

September 1995

Integrated Data Base Report—1994: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics



Prepared for

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
Office of Environmental Management
Washington, D.C. 20585

Prepared by

Oak Ridge National Laboratory
Managed by Lockheed Martin Energy Systems, Inc., for the
U.S. Department of Energy under contract DE-AC05-84OR21400

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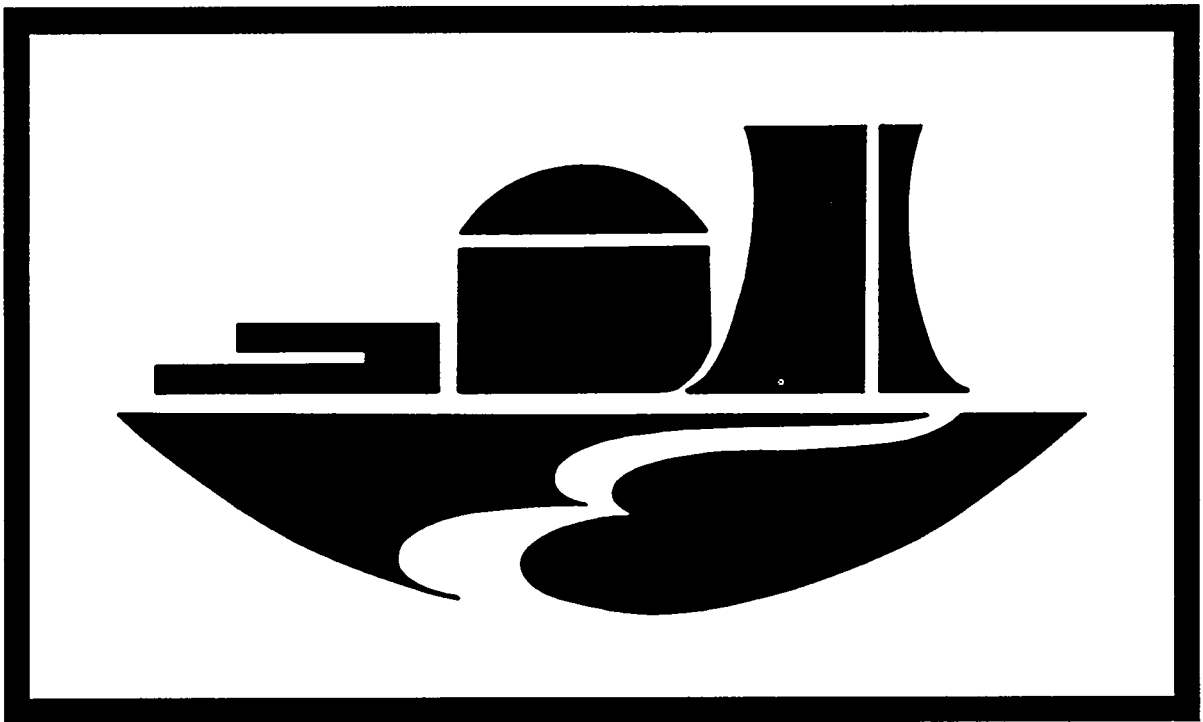
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PREFACE

The information in this report summarizes the U.S. Department of Energy (DOE) data base for inventories, projections, and characteristics of domestic spent nuclear fuel and radioactive waste. This report is updated annually to keep abreast of continual waste inventory and projection changes in both the government and commercial sectors. Baseline information is provided for DOE program planning purposes and to support DOE program decisions. Although the primary purpose of this document is to provide background information for program planning within the DOE community, it has also been found useful by state and local governments, the academic community, and some private citizens. To sustain the objectives of this program in providing accurate and complete data in this field of operation, comments and suggestions to improve the quality and coverage are encouraged. Such comments and any general inquiries should be directed to the U.S. Department of Energy at either of the following:

Office of Civilian Radioactive Waste
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1000 Independence Avenue, SW
Washington, DC 20585-0001

Office of Environmental Management
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Washington, DC 20585-0002

This report was prepared by the Integrated Data Base Program, which is jointly sponsored by the DOE Office of Civilian Radioactive Waste Management and the DOE Office of Environmental Management. Suggestions, questions, and requests for information may be directed to any of the following:

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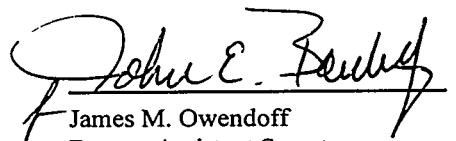
An important part of the Integrated Data Base Program is the Steering Committee, whose members provide both generic guidance and technical input. The membership of this committee, shown on the following page, represents all of the major DOE sites and programs for spent nuclear fuel and radioactive waste management. Each support committee member is assisted by a technical liaison as needed. The participation and assistance of these individuals are acknowledged with appreciation.



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^bWaste Isolation Pilot Plant Technical Assistance Contractor (WTAC). The WTAC provided the transuranic waste chapter for this report. Support for this chapter was also provided by MAC Technical Services Company.

^cWith support from DOE LLW Management Program (Cadmus Group) and National Low-Level Waste Management Program.

^dWith support from INEL Technical Support Program.

Major DOE data sources supporting the Integrated Data Base Program report

Name of data source	Waste type information provided	Supporting DOE program office	Principal contractor and mailing address (Phone number)
DOE Spent Nuclear Fuel Management Program	DOE spent nuclear fuel	Office of Spent Fuel Management (EM-37)	Lockheed Martin Idaho Technologies P.O. Box 1625 Idaho Falls, ID 83415 (208/526-8909)
Environmental Restoration Core Data Base	DOE/EM-40 contaminated media/waste	Office of Environmental Restoration (EM-40)	DOE/EM Office of Program Integration (DOE/EM-43) Cloverleaf Building U.S. Department of Energy 19901 Germantown Road Germantown, MD 20874 (301/903-8121)
International Nuclear Model, Personal Computer Version (PCINM)	Commercial spent nuclear fuel	Energy Information Administration (DOE/EIA)	DOE/EIA Analysis and Systems Division Nuclear Fuel Cycle Branch Route Symbol EI-531 1707 H Street, N.W. Washington, DC 20585-0001 (202/254-5536)
Manifest Information Management System (MIMS)	Commercial low-level waste	Office of Waste Management (EM-30)	Lockheed Martin Idaho Technologies National Low-Level Waste Management Program P.O. Box 1625 Idaho Falls, ID 83415 (208/526-9717)
Uranium Reserve Assessment Program	Commercial uranium mill tailings	Energy Information Administration (DOE/EIA)	DOE/EIA Analysis and Systems Division Nuclear Fuel Cycle Branch Route Symbol EI-531 1707 H Street, N.W. Washington, DC 20585-0001 (202/254-5556)

Major DOE data sources supporting the Integrated Data Base Program report (continued)

Name of data source	Waste type information provided	Supporting DOE program office	Principal contractor and mailing address (Phone number)
Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report (WTWBIR)	DOE transuranic waste	DOE Carlsbad Area Office National Transuranic Program Office (NTPO)	Drez Environmental Associates 8816 Cherry Hills Road, N.E. Albuquerque, NM 87111 (505/828-9857)
1995 Mixed Waste Inventory Report (MWIR) Data Base	RCRA- and state-regulated DOE mixed wastes (high-level, transuranic, and low-level waste)	Office of Waste Management (EM-30)	Lockheed Martin Idaho Technologies P.O. Box 1625 Idaho Falls, ID 83405 (208/526-2746)

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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND INITIALISMS

In this report, all abbreviations, acronyms, and initialisms are defined in text before they are used. In some cases, they are redefined in text for the reader's convenience.

AEA	Atomic Energy Act of 1954
AEC	Atomic Energy Commission
Ames	Ames Laboratory, Ames, Iowa
ANL-E	Argonne National Laboratory-East, Argonne, Illinois
ANL-W	Argonne National Laboratory-West, INEL, Idaho
APPR	Army Package Power Reactor
ASI	Advanced Sciences, Inc.
ATL 1	Atlantic Site 1 (38°30'N, 72°06'W)
ATL 2	Atlantic Site 2 (37°50'N, 70°35'W)
ATR	Advanced test reactor
BAPL	Bettis Atomic Power Laboratory, West Mifflin, Pennsylvania
BARN	Barnwell, South Carolina (commercial waste site)
BCL	Battelle Columbus Laboratories, Columbus, Ohio
BCLDP	Battelle Columbus Laboratories Decommissioning Project, Columbus, Ohio
BDM	BDM Federal, Inc., Germantown, Maryland
BETY	Beatty, Nevada (commercial waste site)
BMI	Battelle Memorial Institute, Columbus, Ohio
BNI	Bechtel National, Inc., Oak Ridge, Tennessee
BNL	Brookhaven National Laboratory, Upton, New York
BR	Belgium reactor
B&W-NES	Babcock and Wilcox Nuclear Environmental Services, Lynchburg, Virginia
BWR	Boiling-water reactor
CADMUS	The Cadmus Group, Inc.
CANDU	Canadian Deuterium Reactor
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CEU	Consolidated Edison Uranium
CFC	Chlorinated fluorocarbon
CH	Contact-handled (transuranic waste)
CISS	Colonie Interim Storage Site, Colonie, New York
CRWMS-M&O	Civilian Radioactive Waste Management System—Management and Operating (contractor)
CY	Calendar year
DAW	Dry active waste
DOD	Department of Defense, U.S.
DOE	Department of Energy, U.S.
DOE/AL	DOE Albuquerque Operations Office, Albuquerque, New Mexico

DOE/CAO	DOE Carlsbad Area Office, Carlsbad, New Mexico
DOE/CH	DOE Chicago Operations Office, Argonne, Illinois
DOE/DP	DOE/Office of Defense Programs (Headquarters), Germantown, Maryland
DOE/EIA	DOE/Energy Information Administration, Washington, D.C.
DOE/EM	DOE/Office of Environmental Management (Headquarters), Germantown, Maryland
DOE/FN	DOE Fernald Area Office, Cincinnati, Ohio
DOE/HQ	DOE Headquarters, Washington, D.C. and Germantown, Maryland
DOE/ID	DOE Idaho Operations Office, Idaho Falls, Idaho
DOE/NV	DOE Nevada Operations Office, Las Vegas, Nevada
DOE/OAK	DOE Oakland Operations Office, Oakland, California
DOE/OH	DOE Ohio Field Office, Miamisburg, Ohio
DOE/OR	DOE Oak Ridge Operations Office, Oak Ridge, Tennessee
DOE/OSTI	DOE/Office of Scientific and Technical Information, Oak Ridge, Tennessee
DOE/RF	DOE Rocky Flats Office, Golden, Colorado
DOE/RL	DOE Richland Operations Office, Richland, Washington
DOE/RW	DOE/Office of Civilian Radioactive Waste Management (Headquarters), Washington, D.C.
DOE/SR	DOE Savannah River Operations Office, Aiken, South Carolina
DOE/WIPP	DOE/WIPP Project Office, Carlsbad, New Mexico
DOE/WVAO	DOE/West Valley Area Office, West Valley, New York
DOT	Department of Transportation, U.S.
DRCT	Dry rod consolidation technology
DWCS	Defueling water cleanup system
DWMP	Defense Waste Management Plan
DWPF	Defense Waste Processing Facility
D&D	Decontamination and decommissioning
EA	Environmental assessment
EBR	Experimental Breeder Reactor
EBWR	Experimental Boiling-Water Reactor
EG&G/ID	EG&G Idaho, Inc., Idaho Falls, Idaho (former management and operating contractor for Idaho National Engineering Laboratory)
EIA	Energy Information Administration
EIS	Environmental impact statement
EMAD	Engine maintenance assembly and disassembly
ENVR	Envirocare facility, Clive, Utah
EOY	End of (calendar) year
EPA	Environmental Protection Agency, U.S.
EPR	Experimental power reactor
ERR	Elk River Reactor
ETEC	Energy Technology Engineering Center, Canoga Park, California [also referred to as the Santa Susana Field Laboratory (SSFL)]
FEMP	Fernald Environmental Management Project, Fernald, Ohio
FFCA	Federal Facility Compliance Act of 1992
FFTF	Fast Flux Test Facility, Hanford, Washington
FIS	Farallon Islands (Pacific Ocean off Central California)
FNAL	Fermi National Accelerator Laboratory, Batavia, Illinois
FRR	Foreign Research Reactor
FSVR	Fort St. Vrain Reactor, Platteville, Colorado
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	Fiscal year

GA	General Atomics, San Diego, California
GAP CON	Gap conductance
GCRE	Gas-Cooled Reactor Experiment
GDP	Gaseous diffusion plant
GE	General Electric
GETR	General Electric Test Reactor
GEVNC	General Electric Vallecitos Nuclear Center, Vallecitos, California
GJPO	(DOE) Grand Junction Projects Office, Grand Junction, Colorado
GJRAP	Grand Junction Remedial Action Project
GPU	General Public Utilities Corporation, Parsippany, New Jersey
GTCC	Greater-than-Class-C (low-level waste)
Hanford	Hanford Site, Richland, Washington
HAZWRAP	Hazardous Waste Remedial Actions Program
HEDL	Hanford Engineering Development Laboratory
HEN	Cape Henry (Atlantic Ocean off Virginia)
HFBR	High-Flux Beam Reactor
HIC	High-integrity containers
HLW	High-level waste
HTGR	High-temperature, gas-cooled reactor
HTRE	High-Temperature Reactor Experiment
HWCTR	Heavy-water components test reactor
HWVP	Hanford Waste Vitrification Plant, Hanford Site
ICPP	Idaho Chemical Processing Plant, Idaho National Engineering Laboratory
IDB	Integrated Data Base (Program)
IE	Irradiation effects
I/I	Industrial and institutional (waste)
INEL	Idaho National Engineering Laboratory, Idaho Falls, Idaho
ISL	In situ leaching
ITRI	Inhalation Toxicology Research Institute, Kirtland Air Force Base, Albuquerque, New Mexico
JAI	(E.R.) Johnson Associates, Inc., Oakton, Virginia
JIO	Joint Integration Office, Albuquerque, New Mexico
K-25	Oak Ridge K-25 Site, Oak Ridge, Tennessee (formerly called the Oak Ridge Gaseous Diffusion Plant)
KAPL	Knolls Atomic Power Laboratory, Schenectady, New York
KCP	Kansas City Plant, Kansas City, Missouri
KESS	Kesselring Site, Knolls Atomic Power Laboratory (KAPL)
LANL	Los Alamos National Laboratory, Los Alamos, New Mexico
LBL	Lawrence Berkeley Laboratory, Berkeley, California
LDR	Land disposal restriction
LEHR	Laboratory for Energy-Related Health Research
LEU	Low-enriched uranium
LFRSB	Loose fuel-rod shipping basket
LGR	Light-water cooled, graphite-moderated reactor
LLNL	Lawrence Livermore National Laboratory, Livermore, California
LLR	LOFT lead rod
LLRWPA	Low-Level Radioactive Waste Policy Act of 1980
LLRWPA	Low-Level Radioactive Waste Policy Amendments Act of 1985

LLW	Low-level waste
LLWMP	Low-Level Waste Management Program
LMES	Lockheed Martin Energy Systems, Inc.
LMFBR	Liquid Metal Fast Breeder Reactor
LMIT	Lockheed Martin Idaho Technologies, Idaho Falls, Idaho
LOC	Loss of coolant
LOFT	Loss-of-fluid test
LSA	Low specific activity
LTC	Lynchburg Technology Center, Lynchburg, Virginia
LWBR	Light-water breeder reactor
LWR	Light-water reactor
MACTEC	MAC Technical Services Company
MAPI	Mitsubishi Atomic Power Industries
MASS	Massachusetts Bay
MED	Manhattan Engineer District (Manhattan Project)
MFKY	Maxey Flats, Kentucky (commercial waste site)
MFRP	Midwest Fuel Recovery Plant, Morris, Illinois (commercial spent fuel storage site)
MIMS	Manifest Information Management System
MLLW	Mixed low-level waste
Mound	Mound Plant, Miamisburg, Ohio
MRM	Miscellaneous radioactive material
MSRE	Molten Salt Reactor Experiment
MTIHM	Metric tons initial heavy metal
MTRUW	Mixed transuranic waste
MTU	Metric tons uranium
MURR	Missouri University Research Reactor
MWIR	Mixed Waste Inventory Report
NA	Not applicable
NARM	Naturally occurring or accelerator-produced radioactive material
NEPA	National Environmental Policy Act of 1969
NFS	Nuclear Fuel Services, Erwin, Tennessee
NORM	Naturally occurring radioactive material
NPL	National priorities list
NR	Naval reactors
NRC	Nuclear Regulatory Commission
NRF	Naval Reactors Facility, INEL, Idaho
NTIS	National Technical Information Service, Springfield, Virginia
NTPO	National Transuranic Waste Program Office
NTS	Nevada Test Site, Mercury, Nevada
NUMEC	Nuclear Uranium Materials and Equipment Corporation
NUS	NUS Corporation, Gaithersburg, Maryland
NWPA	Nuclear Waste Policy Act of 1982
NYSERDA	New York State Energy Research and Development Authority, Albany, New York
OPTRAN	Operational transit
OR	Oak Ridge complex: Oak Ridge National Laboratory, K-25 Site, and Y-12 Plant, Oak Ridge, Tennessee
ORAU	Oak Ridge Associated Universities, Oak Ridge, Tennessee
ORIGEN2	Oak Ridge Isotope Generation and Depletion Code (Version 2)
ORISE	Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee

ORNL	Oak Ridge National Laboratory, Oak Ridge, Tennessee
ORR	Oak Ridge Research Reactor
OTS	Office of Technical Services, Roy F. Weston, Inc./H&R Technical Associates, Inc., Germantown, Maryland
PAD	Paducah Gaseous Diffusion Plant, Paducah, Kentucky
PANT	Pantex Plant, Amarillo, Texas
PBF	Power Burst Facility
PCB	Polychlorinated biphenyl
PCM	Power coolant mismatch
Pinellas	Pinellas Plant, Largo, Florida
PNL	Pacific Northwest Laboratory, Richland, Washington
PNRO	DOE Pittsburgh Naval Reactors Office, West Mifflin, Pennsylvania
PORTS	Portsmouth Gaseous Diffusion Plant, Portsmouth, Ohio
PPPL	Princeton Plasma Physics Laboratory, Princeton, New Jersey
PWR	Pressurized-water reactor
PUREX	Plutonium/uranium extraction
RA	Remedial action
RAP	Remedial action project
RCF	RCRA (see below) facility assessment
RCRA	Resource Conservation and Recovery Act of 1976
REECO	Reynolds Electrical and Engineering Co., Inc., Mercury, Nevada
RFETS	Rocky Flats Environmental Technology Site, Golden, Colorado
RH	Remote-handled (transuranic waste)
RI	Rockwell International Corporation, Pittsburgh, Pennsylvania
RIA	Reactivity initiated accident
RICH	Richland, Washington (commercial waste site)
RMI	Reactive Metals, Incorporated Titanium Company Extrusion Plant, Ashtabula, Ohio
SCB	Santa Cruz Basin (Pacific Ocean off Santa Cruz, California)
SDG	San Diego (Pacific Ocean off San Diego, California)
SDS	Submerged demineralizer system
SEG	Scientific Ecology Group, Inc., Oak Ridge, Tennessee
SFD	Severe fuel damage
SFMP	Surplus Facilities Management Program
SHEF	Sheffield, Illinois (commercial waste site)
SLAC	Stanford Linear Accelerator Center, Palo Alto, California
SM	Stationary media
SNAP	Space Nuclear Auxiliary Power
SNF	Spent nuclear fuel
SNL/CA	Sandia National Laboratories/California, Livermore, California
SNL/NM	Sandia National Laboratories/New Mexico, Albuquerque, New Mexico
SNM	Special nuclear material
SNRO	DOE Schenectady Naval Reactors Office, Schenectady, New York
SPERT	Special Power Excursion Reactor Test
SRE	Sodium Reactor Experiment
SRS	Savannah River Site, Aiken, South Carolina
SS	Stainless steel
SSFL	Santa Susana Field Laboratory, Canoga Park, California [also referred to as the Energy Technology Engineering Center (ETEC)]
SWIMS	Solid Waste Information Management System

SWU	Separative work unit
TAN	Test Area North, Idaho National Engineering Laboratory
TBD	To be determined
TC	Thermocouple
TCLP	Toxicity characteristic leaching procedure
TESS	TRW Environmental Safety Systems, Inc.
THOREX	Thorium extraction
TMI	Three Mile Island reactor site, Middletown, Pennsylvania
TRIGA	Training Reactor, Isotopes, General Atomic
TRU	Transuranic
TRUW	Transuranic waste
TSCA	Toxic Substances Control Act of 1976
T/S/D	Treatment, storage, and disposal
TVA	Tennessee Valley Authority, Knoxville, Tennessee
UMT	Uranium mill tailings
UMTRAP	Uranium Mill Tailings Remedial Action Program
VBWR	Vallecitos Boiling-Water Reactor
VEPCO	Virginia Electric Power Company
WAC	Waste acceptance criteria
WEC	Westinghouse Electric Corporation, Pittsburgh, Pennsylvania
WHC	Westinghouse Hanford Company, Richland, Washington
WHPP	(Transuranic) Waste Handling and Packaging Plant, Oak Ridge National Laboratory
WIND	Windsor Site, Knolls Atomic Power Laboratory (KAPL)
WIPP	Waste Isolation Pilot Plant, Carlsbad, New Mexico
WMin	Waste minimization
WPIO	Waste Isolation Pilot Plant Project Integration Office, Albuquerque, New Mexico
WSSRAP	Weldon Spring Site Remedial Action Project, Weldon Spring, Missouri
WTAC	Waste Isolation Pilot Plant Technical Assistance Contractor
WTWBIR	Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report
WVDP	West Valley Demonstration Project, West Valley, New York
WVNS	West Valley Nuclear Services Company, Inc., West Valley, New York
WVNY	West Valley, New York (commercial waste site from 1963–1981)
W/WIPP	Westinghouse/WIPP Project, Carlsbad, New Mexico
Y-12	Oak Ridge Y-12 Plant, Oak Ridge, Tennessee

INTEGRATED DATA BASE REPORT—1994: U.S. SPENT NUCLEAR FUEL AND RADIOACTIVE WASTE INVENTORIES, PROJECTIONS, AND CHARACTERISTICS

ABSTRACT

The Integrated Data Base Program has compiled historic data on inventories and characteristics of both commercial and U.S. Department of Energy (DOE) spent nuclear fuel and commercial and U.S. government-owned radioactive wastes. Except for transuranic wastes, inventories of these materials are reported as of December 31, 1994. Transuranic waste inventories are reported as of December 31, 1993. All spent nuclear fuel and radioactive waste data reported are based on the most reliable information available from government sources, the open literature, technical reports, and direct contacts. The information forecasted is consistent with the latest DOE/Energy Information Administration (EIA) projections of U.S. commercial nuclear power growth and the expected DOE-related and private industrial and institutional activities.

The radioactive materials considered, on a chapter-by-chapter basis, are spent nuclear fuel, high-level waste, transuranic waste, low-level waste, commercial uranium mill tailings, DOE Environmental Restoration Program contaminated environmental media, commercial reactor and fuel-cycle facility decommissioning wastes, and mixed (hazardous and radioactive) low-level waste. For most of these categories, current and projected inventories are given through the calendar-year 2030, and the radioactivity and thermal power are calculated based on reported or estimated isotopic compositions.

0. OVERVIEW

0.1 INTRODUCTION

This report is an update of the previous document¹ on spent nuclear fuel (SNF) and radioactive waste inventories and projections that was prepared for use in the planning and analysis of various SNF and waste management functions. Quantities of SNF and radioactive wastes produced from both commercial and U.S. Department of Energy (DOE)-sponsored activities are reported. Except for transuranic wastes, whose inventories are reported as of December 31, 1993, historical SNF and radioactive waste inventories are reported as of December 31, 1994. Projections of future SNF and radioactive wastes are generally reported for the calendar-year (CY) period 1995–2030. Such projections may change in future revisions of this report as waste minimization (WMin), environmental restoration, and decontamination and decommissioning (D&D) programs and activities at various government and commercial sites are defined and become operative. The tables of this document report historical inventories and projection data on a CY basis. These tables use a horizontal line to mark the point in time when past history ends and future projections begin. Because historical SNF and radioactive waste inventories are generally reported as of December 31, 1994, the line is drawn between the data entries for 1994 and 1995. Data reported for 1995 in this document are regarded as projected information.

This document contains information that has been assembled as a part of the Integrated Data Base (IDB) Program at Oak Ridge National Laboratory (ORNL), which has the lead responsibility for maintaining and reporting summary files of pertinent data on current and projected inventories and characteristics of permanently discharged domestic SNF and radioactive wastes. While this report documents inventories and projections of radioactive wastes from commercial and DOE site activities, estimates for certain other waste categories are not fully reported because of the current unavailability of data. These categories include naturally occurring radioactive material (NORM) or accelerator-produced radioactive material (NARM), discussed in Sect. 0.2, and

wastes from U.S. Department of Defense (DOD) activities, particularly those resulting from the cleanup of military sites contaminated with significant amounts of radioactive waste. A study² by the U.S. General Accounting Office indicates that as many as 420 DOD locations could be contaminated with radioactive wastes. Future updates of this report will work toward reporting information and data on NARM and DOD site radioactive wastes as they become available.

This report also does not report inventories of nonradioactive materials. These include hazardous wastes, sanitary wastes, and materials not categorized as waste (MNCAW), such as uncontaminated scrap metal. Preliminary estimates of inventories of MNCAW are reported in ref. 3.

Radioactive waste originates from five major sources: (1) the commercial nuclear fuel cycle; (2) DOE-related activities; (3) institutions such as hospitals, universities, and research foundations; (4) industrial uses of radioisotopes; and (5) mining and milling of uranium ore. The waste is broadly categorized as SNF, high-level waste (HLW), transuranic waste (TRUW), low-level waste (LLW), and uranium mill tailings (UMT). Large quantities of radioactive waste also result from DOE site environmental restoration activities and the D&D programs of DOE and commercial nuclear facilities. This report also documents inventories and projections of mixed low-level waste (MLLW), which is both hazardous and radioactive.

The primary purpose of this document is to report U.S. SNF and radioactive waste inventories, projections, and characteristics. The data presented were obtained through the cooperation and assistance of the offices and programs that were established by DOE to oversee the management of the various radioactive wastes and SNFs. In addition, the recent literature was reviewed to aid in selecting the data that are presented here and to help establish a basis for many of the calculated radioactivity levels and heat-generation rates that are included. In this report, SNF and radioactive wastes are characterized from the standpoint of their volumes (or masses) and their nuclear, physical, and chemical properties. The data reported are selected from

more extensive information; that information is available upon request.

This annual inventory report contains summarized data of types found to be useful for programmatic planning purposes within the DOE community. The data are intended to provide a common basis for both DOE management-level planning and for more detailed analyses of the waste management system that are conducted by DOE contractors and field offices. However, this report is not intended to present the detailed types of information required as input to such analyses. The best sources of such information are the appropriate DOE operations offices, waste sites, or relevant documents previously issued, some of which may be referenced in this report.

This report does not address the programmatic implications of the data presented, such as the possible future need for interim SNF storage facilities. Discussion of the data is minimized to explain mainly what the data represent. Major DOE data sources providing information and data for this report are identified in a table following the preface. Likewise, discussions of packaging details, shielding and transportation requirements, health and environmental effects, and costs are purposely avoided. Questions regarding the information and data presented may be addressed to the IDB Program.

The DOE waste information and data contained in this report are furnished by the DOE contractor sites listed in Table 0.1. This table indicates also the types of radioactive waste managed at each site. The DOE site data (waste inventories, projections, and characteristics) are used by DOE-Headquarters (DOE-HQ), operations offices, and operating contractors for the management and strategic planning of various waste programs. The objective of this report is to provide waste information that is consistent, reflects current inventories and projections, and includes the types of basic data best suited to meet DOE waste program planning needs.

Information for this report is provided by a variety of sources. The DOE site waste data reported were received from DOE contractors through DOE operations offices. DOE-HQ assigns to selected organizations major responsibilities for providing information on particular topics involving SNF and radioactive waste management. Further detailed information is generally available from data bases maintained at the specific DOE and commercial sites. Additional information on the reference sites and facilities referred to in this report is provided in Appendix C.

0.2 CHARACTERIZATION OF WASTE FORMS

The major characteristics of radioactive materials and wastes are described below.

● Spent Nuclear Fuel (SNF)

SNF consists of irradiated fuel discharged from a nuclear reactor. Unless otherwise identified, all SNFs discussed in this report are assumed to be permanently discharged and eligible for repository disposal. Three categories of permanently discharged SNF are considered: (1) fuel from commercial light-water reactors (LWRs); (2) fuel from non-LWR commercial reactors [e.g., the Fort St. Vrain high-temperature, gas-cooled reactor (HTGR)]; and (3) special fuels associated with government-sponsored research and demonstration programs, universities, and private industries. This report does not track the inventories of government production reactor SNFs that have been reprocessed in the manufacture of nuclear weapons for national defense. However, the inventories of HLW resulting from the reprocessing of these fuels are reported in Chapter 2. Also, Chapter 1 reports quantities of DOE SNF.

Currently, most LWR SNF assemblies are stored in pools at the reactor sites. The bulk of the remainder is in storage at the West Valley Demonstration Project (WVDP) site at West Valley, New York; the Idaho National Engineering Laboratory (INEL) at Idaho Falls, Idaho; and the Midwest Fuel Recovery Plant (MFRP) at Morris, Illinois. The WVDP facility is currently being decommissioned. All utility-owned SNF assemblies previously stored there have been returned to the utilities, and the fuel remaining is DOE-owned material.

SNFs discharged from a variety of reactors are currently stored at the Hanford Site (Hanford) and INEL. Hanford contains inventories of fuel from the N Reactor, the Fast Flux Test Facility (FFTF), and pressurized-water reactor (PWR)—Core II fuel from Shippingport. Fuel from the damaged Three Mile Island (TMI)—Unit 2 reactor, as well as some of the SNF from the Fort St. Vrain HTGR, are stored at INEL. Some special SNFs are stored at the Savannah River Site (SRS) and at INEL. These special fuels are government owned and are not scheduled for reprocessing in support of DOE activities.

- **High-Level Waste (HLW)**

For this report, HLW means the highly radioactive material resulting from the reprocessing of SNF. This includes mainly the liquid wastes remaining from the recovery of uranium and plutonium in a fuel reprocessing plant. This HLW may also be in the form of sludge, calcine, or other products into which such liquid wastes are converted to facilitate their handling and storage. Such waste contains fission products that result in the release of considerable decay energy.⁴ For this reason, heavy shielding is required to absorb penetrating radiation, and provisions (e.g., cooling systems) are needed to dissipate decay heat from HLW.

- **Transuranic Waste (TRUW)**

TRUW refers to radioactive waste that contains more than 100 nCi/g of alpha-emitting isotopes with atomic numbers greater than 92 and half-lives greater than 20 years.^{5,6} Such waste results primarily from fuel reprocessing and from the fabrication of plutonium weapons and plutonium-bearing reactor fuel. Generally, little or no shielding is required ["contact-handled" (CH) TRUW], but energetic gamma and neutron emissions from certain transuranic (TRU) nuclides and fission-product contaminants may require shielding or remote handling ["remote-handled" (RH) TRUW].

- **Low-Level Waste (LLW)**

Several statutes (refs. 4, 6, and 7) define LLW not by what it is, but by what it is not. In general, LLW is radioactive waste not classified as SNF, HLW, TRUW, nor by-product materials such as UMT or thorium mill tailings. However, there are slight differences between the specific regulatory definitions of DOE-generated LLW and commercial LLW.

The definition of DOE LLW is based on DOE Order 5820.2A,⁶ which specifies DOE's policy for radioactive waste management. According to this order, LLW includes all radioactive waste not classified as either HLW, TRUW, SNF, or the bulk of the by-product tailings containing uranium or thorium from processed ore. The DOE policy, as stated in Order 5820.2A, allows small volumes of fissionable material to be irradiated for research and development (R&D) only—but not for the production of power or plutonium—and small concentrations of TRU (<100 nCi/g) radionuclides to be managed as LLW.

The same DOE policy allows small volumes of DOE waste containing by-product material [specified in Sect. 11e(2) of the Atomic Energy Act of 1954 (AEA)]⁸ or NARM to be managed as LLW. Any LLW that also contains hazardous chemicals covered by either the Resource Conservation Recovery Act (RCRA)⁹ or the Toxic Substances Control Act (TSCA)¹⁰ requires management as a "mixed waste."

The definition of commercial LLW is based on two statutes, the Nuclear Waste Policy Act (NWPA)⁴ and the Low-Level Radioactive Waste Policy Amendments Act (LLRWPA).⁷ According to both the NWPA and the LLRWPA, commercial LLW is radioactive material that (a) is not HLW, SNF, TRUW, or by-product material as defined in Sect. 11e(2) of the AEA; and (b) consistent with existing law, is classified by the U.S. Nuclear Regulatory Commission (NRC) as LLW.

The radiation level from LLW waste may sometimes be high enough to require shielding for handling and transport. For commercial LLWs, the NRC has defined, in ref. 11, four disposal categories of LLW that require differing degrees of confinement and/or monitoring: classes A, B, C, and Greater-Than-Class-C (GTCC). The NRC excludes NARM from the LLW category. DOE LLWs are classified by groupings of disposal categories that are site specific, yet similar to the NRC categories. This report documents only those inventories of solid LLW destined for disposal. It includes no liquid or gas waste in storage.

- **Commercial Uranium Mill Tailings (UMT)**

Commercial UMT are the earthen residues that remain after the extraction of uranium from ores. Tailings are generated in very large volumes and contain low concentrations of naturally occurring radioactive materials. These materials comprise a potential health hazard; the isotopes of major concern are ²²⁶Ra and its daughter, ²²²Rn.

- **Mixed Low-Level Waste (MLLW)**

MLLW contains concentrations of both low-level radioactive materials and hazardous chemicals. The hazardous component of mixed waste has characteristics identified by any or all of the following statutes: the RCRA, as amended;⁹ the TSCA;¹⁰ and state regulations. Typically, MLLW from activities supporting DOE programs includes a variety of

contaminated materials, such as air filters, cleaning solutions, engine oils and grease, paint residues, soils, construction and building materials, water-treatment chemicals, and decommissioned plant equipment. This report documents inventories and generation rates of various types of mixed wastes stored at DOE sites based on information reported in the Federal Facilities Compliance Act (FFCA) Mixed Waste Inventory Report (MWIR)¹² and TSCA waste information recently provided by DOE sites.

- **Naturally Occurring Radioactive Material (NORM) or Accelerator-Produced Radioactive Material (NARM)**

NARM wastes include both accelerator wastes (LLW) and naturally occurring radioactive material (NORM) that contain radionuclides (e.g., ²²⁶Ra, ²²²Rn, ²³²Th, ²³⁸U) existing throughout the earth's crust. Accelerator wastes include accelerator targets, wastes from accelerator maintenance or D&D, and wastes from radiopharmaceutical manufacture. NORM wastes are classified according to their specific activity as either discrete or diffuse. Discrete NORM wastes have a relatively small volume but large radioactivity and include industrial gauges, old radium watch and industrial dials, radium needles in medical equipment, and resins (filters) that remove radioactive radium and some radiopharmaceutical waste from contaminated public drinking water. Diffuse NORM wastes are characterized by a relatively large volume with small radioactivity. These materials result from industrial processes and include:

- tailings from metal (e.g., copper and uranium) mining and processing,
- fossil fuel wastes (viz., coal ash from utility electrical generation),
- phosphate mining ore wastes for fertilizer (ammonium phosphate) production,
- sludge from drinking water treatment,
- contaminated water and drilling equipment from oil and natural gas drilling, and
- wastes from geothermal energy production.¹³

Current inventories of domestic NARM wastes are not known. Future updates of this document will include additional information on NARM waste inventories, projections, and characteristics as they become available.

- **Generated, Treated, Stored, and Disposed Wastes**

It should be emphasized that all of the types of radioactive materials and wastes discussed in this report can exist either as material generated, treated, stored, or disposed. The distinctions among these various waste conditions or "states" are as follows:

- *Generated waste.* A material recently discharged from a facility production process or operation that can be regarded as a waste because it has no economic value. In this report, quantities of generated waste are measured in units of volume [cubic meters (m³)] or mass (kg) produced during a calendar year.
- *Treated waste.* A waste that, following generation, has been altered chemically or physically to reduce its toxicity or prepare it for storage or disposal on- or off-site. Waste treatment can include volume-reduction activities, such as incineration or compaction, which may be done prior to either storage or disposal or both (discussed next).
- *Stored waste.* A waste that, following generation (and usually some treatment), is being (temporarily) retained and monitored in a retrievable manner pending disposal. In this report, inventories and projections of stored radioactive materials or wastes are reported in volume (m³) or mass (kg) units or both.
- *Disposed waste.* A waste that has been put in final emplacement to ensure its isolation from the biosphere, with no intention of retrieval. Deliberate action is required to regain access to the waste. Disposed waste includes materials placed in a geologic repository, buried underground in shallow pits, dumped at sea, or discarded by hydrofracture injection. The latter two techniques were past practices and are no longer performed.

Throughout this report, the reader is urged to note the distinctions among these waste conditions. Such conditions have a great impact on the regulatory status of the waste materials considered in this report.

0.3 METHODS AND ASSUMPTIONS USED IN REPORT PREPARATION

This report consolidates a large amount of information from many sources. Some of these data are historical in nature, some are current, and some are projected; some have been calculated or estimated, and some have been measured. Over the years, waste regulations have been revised, waste category definitions have changed, measurement instruments and calibration methods have been improved, and record-keeping has been upgraded at all waste-generating and -receiving sites. In preparing this report, a major effort has been made to integrate waste data from many sources and to strive for a consistent and technically rational approach for the entire scope of coverage. Our primary sources of data are referenced, and, for calculated values (e.g., decayed radioactivity and thermal power), the bases for the calculations are identified. To achieve adequate integration of data, numerous factors had to be considered; these are cited in footnotes that generally accompany the tables and figures of this report. In some cases, a more thorough explanation is provided in the text.

Each chapter details the assumptions on which its waste inventories and projections are based. The broader assumptions are mentioned here and are listed in Table 0.2. These include the projected time frame and specific assumptions used for estimating commercial and government (DOE) waste projections. For the commercial fuel cycle, the SNF and waste projections depend upon the nuclear power growth scenario. The commercial fuel cycle waste projections reported in this document assume a reference projection of nuclear power growth and no SNF reprocessing. The reference nuclear power electrical growth projection (and associated discharged SNF schedule) used throughout this report is the 1995 DOE/Energy Information Administration (EIA) Low Case (No New Orders).¹⁴ Throughout this report this case will be referred to as the Low Case. The Low Case SNF and power-capacity projection cases are based on a set of assumptions involving nuclear electricity generation growth, reactor fuel burnup levels, reactor construction schedules, and reactor operating lifetimes and capacity factors. These assumptions are documented by DOE/EIA in ref. 14. In particular, the Low Case assumes that no new advanced LWRs will become operational before the year 2015 and that all current nuclear units are retired on the dates when their initial license-terms expire.

Detailed information about reactors already built, being built, or planned in the United States for domestic use or export as of December 31, 1994, is provided in report DOE/OSTI-8200-R58 (ref. 15), which contains a comprehensive listing of all domestic reactors categorized

by primary function or purpose: viz., civilian, production, military, export, and critical assembly.

The data for total waste inventories (which comprise historical data) are obviously less accurate than the values recorded for recent waste additions. The number of digits used in reporting these values is generally greater than justified in terms of numerical significance, but this proves useful and necessary for bookkeeping purposes. In some cases, the values cited are significantly different from those previously reported. This is generally a result of improved estimates, new measurements, or redefinition of terms. Explanations are given in such cases. Many of the comments received during the final review stage of this report deal with changes that have occurred after December 31, 1994—some as recently as September 1995. These changes are generally cited in footnotes.

For the sake of brevity, many of the figures and tables of this report use the exponential (E) notation. As examples of this notation, the constant 1.234E+2 means 1.234×10^2 , or 123.4; and 1.234E-4 means 1.234×10^{-4} , which is 0.0001234.

0.4 WASTE CHARACTERISTICS AND UNITS REPORTED

Principal characteristics reported for most radioactive wastes discussed in this report include volume, radioactivity, and thermal power. All characteristics are reported in metric units and, depending on the waste form, can be significant considerations in meeting the requirements for waste treatment, storage, and disposal. Waste volume is reported in cubic meters (m³) and generally reflects the amount of space occupied by the waste and its container. Radioactivity represents the rate of spontaneous disintegration of the radionuclides comprising the waste. In this report, radioactivity is measured by a unit called a curie (Ci), which is 3.7×10^{10} nuclear disintegrations per second. Over time, radionuclides decay to nonradioactive, stable isotopes. As an example, the short-lived radionuclides found in SNF rapidly decay during the first few years after the fuel is removed from a reactor.

It should be noted that while waste volumes accumulate with time by conventional addition, total radioactivity does not. Because of radioactive decay, cumulative activity cannot be based on reported annual additions; rather it must be estimated from knowledge of the waste composition, which includes the radionuclides comprising the waste, their concentrations, and decay attributes (e.g., half-lives and decay schemes). In this report, decayed radioactivity is generally estimated for various wastes by an abridged version of the ORIGEN2

code (ref. 16). Annual levels of radioactivity (Ci) reported in this document include contributions from both parent and daughter decay products.

Thermal power is a measure of the rate of heat-energy emission resulting from the decay of radionuclides in a waste. Like radioactivity, thermal power is not cumulative by conventional addition because of radioactive decay. Information on thermal power is needed in the design of shipping casks, storage facilities, and repositories where temperature rise, especially with regard to SNF and HLW, is an important concern. Thermal energy generation rates are highest for SNF, HLW, and RH TRUW. They may also be important for certain types of LLW. The unit of thermal power used in this report is the watt (W), which represents 1 joule (J) of thermal energy emitted per second. Estimates of thermal power are based on radionuclide composition as well as total activity. While levels of thermal power may not be significant for certain waste forms (particularly some types of LLW), they are nevertheless reported for the major radioactive waste categories referenced in this report to provide a standard for comparison.

For SNF and TRUW, mass is reported to provide better assurances of accountability. SNF is reported in units of metric tons of *initial* heavy metal (MTIHM) to avoid difficulties and confusion arising from the need to estimate ranges of varied heavy-metal content (MTHM) that result from different levels of enrichment and reactor fuel burnup. Mass is reported in kilograms (kg) for the TRU radionuclides comprising TRUWs.

In this report, quantities of generated wastes are expressed in terms of either the amount of mass (kg) or volume (m^3) produced in a given CY. Thus, generation rates for wastes are expressed in either kilograms per year (kg/year) or cubic meters per year (m^3 /year), depending on the availability of site information. Annual generation rates are reported in this document for SNF, TRUW, LLW, and MLLW. Annual generation rates are not reported for HLW in part because of security restrictions for the DOE nuclear weapon production activities that produce these wastes. Additionally, there are problems in accurately estimating HLW generation levels. One major difficulty is accounting for net waste-quantity changes due to the combined effects of various modes of site waste management operations such as evaporation and calcination.

