Two commercial generators of GTCC LLRW Other Waste were identified during this data compilation. They are located in Virginia and Texas. The volume of stored waste was reported to be 75 m^3 (2,600 ft^3), with an additional 1 m^3 (35 ft^3) projected to be generated in the future (Sandia 2008). Various isotopes of plutonium are the most prevalent radionuclides in this GTCC LLRW, with smaller amounts of neutron activation products, fission products, and other actinides being present. For use in the EIS analyses, the activities of the stored wastes have been subjected to decay until 2019, when it is assumed that the wastes will become available for disposal. It is assumed that the projected wastes would be disposed of shortly after generation.

The total volume of Group 1 GTCC-like Other Waste is estimated to be about 1,500 m^3 (53,000 ft^3), as given in Table 2-1. Of this total, about 950 m^3 (34,000 ft^3) is in storage, and an additional 510 m^3 (18,000 ft^3) is projected to be generated in the future. This updated inventory was based on information from DOE databases, other documented information sources, and responses to a DOE-complex-wide data call performed in August 2005 and updated in 2007. The results of the data call were compiled and provided to the generator sites for verification prior to being used in the EIS. Various isotopes of plutonium are the most prevalent radionuclides in this waste, with smaller amounts of neutron activation products, fission products, and other actinides being present.

These inventory values reflect more recent updates to the information for the West Valley Site associated with decontamination and decommissioning of the MPPB and WTF at the site (Bohan 2008a,b; Joyce 2009a). The total volume of GTCC-like Other Waste associated with these activities is estimated to be about 2,240 m^3 (79,100 ft^3). Of this total volume, about 1,260 m^3 (44,500 ft^3) is in Group 1 and results from past decontamination activities at the site and ongoing decontamination of the MPPB to make it ready for demolition, and 980 m^3 (35,000 ft^3) is in Group 2 (see Section 4.2). Of the Group 1 total, about 880 m^3 (31,000 ft^3) is in storage and 370 m^3 (13,000 ft^3) is projected to be generated in the future.

3.3.2 Radionuclide Activity Estimates

Estimates of the radionuclide activities (in Ci) in the Group 1 Other Waste category are provided in Sandia (2008). To ensure the completeness of this information, several additional references were reviewed to determine if additional radionuclides should be considered for this waste category in the EIS analyses. Since much of the GTCC-like waste is TRU waste, information on the radionuclide characteristics of TRU wastes as given in DOE (1997a,b) was reviewed to verify that the current information was comprehensive. No radionuclides in addition to those already included in Sandia (2008) for the Other Waste category were identified for inclusion in the list of radionuclides to be used in the EIS analyses.

The radionuclide activities for the West Valley Site GTCC-like wastes were determined by using the updated radionuclide information provided by the DOE West Valley Site Office (Bohan 2008a,b). A number of radionuclide profiles were provided for the various waste streams, and the DOE West Valley Site Office indicated which profile was most applicable to each waste stream. Radionuclides in addition to those given in Sandia (2008) were included in these profiles for some of these wastes, and all of the radionuclides identified in these profiles by the DOE West Valley Site are used in the EIS analyses.

The DOE West Valley Site Office divided the waste streams into CH wastes and RH wastes for stored and projected wastes (Bohan 2008a). The inventories for the CH wastes were determined by using the estimated packaged waste volume for each waste stream along with the appropriate radionuclide profile, then summing over all CH waste streams for the stored and projected wastes.

For the RH wastes, the DOE West Valley Site Office provided estimated surface dose rates on the waste packages for the various waste streams (generally as a range) along with a recommended value to use in the calculation. A radionuclide profile was provided for each waste stream on the basis of the expected radioactive characteristics of the wastes (Bohan 2008b). For these RH wastes, it was first necessary to develop a correlation between the indicated radionuclide profile and surface dose rate on the package (taken to be a 55-gal [208-L] drum). This was done by using the computer code MicroShield (Grove Software 2005) and an assumed waste density of 0.44 g/cm^3, consistent with the information provided by the DOE West Valley Site Office for waste from the product purification cell.

By using this correlation and the recommended surface dose rate, the concentrations of the major gamma-emitting radionuclides (generally Co-60 and Cs-137) could be calculated for each RH waste stream. The concentrations of the other radionuclides in the waste stream were then determined by using the indicated profile. The activities for each waste stream were determined separately by using the estimated packaged waste volume and radionuclide concentrations for the waste stream, and the individual waste stream activities were summed to provide the total activities for the stored and projected RH wastes. The updated estimates for the West Valley Site decommissioning project were added to the values for the other sites having GTCC-like wastes on the basis of information in Sandia (2008). The estimated radionuclide activities for the GTCC-like Other Waste are given in Table 2-1 and Tables 3-1 through 3-3.

All of the radionuclide activities for the West Valley Site Group 1 GTCC-like wastes were decay-corrected to 2019 to reflect the time when, for purposes of analysis in the EIS, it is assumed that a disposal facility would be available for these wastes. The radionuclide activities associated with these wastes were determined by using the updated information provided by the DOE West Valley Site Office and are much lower than the original estimates. The total activity of all GTCC-like wastes (Groups 1 and 2) associated with decontamination and decommissioning of the MPPB and WTF at the West Valley Site is currently estimated to be about 0.52 MCi. The radionuclide activity for the Group 1 GTCC-like wastes is about 0.12 MCi, and the activity for the Group 2 wastes is about 0.40 MCi. The estimated activity was previously estimated to be 15 MCi in Sandia (2007) and 24 MCi in Sandia (2008).

The current estimate is much more realistic, given the radionuclide inventory in the spent nuclear fuel reprocessed at the West Valley Site and the expected amount of contamination remaining in the MPPB and WTF at the site. The total activity in this spent nuclear fuel (as represented by the activity in the high-level radioactive waste at the site) is estimated to be about

23 MCi (DOE 2001b). The total activity in the GTCC-like wastes associated with decontamination and decommissioning of the MPPB and WTF would be expected to be no more than a few percent of this total. The current estimate of 0.52 MCi represents about 2% of the activity in the high-level radioactive wastes at the West Valley Site, which is reasonable. These estimates will continue to be reviewed with the DOE West Valley Site Office throughout the EIS process to ensure that the best available information is used in the EIS.

3.4 SUMMARY OF GROUP 1 VOLUME AND RADIONUCLIDE ACTIVITY ESTIMATES

The estimated volumes of Group 1 GTCC LLRW and GTCC-like waste currently in storage and projected to be generated in the future are summarized in Table 2-1. As noted previously, the activated metal waste is assumed to be all RH waste, and the sealed sources are assumed to be CH waste (with the possible exception of two sources that may be RH waste). Separate estimates of RH and CH waste volumes are given for the Other Waste category. These volume estimates represent the best information currently available and are largely summarized from Sandia (2007, 2008), with several modifications as noted in the preceding text. Additional details on these estimates are provided in the two Sandia reports. The updated information provided by the DOE West Valley Site Office is reflected in the values given in this report.

The total volume of Group 1 GTCC LLRW and GTCC-like waste is estimated to be about 5,300 m^3 (190,000 ft^3). Of this total, about 1,100 m^3 (39,000 ft^3) has already been generated and is in storage, and 4,200 m^3 (150,000 ft^3) is projected to be generated in the future. About 72% of the Group 1 waste volume is GTCC LLRW, and 28% is GTCC-like waste. Most of the stored waste is GTCC-like waste, and much of this waste is TRU waste being stored at the West Valley Site. About 88% of the projected waste volume is GTCC LLRW; GTCC-like waste accounts for the remaining 12%. About 17% of the total Group 1 waste volume is activated metals, 54% is from sealed sources, and 29% is Other Waste.

A relatively small amount of the Group 1 GTCC LLRW and GTCC-like wastes may be mixed waste. Mixed waste is waste that contains both (1) source material, special nuclear material, or by-product material subject to the Atomic Energy Act of 1954, as amended, and (2) a hazardous component subject to the Resource Conservation and Recovery Act (RCRA, P.L. 94-580). The total volume of mixed waste was previously estimated to be 90 m^3 (3,200 ft^3) in Sandia (2007). This volume includes 4 m^3 (140 ft^3) of GTCC mixed LLRW and 86 m^3 (3,000 ft^3) of GTCC-like mixed waste. The GTCC-like mixed waste consists of 42 m^3 (1,500 ft^3) for INL, 7.3 m^3 (260 ft^3) for ORNL, and 37 m^3 (1,300 ft^3) for the West Valley Site. The mixed wastes at ORNL and West Valley are in storage, while the value given for INL includes both stored and projected wastes.

An updated value has been provided for the West Valley Site. The DOE West Valley Site Office indicated that about 120 m^3 (4,200 ft^3) of GTCC-like mixed waste is currently in storage at the site (Joyce 2009a). When this updated information is used, the total volume of Group 1 mixed GTCC LLRW and GTCC-like waste is estimated to be about 170 m^3 (6,000 ft^3). This volume represents less than 4% of the total volume of Group 1 GTCC LLRW and GTCC-like waste. Most of this mixed waste is GTCC-like waste, with only 4 m^3 (140 ft^3) being GTCC mixed LLRW. This waste is generally expected to be characteristic hazardous waste, which can be treated to remove the hazardous characteristic, rending the waste solely a radioactive waste.