Quantities of wastes can also be reported in terms of the number and types of waste containers. LWR SNF inventories and projections can be expressed in terms of the number of permanently discharged boiling-water reactor (BWR) and PWR fuel assemblies. HLW will be immobilized in either borosilicate glass or a glass/ceramic matrix solidified in stainless steel canisters. Estimates of the quantities of HLW to be disposed of in a geologic

repository are based on the number and types of these canisters. Quantities of LLW and stored TRUW can be based on the number and types of drums, boxes, or containers used or scheduled for use.

Waste characteristics are also identified by waste composition. Throughout this report, waste composition is expressed in terms of the following:

- radioactivity (Ci) or specific-activity (Ci/m^3) breakdown by radionuclide (with accompanying daughter products) and
- physical form (solid, liquid, gas, or sludge) or chemical content (by chemical component), expressed in terms of either volume (m^3) or mass (kg) or as a percentage of total weight (wt %), volume (vol %), or activity (act %).

0.5 CHAPTER OVERVIEWS

A brief summary of each chapter in this report is presented in the following paragraphs.

0.5.1 Spent Nuclear Fuel (SNF)

Chapter 1 of this report presents national data on the quantities of permanently discharged SNF from commercial nuclear power reactors. Historical data on commercial SNF inventories¹⁷ are reported along with 1995 DOE/EIA projections for the Low Case.¹⁴ The Low Case is the baseline commercial scenario used throughout this report to make waste projections. For the projection period considered in this report (CYs 1995–2030), the Low Case assumes that no new reactors will be ordered.

DOE SNF inventories are also reported in Chapter 1. These include various types of research reactor SNFs which are stored at the SRS and the INEL.

In this report, the mass of discharged SNF is generally measured in MTIHM. The term “initial heavy metal” refers to the original mass of the actinide elements of the fuel, most of which is uranium. (Elements of the actinide group are those with atomic numbers greater than 89.)

0.5.2 High-Level Waste (HLW)

The inventories of HLW in storage at the end of CY 1994 and projected through CY 2030 are given in Chapter 2. The waste forms include liquid, sludge, salt cake, slurry, calcine, precipitate, zeolite, glass, and capsules of separated strontium and cesium. Vitrified defense HLW is projected after the startup of the Defense Waste Processing Facility (DWPF) at SRS in 1996, and

projections of vitrified HLW from commercial reprocessing activities are given for the WVDP. Projections recently made of the number of canisters containing the final immobilized form for the DOE HLW at Hanford and the INEL are also reported. In addition, Chapter 2 gives the locations, volumes, and radioactivities of HLW.

In 1992, DOE decided to phase out the reprocessing of its production reactor SNFs. Until then, the reprocessing activities recovered enriched uranium and plutonium which were used to support nuclear weapons production. As a consequence of ceasing to reprocess reactor SNFs, little additional HLW is expected to be generated at DOE sites in the future. However, DOE site D&D activities may generate some wastes with radioactivity levels high enough to require disposal in a deeply mined geologic repository.

0.5.3 Transuranic Waste (TRUW)

The locations, inventories, and projections of TRUW buried and stored at DOE sites are presented in Chapter 3. Inventories of TRUW are reported as of December 31, 1993, and are virtually all derived from government operations. The inventories documented in this report are based on data provided by the sites and include waste volumes and the masses and radioactivities of contained radionuclides. Projected future TRUW volumes through CY 2022 were also requested from the sites, but the sites were not able to make such estimates in all cases. Projections are reported through CY 2022 for those sites that provided estimates.

In 1984, DOE (with input from other federal agencies) revised the minimum radioactivity concentration level for defining TRUW from greater than 10 nCi/g to greater than 100 nCi/g.¹⁸ Consequently, some waste currently in the inventory may contain wastes stored under both criteria. This redefinition, as well as the development of instrumentation to detect these low levels of radioactivity, may reduce the volume of TRUW. As the waste is assayed, that portion of it which is greater than 10 nCi/g and less than 100 nCi/g will be reclassified to other waste categories.

0.5.4 Low-Level Waste (LLW)

Data for LLW from commercial and government activities are given in Chapter 4 and Appendix A. Commercial fuel-cycle LLW is generated from the conversion of yellowcake to uranium hexafluoride (UF₆), enrichment, fuel fabrication, and reactor operation. LLW also results from commercial operations by private organizations that are licensed to use radioactive materials.

These include institutions and industries engaged in research and various medical and industrial activities. DOE LLW is similar in nature to the commercial industrial and institutional (I/I) waste and the commercial fuel cycle LLW.

A wide variety of radionuclides are found in LLW. Uranium isotopes and their daughters dominate in the conversion, enrichment, and fuel-fabrication steps of the nuclear fuel cycle. Reactor operations produce LLW containing mostly activation products and fission products. A significant fraction of institutional LLW that is shipped to disposal sites is contaminated with small quantities of ³H and ¹⁴C.

By the end of 1994, approximately 66% of the total cumulative volume of disposed LLW resulted from various DOE activities. The remaining 34% resulted from domestic commercial activities. About 32% of the volume of LLW disposed during 1994 resulted from commercial activities.

0.5.5 Commercial Uranium Mill Tailings (UMT)

Current inventories and projections of tailings from commercial uranium mill operations are summarized in Chapter 5. Twenty-six licensed uranium mills have accumulated tailings from their operations. Half of these mills have accumulated both commercial and government tailings. By the end of 1994, only two of the NRC-licensed mills were still active. To date, almost all domestic uranium has been produced by conventional mining and milling methods from which these tailings derive. A small portion has been obtained via in situ leaching, recovery from mine water, recovery from copper/vanadium dump leach liquor, and recovery from wet-process phosphoric acid effluents. Projections of uranium mill tailings are based on commercial fuel-cycle requirements, adjusted for foreign imports, as specified by the DOE/EIA Low Case projection of commercial reactor power growth. Tailings from the now inactive mills that produced uranium only for government operations are classified as Environmental Restoration Program wastes (see Chapter 6).

0.5.6 Environmental Restoration Program

An overview of DOE environmental restoration projects and activities is given below. Further details are provided in Chapter 6. The scope of Chapter 6 is limited to radioactive and mixed (radioactive and chemically hazardous) wastes that could be generated by environmental restoration activities. Nonradioactive hazardous and sanitary wastes are outside the scope of this report.

The major objective for DOE environmental restoration activities is to ensure that risks to the environment and to human health and safety posed by inactive and surplus facilities and sites contaminated by radioactive and chemically hazardous materials are either eliminated or reduced to prescribed, safe levels. Projects within the Office of Environmental Restoration (EM-40) are comprised of remedial action (RA) and decommissioning activities. RA involves the assessment and cleanup of inactive sites and deals mainly with contaminated environmental media such as soil, sediment, and ground water. Decommissioning activities are primarily concerned with the safe caretaking of surplus nuclear facilities following shutdown and for either their ensuing decontamination for reuse or their complete dismantlement. About 500 contaminated facilities are currently included in the EM-40 inventory for future action.

An intensive effort is currently under way to better define waste management requirements for implementing the DOE environmental restoration program. This information will assist DOE in planning, constructing, and operating appropriate treatment, storage, and disposal facilities to manage the wastes resulting from implementation of the EM-40 program. Waste projections are currently available for only a few sites. Hence, environmental restoration waste volumes are not provided in this report. However, the volumes of contaminated solid media, such as soils and debris from which environmental restoration wastes will be generated, are known at most EM-40 sites. Estimates of the volumes of such contaminated media are reported in Chapter 6.

0.5.7 Commercial Decommissioning Wastes

Chapter 7 presents waste projections for the decommissioning of commercial power reactors and fuel cycle facilities. The D&D activities at such installations may result in very large volumes of LLW, depending on the methods selected. The major LLW volumes will result from the decommissioning of power reactors, which will also produce a small volume of high-activity waste. Unlike that for other waste generation activities, the timing of decommissioning operations is very uncertain, since facilities may be either decommissioned upon shutdown or put into a mothballed or protective storage condition to allow for sufficient radioactive decay before decommissioning. Chapter 7 reports a set of projected characteristics for wastes from commercial LWR decommissioning activities. These projections are based on the assumption that each power reactor is decommissioned soon after it is shut down. To date, only a few commercial reactors have been fully

decommissioned, and several have been placed in protective storage. Wastes from completed decommissioning actions have been included with existing inventories discussed in other chapters. Because of timing uncertainties, projected commercial decommissioning wastes are not included in the projections of LLW (Chapter 4). Rather, commercial decommissioning waste projections are reported separately in Chapter 7.

0.5.8 Mixed Low-Level Waste (MLLW)

Current inventories and generation rates of MLLW from both DOE and commercial sources are summarized in Chapter 8. These wastes are contaminated with both low-level radioactivity and chemically hazardous substances. The radioactive components are defined by the AEA,⁸ while the hazardous components are defined by the RCRA,⁹ the TSCA,¹⁰ and pertinent state regulations. As of the end of 1994, inventories of MLLW at DOE sites totaled about 162,400 m³. It is estimated that about 97,100 m³ of MLLW will be generated during the period 1994–1998.

0.5.9 Appendixes

Several appendixes are included in this report. Appendix A is a compilation of waste flowsheets, source terms, and characteristics used for waste projections. Source terms include both quantitative and descriptive characteristics used to describe radioactive wastes. As developed and used in the IDB Program, the source term for a particular waste is comprised of two components unique to that waste: (1) the number of curies of radioactivity, expressed either per unit of facility production or per unit of waste volume or mass, and (2) a listing of the relative contributions of component radioisotopes per curie of radioactivity of the waste. A tabulation of the properties of important radionuclides is given in Appendix B. Appendix C lists the sites and facilities referred to in this report. Appendix D describes how to get computer access to this document via the Internet, and Appendix E describes a reader comment form, which is provided in the front of this report.

0.6 SUMMARY DATA

A few graphical presentations and summary tables are included in this chapter to provide a broad overview. Figures 0.1 and 0.2, respectively, show the volumes and decayed radioactivities of commercial and DOE wastes and SNF accumulated through 1994.

Summaries of SNF and radioactive waste inventories and projections are provided in Tables 0.3 and 0.4. In general, material to be sent to R&D facilities or to the proposed national geologic repository for SNF and HLW is still listed in each individual site's inventory.

DOE waste volume summaries for specific sites are given in Tables 0.5–0.7. Waste generation for 1994 is presented in Table 0.5, and cumulative 1994 inventories

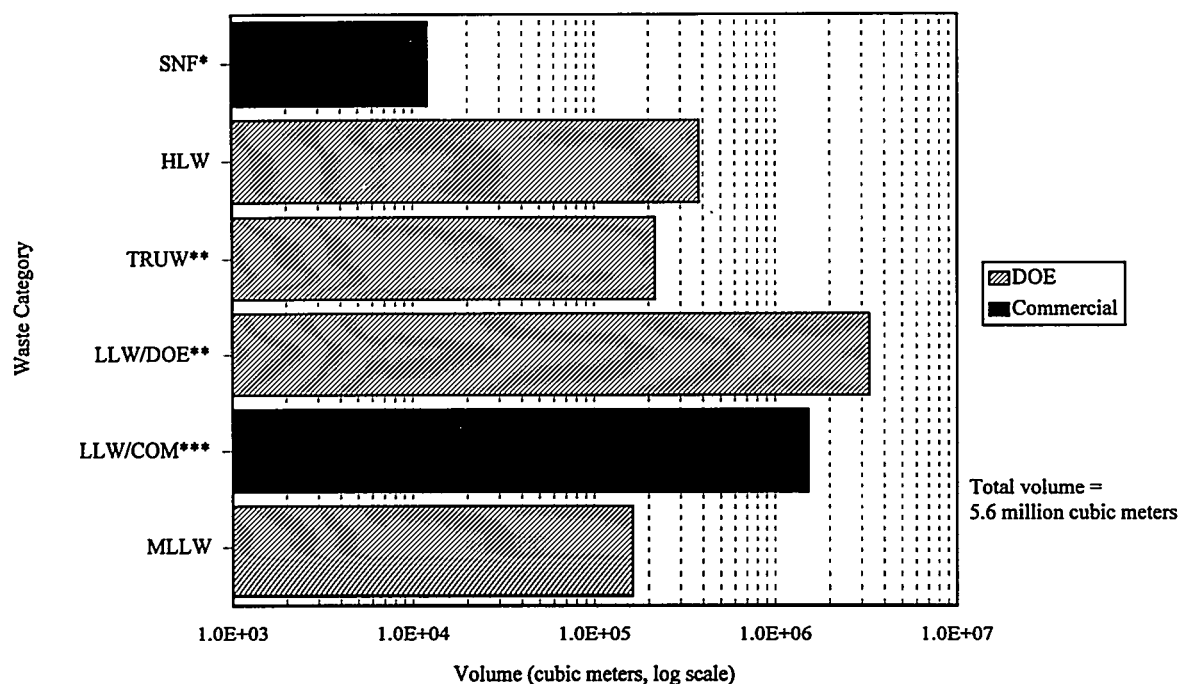
for stored and buried wastes are provided in Tables 0.6 and 0.7, respectively.

In recent years, various types of DOE and commercial wastes have been disposed of at a facility operated by Envirocare of Utah, Inc., near Clive, Utah. A summary of 1994 disposed waste volume inventories at the Envirocare Facility is given in Table 0.8 (data from ref. 19).

0.7 REFERENCES

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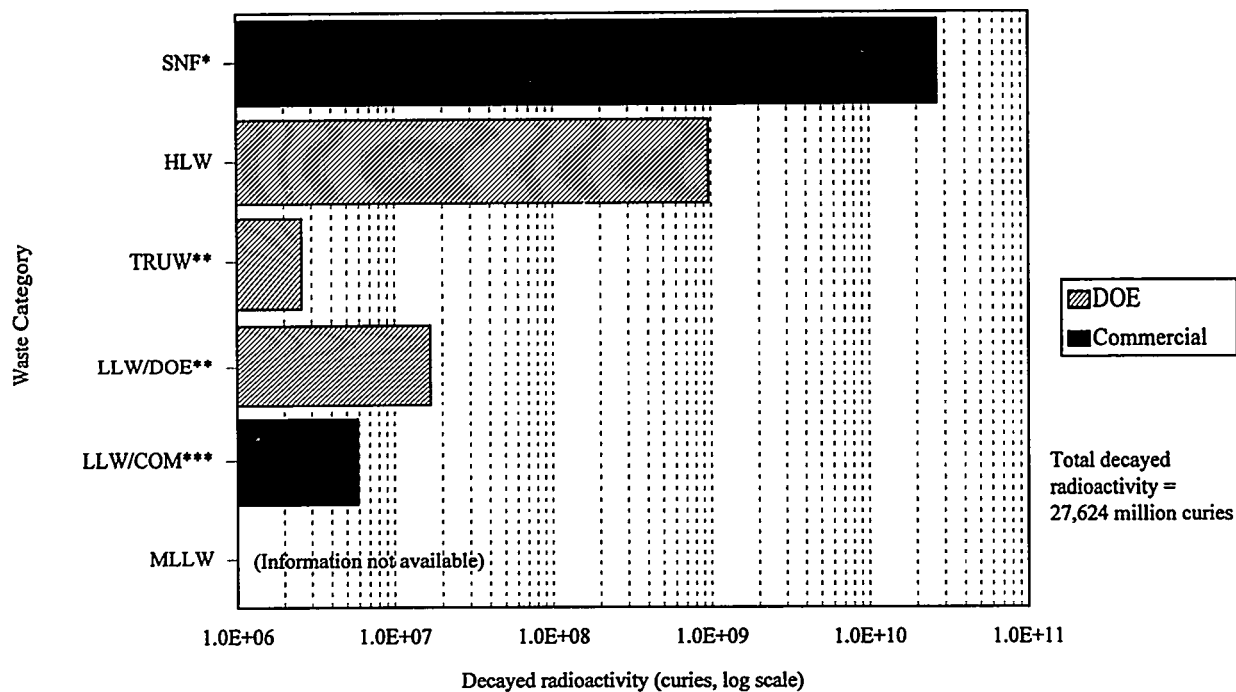


* Commercial LWR fuel permanently discharged. Includes spacing between fuel assembly rods.

** DOE wastes include both retrievably stored and buried materials. Excludes LLW disposed of at Envirocare facility.

*** Includes contributions from disposed wastes only. Excludes LLW disposed of at the Envirocare facility.

Fig. 0.1. Total volumes of DOE and commercial radioactive wastes and spent nuclear fuel through 1994.



* Commercial LWR fuel permanently discharged.

** DOE wastes include both retrievably stored and buried materials. Excludes LLW disposed of at Envirocare facility.

*** Includes contributions from disposed wastes only. Excludes LLW disposed of at Envirocare facility.

Fig. 0.2. Total decayed radioactivities of DOE and commercial radioactive wastes and spent nuclear fuel through 1994.

Table 0.1. Types of radioactive wastes managed at DOE sites referenced in this report^a

Site(s)	Symbol/label	SNF	HLW	TRUW	LLW	MLLW	UMT
Ames Laboratory	Ames			X	X	X	
Argonne National Laboratory-East	ANL-E	X		X	X	X	
Argonne National Laboratory-West	ANL-W	X		X	X	X	
Battelle Columbus Laboratories	BCL			X	X		
Brookhaven National Laboratory	BNL	X			X	X	
Energy Technology Engineering Center	ETEC			X	X	X	
Fermi National Accelerator Laboratory	FNAL				X		
Fernald Environmental Management Project	FEMP				X	X	
Hanford Site ^b	Hanford	X	X	X	X	X	
Idaho National Engineering Laboratory ^c	INEL	X	X	X	X	X	
Inhalation Toxicology Research Institute	ITRI				X	X	
K-25 Site (Oak Ridge)	K-25				X	X	
Kansas City Plant	KCP				X	X	
Lawrence Berkeley Laboratory	LBL			X	X	X	
Lawrence Livermore National Laboratory	LLNL			X	X	X	
Los Alamos National Laboratory	LANL	X		X	X	X	
Missouri (Univ. of) Research Reactor	MURR			X			
Mound Plant	Mound			X	X	X	
Naval Reactors Facilities and Shipyards ^d	NR Sites			X	X	X	
Nevada Test Site	NTS			X	X	X	
Oak Ridge Institute of Science and Education	ORISE				X		
Oak Ridge National Laboratory	ORNL	X		X	X	X	
Paducah Gaseous Diffusion Plant	PAD			X	X	X	
Pantex Plant	PANT			X	X	X	
Pinellas Plant	Pinellas				X	X	
Portsmouth Gaseous Diffusion Plant	PORTS				X	X	
Princeton Plasma Physics Laboratory	PPPL				X	X	
Reactive Metals, Inc., Extrusion Plant	RMI				X	X	
Remedial Action Program Sites ^e	RAP Sites			X	X	X	X
Rocky Flats Environmental Technology Site	RFETS			X	X	X	
Sandia National Laboratory/California	SNL/CA				X	X	

Table 0.2. Major assumptions used in this report

Inventory/projection basis

- Inventories are reported as of December 31, 1994
- Projections are made for the CYs 1995–2030

HLW solidification activities

- For WVDP, HLW solidification (glass production) starts in 1996 and is completed in 1998
- For SRS, HLW solidification [glass production at the Defense Waste Processing Facility (DWPF)] starts in 1996 and continues through 2021
- For INEL, HLW solidification (immobilization) starts in 2019 and continues through 2045
- For Hanford, HLW solidification (borosilicate glass production at the Hanford Waste Vitrification Plant) starts in 2010 and continues through 2028

Commercial activities

- DOE/EIA projections of installed net LWR electrical capacity for the Low Case^a of ref. 14:

Low Case

Year	1995	2000	2005	2010	2015	2020	2025	2030
GW(e)	99	100	100	91	61	47	22	2

- DOE/EIA assumptions for LWR fuel enrichment and design burnup:

<u>LWR fuel</u>	<u>CY fuel is loaded</u>	<u>Fuel enrichment (% ²³⁵U)</u>	<u>Design burnup (MWd/MTIHM)</u>
BWR	1993	3.20	36,000
	1998	3.35	40,000
	2006	3.50	43,000
	2018	3.67	46,000
PWR	1993	3.81	42,000
	1998	4.06	46,000
	2004	4.38	50,000
	2008	4.72	55,000
	2018	5.03	60,000

- SNF from commercial reactors is not reprocessed. Thus, a fuel cycle without reprocessing is assumed for all commercial projections

^aThis case assumes that each reactor will be retired when the expiration date specified in its operating license is reached. Previously, this case was referred to as the No New Orders Case.

Table 0.3. Spent nuclear fuel and radioactive waste inventories as of December 31, 1994

Waste category	TRU isotopes (kg)	Mass (MTIHM)	Volume (m ³)	Radioactivity ^a (10 ⁶ Ci)	Thermal power (10 ³ W)
Spent nuclear fuel					
Commercial					
BWRs		10,788	4,349 ^b	7,540	27,800
PWRs		19,024	7,669 ^b	19,100	72,500
DOE		>2,643	1,213	c	c
High-level waste					
Savannah River (DOE)			126,300	534.5	1,497.3
Idaho (DOE)			11,000	51.6	150.8
Hanford (DOE) ^d			238,900	348.0	999.8
West Valley (commercial)			2,180	24.7	78.1
Transuranic waste (DOE) ^c					
Buried TRUW	c		141,100	>0.75	c
Potentially contaminated soil	c		>32,000	>0.08	c
Stored TRUW	c		74,200	1.84	c
Low-level waste					
DOE sites					
Generated			37,985	0.9	c
Cumulative stored			125,890 ^f	3.9	c
Cumulative disposed			2,963,349	12.9	21.5
Commercial sites					
Cumulative disposed			1,518,878	5.8	22.7
Envirocare disposal facility			40,461	c	c
Uranium mill tailings (commercial)					
Licensed mill sites ^g			118,600,000	c	c
Environmental restoration program wastes (DOE) ^h			c	c	c
Commercial reactor decommissioning			27,156 ⁱ	c	c
MLLW (cumulative stored)					
DOE		105,666 ^j	162,377	c	c
Commercial		c	c	c	c
Envirocare disposal facility		c	3,621	c	c

^aExcept for transuranic wastes, radioactivity data are calculated decayed values as of December 31, 1994.

^bIncludes volume of spacing between the fuel rods of each assembly.

^cInformation not available.

^dHanford tank wastes consist of HLW, TRUW, and LLW. However, in the interim storage mode, the tank wastes are managed as if they contain HLW and, therefore, are included in the HLW inventory.

^eData as of December 31, 1993.

^fExcludes 200,000 m³ of 11e(2) by-product material that is in storage.

^gIncludes contributions from 26 NRC-licensed mills.

^hInformation currently not available. DOE is undertaking several initiatives to better define the volumes and types of wastes currently in storage at environmental restoration sites and those which may be generated during future remediation activities across the entire DOE complex. This information, which should become available in a few years, will be included in future revisions of this report.

ⁱQuantity of LLW shipped from completed and ongoing reactor decommissioning projects. This inventory is included in the commercial LLW inventory listed above.

^jMass of MLLW is expressed in metric tons (t) and includes other elements in addition to heavy metals. Does not include contributions from some sites that reported volume data.

Table 0.4. Current and projected cumulative quantities of radioactive waste and spent nuclear fuel

[Quantities are expressed as volume (10³ m³) unless otherwise indicated]

Source and type of material	End of calendar year				
	1994	2000	2010	2020	2030
DOE sites					
SNF, mass, MTIHM ^a	>2,643	b	b	b	b
HLW					
Interim storage	378.4	341	259	83	7
Glass or glass/ceramic ^c	0	0.3	2.0	8.7	12.8
TRUW					
Buried	141 ^d	141	141	141	141
Stored	75.4 ^d	b	b	b	b
LLW (buried) ^e	2,963	3,572	4,534	5,494	5,926
Environmental restoration program wastes ^f	b	b	b	b	b
MLLW	162.4	b	b	b	b
Commercial sites					
LWR SNF, mass, MTIHM ^{a,g}					
(no reprocessing)					
Low Case	29,812	42,300	61,800	77,100	84,100
HLW (WVDP)					
Interim storage	2.180	0.0	0.0	0.0	0.0
Glass	0.0	0.24	0.24	0.24	0.24
LLW (no reprocessing)	1,519	1,665	b	b	b
D&D (LLW) ^h					
Classes A, B, and C LLW	i	0.00	0.83	124.23	453.22
Greater-than-Class-C LLW	i	0.00	0.00	0.10	0.45
Mill tailings (no reprocessing)	118,600	118,800	120,500	b	b
MLLW	b	b	b	b	b
Envirocare disposal facility					
LLW	40.5	b	b	b	b
MLLW	3.6	b	b	b	b
NARM/NORM	3.3	b	b	b	b
11e(2) by-product	16.8	b	b	b	b

^aHistorically, spent nuclear fuel has been measured in units of mass (MTIHM) rather than units of volume.^bInformation not available.^cIncludes projections for glass at SRS and glass/ceramic at INEL.^dProjected inventory level for end of CY 1994.^eProjections include contributions from SRS saltstone.^fInformation currently not available. DOE is undertaking several initiatives to better define the volumes and types of wastes currently in storage at environmental restoration sites and those which may be generated during future remediation activities across the entire DOE complex. This information, which should be available in a few years, will be included in future revisions of this report.^gThe 1994 discharged spent nuclear fuel mass is a BWR and PWR mass sum rounded to the nearest metric ton. Such rounding may result in slight differences between the spent nuclear fuel inventories and projections reported in this document and those reported by DOE/EIA.^hProjected D&D wastes from light-water reactors shut down after 1994. Wastes collected from historical D&D of reactors are included in the LLW inventories listed above.ⁱInformation not applicable.

Table 0.5. Volume (m³) of DOE site wastes generated during calendar year 1994

Site(s)	HLW	TRUW		LLW ^b	MLLW		Total (site)
		CH ^a	RH ^a		RCRA ^c	TSCA	
Ames				5	d		5
ANL-E		2		669	14	52	737
ANL-W		2	d		3	e	5
BNL				254	<1	d	255
ETEC					e	8	8
FEMP					e	e	e
FNAL				61	e		61
GJPO					d	2	2
Hanford		169	2	4,498	1,312	3	5,984
INEL				2,665	160	1	2,826
ITRI				31	15		46
K-25				8,135	215	5,587	13,937
KCP				<1	e		<1
LANL		254	12	1,898	17	167	2,348
LBL				15	1	3	19
LLNL		21		53	282	1	357
Mound				909	e	7	916
NR sites			1	1,568	224	344	2,137
NTS				71	507		578
ORISE				12	e		12
ORNL		9	12	1,322	115	13	1,471
PAD					e	1,061	1,061
PANT				122	177	3	302
Pinellas				52	e		52
PORTS					330	260	590
PPPL				42	2		44
RFETS		66		503	725	36	1,330
SLAC				81	e		81
SNL/CA				24	1	d	25
SNL/NM					6	e	6
SRS		509	4	10,491	1,846	12	12,862
WVDP		55		1,372	6	4	1,437
Y-12				3,131	310	21	3,462
Others ^f					6,078		6,078
Total (complex)	0	1,087	31	37,985	12,347	7,585	59,035

^aProjected annual addition to stored inventory during 1994. Includes contributions from both mixed and nonmixed wastes.

^bExcludes wastes from DOE environmental restoration programs.

^cAnnual average estimated for the period 1994-1998.

^dTrace amount.

^eInformation unavailable or unknown.

^fIncludes contributions from 14 sites.

Table 0.6. Cumulative volume (m³) of stored DOE site wastes as of December 31, 1994

Site(s)	HLW	TRUW ^a		LLW	MLLW		Total (site)
		CH	RH		RCRA	TSCA	
Ames				16	b	3	19
ANL-E		31		284	34	52	401
ANL-W		2	9		391	c	402
BNL				556	27	2	585
ETEC				565	1	11	577
FEMP				27,000 ^d	2,151	c	29,151
FNAL				83	c		83
GJPO					<1	47	48
Hanford	238,900	9,559	35	51	6,331	96	254,972
INEL	11,000	34,700	31	14,080	25,440	2	85,253
ITRI				51			51
K-25				14,586	29,473	9,493	53,552
KCP				9	c		9
LANL		11,154	103		609	5,993	17,859
LBL				19	6	b	25
LLNL		245		606	457	2	1,310
Mound		263		8,860	98	16	9,237
NR sites			12		48	22	82
NTS		620		270	908		1,798
ORISE					c		c
ORNL		792	1,006	3,538	3,020	15	8,371
PAD				5,400	1,028	4,359	10,787
PANT				209	128	3	340
Pinellas				66			66
PORTS				25,000	7,514	3,670	36,184
PPPL				3			3
RFETS		1,196		5,315	13,550	112	20,173
SLAC				242	6		248
SNL/CA				26	<1	b	27
SNL/NM					75	c	75
SRS	126,300	15,109	4	1,655	7,200	142	150,410
WVDP	2,200		427	14,274	86	44	17,031
Y-12				825	13,465	150	14,440
Others ^e				2,301 ^f	26,706		29,007
Total (complex)	378,400	73,671	1,627	125,890	138,754	24,234	742,576

^aProjected for the end of CY 1994. Includes both mixed and nonmixed wastes.

^bTrace amount.

^cInformation unavailable or unknown.

^dExcludes 10,000 m³ of 11e(2) by-product material that is in storage.

^eIncludes contributions from 14 sites.

^fExcludes 190,000 m³ of 11e(2) by-product material that is in storage at the Weldon Spring Site Remedial Action Project.

Table 0.7. Cumulative volume (m³) of buried DOE site wastes^{a,b,c,d}

Site(s)	TRUW ^e	LLW ^f	Total (site)
Ames		200	200
ANL-E			
ANL-W			
BNL		839	839
ETEC		343,218	343,218
FEMP			
FNAL			
GJPO			
Hanford	63,600	615,283	678,883
INEL	57,100	148,990	206,090
ITRI			
K-25		81,048	81,048
KCP			
LANL	14,000	222,610	236,610
LBL			
LLNL		9,102	9,102
Mound			
NR sites			
NTS		481,308	481,308
ORISE			
ORNL	176	209,665	209,841
PAD		7,613	7,613
PANT		134	134
Pinellas			
PORTS		12,110	12,110
PPPL			
RFETS			
SLAC			
SNL/CA			
SNL/NM	1	3,218	3,219
SRS	4,870	676,668	681,538
WVDP	1,350	^g	1,350
Y-12		151,343	151,343
Total (complex)	141,097	2,963,349	3,104,446

^aExcludes 89,472 containers (94,273 Ci, undecayed) of LLW in 50- and 80-gal drums disposed of by sea dumping.

^bExcludes 17,300 m³ (1,300,000 Ci, undecayed) of LLW grout injected into shale underlying the ORNL site.

^cExcludes wastes from environmental restoration activities.

^dExcludes contributions from the following DOE wastes disposed of at the Envirocare Facility as of the end of 1994: LLW (1,759 m³), MLLW (1,356 m³), and 11e(2) by-product material (3,822 m³).

^eAs of December 31, 1993.

^fAs of December 31, 1994. The data listed for LLW represent disposed inventories and include materials that are not buried.

^gOnly commercial LLW is buried at WVDP.

Table 0.8. Volume (m³) summary of radioactive wastes disposed of at the Envirocare Facility near Clive, Utah^a

Waste type	DOE wastes		Commercial wastes	
	1994	Cumulative ^b	1994	Cumulative ^c
LLW	1,427	1,759	11,957	38,702
MLLW	1,288	1,356	851	2,265
NARM/NORM ^d	0	0	811	3,320
11e(2) ^e	3,822	3,822	13,005	13,005
Total	6,537	6,937	26,624	57,292

^aBased on ref. 19.

^bCovers wastes disposed during 1992–94.

^cCovers wastes disposed during 1988–94.

^dSoil contaminated with radium and building debris.

^eBy-product material as defined in Section 11e(2) of the Atomic Energy Act of 1954 (P.L. 83–703).



Spent nuclear fuel being generated in the assemblies of the core of the Advanced Test Reactor at the Idaho National Engineering Laboratory, Idaho Falls, Idaho. *Courtesy of Lockheed Martin Idaho Technologies, Idaho Falls, Idaho.*

1. SPENT NUCLEAR FUEL

1.1 INTRODUCTION

This chapter reports the quantities and characteristics of spent nuclear fuel (SNF) that has been permanently discharged from commercial LWRs and one-of-a-kind reactors. In addition, this chapter contains a mass summary report of DOE SNF (see Sect. 1.4) which is not scheduled for reprocessing. Though currently in storage at numerous commercial and DOE sites, this fuel will ultimately require geologic disposal.

Some commercial SNF in inventory will be reinserted into reactors for further irradiation. However, this amount is relatively small, and the schedules for reinsertion are not always predictable. Therefore, for the purposes of this report, all SNF is considered permanently discharged from the reactors.

Historical inventories of LWR SNF have been updated through December 31, 1994.¹ The data reported in this chapter include the inventories of SNF stored at the West Valley Demonstration Project (WVDP), the Midwest Fuel Recovery Plant (MFRP), and the Idaho National Engineering Laboratory (INEL) sites in addition to those stored at the various reactor sites. The map in Fig. 1.1 shows the locations of existing and planned power reactor sites and commercial LWR SNF storage facilities. A list of commercial reactors is given also in report DOE/OSTI-8200-R58 (ref. 2).

Projections of nuclear capacity and SNF discharges are given for the years 1995–2030 for the DOE/EIA Low Case (No New Orders) forecast schedule reported in ref. 3. The Low Case (No New Orders) forecast, hereafter referred to simply as the Low Case, projects installed capacity to increase from 99.1 GW(e) at the end of 1994 to 100.3 GW(e) by the year 2000, ultimately decreasing to 2.3 GW(e) by 2030.

The Low Case reference scenario considered for projecting accumulated SNF assumes a fuel cycle with no reprocessing. Commercial SNF projections developed for the DOE/EIA Low Case are illustrated, along with historical discharge data, in Figs. 1.2–1.4. SNF discharge projections, in terms of annual mass discharged and accumulated radioactivity, are graphically illustrated in Figs. 1.2 and 1.3, respectively. A graph showing the

increase in the cumulative mass of discharged SNF for the DOE/EIA Low Case is shown in Fig. 1.4. This plot also shows both the age and mass distribution for SNF from 1970 to 2030.

DOE/EIA projections for the Low Case assume that burnup levels of discharged SNF will increase from their current average levels of 33,065 and 39,989 MWd/MTIHM for BWR and PWR fuel, respectively, at the rate of about 0.5%/year for BWR fuel and about 1.0% per year for PWR fuel. This increase in burnup is projected to occur from 1994 to approximately 2020, at which time the equilibrium cycle burnup is projected to be roughly 42,000 and 54,000 MWd/MTIHM (ref. 3) for BWR and PWR fuel, respectively. The final cycle discharges will be somewhat lower because most of the final cycle cores will not have achieved the projected design burnups. Figure 1.5 graphically illustrates how the activity and thermal power of BWR and PWR SNF vary with burnup and time from discharge.⁴

1.2 COMMERCIAL SPENT NUCLEAR FUEL

1.2.1 Inventories and projections

The total inventory of commercial LWR SNF in storage at the WVDP site, the MFRP, INEL, and the reactor sites as of December 31, 1994, amounted to 29,812 MTIHM. Of this total amount, 27 MTIHM are in storage at the WVDP site,⁵ 674 MTIHM are in storage at the MFRP,¹ and 43 MTIHM are in storage at INEL.¹ The remainder is stored at the reactor sites. These inventories do not include the SNF reprocessed at the WVDP site when the facility was operated as a fuel reprocessing plant. Additional information on WVDP SNF inventories is given in Chapter 7, Table 7.22. Details concerning the SNF reprocessed at West Valley may be obtained from ref. 6.

A BWR/PWR breakdown of the electric power generating capacity for the Low Case forecast, along with historical reactor capacity data, is given in Table 1.1. Table 1.2 gives the projected cumulative mass of

commercial SNF discharges associated with the DOE/EIA capacity-growth forecast given in Table 1.1. The historical and projected buildups of permanently discharged BWR and PWR SNF mass, radioactivity, and thermal power are given for the DOE/EIA Low Case in Table 1.3. Projections of the number of permanently discharged BWR and PWR SNF assemblies for the DOE/EIA Low Case are given in Table 1.4.

The historical and projected mass of SNF discharged from a one-of-a-kind reactor, the Fort St. Vrain HTGR,⁷ is given in Table 1.5. All of the discharged nuclear fuel from the Fort St. Vrain reactor that has been shipped off-site is located at the ICPP. The Fort St. Vrain reactor was permanently shut down in 1989.

1.2.2 Characterization

Reference characteristics of BWR and PWR fuel assemblies, obtained from refs. 8 and 9, were used for this report. These characteristics are summarized in Table 1.6. Fuel assembly structural material masses and compositions, nonactinide fuel impurities, and other physical and irradiation characteristics of LWR SNF are discussed in ref. 10. More detailed information on SNF characteristics may be found in ref. 11. The BWR and PWR SNF annually discharged has a broad range of burnup levels, as illustrated in Tables 1.7 and 1.8, respectively. The mass, radioactivity, and thermal power of the nuclides contained in all stored domestic commercial LWR SNF as of December 31, 1994, are listed in Table A.2 in Appendix A.

1.3 DISPOSAL

Through the first half of 1995, the Office of Civilian Radioactive Waste Management (OCRWM) met regulatory milestones by completing the first Technical Basis Report on surface processes and by submitting the Annotated Outline for the License Application. Extensive surface-based and underground investigation is being conducted. This investigation is essential to evaluate the suitability of the Yucca Mountain site before a license

application can be submitted to the Nuclear Regulatory Commission (NRC). This work is well underway and will lead to a determination of the suitability of the Yucca Mountain site in 1998.

Tunnel excavation is proceeding well despite ground conditions that have been more difficult than anticipated. The assembly of the 25-ft diameter Tunnel Boring Machine (TBM) was completed, and the TBM was moved into the Starter Tunnel in early August 1994. The TBM had advanced to 3,733 ft by the end of June 1995, when it was shut down for a scheduled maintenance service and the installation of a muck conveyor.

As of this writing (late summer, 1995), the Congress was involved in a broad debate regarding the future direction of the Repository Program. A number of bills were introduced, and hearings were held. The discussion focused on the interim storage issue and the related aspects of the budget.

1.4 DOE SPENT NUCLEAR FUEL

Summary inventory characteristics of DOE SNF as of July 1995 are given in Table 1.9 (based on ref. 12). Projected site inventories for the year 2035 are also included.

For purposes of clarification, the quantities of SNF reported in Table 1.9 include contributions from other nuclear fuels besides those permanently discharged from production reactors. SNFs reported in this table also include DOE-owned nuclear fuel that has been withdrawn from or resides for storage in a nuclear reactor following irradiation, the constituent elements of which have not been separated by processing. In addition to intact fuel, reactor-irradiated fuel materials requiring special handling (e.g., defective fuel and special fuel forms) are also considered SNF and are eligible for inclusion in Table 1.9. This table also lists some commercially generated nuclear fuels and nuclear fuels from foreign reactors and university research reactors which are stored at DOE sites. More detailed information on these special nuclear fuels will be included in future updates of this report.

1.5 REFERENCES

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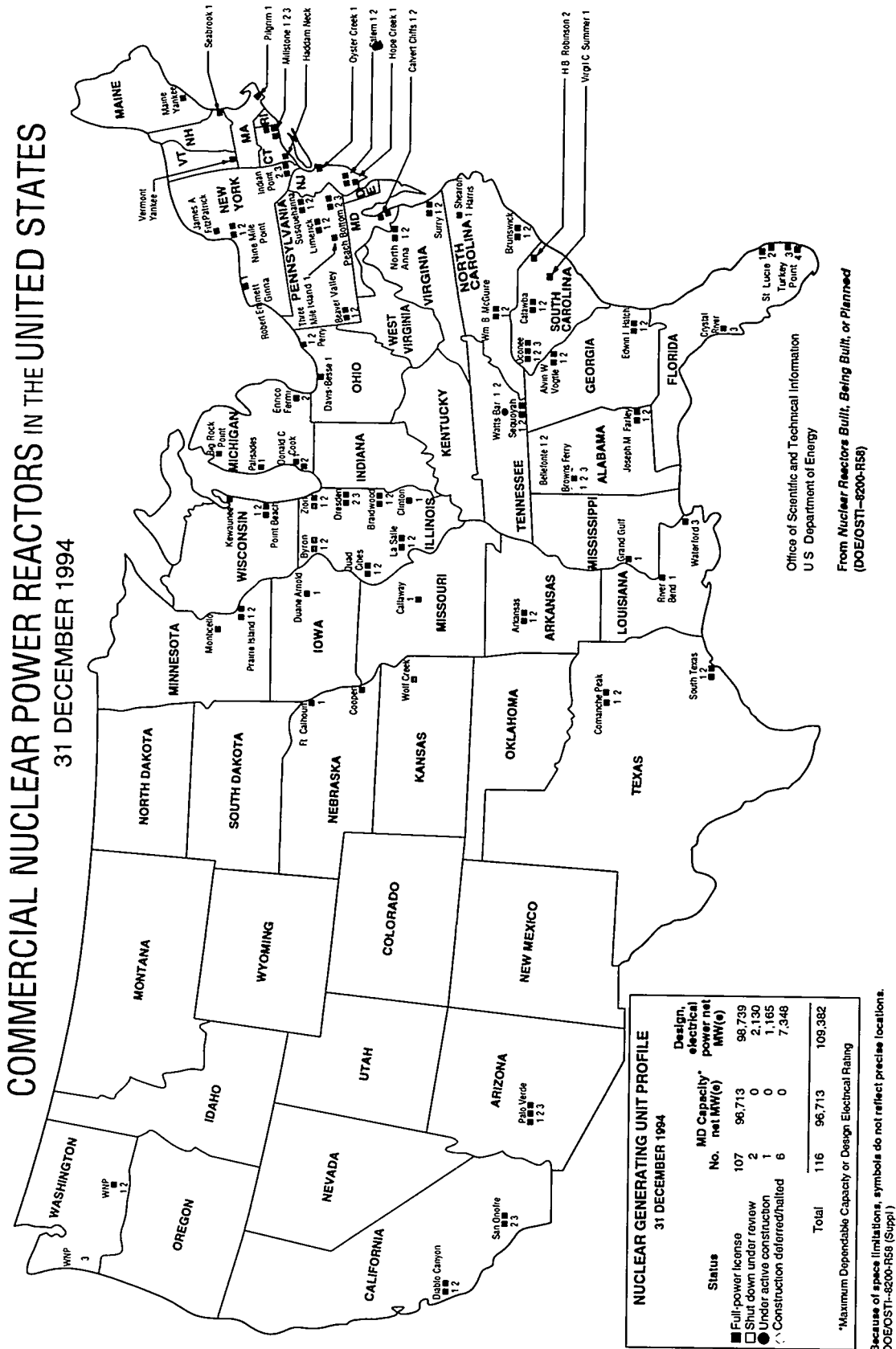


Fig. 1.1. Locations of existing and planned commercial reactors as of December 31, 1994. Courtesy of U.S. Department of Energy, Office of Scientific and Technical Information, Oak Ridge, Tennessee.

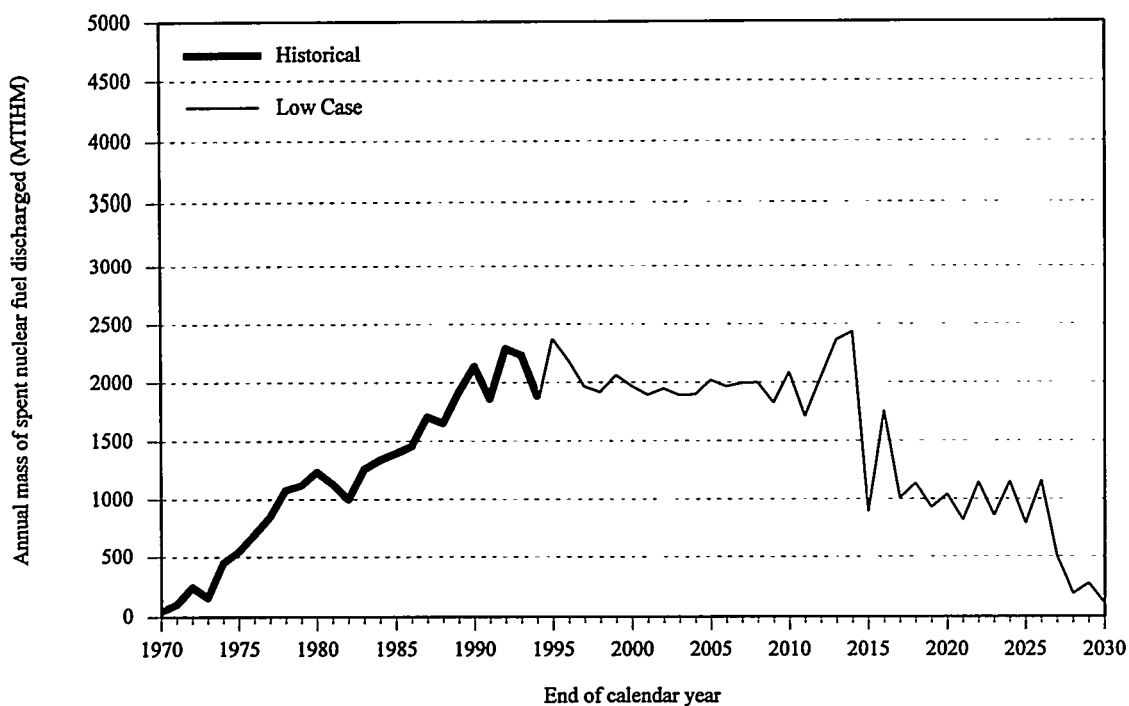


Fig. 1.2. Projected mass (MTIHM) of annual commercial spent nuclear fuel discharges for the DOE/EIA Low Case.

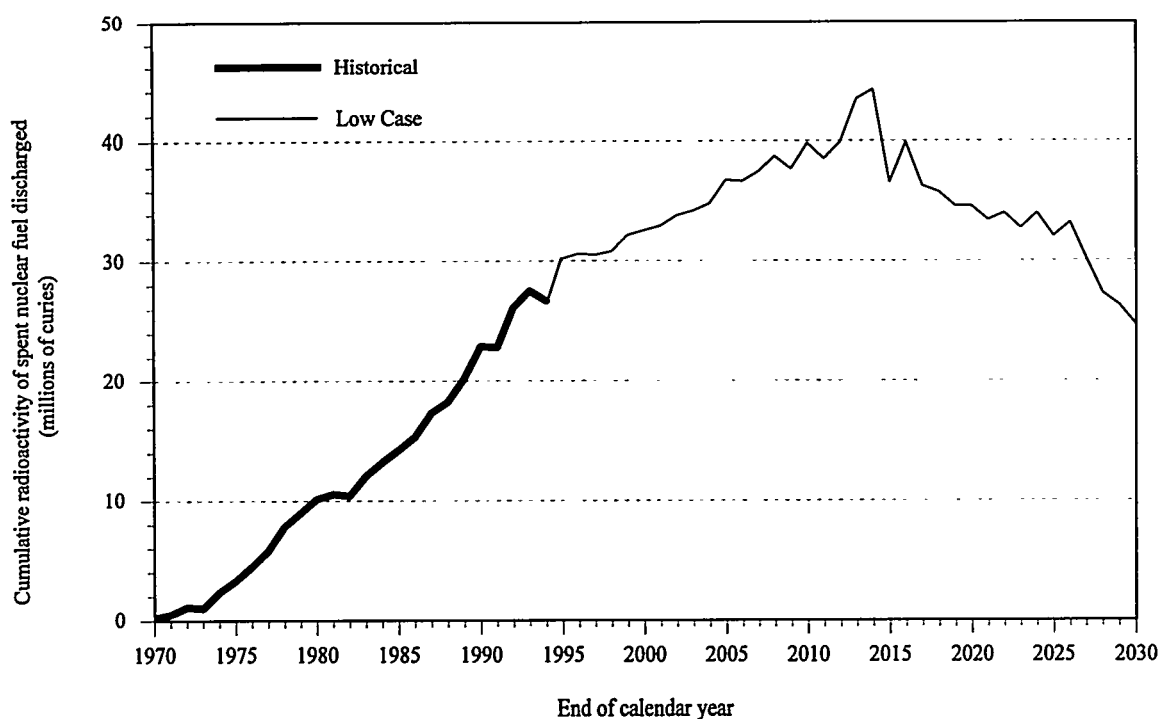


Fig. 1.3. Projected cumulative radioactivity of commercial spent nuclear fuel discharges for the DOE/EIA Low Case.

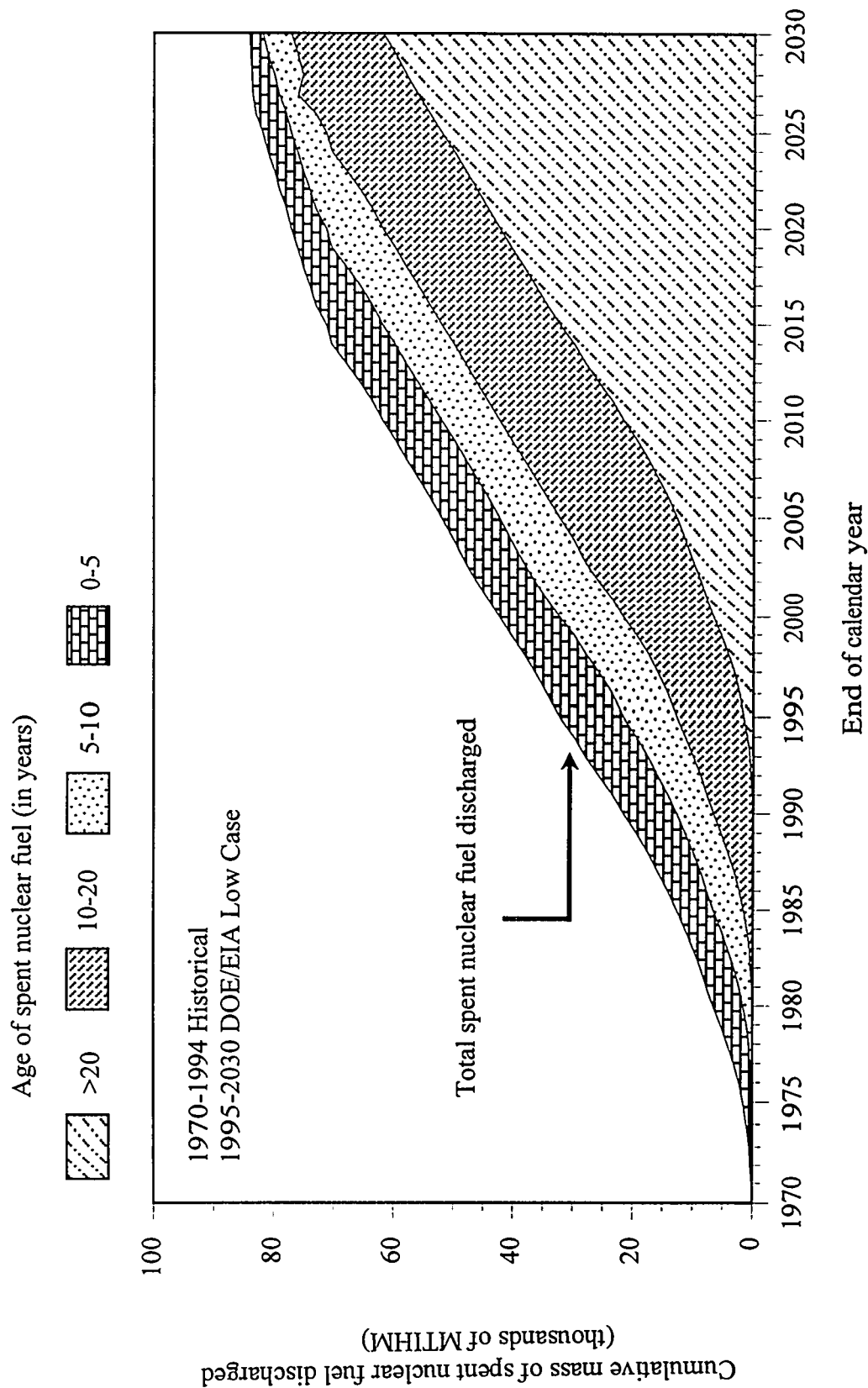
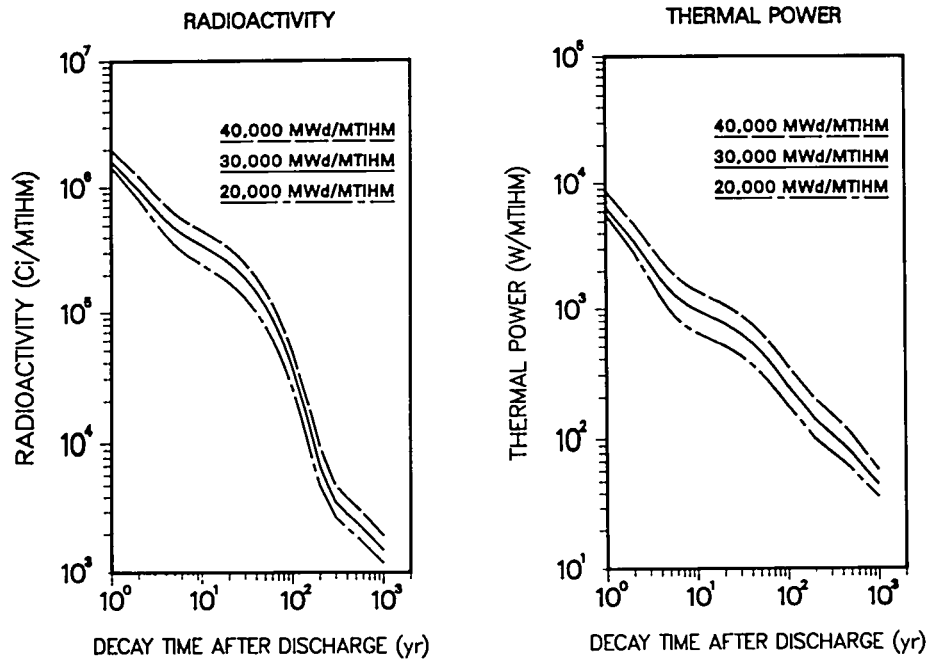


Fig. 1.4. Projected cumulative mass (MTIHM) of commercial spent nuclear fuel discharges for the DOE/EIA Low Case.

BOILING-WATER REACTOR SPENT NUCLEAR FUEL



PRESSURIZED-WATER REACTOR SPENT NUCLEAR FUEL

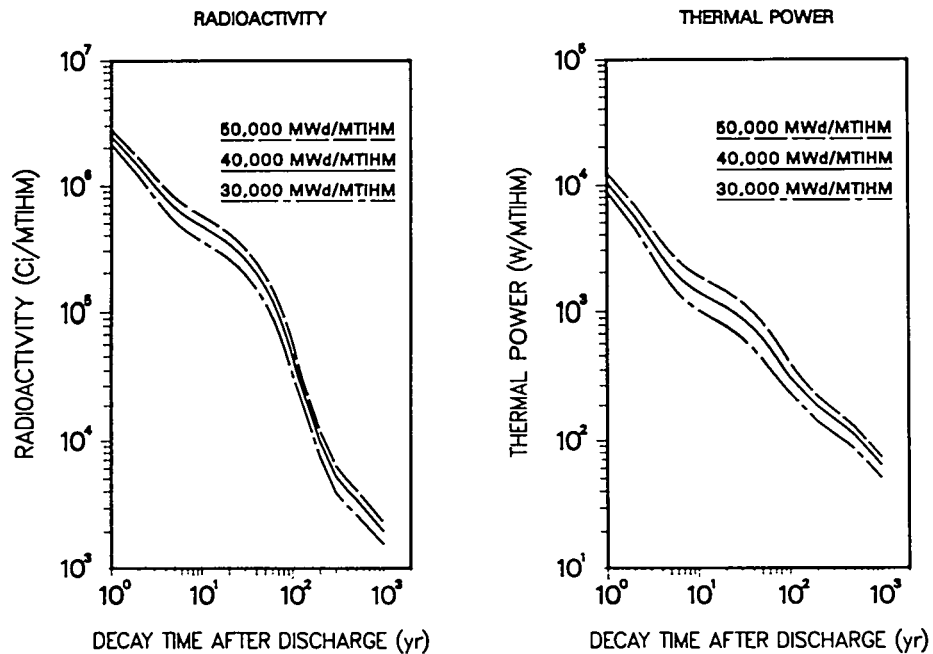


Fig. 1.5. Radioactivity and thermal power of 1 MTIHM of BWR and PWR spent nuclear fuel as a function of burnup and time from reactor discharge.

Table 1.1. Historical and projected installed LWR electric power generating capacity for the DOE/EIA Low Case

End of calendar year	Historical capacity ^a [GW(e)]			End of calendar year	Low Case projected capacity ^b [GW(e)]		
	BWR	PWR	Total		BWR	PWR	Total
1960	0.1	0.2	0.3	1995	31.9	67.2	99.1
1961	0.1	0.2	0.3	1996	31.9	68.4	100.3
1962	0.1	0.2	0.4	1997	31.9	68.4	100.3
1963	0.1	0.2	0.4	1998	31.9	68.4	100.3
1964	0.1	0.2	0.4	1999	31.9	68.4	100.3
1965	0.1	0.2	0.4	2000	31.9	68.4	100.3
1966	0.1	0.2	0.4	2001	31.9	68.4	100.3
1967	0.1	1.3	1.4	2002	31.9	68.4	100.3
1968	0.2	1.2	1.4	2003	31.9	68.4	100.3
1969	0.8	1.7	2.6	2004	31.9	68.4	100.3
1970	2.9	2.9	5.8	2005	31.9	68.4	100.3
1971	4.3	3.7	8.0	2006	31.1	68.4	99.5
1972	7.0	6.5	13.5	2007	31.1	67.1	98.2
1973	8.1	14.1	22.1	2008	31.1	65.1	96.2
1974	13.3	19.4	32.7	2009	29.9	64.7	94.5
1975	15.0	23.3	38.3	2010	28.7	62.4	91.1
1976	16.8	27.9	44.7	2011	27.9	62.4	90.3
1977	16.8	30.4	47.2	2012	25.2	61.0	86.2
1978	17.6	32.2	49.8	2013	23.1	50.7	73.7
1979	17.6	32.2	49.8	2014	17.4	45.8	63.2
1980	17.6	34.3	51.9	2015	17.4	44.0	61.4
1981	17.6	38.6	56.2	2016	15.5	39.6	55.1
1982	18.7	40.5	59.2	2017	15.5	36.8	52.4
1983	19.7	43.6	63.3	2018	14.8	35.1	49.8
1984	24.2	45.8	70.0	2019	14.8	35.1	49.8
1985	26.8	51.7	78.5	2020	14.8	32.0	46.7
1986	28.9	55.2	84.1	2021	14.8	28.9	43.7
1987	31.8	60.8	92.6	2022	11.5	28.0	39.6
1988	31.8	63.1	94.9	2023	9.4	26.1	35.5
1989	33.8	64.1	97.9	2024	7.2	20.4	27.6
1990	32.9	66.7	99.6	2025	5.2	16.8	22.0
1991	32.0	67.7	99.6	2026	1.1	11.5	12.5
1992	31.8	67.1	98.9	2027	1.1	5.9	6.9
1993	31.8	67.2	99.0	2028	1.1	4.6	5.7
1994	31.9	67.2	99.1	2029	0.0	3.5	3.5
				2030	0.0	2.3	2.3

^aBased on ref. 1.

^bData from ref. 3. Assumes that no new reactors will be ordered.

Table 1.2. Projected cumulative mass of commercial spent nuclear fuel discharges for the DOE/EIA Low Case

End of calendar year	Mass (10 ³ MTIHM)	End of calendar year	Mass (10 ³ MTIHM)
1994 ^a	29.8	2013	67.9
1995 ^b	32.2	2014	70.4
1996	34.4	2015	71.3
1997	36.3	2016	73.0
1998	38.2	2017	74.0
1999	40.3	2018	75.2
2000	42.3	2019	76.1
2001	44.2	2020	77.1
2002	46.1	2021	78.0
2003	48.0	2022	79.1
2004	49.9	2023	80.0
2005	52.0	2024	81.1
2006	53.9	2025	81.9
2007	55.9	2026	83.1
2008	57.9	2027	83.6
2009	59.7	2028	83.8
2010	61.8	2029	84.0
2011	63.5	2030	84.1
2012	65.6		

^aReported historical data from ref. 1.

^bData for years 1995–2030 from ref. 3.

Table 1.3. Historical and projected mass, radioactivity, and thermal power of permanently discharged spent nuclear fuel by reactor type for the DOE/EIA Low Case

End of calendar year	Mass, ^{a,b} MTIHM		Radioactivity, 10 ⁶ Ci		Thermal power, 10 ⁶ W	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
<i>Boiling-water reactor</i>						
1968–1970		16		11		0.0
1971	65	81	193	199	0.8	0.8
1972	146	226	447	481	1.7	1.9
1973	94	320	344	439	1.4	1.7
1974	242	562	898	1,033	3.5	4.0
1975	226	787	921	1,217	3.7	4.7
1976	298	1,085	1,154	1,584	4.6	6.1
1977	383	1,469	1,567	2,131	6.2	8.2
1978	384	1,852	1,620	2,414	6.5	9.3
1979	400	2,252	1,735	2,730	7.1	10.5
1980	620	2,872	2,685	3,889	10.9	15.1
1981	459	3,331	2,014	3,664	8.2	14.0
1982	357	3,688	1,582	3,362	6.5	12.6
1983	491	4,179	2,218	4,016	9.1	15.1
1984	498	4,677	2,210	4,283	9.0	16.0
1985	532	5,209	2,317	4,590	9.4	17.0
1986	458	5,667	1,963	4,424	8.0	16.1
1987	597	6,264	2,584	5,088	10.5	18.7
1988	536	6,799	2,363	5,134	9.7	18.7
1989	698	7,497	3,023	5,953	12.3	21.8
1990	633	8,130	2,821	6,076	11.6	22.2
1991	588	8,718	2,696	6,173	11.1	22.5
1992	695	9,413	3,212	6,881	13.3	25.3
1993	700	10,113	3,255	7,285	13.5	26.8
1994	675	10,788	3,200	7,542	13.4	27.8
1995	700	11,500	3,500	8,100	14.7	30.0
1996	800	12,300	3,800	8,800	16.2	32.8
1997	600	12,900	2,900	8,300	12.1	30.4
1998	600	13,500	2,900	8,300	12.1	30.3
1999	700	14,200	3,600	9,200	15.3	33.8
2000	600	14,900	3,100	9,100	13.0	33.1
2001	600	15,400	2,900	9,100	12.4	33.0
2002	600	16,100	3,200	9,500	13.7	34.7
2003	600	16,700	2,900	9,500	12.4	34.4
2004	700	17,300	3,300	10,000	13.9	36.4
2005	600	17,900	2,800	9,800	11.9	35.4
2006	800	18,700	3,900	11,000	16.6	40.3
2007	700	19,400	3,500	11,000	14.9	40.4
2008	500	19,900	2,500	10,300	10.6	37.0
2009	800	20,700	4,000	11,700	16.8	42.6
2010	700	21,400	3,500	11,700	14.9	42.5
2011	600	22,000	2,800	11,200	11.8	40.1
2012	1,000	23,000	4,800	13,100	20.1	48.0
2013	600	23,600	2,800	11,800	11.6	42.2
2014	1,200	24,800	5,600	14,400	23.1	52.7
2015	200	25,000	1,200	10,900	5.2	38.1
2016	600	25,600	3,000	11,900	12.7	42.2
2017	200	25,900	1,100	10,200	4.8	35.1
2018	400	26,300	2,100	10,600	8.8	37.1
2019	300	26,500	1,300	9,800	5.5	34.0
2020	400	26,900	1,900	10,300	8.4	36.0

Table 1.3 (continued)

End of calendar year	Mass, ^{a,b} MTIHM		Radioactivity, 10 ⁶ Ci		Thermal power, 10 ⁶ W	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
<i>Boiling-water reactor (continued)</i>						
2021	200	27,100	800	9,200	3.4	31.5
2022	700	27,800	3,200	11,300	13.4	40.2
2023	400	28,100	1,700	10,300	7.2	36.3
2024	400	28,600	2,000	10,400	8.4	36.8
2025	300	28,900	1,600	10,000	6.6	35.1
2026	600	29,500	2,600	10,800	10.4	38.4
2027	0	29,500	200	8,700	0.8	29.6
2028	0	29,500	0	7,800	0.0	26.4
2029	100	29,600	600	8,000	2.5	27.3
2030	0	29,600	0	7,200	0.0	24.5
<i>Pressurized-water reactor</i>						
1970	39	39	204	204	0.8	0.8
1971	44	83	247	296	1.0	1.2
1972	100	183	545	638	2.2	2.5
1973	67	250	374	571	1.5	2.2
1974	208	458	1,097	1,320	4.4	5.2
1975	322	780	1,683	2,098	6.7	8.2
1976	401	1,181	2,222	2,894	8.9	11.3
1977	467	1,648	2,659	3,676	10.8	14.5
1978	699	2,346	4,028	5,426	16.4	21.5
1979	721	3,068	4,185	6,253	17.1	24.7
1980	618	3,686	3,667	6,248	15.0	24.5
1981	676	4,362	4,025	6,887	16.5	26.9
1982	640	5,002	3,797	7,037	15.6	27.2
1983	771	5,773	4,585	8,072	18.8	31.1
1984	841	6,614	4,975	8,939	20.4	34.4
1985	861	7,475	5,195	9,639	21.4	37.0
1986	996	8,472	5,944	10,884	24.4	41.7
1987	1,109	9,581	6,657	12,204	27.4	46.8
1988	1,117	10,697	6,819	13,073	28.1	50.1
1989	1,215	11,913	7,353	14,256	30.3	54.4
1990	1,504	13,417	9,247	16,833	38.2	64.7
1991	1,271	14,688	7,889	16,652	32.7	63.5
1992	1,596	16,284	10,006	19,255	41.6	73.8
1993	1,532	17,816	9,813	20,231	41.0	77.6
1994	1,207	19,024	7,809	19,120	32.7	72.5
1995	1,600	20,700	10,600	22,100	44.5	84.4
1996	1,400	22,100	9,100	21,800	38.2	82.8
1997	1,400	23,400	9,000	22,200	37.7	83.8
1998	1,300	24,800	8,700	22,400	36.7	84.5
1999	1,300	26,100	8,800	23,000	37.1	86.4
2000	1,300	27,400	8,800	23,600	37.4	88.6
2001	1,300	28,700	8,600	23,900	36.4	89.5
2002	1,300	30,000	8,600	24,400	36.6	91.3
2003	1,300	31,300	8,600	24,900	36.4	92.7
2004	1,200	32,600	8,200	24,900	34.7	92.6
2005	1,500	34,100	10,100	27,100	42.8	101.8
2006	1,200	35,200	7,700	25,800	32.9	95.8
2007	1,300	36,500	8,500	26,600	35.9	98.7
2008	1,500	38,000	10,000	28,500	42.4	106.6

Table 1.3 (continued)

End of calendar year	Mass, ^{a,b} MTIHM		Radioactivity, 10 ⁶ Ci		Thermal power, 10 ⁶ W	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
<i>Pressurized-water reactor (continued)</i>						
2009	1,000	39,000	6,700	26,100	28.5	96.3
2010	1,400	40,400	9,100	28,200	38.5	104.6
2011	1,100	41,500	7,600	27,400	32.3	101.3
2012	1,000	42,600	6,900	26,800	29.2	98.6
2013	1,800	44,300	11,600	31,500	48.8	117.7
2014	1,300	45,600	8,300	29,700	35.0	110.0
2015	600	46,200	4,400	25,800	18.5	93.3
2016	1,100	47,400	7,600	28,000	32.3	102.5
2017	800	48,200	5,300	26,200	22.5	95.0
2018	700	48,900	4,700	25,300	20.2	91.1
2019	700	49,600	4,600	24,800	19.7	89.4
2020	700	50,200	4,400	24,500	18.8	88.0
2021	700	50,900	4,500	24,400	19.1	87.7
2022	500	51,300	3,100	22,900	13.3	81.7
2023	500	51,800	3,300	22,500	13.8	80.3
2024	700	52,500	4,700	23,700	19.6	85.1
2025	500	53,000	3,000	22,100	12.4	78.8
2026	600	53,600	3,800	22,400	15.6	80.2
2027	500	54,100	3,000	21,500	12.2	76.6
2028	200	54,300	1,200	19,400	5.2	68.2
2029	100	54,400	900	18,300	3.9	64.0
2030	100	54,500	700	17,400	2.9	60.8
<i>Total</i>						
1968–1970		55		215		0.8
1971	109	164	440	494	1.7	1.9
1972	246	410	991	1,120	3.9	4.4
1973	161	570	718	1,011	2.9	3.9
1974	449	1,020	1,995	2,353	7.9	9.2
1975	548	1,567	2,604	3,315	10.3	12.9
1976	699	2,266	3,376	4,478	13.5	17.4
1977	850	3,116	4,226	5,807	17.0	22.7
1978	1,082	4,199	5,648	7,841	22.9	30.8
1979	1,121	5,320	5,920	8,983	24.1	35.2
1980	1,238	6,558	6,351	10,137	26.0	39.6
1981	1,135	7,692	6,039	10,552	24.7	40.9
1982	998	8,690	5,378	10,400	22.0	39.8
1983	1,263	9,952	6,804	12,088	27.9	46.3
1984	1,339	11,291	7,185	13,222	29.4	50.4
1985	1,393	12,684	7,512	14,228	30.8	54.0
1986	1,454	14,139	7,907	15,308	32.4	57.9
1987	1,706	15,844	9,241	17,292	37.9	65.5
1988	1,652	17,497	9,182	18,207	37.8	68.8
1989	1,913	19,410	10,376	20,209	42.6	76.3
1990	2,137	21,547	12,068	22,910	49.8	86.9
1991	1,859	23,406	10,584	22,825	43.8	86.0
1992	2,291	25,697	13,218	26,136	54.9	99.2
1993	2,232	27,929	13,068	27,516	54.5	104.4
1994	1,882	29,811	11,009	26,661	46.1	100.2
1995	2,400	32,200	14,100	30,200	59.2	114.5
1996	2,200	34,400	12,900	30,600	54.4	115.7

Table 1.3 (continued)

End of calendar year	Mass, ^{a,b} MTIHM		Radioactivity, 10 ⁶ Ci		Thermal power, 10 ⁶ W	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
<i>Total (continued)</i>						
1997	2,000	36,300	11,800	30,500	49.8	114.2
1998	1,900	38,200	11,600	30,800	48.8	114.8
1999	2,100	40,300	12,400	32,200	52.4	120.3
2000	2,000	42,300	11,900	32,600	50.3	121.7
2001	1,900	44,200	11,500	33,000	48.8	122.5
2002	1,900	46,100	11,900	33,900	50.4	126.0
2003	1,900	48,000	11,500	34,300	48.8	127.2
2004	1,900	49,900	11,500	34,900	48.6	129.0
2005	2,100	52,000	12,900	36,900	54.7	137.2
2006	2,000	53,900	11,600	36,800	49.5	136.1
2007	2,000	55,900	12,000	37,600	50.8	139.1
2008	2,000	57,900	12,500	38,800	53.1	143.6
2009	1,800	59,700	10,700	37,800	45.2	138.9
2010	2,100	61,800	12,600	39,800	53.4	147.1
2011	1,700	63,500	10,400	38,600	44.1	141.4
2012	2,000	65,600	11,700	39,900	49.3	146.5
2013	2,400	67,900	14,400	43,300	60.4	159.9
2014	2,400	70,400	13,900	44,100	58.1	162.7
2015	900	71,300	5,600	36,700	23.8	131.5
2016	1,800	73,000	10,600	39,900	45.0	144.7
2017	1,000	74,000	6,400	36,400	27.3	130.1
2018	1,100	75,200	6,800	35,900	29.0	128.2
2019	900	76,100	5,900	34,700	25.2	123.4
2020	1,000	77,100	6,400	34,700	27.2	123.9
2021	800	78,000	5,300	33,500	22.5	119.2
2022	1,100	79,100	6,300	34,100	26.7	121.9
2023	900	80,000	5,000	32,800	21.0	116.7
2024	1,200	81,100	6,700	34,100	28.0	122.0
2025	800	81,900	4,600	32,100	19.0	114.0
2026	1,200	83,100	6,300	33,300	26.0	118.7
2027	500	83,600	3,200	30,200	13.1	106.2
2028	200	83,700	1,200	27,300	5.2	94.7
2029	300	84,000	1,500	26,300	6.3	91.3
2030	100	84,100	700	24,700	2.9	85.3

^aRef. 1 (1968–1994).^bRef. 3 (1995–2030). Assumes no future reprocessing.

Table 1.4. Projected number of permanently discharged LWR spent nuclear fuel assemblies for the DOE/EIA Low Case

End of calendar year	BWR		PWR		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1994 ^a	3,781	59,518	2,824	44,426	6,605	103,944
1995 ^b	4,100	63,600	3,800	48,200	7,900	111,800
1996	4,500	68,100	3,200	51,400	7,700	119,500
1997	3,400	71,500	3,100	54,600	6,500	126,000
1998	3,400	74,800	3,100	57,700	6,500	132,500
1999	4,200	79,000	3,000	60,700	7,200	139,800
2000	3,600	82,600	3,100	63,900	6,700	146,500
2001	3,400	86,000	2,900	66,800	6,300	152,800
2002	3,700	89,700	3,100	69,900	6,800	159,600
2003	3,300	93,000	3,000	72,900	6,300	165,900
2004	3,800	96,800	2,800	75,700	6,600	172,500
2005	3,200	100,000	3,500	79,200	6,800	179,300
2006	4,600	104,700	2,700	81,900	7,300	186,600
2007	4,000	108,700	3,000	84,900	7,000	193,600
2008	2,800	111,600	3,500	88,400	6,300	200,000
2009	4,700	116,300	2,300	90,700	7,000	207,000
2010	4,200	120,400	3,100	93,800	7,300	214,300
2011	3,400	123,800	2,600	96,500	6,000	220,200
2012	5,700	129,500	2,300	98,800	8,000	228,300
2013	3,300	132,800	4,200	102,900	7,400	235,700
2014	6,600	139,400	2,900	105,800	9,500	245,200
2015	1,400	140,800	1,500	107,300	2,900	248,100
2016	3,400	144,200	2,600	109,900	6,100	254,200
2017	1,300	145,500	1,800	111,700	3,100	257,200
2018	2,400	147,900	1,600	113,300	4,100	261,300
2019	1,400	149,400	1,500	114,900	3,000	264,200
2020	2,200	151,600	1,500	116,400	3,700	267,900
2021	900	152,500	1,500	117,900	2,400	270,300
2022	3,900	156,400	1,000	118,900	4,900	275,300
2023	2,100	158,400	1,100	120,000	3,200	278,400
2024	2,400	160,900	1,700	121,700	4,200	282,600
2025	1,900	162,700	1,000	122,700	2,900	285,500
2026	3,100	165,900	1,400	124,100	4,500	290,000
2027	200	166,100	1,000	125,100	1,200	291,200
2028	0	166,100	400	125,500	400	291,600
2029	800	166,800	300	125,800	1,100	292,700
2030	0	166,800	300	126,100	300	293,000

^aReported historical data (ref. 1).

^bData for years 1995–2030 are based on 100.3 GW(e) installed in the year 2000 and on 2.3 GW(e) installed in the year 2030 (ref. 3). Number of projected fuel assemblies reported has been rounded to the nearest 100.

Table 1.5. Spent nuclear fuel discharges from the Fort St. Vrain HTGR^a

End of calendar year	Number of fuel assemblies discharged		Mass of fuel discharged (MTIHM)	
	Annual	Cumulative	Annual	Cumulative
1979	246 ^b	246	2.80	2.80
1980	0	246	0.00	2.80
1981	240	486	2.77	5.57
1982	0	486	0.00	5.57
1983	0	486	0.00	5.57
1984	240	726	2.85	8.42
1985	0	726	0.00	8.42
1986	0	726	0.00	8.42
1987	0	726	0.00	8.42
1988	0	726 ^c	0.00	8.42
1989 ^{d,e}	126	852	1.32	9.74
1990 ^d	332	1,184	3.49	13.23
1991 ^f	42	1,226	0.48	13.71
1992 ^g	982	2,208	10.29	24.00
1993	0	2,208	0.00	24.00
1994	0	2,208	0.00	24.00
1995–1998 ^h	0	2,208	0.00	24.00

^aData obtained from ref. 7. Discharges identified in this table are those made directly from the reactor.

^bThis refueling replaced 240 standard fuel elements and 6 fuel test elements.

^cAll spent nuclear fuel discharged prior to December 31, 1988, is located at the ICPP.

^dFuel removed from the reactor in 1989 and 1990 was temporarily stored in on-site storage wells.

^ePower operations effectively ceased on August 18, 1989.

^fIn 1991, 18 of the discharged spent nuclear fuel elements were sent to ICPP, 18 elements were transferred to an on-site independent spent nuclear fuel storage installation (ISFSI), and 6 elements were temporarily stored in on-site storage wells.

^gAll spent nuclear fuel elements have been discharged from the reactor and transferred to the ISFSI. All spent nuclear fuel elements in temporary on-site storage wells have been relocated to the ISFSI.

^hDuring this period, Public Service Company of Colorado plans to ship the 1,464 elements currently in the ISFSI to ICPP once legal issues have been resolved.

Table 1.6. IDB reference characteristics of LWR nuclear fuel assemblies

Characteristics	BWR ^a	PWR ^b
Overall assembly length, m	4.470	4.059
Cross section, cm	13.9 × 13.9	21.4 × 21.4
Fuel rod length, m	4.064	3.851
Active fuel height, m	3.759	3.658
Fuel rod outer diameter, cm	1.252	0.950
Fuel rod array	8 × 8	17 × 17
Fuel rods per assembly	63	264
Assembly total weight, kg	319.9	657.9
Uranium/assembly, kg	183.3	461.4
UO ₂ /assembly, kg	208.0	523.4
Zircaloy/assembly, kg	103.3 ^c	108.4 ^d
Hardware/assembly, kg	8.6 ^e	26.1 ^f
Total metal/assembly, kg	111.9	134.5
Nominal volume/assembly, m ³	0.0864 ^g	0.186 ^g

^aRef. 8.^bRef. 9.^cIncludes Zircaloy fuel-rod spacers and fuel channel.^dIncludes Zircaloy control-rod guide thimbles.^eIncludes stainless steel tie-plates, Inconel springs, and plenum springs.^fIncludes stainless steel nozzles and Inconel-718 grids.^gBased on overall outside dimension. Includes spacing between the stacked fuel rods of an assembly.

Table 1.7. Historical mass of commercial BWR spent nuclear fuel discharged at various ranges of burnup^{a,b}

End of calendar year	Annual mass of discharged spent nuclear fuel for various burnup ranges, MTIHM										Total annual mass over all burnup ranges (MTIHM)
	0- 4,999 ^c	5,000- 9,999	10,000- 14,999	15,000- 19,999	20,000- 24,999	25,000- 29,999	30,000- 34,999	35,000- 39,999	40,000- 44,999	45,000- 49,999	
1968	0.6										0.6
1969		1.2	1.0	7.3	0.2	0.1					9.8
1970	5.6										5.6
1971	41.7	8.6	2.8	10.0	1.6						64.7
1972	98.1	11.9	31.1	4.2	0.5						145.8
1973	9.7	17.2	28.8	36.7	1.0	0.1					93.5
1974		78.6	114.4	44.8	3.8						241.6
1975	0.3	1.7	62.2	136.4	25.3						225.8
1976	0.9	67.1	108.7	119.1	2.3						298.1
1977		48.0	40.3	235.2	58.9	0.7					383.2
1978	6.3	32.4	13.1	84.2	232.4	15.2					383.6
1979			18.6	108.7	149.2	123.0	0.3				399.8
1980	14.0	0.4	0.6	93.3	413.3	87.6	10.7				619.8
1981		0.2	0.2	58.1	265.4	133.3	0.7	0.7			458.7
1982		0.2	4.6	22.6	141.5	173.6	13.8	0.6	0.4		357.2
1983			0.9	2.9	113.5	337.8	35.7	0.4			491.3
1984		7.9	43.0	0.3	136.0	239.5	70.8		0.4		497.9
1985	16.9	42.5	18.5	39.5	106.3	297.4	10.2		0.2		531.6
1986	50.8	32.4	42.5	66.6	43.1	180.8	41.7	0.4			458.3
1987	31.0	36.1	68.8	40.8	24.7	352.5	42.9		0.4		597.0
1988	17.0	24.5	1.8	42.9	168.3	192.4	88.7				535.6
1989	30.9	16.9	68.4	71.8	193.2	227.7	85.5	3.6			698.0
1990	17.0		34.0	67.6	106.2	247.5	158.9	1.6			632.8
1991		24.6		7.2	23.9	215.1	287.2	12.1			588.0
1992	17.8		7.6	75.7	62.5	83.9	361.8	103.4			694.8
1993				31.0	47.4	144.8	353.8	122.7			699.7
1994			0.8	1.1	19.0	113.5	275.4	256.8	7.6	0.7	675.0

^aBased on ref. 1.^bDoes not include commercial spent nuclear fuel reprocessed at WVDP.^cBurnup range is given in units of MWd/MTIHM.

Table 1.8. Historical mass of commercial PWR spent nuclear fuel discharged at various ranges of burnup^{a,b}

End of calendar year	Annual mass of discharged spent nuclear fuel for various burnup ranges, MTIHM												Total annual mass over all burnup ranges (MTIHM)
	0- 4,999 ^c	5,000- 9,999	10,000- 14,999	15,000- 19,999	20,000- 24,999	25,000- 29,999	30,000- 34,999	35,000- 39,999	40,000- 44,999	45,000- 49,999	50,000- 54,999	55,000- 59,999	
1970			1.7	37.3									39.0
1971		4.6			6.2	33.7							44.5
1972			11.9	29.3	27.8	8.9	22.1						99.9
1973				26.1	33.3	33.3	7.6						67.1
1974	7.4	1.5	86.4	13.6	40.5	57.2	1.1						207.7
1975	2.7	42.6	95.0	53.6	79.3	25.3	23.1						321.8
1976			5.6	194.2	82.4	63.3	55.4						401.0
1977			2.8	108.3	113.0	140.3	87.1	15.4					466.9
1978		0.9	47.9	89.8	45.1	329.0	125.0	60.4	0.4				698.6
1979			30.6	109.4	64.0	227.6	239.1	50.1	0.5				721.2
1980			0.4		66.8	246.1	276.4	26.3	2.0				618.1
1981			17.2	1.9	25.8	228.5	351.6	49.6	1.3				675.9
1982			1.8	81.2	80.4	61.4	290.6	119.7	2.7	0.4	1.3	0.9	640.4
1983			3.1	80.6	44.7	166.7	327.6	137.3	5.4		0.5		771.3
1984		5.5	58.0	45.2	56.3	195.3	365.0	117.4	4.1				841.3
1985				49.0	13.6	218.7	317.8	237.5	24.1	0.4			861.0
1986		0.8	27.6	131.1	15.6	181.2	336.3	265.6	35.5	1.3	1.3		996.2
1987			27.2	77.7	53.4	175.3	411.9	311.7	51.8				1,108.9
1988				79.7	14.7	138.4	345.1	428.9	103.1	4.6	0.4	2.0	1,116.9
1989			47.1	91.4	68.6	112.1	283.0	408.4	189.1	15.2		0.4	1,215.3
1990			22.3	83.4	16.2	121.2	393.8	611.0	249.2	7.0	0.3		1,504.3
1991						52.5	148.8	606.2	253.1	64.2	3.4		1,271.0
1992		19.8	14.8	43.7	12.3	115.5	287.7	463.9	504.9	118.9	14.8		1,596.4
1993			0.5	2.3	22.4	67.4	167.3	444.6	627.4	197.8	2.1		1,531.9
1994	3.2		27.8	9.8	6.5	7.5	107.5	292.9	506.1	225.5	19.4	1.3	1,207.5

^aBased on ref. 1.^bDoes not include commercial spent nuclear fuel reprocessed at WVDP.^cBurnup range is given in units of MWd/MTIHM.