The radionuclide activities for Group 1 GTCC LLRW and GTCC-like waste in the three waste categories are given in Table 2-1 and Tables 3-1 through 3-3. Table 3-1 contains the total (stored and projected) activities for GTCC LLRW and GTCC-like waste; the activities are divided into stored activities in Table 3-2 and projected activities in Table 3-3. Most of the activity is associated with the neutron activation products in commercial nuclear reactors (i.e., the activated metals category under GTCC LLRW). The sealed sources contribute a relatively small amount to the total radionuclide activity, except for Cs-137 (which has a half-life of 30 years). While the total activities of the Other Waste are significantly lower than those for the activated metal wastes, much of this activity is attributable to long-lived TRU radionuclides. It is these long-lived radionuclides that are of importance in evaluating the viability of various disposal alternatives in the EIS.

To provide additional perspective on the Group 1 radionuclide activities, the key properties of the radionuclides discussed in this supplement are given in Table 3-4. This table identifies the major modes of decay for the 44 radionuclides given in Tables 3-1 through 3-3, the half-lives and radiation energies of the alpha and beta particles, and the photons (gamma rays and x-rays) emitted by these radionuclides. Also indicated are the short-lived radionuclides that accompany these 44 radionuclides. All of the radionuclide activities used in the EIS have been adjusted for radioactive decay to a common time basis so that the results best reflect available information and reasonably expected environmental impacts. The activities developed for the radionuclides being addressed in the EIS will continue to be reviewed and updated as the analyses proceed.

TABLE 3-4 Key Properties of the Major Radionuclides Addressed in the EIS[a]

				Radiation Energy per Decay (MeV)		
Radionuclide	Half-Life	Specific Activity (Ci/g)	Decay Mode	Alpha (α)	Beta (β)	Photon (γ)
Actinium-227[b]	22 yr	73	α, β	0.068	0.016	<0.001
Thorium-227 (99%)	*19 days*	*31,000*	*α*	*5.9*	*0.053*	*0.11*
Francium-223 (1%)	*22 min*	*39 million*	*β*	-	*0.40*	*0.059*
Radium-223	*11 days*	*52,000*	*α*	*5.7*	*0.076*	*0.13*
Radon-219	*4.0 s*	*13 billion*	*α*	*6.8*	*0.0063*	*0.056*
Polonium-215	*0.0018 s*	*30 trillion*	*α*	*7.4*	*<0.001*	*<0.001*
Lead-211	*36 min*	*25 million*	*β*	-	*0.46*	*0.051*
Bismuth-211	*2.1 min*	*420 million*	*α*	*6.6*	*0.010*	*0.047*
Thallium-207	*4.8 min*	*190 million*	*β*	-	*0.49*	*0.0022*
Americium-241	430 yr	3.5	α	5.5	0.052	0.033
Americium-243	7,400 yr	0.20	α	5.3	0.022	0.056
Neptunium-239	*2.4 days*	*230,000*	*β*	-	*0.26*	*0.17*
Carbon-14	5,700 yr	4.5	β	-	0.049	-
Cesium-137	30 yr	88	β	-	0.19	-
Barium-137m (95%)[c]	*2.6 min*	*540 million*	*IT*	-	*0.065*	*0.60*
Cobalt-60	5.3 yr	1,100	β	-	0.097	2.5
Curium-243	29 yr	52	α	5.8	0.14	0.13
Curium-244	18 yr	82	α	5.8	0.086	00017
Curium-245	8,500 yr	0.17	α	5.4	0.065	0.096
Curium-246	4,700 yr	0.31	α	5.4	0.0080	0.0015
Europium-152	13 yr	180	β, EC	-	0.14	1.2
Europium-154	8.8 yr	270	β	-	0.29	1.2
Europium-155	5.0 yr	470	β	-	0.063	0.061
Hydrogen-3	12 yr	9,800	β	-	0.0057	-
Iodine-129	16 million yr	0.00018	β	-	0.064	0.025
Iron-55	2.7 yr	2,400	EC	-	0.0042	0.0017
Lead-210	22 yr	77	β	-	0.038	0.0048
Bismuth-210	*5.0 days*	*130,000*	*β*	-	*0.39*	-
Polonium-210	*140 days*	*4,500*	*α*	*5.3*	*<0.001*	*<0.001*
Manganese-54	310 days	7,700	EC	-	0.0042	0.84
Molybdenum-93	3,500 yr	1.1	EC	-	0.0055	0.011
Niobium-93m	*14 yr*	*280*	*IT*	-	*0.028*	*0.0019*
Neptunium-237	2.1 million yr	0.00071	α	4.8	0.070	0.035
Protactinium-233	*27 days*	*21,000*	*β*	-	*0.20*	*0.20*
Nickel-59	75,000 yr	0.082	EC	-	0.0046	0.0024
Nickel-63	96 yr	60	β	-	0.17	-
Niobium-94	20,000 yr	0.19	β	-	0.17	1.6
Plutonium-238	88 yr	17	α	5.5	0.011	0.0018
Plutonium-239	24,000 yr	0.063	α	5.1	0.0067	<0.001
Plutonium-240	6,500 yr	0.23	α	5.2	0.011	0.0017
Plutonium-241	14 yr	100	β	<0.001	0.0052	<0.001
Plutonium-242	380,000 yr	0.0040	α	4.9	0.0087	0.0014
Promethium-147	2.6 yr	940	β	-	0.062	<0.001
Samarium-147	*110 billion yr*	*0.000000023*	*α*	*2.2*	-	-
Protactinium-231	33,000 yr	0.048	α	5.0	0.065	0.048
Radium-226	1600 yr	1.0	α	4.8	0.0036	0.0067
Radon-222	*3.8 days*	*160,000*	*α*	*5.5*	*<0.001*	*<0.001*
Polonium-218	*3.1 min*	*290 million*	*α*	*6.0*	*<0.001*	*<0.001*
Lead-214	*27 min*	*33 million*	*β*	-	*0.29*	*0.25*
Bismuth-214	*20 min*	*45 million*	*β*	-	*0.66*	*1.5*
Polonium-214	*0.00016 s*	*330 trillion*	*α*	*7.7*	*<0.001*	*<0.001*

TABLE 3-4 (Cont.)

Radionuclide	Half-Life	Specific Activity (Ci/g)	Decay Mode	Radiation Energy per Decay (MeV) Alpha (α)	Beta (β)	Gamma (γ)
Radium-228	5.8 yr	280	β	-	0.017	<0.001
Actinium-228	*6.1 h*	*2.3 million*	*β*	-	*0.48*	*0.97*
Thorium-228	*1.9 yr*	*830*	*α*	*5.4*	*0.021*	*0.0033*
Samarium-151	90 yr	27	β	-	0.020	<0.001
Strontium-90	29 yr	140	β	-	0.20	-
Yttrium-90	*64 h*	*550,000*	*β*	-	*0.94*	*<0.001*
Technetium-99	210,000 yr	0.017	β	-	0.10	-
Thorium-229	7,300 yr	0.22	α	4.9	0.12	0.096
Radium-225	*15 days*	*40,000*	*β*	-	*0.11*	*0.014*
Actinium-225	*10 days*	*59,000*	*α*	*5.8*	*0.022*	*0.018*
Francium-221	*4.8 min*	*180 million*	*α*	*6.3*	*0.010*	*0.031*
Astatine-217	*0.032 s*	*1.6 trillion*	*α*	*7.1*	*<0.001*	*<0.001*
Bismuth-213	*46 min*	*20 million*	*α, β*	*0.13*	*0.44*	*0.13*
Polonium-213 (98%)	*0.0000042 s*	*13,000 trillion*	*α*	*8.4*	-	-
Thallium-209 (2%)	*2.2 min*	*410 million*	*β*	-	*0.69*	*2.0*
Lead-209	*3.3 h*	*4.7 million*	*β*	-	*0.20*	-
Thorium-230	77,000 yr	0.020	α	4.7	0.015	0.0016
Thorium-232	14 billion yr	0.00000011	α	4.0	0.012	0.0013
Uranium-232	72 h	22	α	5.3	0.017	0.0022
Uranium-233	160,000 yr	0.0098	α	4.8	0.0061	0.0013
Uranium-234	240,000 yr	0.0063	α	4.8	0.013	0.0017
Uranium-235	700 million yr	0.0000022	α	4.4	0.049	0.16
Thorium-231	*26 h*	*540,000*	*β*	-	*0.17*	*0.026*
Uranium-236	23 million yr	0.000065	α	4.5	0.011	0.0016
Uranium-238	4.5 billion yr	0.00000034	α	4.2	0.010	0.0014
Thorium-234	*24 days*	*23,000*	*β*	-	*0.060*	*0.0093*
Protactinium-234m	*1.2 min*	*690 million*	*β*	-	*0.82*	*0.012*

[a] This table provides a summary of the key radioactive properties of the major radionuclides addressed in the EIS. Many of these radionuclides have short-lived decay products, which will accompany them in the wastes or be present in the future as a result of ingrowth. These associated radionuclides are indicated in italics following the parent radionuclide. A dash means the entry is not applicable. EC = electron capture, IT = isomeric transition, Ci = curie, g = gram, and MeV = million electron volts. Values are given to two significant figures and were obtained from Appendix G of Federal Guidance Report Number 13 issued by the U.S. Environmental Protection Agency (EPA 1999) and Publication 38 of the International Commission on Radiological Protection (ICRP 1983).

[b] Some radionuclides, such as actinium-227 and bismuth-213, decay by more than one mode. Where this occurs and the resultant decay products are also radioactive, the relative percentages of the decay products are indicated in the table.

[c] An “m” following the isotopic number, such as barium-137m, indicates that this radionuclide is metastable and reaches a more stable energy configuration by isomeric transition, generally accompanied with one or more gamma rays.