Table 1.9. Summary inventory of DOE spent nuclear fuel for years 1995 and 2035^a

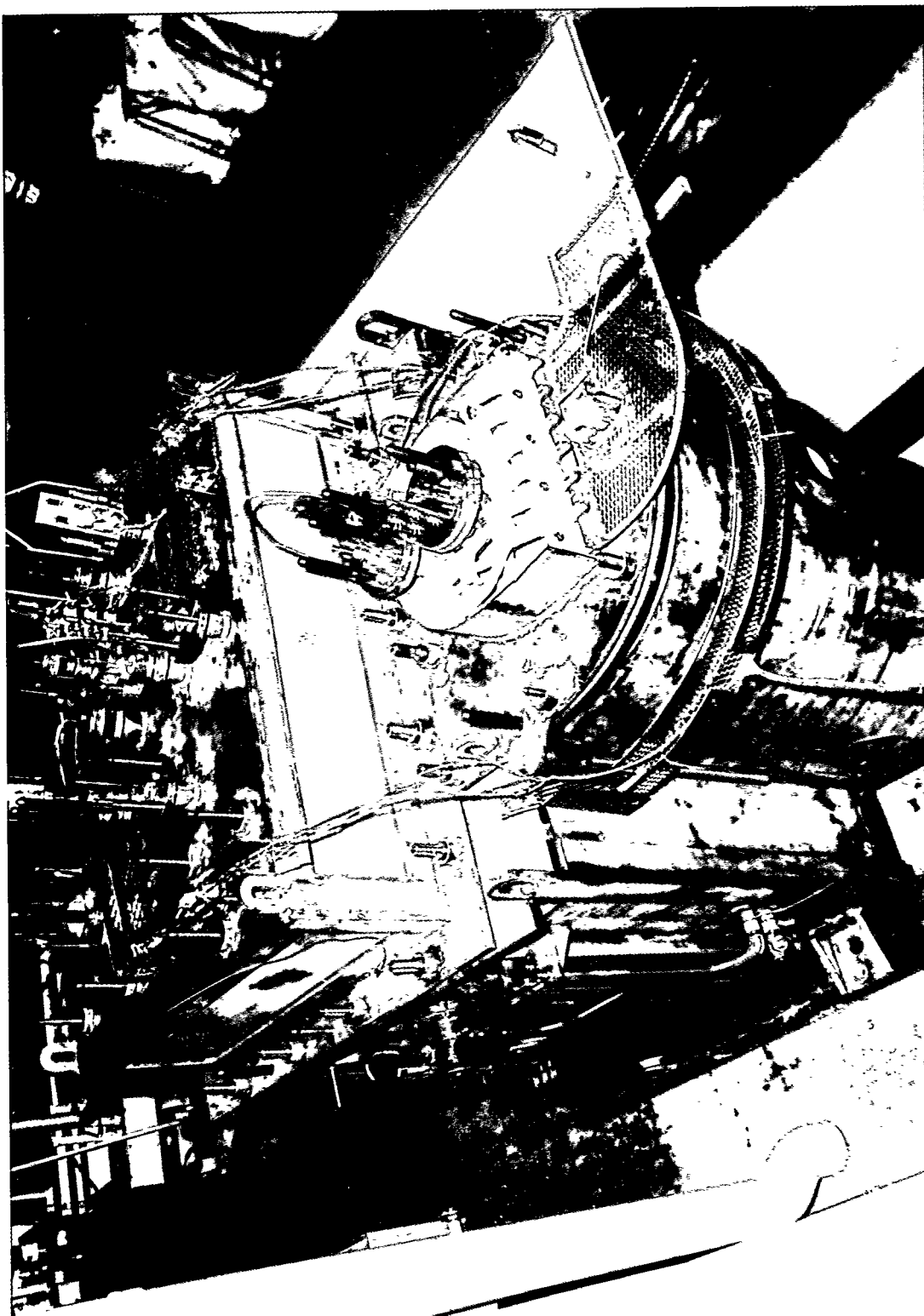
Site	Facility ^b	1995 total mass (kg)	1995 volume (m ³)	Discharged heavy metal (MTHM)	
				1995	2035
ANL-E	Alpha-gamma hot cell	257.10	0.10	0.08	0.08
	CP-5	2.00	0.02	0.00	0.00
	Subtotal	259.10	0.12	0.08	0.08
ANL-W	EBR-II	90,000.00	100.00	14.31	14.31
	HFEF	4,999.99	5.00	2.04	2.04
	NRAD	193.80	0.04	0.01	0.01
	RSWF	15,000.00	32.99	11.91	11.91
	TREAT	15.00	11.00	0.02	0.02
	Subtotal	110,208.79	149.03	28.29	28.29
BNL	BMRR	160.99	0.13	0.00	0.01
	HFBR	4,136.61	3.41	0.25	1.70
	Subtotal	4,297.60	3.54	0.25	1.71
FRR	FRR-East	—	—	—	13.24
	FRR-West	—	—	—	4.76
	Subtotal	—	—	—	18.00
Hanford	Area 200	900.07	21.77	0.33	0.33
	Bldg. 308	224.52	0.08	0.02	0.02
	Bldgs. 324, 325, 327	3,743.00	1.30	2.30	2.30
	FFTF	55,950.00	16.51	11.01	11.01
	PUREX	3,215.00	0.23	3.14	3.14
	T-plant	38,500.00	9.45	15.82	15.82
	105-K East Basin	1,235,172.59	112.05	1,146.34	1,146.34
	105-K West Basin	1,028,048.90	93.22	953.89	953.89
	Subtotal	2,365,754.08	254.61	2,132.85	2,132.85
INEL	ICPP-603	49,590.32	18.61	2.66	2.66
	ICPP-666	358,530.42	114.18	12.36	12.36
	ICPP-749	210,950.00	87.36	78.37	78.37
	ICPP-IFSF	130,906.35	85.81	10.03	10.03
	MTR canal	4,204.00	3.00	0.26	0.26
	PER-620	5,577.50	0.84	0.56	0.56
	TAN-607	331,338.07	130.94	85.27	85.27
	TAN-790	56,375.01	11.78	38.37	38.37
	TRA-660	598.58	0.48	0.23	0.23
	TRA-670	7,197.96	7.38	0.76	2.70
	Subtotal	1,155,268.21	460.38	228.87	230.81
INEL/NRF	ECF	192,784.69	44.34	3.06	3.06
LANL	Omega West Reactor	507.40	0.60	0.01	0.01
ORNL	Bldg. 3525	1.00	0.10	0.00	0.00
	Bldg. 7823A	175.00	1.20	0.00	0.00

Table 1.9 (continued)

Site	Facility ^b	1995 total mass (kg)	1995 volume (m ³)	Discharged heavy metal (MTHM)	
				1995	2035
ORNL (contd.)	Bldg. 7827	2,009.00	3.68	0.16	0.16
	Bldg. 7829	552.00	1.15	0.02	0.02
	Bldg. 7920	996.00	0.10	0.00	0.00
	BSR	327.22	0.39	0.06	0.06
	HFIR	8,673.80	7.37	0.63	1.64
	MSR	8,940.00	3.86	0.04	0.04
	SWSA6	132.00	0.01	0.02	0.02
	TSR	182.00	0.10	0.01	0.01
	Subtotal	21,988.02	17.96	0.94	1.95
SNL/NM	ACRR	151.00	1.10	0.04	0.04
	HCF	20.00	0.01	0.01	0.01
	Manzano storage	50.00	0.10	0.03	0.03
	SNM storage	970.00	2.00	0.03	0.03
	SPR	1,140.00	1.90	0.26	0.26
	Subtotal	2,331.00	5.11	0.37	0.37
SRS	F-Canyon	23,268.24	5.20	22.61	22.61
	H-Canyon	430.00	0.42	0.07	0.07
	K-Basin	20,400.00	29.14	3.24	3.24
	K/L/P-Basin	2,478.40	3.36	0.06	0.06
	L-Basin	135,986.46	43.22	117.96	117.96
	P-Basin	10,700.00	14.51	1.39	1.39
	RBOF	358,119.75	29.00	60.84	60.84
	SRTC	5.28	0.01	0.00	0.00
	Subtotal	551,388.13	124.86	206.17	206.17
U.S. Navy	U.S. Navy Shipyards	—	—	—	54.48
Other	Special-case commercial— B&W, FSVR, WV FRS	233,148.04	144.56	40.65	40.76
	University	10,129.00	8.21	1.81	4.18
	Subtotal	243,277.04	152.77	42.46	44.94
	Grand total	4,648,064.06	1,213.32	2,643.35	2,722.72

^aBased on ref. 12.

^bAbbreviations used in this table: ACRR—Annular Core Research Reactor, BMRR—Brookhaven Medical Research Reactor, BSR—Bulk Shielding Reactor, B&W—Babcock and Wilcox, CP-5—Chicago Pile-5, EBR—Experimental Breeder Reactor, ECF—Extended Core Facility, FFTF—Fast Flux Test Facility, FRR—Foreign Research Reactor, FSVR—Fort St. Vrain Reactor, HCF—Hot Cell Facility, HFBR—(Brookhaven) High Flux Beam (Research) Reactor, HFEF—Hot Fuel Examination Facility, HFIR—High Flux Isotope Reactor, ICPP—Idaho Chemical Processing Plant, IFSF—Irradiated Fuel Storage Facility, MSR—Molten Salt Reactor, MTR—Materials Test Reactor, NRAD—Neutron Radiography (Reactor), PER—(Special) Power Excursion Reactor (Test), PUREX—plutonium/uranium extraction, RBOF—Receiving Basin for Off-Site Fuels, RSWF—Radioactive Scrap and Waste Facility, SNM—special nuclear material, SPR—Sandia Pulse Reactor, SRTC—Savannah River Technical Center, SWSA6—Solid Waste Storage Area (Number) 6, TAN—Test Area North, TRA—Test Reactor Area, TREAT—Transient Reactor Test Facility, TSR—Tower Shielding Reactor, WV FRS—West Valley Fuel Receiving and Storage.



The pilot-scale liquid-fed ceramic melter used for Hanford radioactive vitrification demonstration during the period 1984-1988. *Courtesy of the Westinghouse Hanford Company, Richland, Washington.*

2. HIGH-LEVEL WASTE

2.1 INTRODUCTION

High-level waste (HLW) is generated by the chemical reprocessing of spent research and production reactor fuel, irradiated targets, and naval propulsion fuel. HLW generally contains more than 99% of the nonvolatile fission products produced during reactor operation. HLW from a facility that recovers both uranium and plutonium contains a residual amount of about 0.5% of those elements, while HLW from a facility that recovers only uranium contains a residual 0.5% of the uranium and essentially all of the plutonium. Most fission products have short half-lives and therefore quickly decay. HLW older than 1 year contains primarily the fission radionuclides ^{137}Cs and ^{90}Sr and very small amounts of transuranic (TRU) nuclides.

When generated, HLW is a highly radioactive, acidic liquid which generates heat and must be handled remotely behind heavy shielding in corrosion-resistant vessels, usually made of stainless steel. At the Hanford Site (Hanford), because stainless steel was in short supply, HLW was neutralized with caustic soda, and sodium nitrite was then added for corrosion control so that the HLW could be stored safely in carbon-steel tanks. This practice continued at Hanford and the Savannah River Site (SRS) even when stainless steel became more readily available. Neutralization with caustic soda forms sodium nitrate (which remains in solution) and hydrated oxides of certain radionuclides and nonradioactive chemicals (which precipitate and collect as a sludge on the floor of the tank). In addition, the ^{137}Cs remains largely in solution. At the Idaho National Engineering Laboratory (INEL), however, the waste has always been stored as an acidic liquid and then converted later into a granular solid (calcine) by thermal processing, which drives off water and decomposes nitrate salts to oxides.

The supernatant liquid resulting from neutralization may become concentrated by evaporation—either by self-boiling or in evaporators. If enough water is removed from the waste, sodium nitrate and sodium nitrite will crystallize from the solution. The crystals then will settle to the bottom of the tank liquid and on top of the sludge. If there are many crystals, a salt cake will form.

To reduce heat generation in tanks, the radionuclides ^{137}Cs and ^{90}Sr were removed from some Hanford HLW and stored in concentrated form as purified compounds in capsules. Some of these capsules were leased to non-DOE organizations for beneficial uses. The leased capsules are planned to be returned to DOE by 1996.

In summary, HLW exists in a variety of physical or chemical forms (alkaline or acidic, supernatant liquid, sludge, salt cake, calcine solid, etc.), all of which must be stored behind heavy shielding and usually in underground tanks or bins.

Most of the current U.S. inventory of HLW has resulted from DOE activities. HLW is stored at SRS (Aiken, South Carolina), INEL (Idaho Falls, Idaho), and Hanford (Richland, Washington). A small amount of HLW was generated by commercial operations at the Nuclear Fuel Services (NFS) plant, near West Valley, New York, between 1966 and 1972, at a site owned by the New York State Energy Research and Development Authority (NYSERDA). After 1972, fuel reprocessing operations at this plant were discontinued. In 1980, Congress passed the West Valley Demonstration Project (WVDP) Act (P.L. 96-368), which authorizes DOE to conduct, jointly with NYSERDA (90% DOE, 10% NYSERDA), a demonstration of solidification of HLW for disposal and the decontamination and decommissioning (D&D) of facilities used in the demonstration. The HLW data presented in this chapter are based on separate submittals provided by Hanford, INEL, SRS, and WVDP in ref. 1.

In 1992, DOE decided to phase out the domestic reprocessing of irradiated nuclear fuel for the recovery of enriched uranium or plutonium in support of defense activities; thus, little additional HLW is expected to be generated by this source for the immediate future. However, some future D&D activities may generate waste with radioactivity levels high enough such that the waste will require management in ways similar to HLW. An example of such a future activity is flushing residual wastes found in reprocessing facilities.

2.2 AGREEMENTS AND INTERFACES

HLW is considered to be a mixed waste (i.e., waste containing both radioactivity and hazardous substances) unless demonstrated to the contrary. The hazardous substances of HLW are defined by the Resource Conservation and Recovery Act (RCRA).² Liquid HLW is *characteristic* mixed waste (i.e., as stored, it shows the characteristic of corrosivity because of its acidity or alkalinity). Some HLW may also be *listed* mixed waste (i.e., it contains substances on any one of several lists regulated under RCRA). Mixed wastes must be managed according to RCRA² and Atomic Energy Act (AEA)³ requirements.

The Federal Facility Compliance Act (FFCA)⁴ of 1992 amends the Solid Waste Disposal Act to require (among other things) that DOE prepare a Site Treatment Plan (STP) for each site which generates, stores, or treats mixed waste. In effect, these STPs constitute a legally enforceable agreement between DOE and the host state that DOE must comply with certain requirements for mixed waste management. STPs must be approved by the host state for the site and must be in place by October 6, 1995, unless another agreement was in place before the law was enacted. Two such prior agreements exist: both involve tri-party arrangements. One (for Hanford) is among DOE, the U.S. Environmental Protection Agency (EPA), and the state of Washington. This Tri-Party Agreement⁵ serves as an STP, is legally enforceable, and requires DOE to undertake specific actions at Hanford on a prescriptive timetable. The other tri-party agreement (for SRS) involves DOE, EPA, and the state of South Carolina. However, this agreement applies only to those waste storage tanks that do not meet current DOE and regulatory criteria for secondary containment and leak detection. Consequently, an STP is being prepared for SRS. Concerning INEL, an amended Notice of Noncompliance Consent Order was issued to DOE in March 1994 by the Idaho Department of Health and Welfare. The Order includes provisions for proposing waste treatment technologies and deadlines for removing liquid waste from specific tanks. Because no prior agreements with WVDP specifically address mixed waste treatment, an STP is being prepared for that site to address such treatment.

2.3 WASTE CHARACTERIZATION

Generic characterization of HLW at some sites has been hampered over the years by the use of several different flowsheets for the processes that generated the waste or prepared the wastes for storage (e.g., nuclide separation, precipitation, and evaporation). In some

instances, wastes have been blended. Information for all sites is based on historic records of reprocessing feeds and, for Hanford, SRS, and WVDP, extensive sampling of stored HLW.

Previous versions of this report have presented HLW data by physical form in some detail (e.g., liquid, sludge, slurry, salt cake, and precipitate). This revision clusters the data into just three distinct categories: solid, liquid, and process solidified (canistered) material. This approach is taken because, for example, all "liquid" materials (free tank supernatant and drainable interstitial liquid) must be stored and handled in essentially the same manner. Likewise, "solids" (sludge, salt cake, zeolite, calcine, capsules, and precipitate) and "canistered material" (the final waste form) require different handling methods, respectively. As HLW pretreatment and vitrification processes proceed, inventories of particular categories will decrease or increase.

Chemical and radionuclide compositions and inventories are given for the current and projected HLW at Hanford (Tables 2.11 and 2.16), INEL (Tables 2.12 and 2.17), SRS (Tables 2.13 and 2.18); and WVDP (Tables 2.14 and 2.19).

2.4 INVENTORIES AND PROJECTIONS

Tables 2.1–2.3, respectively, present historical and projected volumes, radioactivity, and thermal power inventories of HLW currently in storage. The radioactivity and resultant thermal power of HLW decay, over time, in a manner characteristic of the constituent radionuclides, but, as previously mentioned, the volume depends significantly on the specific treatment history of the waste. When one takes into account all radionuclides in HLW, total radioactivity and thermal power each decrease about 2 to 4% per year within storage units to which no new waste has been added.

Locations of the four HLW sites and the relative volumes of HLW are represented in Fig. 2.1. The total volume and radioactivity for the HLW (solid and liquid) stored at the four sites is shown graphically in Fig. 2.2. Pie charts show the relative breakdown of stored HLW volume (Fig. 2.3) and radioactivity (Fig. 2.4) as of 1994. Historical and projected cumulative volumes of HLW stored or produced at each site are graphically illustrated in Fig. 2.5a. The number of waste canisters projected to be produced by each site are depicted in Fig. 2.5b.

Current DOE plans are to immobilize and package HLW for disposal in a licensed, underground geologic repository. Figures 2.6–2.9 show, for each of the four sites, the general treatment processes by which the HLW will be immobilized to a form acceptable for disposal in a

repository. Tables 2.4–2.6, respectively, give the projected volume, radioactivity, and thermal power for HLW immobilized as borosilicate glass. Table 2.7 gives estimates, year by year and by site, of the number of HLW canisters to be produced based on reference flowsheets. Canister estimates for SRS [Defense Waste Processing Facility (DWPF)] and WVDP are fairly well established (both projects are scheduled to begin radioactive operations in FY 1996), while canister estimates for INEL and Hanford are less certain because pretreatment and waste minimization processes have not yet been finalized. Tables 2.8–2.10 give the volume, radioactivity, and thermal power, respectively, of stored HLW by site and by physical form. Currently available summary information about the radionuclide distribution for stored HLW and projected associated wastes for each site has been given in Tables 2.11–2.14. Significant changes in any of these tables from the previous IDB report (Rev. 10)⁶ are presented in Table 2.15. It should be noted that the radioactivity reported in Tables 2.2, 2.5, and 2.9 include contributions from both parent and daughter products.

Projected inventories (volume, radioactivity, and thermal power) for HLW presented in Tables 2.1–2.6 have been generated by each site based on certain assumptions and therefore should be considered only as current best estimates. It is possible that new treatment methods or waste forms may be developed and may supersede current baseline projections for Hanford or INEL. All sites are moving toward shutdown; consequently, very little additional HLW will be generated. Major HLW activities will be (a) continued safe storage, (b) preparation for solidification, (c) solidification, and (d) interim storage pending shipment to a national repository. Thus, the inventory of liquid HLW in storage generally will decrease, and the inventory of solidified HLW in interim storage, pending shipment to a national repository, will increase. The *Waste Acceptance System Requirements Document*⁷ for the national repository states that receipt of DOE HLW will begin no sooner than 6 years after initial receipt of utility spent nuclear fuel (SNF). Thus, the canisters of solidified HLW will remain in interim storage, most likely at the production site. The current projected number of HLW canisters (Table 2.7) for Hanford, INEL, and SRS is significantly different from the value reported in the previous IDB report. For INEL, the new projections reflect recent funding and program guidance from DOE that effectively delays completion of the HLW solidification programs at these sites.

Summary flowsheets of the reference solidification processes are given for Hanford (Fig. 2.6), INEL (Fig. 2.7), SRS (Fig. 2.8), and WVDP (Fig. 2.9). Overall, these flowsheets are very similar; process differences reflect differences among sites in waste characteristics.

2.4.1 Hanford

Hanford HLW is stored in underground carbon-steel tanks. Current HLW inventory consists of 155,800 m³ considered to be “solid” HLW (salt cake and sludge in single- and double-shell tanks) and 83,200 m³ of “liquid” HLW (supernatant in single- and double-shell tanks and drainable interstitial liquid in single-shell tanks), for a total of 239,000 m³. At Hanford, waste in single-shell and double-shell tanks consists of HLW, TRUW, and several LLWs. However, in the interim storage mode, the tanks are managed as if they contain only HLW. Thus, their contents are included in the HLW inventory.

A total of 2,217 capsules have been manufactured at Hanford, some of which have been leased off-site for beneficial purposes. Of the 1,577 cesium and 640 strontium capsules, a total of 249 cesium capsules and 35 strontium capsules have been dismantled. The inventory of capsules that have been dismantled is not expected to be returned to Hanford for interim storage and future processing. This leaves 1,328 cesium capsules and 605 strontium capsules to be processed (overpacked) and disposed of as HLW.

The HLW projections for Hanford are based on the assumptions that (1) fuel reprocessing is not resumed, (2) irradiated fuel remains in storage, (3) pumpable liquids are transferred from single-shell tanks to double-shell tanks, (4) double-shell tanks will continue to receive any newly generated waste, and (5) volume reduction of stored wastes through evaporation will continue.

2.4.2 INEL

INEL HLW is currently being stored as both acidic liquid and calcined solids (calcine). Underground, high-integrity, stainless-steel tanks contain about 7,200 m³ of acidic liquid waste. (Of this waste, only 1,306 m³ is actual HLW; the rest is sodium-bearing waste, which is managed the same way as is HLW because of site practice.) Underground stainless-steel bins currently store (retrievably) about 3,800 m³ of calcine, an interim waste form. More than 90% of the total radioactivity is in the calcine.

For INEL, HLW projections are based on the recommended option from a new systems engineering approach to integrate all DOE Office of Environmental Management waste streams at the INEL. The HLW projections include streams associated with the intermediate calcining of liquid waste, followed by separation of HLW and LLW fractions in the remaining liquid waste and redissolved calcine. No new HLW from reprocessing activities was produced after FY 1992; SNF reprocessing facilities are being placed into cold standby

pending D&D. In June 1995, DOE selected a waste form and a process technology to treat the sodium-bearing waste and immobilized calcine. The current reference waste form at INEL is a glass. It is assumed that INEL will begin radioactive operations and thus produce canisters in 2019 and continue this operation through 2045 (see Fig. 2.7). The projections reported in Tables 2.1–2.7 reflect this assumption.

2.4.3 SRS

SRS HLW is stored as alkaline liquid, sludge, salt cake, and precipitate. The current inventory of about 126,300 m³ is stored in underground, single- and double-shelled carbon-steel tanks. This waste consists mainly of alkaline liquid, sludge, and salt cake. Although reprocessing operations are being phased out, the HLW tank farms are continuing to receive HLW from the canyons. The preparation of some HLW for vitrification during the original in-tank precipitation demonstration generated cesium precipitate, and on-going HLW sludge-washing in extended sludge processing (ESP) has generated partially washed sludge. Pretreatment of HLW salt solution is scheduled to begin at the In-Tank Precipitation Facility in August 1995. Characterization data for SRS HLW are based on sampling and process knowledge. Allowable facility design variability of feed composition is limited; therefore, the data reported in Tables 2.1–2.6 assume a uniform feed rate and composition. The current budget projections have both (a) limited the waste-blending capability to feed a uniform composition and (b) reduced the feed rate. The radiochemical streams are assumed to be processed at a uniform rate with adjustments made for radioactive decay.

2.4.4 WVDP

Reprocessing at the West Valley NFS plant was terminated in 1972, after which no additional HLW has been generated. HLW at WVDP is stored in underground tanks. The current HLW inventory of 2,180 m³ consists of 2,040 m³ of liquid alkaline waste and 140 m³ of solid waste (composed of both alkaline sludge and inorganic zeolite ion-exchange material contaminated with radio-cesium). The alkaline waste is stored in an underground carbon-steel tank, and the zeolite is stored in an underground carbon-steel tank covered by an aqueous alkaline solution. The small amount of acidic waste remaining from reprocessing of a thorium fuel was blended into the alkaline waste in 1995.

2.5 SOLIDIFICATION FOR PERMANENT DISPOSAL

All HLW will be processed and solidified to a form acceptable for permanent disposal in a geologic repository.^{8–12} Borosilicate glass has been selected as the reference waste form for all sites.¹³ Projections are based on current funding guidance provided to the sites by DOE.

2.5.1 Hanford

Plans are to retrieve waste from both single- and double-shell tanks, pretreat the waste as necessary to provide HLW and LLW fractions, and immobilize both fractions by vitrification (see Fig. 2.6). Waste retrieval will begin in December 2003, and pretreatment operations will begin in December 2004. Initiation of operations at an LLW vitrification facility is planned for June 2005, while operations at an HLW vitrification facility are scheduled to begin in December 2009. Vitrification of all waste from tanks is expected to be completed by December 2028.

Pretreatment enables the majority of the radioactivity of retrieved waste to be effectively routed through the HLW vitrification facility and the bulk of the tank waste material to be directed to the LLW vitrification facility. The current baseline pretreatment processes are enhanced (caustic) sludge-washing, liquid-solid separation, and cesium removal from liquids. Other pretreatment processes that will be evaluated in the *Tank Waste Remediation System Program Environmental Impact Statement*¹⁴ are acid dissolution, advanced separations of wastes, and organic destruction.

Hanford's reference canister for HLW disposal has a diameter of 68 cm and a length of 457 cm. The nominal glass volume is estimated to be 1.26 m³ with an average waste oxide loading of 45%. Capsule processing will be performed in the HLW vitrification facility concurrent with the HLW tank waste vitrification. An accelerated schedule for capsule processing (overpacking) is assumed. Eight capsules will be stacked axially along the centerline of each reference canister. Alternatively, cesium and strontium salts currently contained in capsules could be vitrified if it is decided that overpacking of existing capsules would not result in an acceptable waste form for the national repository. Because the projected volume, radioactivity, and thermal power for the LLW resulting from the production of the HLW final waste form have not been finalized, no data on the final LLW form are presented in Table 2.11.

An interim storage facility will be built at Hanford with sufficient capacity to store the entire HLW volume of glass and the overpacked capsules produced by the HLW vitrification facility. Storage will continue until the canisters and overpacked capsules are shipped to a geologic repository. Shipment to the repository will commence no sooner than 2035. Thus, values for glass volume, curies, watts, and number of canisters given, respectively, in Tables 2.4–2.7 represent the total accumulation of Hanford's HLW disposal form, with no projected decrement for waste shipment off site.

The technical strategy for treatment and disposal of tank waste is based on the January 1994 amendments to the action plan of the *Hanford Federal Facility Agreement and Consent Order*.⁵

2.5.2 INEL

The preferred Full Treatment Alternative¹⁵ was selected for integrating all waste streams (at INEL) which are managed under DOE-EM. This flexible path forward emphasizes direct action, including treating and preparing waste for shipment to final disposition. In this alternative, the New Waste Calcining Facility is assumed to operate through 2008. A new separations-vitrification facility is planned to be on line after 2017. The remote-handled TRU waste (TRUW) will be processed first in the vitrification facility from 2017 to 2019. After 2019, both the liquid HLW and calcine will be processed to separate the high-activity radionuclides from the low-activity waste. The high-activity waste will be vitrified in the new facility and the separated low-activity waste will be grouted and sent to LLW disposal. The vitrified HLW will be stored until the repository is ready. All HLW is projected to be processed by 2045 under this scenario.

2.5.3 SRS

The plan to process SRS HLW into glass is detailed in *High Level Waste System Plan Revision 5(U)*¹⁶ (i.e.,

Rev. 5 baseline case, similar to Rev. 4) which was transmitted to DOE April 27, 1995. Briefly, Rev. 5 depicts three funding cases and the data included in this report represent the baseline case with completion of the immobilization of the current inventory of HLW in FY 2021.

For SRS, reprocessing operations are scheduled to be completed by FY 2002. Additional HLW from reprocessing activities until then will represent a maximum increase of about 14.5% of current inventory. Pretreatment (sludge-washing) of liquid HLW has been started, and the DWPF will begin producing canisters of solidified HLW in FY 1996. The HLW glass waste forms will be stored at SRS until a national repository is ready to accept them (see Fig. 2.8).

2.5.4 WVDP

Currently, pretreatment at the WVDP is essentially completed. In May 1988, the processing of liquid HLW was initiated. This alkaline liquid was decontaminated to LLW in the WVDP Supernatant Treatment System (STS) in preparation for the incorporation of all HLW at the WVDP into a glass. In the STS, an ion-exchange process that is operated in a batch mode is used to remove cesium from the alkaline liquid waste (see Fig. 2.9). The ion-exchange columns are located in the underground carbon-steel tank, which was originally installed as a backup tank for the storage of alkaline HLW. The sludge in the bottom of the tank has been mixed with the residual supernatant and an alkaline solution. Both sludge-wash processing cycles were completed in 1994. The wash solutions are also treated in the STS before they are incorporated in cement. The washed sludge, the acidic waste, and the loaded zeolite will be combined and incorporated into a glass. At WVDP, vitrification of the HLW will start in FY 1996 and be completed in FY 1998. The glass will be stored on-site until it is transferred to a federal repository.

2.6 REFERENCES

1. DOE site HLW data submittal attachments, submitted to the IDB Program during June–July 1995. The following HLW submittals were received and reviewed by the IDB Program before analysis and integration. Preceding each submittal is the site (in parentheses) to which it refers.
 - a. (Hanford) George Sanders, DOE Richland Operations Office, Richland, Washington, correspondence to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, "Hanford Site High-Level Waste Information for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," dated June 1, 1995.

- b. (INEL) D. A. Knecht, Lockheed Martin Idaho Technologies, Idaho Falls, Idaho, correspondence to J. G. Smook, DOE-ID, Idaho Falls, Idaho, copy to S. Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, "INEL HLW Integrated Data Base Submittal for 12/31/94 Waste Quantities," DAK-28-95, dated July 20, 1995.
 - c. (SRS) William F. Spader, DOE Savannah River Operations Office, Aiken, South Carolina, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Savannah River Site (SRS) High Level Waste Information for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," MC-95-0043, dated June 8, 1995.
 - d. (SRS) Margaret Schwenker, DOE Savannah River Operations Office, Aiken, South Carolina, telefax to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, "FY 95 Integrated Data Base, Chapter II, Savannah River Site Revised Input," dated Aug. 23, 1995.
 - e. (WVDP) P. S. Klanian, West Valley Nuclear Services Company, Inc., West Valley, New York, correspondence to Steven N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Submittal of High-Level Waste Information for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," WZ:95:0088, dated June 1, 1995.
2. U.S. Congress, Resource Conservation and Recovery Act of 1976, P.L. 94-580, 1976, as amended.
 3. U.S. Congress, Atomic Energy Act of 1954, P. L. 83-703, Aug. 15, 1994.
 4. U.S. Congress, The Federal Facility Compliance Act of 1992, P.L. 102-386, Oct. 6, 1992.
 5. Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, *Hanford Federal Facility Agreement and Consent Order*, EPA Docket Number 1089-03-040120, Ecology Docket Number 89-54, Richland, Washington (May 1989).
 6. U.S. Department of Energy, *Integrated Data Base Report—1993: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 10, Oak Ridge National Laboratory, Oak Ridge, Tennessee (December 1994).
 7. U.S. Department of Energy, Office of Civilian Radioactive Waste Management, *Waste Acceptance System Requirements Document*, DOE/RW-0351P, Rev. 1, Washington, D.C., (March 1994).
 8. U.S. Department of Energy, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic, and Tank Waste, Hanford Site, Richland, Washington*, DOE/EIS-0113, DOE Richland Operations Office, Richland, Washington (December 1987).
 9. U.S. Congress, The Nuclear Waste Policy Act of 1982, P.L. 97-425, Sect. 8, Jan. 7, 1983, as amended.
 10. Ronald Reagan, President of the United States, Washington, D.C., letter to John S. Herrington, Secretary of Energy, "Disposal of Defense Waste in a Commercial Repository," dated Apr. 30, 1985.
 11. U.S. Department of Energy, "Civilian Radioactive Waste Management: Calculating Nuclear Waste Fund Disposal Fees for Department of Energy Defense Program Waste; Notice," *Fed. Regis.* 56(161), 31508 (Aug. 20, 1987).
 12. U.S. Congress, The Nuclear Waste Policy Amendments Act of 1987, P.L. 100-203, Title V, Subtitle A, Dec. 22, 1987.
 13. U.S. Department of Energy, Office of Defense Waste and Transportation Management, *Defense Waste and Transportation Management Program Implementation Plan*, DOE/DP-0059, Washington, D.C. (August 1988).
 14. U.S. Department of Energy, "Notice of Intent to Prepare the Hanford Site Tank Waste Remediation System Environmental Impact Statement," *Fed. Regis.* 59(19), 4052 (Jan. 28, 1994).

15. U.S. Department of Energy, *Integration of EM Activities at the INEL*, Idaho National Engineering Laboratory, Idaho Falls, Idaho (March 31, 1995).
16. U.S. Department of Energy, *High-Level Waste System Plan Revision 5(U)*, HLW-OVP-95-0031, Savannah River Site, Aiken, South Carolina (April 26, 1995).

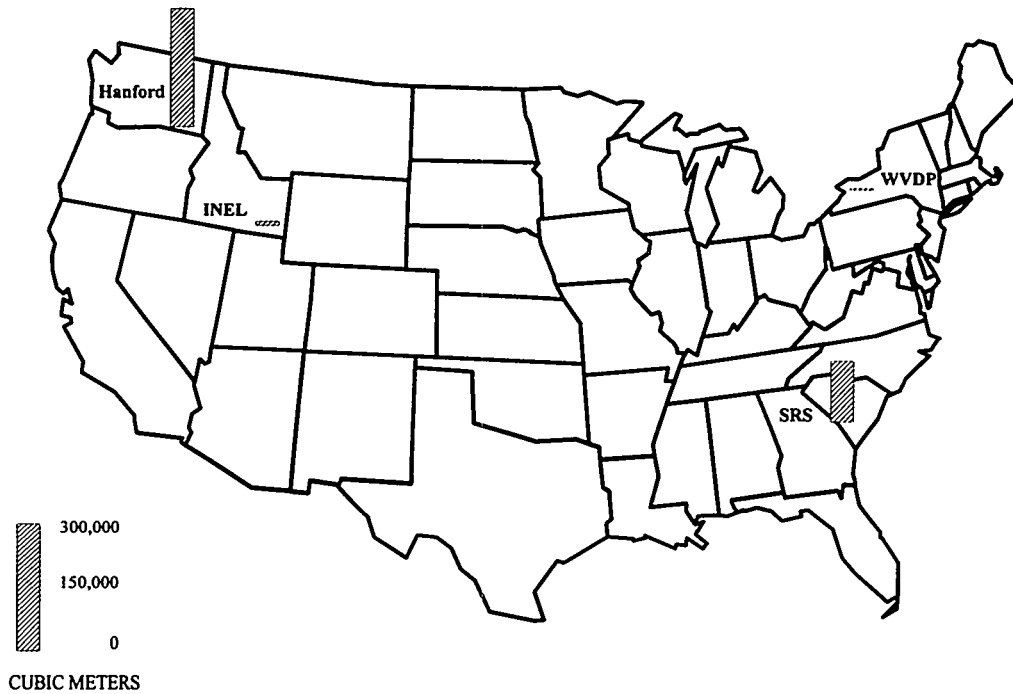


Fig. 2.1. Locations and total volumes of HLW through 1994.

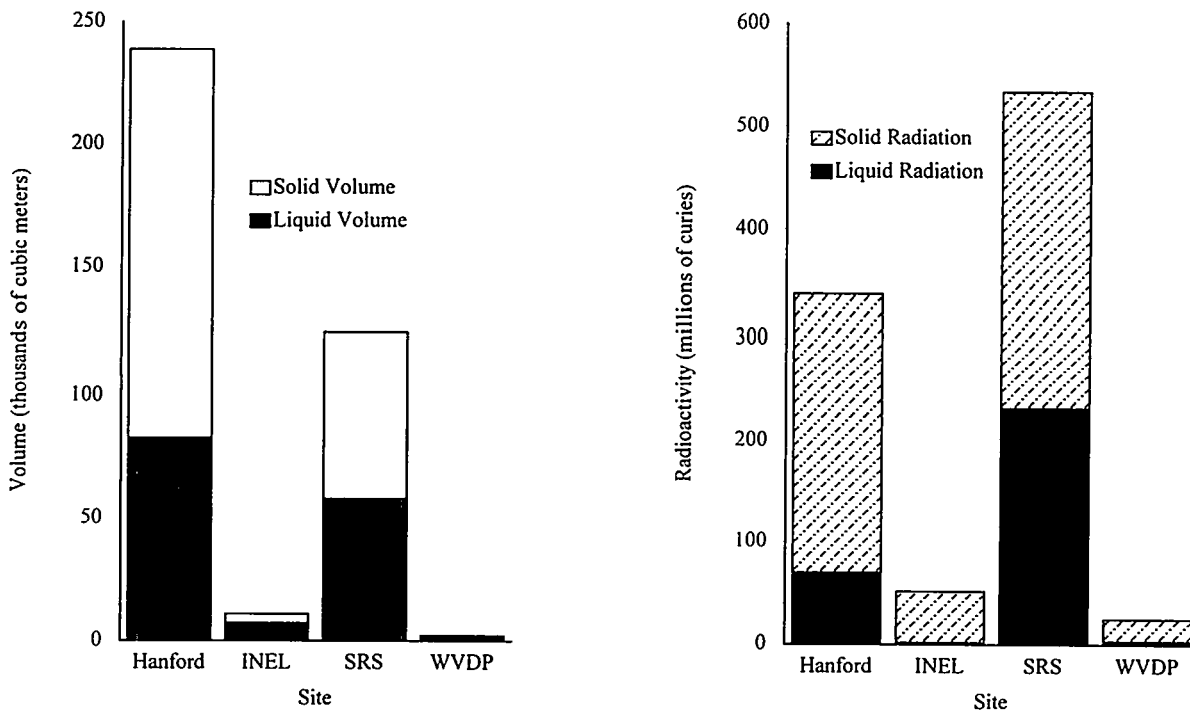


Fig. 2.2. Total volume and radioactivity of solid and liquid HLW through 1994.

ORNL DWG 95-8224

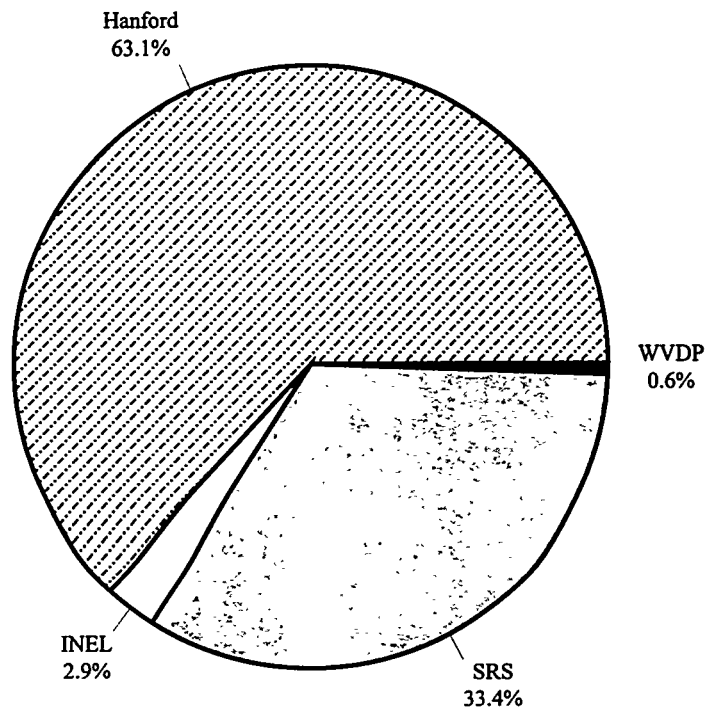


Fig. 2.3. Total volume of HLW through 1994.

ORNL DWG 95-8225

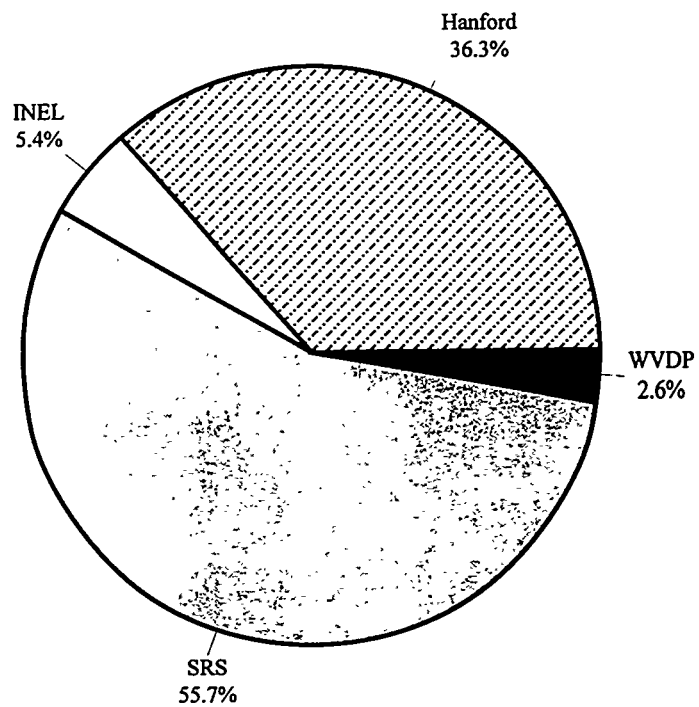


Fig. 2.4. Total decayed radioactivity of HLW through 1994.

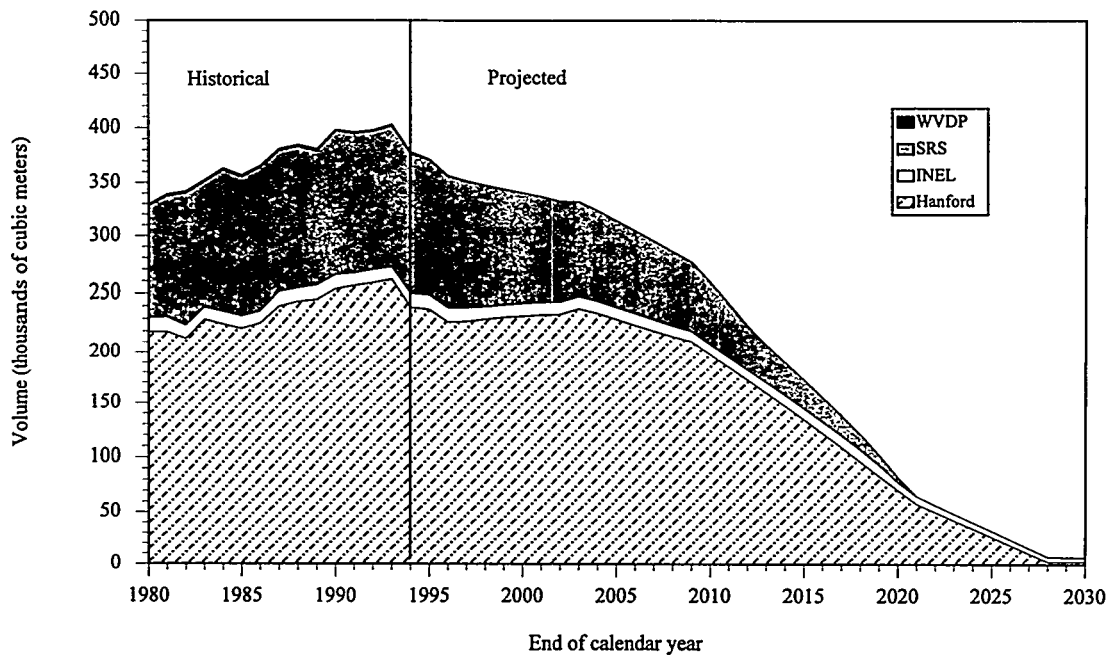


Fig. 2.5a. Historical and projected cumulative volumes of HLW in storage.