4 WASTES INCLUDED AS GROUP 2

The inventory discussed in this section as Group 2 is primarily projected waste from five potential future actions as follows: (1) waste from an assumed number of new, yet to be licensed and constructed commercial nuclear reactors; (2) decommissioning of the MPPB and WTF at the West Valley Site; (3) the exhumation of buried waste at the West Valley Site; (4) planned Mo-99 production activities; and (5) the DOE Pu-238 production project. Whereas the information for Group 1 was provided according to waste type (activated metals, sealed sources, or Other Waste), the information for Group 2 is provided according to the five potential future actions noted above. Most of these actions will produce only one waste type (like activated metals or Other Waste). However, the potential exhumation of the two disposal areas at the West Valley Site (NDA and SDA) will produce all three waste types.

4.1 DECOMMISSIONING NEW COMMERCIAL REACTORS

This section presents volume and radionuclide activity estimates for Group 2 activated metal wastes associated with the future decommissioning of commercial nuclear reactors that have not yet been licensed by the NRC or constructed. All of this waste is GTCC LLRW; there is no GTCC-like Group 2 activated metal waste from new reactors. There is also Group 2 GTCC LLRW activated metal waste included in the West Valley Site disposal areas as discussed in Section 4.3.

The NRC has indicated that a number of utilities have plans for constructing new commercial nuclear power plants in the future. The total number of planned reactors is 33 as identified by the NRC (NRC 2009). Since these reactors have not yet been constructed, use was made of information reported by the DOE EIA to determine the characteristics of new reactor designs, including the approximate operating capacities (EIA 2008). Of the planned 33 new reactors, the NRC has indicated that 23 are PWRs, 8 are BWRs, and 2 are identified as “to be determined.” The two “to be determined” reactor designs were assumed to be PWRs for purposes of estimating waste volumes and radionuclide activities.

This GTCC LLRW is expected to be very similar to the Group 1 activated metal GTCC LLRW associated with nuclear reactor decommissioning. The same approach was used to determine the volumes and radionuclide inventories for these wastes as was used for the Group 1 wastes described previously. As noted for the Group 1 activated metal wastes, all of this material is expected to be RH waste, and it consists of solid metal that is both physically and chemically inert.

4.1.1 Volume Estimates

The total volume of Group 2 activated metal wastes from decommissioning the 33 planned reactors is estimated to be about 380 m^3 (13,000 ft^3), with PWRs accounting for about 300 m^3 (11,000 ft^3) of this total, and BWRs accounting for the remainder. These volume estimates were developed by using the operating capacities for the planned reactors and the same scaling factors as those described previously in Section 3.1.1 for the Group 1 activated metal wastes from decommissioning commercial nuclear reactors. Projected operation dates for these reactors were assigned to allow the use of this information to evaluate waste handling, transportation, and disposal impacts in the EIS. For purposes of analysis in the EIS, it is assumed that these new reactors would begin operations between 2015 and 2017.

As was the case for the Group 1 waste volume estimates, it is assumed that the reactors would operate for 60 years and have a six-year cooling period after the end of reactor operations and before decommissioning activities began. Assuming that the last reactors would have a starting date of 2017, the GTCC LLRW decommissioning wastes would become available for disposal in 2083. Please note that these assumptions are made simply to allow for an assessment of these wastes in the EIS; they may not actually reflect current utility plans for constructing and operating new commercial nuclear power reactors.

4.1.2 Radionuclide Activity Estimates

The same scaling factors as those described previously for estimating the radionuclide activities of the Group 1 activated metal wastes were used for the Group 2 wastes. In addition, the same 17 radionuclides and profiles as those used for the Group 1 wastes were assumed to apply to the Group 2 wastes. Radionuclide activities were determined separately for the 25 PWRs and 8 BWRs. The radionuclide activities for the Group 2 activated metal wastes are given in Table 4-1; they represent the activities when it is assumed that the wastes would be available for disposal (i.e., after 60 years of operation and a cooling period of six years). The total activity associated with these wastes is estimated to be about 48 MCi (see Table 2-1).

4.2 DECOMMISSIONING THE MPPB AND WTF AT WEST VALLEY SITE

The West Valley Site in western New York is the location of the only commercial nuclear fuel reprocessing plant ever to operate in the United States. This plant was located on the Western New York Nuclear Service Center. Decisions on decommissioning of the West Valley Site are subject to a recently completed EIS process for the West Valley Site (Joyce 2009a). These future actions would produce a combination of activated metal wastes, sealed sources, and Other Waste, if implemented. The wastes that would be generated by these decommissioning activities have been included in Group 2.

Future decommissioning of the West Valley Site can be divided into two distinct activities for purposes of developing Group 2 GTCC waste estimates for use in the EIS. The first activity is the decommissioning of the MPPB and WTF, and the second activity is the possible exhumation of the GTCC wastes in the NDA and SDA at the site. The first activity is discussed in this section, and the GTCC LLRW and GTCC-like wastes associated with the exhumation of the NDA and SDA are addressed in Section 4.3.

TABLE 4-1 Radionuclide Activity (in curies) of Group 2 GTCC LLRW and GTCC-Like Waste[a]

	GTCC LLRW					GTCC-Like Waste				
		Sealed Sources[b]		Other Waste			Sealed Sources		Other Waste	
Radionuclide	Activated Metals[c]	Actinides	Nonactinides	CH	RH	Activated Metals[c]	Actinides	Nonactinides	CH	RH
Hydrogen-3	3.6×10^{3}	–	–	2.0×10^{2}	1.9×10^{2}	–	–	–	1.1×10^{-1}	1.7×10^{-1}
Carbon-14	1.0×10^{4}	–	–	4.4	1.5×10^{2}	–	–	–	5.9	9.0
Manganese-54	2.3×10^{4}	–	–	–	1.8×10^{-7}	–	–	–	9.4×10^{-3}	1.4×10^{-2}
Iron-55	1.8×10^{7}	–	–	3.9×10^{-1}	3.1	–	–	–	9.4	1.4×10^{1}
Nickel-59	5.4×10^{4}	–	–	3.3×10^{-2}	2.1	–	–	–	3.3×10^{-2}	5.1×10^{-2}
Cobalt-60	2.3×10^{7}	–	–	6.5	4.8×10^{1}	–	–	–	2.0×10^{-4}	3.0×10^{-4}
Nickel-63	7.5×10^{6}	–	–	3.7	1.8×10^{2}	–	–	–	–	–
Strontium-90	1.3×10^{4}	–	–	2.8	1.0×10^{5}	–	–	–	6.1	5.1×10^{4}
Molybdenum-93	4.7×10^{1}	–	–	–	5.5×10^{-5}	–	–	–	–	–
Niobium-94	2.7×10^{2}	–	–	1.0×10^{-3}	2.8×10^{-2}	–	–	–	–	–
Technetium-99	1.9×10^{3}	–	–	1.0×10^{-3}	1.7×10^{1}	–	–	–	1.3×10^{-1}	3.2
Iodine-129	2.1	–	–	2.9×10^{-3}	5.4×10^{-2}	–	–	–	–	3.8×10^{-3}
Cesium-137	2.3×10^{4}	–	–	2.2×10^{1}	1.1×10^{5}	–	–	–	3.3	3.4×10^{5}
Promethium-147	1.1×10^{-1}	–	–	–	1.7×10^{5}	–	–	–	–	4.4×10^{3}
Samarium-151	1.7×10^{2}	–	–	–	2.4×10^{3}	–	–	–	–	–
Europium-152	3.3×10^{-1}	–	–	–	1.1	–	–	–	–	–
Europium-154	1.8×10^{1}	–	–	–	5.9×10^{1}	–	–	–	1.5×10^{-1}	2.3×10^{-1}
Europium-155	7.0×10^{-1}	–	–	–	2.0×10^{3}	–	–	–	–	–
Lead-210	3.3×10^{-7}	–	–	–	5.1×10^{-7}	–	–	–	–	–
Radium-226	1.5×10^{-6}	–	–	–	2.5×10^{-6}	–	–	–	1.9	2.9
Actinium-227	1.1×10^{-2}	–	–	–	1.8×10^{-2}	–	–	–	1.9×10^{-2}	2.9×10^{-2}
Radium-228	3.2×10^{-4}	–	–	–	5.6×10^{-4}	–	–	–	2.4×10^{-1}	3.6×10^{-1}
Thorium-229	1.2×10^{-2}	–	–	–	2.2×10^{-2}	–	–	–	9.8×10^{-1}	1.5
Thorium-230	1.3×10^{-4}	–	–	–	2.4×10^{-4}	–	–	–	1.8×10^{-1}	2.7×10^{-1}
Protactinium-231	3.0×10^{-2}	–	–	–	5.2×10^{-2}	–	–	–	–	–
Thorium-232	3.2×10^{-3}	–	–	–	5.6×10^{-3}	–	–	–	1.2×10^{-1}	1.9×10^{-1}
Uranium-232	1.4	–	–	–	2.9	–	–	–	1.1×10^{1}	1.7×10^{1}
Uranium-233	3.8	–	–	–	7.4	–	–	–	4.1	6.4
Uranium-234	2.0×10^{-1}	–	–	9.7×10^{-3}	3.9×10^{-1}	–	–	–	1.9×10^{1}	2.9×10^{1}
Uranium-235	7.2×10^{-2}	–	–	4.8×10^{-4}	3.7	–	–	–	8.0×10^{-3}	1.4×10^{-2}
Uranium-236	1.1×10^{-1}	–	–	–	4.4×10^{-1}	–	–	–	2.4×10^{-2}	3.6×10^{-2}

TABLE 4-1 (Cont.)