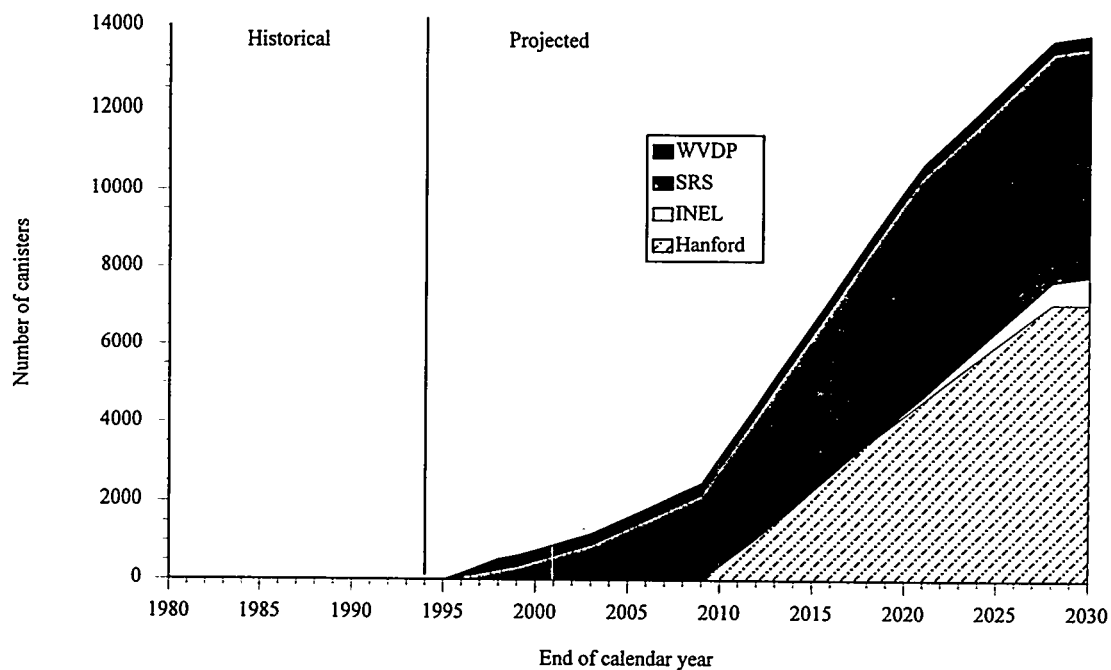


Fig. 2.5b. Projected cumulative number of HLW canisters.

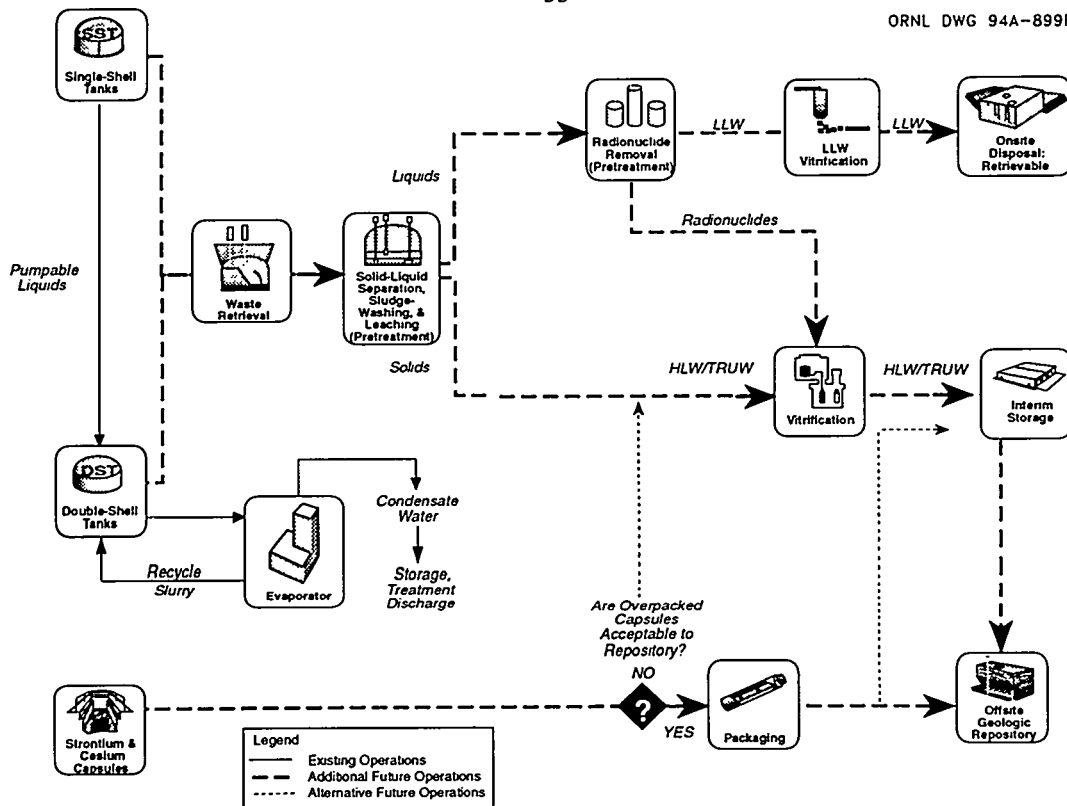


Fig. 2.6. Treatment methods for tank waste and capsules at Hanford.

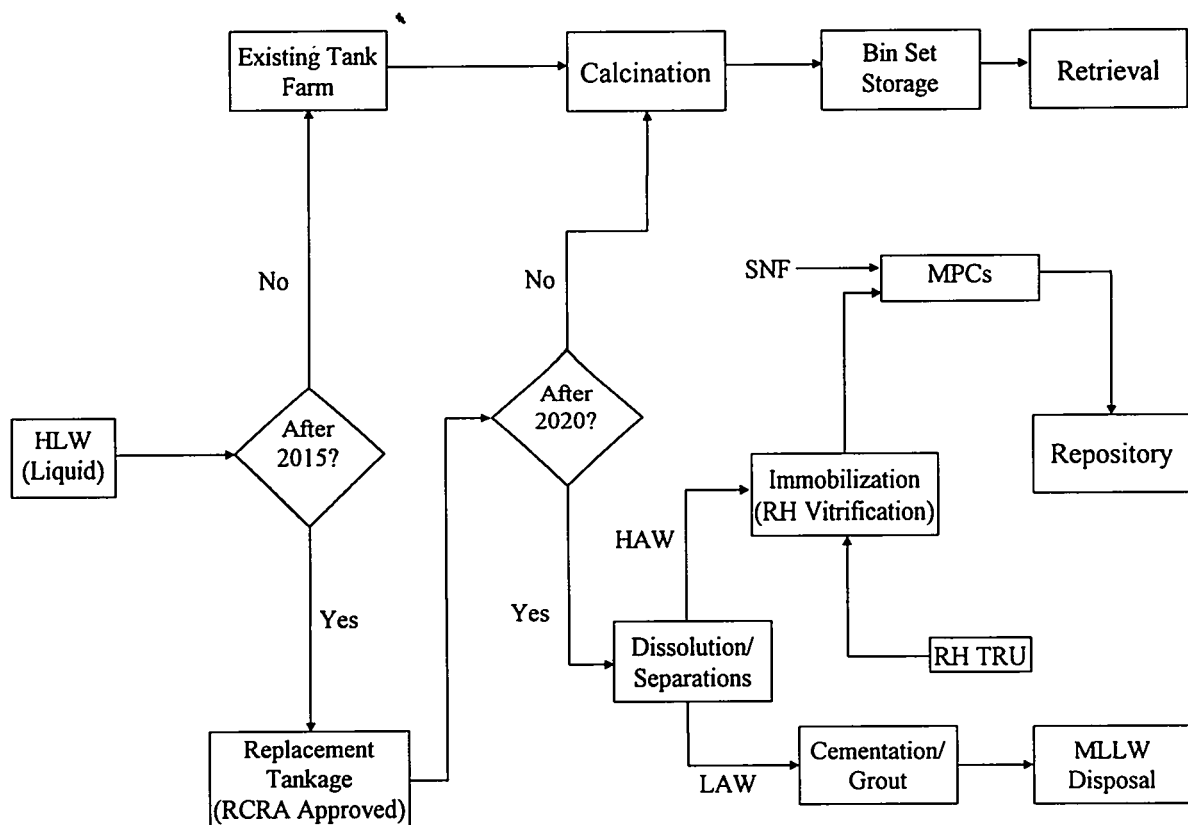


Fig. 2.7. Treatment methods for HLW in tanks, bins, and canisters at INEL.

SRS HLW Management Process

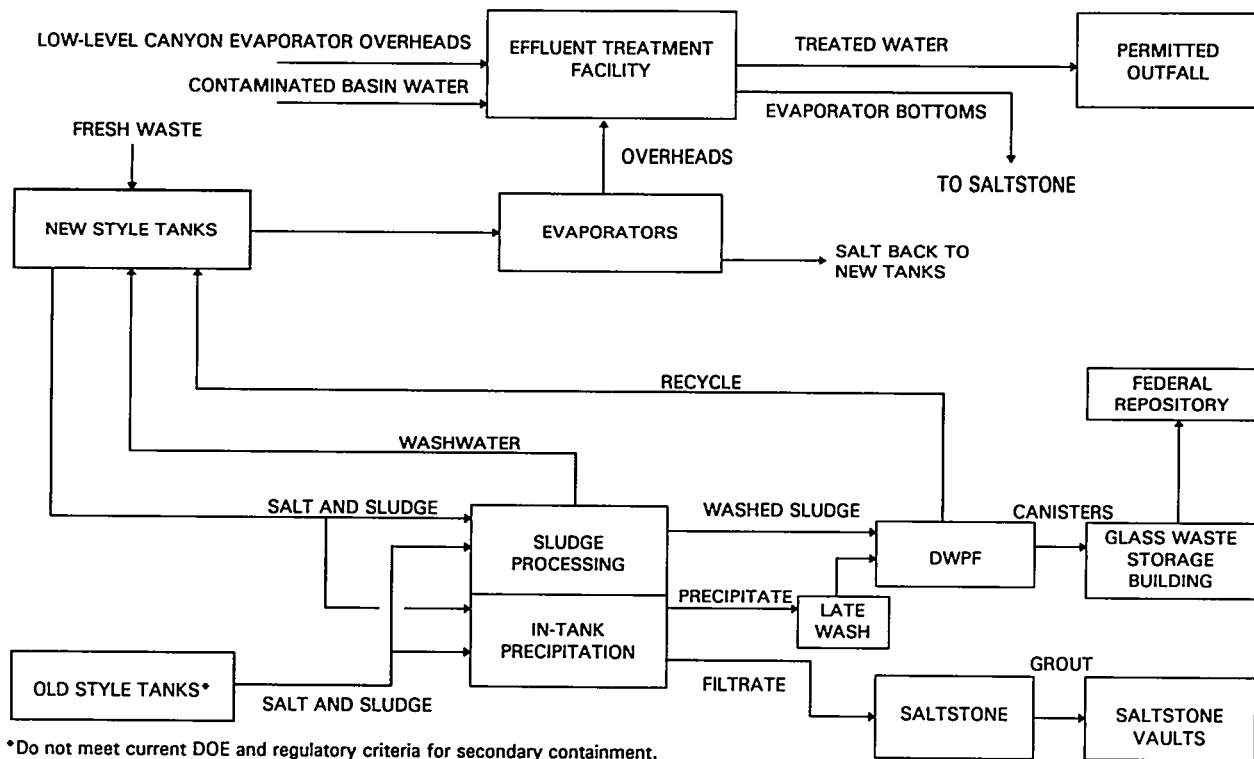


Fig. 2.8. Treatment methods HLW in tanks and canisters at SRS.

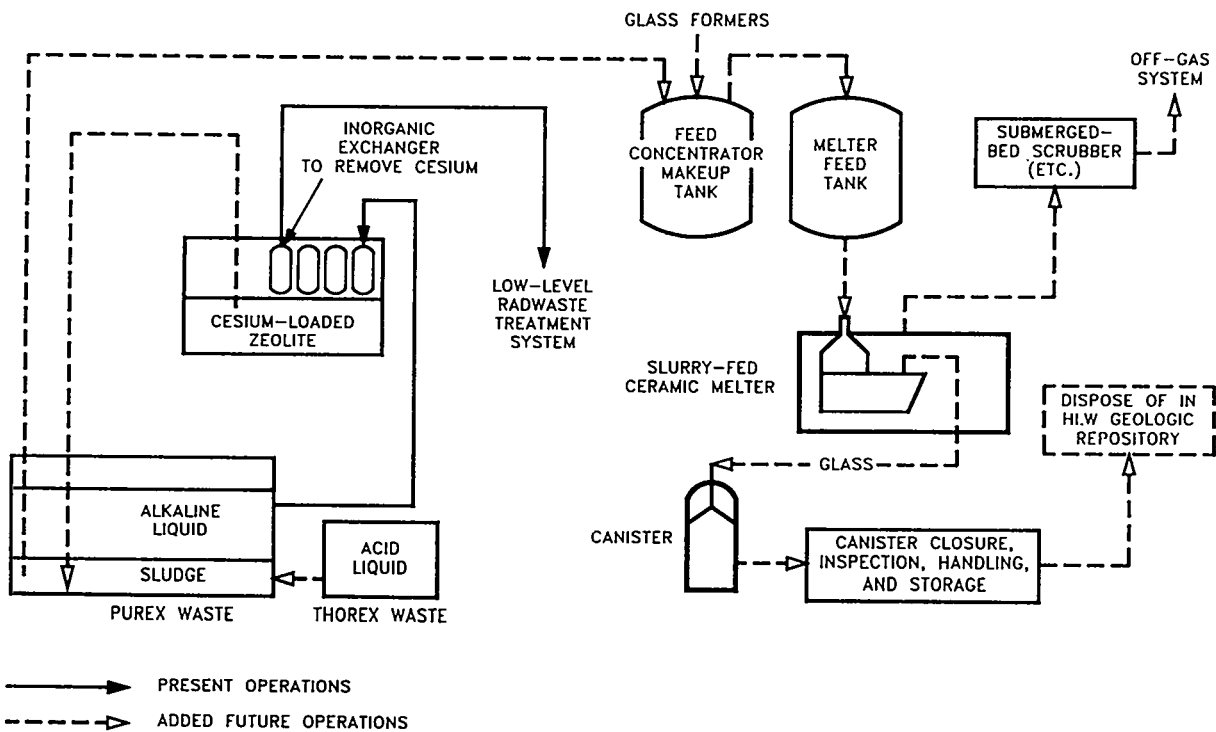


Fig. 2.9. Treatment methods for HLW in tanks and canisters at WVDP.

Table 2.1. Historical and projected cumulative volume of HLW stored in tanks, bins, and capsules, by site^a

End of calendar year	Volume, 10 ³ m ³				Total
	Hanford	INEL	SRS	WVDP	
1980	219.4	11.4	96.7	2.2	329.7
1981	219.4	12.0	105.7	2.2	339.3
1982	213.3	11.5	115.0	2.2	342.0
1983	229.4	9.7	111.4	2.2	352.7
1984	225.6	10.1	125.6	2.2	363.5
1985	222.1	10.1	122.7	2.2	357.1
1986	226.4	9.5	127.8	2.2	365.9
1987	239.7	11.9	127.6	2.2	381.4
1988	243.4	11.0	128.4	2.1	384.9
1989	244.8	12.0	122.0	2.4	381.1
1990	253.6	12.0	131.7	1.2	398.5
1991	256.4	10.4	127.9	1.7	396.5
1992	258.7	11.2	126.9	1.6	398.3
1993	261.7	10.5	129.3	2.0	403.5
1994	238.9	11.0	126.3	2.2	378.4
1995	237.3	11.4	122.1	0.9	371.7
1996	227.3	11.3	117.4	0.6	356.6
1997	228.0	10.6	112.7	0.3	351.8
1998	229.7	9.8	108.0		347.5
1999	231.2	9.6	103.3		344.2
2000	232.1	9.8	98.7		340.6
2001	233.0	10.0	94.0		336.9
2002	233.6	9.7	89.3		332.6
2003	237.8	9.7	84.6		332.1
2004	234.3	9.6	79.9		323.8
2005	229.6	9.5	75.2		314.2
2006	224.8	9.6	70.5		304.9
2007	220.1	9.4	65.8		295.2
2008	215.3	9.4	61.1		285.8
2009	210.6	9.6	56.4		276.6
2010	197.9	9.8	51.7		259.4
2011	185.2	10.0	47.0		242.1
2012	172.5	10.1	42.3		224.9
2013	159.8	10.2	37.6		207.6
2014	147.1	10.3	32.9		190.3
2015	134.4	10.4	28.2		173.0
2016	121.7	10.5	23.5		155.7
2017	109.0	10.6	18.8		138.4
2018	96.3	10.7	14.1		121.1
2019	83.6	9.6	9.4		102.5
2020	70.8	7.2	4.7		82.8
2021	58.1	7.1			65.2
2022	50.2	6.7			56.9
2023	42.2	6.4			48.6
2024	34.2	6.1			40.3
2025	26.3	5.8			32.0
2026	18.3	5.4			23.7
2027	10.3	5.1			15.4
2028	2.4	4.8			7.1
2029	2.4	4.4			6.8
2030	2.4	4.1			6.5

^aHistorical inventories for HLW volume are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 10 (December 1994)]. The inventories for 1994 and the projections through 2030 are taken from ref. 1.

Table 2.2. Historical and projected cumulative decayed radioactivity of HLW stored in tanks, bins, and capsules, by site^a

End of calendar year	Radioactivity, 10 ⁶ Ci				
	Hanford	INEL	SRS	WVDP	Total
1980	576.7	53.4	699.0	33.5	1,362.6
1981	550.2	63.6	982.0	32.7	1,628.5
1982	437.1	71.6	828.8	31.9	1,369.4
1983	427.5	64.8	776.2	31.2	1,299.7
1984	470.2	58.6	795.9	30.5	1,355.2
1985	519.0	69.4	841.4	29.7	1,459.5
1986	534.6	60.6	794.7	29.1	1,419.0
1987	478.2	62.5	734.0	28.4	1,303.1
1988	447.4	67.0	664.4	27.9	1,206.7
1989	419.3	68.4	598.9	27.3	1,113.9
1990	399.3	63.2	561.6	26.7	1,050.8
1991	384.2	59.4	537.6	26.2	1,007.4
1992	372.1	50.8	632.4	25.9	1,081.2
1993	361.4	52.5	606.0	25.3	1,045.3
1994	348.0	51.6	534.5	24.7	958.8
1995	339.9	50.5	502.2	24.1	916.7
1996	332.1	49.1	461.5	15.7	858.4
1997	324.4	47.7	432.5	7.6	812.1
1998	316.9	46.5	404.8		768.2
1999	309.6	45.2	378.2		733.0
2000	302.4	44.1	352.7		699.2
2001	295.4	43.0	328.2		666.6
2002	288.6	42.0	304.7		635.2
2003	281.9	41.0	282.1		605.0
2004	275.4	39.9	260.4		575.7
2005	269.1	38.9	239.5		547.5
2006	262.8	38.1	219.5		520.4
2007	256.8	37.1	200.2		494.1
2008	250.8	36.3	181.8		468.9
2009	245.1	35.4	164.0		444.5
2010	232.2	34.6	147.0		413.8
2011	219.8	33.8	130.7		384.3
2012	207.9	33.0	115.0		355.9
2013	180.4	32.2	99.9		312.6
2014	154.1	31.5	85.5		271.1
2015	128.9	30.8	71.7		231.3
2016	104.7	30.1	58.4		193.2
2017	81.6	29.4	45.7		156.7
2018	59.5	28.7	33.5		121.7
2019	52.4	27.6	21.9		101.9
2020	45.5	26.9	10.7		83.1
2021	38.9	24.4			63.3
2022	32.5	21.2			53.7
2023	26.5	18.6			45.1
2024	20.7	16.0			36.7
2025	15.2	13.8			29.0
2026	9.9	11.7			21.6
2027	4.8	9.7			14.5
2028		7.6			7.6
2029		5.5			5.5
2030		3.9			3.9

^aHistorical inventories for HLW radioactivity are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 10 (December 1994)]. The inventories for 1994 and the projections through 2030 are taken from ref. 1.

Table 2.3. Historical and projected cumulative decayed thermal power of HLW stored in tanks, bins, and capsules, by site^a

End of calendar year	Thermal power, 10 ³ W				
	Hanford	INEL	SRS	WVDP	Total
1980	1,142.7	169.0	2,050.0	96.9	3,458.6
1981	1,671.0	210.0	2,900.0	94.8	4,875.8
1982	1,261.5	217.0	2,490.0	92.6	4,061.1
1983	1,233.6	190.0	2,279.6	90.5	3,793.7
1984	1,388.9	170.8	2,349.6	88.4	3,997.7
1985	1,557.4	209.9	2,537.2	86.4	4,390.9
1986	1,605.9	175.9	2,575.3	84.5	4,441.6
1987	1,395.3	182.5	2,151.9	81.2	3,810.9
1988	1,306.4	195.6	1,883.7	80.9	3,466.6
1989	1,211.9	199.2	1,673.7	79.3	3,164.1
1990	1,150.3	184.4	1,566.7	76.9	2,978.3
1991	1,106.5	172.0	1,509.3	75.9	2,863.7
1992	1,073.1	147.3	1,724.3	79.1	3,023.8
1993	1,043.1	153.7	1,615.3	74.1	2,886.3
1994	999.8	150.8	1,497.3	78.1	2,726.0
1995	976.7	146.6	1,407.4	69.7	2,600.4
1996	954.1	142.2	1,300.3	45.6	2,442.2
1997	932.1	138.3	1,226.7	21.9	2,319.0
1998	910.5	135.1	1,155.5		2,201.1
1999	889.5	131.6	1,085.9		2,107.0
2000	868.9	128.1	1,017.8		2,014.8
2001	848.9	125.0	951.3		1,925.2
2002	829.2	121.8	886.5		1,837.5
2003	810.1	118.6	823.5		1,752.2
2004	791.4	115.4	762.4		1,669.1
2005	773.1	113.2	703.2		1,589.4
2006	755.3	110.1	645.9		1,511.2
2007	737.8	107.7	590.6		1,436.2
2008	720.8	104.7	537.2		1,362.7
2009	704.2	102.7	485.8		1,292.6
2010	666.4	99.9	436.2		1,202.5
2011	630.0	97.6	388.4		1,115.9
2012	594.9	95.3	342.4		1,032.6
2013	517.8	93.1	298.1		909.0
2014	443.9	91.0	255.5		790.4
2015	373.2	88.8	214.5		676.5
2016	305.5	86.8	175.1		567.4
2017	240.7	84.8	137.2		462.7
2018	178.8	82.8	100.8		362.4
2019	157.2	79.7	65.9		302.8
2020	136.5	77.7	32.3		246.5
2021	116.7	70.4			187.2
2022	97.7	61.3			159.0
2023	79.6	53.6			133.2
2024	62.2	46.3			108.5
2025	45.6	39.9			85.5
2026	29.7	33.8			63.5
2027	14.5	27.9			42.4
2028		21.9			21.9
2029		15.9			15.9
2030		11.1			11.1

^aHistorical inventories for HLW thermal power are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 10 (December 1994)]. The inventories for 1994 and the projections through 2030 are taken from ref. 1.

Table 2.4. Projected annual and cumulative volume (10^3 m^3) of HLW glass stored in canisters, by site^{a,b}

End of calendar year	Hanford ^c		INEL ^d		SRSe		WVDPf		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					0.038	0.038	0.080	0.080	0.118	0.118
1997					0.054	0.092	0.080	0.160	0.134	0.252
1998					0.054	0.146	0.080	0.240	0.134	0.386
1999					0.054	0.201	0.080	0.240	0.134	0.441
2000					0.087	0.288		0.240	0.087	0.528
2001					0.089	0.377		0.240	0.089	0.617
2002					0.089	0.467		0.240	0.089	0.707
2003					0.089	0.556		0.240	0.089	0.796
2004					0.133	0.690		0.240	0.133	0.930
2005					0.133	0.823		0.240	0.133	1.063
2006					0.133	0.956		0.240	0.133	1.196
2007					0.133	1.090		0.240	0.133	1.330
2008					0.133	1.223		0.240	0.133	1.463
2009					0.130	1.353		0.240	0.130	1.593
2010	0.453	0.453			0.196	1.548		0.240	0.649	2.241
2011	0.453	0.905			0.196	1.744		0.240	0.649	2.890
2012	0.453	1.358			0.196	1.940		0.240	0.649	3.538
2013	0.503	1.861			0.196	2.136		0.240	0.699	4.237
2014	0.503	2.365			0.183	2.319		0.240	0.686	4.924
2015	0.503	2.868			0.183	2.502		0.240	0.686	5.610
2016	0.503	3.372			0.183	2.684		0.240	0.686	6.296
2017	0.503	3.875			0.188	2.872		0.240	0.691	6.987
2018	0.503	4.379			0.188	3.060		0.240	0.691	7.678
2019	0.453	4.831	0.012	0.012	0.188	3.248		0.240	0.653	8.331
2020	0.453	5.284	0.024	0.036	0.165	3.413		0.240	0.641	8.972
2021	0.453	5.736	0.015	0.050	0.165	3.578		0.240	0.633	9.605
2022	0.453	6.189	0.029	0.080		3.578		0.240	0.482	10.087
2023	0.453	6.642	0.029	0.109		3.578		0.240	0.482	10.569
2024	0.453	7.094	0.029	0.138		3.578		0.240	0.482	11.051
2025	0.453	7.547	0.029	0.167		3.578		0.240	0.482	11.532
2026	0.453	8.000	0.029	0.197		3.578		0.240	0.482	12.014
2027	0.453	8.452	0.029	0.226		3.578		0.240	0.482	12.496
2028	0.453	8.905	0.029	0.255		3.578		0.240	0.482	12.978
2029		8.905	0.029	0.284		3.578		0.240	0.029	13.007
2030		8.905	0.029	0.313		3.578		0.240	0.029	13.036

Table 2.4 (continued)

^aTaken from data given in ref. 1. Glass may be in storage at the site, in transit to a repository, or in a repository.

^bSee Table 2.7 for the projected number of canisters.

^cHanford's reference canister has a diameter of 68 cm and is 457 cm long (about 2 ft in diam by about 15 ft in length). The nominal glass volume is expected to be 1.26 m³ with an average waste oxide loading of 45%. Cesium and strontium capsules will also be disposed of in these canisters.

^dAt INEL, each canister is assumed to contain nominally 0.92 m³ of a glass waste form made with HLW from the reprocessing of SNF.

^eAt SRS, the DWPF canisters are 0.6 m in diam by 3.0 m in length (about 2 ft in diam by about 10 ft in length). Each canister is assumed to contain 0.625 m³ of glass [i.e., 85% of the usable capacity (0.735 m³)] made with HLW from the reprocessing of SNF at SRS. The glass incorporates 36 wt % oxides from waste (28 wt % from SNF and 8 wt % from processing chemicals) and 64 wt % oxides from nonradioactive glass frit. Volumes reported are for the glass waste form and not the canisters.

^fFor WVDP, it is assumed that 300 canisters 0.6 m in diam by 3.0 m in length (2 ft in diam by 10 ft in length) are filled with waste glass during 1996–1998 and that each canister contains 0.8 m³ of glass at the filling temperature.

Table 2.5. Projected annual and cumulative decayed radioactivity (10^6 Ci) of HLW glass stored in canisters, by site^{a,b}

End of calendar year	Hanford ^c		INEL		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					18.31	18.31	7.75	7.75	26.06	26.06
1997					17.88	35.75	7.62	15.37	25.50	51.12
1998					17.47	52.37	7.03	22.40	24.50	74.77
1999					17.07	68.20		21.88	17.07	90.08
2000					16.68	83.29		21.37	16.68	104.66
2001					16.30	97.66		20.87	16.30	118.53
2002					15.94	111.35		20.39	15.94	131.74
2003					15.58	124.36		19.91	15.58	144.27
2004					15.23	136.74		19.45	15.23	156.19
2005					14.89	148.50		18.99	14.89	167.49
2006					14.56	159.67		18.55	14.56	178.22
2007					14.24	170.27		18.12	14.24	188.39
2008					13.92	180.32		17.69	13.92	198.01
2009					13.61	189.84		17.28	13.61	207.12
2010	7.18	7.18			13.31	198.86		16.88	20.49	222.91
2011	7.01	14.02			13.02	207.38		16.48	20.03	237.88
2012	6.85	20.55			12.73	215.42		16.10	19.58	252.07
2013	22.70	42.77			12.45	223.02		15.73	35.15	281.52
2014	22.17	63.96			12.18	230.18		15.36	34.35	309.49
2015	21.66	84.14			11.91	236.91		15.00	33.57	336.06
2016	21.16	103.37			11.65	243.25		14.65	32.82	361.26
2017	20.67	121.65			11.40	249.19		14.31	32.07	385.16
2018	20.20	139.05			11.15	254.76		13.98	31.35	407.79
2019	5.82	141.65	0.42	0.42	10.91	259.98		13.65	17.15	415.71
2020	5.68	144.07	0.03	0.45	10.68	264.85		13.33	16.39	422.69
2021	5.55	146.30	1.92	2.36	10.45	269.39		13.02	17.92	431.06
2022	5.42	148.34	2.62	4.89		263.39		12.72	8.04	429.34
2023	5.30	150.22	2.20	6.96		257.53		12.42	7.50	427.13
2024	5.17	151.93	2.15	8.92		251.81		12.13	7.32	424.79
2025	5.06	153.48	1.87	10.60		246.23		11.85	6.93	422.16
2026	4.94	154.88	1.83	12.10		240.78		11.57	6.77	419.32
2027	4.82	156.13	1.78	13.60		235.45		11.30	6.60	416.48
2028	4.71	157.24	1.87	15.10		230.25		11.04	6.58	413.63
2029		153.62	1.93	16.70		225.17		10.78	1.93	406.27
2030		150.07	1.54	17.80		220.22		10.53	1.54	398.62

^aTaken from data given in ref. 1.^bRadioactive decay is taken into account by each site by means of radioisotope generation and depletion codes.^cThe significant increase in annual radioactivity for the years 2013–2018 reflects the accelerated processing schedule for the strontium and cesium capsules at Hanford (see Sect. 2.5.1).

Table 2.6. Projected annual and cumulative decayed thermal power (10³ W) of HLW glass stored in canisters, by site^{a,b}

End of calendar year	Hanford ^c		INEL		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					51.59	51.59	22.46	22.46	74.05	74.05
1997					50.71	101.39	22.08	44.54	72.79	145.93
1998					49.87	149.49	20.38	64.92	70.25	214.41
1999					49.01	195.85		63.40	49.01	259.25
2000					48.14	240.39		61.92	48.14	302.31
2001					47.26	283.11		60.47	47.26	343.58
2002					46.38	324.01		59.05	46.38	383.06
2003					45.49	363.09		57.67	45.49	420.76
2004					44.60	400.41		56.32	44.60	456.73
2005					43.72	436.00		55.00	43.72	491.00
2006					42.85	469.92		53.71	42.85	523.63
2007					41.99	502.23		52.45	41.99	554.68
2008					41.14	532.97		51.22	41.14	584.19
2009					40.31	562.20		50.02	40.31	612.22
2010	21.54	21.54			39.49	589.99		48.85	61.03	660.37
2011	21.04	42.08			38.69	616.38		47.71	59.73	706.16
2012	20.55	61.66			37.91	641.42		46.59	58.46	749.68
2013	63.39	123.63			37.14	665.18		45.50	100.53	834.31
2014	61.92	182.70			36.39	687.69		44.43	98.31	914.83
2015	60.50	238.98			35.65	709.02		43.39	96.15	991.39
2016	59.10	292.57			34.93	729.19		42.38	94.03	1,064.15
2017	57.74	343.56			34.23	748.27		41.39	91.97	1,133.22
2018	56.41	392.05			33.54	766.28		40.42	89.95	1,198.75
2019	17.46	400.47	1.22	1.21	32.87	783.28		39.47	51.55	1,224.43
2020	17.06	408.30	0.10	1.28	32.22	799.31		38.55	49.38	1,247.43
2021	16.67	415.55	5.55	6.79	31.58	814.39		37.64	53.80	1,274.38
2022	16.28	422.26	7.54	14.10		797.63		36.76	23.82	1,270.75
2023	15.91	428.44	6.34	20.00		781.24		35.90	22.25	1,265.58
2024	15.54	434.12	6.19	25.70		765.22		35.06	21.73	1,260.10
2025	15.19	439.31	5.39	30.40		749.58		34.24	20.58	1,253.53
2026	14.84	444.04	5.27	34.90		734.29		33.44	20.11	1,246.66
2027	14.50	448.32	5.15	39.20		719.34		32.66	19.65	1,239.52
2028	14.17	452.17	5.40	43.60		704.74		31.89	19.57	1,232.40
2029		441.77	5.57	48.10		690.48		31.15	5.57	1,211.49
2030		431.61	4.45	51.40		676.54		30.42	4.45	1,189.97

^aTaken from data given in ref. 1.^bThermal power is taken into account by each site by means of radioisotope generation and depletion codes.^cThe significant increase in annual thermal power for the years 2013–2018 reflects the accelerated processing schedule for the strontium and cesium capsules at Hanford (see Sect. 2.5.1).

Table 2.7. Estimated potential number of HLW canisters, by site^a

End of calendar year	Hanford ^b		INEL ^c		SRS ^d		WVDP ^e		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					60	60	100	100	160	160
1997					87	147	100	200	187	347
1998					87	234	100	300	187	534
1999					87	321		300	87	621
2000					139	460		300	139	760
2001					143	603		300	143	903
2002					143	746		300	143	1,046
2003					143	889		300	143	1,189
2004					213	1,102		300	213	1,402
2005					213	1,315		300	213	1,615
2006					213	1,528		300	213	1,828
2007					213	1,741		300	213	2,041
2008					213	1,954		300	213	2,254
2009					207	2,161		300	207	2,461
2010	359	359			313	2,474		300	672	3,133
2011	359	718			313	2,787		300	672	3,805
2012	359	1,078			313	3,100		300	672	4,478
2013	400	1,477			313	3,413		300	713	5,190
2014	400	1,877			292	3,705		300	692	5,882
2015	400	2,276			292	3,997		300	692	6,573
2016	400	2,676			292	4,289		300	692	7,265
2017	400	3,076			300	4,589		300	700	7,965
2018	400	3,475			300	4,889		300	700	8,664
2019	359	3,834	27	27	300	5,189		300	687	9,351
2020	359	4,194	53	80	264	5,453		300	676	10,027
2021	359	4,553	33	113	264	5,717		300	656	10,683
2022	359	4,912	66	179		5,717		300	425	11,108
2023	359	5,271	66	244		5,717		300	425	11,533
2024	359	5,630	66	310		5,717		300	425	11,958
2025	359	5,990	66	376		5,717		300	425	12,383
2026	359	6,349	66	442		5,717		300	425	12,808
2027	359	6,708	66	507		5,717		300	425	13,232
2028	359	7,067	66	573		5,717		300	425	13,658
2029		7,067	66	639		5,717		300	66	13,723
2030		7,067	66	704		5,717		300	66	13,789

Table 2.7 (continued)

^a Taken from ref. 1. The projected waste volume, radioactivity, and thermal power values (Tables 2.4-2.6) are consistent with the number of canisters reported. The projections reported for Hanford, INEL, and SRS reflect major changes in the HLW solidification schedule. These changes are mainly caused by current DOE funding guidance.
^b Hanford's reference canister has a diameter of 68 cm and is 457 cm long (about 2 ft in diam by about 15 ft in length). The nominal glass volume is expected to be 1.26 m ³ with an average waste oxide loading of 45%. Cesium and strontium capsules will also be disposed of in these canisters.
^c At INEL, each canister is assumed to contain nominally 0.92 m ³ of glass.
^d Canisters are 0.6 m in diam by 3.0 m in length (about 2 ft in diam by about 10 ft in length). Each canister is assumed to contain 0.625 m ³ of glass made with HLW from the reprocessing of SNF at SRS. The glass incorporates 36 wt % oxides from waste (28 wt % from SNF and 8 wt % from processing chemicals) and 64 wt % oxides from nonradioactive glass frit.
^e Canisters are 0.6 m in diam by 3.0 m in length (about 2 ft in diam by 10 ft in length). Each canister is assumed to contain 0.8 m ³ of a borosilicate glass incorporating waste solids.

Table 2.8. Current volume of HLW in storage by site through 1994^a

Site	Volume, 10 ³ m ³				Canister material	Total
	Tank waste		Capsules			
	Liquid ^b	Solid ^c	Sr	Cs		
Hanford	83.2	155.8	0.0010954	0.0024046		239.0
INEL	7.2	3.8				11.0
SRS	58.1	68.2				126.3
WVDP	2.0	0.14				2.1
Total	150.5	227.9	0.0010954	0.0024046	0	378.4

^aTaken from ref. 1.^bLiquid tank waste consists of free tank supernatant and drainable interstitial liquid.^cSolid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate.Table 2.9. Current radioactivity of HLW in storage by site through 1994^a

Site	Radioactivity, 10 ⁶ Ci					Total
	Tank waste		Capsules		Canister material	
	Liquid ^b	Solid ^c	Sr	Cs		
Hanford	70.1	128.3	46.0	103.5		347.9
INEL	2.0	49.6				51.6
SRS	231.4	302.3				533.7
WVDP	3.5	21.2				24.7
Total	307.0	501.4	46.0	103.5	0	957.9

^aTaken from ref. 1.^bLiquid tank waste consists of free tank supernatant and drainable interstitial liquid.^cSolid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate.

Table 2.10. Current thermal power of HLW in storage by site through 1994^a

Site	Thermal power, 10 ³ W					Total
	Tank waste		Capsules		Canister material	
	Liquid ^b	Solid ^c	Sr	Cs		
Hanford	170.6	424.1	153.9	251.1		999.7
INEL	5.8	145.0				150.8
SRS	491.5	998.7				1,490.2
WVDP	12.9	65.2				78.1
Total	680.8	1,633.0	153.9	251.1	0	2,718.8

^aTaken from ref. 1.^bLiquid tank waste consists of free tank supernatant and drainable interstitial liquid.^cSolid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate.Table 2.11. Major radionuclides comprising HLW and associated wastes at Hanford^a

Radionuclides	Radioactivity (Ci) by waste category					
	Interim forms ^b		Final forms ^c			
	Tank waste	Other (capsules)	HLW glass canisters	LLW form (glass) ^d	Cumulative out of system	Other (capsule canisters)
³ H	e	e	0.000E+00		0.000E+00	0.000E+00
¹⁴ C	4.575E+03	0.000E+00	0.000E+00		4.555E+03	0.000E+00
⁹⁰ Sr	6.096E+07	2.301E+07	2.714E+07		0.000E+00	1.024E+07
⁹⁰ Y	6.096E+07	2.301E+07	2.714E+07		0.000E+00	1.024E+07
⁹⁹ Tc	3.210E+04	0.000E+00	3.206E+04		4.173E+01	0.000E+00
¹²⁹ I	2.980E-01	0.000E+00	0.000E+00		2.980E-01	0.000E+00
¹³⁷ Cs	3.860E+07	5.318E+07	1.760E+07		0.000E+00	2.425E+07
^{137m} Ba	3.656E+07	5.036E+07	1.667E+07		0.000E+00	2.296E+07
¹⁵¹ Sm	1.066E+06	0.000E+00	8.206E+05		0.000E+00	0.000E+00
²³⁸ Pu	1.427E+03	0.000E+00	1.091E+03		0.000E+00	0.000E+00
²³⁹ Pu	2.635E+04	0.000E+00	2.633E+04		0.000E+00	0.000E+00
²⁴⁰ Pu	6.692E+03	0.000E+00	6.668E+03		0.000E+00	0.000E+00
²⁴¹ Pu	9.775E+04	0.000E+00	1.903E+04		0.000E+00	0.000E+00
²⁴² Pu	2.802E-01	0.000E+00	2.802E-01		0.000E+00	0.000E+00
²⁴¹ Am	1.038E+05	0.000E+00	1.007E+05		0.000E+00	0.000E+00
²⁴² Am	6.275E+01	0.000E+00	5.374E+01		0.000E+00	0.000E+00
Total	1.984E+08	1.495E+08	8.955E+07		4.597E+03	6.769E+07

^aData taken from ref. 1(a).^bAs of December 31, 1994.^cAs of December 31, 2028.^dRadionuclide distribution projections have not been finalized for the final LLW form.^eEstimate of December 31, 1994, inventory for ³H is currently unavailable.

Table 2.12. Major radionuclides comprising HLW and associated wastes at INEL^a

Radionuclides	Radioactivity (Ci) by waste category			
	Interim forms ^b		Final forms ^c	
	Liquid	Calcine	Glass	Grout
⁹⁰ Sr	4.52E+05	1.16E+07	3.54E+06	7.07E+02
⁹⁰ Y	4.52E+05	1.16E+07	3.54E+06	7.07E+02
¹⁰⁶ Ru	1.66E+03	1.04E+04	4.18E-12	4.18E-12
¹⁰⁶ Rh	1.66E+03	1.04E+04	4.18E-12	4.18E-12
¹³⁴ Cs	1.04E+04	1.43E+05	6.72E-03	1.34E-06
¹³⁷ Cs	5.33E+05	1.33E+07	4.21E+06	8.43E+02
^{137m} Ba	5.05E+05	1.26E+07	3.99E+06	7.99E+02
¹⁴⁴ Ce	9.27E+03	5.33E+04	2.46E-15	4.92E-19
¹⁴⁴ Pr	9.27E+03	5.33E+04	2.46E-15	4.92E-19
¹⁴⁷ Pm	0.00E+00	1.94E+05	3.01E-01	6.02E-05
¹⁵⁴ Eu	3.46E+03	6.50E+04	1.12E+03	2.24E-01
Total	1.98E+06	4.96E+07	1.53E+07	3.06E+03

^aData taken from ref. 1(b).

^bAs of December 31, 1994.

^cAs of December 31, 2045.

Table 2.13. Major radionuclides comprising HLW and associated wastes at SRS^a

Radionuclides	Radioactivity (Ci) by waste category			
	Interim form ^b	Final forms ^c		
	Tank waste	Canister material	Saltstone (LLW)	Outfall
³ H	8.53E+04	3.25E+03	8.27E-01	d
¹⁴ C	2.00E+01	7.63E-01	1.94E-04	d
⁹⁰ Sr	1.22E+08	4.66E+06	1.18E+03	d
⁹⁰ Y	1.22E+08	4.66E+06	1.18E+03	d
⁹⁹ Tc	2.28E+04	8.69E+02	2.21E-01	d
¹²⁹ I	3.68E+01	1.41E+00	3.57E-04	d
¹³⁷ Cs	1.19E+08	4.53E+06	1.15E+03	d
^{137m} Ba	1.12E+08	4.28E+06	1.09E+03	d
²³⁸ Pu	1.73E+06	6.59E+04	1.68E+01	d
²³⁹ Pu	3.64E+04	1.39E+03	3.54E-01	d
²⁴⁰ Pu	1.66E+04	6.32E+02	1.61E-01	d
²⁴¹ Pu	7.91E+05	3.02E+04	7.67E+00	d
²⁴² Pu	2.84E+01	1.08E+00	2.76E-04	d
²⁴¹ Am	2.35E+04	8.97E+02	2.28E-01	d
^{242m} Am	6.41E+01	2.45E+00	6.22E-04	d
²³² Th	1.47E+00	5.62E-02	1.43E-05	d
²³³ U	1.08E+02	4.13E+00	1.05E-03	d
²³⁴ U	3.01E+01	1.15E+00	2.92E-04	d
²³⁷ Np	7.04E+01	2.69E+00	6.83E-04	d
²⁴⁴ Cm	2.60E+03	9.92E+01	2.52E-02	d
Total	4.78E+08	1.82E+07	4.64E+03	d

^aData taken from refs. 1(c) and 1(d).

^bAs of December 31, 1994.

^cAs of December 31, 1996, the first year of glass production.

^dNegligible contribution.

Table 2.14. Major radionuclides comprising HLW and associated wastes at WVDP^a

Radionuclides	Radioactivity, Ci, by waste waste category			
	Interim form ^b	Final forms ^c		
		Canister material	LLW form	Emissions
⁹⁰ Sr	5.93E+06			
⁹⁰ Y	5.93E+06			
¹⁰⁶ Ru	8.96E-01			
¹⁰⁶ Rh	8.96E-01			
¹³⁴ Cs	1.30E+03			
¹³⁵ Cs	1.56E+02			
¹³⁷ Cs	6.57E+06			
^{137m} Ba	6.21E+06			
¹⁴⁷ Pm	9.00E+01			
²³⁸ Pu	7.56E+03			
²³⁹ Pu	2.11E+00			
²⁴¹ Pu	1.04E+03			
²⁴¹ Am	9.10E+04			
²⁴⁴ Cm	1.04E+01			
Total	2.47E+07			

^aData taken from ref. 1(c).

^bAs of December 31, 1994.

^cRadionuclide information for the final forms generated from HLW treatment is currently unavailable.

Table 2.15. Significant revisions and changes in the current values for HLW compared to the values in the previous year.^{a,b}

Waste characteristics	Previous report values ^a	Significant revisions and changes	Updated values ^b	Explanation
<i>Hanford Site</i>				
Number of canisters	See Table 2.3	Projected number of canisters significantly reduced	See Table 2.7	Hanford selected a canister with a larger volume than the canister used for previous estimates
<i>Idaho National Engineering Laboratory</i>				
Number of canisters	See Table 2.3	Canister production schedule updated	See Table 2.7	Based on current funding guidance from DOE and the INEL Full Treatment Alternative (see ref. 15)
<i>Savannah River Site</i>				
Number of canisters	See Table 2.3	Canister production schedule updated	See Table 2.7	Based on current funding guidance from DOE and the SRS High-Level Waste System Plan Revision 5(U) (see ref. 16)
<i>West Valley Demonstration Project</i>				
Radioactivity and thermal power	See Tables 2.1 and 2.4–2.8	Radioactivity values for 1995, 1996, and 1997 were updated	See Tables 2.2, 2.3, 2.9, and 2.10	The radioactivity values did not reflect accurate sludge radioactivity values for yttrium and strontium in the previous report. The current report reflects the updated values

^aData are for December 31, 1993. See tables and text cited in Chapter 2 of ref. 6 (DOE/RW-0006, Rev. 10).^bData are for December 31, 1994, as reported in this document (DOE/RW-0006, Rev. 11).

Table 2.16. Representative chemical composition of future HLW glass to be generated at Hanford^a

Component	Wt %	Component	Wt %
Al ₂ O ₃	6.01	Na ₂ O	11.28
B ₂ O ₃	9.70	Na ₂ SO ₄	0.15
Bi ₂ O ₃	0.97	NiO	0.99
CaO	0.95	P ₂ O ₅	2.18
Ce ₂ O ₃	1.20	PbO ₂	0.15
Cr ₂ O ₃	0.21	SiO ₂	46.08
Fe ₂ O ₃	5.09	SrO	0.19
K ₂ O	0.10	ThO ₂	0.07
La ₂ O ₃	0.20	UO ₃	6.76
Li ₂ O	2.69	ZrO ₂	3.27
MnO ₂	0.84	Other	0.37
NaF	0.57		
		Total	100.00

^aData taken from ref. 1(a).

Table 2.17. Representative chemical composition of future HLW glass to be produced at INEL^a

Chemical compound	Glass, wt %, formed from high-activity fraction from		
	Dissolved Zr calcine	Dissolved Al calcine	Na-bearing-waste
Al ₂ O ₃	0.5	12.7	17.2
AMP ^b	0.8	6.6	
B ₂ O ₃	12.2	8.1	11.3
CaF ₂	14.5		
CaO	0.4		
Cs ₂ O		0.1	
Fe ₂ O ₃		0.1	0.1
Na ₂ O	12.9	18.0	13.8
P ₂ O ₅	0.1		
SiO ₂	56.8	54.4	57.6
ZrO ₂	1.8		
Total	100.0	100.0	100.0

^aData taken from ref. 1(b); flowsheet estimate, not verified by laboratory tests.

^bAmmoniummolybdophosphate.

Table 2.18. Representative chemical composition of future HLW glass to be generated at SRS^a

Component	Wt %	Component	Wt %
Al ₂ O ₃	3.9	MgO	2.0
B ₂ O ₃	7.3	MnO	1.2
CaO	0.6	Na ₂ O	8.7
Ca ₃ (PO ₄) ₂	1.1	NiO	0.1
Cr ₂ O ₃	0.2	SiO ₂	53.4
CuO	0.4	TiO ₂	0.3
FeO	1.1	U ₃ O ₈	0.9
Fe ₂ O ₃	11.1	ZnO	0.1
K ₂ O	2.4	Other	0.4
Li ₂ O	4.8		
		Total	100.0

^aData taken from ref. 1(c).

Table 2.19. Representative chemical composition of future HLW glass to be generated at WVDP^a

Component	Wt %	Composition	Wt %
Al ₂ O ₃	6.00	Nd ₂ O ₃	0.14
B ₂ O ₃	12.89	NiO	0.25
BaO	0.16	P ₂ O ₅	1.20
CaO	0.48	PdO	0.03
Ce ₂ O ₃	0.31	Pr ₆ O ₁₁	0.04
CoO	0.02	Rh ₂ O ₃	0.02
Cr ₂ O ₃	0.14	RuO ₂	0.08
Cs ₂ O	0.08	SO ₃	0.23
CuO	0.03	SiO ₂	40.98
Fe ₂ O ₃	12.02	Sm ₂ O ₃	0.03
K ₂ O	5.00	SrO	0.02
La ₂ O ₃	0.04	ThO ₂	3.56
Li ₂ O	3.71	TiO ₂	0.80
MgO	0.89	UO ₃	0.63
MnO	0.82	Y ₂ O ₃	0.02
MoO ₃	0.04	ZnO	0.02
Na ₂ O	8.00	ZrO ₂	1.32
		Total	100.00

^aData taken from ref. 1(e).



A TRUPACT-II (transuranic package transporter-II, a package to transport contact-handled transuranic waste) practice shipment nears the Waste Isolation Pilot Plant in southeastern New Mexico. *Courtesy of the Westinghouse Electric Corporation, WIPP Project Office, Carlsbad, New Mexico.*

3. TRANSURANIC WASTE

3.1 INTRODUCTION

This chapter presents information on the inventories and characteristics of transuranic waste (TRUW) at various DOE waste generator and/or storage sites in the United States. TRUW is a waste category specific to DOE; it does not apply to wastes regulated by the U.S. Nuclear Regulatory Commission. DOE Order 5820.2A defines TRUW as waste that (1) is contaminated with alpha-emitting transuranic (TRU) (i.e., atomic numbers greater than 92) radionuclides with half-lives greater than 20 years and (2) contains a total concentration of such radionuclides in excess of 100 nCi/g of waste at the time of assay.¹

DOE Order 5820.2A also states that heads of field elements can determine that other alpha-contaminated waste at the site(s) may be managed as TRUW.¹ As a consequence of this provision, wastes containing radionuclides such as ²³³U, ²⁴¹Pu, and ²⁴⁴Cm, which do not meet the strict definition of TRU radionuclides because of their respective atomic numbers or half-lives, may be managed as TRUW at some sites.

Most TRUW exists in solid form (e.g., items such as protective clothing, paper, rags, glass, miscellaneous tools, and equipment that have become contaminated with TRU radionuclides).² Some TRUW is in the form of sludges or liquids resulting from chemical processing for recovery of plutonium or other TRU elements.² Some of the liquids have been solidified, and some sludges have been dewatered. All sludge and liquid wastes scheduled for disposal in the Waste Isolation Pilot Plant (WIPP) will be solidified prior to shipment to meet the current WIPP waste acceptance criteria.³

Before 1970, TRUW was disposed of on-site in shallow, landfill-type, DOE-owned burial sites. TRUW disposed of in this manner is referred to as "buried" TRUW. In 1970, DOE's predecessor agency, the U.S. Atomic Energy Commission, concluded that waste containing long-lived alpha-emitting radionuclides should have greater confinement from the environment. Thus, TRUW generated since the early 1970s has been segregated from other waste types and placed in retrievable storage pending shipment and final disposal in a permanent

geologic repository.⁴ This waste is referred to as "retrievably stored" TRUW.

Retrievably stored waste is contained in a variety of packagings (e.g., metal drums and wooden and metal boxes) and is stored in various facilities such as earth-mounded berms, concrete culverts, buildings, and on outdoor pads. Many of these facilities have been upgraded and are now in compliance with applicable hazardous waste storage regulations.

TRUW packages are classified as either "contact handled" (CH) or "remote handled" (RH), depending on the radiation level at the surface of the package at the time of packaging. If this level exceeds 200 mrem/h, the package is classified as RH TRUW.

CH TRUW contains relatively small quantities of fission and activation products that produce highly penetrating radiation; typically, its emissions consists mostly of alpha particles and some neutrons and primarily low-energy gamma and X-rays. RH TRUW typically contains a greater proportion of fission and activation products that produce highly penetrating radiation and produce a higher level of radiation at the surface of the package.

TRUW waste which contains, in addition to radioactive constituents, hazardous constituents defined and regulated in accordance with the Resource Conservation and Recovery Act (RCRA) is defined as mixed TRUW. Examples of mixed TRUW are radionuclide-contaminated sludges from plutonium recovery, discarded materials contaminated with both solvents and radioactive materials, scintillation fluids, and discarded contaminated lead shielding. Mixed TRUW must be managed to comply with both the applicable hazardous waste regulations (e.g., RCRA), as well as the regulations applying only to radioactive TRUW.

Some TRUW may also be contaminated with hazardous materials defined by regulations other than RCRA (e.g., Toxic Substances Control Act and state regulations). Once identified, DOE continues to manage these wastes appropriately to meet all other hazardous waste regulations in addition to RCRA (if applicable).

Under existing arrangements, retrievably stored TRUW is the responsibility of the DOE Office of Waste

Management (EM-30). It is planned that the retrievably stored TRUW and newly generated TRUW from routine site operational activities will be shipped to WIPP for disposal; whereas, buried TRUW and TRUW generated from site remediation activities and decontamination and decommissioning (D&D) activities are the responsibility of the Office of Environmental Restoration (EM-40). (See Chapter 6 of this document for a discussion of environmental restoration wastes.)

3.2 TRUW INVENTORIES

3.2.1 Sources of Data

Quantitative information contained in this chapter is derived from data furnished by the DOE sites in response to the integrated data call issued for Rev. 10 of this report⁵ and Rev. 1 of the *Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report* (WTWBIR)² (Sect. 3.2.3.1). As programs and plans evolve or are changed, modifications or additions will be made to the data and other information in this chapter. It is expected that the quality and accuracy of the data will improve with each annual revision of this document, thus improving the usefulness of the data for program planning and decision purposes.

Early TRUW inventory practices were not as stringent as current ones with regard to requirements for waste identification, categorization, and segregation. Consequently, early inventory data are based largely on process knowledge and on various studies and summaries related to site-specific practices.⁶ As these efforts continue and TRUW is further characterized, there may be revisions in the estimated overall quantities of TRUW.

3.2.2 Site Locations—Summarized Volumes and Radioactivity

TRUW management activities (generation, retrievable storage, etc.) are performed at 10 major sites and 13 small-quantity sites (SQS). Figure 3.1 shows the locations of the DOE's TRUW generator and/or storage sites. Tables 3.1–3.10 and Figs. 3.2–3.5, which are discussed later in this chapter, summarize the distribution of retrievably stored and projected TRUW in its final form at various DOE generator and storage sites. Unlike previous versions of this report, the volumes reported in this revision are final-form volumes (i.e., after the sites process, treat, or repackage the waste). Tables 3.11 and 3.12 provide a breakdown of the major TRUW radionuclides by radioactivity. These tables display the decayed radioactivities that have been estimated from the data

reported by the sites for retrievably stored CH and RH TRUW, as of December 31, 1993. A breakdown for CH and RH TRUW in terms of decayed mass is provided in Tables 3.13 and 3.14, respectively.

3.2.3 Development of Detailed Inventory Data

To optimize its resources and to enhance data quality, DOE integrated the TRUW data needs of the IDB report (Rev. 10)⁵ with those of the WTWBIR, Rev. 1,² in forming a joint data call to the sites.⁷ The information contained in this chapter is a summary of the detailed data gathered through this integrated data-call process and is based on the TRUW final-form-volume projections, as reported in the WTWBIR, Rev. 1.² For a complete set of the information collected, refer to the source documents.

The WTWBIR, Rev. 1,² describes the disposal inventory of TRUW to be emplaced in WIPP, as defined by the DOE TRUW generator and/or storage sites. This information will be used to support the development of various compliance applications for the operations and postclosure phases of the WIPP repository. To meet the needs of the WTWBIR, site data were collected at the waste-stream level in both their initial and final forms. The data were grouped by similar physical and chemical properties and aggregated to produce estimated total volumes of the waste.

To maintain continuity with the previous revision of the IDB, Table 3.1 presents the changes in reported retrievably stored volumes between the IDB and the WTWBIR. The first column in this table presents the volumes at the end of 1993 that were reported in the previous revision of the IDB (Rev. 10).⁵ The next two columns present updated estimates of this same volume (i.e., end of 1993 data) in terms of both initial and final forms, respectively, as reported in the WTWBIR, Rev. 1.² The data derived from the WTWBIR, Rev. 1,² and reported in subsequent tables in this chapter include the final-form volumes at the end of 1993, and the projected increase in these final-form volumes from 1994 through 2022. In addition, the volumes reported in the attached tables are higher for some sites than those reported in the WTWBIR, Rev. 1,² because these volumes include some TRUW regulated under TSCA that was not included in the WIPP inventory defined in WTWBIR, Rev. 1.²

Because the radionuclide inventory is not yet available for each waste stream, the radionuclide data in this chapter are derived from the data submittal in support of Rev. 10 of the IDB report.⁵ Also taken from the IDB report are the volume data for buried TRUW (Table 3.15), TRU-contaminated soil (Table 3.16), and the retrievably stored TRUW (as of the end of 1993) that is shown in Table 3.1.

The remaining data are compiled from data presented earlier in Rev. 1 of the WTWBIR.²

3.2.3.1 Site data submittal process

As stated previously, all of the quantitative TRUW information presented in this chapter was derived from the data received from the sites in response to the integrated WTWBIR-IDB data call. In response to the data call, the sites provided waste stream profiles for each waste stream in their respective current and projected inventories through 2022. The waste stream profiles included such information as waste stream description, initial- and final-form volumes, specific container data, and estimates of the amount of various materials present in the waste (e.g., iron-based metals and alloys, cellulose, plastics, etc.). In addition, the sites were provided with a list of acceptable final waste forms for disposal at WIPP and asked to assign the appropriate final waste form to each waste stream. The assignment of final waste form helps to identify the general physical and chemical properties of the final form for each waste stream.

The sites provided radionuclide compositions and curies of each radionuclide added in each year of TRUW accumulation. The annual radioactivities in the site submittals were on an as-stored basis; that is, they represent the curies of each radionuclide added each year at the end of the year in which the waste was placed in storage. Only the cumulative site radioactivities have been included in this chapter. For a complete set of references for the TRUW site data submittals, see ref. 7 of Sect. 3.5.

3.2.3.2 Site data review and modification

The site data submittals for TRUW were reviewed to make certain, to the greatest extent possible, that the data supplied met the requirements of completeness and consistency. The data review process included modifying the formats of the data so that they could be easily converted to input data files.

In support of the WTWBIR, waste streams at each TRUW generator and/or storage site that were assigned the same final waste form were grouped together to form site-specific waste profiles. These profiles provide a condensed summary of the volume and waste material information found in the waste stream profiles for each site. Site-specific waste profiles with the same final waste form were then combined for all the TRUW generator and/or storage sites to produce WIPP waste profiles. The summary tables and figures presented in this chapter are based on the detailed waste stream profile data reported in the WTWBIR, Rev. 1.²

3.2.3.3 As-stored TRUW volumes

Tables 3.2–3.14 and Figs. 3.2–3.5 summarize a small portion of the information in the WTWBIR site submittals. These tables show the volumes and decayed radioactivities of retrievably stored CH and RH TRUW at each site at the end of 1993, projected generation from 1994 through 2022, and the ending volume inventory amounts at the end of 2022. Each table is constructed to highlight a different aspect of TRUW characteristics.

Table 3.2 shows the total estimated TRUW inventory in storage at the end of 1993 and projected through 2022 for each DOE site, and Tables 3.3–3.8 show the breakup of this total inventory into total CH TRUW (Table 3.3), mixed CH TRUW (Table 3.4), nonmixed CH TRUW (Table 3.5), total RH TRUW (Table 3.6), mixed RH TRUW (Table 3.7), and nonmixed RH TRUW (Table 3.8). The information in these tables is also presented graphically in Figs. 3.2–3.5.

Tables 3.9 and 3.10 show the volumes of TRUW at each site distributed among the 11 final waste forms (plus unknown) defined in the WTWBIR, Rev. 1.² Table 3.9 shows the final waste form distribution for the major sites, whereas Table 3.10 presents the same for the SQS.

3.2.3.4 Calculation of annual decayed radioactivities

Decayed radioactivities shown in Rev. 10 of the IDB report⁵ were calculated by the ORNL computer code RADAC, using the end-of-1993 data submitted to the IDB by the sites. This code converts the annual as-stored radioactivities to annual decayed radioactivities and accumulates these quantities to produce tables showing decayed grams, curies, and watts on a year-by-year, site-by-site, and radionuclide-by-radionuclide basis. Annual added volumes and cumulative volumes are also calculated. Volumes are assumed to be unaffected by decay.

In some cases, the site data were not sufficiently detailed to permit the desired decay calculations. The difficulty most frequently encountered was that radionuclide compositions were not adequately specified on a radionuclide-by-radionuclide basis. In such cases, data conversion codes were used to convert site input data to the radionuclide-specific forms required for decay calculations. The procedures followed in making these adjustments follow accepted precedents set in previous IDB editions and are described in Rev. 9 of the IDB report.⁸

3.2.4 Results of Radionuclide Inventory Calculations

For the purposes of this report, primary radionuclides are those that cumulatively contribute 98% of either the total radionuclide activity or mass.

3.2.4.1 Retrievably stored wastes

Tables 3.11–3.14 show the distribution of the primary TRUW radionuclides for all the DOE sites (decayed to the end of 1993) for both CH TRUW and RH TRUW both by radioactivity and by mass. As shown in these tables, ^{238}Pu , ^{241}Pu , ^{239}Pu , ^{241}Am , and ^{240}Pu cumulatively contribute more than 98% of the total activity for the CH TRUW (Table 3.11), whereas ^{238}U , ^{232}Th , ^{239}Pu , ^{235}U , and ^{242}Pu contribute more than 98% of the total radionuclide mass for CH TRUW (Table 3.13). Similar information on RH TRUW and on the relative distribution of both the radioactivity and mass of the primary radionuclides for the various DOE sites can also be derived from Tables 3.12 and 3.14.

3.2.4.2 Buried TRUW

Table 3.15 summarizes the buried TRUW volumes and associated radioactivity, both as-stored and as-decayed. Buried TRUW volumes and radioactivities shown in Table 3.15 are based on data provided in the site submittals. The form of the site-submitted data for buried waste is identical to that of the retrievably stored waste except that no distinction is made between CH and RH buried wastes. Table 3.15 shows both cumulative as-stored and as-decayed radioactivities for all nuclides, as well as for TRU nuclides only.

3.2.4.3 Contaminated soil

Over the years, many of the older buried waste containers have developed leaks and contaminated the adjacent soil. Also, at some sites, soil has become contaminated by liquid spills or has been used as an ion-exchange medium for dilute liquid waste streams. It is difficult to make accurate estimates of the actual quantity of the contaminated soil. The data reported by the sites are shown in Table 3.16. Additional characterization efforts will be required to reduce the uncertainties of this data.

3.3 PROJECTED FUTURE QUANTITIES OF TRUW

Tables 3.2–3.10 show the data submitted by the sites for estimated future volumes of TRUW generation. The sites were not requested to estimate the radioactivities or isotopic compositions of these wastes because it was believed that there would be little basis for such estimates. The estimated volumes are given in terms of average annual rates (m^3/year) for four time periods from 1994 to 1997 and for two cumulative time periods (1998–2002 and 2003–2022).

3.4 TRUW DISPOSAL

The goals of the DOE TRUW Program are to terminate interim storage and achieve permanent disposal of DOE TRUW.⁹ As stated in Public Law 96-164,¹⁰ WIPP was to be constructed “. . . as a defense activity of the DOE for the purpose of providing a research and development facility to demonstrate the safe disposal of radioactive waste resulting from defense activities and programs of the United States.” Construction of the facility is essentially complete, and WIPP is now the only facility specifically designed for isolation of TRUW. It is designed to contain about 175,000 m^3 (6.2 million ft^3)¹¹ of TRUW 650 m below ground in a mined salt formation.

Waste received at WIPP must meet the WIPP waste acceptance criteria and associated quality assurance requirements specified in WIPP/DOE-069.³ A number of other approvals remain to be completed before DOE can begin disposal operations at the facility. DOE is committed to demonstrating compliance with all applicable regulations before the permanent disposal of TRUW in the WIPP repository. These regulations are the environmental standards for management and disposal of TRU wastes, as mandated in 40 CFR Part 191 (ref. 12) and Part 194 (ref. 13), and the RCRA regulations. Compliance will be demonstrated through performance assessment calculations based on the inventory of existing and currently projected waste streams as reported by the DOE TRUW generator and/or storage sites in the WTWBIR, Rev. 1.²

In 1992 the WIPP Legislative Land Withdrawal Act¹¹ was passed, confirming congressional intent to have DOE continue with development and permitting of the facility. Since then, DOE has stated its intent to accelerate processes leading to the start of waste disposal operations at the WIPP.

3.5 REFERENCES

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7. DOE site TRUW data submittal attachments, submitted to the IDB Program and WTWBIR Project. The following TRUW submittals were received and reviewed by the IDB Program and WTWBIR Project before analysis and integration. Preceding each submittal is the site (in parentheses) to which it refers.
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 - b. (ANL-E) Michael Sodaro, Argonne National Laboratory, Argonne, Illinois, correspondence to Jeff Williams, DOE Carlsbad Area Office, Carlsbad, New Mexico, "WIPP TRU Baseline Inventory Report and Integrated Database Forecasts," dated Sept. 30, 1994.
 - c. (ANL-W) Nancy Stewart and Roy Grant, Argonne National Laboratory—West, Idaho Falls, Idaho, correspondence to E. W. Krieger, MAC Technical Services Company, Albuquerque, New Mexico, transmitting site data for inclusion into the IDB report (Rev. 10) and WTWBIR (Rev. 1), dated Jan. 17, 1995.
 - d. (BAPL) E. D. Shollenberger, DOE Pittsburgh Naval Reactors Office, West Mifflin, Pennsylvania, correspondence to Mark L. Matthews, DOE Carlsbad Area Office, Carlsbad, New Mexico, "Waste Isolation Pilot Project Transuranic Waste (TRU) Baseline Inventory Report and Updated Integrated Database TRU Information for the Bettis Atomic Power Laboratory," dated Oct. 21, 1994.
 - e. (BAPL) Jim Sage, DOE Pittsburgh Naval Reactors Office, West Mifflin, Pennsylvania, correspondence to E. W. Krieger, MAC Technical Services Company, Albuquerque, New Mexico, "WTWBIR Input for the Bettis Atomic Power Laboratory," dated Oct. 21, 1994.
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 - g. (ETEC) G. G. Gaylord, Rockwell International Corporation, Canoga Park, California, correspondence to Mark L. Matthews, DOE Carlsbad Area Office, Carlsbad, New Mexico, "TRU Inventory at ETEC," 94ETEC-DRF-1667, dated Oct. 31, 1994.

- h. (ETEC) Alan Von Arx, Energy Technology Engineering Center, Canoga Park, California, correspondence to E. W. Krieger, MAC Technical Services Company, Albuquerque, New Mexico, "Updated Tables 2, 3, 5, 9, & 11," dated Nov. 17, 1994.
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- j. (Hanford) F. M. Coony, Westinghouse Hanford Company, Richland, Washington, correspondence to E. W. Krieger, MAC Technical Services Company, Albuquerque, New Mexico, transmitting information on TRUW added to Hanford inventory during CY 1993, dated Dec. 7, 1994.
- k. (Hanford) F. M. Coony, Westinghouse Hanford Company, Richland, Washington, correspondence to Jim Teak, Advanced Sciences, Inc., Albuquerque, New Mexico, "Memorandum, Mark L. Matthews, P.E., National TRU Program Office, to Distribution, Extension of Data Package Review, dated Oct. 13, 1994," dated Nov. 1, 1994.
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- n. (INEL) Joel T. Case, DOE Idaho Operations Office, Idaho Falls, Idaho, correspondence to Jim Teak, Advanced Sciences, Inc., Albuquerque, New Mexico, "Integrated Data Base (IDB) TRU Waste 1994 Data Call," OPE-WM 94-308, dated Oct. 6, 1994.
- o. (INEL) T. L. Clements, Jr., Idaho National Engineering Laboratory, Idaho Falls, Idaho, correspondence to J. T. Case, DOE Idaho Operations Office, Idaho Falls, Idaho, "Integrated Data Base (IDB) TRU Waste 1994 Data Call," TLC-122-94, dated Sept. 29, 1994.
- p. (ITRI) Bruce B. Boecker, Inhalation Toxicology Research Institute, Albuquerque, New Mexico, correspondence to Jeff Williams, DOE Carlsbad Area Office, Carlsbad, New Mexico, "Response to the Waste Isolation Pilot Plant (WIPP) Transuranic Waste Baseline Inventory Report (WTWBIR) Data Package," dated Nov. 29, 1994.
- q. (KAPL) M. Monaco, Knolls Atomic Power Laboratory, Schenectady, New York, correspondence to E. W. Krieger, MAC Technical Services Company, Albuquerque, New Mexico, transmitting data for inclusion into the IDB report (Rev. 10) and WTWBIR (Rev. 1), dated Jan. 16, 1995.
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 - ak. (SRS) S. J. Mentrup, Westinghouse Savannah River Company, Aiken, South Carolina, correspondence to Stan Massingill, DOE Savannah River Operations Office, Aiken, South Carolina, "SRS Data Package for WIPP TRU Waste Baseline Inventory Report (U)," SWE-SWE-94-0550, dated Oct. 12, 1994.
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 - am. (WVDP) Connie King, West Valley Nuclear Services Company, Inc., West Valley, New York, correspondence to Royes Salmon, Oak Ridge National Laboratory, Oak Ridge, Tennessee, transmitting input to IDB report (Rev. 10), dated Nov. 14, 1994.
 - an. (WVDP) Connie King, West Valley Nuclear Services Company, Inc., West Valley, New York, correspondence to E. W. Krieger, MAC Technical Services Company, Albuquerque, New Mexico, transmitting responses to WTWBIR Comments, dated Dec. 12, 1994.
8. U.S. Department of Energy, *Integrated Data Base for 1993: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 9, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 1994).
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 13. U.S. Environmental Protection Agency, *Criteria for Certification of Compliance with Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Wastes*, 40 CFR Part 194, notice of proposed rulemaking, *Fed. Regist.* 58, 792 (Jan. 30, 1995).

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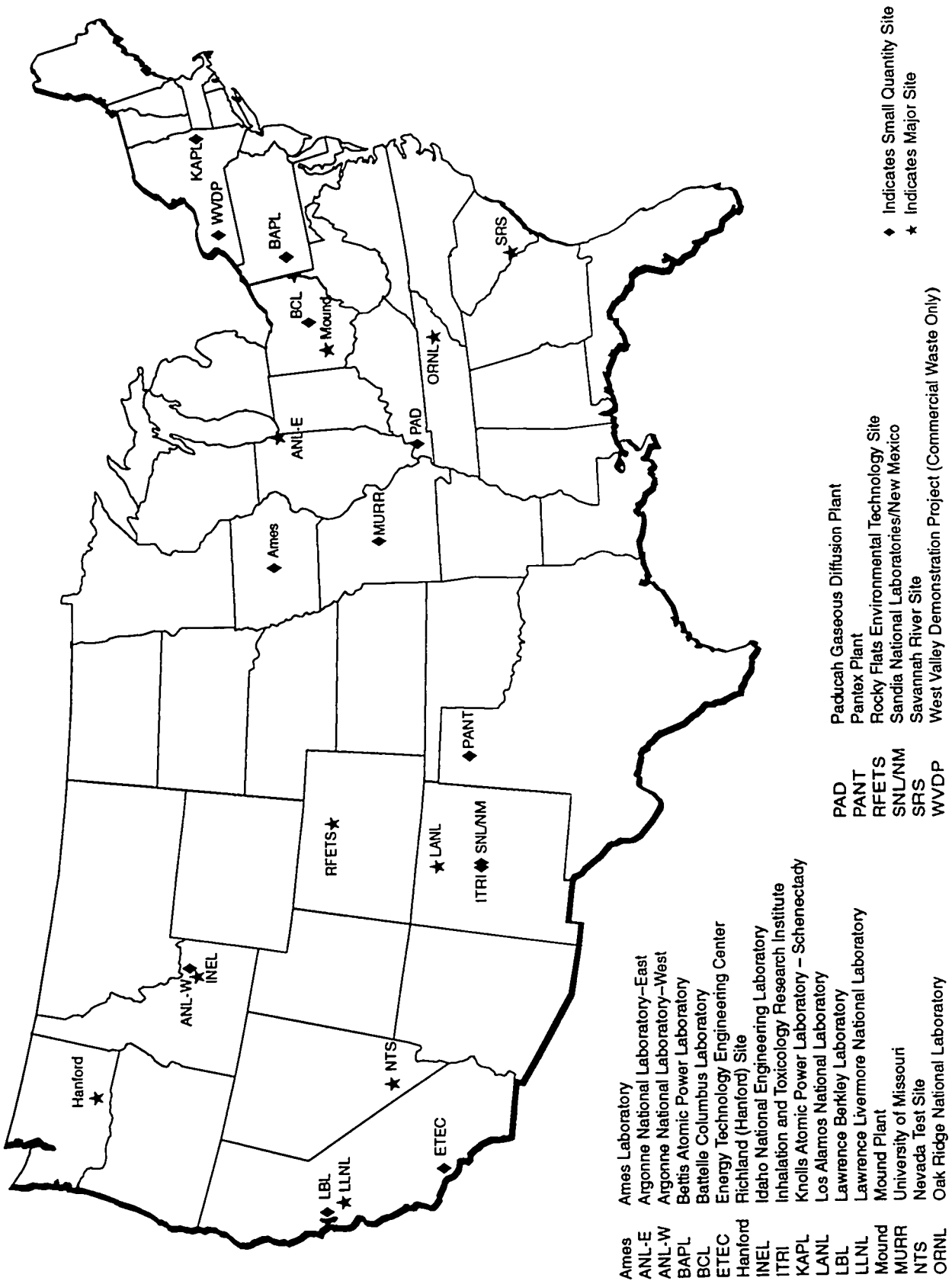
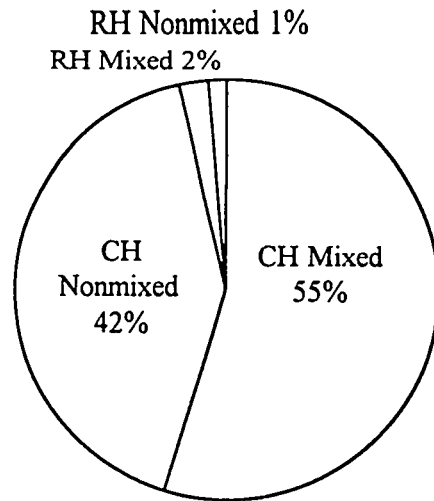
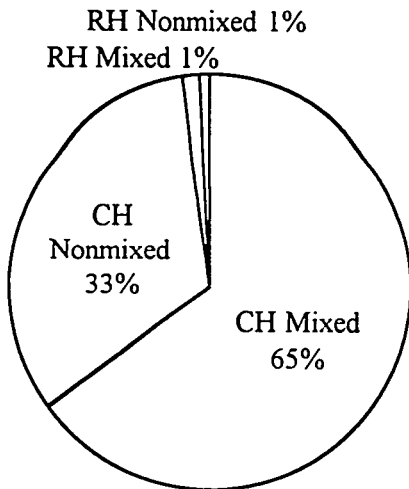


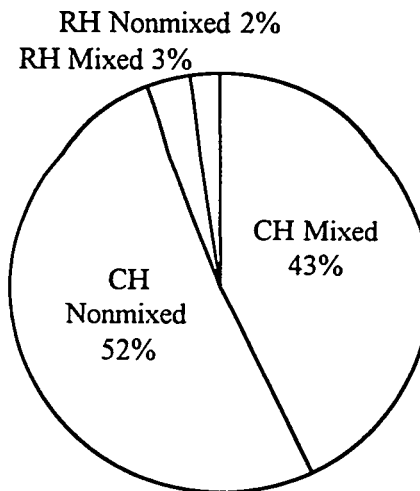
Fig. 3.1. U.S. Department of Energy transuranic waste generation/storage sites.



Total TRUW at End of 2022



**Total Stored
TRUW**

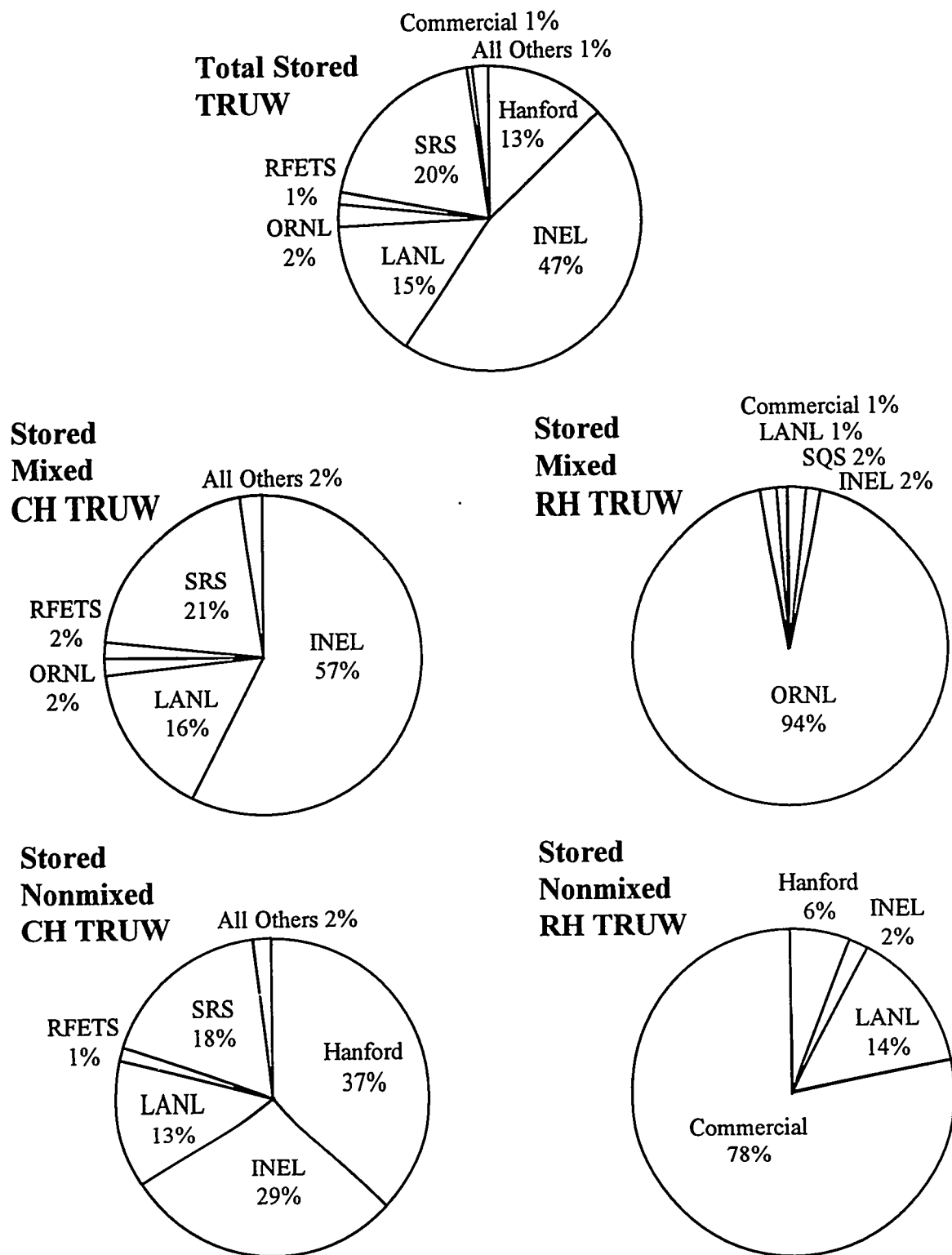


**Total Projected
TRUW**

NOTE: All amounts shown are for final waste form

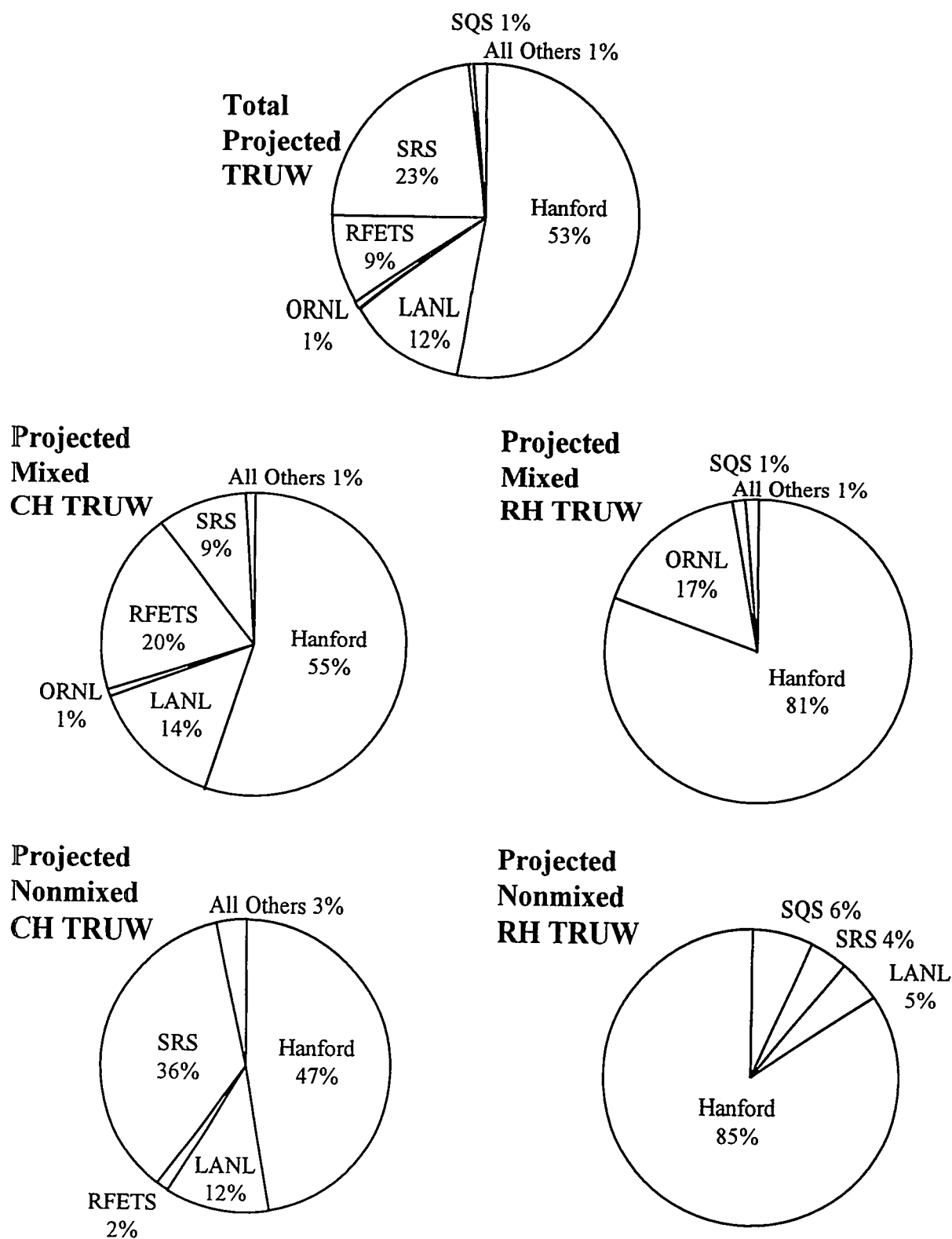
Fig. 3.2. Retrievably stored and projected TRUW volumes by radioactivity classification.