Radionuclide	GTCC LLRW: Activated Metals[c]	GTCC LLRW: Sealed Sources[b]: Actinides	GTCC LLRW: Sealed Sources[b]: Nonactinides	GTCC LLRW: Other Waste: CH[d]	GTCC LLRW: Other Waste: RH[d]	GTCC-Like Waste: Activated Metals[c]	GTCC-Like Waste: Sealed Sources: Actinides	GTCC-Like Waste: Sealed Sources: Nonactinides	GTCC-Like Waste: Other Waste: CH	GTCC-Like Waste: Other Waste: RH
Neptunium-237	6.7×10^{-2}	–	–	3.4×10^{-9}	9.9×10^{-2}	–	–	–	2.2×10^{-2}	2.3
Uranium-238	8.4×10^{-1}	–	–	1.0×10^{-2}	3.1	–	–	–	3.9×10^{-2}	7.3×10^{-2}
Plutonium-238	1.3×10^{2}	–	–	2.1×10^{4}	2.1×10^{2}	–	–	–	5.7×10^{2}	1.9×10^{3}
Plutonium-239	2.1×10^{3}	–	–	4.9×10^{1}	4.5×10^{2}	–	–	–	4.0×10^{2}	6.4×10^{2}
Plutonium-240	1.6×10^{2}	–	–	4.5×10^{1}	2.4×10^{2}	–	–	–	3.2×10^{2}	5.1×10^{2}
Plutonium-241	2.5×10^{3}	–	–	2.7×10^{3}	3.9×10^{3}	–	–	–	9.3×10^{3}	1.5×10^{4}
Americium-241	7.2×10^{2}	–	–	1.2×10^{-2}	1.0×10^{3}	–	–	–	1.4×10^{3}	2.6×10^{3}
Plutonium-242	1.4×10^{-1}	–	–	4.4×10^{-2}	2.0×10^{-1}	–	–	–	2.0	3.0
Americium-243	1.1	–	–	6.8×10^{-4}	6.8×10^{-1}	–	–	–	1.5×10^{1}	2.3×10^{1}
Curium-243	1.4×10^{-1}	–	–	7.4×10^{-6}	2.4×10^{-1}	–	–	–	3.9×10^{-2}	3.9
Curium-244	8.0	–	–	4.9×10^{-3}	5.3	–	–	–	1.0	9.1×10^{1}
Curium-245	8.0×10^{-4}	–	–	–	1.3×10^{-3}	–	–	–	–	–
Curium-246	6.4×10^{-5}	–	–	–	1.1×10^{-4}	–	–	–	–	–

[a] There is a large degree of uncertainty in the schedules and plans for the projects that will generate these wastes. The activities represent values at the time the wastes are projected to be available for disposal and are given to two significant figures. Separate estimates were developed for GTCC LLRW and GTCC-like waste. All of these wastes will be generated in the future, and there are no Group 2 GTCC-like activated metal and sealed source wastes. A dash means there is no value for that entry. CH = contact-handled (waste), RH = remote-handled (waste).

[b] The radionuclide activities for the small volume of sealed sources in the SDA are included with the activities reported for the GTCC LLRW Other Waste - RH category.

[c] All of the activated metal wastes are expected to be RH waste.

The decommissioning of the MPPB and WTF would produce GTCC-like Other Waste. The approach and information used to develop estimates for the volumes and radionuclide activities for this Group 2 GTCC-like Other Waste are the same as those used to develop comparable information for the Group 1 Other Waste as described in Sections 3.3.1 and 3.3.2. The information summarized here for the West Valley Site reflects the recent input from the DOE West Valley Site Office as given in Bohan (2008a,b) and Joyce (2009a).

4.2.1 Volume Estimates

The total volume of Group 2 GTCC-like Other Waste associated with decommissioning the MPPB and WTF is estimated to be about 980 m^3 (35,000 ft^3), with 220 m^3 (7,800 ft^3) being CH waste and 760 m^3 (27,000 ft^3) being RH waste.

4.2.2 Radionuclide Activity Estimates

The total radionuclide activity for these Group 2 GTCC-like Other Wastes is estimated to be about 0.40 MCi. This activity is more than three times the value for the Group 1 GTCC-like Other Waste (0.12 MCi). All of the radionuclide activities for the West Valley Site were decay-corrected to 2019. The radionuclide activities for these wastes are included in the Other Waste values given in Table 4-1.

4.3 DECOMMISSIONING THE NDA AND SDA AT WEST VALLEY SITE

Radioactive wastes were disposed of in two separate areas of the West Valley Site during operations. The higher-activity radioactive wastes are generally located in the NDA, and lower-activity wastes are in the SDA. A portion of these wastes are expected to be GTCC wastes. DOE intends to complete any remaining WVDP decommissioning decision-making with its Phase 2 decision (to be made within 10 years of the ROD), and it expects to select either removal or in-place closure, or a combination of the two, for those portions of the site for which it has decommissioning responsibility. The Phase 2 decision will include whether to remove or to close in-place the buried waste at the NDA and SDA (DOE 2010); therefore, these wastes are included within the scope of the GTCC EIS.

4.3.1 NRC-Licensed Disposal Area

The NDA was originally dedicated to the disposal of wastes from the spent fuel reprocessing plant operated by Nuclear Fuel Services (NFS) from 1966 through 1972. Wastes disposed of during this period consisted of leached hulls, non-fuel-bearing assembly components, and other plant-generated wastes that were too radioactive for disposal in the SDA. The SDA was licensed by the State of New York and had limitations on the types of materials and radioactive properties of the wastes that could be disposed of there (see Section 4.3.2). The spent fuel reprocessing plant was shut down in 1972. From 1973 through 1981, NFS decontaminated various areas of the plant, and certain wastes from these activities were disposed of in the NDA. Lower-activity wastes continued to be disposed of in the SDA until it was closed in 1975. After 1975, all wastes generated by NFS were disposed of in the NDA.

The WVDP initiated activities to vitrify the high-level radioactive wastes stored in two underground tanks at the site in 1982. From 1982 through 1986, lower-activity wastes generated by the WVDP were disposed of in the NDA. Higher-activity wastes were generally stored on site. The wastes disposed of in the NDA by DOE as part of the WVDP included decontamination and demolition wastes, wastes from water and gas treatment systems, and radioactively contaminated soil.

The wastes in the NDA were buried in a series of "holes." Deep holes were used for the highest-activity wastes, such as the leached spent fuel hulls generated during operation of the fuel reprocessing plant. The other radioactive wastes were generally buried in wider, shallower holes of various dimensions. The WVDP wastes were buried in 12 trenches and four steel-lined caissons (Wild 2000).

A summary of the wastes in the NDA that may be GTCC wastes is provided in Wild (2000). This information is summarized in Table 4-2, which provides the in-situ waste volume (in ft^3) and total activity (in Ci) of the wastes that may be considered to be GTCC waste. This information was used by the DOE West Valley Site Office in providing information for the GTCC EIS. The volume of packaged waste associated with retrieving these wastes from the NDA, treating them to reduce their volume and improve their form, and repackaging them for disposal is included in the values given in Table 2-1.

4.3.1.1 Volume Estimates

The in-situ volume of GTCC waste in the NDA is estimated to be about 2,100 m^3 (74,000 ft^3). As shown in Table 4-2, these wastes consist of a wide range of items — from trash and debris to hardware and failed equipment — and include 42 elements of irradiated, ruptured Hanford N Reactor spent nuclear fuel that was disposed of in three drums in Hole 48. This failed spent fuel was identified as GTCC waste in Wild (2000) and is included with the estimates given in this supplement for GTCC waste to maintain consistency with the approach being used by the DOE West Valley Site Office.

The DOE West Valley Site Office increased the waste volumes given in the Wild (2000) report by 2% when providing information for the EIS (Bohan 2008a). This factor reflects the expected slight increase in volume when the wastes are exhumed and treated before being repackaged for disposal. The volumes given in Table 2-1 for the NDA reflect this factor. This factor is not included in the volumes given in Table 4-2 in order to maintain consistency with the manner in which this information is provided in Wild (2000).

TABLE 4-2 Summary of GTCC Waste Estimates at the West Valley Site NDA[a]

Waste Category	Volume (ft^3)[b] CH	RH	Activity (Ci)[c]
Failed spent fuel[d]	–[e]	12	12,316
Hardware	–	7,266	196,838
Ion exchange	–	6,240	10,464
Degraded solvent[f]	–	2,385	3,137
Air filters	–	7,452	1,918
Failed equipment	–	13,272	24,918
Compacted trash	–	79	850
Noncompacted trash	–	226	281
General waste	–	10,726	6,963
Combination	–	26,893	39,489
Debris	–	27	5.62

[a] The waste volumes and activities were obtained from Tables S-1 and S-2 of Wild (2000). The activities of the individual radionuclides in these wastes were obtained from the radionuclide profile in Table 2-2 of Wild (2000). Most of this waste is GTCC LLRW; about 31 m^3 (1,100 ft^3) may be GTCC-like waste.

[b] Volumes are in-place estimates, and all of these wastes are expected to be RH wastes on the basis of the activity concentrations of the major gamma-emitting radionuclides (principally Co-60 and Cs-137) given in Table 2-2 of Wild (2000). The volumes given in this table need to be multiplied by 1.02 to reflect the ex-situ packaged waste volumes as noted by the DOE West Valley Site Office. To convert ft^3 to m^3, multiply by 0.02832.

[c] The radionuclide activities in this table represent values as of January 1, 2000, consistent with the information provided in Wild (2000), and include radionuclides in addition to the 44 identified in Table 4-1. All of the radionuclides given in Wild (2000) for these wastes were used in the EIS analyses, and all activities were decay-corrected to 2019. The radionuclide activities given in Tables 2-1 and 4-1 reflect radioactive decay to 2019.

[d] Failed spent fuel consists of 42 ruptured spent fuel assemblies from the Hanford N Reactor that were disposed of in three drums in Hole 48. These spent fuel assemblies are considered to be GTCC waste in Wild (2000).

[e] A dash means there is no value for that entry.

[f] Degraded solvent consists of degraded organic solvents used to separate uranium and plutonium from fission products and actinides. These solvents were usually mixed with absorbent material and disposed of in steel drums or steel tanks. Some of this material may be mixed waste.

The total packaged volume of potentially exhumed GTCC waste from the NDA is estimated to be about 2,200 m^3 (78,000 ft^3). Of this total volume, about 31 m^3 (1,100 ft^3) may be GTCC-like waste, and the rest is GTCC LLRW. This 31 m^3 (1,100 ft^3) of GTCC-like waste is included with the volume of GTCC LLRW from the NDA and SDA for purposes of analysis in the EIS.

The first two entries in Table 4-2 (failed spent fuel and hardware) are considered to be activated metals, and the packaged volume of this material is about 210 m^3 (7,400 ft^3). The remaining waste is considered to be Other Waste. The Other Waste has a volume of about 1,900 m^3 (67,000 ft^3). These volumes are reflected in Table 2-1. All of this waste is expected to be RH waste, given the generally high concentrations of gamma-emitting radionuclides.

4.3.1.2 Radionuclide Activity Estimates

The total radionuclide activity associated with the potentially exhumed NDA GTCC LLRW and GTCC-like waste was reported in Wild (2000) to be about 0.30 MCi as of January 1, 2000. This activity was subjected to radioactive decay to 2019 for use in the EIS analyses. The decay-corrected activity in this waste is about 0.16 MCi, with the activated metal waste containing 0.13 MCi, and the Other Waste containing 0.031 MCi. These values are included in the information given in Table 2-1.

As shown in Table 4-2, most of the radionuclide activity in this waste is associated with the failed spent fuel, hardware, ion-exchange media, failed equipment, and what is termed "combination" waste in Wild (2000). More than 99% of the activity in the wastes previously disposed of in the NDA is attributable to wastes now identified as being GTCC wastes; the remaining activity is distributed among Class A, B, and C LLRW (see Table S-1 of Wild [2000]). For this supplement, it is assumed that all of the activity in the NDA wastes can be attributed to GTCC wastes. This is a conservative assumption for the EIS analysis. With this assumption, the activities for the various waste streams making up the GTCC wastes in the NDA can be obtained from Table 2-2 of Wild (2000). All of the radionuclides given in Wild (2000) are included in the EIS analyses.

A summary of the radionuclide activities of all of the Group 2 wastes is provided in Table 4-1. The same 44 radionuclides that were used to summarize information for Group 1 wastes in Tables 3-1 through 3-3 were used to develop Table 4-1. The activities for the NDA included in Table 4-1 are based on the values given in Table 2-2 of Wild (2000). These activities were subjected to radioactive decay for 19 years (to 2019) for inclusion in Tables 2-1 and 4-1.

4.3.2 State-Licensed Disposal Area

The SDA was constructed and operated by NFS under the regulatory oversight of the New York State Department of Labor and New York State Department of Health. Waste disposal operations were conducted from 1963 through 1975. The New York State Department of Environmental Conservation assumed regulatory responsibility for the SDA in 1974, and in

1983, the license for the SDA was transferred from NFS to the New York State Energy Research and Development Authority.

Wastes were disposed of in 14 trenches in the SDA. Except for Trenches 6 and 7, the trenches are about 10 m (33 ft) wide and 5.8 m (19 ft) deep, with lengths ranging from about 107 m (350 ft) to nearly 213 m (700 ft). Trench 6 is a series of narrow, deep holes that were used for disposal of irradiated reactor components. Widths ranged from 0.6 m (2 ft) to 1.8 m (6 ft), lengths from 1.4 m (4 ft) to 4.0 m (13 ft), and depths from 2.4 m (8 ft) to 3.7 m (12 ft). Trench 7 is a concrete vault that is about 3.4 m (11 ft) deep and 23 m (75 ft) long. It was used for waste that was received during the earliest years of operation but was not in an appropriate physical form for disposal in the other trenches.

A wide variety of wastes were disposed of in the SDA. Most of these wastes were from off-site sources, and they had a wide variety of radionuclides and contact dose rates, ranging from less than 100 mrem/h up to 10,000 rem/h. Wastes having removable activity were limited to contact dose rates not exceeding 200 rem/h, and wastes with fixed activity (such as activated metal wastes) were limited to contact dose rates of 10,000 rem/h. Packages containing removable activity and with contact dose rates that were more than 200 mrem/h but less than 200 rem/h had to be solidified in concrete and placed inside sealed metallic containers or in packaging approved by NFS. Trench 7 was constructed for disposal of waste that did not meet this requirement as received.

A summary of the wastes in the SDA that may be GTCC LLRW is provided in Wild (2002). This information is summarized in Table 4-3, which provides the in-situ waste volume (in ft^3) and total activity (in Ci) of the wastes that may be considered to be GTCC LLRW. This information was used by the DOE West Valley Site Office in providing information for the EIS. The volume of packaged waste associated with retrieving these wastes from the SDA, treating them to reduce their volume and improve their form, and repackaging them for disposal is included in the values given in Table 2-1.

4.3.2.1 Volume Estimates

The in-situ volume of GTCC LLRW in the SDA is estimated to be about 2,100 m^3 (74,000 ft^3). As shown in Table 4-3, these wastes consist of a number of industrial, medical, and nuclear reactor wastes and come in a number of physical and chemical forms. As noted above, many of these wastes were not associated with the fuel reprocessing activities previously conducted at the site but originated from commercial and government sources outside the West Valley Site.

As was the case for the NDA, the DOE West Valley Site Office updated the waste volumes given in the Wild (2002) report when providing information for the EIS (Bohan 2008a). The update reflects the expected slight increase in volume (by 2%) when the wastes are exhumed and treated before being repackaged for disposal. The volumes given in Table 2-1 for the SDA reflect this factor. This factor is not included in the volumes given in Table 4-3 to maintain consistency with the manner in which this information is provided in Wild (2002).

TABLE 4-3 Summary of GTCC LLRW Estimates at the West Valley Site SDA[a]

Primary Group	Secondary Group	Volume (ft^3)[b] CH	RH	Activity (Ci)[c]	Radiological Profile
Fuel cycle	MOX	11,146.88	–[d]	4,484.39	Table 2-3 of Wild (2002)
Fuel cycle	SNAP	42,220.90	–	26,218.15	80% Pu-238, 16% Pu-239, 3% Pu-240, 1% Pu-241 (by mass)
Industrial	Biomedical[e]	5.10	–	8.42	Table 2-5 of Wild (2002)
Industrial	LSA trash	33.41	–	0.13	Table 2-5 of Wild (2002)
Industrial	Sealed sources	1.20	–	0.48	Not provided[f]
Institutional	Bioresearch[e]	29.40	–	79.62	Table 2-7 of Wild (2002)
Isotope production	Large tritium	9.35	–	444.28	Table 2-8 of Wild (2002)
Isotope production	Reactor targets	–	1.00	15.89	Table 2-8 of Wild (2002)
Isotope production	Sealed sources	792.12	–	30.17	Not provided[f]
Power reactor	BWR	188.00	188.00	878.77[g]	RH: Table 2-9 of Wild (2002), evaporator bottoms CH: Table 2-9 of Wild (2002), noncompactable trash
Power reactor	PWR	64.95	64.95	126.32[g]	RH: Table 2-10 of Wild (2002), evaporator bottoms CH: Table 2-10 of Wild (2002), noncompactable trash
Special-purpose reactor	D&D	–	2,816.45	2,952.50	Table 2-13 of Wild (2002)
Special-purpose reactor	Internals	–	27.40	9,574.62	Table 2-13 of Wild (2002)
Special-purpose reactor	Naval	–	12,653.21	17,209.36	Table 2-13 of Wild (2002)
Special-purpose reactor	Small research	–	2,683.04	210.86	Table 2-13 of Wild (2002)

[a] The volumes and activities were obtained from Tables S-1 and S-2 of Wild (2002) by using the variable concentration method as recommended in that report. The tables identified in the Radiological Profile column are those provided in Wild (2002). The tables in Wild (2002) were used to obtain the activities of the individual radionuclides in these wastes. MOX = mixed oxide, SNAP = systems for nuclear auxiliary power, LSA = low specific activity, BWR = boiling water reactor, PWR = pressurized water reactor, D&D = decontamination and decommissioning.

[b] Volumes are in-place estimates and were divided into CH and RH wastes on the basis of the activity concentrations of the major gamma-emitting radionuclides (principally Co-60 and Cs-137) provided in the radionuclide profiles given in Wild (2002) for the various wastes. The volumes given in this table need to be multiplied by 1.02 to reflect the ex-situ packaged waste volumes as noted by the DOE West Valley Site Office. To convert from ft^3 to m^3, multiply by 0.02832.

Footnotes continue on next page.

TABLE 4-3 (Cont.)