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NOTE: All amounts shown are for final waste form

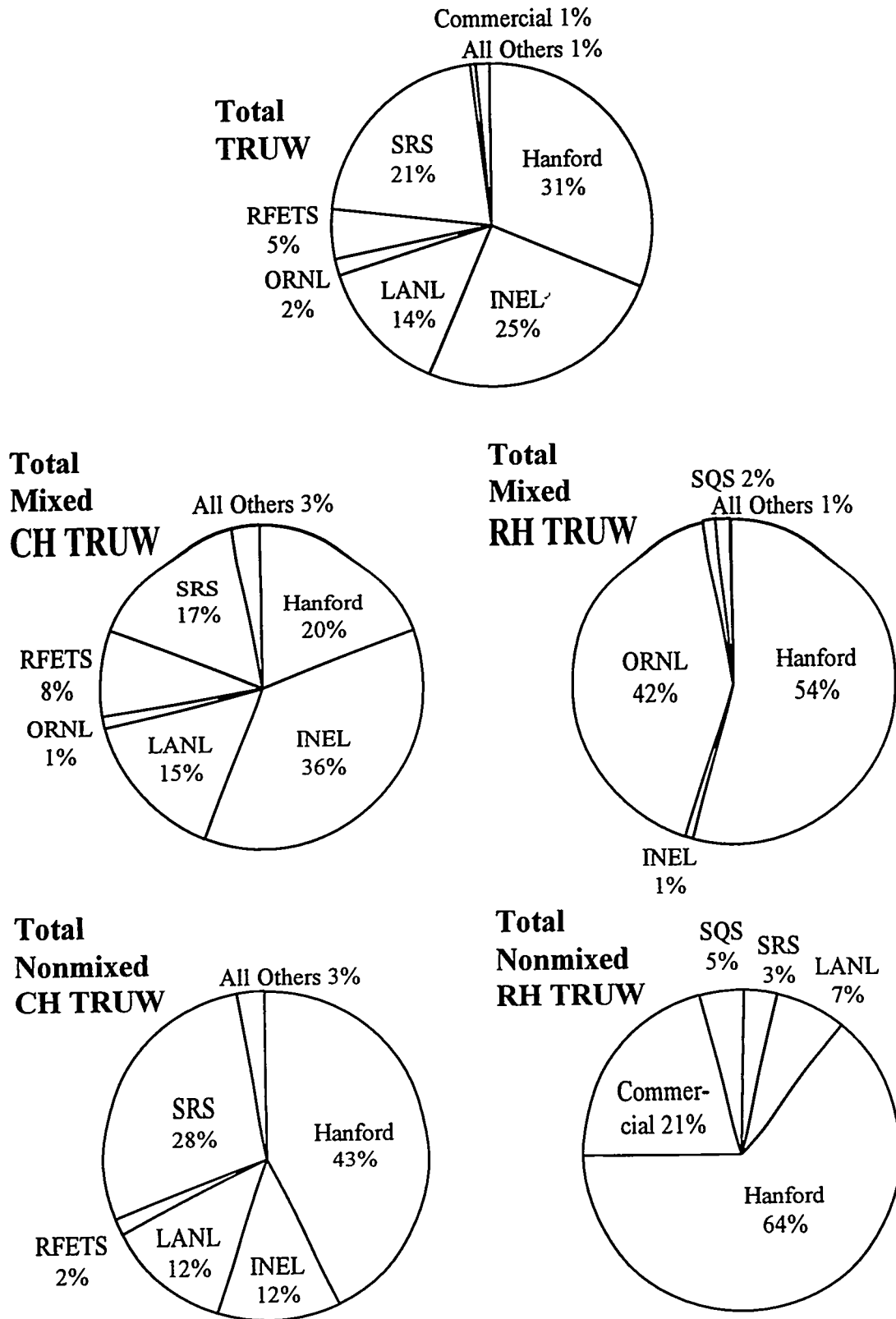
Fig. 3.3. Retrievably stored TRUW volumes by site.



NOTE: All amounts shown are for final waste form

Fig. 3.4. Projected TRUW volumes by site.

ORNL DWG 95-1593R



NOTE: All amounts shown are for final waste form

Fig. 3.5. Estimated TRUW volumes by end of year 2022.

Table 3.1. Comparison of IDB and WTWBIR retrievably stored volumes of TRUW^{a,b}
(Volumes are expressed in m³)

Site	Contact-handled TRUW			Remote-handled TRUW		
	As stored		In final form 1993 WTWBIR ^d	As stored		In final form 1993 WTWBIR ^d
	1993 IDB ^c	1993 WTWBIR ^d		1993 IDB ^c	1993 WTWBIR ^d	
Major sites						
ANL-E	2.91E+01	2.91E+01	2.91E+01	1.70E+00	0.00E+00 ^e	0.00E+00
Hanford	1.56E+04	8.06E+03 ^f	9.39E+03 ^g	2.01E+02	3.20E+01 ^h	3.32E+01 ^g
INEL	6.48E+04	3.92E+04 ^f	3.47E+04 ^g	7.98E+01	3.10E+01 ⁱ	3.10E+01
LANL	1.08E+04	1.09E+04	1.09E+04	9.13E+01	9.13E+01	9.13E+01
LLNL	2.35E+02	2.24E+02	2.24E+02	0.00E+00	0.00E+00	0.00E+00
Mound	1.19E+01	2.63E+02 ⁱ	2.63E+02	0.00E+00	0.00E+00	0.00E+00
NTS	6.07E+02	6.13E+02	6.20E+02 ^g	5.30E+00	0.00E+00	0.00E+00
ORNL	2.02E+03	7.83E+02 ⁱ	7.83E+02	5.64E+02	9.94E+02 ⁱ	9.94E+02
RFETS	1.04E+03	1.06E+03	1.13E+03 ^g	0.00E+00	0.00E+00	0.00E+00
SRS	8.93E+03	9.34E+03 ⁱ	1.46E+04 ^g	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.04E+05	7.04E+04	7.26E+04	9.43E+02	1.15E+03	1.15E+03
Small-quantity sites						
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	0.00E+00	2.00E-02 ^j	2.00E-02	0.00E+00	8.65E+00 ^j	8.65E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	1.90E+00	1.87E+00	1.87E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	0.00E+00	2.40E+00 ⁱ	2.40E+00	2.40E+00	1.12E+01 ⁱ	1.12E+01
LBL	9.00E-01	8.40E-01	8.40E-01	0.00E+00	0.00E+00	0.00E+00
MURR	1.00E-01	6.00E-02 ⁱ	6.00E-02	0.00E+00	0.00E+00	0.00E+00
PAD	4.30E+00	2.10E+00 ⁱ	3.45E+00 ^g	0.00E+00	0.00E+00	0.00E+00
PANT	6.00E-01	6.24E-01	6.24E-01	0.00E+00	0.00E+00	0.00E+00
SNL/NM	9.00E-01	8.04E+00 ⁱ	8.04E+00	9.00E-01	0.00E+00 ⁱ	0.00E+00
Subtotal	8.70E+00	1.60E+01	1.73E+01	3.30E+00	1.99E+01	1.99E+01

Table 3.1 (continued)

Site	Contact-handled TRUW			Remote-handled TRUW		
	As stored		In final form 1993 WTWBIR ^d	As stored		In final form 1993 WTWBIR ^d
	1993 IDB ^c	1993 WTWBIR ^d		1993 IDB ^c	1993 WTWBIR ^d	
Commercial site WVDP	4.91E+01	5.06E+01	5.06E+01	4.27E+02	4.27E+02	4.27E+02
Total	1.04E+05	7.05E+04	7.26E+04	1.37E+03	1.59E+03	1.60E+03

^aSmall changes between the 1993 IDB and 1993 WTWBIR (as stored) volumes are expected because of anticipated rounding methods and differences in reporting methodologies. Volumes reported by the IDB are the as-stored volumes shown by the sites in their data submittals to the IDB.

^bSome volumes of TSCA waste are included in this table that are not included in the WIPP inventory defined in WTWBIR, Rev. 1. See Tables 3.3, 3.4, and 3.5 for details.

^cSee ref. 5.

^dSee ref. 2.

^eVolume reported in Hanford submittal.

^fAdjusted to delete α -LLW volume included in previous IDB submittals.

^gDifference between "as-stored" and "final-form" volumes primarily caused by volume expansion from repackaging for WIPP waste acceptance criteria (WAC) compliance. INEL shows an overall decrease in volume because of thermal processing of some waste streams.

^hApproximately 200 m³ reported with CH-TRUW inventory are from waste streams containing both CH TRUW and RH TRUW (ref. 2, WTWBIR, Rev. 1, Table 6-1).

ⁱVolume differences resulting from revised inventory assessment.

^jVolume previously included in INEL submittal.

Table 3.2. Summary of final waste-form volumes (m³) of retrievably stored and projected TRUW (mixed and nonmixed CH and RH wastes)^{a,b}

Site	EOY ^c 1993	Annual increase					Cumulative increase		Projected increase	Total EOY 2022
		1994	1995	1996	1997	1998–2002	2003–2022	1994–2022		
Major sites										
ANL–E	2.91E+01	1.68E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E+00	3.08E+01
Hanford	9.42E+03	1.71E+02	4.91E+02	6.19E+02	1.91E+02	1.29E+03	3.11E+04	3.38E+04	3.38E+04	4.33E+04
INEL	3.47E+04	0.00E+00	6.00E–01	6.00E–01	1.60E+00	3.00E+00	1.20E+01	1.78E+01	1.78E+01	3.47E+04
LANL	1.10E+04	2.66E+02	2.77E+02	2.77E+02	2.77E+02	1.34E+03	5.32E+03	7.76E+03	7.76E+03	1.87E+04
LLNL	2.24E+02	2.11E+01	2.50E+01	2.50E+01	2.50E+01	1.25E+02	5.00E+02	7.21E+02	7.21E+02	9.45E+02
Mound	2.63E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E+02
NTS	6.20E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.20E+02
ORNL	1.78E+03	2.14E+01	2.14E+01	2.14E+01	2.14E+01	1.07E+02	4.28E+02	6.21E+02	6.21E+02	2.40E+03
RFETS	1.13E+03	6.64E+01	1.22E+02	9.31E+01	2.58E+01	1.40E+02	5.45E+03	5.90E+03	5.90E+03	7.03E+03
SRS	1.46E+04	5.13E+02	5.11E+02	5.11E+02	5.11E+02	2.56E+03	1.02E+04	1.48E+04	1.48E+04	2.94E+04
Subtotal	7.37E+04	1.06E+03	1.45E+03	1.55E+03	1.05E+03	5.56E+03	5.30E+04	6.37E+04	6.37E+04	1.37E+05
Small-quantity sites										
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E–01	1.00E–01	1.00E–01	1.00E–01
ANL–W	8.67E+00	2.24E+00	8.60E–01	1.20E+00	1.76E+00	7.01E+00	2.04E+01	3.35E+01	3.35E+01	4.21E+01
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.10E+01	0.00E+00	7.10E+01	7.10E+01	7.10E+01
BAPL	0.00E+00	0.00E+00	7.28E–01	2.68E+01	1.74E+01	7.65E+01	3.90E+00	1.25E+02	1.25E+02	1.25E+02
ETEC	1.87E+00	0.00E+00	5.20E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E+00	5.20E+00	7.07E+00
KAPL	1.36E+01	8.70E–01	8.70E–01	8.70E–01	8.70E–01	4.35E+00	1.74E+01	2.52E+01	2.52E+01	3.89E+01
LBL	8.40E–01	0.00E+00	4.20E–01	0.00E+00	0.00E+00	8.00E–01	3.20E+00	4.42E+00	4.42E+00	5.26E+00
MURR	6.00E–02	8.00E–02	8.00E–02	8.00E–02	1.36E+00	0.00E+00	0.00E+00	1.60E+00	1.60E+00	1.66E+00
PAD	3.45E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E+00
PANT	6.24E–01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E–01
SNL/NM	8.04E+00	0.00E+00	5.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	7.00E+00	7.00E+00	1.50E+01
Subtotal	3.72E+01	3.19E+00	1.32E+01	2.90E+01	2.14E+01	1.61E+02	4.60E+01	2.73E+02	2.73E+02	3.11E+02
Commercial site										
WVDP	4.78E+02	5.46E+01	2.93E+01	6.33E+00	6.33E+00	9.04E+01	0.00E+00	1.87E+02	1.87E+02	6.64E+02
Total	7.42E+04	1.12E+03	1.49E+03	1.58E+03	1.08E+03	5.81E+03	5.31E+04	6.41E+04	6.41E+04	1.38E+05

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.^bSome volumes of TSCA-contaminated wastes are included in this table that are not included in WTWBIR, Rev. 1 (ref. 2). See Tables 3.3, 3.4, and 3.5 for details.^cEOY = end of (calendar) year.

Table 3.3. Summary of final waste-form volumes (m³) of retrievably stored and projected mixed and nonmixed CH TRUW^a

Site	EOY ^b 1993	Annual increase				Cumulative increase		Projected increase 1994-2022	Total EOY 2022
		Annual increase				Cumulative increase			
		1994	1995	1996	1997	1998-2002	2003-2022		
Major sites									
ANL-E	2.91E+01	1.68E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E+00	3.08E+01
Hanford	9.39E+03 ^c	1.69E+02	3.88E+02	5.80E+02	1.82E+02	1.19E+03	2.83E+04	3.09E+04 ^d	4.02E+04
INEL	3.47E+04	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	1.00E+00	3.47E+04
LANL	1.09E+04	2.54E+02	2.65E+02	2.65E+02	2.65E+02	1.33E+03	5.30E+03	7.67E+03	1.85E+04
LLNL	2.24E+02 ^e	2.11E+01	2.50E+01	2.50E+01	2.50E+01	1.25E+02	5.00E+02	7.21E+02 ^f	9.45E+02
Mound	2.63E+02 ^g	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E+02
NTS	6.20E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.20E+02
ORNL	7.83E+02	9.10E+00	9.10E+00	9.10E+00	9.10E+00	4.55E+01	1.82E+02	2.64E+02	1.05E+03
RFETS	1.13E+03	6.64E+01	1.22E+02	9.31E+01	2.58E+01	1.40E+02	5.45E+03	5.90E+03	7.03E+03
SRS	1.46E+04	5.09E+02	5.09E+02	5.09E+02	5.09E+02	2.55E+03	1.02E+04	1.48E+04	2.94E+04
Subtotal	7.26E+04	1.03E+03	1.32E+03	1.48E+03	1.02E+03	5.37E+03	5.00E+04	6.02E+04	1.33E+05
Small-quantity sites									
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-01	1.00E-01	1.00E-01
ANL-W	2.00E-02	1.92E+00	4.40E-01	4.40E-01	4.40E-01	2.20E+00	4.00E-01	5.84E+00	5.86E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	4.16E-01	2.66E+01	1.71E+01	7.59E+01	3.80E+00	1.24E+02	1.24E+02
ETEC	1.87E+00	0.00E+00	5.20E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E+00	7.07E+00
KAPL	2.40E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E+00
LBL	8.40E-01	0.00E+00	4.20E-01	0.00E+00	0.00E+00	8.00E-01	3.20E+00	4.42E+00	5.26E+00
MURR	6.00E-02	8.00E-02	8.00E-02	8.00E-02	1.36E+00	0.00E+00	0.00E+00	1.60E+00	1.66E+00
PAD	3.45E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E+00
PANT	6.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-01
SNL/NM	8.04E+00	0.00E+00	5.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	7.00E+00	1.50E+01
Subtotal	1.73E+01	2.00E+00	1.16E+01	2.71E+01	1.89E+01	7.99E+01	8.50E+00	1.48E+02	1.65E+02

Table 3.3 (continued)

Site	EOY ^b 1993	Annual increase				Cumulative increase		Projected increase 1994–2022	Total EOY 2022
		1994	1995	1996	1997	1998–2002	2003–2022		
Commercial site									
WVDP	5.06E+01	5.46E+01	2.93E+01	6.33E+00	6.33E+00	9.04E+01	0.00E+00	1.87E+02	2.37E+02
Total	7.26E+04	1.09E+03	1.36E+03	1.52E+03	1.04E+03	5.54E+03	5.00E+04	6.05E+04	1.33E+05

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

^bEOY = end of (calendar) year.

^c7.42E+01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^d9.67E+03 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^e1.68E+01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^f3.26E+01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^g8.00E-01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

Table 3.4. Final waste-form volumes (m³) of retrievably stored and projected mixed CH TRUW^a

Site	EOY ^b 1993	Annual increase				Cumulative increase		Projected increase	Total EOY 2022
		Annual increase				Cumulative increase			
		1994	1995	1996	1997	1998-2002	2003-2022		
Major sites									
ANL-E	6.21E+00	5.60E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.60E-01	6.77E+00
Hanford	2.10E+02 ^c	1.41E+01	3.13E+01	4.60E+01	1.39E+01	1.39E+02	1.49E+04	1.51E+04 ^d	1.54E+04
INEL	2.76E+04	0.00E+00	0.00E+00	0.00E+00	1.00E+00	0.00E+00	0.00E+00	1.00E+00	2.76E+04
LANL	7.66E+03	1.24E+02	1.35E+02	1.35E+02	1.35E+02	6.75E+02	2.70E+03	3.90E+03	1.16E+04
LLNL	7.92E+00	6.24E-01	1.57E+00	1.57E+00	1.57E+00	7.87E+00	3.15E+01	4.47E+01	5.26E+01
Mound	2.70E+00 ^e	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E+00
NTS	6.20E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.20E+02
ORNL	7.83E+02	9.10E+00	9.10E+00	9.10E+00	9.10E+00	4.55E+01	1.82E+02	2.64E+02	1.05E+03
RFETS	8.28E+02	4.69E+01	7.49E+01	6.09E+01	2.21E+01	1.13E+02	5.07E+03	5.38E+03	6.21E+03
SRS	1.01E+04	8.84E+01	8.84E+01	8.84E+01	8.84E+01	4.42E+02	1.77E+03	2.56E+03	1.27E+04
Subtotal	4.79E+04	2.84E+02	3.40E+02	3.41E+02	2.71E+02	1.42E+03	2.47E+04	2.73E+04	7.52E+04
Small-quantity sites									
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-01	1.00E-01	1.00E-01
ANL-W	2.00E-02	1.92E+00	2.00E-02	2.00E-02	2.00E-02	1.00E-01	4.00E-01	2.48E+00	2.50E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
E/TEC	2.10E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-01
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	6.00E-02	8.00E-02	8.00E-02	8.00E-02	1.36E+00	0.00E+00	0.00E+00	1.60E+00	1.66E+00
PAD	3.45E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.45E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	1.04E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E+00
Subtotal	4.78E+00	2.00E+00	1.00E-01	1.00E-01	1.38E+00	1.00E-01	5.00E-01	4.18E+00	8.96E+00
Commercial site									
WVDP	3.19E+01	4.36E+01	2.38E+01	7.90E-01	7.90E-01	6.27E+01	0.00E+00	1.32E+02	1.64E+02
Total	4.79E+04	3.29E+02	3.64E+02	3.42E+02	2.73E+02	1.48E+03	2.47E+04	2.74E+04	7.54E+04

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

^bEOY = end of (calendar) year.

^c7.40E+01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^d9.62E+03 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^e2.00E-01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

Table 3.5. Final waste-form volumes (m³) of retrievably stored and projected nonmixed CH TRUW^a

Site	EOY ^b 1993	Annual increase					Cumulative increase		Projected increase	Total EOY 2022
		1994	1995	1996	1997	1998–2002	2003–2022	1994–2022		
Major sites										
ANL-E	2.29E+01	1.12E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E+00	2.40E+01
Hanford	9.18E+03 ^c	1.55E+02	3.56E+02	5.34E+02	1.68E+02	1.05E+03	1.34E+04	1.57E+04 ^d	1.57E+04	2.49E+04
INEL	7.02E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.02E+03
LANL	3.20E+03	1.30E+02	1.30E+02	1.30E+02	1.30E+02	6.50E+02	2.60E+03	3.77E+03	3.77E+03	6.97E+03
LLNL	2.16E+02 ^e	2.05E+01	2.34E+01	2.34E+01	2.34E+01	1.17E+02	4.68E+02	6.76E+02 ^f	6.76E+02	8.92E+02
Mound	2.61E+02 ^g	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E+02
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RFETS	3.05E+02	1.96E+01	4.67E+01	3.22E+01	3.67E+00	2.70E+01	3.88E+02	5.17E+02	5.17E+02	8.22E+02
SRS	4.47E+03	4.21E+02	4.21E+02	4.21E+02	4.21E+02	2.10E+03	8.42E+03	1.22E+04	1.22E+04	1.67E+04
Subtotal	2.47E+04	7.47E+02	9.77E+02	1.14E+03	7.46E+02	3.95E+03	2.53E+04	3.29E+04	3.29E+04	5.76E+04
Small-quantity sites										
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	0.00E+00	0.00E+00	4.20E-01	4.20E-01	4.20E-01	2.10E+00	0.00E+00	3.36E+00	3.36E+00	3.36E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	4.16E-01	2.66E+01	1.71E+01	7.59E+01	3.80E+00	1.24E+02	1.24E+02	1.24E+02
ETEC	1.66E+00	0.00E+00	5.20E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E+00	5.20E+00	6.86E+00
KAPL	2.40E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E+00
LBL	8.40E-01	0.00E+00	4.20E-01	0.00E+00	0.00E+00	8.00E-01	3.20E+00	4.42E+00	4.42E+00	5.26E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	6.24E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.24E-01
SNL/NM	7.00E+00	0.00E+00	5.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00	7.00E+00	7.00E+00	1.40E+01
Subtotal	1.25E+01	0.00E+00	1.15E+01	2.70E+01	1.75E+01	7.98E+01	8.00E+00	1.44E+02	1.44E+02	1.56E+02

Table 3.5 (continued)

Site	EOY ^b 1993	Annual increase				Cumulative increase		Projected increase 1994-2022	Total EOY 2022
		1994	1995	1996	1997	1998-2002	2003-2022		
Commercial site WVDP	1.87E+01	1.10E+01	5.54E+00	5.54E+00	5.54E+00	2.77E+01	0.00E+00	5.53E+01	7.40E+01
Total	2.47E+04	7.58E+02	9.94E+02	1.17E+03	7.69E+02	4.06E+03	2.53E+04	3.31E+04	5.78E+04

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

^bEOY = end of (calendar) year.

^c2.00E-01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^d2.70 E+00 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^e1.68E+01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^f3.26E+01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

^g6.00E-01 m³ (approximately) of TSCA waste included from Table 3-2, WTWBIR, Rev. 1 (ref. 2).

Table 3.6. Summary of final waste-form volumes (m³) of retrievably stored and projected mixed and nonmixed RH TRUW^a

Site	EOY ^b 1993	Annual increase					Cumulative increase		Projected increase	Total EOY 2022
		1994	1995	1996	1997	1998-2002	2003-2022			
Major sites										
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	3.32E+01	2.00E+00	1.03E+02	3.90E+01	8.76E+00	1.00E+02	2.72E+03	2.97E+03	3.01E+03	3.01E+03
INEL	3.10E+01	0.00E+00	6.00E-01	6.00E-01	6.00E-01	3.00E+00	1.20E+01	1.68E+01	4.78E+01	4.78E+01
LANL	9.13E+01	1.17E+01	1.17E+01	1.17E+01	1.17E+01	1.19E+01	2.40E+01	8.27E+01	1.74E+02	1.74E+02
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	9.94E+02	1.23E+01	1.23E+01	1.23E+01	1.23E+01	6.15E+01	2.46E+02	3.57E+02	1.35E+03	1.35E+03
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	4.00E+00	2.14E+00	2.14E+00	2.14E+00	1.05E+01	4.30E+01	6.39E+01	6.39E+01	6.39E+01
Subtotal	1.15E+03	3.00E+01	1.30E+02	6.57E+01	3.55E+01	1.87E+02	3.05E+03	3.49E+03	4.64E+03	4.64E+03
Small-quantity sites										
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	8.65E+00	3.20E-01	4.20E-01	7.56E-01	1.32E+00	4.81E+00	2.00E+01	2.76E+01	3.63E+01	3.63E+01
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.10E+01	0.00E+00	7.10E+01	7.10E+01	7.10E+01
BAPL	0.00E+00	0.00E+00	3.12E-01	2.08E-01	3.12E-01	6.25E-01	1.00E-01	1.56E+00	1.56E+00	1.56E+00
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	1.12E+01	8.70E-01	8.70E-01	8.70E-01	8.70E-01	4.35E+00	1.74E+01	2.52E+01	3.65E+01	3.65E+01
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.99E+01	1.19E+00	1.60E+00	1.83E+00	2.50E+00	8.08E+01	3.75E+01	1.25E+02	1.45E+02	1.45E+02
Commercial site										
WVDP	4.27E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.27E+02	4.27E+02
Total	1.60E+03	3.12E+01	1.31E+02	6.76E+01	3.80E+01	2.68E+02	3.08E+03	3.62E+03	5.22E+03	5.22E+03

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

^bEOY = end of (calendar) year.

Table 3.7. Final waste-form volumes (m³) of retrievably stored and projected mixed RH TRUW^a

Site	EOY ^b 1993	Annual increase				Cumulative increase		Projected increase	Total EOY 2022
		1994	1995	1996	1997	1998–2002	2003–2022	1994–2022	
Major sites									
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.76E+00	2.02E+01	1.70E+03	1.73E+03	1.73E+03
INEL	2.12E+01	0.00E+00	6.00E-01	6.00E-01	6.00E-01	3.00E+00	1.20E+01	1.68E+01	3.80E+01
LANL	1.50E+01	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+01	1.50E+01	3.00E+01
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	9.94E+02	1.23E+01	1.23E+01	1.23E+01	1.23E+01	6.15E+01	2.46E+02	3.57E+02	1.35E+03
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.03E+03	1.33E+01	1.39E+01	1.39E+01	2.07E+01	8.57E+01	1.97E+03	2.12E+03	3.15E+03
Small-quantity sites									
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	8.65E+00	3.20E-01	4.20E-01	4.20E-01	4.20E-01	3.10E-01	2.00E+00	3.89E+00	1.25E+01
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	1.12E+01	8.70E-01	8.70E-01	8.70E-01	8.70E-01	4.35E+00	1.74E+01	2.52E+01	3.65E+01
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.99E+01	1.19E+00	1.29E+00	1.29E+00	1.29E+00	4.66E+00	1.94E+01	2.91E+01	4.90E+01
Commercial site									
WVDP	1.05E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+01
Total	1.06E+03	1.45E+01	1.52E+01	1.52E+01	2.20E+01	9.03E+01	1.99E+03	2.15E+03	3.21E+03

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.^bEOY = end of (calendar) year.

Table 3.8. Final waste-form volumes (m³) of retrievably stored and projected nonmixed RH TRUW^a

Site	EOY ^b 1993	Annual increase				Cumulative increase		Projected increase	Total EOY 2022
								1994–2022	
		1994	1995	1996	1997	1998–2002	2003–2022		
Major sites									
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	3.32E+01	2.00E+00	1.03E+02	3.90E+01	2.00E+00	8.00E+01	1.02E+03	1.25E+03	1.28E+03
INEL	9.76E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.76E+00
LANL	7.63E+01	1.07E+01	1.07E+01	1.07E+01	1.07E+01	1.09E+01	1.40E+01	6.77E+01	1.44E+02
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	0.00E+00	4.00E+00	2.14E+00	2.14E+00	2.14E+00	1.05E+01	4.30E+01	6.39E+01	6.39E+01
Subtotal	1.19E+02	1.67E+01	1.16E+02	5.18E+01	1.48E+01	1.01E+02	1.08E+03	1.38E+03	1.50E+03
Small-quantity sites									
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	0.00E+00	0.00E+00	0.00E+00	3.36E-01	9.00E-01	4.50E+00	1.80E+01	2.37E+01	2.37E+01
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.10E+01	0.00E+00	7.10E+01	7.10E+01
BAPL	0.00E+00	0.00E+00	3.12E-01	2.08E-01	3.12E-01	6.25E-01	1.00E-01	1.56E+00	1.56E+00
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	0.00E+00	0.00E+00	3.12E-01	5.44E-01	1.21E+00	7.61E+01	1.81E+01	9.63E+01	9.63E+01
Commercial site									
WVDP	4.16E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E+02
Total	5.36E+02	1.67E+01	1.16E+02	5.24E+01	1.61E+01	1.78E+02	1.10E+03	1.47E+03	2.01E+03

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

^bEOY = end of (calendar) year.

Table 3.9. Estimated final-form volume (m³) composition of retrievably stored and projected TRUW for major sites^a

Major sites	Category	Contact-handled			Remote-handled		
		Stored	Projected	Total	Stored	Projected	Total
ANL-E	Lead/cadmium metal waste	1.10	0.00	1.10	0.00	0.00	0.00
	Solidified inorganics	23.05	1.12	24.17	0.00	0.00	0.00
	Solidified organics	0.03	0.00	0.03	0.00	0.00	0.00
	Uncategorized metal	4.96	0.56	5.52	0.00	0.00	0.00
	Subtotal	29.14	1.68	30.82	0.00	0.00	0.00
Hanford	Combustible	530.07 ^a	12,698.57 ^b	13,228.64	0.00	0.00	0.00
	Heterogeneous	8,568.55	827.16	9,395.71	33.16	2,973.71	3,006.87
	Lead/cadmium metal waste	3.13	0.29	3.42	0.00	0.00	0.00
	Soils	111.69	309.27	420.96	0.00	0.00	0.00
	Solidified inorganics	2.93 ^c	3,153.57 ^d	3,156.50	0.00	0.00	0.00
	Solidified organics	4.48 ^e	31.44 ^f	35.92	0.00	0.00	0.00
	Uncategorized metal	170.17 ^g	13,837.04 ^h	14,007.21	0.00	0.00	0.00
	Subtotal	9,391.02	30,857.34	40,248.36	33.16	2,973.71	3,006.87
INEL	Combustible	670.90	0.00	670.90	0.00	0.00	0.00
	Filter	323.56	0.00	323.56	0.00	0.00	0.00
	Graphite	650.70	0.00	650.70	0.00	0.00	0.00
	Heterogeneous	9,649.50	1.00	9,650.50	13.63	2.80	16.43
	Inorganic nonmetal	1,052.89	0.00	1,052.89	0.00	0.00	0.00
	Lead/cadmium metal waste	0.00	0.00	0.00	0.00	5.60	5.60
	Salt Waste	22.91	0.00	22.91	0.00	2.80	2.80
	Soils	3.80	0.00	3.80	0.00	0.00	0.00
	Solidified inorganics	12,164.28	0.00	12,164.28	2.10	0.00	2.10
	Solidified organics	912.60	0.00	912.60	0.00	0.00	0.00
	Uncategorized metal	7,564.09	0.00	7,564.09	4.11	5.60	9.71
	Unknown	1,655.91	0.00	1,655.91	11.13	0.00	11.13
	Subtotal	34,671.14	1.00	34,672.14	30.97	16.80	47.77
LANL	Combustible	1,768.33	2,464.60	4,232.93	14.84	3.16	18.00
	Soils	109.37	144.60	253.97	0.00	0.00	0.00
	Solidified inorganics	4,848.38	2,059.03	6,907.41	0.00	0.00	0.00
	Uncategorized metals	4,134.80	3,006.17	7,140.97	76.46	79.50	155.96
	Subtotal	10,860.88	7,674.40	18,535.28	91.30	82.66	173.96
LLNL	Combustible	48.88	372.32	421.20	0.00	0.00	0.00
	Filter	16.63 ⁱ	32.63 ^j	49.26	0.00	0.00	0.00
	Salt waste	0.62	2.91	3.53	0.00	0.00	0.00
	Solidified inorganics	13.30	66.15	79.45	0.00	0.00	0.00
	Uncategorized metal	144.33	247.00	391.33	0.00	0.00	0.00
	Subtotal	223.76	721.01	944.77	0.00	0.00	0.00

Table 3.9 (continued)

Major sites	Category	Contact-handled			Remote-handled		
		Stored	Projected	Total	Stored	Projected	Total
Mound	Combustible	5.61	0.00	5.61	0.00	0.00	0.00
	Heterogeneous	1.04 ^k	0.00	1.04	0.00	0.00	0.00
	Inorganic nonmetal	0.21 ^l	0.00	0.21	0.00	0.00	0.00
	Soils	146.88	0.00	146.88	0.00	0.00	0.00
	Solidified inorganics	7.28	0.00	7.28	0.00	0.00	0.00
	Uncategorized metal	102.28	0.00	102.28	0.00	0.00	0.00
	Subtotal	263.30	0.00	263.30	0.00	0.00	0.00
NTS	Heterogeneous	619.50	0.00	619.50	0.00	0.00	0.00
ORNL	Heterogeneous	672.98	263.90	936.88	382.81	182.70	565.51
	Solidified inorganics	110.00	0.00	110.00	611.00	174.00	785.00
	Subtotal	782.98	263.90	1,046.88	993.81	356.70	1,350.51
RFETS	Filter	103.96	1,087.59	1,191.55	0.00	0.00	0.00
	Graphite	18.06	43.40	61.46	0.00	0.00	0.00
	Heterogeneous	312.86	804.58	1,117.44	0.00	0.00	0.00
	Inorganic nonmetal	110.68	318.68	429.36	0.00	0.00	0.00
	Lead/cadmium metal waste	51.87	124.18	176.05	0.00	0.00	0.00
	Salt waste	9.45	56.60	66.05	0.00	0.00	0.00
	Solidified inorganics	228.63	2,988.11	3,216.74	0.00	0.00	0.00
	Solidified organics	132.80	48.82	181.62	0.00	0.00	0.00
	Uncategorized metal	164.82	429.50	594.32	0.00	0.00	0.00
	Subtotal	1,133.13	5,901.46	7,034.59	0.00	0.00	0.00
SRS	Combustible	4,066.80	11,962.50	16,029.30	0.00	0.00	0.00
	Heterogeneous	10,132.20	2,563.60	12,695.80	0.00	63.92	63.92
	Solidified inorganics	0.04	0.00	0.04	0.00	0.00	0.00
	Solidified organics	404.85	240.70	645.55	0.00	0.00	0.00
	Subtotal	14,603.89	14,766.80	29,370.69	0.00	63.92	63.92
Major sites total		72,578.74	60,187.59	132,766.33	1,149.24	3,493.79	4,643.03

^aIncludes 3.59 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^bIncludes 429.54 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^cIncludes 1.47 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^dIncludes 228.81 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^eIncludes 2.31 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^fIncludes 16.19 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^gIncludes 66.82 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^hIncludes 8,946.09 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).ⁱIncludes 16.63 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^jIncludes 32.63 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^kIncludes 0.62 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).^lIncludes 0.21 m³ of TSCA waste not shown in the WTWBIR, Rev. 1 (ref. 2).

Table 3.10. Estimated final-form volume (m³) composition of retrievably stored and projected TRUW for small-quantity and commercial sites^a

Major sites	Category	Contact-handled			Remote-handled		
		Stored	Projected	Total	Stored	Projected	Total
Small-quantity sites (SQS)							
Ames	Solidified inorganics	0.00	0.10	0.10	0.00	0.00	0.00
ANL-W	Filter	0.00	0.00	0.00	0.89	2.09	2.98
	Heterogeneous	0.00	3.36	3.36	0.59	0.08	0.67
	Lead/cadmium metal waste	0.02	2.48	2.50	0.00	0.36	0.36
	Uncategorized metal	0.00	0.00	0.00	7.17	1.36	8.53
	Unknown	0.00	0.00	0.00	0.00	23.74	23.74
	Subtotal	0.02	5.84	5.86	8.65	27.63	36.28
BCL	Heterogeneous	0.00	0.00	0.00	0.00	71.00	71.00
BAPL	Heterogeneous	0.00	123.82	123.82	0.00	1.56	1.56
ETEC	Heterogeneous	1.66	5.20	6.86	0.00	0.00	0.00
	Lead/cadmium metal waste	0.21	0.00	0.21	0.00	0.00	0.00
	Subtotal	1.87	5.20	7.07	0.00	0.00	0.00
KAPL	Heterogeneous	2.40	0.00	2.40	11.23	25.23	36.46
LBL	Heterogeneous	0.84	4.42	5.26	0.00	0.00	0.00
MURR	Heterogeneous	0.06	1.60	1.66	0.00	0.00	0.00
PAD	Solidified inorganics	3.45	0.00	3.45	0.00	0.00	0.00
PANT	Heterogeneous	0.62	0.00	0.62	0.00	0.00	0.00
SNL/NM	Heterogeneous	8.04	7.00	15.04	0.00	0.00	0.00
	SQS subtotal ^a	17.30	147.98	165.28	19.88	125.41	145.30
Commercial site							
WVDP	Filter	18.97	131.63	150.60	0.00	0.00	0.00
	Heterogeneous	14.76	55.28	70.04	0.00	0.00	0.00
	Lead/cadmium metal waste	0.21	0.00	0.21	0.00	0.00	0.00
	Solidified inorganics	4.57	0.00	4.57	0.00	0.00	0.00
	Solidified organics	0.42	0.00	0.42	0.00	0.00	0.00
	Uncategorized metal	0.42	0.00	0.42	416.46	0.00	416.46
	Unknown	11.23	0.00	11.23	10.49	0.00	10.49
	Commercial site subtotal ^a	50.57	186.91	237.48	426.95	0.00	426.95
	Total	72,646.61	60,522.48	133,169.09	1,596.08	3,619.20	5,215.28

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

Table 3.11. Summary of decayed radioactivity isotopic content of retrievably stored CH TRUW^a

Site	²³⁸ Pu	²⁴¹ Pu	²³⁹ Pu	²⁴¹ Am	²⁴⁰ Pu	¹³⁷ Cs	Sum of curies	Curies (%)
<i>Major sites</i>								
ANL-E	2.14E+00	5.98E+01	3.28E+01	5.73E+00	9.42E+00		1.10E+02	0.01
Hanford	8.18E+04	9.43E+04	2.70E+04	2.98E+03	6.06E+03		2.13E+05	14.11
INEL	6.07E+04	1.65E+05	4.01E+04	8.98E+04	9.82E+03	7.03E+02	3.65E+05	24.19
LANL	1.15E+05	1.77E+00	7.33E+04	8.70E+03	1.52E-01	6.32E+01	1.97E+05	13.08
LLNL	1.97E+01	1.67E+03	1.46E+02	1.26E+02	6.06E+01	5.32E+01	2.03E+03	0.13
Mound	7.16E+02		1.99E+02			1.99E-06	9.14E+02	0.06
NTS	1.98E+02	2.64E+02	2.76E+03	2.84E+02	1.87E+01	3.97E-01	3.53E+03	0.23
ORNL	6.78E+03	5.52E+04	7.95E+02	2.33E+03	7.25E+02	2.17E+03	6.80E+04	4.51
RFETS	3.47E+02	5.72E+04	9.93E+03	1.08E+04	7.21E+03		8.55E+04	5.66
SRS	4.71E+05	6.30E+04	8.56E+03	1.60E+04	2.12E+03	6.77E-01	5.61E+05	37.16
Subtotal	7.37E+05	4.36E+05	1.63E+05	1.31E+05	2.60E+04	2.99E+03	1.50E+06	99.14
<i>Small-quantity sites (SQS)</i>								
Ames								
ANL-W								
BCL								
BAPL								
ETEC								
KAPL								
LBL	1.12E-01	8.06E+00	1.76E+00	4.43E-01	6.01E-01	2.40E-01	1.12E+01	0.00
MURR	2.36E-04	2.89E-07	7.70E-03	9.20E-02	5.07E-03		1.05E-01	0.00
PAD			2.05E-02	4.80E-02			6.85E-02	0.00
PANT			5.56E+01				5.56E+01	0.00
SNL/NM			5.55E-02				5.55E-02	0.00
			2.00E-06	1.00E-02			1.00E-02	0.00
Subtotal	1.12E-01	8.06E+00	5.75E+01	5.93E-01	6.06E-01	2.40E-01	6.71E+01	0.00
<i>Commercial site</i>								
WVDP								
		3.43E+01		2.15E+00		1.95E+00	3.84E+01	0.00
Total (all sites)	7.37E+05	4.37E+05	1.63E+05	1.31E+05	2.60E+04	3.00E+03	1.50E+06	99.15
Total Ci, %	48.84	28.92	10.79	8.68	1.72	0.20		
Cumulative, %	48.84	77.76	88.55	97.23	98.95	99.15		

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

Table 3.12. Summary of decayed radioactivity (Ci) isotopic content of retrievably stored RH TRUW^a

Site	⁹⁰ Sr	⁹⁰ Y	¹³⁷ Cs	^{137m} Ba	¹⁵² Eu	⁶⁰ Co	¹⁵⁴ Eu	²⁴¹ Pu	²⁴⁴ Cm	¹⁵⁵ Eu	Sum of curies	Curies (%)
<i>Major sites</i>												
ANL-E			1.18E+01	1.12E+01				8.23E-01			2.38E+01	0.01
Hanford	5.74E+03	5.74E+03	6.67E+03	6.31E+03	2.83E+02	4.77E+03	1.43E+03	4.58E+03		5.76E+02	3.61E+04	10.37
INEL	1.78E+03	1.78E+03	1.99E+03	1.88E+03	2.07E-02	1.68E+01	8.20E-01	5.30E+01		3.32E-01	7.49E+03	2.15
LANL	2.69E+03	2.69E+03	2.95E+03	2.79E+03	5.96E-04	5.43E+00	4.34E-02			5.45E+01	1.12E+04	3.21
LLNL												
Mound								7.26E-05	1.68E+02		1.68E+02	0.05
NTS					8.75E+03	1.73E+03	4.57E+03	1.03E-07	1.78E+03	9.37E+02	2.88E+05	82.69
ORNL	9.71E+04	9.71E+04	3.90E+04	3.69E+04								
RFETS												
SRS												
Subtotal	1.07E+05	1.07E+05	5.07E+04	4.79E+04	9.04E+03	6.52E+03	6.01E+03	4.63E+03	1.95E+03	1.57E+03	3.43E+05	98.48
<i>Small-quantity sites (SQS)</i>												
Ames												
ANL-W												
BCI												
BAPL												
ETEC												
KAPL	2.46E+01	2.46E+01	2.47E+01	2.33E+01	3.62E-06	1.14E-01	3.56E-04	2.00E-01		8.11E-03	9.76E+01	0.03
LBL												
MURR												
PAD												
PANT												
SNL/NM												
Subtotal	2.46E+01	2.46E+01	2.47E+01	2.33E+01	3.62E-06	1.14E-01	3.56E-04	2.00E-01		8.11E-03	9.76E+01	0.03
<i>Commercial site</i>												
WVDP												
Total (all sites)	1.07E+05	1.07E+05	5.07E+04	4.79E+04	9.04E+03	6.52E+03	6.01E+03	4.63E+03	1.95E+03	1.57E+03	3.43E+05	98.51
Total Ci, %	30.82	30.82	14.56	13.77	2.60	1.87	1.72	1.33	0.56	0.45		
Cumulative, %	30.82	61.65	76.20	89.98	92.57	94.44	96.17	97.50	98.06	98.51		

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

Table 3.13. Summary of decayed mass (g) isotopic content of retrievably stored CH TRUW^a

Site	²³⁸ U	²³² Th	²³⁹ Pu	²³⁵ U	²⁴² Pu	²³³ U	²⁴⁰ Pu	Sum of mass	Mass (%)
<i>Major sites</i>									
ANL-E	1.59E+02	1.48E-09	5.27E+02	2.75E+02	2.62E+00	3.10E+00	4.13E+01	1.01E+03	0.00
Hanford	1.80E+07	5.82E+05	4.35E+05	2.63E+05	9.70E+01	8.18E+03	2.66E+04	1.93E+07	73.79
INEL	3.44E+05	3.01E+06	6.45E+05	2.85E+04	2.47E+02	9.28E+04	4.31E+04	4.16E+06	15.90
LANL	1.20E+04	2.19E+04	1.18E+06	1.93E+05	1.33E+05	4.61E+03	6.65E-01	1.54E+06	5.90
LLNL	1.05E+03	3.37E-09	2.34E+03	6.10E+01	5.04E+00	2.26E-07	2.66E+02	3.72E+03	0.01
Mound			3.20E+03	9.51E-01				3.20E+03	0.01
NTS	1.66E+02	4.19E-09	4.44E+04	2.60E+01	2.28E+01	1.87E+02	8.21E+01	4.49E+04	0.17
ORNL	1.05E+05	3.12E+05	1.28E+04	3.04E+03	1.43E+03	9.22E+03	3.18E+03	4.47E+05	1.71
RFETS		2.97E-07	1.60E+05	1.30E+01		7.78E-06	3.16E+04	1.91E+05	0.73
SRS	1.56E+04	9.41E+04	1.38E+05	2.52E+03	9.82E+01	9.14E-01	9.29E+03	2.59E+05	0.99
Subtotal	1.85E+07	4.02E+06	2.62E+06	4.91E+05	1.35E+05	1.15E+05	1.14E+05	2.60E+07	99.22
<i>Small-quantity sites (SQS)</i>									
Ames									
ANL-W									
BCL									
BAPL			2.83E+01		1.05E-02		2.64E+00	3.10E+01	0.00
ETEC									
KAPL									
LBL	4.55E-05	3.37E-12	1.24E-01	1.75E-05	2.64E+00	4.97E-01	2.23E-02	3.28E+00	0.00
MURR	2.97E-04		3.29E-01					3.30E-01	0.00
PAD			8.95E+02					8.95E+02	0.00
PANT			8.93E-01					8.93E-01	0.00
SNL/NM			3.22E-05	2.73E-09		5.99E-13		3.22E-05	0.00
Subtotal	3.43E-04	3.37E-12	9.24E+02	1.75E-05	2.65E+00	4.97E-01	2.66E+00	9.30E+02	0.00
<i>Commercial site</i>									
WVDP									
Total (all sites)	1.85E+07	4.02E+06	2.62E+06	4.91E+05	1.35E+05	1.15E+05	1.14E+05	2.60E+07	99.22
Total mass, %	70.59	15.35	10.01	1.87	0.52	0.44	0.44		
Cumulative, %	70.59	85.95	95.96	97.83	98.35	98.79	99.22		

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

Table 3.14. Summary of decayed mass (g) isotopic content of retrievably stored RH TRUW^a

Site	²³⁸ U	²³⁵ U	Sum of mass	Mass (%)
ANL-E				
Hanford	3.07E+04		3.07E+04	0.33
INEL	4.11E+03		4.11E+03	0.04
LANL	5.95E+01		5.95E+01	0.00
LLNL				
Mound				
NTS	4.25E-12		4.25E-12	0.00
ORNL	6.46E+06	2.62E+06	9.08E+06	98.98
RFETS				
SRS				
Subtotal	6.49E+06	2.62E+06	9.11E+06	99.36
<i>Small-quantity sites (SQS)</i>				
Ames				
ANL-W				
BCL				
BAPL				
ETEC				
KAPL	2.95E-09		2.95E-09	0.00
LBL				
MURR				
PAD				
PANT				
SNL/NM				
Subtotal	2.95E-9		2.95E-09	0.00
<i>Commercial site</i>				
WVDP				
Total	6.49E+06	2.62E+06	9.11E+06	99.36
Total mass, %	70.80	28.57		
Cumulative, %	70.80	99.36		

^aAny small differences in volumes reported in this table and WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding.