---

c The radionuclide activities in this table represent values as of January 1, 2000, consistent with the information provided in Wild (2002), and include radionuclides in addition to the 44 identified in Table 4-1. All of the radionuclides given in Wild (2002) for these wastes were used in the EIS analyses, and all activities were decay-corrected to 2019. The radionuclide activities given in Tables 2-1 and 4-1 reflect radioactive decay to 2019.

d A dash means there is no value for that entry.

e Biomedical and bioresearch wastes consist of absorbed liquids, scintillation fluids, animal carcasses, plant materials, soil, and general laboratory waste. All of this waste was produced by off-site research and pharmaceutical organizations, and some of this material may be mixed waste.

f The radionuclide profile for the two sealed source entries was not provided in Wild (2002). The total radionuclide activity in the sealed sources was given as 30.65 Ci in Wild (2002), and these activities are included with those given for GTCC LLRW Other Waste - RH in Table 4-1. When the same radionuclide profile as that used for Group 1 sealed source wastes is used, this activity would be about 20 Ci in 2019. Most of these sealed sources are expected to be CH waste, although some may have a surface dose rate that exceeds 200 mrem/h and will be managed as RH waste.

g The total activity of these waste streams was divided between the CH and RH wastes in proportion to the total activity concentrations in the two radiological profiles given in Tables 2-9 and 2-10 of Wild (2002).

The total packaged volume of potentially exhumed SDA GTCC LLRW is estimated to be about 2,100 m^3 (74,000 ft^3). In Table 4-3 under the column heading “primary group,” the last four entries (special purpose reactors) are considered to be activated metals, and the packaged waste volume of this material is about 520 m^3 (18,000 ft^3). Two “secondary source” entries are identified as sealed sources, and the packaged waste volume for this material is about 23 m^3 (810 ft^3). The remaining waste is considered to be Other Waste. The Other Waste is divided into CH and RH waste. The volume of Other Waste - CH is about 1,600 m^3 (56,000 ft^3), and the volume of Other Waste - RH is about 7.3 m^3 (260 ft^3). These values are reflected in Table 2-1.

4.3.2.2 Radionuclide Activity Estimates

The total radionuclide activity associated with the potentially exhumed SDA GTCC LLRW was reported in Wild (2002) to be about 0.062 MCi on January 1, 2000. This activity was subjected to radioactive decay to 2019 for use in the EIS analyses. The decay-corrected activity in this waste is about 0.035 MCi, with the activated metal waste containing 0.011 MCi and the Other Waste containing 0.024 MCi. Essentially all of the activity for the Other Waste is associated with CH waste, with the RH waste contributing less than 1% of the total. The activity for the sealed sources is comparatively very small (value of 30.65 Ci is given in Wild [2002]), and the decayed activity in 2019 would be about 20 Ci when the same radionuclide profile as that for the Group 1 sealed sources is used. These values are included in the information given in Table 2-1.

As shown in Table 4-3, most of the radionuclide activity is associated with SNAP wastes (SNAP is an acronym for “systems for nuclear auxiliary power”) and metal components from a number of nuclear reactors. The radionuclide activity associated with the SNAP wastes consists largely of plutonium, and most of this waste likely meets the DOE definition of TRU waste. Wild (2002), in addition to providing the total activity for each waste category, gives detailed radionuclide profiles for these wastes. This information was used to develop the radionuclide activities for each waste type.

As was the case for the NDA GTCC LLRW, all of the radionuclides included in Wild (2002) for these wastes are included in the EIS analyses. Table 4-1 includes radionuclide activities for the same 44 radionuclides that were used for the Group 1 wastes. These activities were extracted from the more extensive list of radionuclides provided in Wild (2002) and are decay-corrected for 19 years (to 2019) in the information given in Tables 2-1 and 4-1.

To develop the radionuclide activities for each of the waste streams identified in Table 4-3, the total activity of the GTCC LLRW in that stream was first identified in Wild (2002). The radionuclide profile was then used and scaled so that the sum of the resultant radionuclides equaled this total. The radionuclide profile was generally given in concentration units (Ci/m^3) in Wild (2002). This approach was used for each waste stream, and the resultant activities were summed by radionuclide to obtain the total activity for each radionuclide identified as being present in the SDA GTCC LLRW.

4.4 MOLYBDENUM-99 PRODUCTION ACTIVITIES

Mo-99 is a radioactive fission product generated in nuclear reactors, and this radionuclide has a half-life of 66 hours. Mo-99 decays by the emission of a beta particle to a metastable isomer of technetium-99 (Tc-99m). Since Tc-99m is in an elevated energy state, it releases this excess energy by the emission of a gamma ray through an isomeric transition process to become Tc-99. Tc-99m has a half-life of 6.0 hours. Tc-99 is also radioactive and has a very long half-life of 210,000 years.

Tc-99m is the most widely used radionuclide for diagnostic nuclear imaging procedures in the United States (Kram 2009). It is well suited for this procedure, since the radiation exposure of the patient can be kept low. Tc-99m has a short half-life and emits a well-defined gamma ray, allowing small amounts to be easily detected. It decays to the far less radioactive Tc-99, resulting in a relatively low dose per unit of initial activity administered. It is usually administered as pertechnetate, and both technetium isotopes are quickly eliminated from the body, generally within a few days.

In practice, Mo-99 is shipped to the location where the nuclear imagining procedure will be performed, and Tc-99m is chemically extracted from the Mo-99. Since Mo-99 has a half-life of 66 hours, this radionuclide can be readily transported to facilities around the world. A single Tc-99m generator containing a few micrograms of Mo-99 can produce enough Tc-99m to potentially diagnose thousands of patients because it will continue producing Tc-99m for more than a week. Currently a shortage of Mo-99 is projected for the very near future, and two organizations in the United States have developed plans to produce this radionuclide for use in the commercial market: B&W and the MURR.

The B&W concept makes use of a homogenous solution reactor termed the MIPS. The MIPS consists of one or more modular, compact, cylindrical reactor vessels that use a LEU salt solution as the fuel. The reactor would operate in batch mode, in which Mo-99 would build up in the salt solution. When a sufficient amount of Mo-99 was generated by nuclear fission, the reactor would be shut down, and the Mo-99 would be removed from the salt solution. Other fission products and TRU radionuclides would also be periodically removed from the fuel solution, and this process could generate GTCC LLRW. It is projected that an annual volume of about 5 m^3 (180 ft^3) of solid GTCC LLRW would be generated by the MIPS process (Hogg 2009; Joyce 2009b).

Use of the MURR involves irradiating solid targets containing LEU in the research reactor and processing the targets in an adjacent facility to remove Mo-99. The MURR has performed tests to demonstrate its Mo-99 recovery efficiency and has the facilities and capabilities needed to produce this radionuclide for the commercial market. The reactor is currently producing other medical isotopes and appears to have sufficient capability for the necessary target irradiation. As was the case for MIPS, use of MURR to produce Mo-99 would generate a small amount of GTCC LLRW. It is projected that an annual total of about 0.46 m^3 (16 ft^3) of liquid GTCC LLRW would be generated by this process (Meyer 2009a,b). For purposes of analysis in the EIS, it is assumed that this liquid waste would be concentrated and solidified, so that the packaged solid waste volume would remain the same: 0.46 m^3 (16 ft^3)/yr.

Information was provided by B&W (Hogg 2009; Joyce 2009b) and MURR (Meyer 2009a,b) on their planned processes and the amounts and radionuclide characteristics of the radioactive wastes that could be generated. Since neither MIPS nor MURR is currently in operation, the GTCC LLRW that would be generated by both of these processes is included in Group 2. It is assumed that each process would begin operations in the near future and operate for 71 years (to 2083). The information provided by the two organizations is summarized in the following two subsections.

4.4.1 Volume Estimates

The total volume of Group 2 GTCC LLRW associated with Mo-99 production activities is estimated to be about 390 m^3 (14,000 ft^3). This estimate is based on the annual waste volumes identified above, which were provided by the two organizations proposing to produce Mo-99, and on an assumed operating period of 71 years. More than 90% of this waste volume is associated with MIPS. Although MIPS has a greater waste volume, the activity concentrations (in pCi/g) in these wastes are expected to be significantly lower than those in the GTCC LLRW generated at MURR. All of this waste is expected to be RH waste, largely as a result of the concentrations of Cs-137 and several other gamma-emitting radionuclides. This waste is included with the Other Waste volume in Table 2-1.

4.4.2 Radionuclide Activity Estimates

The radionuclide activity estimates for the Mo-99 GTCC LLRW are included in the values given for the Group 2 GTCC LLRW Other Waste in Tables 2-1 and 4-1. The major radionuclides that are expected to be of concern with regard to management of these wastes are given in Table 4-4. A much more complete profile of radionuclides was provided for these two processes, and the entire profile is used for EIS analyses. The values given in Table 4-4 are included in the Group 2 totals given in Table 4-1.

As was the case for the volume estimates, these radionuclide activities were developed on the basis of the information provided by the two organizations proposing to produce Mo-99 and an assumption that the operating period would be 71 years. It is assumed that the wastes would be stored at the generating site for three years to allow for the decay of the short-lived radionuclides, and the values given in Table 2-1 and Tables 4-1 and 4-4 reflect this decay. While the waste volumes for the two processes differ by a factor of 10, the total activities for the major radionuclides are comparable.

TABLE 4-4 Radionuclide Activities Associated with Molybdenum-99 Production Activities

	Radionuclide Activity (Ci)[a]	
Radionuclide	MURR	MIPS
H-3	–[b]	1.7×10^{2}
C-14	5.6×10^{-5}	1.5×10^{2}
Sr-90	4.5×10^{4}	4.6×10^{4}
Tc-99	4.2	7.0
I-129	9.1×10^{-3}	1.1×10^{-2}
Cs-137	4.9×10^{4}	4.6×10^{4}
Pm-147	9.7×10^{4}	7.7×10^{4}
Sm-151	1.1×10^{3}	1.1×10^{3}
Eu-155	1.1×10^{3}	9.2×10^{2}
U-234	–	8.5×10^{-3}
U-235	–	3.6
U-236	–	2.8×10^{-1}
U-238	–	2.3
Np-237	4.9×10^{-5}	6.7×10^{-3}
Pu-238	1.7×10^{-5}	6.0×10^{-1}
Pu-239	1.9×10^{1}	9.1×10^{1}
Pu-240	3.8×10^{-2}	1.6
Pu-241	9.7×10^{-3}	4.9
Am-241	6.5×10^{-8}	2.2×10^{-3}

[a] The radionuclides identified here are those most prevalent in the GTCC LLRW associated with Mo-99 production activities or those expected to be of most concern with regard to long-term management. For purposes of analysis in the EIS, it is assumed that these wastes will be stored for three years at the generating site to allow for radioactive decay of the short-lived radionuclides before the wastes are shipped to the disposal facility. The values given here reflect these three years of decay.

[b] A dash means no values were provided for the indicated radionuclide.

4.5 PLUTONIUM-238 PRODUCTION PROJECT

DOE is planning a new program for producing Pu-238 at the ORNL Radiochemical Engineering Development Center (REDC). This radionuclide is used as a heat source in radiothermal generators; it produces electricity and heat for a variety of purposes in harsh and remote environments, including their use by unmanned spacecraft and satellites.

The Pu-238 production project currently envisioned by DOE involves fabricating targets containing neptunium-237 (Np-237), irradiating them in a nuclear reactor, and processing the irradiated targets to recover Pu-238. The fabrication and target processing activities would occur at the ORNL REDC, and the irradiation could occur in a reactor at ORNL or at another DOE site. The GTCC-like wastes (which are expected to meet the DOE definition of TRU wastes) would be generated at REDC during target fabrication and processing activities.

This Pu-238 production project is estimated to produce up to 380 m^3 (13,000 ft^3) of Group 2 GTCC-like wastes (DOE 2001a). The radionuclide information developed for the former RPS consolidation project and given in Sandia (2007, 2008) was used as the basis for estimating the radionuclide activities of the GTCC-like wastes that could be generated by this new project.

The GTCC-like wastes associated with the proposed Pu-238 production project are included in the estimates given here, even though in the future, this waste might be determined to be defense TRU waste on the basis of the circumstances and determinations made at the time it is generated. Defense TRU waste has a path to disposal (i.e., at WIPP) and is thus outside the scope of the GTCC EIS. In addition, this waste would be produced only if this project was implemented in the future.

4.5.1 Volume Estimates

The estimated volume of GTCC-like Other Waste associated with the planned Pu-238 production project is estimated to be 380 m^3 (13,000 ft^3), and this value is included in the information included in Table 2-1 (DOE 2001a). This waste is expected to meet the DOE definition for TRU waste. The volume of RH waste is estimated to be 260 m^3 (9,200 ft^3), and the CH waste volume is estimated to be 120 m^3 (4,200 ft^3). This waste is expected to consist of a variety of contaminated materials associated with target fabrication, target processing, and plutonium purification activities. These wastes would be generated at the ORNL REDC.

This waste volume is significantly lower than the volume previously projected for the RPS consolidation project as given in Sandia (2007, 2008). The RPS project was estimated to produce about 880 m^3 (31,000 ft^3) of CH waste and 390 m^3 (14,000 ft^3) of RH waste. The total volume of GTCC-like Other Waste from the RPS consolidation project was estimated to be about 1,300 m^3 (46,000 ft^3).

4.5.2 Radionuclide Activity Estimates

The total radionuclide activity for the planned Pu-238 production project waste is estimated to be about 0.094 MCi. Essentially all of this activity is associated with the RH wastes, with the projected activity for the CH wastes being 0.00014 MCi. The major radionuclides for the Other Waste - CH and Other Waste - RH are given in Table 4-5. The values given in Table 4-5 are included in the Group 2 totals given in Table 4-1.

Many of the radionuclides in these wastes have short half-lives and so would not have an impact on long-term management decisions. For purposes of analysis in the EIS, it is assumed that the wastes would be stored at the REDC for three years before being shipped to the disposal facility. This would allow for a significant reduction in the total activity of the wastes due to radioactive decay. The radionuclide values given in Table 2-1 and Tables 4-1 and 4-5 include three years of radioactive decay.

The total radionuclide activity for the RPS consolidation project was initially estimated to be about 16 MCi (Sandia 2007). This is the total activity immediately following generation of the wastes. As noted in Frazier (2009), the same radionuclide profiles as those previously used for the RPS consolidation project wastes could be used to estimate the radionuclide activities for the Pu-238 production project wastes. This means that the initial total activity of the Pu-238 production project wastes can be calculated by simply using the ratio of the total waste volumes, since the same split between RH and CH wastes can be assumed (Frazier 2009). From using this approach, the total initial activity for the Pu-238 production project wastes was calculated to be about 4.8 MCi.

TABLE 4-5 Radionuclide Activities Associated with the Plutonium-238 Production Project

	Radionuclide Activity (Ci)[a]	
Radionuclide	Other Waste - CH	Other Waste - RH
Sr-90	–[b]	6.2×10^3
Cs-137	1.2×10^{-7}	1.8×10^4
Pm-147	–	4.4×10^3
Np-237		1.7
Pu-238	6.0	8.8×10^2
Pu-239	1.3×10^1	4.9×10^{-1}
Pu-240	5.0	2.1×10^{-1}
Pu-241	1.1×10^2	3.9×10^1
Am-241	1.1×10^1	1.2×10^1

[a] The radionuclides identified here are those provided in the data submittal that are expected to be of most concern with regard to long-term management. For purposes of analysis in the EIS, it is assumed that these wastes will be stored for three years at the generating site to allow for radioactive decay of the short-lived radionuclides before the wastes are shipped to the disposal facility. The values given here reflect these three years of decay.

[b] A dash means no values were provided for the indicated radionuclide.

Specific information for the RPS consolidation project GTCC-like waste is given in Sandia (2008) for those radionuclides considered to be significant with regard to waste disposal at WIPP. This list of radionuclides is given in Table 2 of Appendix F of Sandia (2008). All other radionuclides included in the DOE Radioisotope Power Systems Office submittal for the RPS consolidation project were not included in the values given in Sandia (2008). The radionuclides that were eliminated on this basis had half-lives of less than three years. This approach to reduce the number of short-lived radionuclides is reasonable and is also used in this supplement.

All the radionuclides included in the original submittal by the DOE Radioisotope Power Systems Office are included in the EIS analyses for completeness. As noted above, it is assumed that the Pu-238 production wastes would be stored for three years at the ORNL REDC before being shipped to the potential disposal sites. During this time, the total radionuclide activity would decrease from 4.8 to 0.094 MCi.

4.6 SUMMARY OF GROUP 2 VOLUME AND RADIONUCLIDE ACTIVITY ESTIMATES

The estimated volumes of Group 2 GTCC LLRW and GTCC-like waste projected to be generated in the future are summarized in Table 2-1. All of the Group 2 activated metal waste is assumed to be RH waste, since much of this waste is from decommissioning commercial nuclear power reactors. This approach is consistent with that used for Group 1 activated metal wastes.

Some of this activated metal waste has been disposed of in the NDA and SDA at the West Valley Site, and these values are included in the estimates given in Table 2-1.

The Group 2 activated metal waste volumes associated with the decommissioning of commercial nuclear reactors were estimated in the same manner as were the Group 1 activated metal waste volumes, by using information on new commercial reactor applications compiled by the NRC. Information on the activated metal wastes at the West Valley Site NDA and SDA was obtained from Wild (2000, 2002). The only Group 2 sealed source wastes are from the SDA at the West Valley Site, and these are expected to be largely CH wastes.

The Other Waste is separated into CH waste and RH waste in the same manner as that used for Group 1 wastes. All of the Other Waste associated with Mo-99 production activities is expected to be RH waste, whereas about 70% of the waste associated with the Pu-238 production project is expected to be CH waste. More than half of the waste from the two disposal areas at the West Valley Site is expected to be RH waste. Waste volume information for the two disposal areas at the West Valley Site was obtained from reports prepared by DOE for the NDA and SDA as given in Wild (2000, 2002), and the waste volumes for the two Mo-99 production projects and the planned DOE Pu-238 production project were obtained from information provided by the organizations planning to implement these projects in the future.

The total volume of Group 2 GTCC LLRW and GTCC-like waste is estimated to be about 6,400 m^3 (230,000 ft^3). Of this total, about 5,000 m^3 (180,000 ft^3) is GTCC LLRW, and 1,400 m^3 (49,000 ft^3) is GTCC-like waste. About 17% of the total Group 2 waste volume is activated metals, 0.36% is sealed sources excavated from the SDA at the West Valley Site, and about 82% is Other Waste.

As was the case for the Group 1 estimates, a small amount of the Group 2 GTCC LLRW and GTCC-like wastes could be mixed waste. This mixed waste would most likely be associated with the wastes that would potentially be exhumed from the NDA and SDA at the West Valley Site. It is likely that some of the chemical and biological wastes disposed of in the NDA and SDA — such as solvents, scintillation fluids, and laboratory wastes — could be mixed wastes. This assumption cannot be confirmed unless the wastes are exhumed and characterized. Some of this waste might be characteristic hazardous waste, which can be treated to remove the hazardous waste characteristic. There is a very high degree of uncertainty associated with developing mixed waste estimates for Group 2, given the very early stages of planning for decommissioning these two disposal areas.

The radionuclide activities for Group 2 GTCC LLRW and GTCC-like waste in the three waste categories are summarized in Tables 2-1 and 4-1. Much of the activity is associated with the neutron activation products in commercial nuclear reactors (i.e., the activated metal category under GTCC LLRW). Most of the remaining activity is associated with fission products and actinides in the Other Waste category for GTCC LLRW and GTCC-like waste. The Group 2 sealed sources contribute a very small amount to the total radionuclide activity.

The radionuclide activities given for the Group 2 wastes in this supplement represent the activities when it is expected that the wastes would be available for disposal. All activities associated with wastes for the West Valley Site were decay-corrected to 2019 for use in the EIS analyses. The activities for the GTCC LLRW from decommissioning new commercial nuclear reactors represent values associated with six years of radioactive decay following reactor shutdown. The activities for the two Mo-99 production projects and the planned DOE Pu-238 production project reflect three years of radioactive decay at the facilities that generate these wastes.

The same approach as that used for the Group 1 activated metal wastes was used for the Group 2 wastes; that is, additional radionuclides were added to the profile of the activated metal wastes from decommissioning commercial nuclear reactors provided in Sandia (2008) to better address the full spectrum of radionuclides that might be present in these wastes, including those that tend to be more mobile in the environment. The radionuclide data for the other types of Group 2 wastes were used directly as provided, although a certain amount of radioactive decay was assumed, as noted above. A consistent basis was used to estimate the radionuclide activities when it is expected that the wastes would be available for disposal. This approach will ensure that the results of the EIS analyses best represent the expected environmental impacts from the various alternatives.

5 REFERENCES

Argonne (Argonne National Laboratory), 2010, *Conceptual Designs for Greater-Than-Class C Low-Level Radioactive Waste Land Disposal Facilities,* ANL/EVS/R-10/9, prepared by Argonne, Argonne, Ill., for U.S. Department of Energy, Office of Environmental Management, Oct.

Bedore, N., et al., 1987, *Evaluation of Uncertainties in Irradiated Hardware Characterization,* NUREG/CR-4968, prepared by Waste Management Group, Inc., Crompond, N.Y., for U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Oct.

Bohan, C., 2008a, *GTCC Data Call — Updated Table and Report,* email with attachments from Bohan (U.S. Department of Energy [DOE], West Valley Site Office, West Valley, N.Y.) to G. Dixon (DOE, Office of Environmental Management, Office of Disposal Operations, Washington, D.C.), March 26.

Bohan, C., 2008b, *GTCC Data Call,* email with attachments from Bohan (U.S. Department of Energy [DOE], West Valley Site Office, West Valley, N.Y.) to J. Joyce (DOE, Office of Environmental Management, Office of Disposal Operations, Germantown, Md.) and G. Dixon (DOE, Office of Environmental Management, Office of Disposal Operations, Washington, D.C.), June 16.

DOE (U.S. Department of Energy), 1994, *Greater-Than-Class C Low-Level Radioactive Waste Characterization: Estimated Volumes, Radionuclides, Activities, and Other Characteristics,* DOE/LLW-114, prepared by Idaho National Engineering Laboratory, Idaho Falls, Id., Sept.

DOE, 1997a, *Waste Isolation Pilot Plant Disposal Phase Final Environmental Impact Statement,* DOE/EIS-0026-S-2, Carlsbad Area Office, Carlsbad, N.M., Sept.

DOE, 1997b, *Integrated Data Base Report — 1996: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 13, prepared by Oak Ridge National Laboratory, Oak Ridge, Tenn., for Office of Environmental Management, Dec.

DOE, 1999, *Radioactive Waste Management Manual,* DOE M 435.1-1, Office of Environmental Management, Washington, D.C., July.

DOE, 2001a, “Record of Decision for the Programmatic Environmental Impact Statement for Accomplishing Expanded Civilian Nuclear Energy Research and Development and Isotope Production Missions in the United States, Including the Role of the Fast Flux Test Facility,” *Federal Register,* Vol. 66, No. 18, Jan. 26.

DOE, 2001b, *Summary Data on the Radioactive Waste, Spent Nuclear Fuel, and Contaminated Media Managed by the U.S. Department of Energy,* Office of Environmental Management, Washington, D.C., April.

DOE, 2002, *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada,* DOE/EIS-0250, Office of Civilian Radioactive Waste Management, Washington, D.C., Feb.

DOE, 2010, *Record of Decision: Final Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center*, Inés R. Triay, Assistant Secretary for Environmental Management, Apr. 14.

EIA (Energy Information Administration), 2008, *New Commercial Reactor Designs,* U.S. Department of Energy, http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nucenviss2.html. Accessed March 6, 2008.

EPA (U.S. Environmental Protection Agency), 1999, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides,* Federal Guidance Report No. 13, EPA 402-R-99-001, Office of Radiation and Indoor Air, Washington, D.C., Sept.

Grove Software, Inc., 2005, *MicroShield Version 7.0 User's Manual,* Lynchburg, Va.

Frazier, T., 2009, *Pu-238 Production Project Waste,* email from Frazier (U.S. Department of Energy [DOE], Office of Nuclear Energy, Radioisotope Power Systems, Germantown, Md.) to G. Dixon (DOE, Office of Environmental Management, Office of Disposal Operations, Washington, D.C.), Sept. 3.

Henry, K., 1993, *Technically Feasible Systems for the Disposal of Greater-Than-Class C Low-Level Radioactive Waste*, DOE/LLW-176, Final Draft, prepared by Rogers & Associates Engineering Corporation and ERM-Program Management Company, Idaho Falls, Id., for U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Idaho Field Office, April.

Hogg, R.C., 2009, *GTCC Wastes Potentially Generated by MIPS*, email from Hogg (Babcock & Wilcox Company, Lynchburg, Va.) to J. Lacey and R. Hamilton (U.S. Department of Energy, National Nuclear Security Administration, Washington, D.C.), Oct. 28.

IAEA (International Atomic Energy Agency, 2003, *Categorization of Radioactive Sources,* IAEA-TECDOC-1344, Vienna, Austria.

ICRP (International Commission on Radiological Protection), 1983, *Radionuclide Transformations: Energy and Intensity of Emissions,* ICRP Publication 38, Annals of the ICRP, Vols. 11–13, Pergamon Press, New York, N.Y.

Joyce, J., 2009a, *Corrections to Group 1 and Group 2 West Valley Waste,* email with attachments from Joyce (U.S. Department of Energy, Office of Environmental Management, Office of Disposal Operations, Germantown, Md.) to M. Picel (Argonne National Laboratory, Argonne, Ill.), July 1.

Joyce, J., 2009b, *GTCC Wastes Potentially Generated by MIPS*, email from Joyce (U.S. Department of Energy, Office of Environmental Management, Office of Disposal Operations, Germantown, Md.) to M. Picel (Argonne National Laboratory, Argonne, Ill.), Oct. 2.

Kram, B., 2009, *Lantheus Medical Imaging Takes Steps on Mo-99 Shortage*, DOTMED News, May 28, http://www.dotmed.com/news.story/9206. Accessed Nov. 11, 2009.

Meyer, W., 2009a, *Clarification of Preliminary Information*, email from Meyer (University of Missouri Research Reactor, Columbia, Mo.) to M. Picel (Argonne National Laboratory, Argonne, Ill.), Oct. 8.

Meyer, W., 2009b, *Follow-on Questions for the MURR Waste Stream*, email from Meyer (University of Missouri Research Reactor, Columbia, Mo.) to M. Picel (Argonne National Laboratory, Argonne, Ill.), Oct. 28.

NRC (U.S. Nuclear Regulatory Commission), 1978, *Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station,* NUREG/CR-0130, prepared by Battelle Pacific Northwest Laboratory, Richland, Wash., June.

NRC, 1980, *Technology, Safety and Costs of Decommissioning a Reference Boiling Water Reactor Power Station,* NUREG/CR-0672, prepared by Battelle Pacific Northwest Laboratory, Richland, Wash., June.

NRC, 2009, *Expected New Nuclear Power Plant Applications, Updated July 2, 2009,* Office of New Reactors, http://www.nrc.gov/reactors/new-reactors.html. Accessed July 28, 2009.

Robertson, D.E., et al., 2000, *Low-Level Radioactive Waste Classification, Characterization, and Assessment: Waste Streams and Neutron-Activated Metals,* NUREG/CR-6567, PNNL-11659, prepared by Pacific Northwest National Laboratory, Richland, Wash., for U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Aug.

Sandia (Sandia National Laboratories), 2007, *Greater-Than-Class C Low-Level Radioactive Waste and DOE Greater-Than-Class C-Like Waste Inventory Estimates,* prepared by Sandia, Albuquerque, N.M., for U.S. Department of Energy, Office of Environmental Management, July.

Sandia, 2008, *Basis Inventory for Greater-Than-Class C Low-Level Radioactive Waste Environmental Impact Statement Evaluations*, Task 3.2 Report, Rev. 1, prepared by Sandia, Albuquerque, N.M., for U.S. Department of Energy, Office of Environmental Management, May.

Wild, R.E., 2000, *Estimated Radionuclide Inventory for the NRC-Licensed Disposal Area at the West Valley Demonstration Project*, prepared by URS/Dames & Moore, Orchard Park, N.Y., for West Valley Nuclear Services Company, Inc., Aug.

Wild, R.E., 2002, *SDA Radiological Characterization Report*, prepared by URS Corporation, Orchard Park, N.Y., for West Valley Nuclear Services Company, Inc., Sept.

This page is intentionally left blank.

Environmental Science Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 240
Argonne, IL 60439-4847

www.anl.gov