**Table 3.15. Summary of buried TRUW volume and radioactivity
as of December 31, 1993^a**

Site	Cumulative volume (m ³)	Cumulative as-stored radioactivity		Decayed radioactivity	
		All nuclides (10 ³ Ci)	TRU only (10 ³ Ci)	All nuclides (10 ³ Ci)	TRU only (10 ³ Ci)
Major sites					
ANL-E	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hanford	6.36E+04	6.02E+02	1.14E+02	1.73E+02	9.38E+01
INEL	5.71E+04	2.49E+02	b	b	b
LANL	1.40E+04	c	d	c	c
LLNL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mound	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NTS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ORNL	1.76E+02	2.40E-01	1.00E-01	5.43E+02	2.00E-01
RFETS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SRS	4.87E+03	3.37E+01	3.37E+01	3.05E+01	3.05E+01
Subtotal	1.40E+05	8.84E+02	1.48E+02	7.47E+02	1.25E+02
Small-quantity sites (SQS)					
Ames	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ANL-W	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BCL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ETEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
KAPL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LBL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MURR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PAD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PANT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SNL/NM	1.33E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Subtotal	1.33E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Commercial site					
WVDP	1.35E+03	6.52E+02	6.52E+02	0.00E+00	0.00E+00
Total	1.41E+05	1.54E+03	8.00E+02	7.47E+02	1.25E+02

^aAny small differences in volumes reported in this table and in WTWBIR, Rev. 1 (ref. 2) and in the numerical totals shown result from rounding. See ref. 5.

^bINEL data did not include any isotopic compositions, so no TRU isotope or decay calculations could be made.

^cInformation not available.

^dAn estimate of 9230 Ci was reported for LANL as-stored TRU alpha radioactivity (as of the end of CY 1991) in *Integrated Data Base for 1992: U.S. Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 8 (October 1992).

Table 3.16. Volumes and radioactivities of TRU-contaminated soils^a

Site	Soil contaminated with TRUW			
	Solid		Liquid	
	Volume (m ³)	Radioactivity (Ci)	Volume (m ³)	Radioactivity (Ci)
<i>Major sites</i>				
ANL-E	0	0	0	0
Hanford	b	b	32,000	80,591
INEL	c	c	c	c
LANL	d	c	d	c
LLNL	0	0	0	0
Mound	d	d	d	d
NTS	d	d	c	c
ORNL	d	d	d	d
RFETS	2	40	c	c
SRS	0	0	0	0
<i>Small-quantity sites (SQS)</i>				
Ames	f	f	f	f
ANL-W	f	f	f	f
BCL	f	f	f	f
BAPL	f	f	f	f
ETEC	0	0	0	0
ITRI	f	f	f	f
KAPL	0	0	0	0
LBL	0	0	0	0
MURR	f	f	f	f
PAD	c	c	c	c
PANT	f	f	f	f
SNL/NM	d	d	d	d
<i>Commercial site</i>				
WVDP	f	f	f	f

^aSee ref. 5 of this chapter.^bIncluded in buried TRUW.^cListed in submittal as not applicable.^dUnknown.^ePartial data submitted.^fNo data submitted.



An aerial view of the Oak Ridge National Laboratory Interim Waste Management Facility. Courtesy of Oak Ridge National Laboratory, Oak Ridge, Tennessee.

4. LOW-LEVEL WASTE

4.1 INTRODUCTION

As used in this chapter, LLW has the same meaning as in The Low-Level Waste Policy Act (Pub. L. 95-573, Dec. 22, 1980). Namely, LLW is radioactive waste not classified as high-level radioactive waste, transuranic waste (TRUW), spent nuclear fuel (SNF), or by-product material specified as uranium or thorium tailings and waste. The naturally occurring or accelerator-produced radioactive material that is disposed of at DOE or commercial disposal sites is included in the inventories given, but they are not treated as separate entities in this chapter. Tailings (viz., mill tailings) are considered in Chapters 5 and 6. Another waste classification not delineated in this chapter is "mixed" low-level waste (MLLW), which contains both chemically hazardous and radioactive constituents (see Chapter 8). Specific definitions of these waste types (as defined by DOE Order 5820.2A) are given in the glossary of this report. DOE generates LLW through its defense activities, naval nuclear propulsion program, and various R&D activities. The data for DOE sites represent a summary of information obtained from each site.¹

Disposal of LLW at commercial sites accounted for about 32% of the LLW disposed during 1994 (see Fig. 4.1). Commercially disposed LLW is generally divided into five categories: academic, government, industrial, medical, and utility.² The academic category includes university hospitals and university medical and nonmedical research facilities. The government category includes state and non-DOE federal agencies. The industrial category is comprised of private entities such as R&D companies, manufacturers, nondestructive-testing operations, mining works, fuel fabrication facilities, and radiopharmaceutical manufacturers. The medical category includes hospitals and clinics, research facilities, and private medical offices. The utility category includes commercial nuclear reactors. In earlier revisions of the IDB report, commercially disposed waste was reported by fuel cycle and industrial/institutional (I/I) type activities. However, to achieve more consistency with other reporting agencies, the five categories previously described were used, starting with Rev. 9 of the IDB report.

Some LLW is also generated by DOE environmental restoration programs (see Chapter 6). Other LLW will be generated in future years by nonroutine D&D operations. Waste from past commercial D&D operations is included with the commercial waste disposal portion in this chapter because it has not been reported separately. However, projections of commercial D&D wastes are not included here but, instead, are discussed in Chapter 7.

The categorization of LLW according to DOE and commercial activities permits a comparison of the radioactivity levels and volumes of waste arising from each of these major sources (Figs. 4.1 and 4.2). Summary data on LLW disposal (DOE and commercial) are given in Table 4.1. Historical and projected data by year for DOE LLW disposal are presented in Table 4.2. In Table 4.3, similar data are shown for commercial LLW disposal.

4.2 DOE LLW

4.2.1 Inventories of LLW at DOE Sites

An abridged picture of DOE LLW inventories, projections, and characteristics through 1994 is given in Figs. 4.1–4.4, as well as Tables 4.1, 4.2, and 4.4–4.18. The data in these tables are derived from responses to questionnaires submitted to DOE sites.¹ As reflected in the tables, DOE LLW data can be grouped into three major areas: generation, storage, and disposal.

Summaries of DOE site-generated LLW volumes and associated radioactivity are presented in Tables 4.6, 4.9, and 4.10.

Tables 4.7, 4.11, and 4.12 provide summary volume and radioactivity data concerning LLW storage at DOE sites.

A summary of DOE LLW disposed volume and radioactivity is presented in Tables 4.1, 4.2, 4.4, 4.8, 4.13, 4.14, and 4.17. Before October 1979, some LLW generated by DOE contractors was shipped to commercial disposal sites. The volume and radioactivity data for DOE LLW that were shipped to commercial disposal sites are contained in the commercial LLW tables in this chapter.

Currently, LLW generated by DOE activities is generally disposed of at DOE sites (see Figs. 4.3 and 4.4).

Small quantities of DOE LLW have been disposed of by dumping the LLW into the sea or by hydrofracture.³ Table 4.15 shows the estimated quantity and radioactivity of LLW disposed of by these methods. Dumping of LLW into the sea was halted by the United States in 1970, and hydrofracture was terminated in 1983.

4.2.2 Characterization of LLW at DOE Sites

Based on information reported in ref. 1, summaries of physical characteristics of DOE LLW are reported in Tables 4.6–4.14. Table 4.5 provides definitions of each of the physical forms used in the tables. This breakdown of LLW data is different from that presented in previous revisions of the IDB report (i.e., Revs. 1–10). The new set of physical forms provides a more detailed description of the LLW that has been generated, stored, or disposed. Actual 1994 and projected generation, storage, and disposal volume and radioactivity data are presented in Tables 4.6–4.8, respectively. A more detailed breakdown of this data, by DOE site, is provided in Tables 4.9–4.14.

In addition to shallow-land burial, DOE LLW has been disposed by dumping wastes into the sea and hydrofracture (Table 4.15). Most of the DOE wastes that were dumped into the sea were incorporated into cement matrix material and packaged in steel drums (55- or 80-gal capacity). Hydrofracture was developed at ORNL for the permanent disposal of locally generated, low-level (approximately 0.25 Ci/L) liquid waste concentrates.⁴ Waste was mixed with a blend of cement and other additives, and the resulting grout was injected into shale at a depth of 200 to 300 m. The injected grout hardened into thin, horizontal sheets several hundred meters wide.

Significant changes in DOE LLW inventory and characteristics data from that reported in the 1994 edition (1993 data) of this report are summarized in Table 4.16.

4.2.3 DOE LLW Projections

Low-level waste generation, storage, and disposal projections reported by DOE sites are presented in Tables 4.6–4.8, respectively. Projections are provided for three time periods: 1995, 1996–2000, and 2001–2030. The data presented in Tables 4.6–4.8 represent the average annual generation, addition to storage, or disposal, respectively, during each of the three periods.

The projected disposal data (Table 4.8), combined with actual 1994 (Tables 4.8, 4.13, and 4.14) and historical (ref. 5) disposal data, were used to calculate historical and projected volume, radioactivity, and thermal power of DOE disposed LLW. As stated in Sect. 4.2.2,

LLW data were collected by a different breakdown in previous revisions of the IDB report. Historical disposal data through 1993 were decayed from the year of addition through 2030 using the representative radionuclide compositions given in Table A.3 of Appendix A.⁶ Actual 1994 and projected disposal data were decayed from the year of addition through 2030 using radionuclide compositions provided by each disposal site in ref. 1.

Projected volume, radioactivity, and thermal power for disposed DOE LLW are presented in Tables 4.2, 4.17, and 4.18. Table 4.17 summarizes disposed DOE LLW excluding SRS saltstone. Table 4.18 summarizes projections of saltstone, an LLW by-product from the solidification of HLW at SRS. This saltstone (see Fig. 2.8 in Chapter 2) is to be stored in concrete vaults at SRS. Table 4.2 is the summation of Tables 4.17 and 4.18. Grout-immobilized LLW derived from processing double-shell waste at Hanford (see Fig. 2.6 in Chapter 2) is excluded from the projections in Table 4.2 because the schedule and formulation for immobilization are not yet firmly defined.

4.3 COMMERCIAL LLW

4.3.1 Inventories at Commercial LLW Disposal Sites

There are six commercial shallow-land disposal sites for LLW (Figs. 4.2, 4.5, and 4.6), but only two are currently in operation: Barnwell, South Carolina; and Richland, Washington. Commercial operations at the Maxey Flats, Kentucky; West Valley, New York; Sheffield, Illinois; and Beatty, Nevada, sites have been halted. Until 1986, a second NRC-licensed burial ground at West Valley continued to receive wastes generated on-site from cleanup and water treatment operations. However, disposal operations at the WVDP have been suspended since 1986 pending the preparation of an environmental impact statement (EIS) report for the West Valley site closure. The historical data for annual additions and inventories of volume and radioactivity (undecayed) at each commercial disposal site through the end of 1994 are listed in Tables 4.19 and 4.20, respectively (compiled from refs. 5 and 7). The volumes are depicted in Figs. 4.2, 4.5, and 4.6. Sources of the historical reported data through 1984 are given in ref. 3, and those through 1993 are given in ref. 5. Quantities of LLW shipped to disposal sites during 1994 are listed in Table 4.21 on a state-by-state basis.⁷ Table 4.3 is a summary of historical and projected volumes, radioactivity (decayed), and thermal power for commercial LLW. Projections are made only through 2005 because of large

uncertainties in commercial disposal facility operations. Not included in Table 4.3 are the drums of cemented LLW to be generated by the WVDP as a result of the vitrification of HLW. This LLW from the WVDP is described in Table A.6 of Appendix A. Table 4.3 also does not include 40,461 m³ (1,759 m³ from DOE generators and 38,702 m³ from commercial generators) of LLW disposed of at the Envirocare disposal facility near Clive, Utah. Additional information on Envirocare disposals can be found in Table 0.8 of Chapter 0.

4.3.2 Characterization of LLW at Commercial Disposal Sites

All of the LLW accepted for commercial disposal is categorized as Class A, B, or C in compliance with NRC specifications.⁸ The LLW that exceeds these specifications is currently in storage at the generator site or at a DOE site which has accepted it for study (see Sect. 4.3.3). A calculated representative radionuclide composition for disposed commercial LLW is given in Table A.4 of Appendix A. This composition is periodically updated to reflect changes in waste management practices and in the regulations governing LLW disposal.

4.3.3 Greater-Than-Class-C Low-Level Waste (GTCC LLW)

In 1980, federal law made each state responsible for providing the disposal capacity for LLW generated within its borders, except for certain waste generated by the federal government.⁹ In 10 CFR Part 61 (ref. 8), the NRC codifies disposal requirements for three classes of LLW, as mentioned above, generally suitable for near-surface disposal, namely, Class A, B, and C (with Class C waste requiring the most rigorous disposal specifications). Waste with concentrations above Class C limits for certain short- and long-lived radionuclides (i.e., GTCC LLW) was found not generally suitable for near-surface disposal, except on a case-by-case evaluation of the waste and the proposed disposal method by NRC or state licensing agency. The Low-Level Radioactive Waste Policy Amendments Act (LLRWPA)¹⁰ made the states responsible for the disposal of Classes A, B, and C LLW and made the federal government (viz., DOE) responsible for disposal of GTCC LLW. The law also required that GTCC LLW generated by licensees of NRC be disposed of in a facility licensed by NRC. The projected amounts of GTCC LLW are uncertain, both because of regulatory uncertainties affecting the definition of HLW (i.e., a clearly defined all-inclusive list of wastes considered HLW may include more than those described in Chapter 2) and

because of the lack of information on the sources, volumes, and characteristics of GTCC LLW.¹¹

In May 1989, NRC promulgated a rule that requires disposal of GTCC LLW in a deep geologic repository unless disposal elsewhere has been approved by NRC. The rule as amended states: "Waste that is not generally acceptable for near-surface disposal is waste for which form and disposal methods must be different and, in general, more stringent than those specified for Class C waste. In the absence of specific requirements in this part, such waste must be disposed of in a geologic repository as defined in Part 60 of this chapter unless proposals for disposal of such waste in a disposal site licensed pursuant to this part are approved by the Commission."¹² A disposal facility (other than a deep geologic repository) for GTCC LLW will probably not be available for several decades because of the complexities of siting and of NRC licensing. A generic description of estimated sources and forms of GTCC LLW is presented in Table A.5 of Appendix A.

DOE recently revised an earlier study to provide information about estimates of present and future GTCC LLW to the year 2035 (2055 in some instances). Information garnered during the study¹³ includes identification of generators, waste form characteristics, volumes, and radionuclide activities. The study categorizes GTCC LLW as (1) nuclear utilities waste, (2) sealed-sources waste, (3) DOE-held potential GTCC LLW, and (4) other generator waste. Various scenarios for data projection were used: (a) unpackaged volumes; (b) packaged volumes based on the application of packaging factors to the unpackaged volumes; and (c) concentration averaging, mixing, or blending of similar materials with different radionuclide concentration values applied to the packaged volumes. Each of the three scenarios is treated for three cases: low, base, and high.

Based on base-case projections of after-concentration-averaged-packaged waste to the year 2035, the study determined that the largest volume of GTCC wastes (approximately 53%) is generated by nuclear power plants. The "other" generator waste category contributes approximately 31% of the total GTCC LLW volume projected to the year 2035. Sealed sources are about 16% of the total projected volume of GTCC LLW. A summary of historical and projected cumulative volume and radioactivity for GTCC LLW is presented in Table 4.22.

4.3.4 Commercial LLW Disposal Sites

Of the six commercial LLW disposal sites, only two remain open: Barnwell and Richland. Historical information regarding commercial LLW facilities can be

found in previous editions of the IDB report. Closure dates for the four closed facilities are presented in the footnotes of Tables 4.19 and 4.20.

The Barnwell, South Carolina, disposal site is operated by Chem-Nuclear Systems, Inc. During 1994, Barnwell received about 85% of the total volume of commercial LLW shipped for disposal. Barnwell accepted LLW from all states with the exceptions of Michigan, New Hampshire, Rhode Island, and states that had access to the Richland facility. Barnwell was scheduled to restrict access to Southeast compact members starting July 1, 1995. However, Barnwell withdrew from the Southeast compact. This action allows all states to dispose of their waste at Barnwell.

The Richland, Washington, disposal site is operated by U.S. Ecology, Inc. During 1994, Richland received about 15% of the total volume of commercial LLW shipped for disposal. Richland accepted wastes only from member states of the Northwest and Rocky Mountain compacts (Alaska, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming).

Table 4.23 provides a breakdown of waste received at Barnwell and Richland in 1994 by category (i.e., academic, government, industrial, medical, or utility LLW).

4.4 REFERENCES

1. DOE site LLW data submittal attachments, submitted to the IDB Program during July–August 1995. The following LLW submittals were received and reviewed by the IDB Program before analysis and integration. Preceding each submittal is the site (in parentheses) to which it refers.
 - a. (Ames) Kay Lampe Hannasch, Ames Laboratory, Ames, Iowa, correspondence to Jerry Klein, IDB Program, ORNL, Oak Ridge, Tennessee, “FY 1995 Low-Level Waste Management Data Call,” dated July 7, 1995.
 - b. (ANL-E) M. A. Sodaro, Argonne National Laboratory, Argonne, Illinois, correspondence to S. N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, “Low-Level Waste Management Data Call for 1995,” dated July 17, 1995.
 - c. (ANL-W) See reference for INEL.
 - d. (BNL) Carson L. Nealy, DOE Brookhaven Area Office, Upton, New York, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, “Brookhaven National Laboratory’s Response to the Low-Level Waste Management Data Call for the Integrated Data Base,” dated July 14, 1995.
 - e. (FNAL) Andrew E. Mravca, DOE Batavia Area Office, Batavia, Illinois, correspondence to Alan Icenhour, IDB Program, ORNL, Oak Ridge, Tennessee, “Low-Level Waste Management Data Call for 1995,” dated July 7, 1995.
 - f. (Hanford) A. K. Crowell, DOE Richland Operations Office, Richland, Washington, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, “LLW Data Call,” dated July 17, 1995.

4.3.5 Commercial LLW Projections

This report presents summary information for disposed commercial waste. Historical volume, radioactivity, and thermal power data through 1979 are taken from an earlier version of this report (DOE/RW-0006, Rev. 8). After 1979, the source term for commercial LLW in Table A.4 of Appendix A is used to decay the annual waste additions to the commercial sites.

Projections for disposed commercial LLW are made only through 2005 because of uncertainties in current facility operations and the availability of future sites. Projections (1995–2005) are made for Barnwell and Richland and are based on ref. 7. Barnwell is projected to remain open to all states for 10 years and then to close. Richland is projected to remain open beyond 2005 to only the Northeast and Rocky Mountain compacts. Historical and projected volume, radioactivity, and thermal power for disposed commercial LLW are presented in Table 4.3.

Because of timing uncertainties, projected commercial decommissioning wastes are not included in the projections of this chapter. Rather, waste projections for such wastes are reported separately in Chapter 7. Former DOE facilities that will be affected by environmental restoration activities are discussed in Chapter 6 and are also excluded from the projected values in this chapter.

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- q. (ORISE) James E. Drewry, Director, ORISE, Oak Ridge, Tennessee, correspondence to Thomas M. Jelinek, DOE Oak Ridge Operations Office, Oak Ridge, Tennessee, "Low-Level Waste Management: Data Call (1995)," dated Aug. 22, 1995.
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- s. (PANT) W. A. Weinreich, Mason & Hanger-Silas Mason Company, Inc., Amarillo, Texas, correspondence to S. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "1995 Low-Level Waste (LLW) Management Data Call," GM95-01592-791, dated July 17, 1995.
- t. (Pinellas) Gary C. Schmidtke, DOE Pinellas Area Office, Largo, Florida, correspondence to Alan Icenhour, IDB Program, ORNL, Oak Ridge, Tennessee, "Pinellas Plant Response to Low-Level Waste Management Data Call for 1995," PAO:GHS:ENV081, dated July 17, 1995.

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 - ab. (Y-12) A. L. Rivera, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, correspondence to S. N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Low-Level Waste (LLW) Management Data Call for 1995," dated July 31, 1995.
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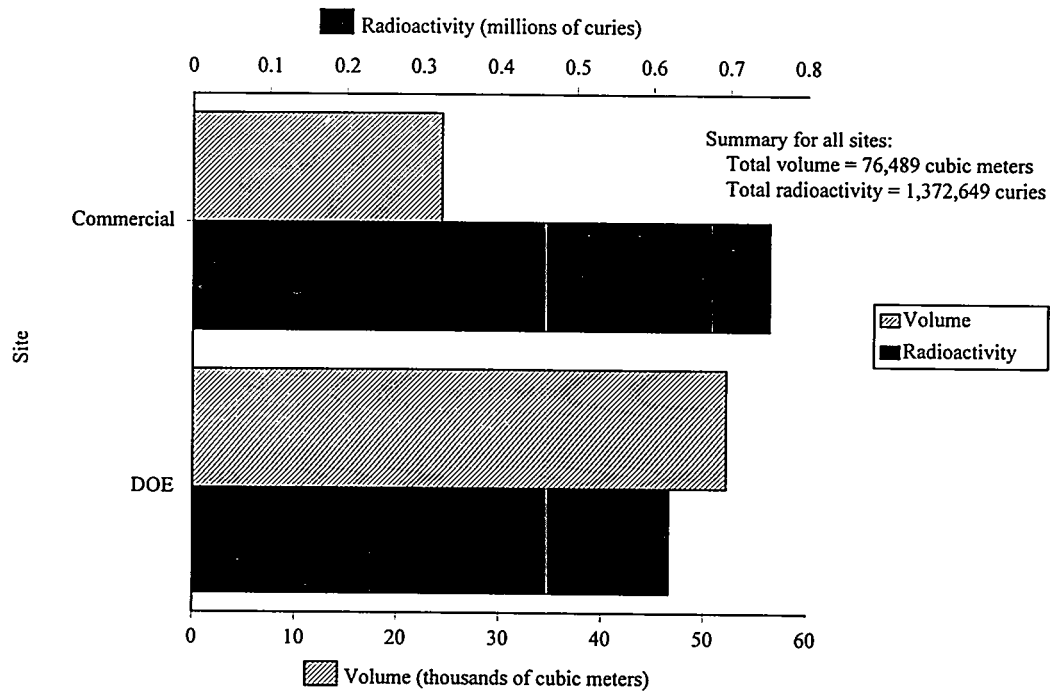
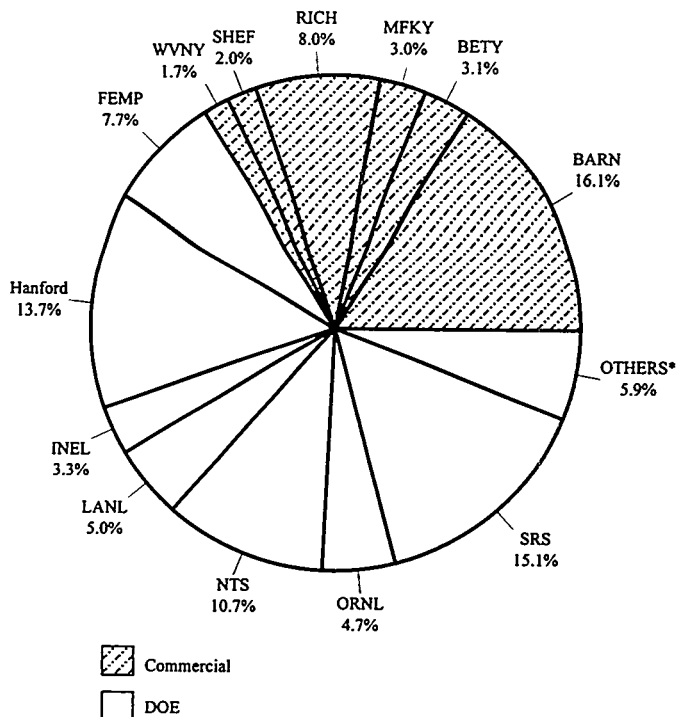


Fig. 4.1. Volume and radioactivity of LLW disposed at commercial and DOE facilities during 1994.



SITE	CUBIC METERS
BARN	7.221E+05
BETY	1.375E+05
MFKY	1.353E+05
RICH	3.586E+05
SHEF	8.833E+04
WVNY	7.707E+04
FEMP	3.432E+05
Hanford	6.153E+05
INEL	1.489E+05
LANL	2.226E+05
NTS	4.813E+05
ORNL	2.097E+05
SRS	6.764E+05
OTHERS*	2.655E+05
TOTAL	4.482E+06

* Includes contributions from Ames, BNL, K-25, LLNL, PANT, PAD, PORTS, SNL/NM, and Y-12.

Fig. 4.2. Total volume of LLW disposed through 1994.

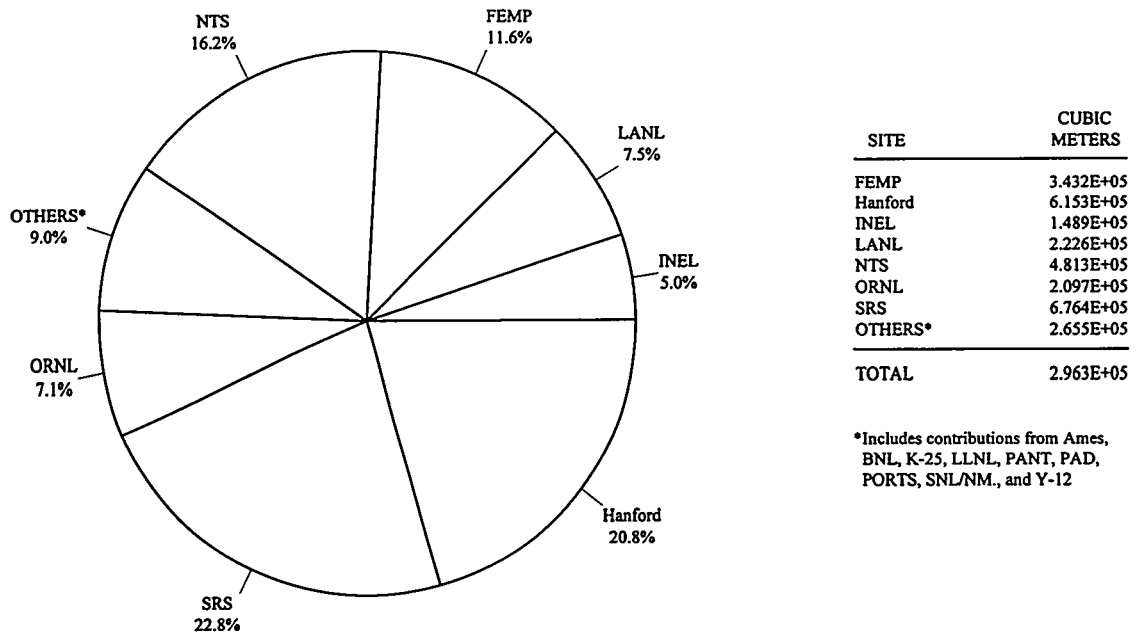


Fig. 4.3. Total volume of DOE LLW disposed through 1994.

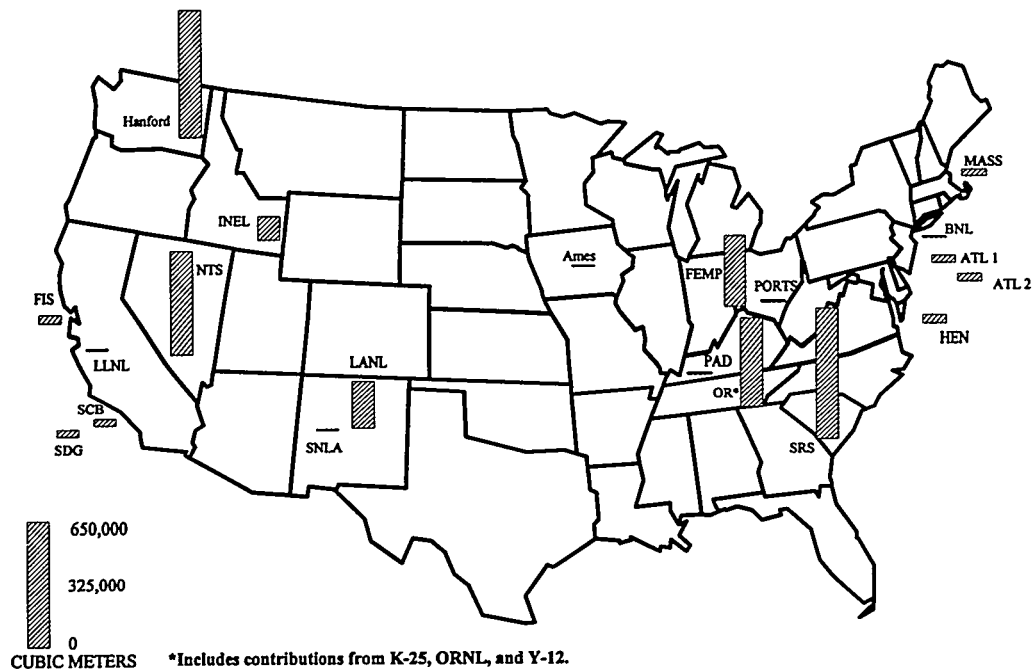


Fig. 4.4. Locations and total volumes of DOE LLW disposed through 1994.

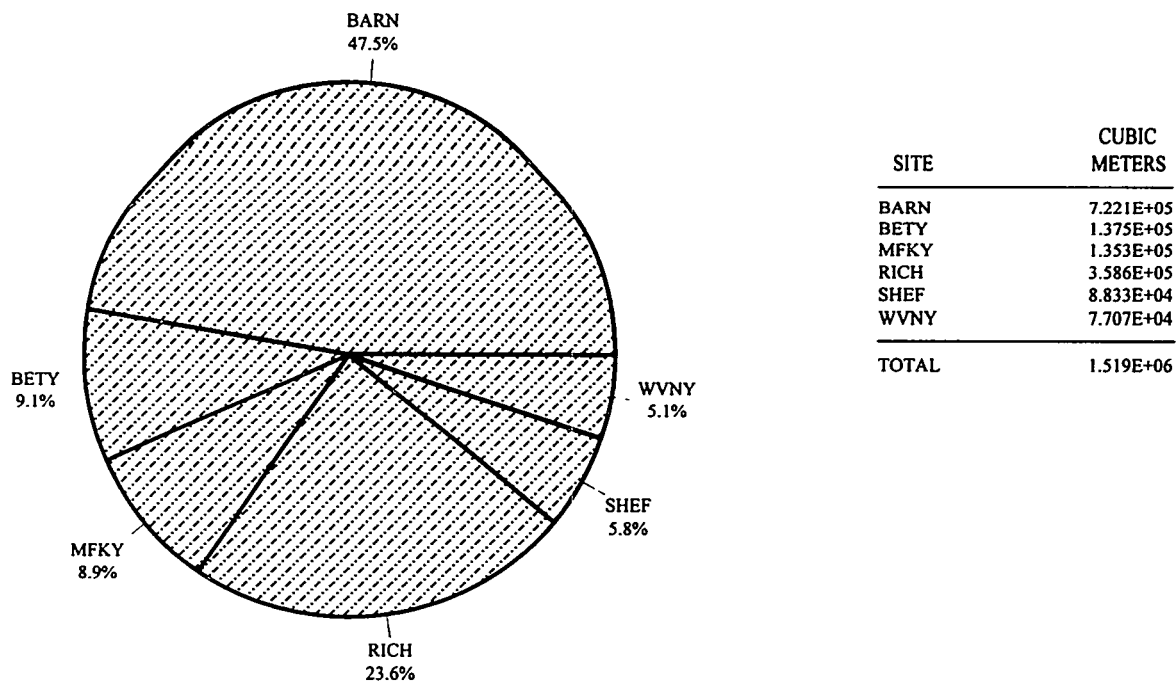


Fig. 4.5. Total volume of commercial LLW disposed through 1994.

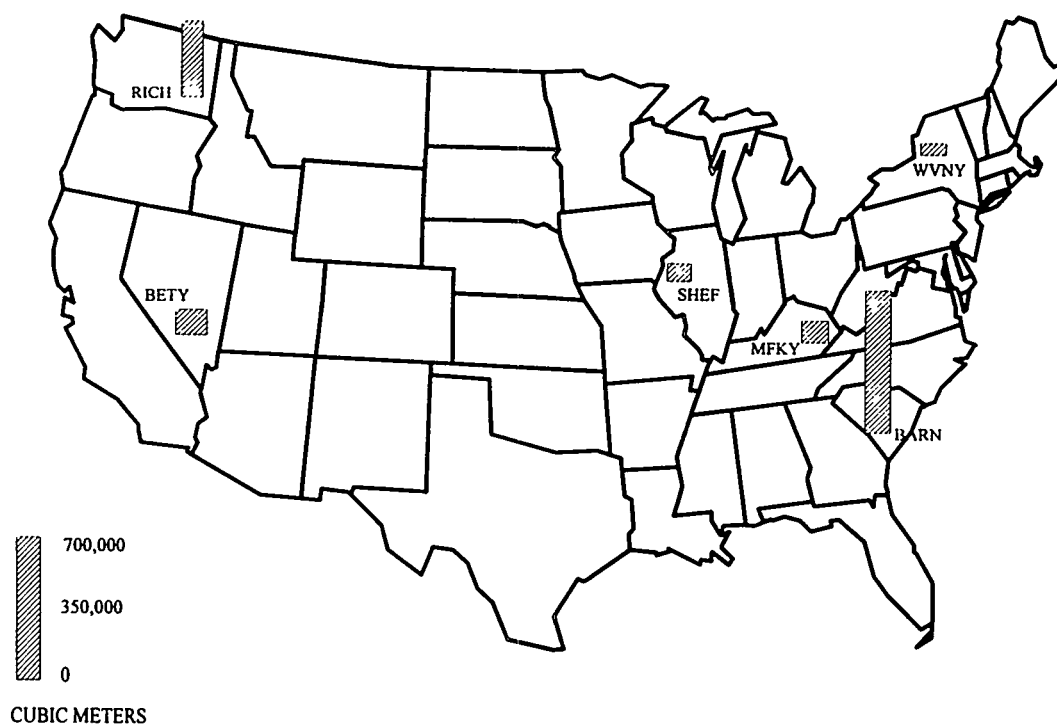


Fig. 4.6. Locations and total volumes of commercial LLW disposed through 1994.

Table 4.1. Summary of characteristics for disposed LLW as of December 31, 1994

Category	Volume (10 ³ m ³)		Radioactivity (10 ³ Ci)		Thermal power (W)	
	Annual ^a	Cumulative	Annual	Cumulative	Annual	Cumulative
DOE sites	52.2	2,963	621	12,858	3,463	21,534
Commercial sites	24.3	1,519	751	5,841	3,799	22,746
Total	76.5	4,482	1,372	18,699	7,262	44,280

^aAddition during 1994.

Table 4.2. Historical and projected volume, radioactivity, and thermal power of disposed DOE LLW^a

End of calendar year	Volume (10 ³ m ³)		Radioactivity (10 ³ Ci)		Thermal power (W)	
	Annual	Cumulative	Annual	Cumulative ^b	Annual	Cumulative
1990	60.0	2,759	545	13,516	2,013	17,844
1991	53.6	2,812	717	13,277	2,788	18,220
1992	48.3	2,860	1,078	13,401	4,947	20,741
1993	50.5	2,911	894	13,147	3,263	20,398
1994	52.2	2,963	621	12,858	3,463	21,534
1995	108.0	3,093	981	13,109	3,533	23,351
1996	95.8	3,189	845	13,074	3,447	23,835
1997	95.8	3,285	844	13,023	3,442	24,254
1998	95.8	3,381	844	12,959	3,441	24,614
1999	95.8	3,476	845	12,882	3,440	24,904
2000	95.8	3,572	845	12,797	3,438	25,124
2001	96.0	3,669	846	12,707	3,441	25,289
2002	96.0	3,765	846	12,611	3,437	25,400
2003	96.0	3,861	846	12,515	3,435	25,468
2004	96.0	3,957	846	12,418	3,433	25,505
2005	96.0	4,054	846	12,322	3,432	25,517
2006	96.0	4,149	846	12,229	3,432	25,509
2007	96.0	4,245	846	12,139	3,432	25,483
2008	96.0	4,341	846	12,052	3,432	25,442
2009	96.0	4,438	846	11,968	3,432	25,388
2010	96.0	4,534	846	11,889	3,432	25,325
2011	96.0	4,630	846	11,814	3,432	25,254
2012	96.0	4,725	846	11,743	3,433	25,176
2013	96.0	4,822	846	11,677	3,433	25,093
2014	96.0	4,918	846	11,614	3,433	25,006
2015	96.0	5,014	846	11,556	3,433	24,917
2016	96.0	5,110	846	11,501	3,433	24,825
2017	96.0	5,207	846	11,451	3,434	24,733
2018	96.0	5,303	846	11,403	3,434	24,641
2019	96.0	5,398	845	11,360	3,434	24,549
2020	96.0	5,494	845	11,319	3,434	24,457
2021	96.0	5,590	845	11,283	3,434	24,367
2022	37.2	5,628	841	11,245	3,410	24,253
2023	37.2	5,665	841	11,211	3,410	24,141
2024	37.2	5,702	841	11,179	3,410	24,030
2025	37.2	5,739	841	11,150	3,410	23,922
2026	37.2	5,777	841	11,124	3,410	23,815
2027	37.2	5,814	841	11,101	3,410	23,710
2028	37.2	5,851	841	11,080	3,410	23,607
2029	37.2	5,888	841	11,062	3,410	23,507
2030	37.2	5,926	841	11,046	3,410	23,409

^aSummation of values in Tables 4.17 (buried DOE LLW, except SRS saltstone) and 4.18 (LLW saltstone at SRS).

^bThe radioactivity added each year for each waste type is decayed as described in the footnotes of Tables 4.17 and 4.18.

Table 4.3. Historical and projected volume, radioactivity, and thermal power of commercial LLW shipped for disposal^a

End of calendar year	Volume (10 ³ m ³)		Radioactivity (10 ³ Ci)		Thermal power (W)	
	Annual	Cumulative	Annual	Cumulative ^b	Annual	Cumulative
1990	32.4	1,384	549	4,979	2,774	16,457
1991	38.8	1,423	800	5,272	4,044	18,424
1992	49.4	1,472	1,000	5,708	5,057	21,117
1993	22.4	1,495	643	5,709	3,252	21,627
1994	24.3	1,519	751	5,841	3,799	22,746
1995 ^c	24.3	1,543	751	5,955	3,799	23,745
1996	24.3	1,568	751	6,058	3,799	24,654
1997	24.3	1,592	751	6,151	3,799	25,485
1998	24.3	1,616	751	6,236	3,799	26,249
1999	24.3	1,640	751	6,316	3,799	26,954
2000	24.3	1,665	751	6,390	3,799	27,607
2001	24.3	1,689	751	6,460	3,799	28,215
2002	24.3	1,713	751	6,527	3,799	28,783
2003	24.3	1,738	751	6,590	3,799	29,316
2004	24.3	1,762	751	6,652	3,799	29,819
2005	3.5	1,766	6	5,965	31	26,526

^aIncludes LLW disposed of at the following commercial sites: Beatty, Nevada; West Valley, New York; Maxey Flats, Kentucky; Richland, Washington; Sheffield, Illinois; and Barnwell, South Carolina.

^bThe radioactivity through 1979 was decayed using a multiple source term methodology (see Tables 4.3 and 4.20–4.25 of Rev. 8 of this report for a description of this method). After 1979, the radioactivity is decayed from the year of addition using the representative compositions given in Table A.4 of Appendix A.

^cProjections were made based on disposal operations at Richland, Washington, and Barnwell, South Carolina, as described in Sect. 4.3.5. Projections were made only through 2005 because of large uncertainties in commercial disposal facility operations.

Table 4.4. Historical annual additions and total volume of LLW disposed at DOE sites^{a,b}

Year	Volume of waste disposed annually, 10 ³ m ³									Total annual addition	Total cumulative volume
	FEMP	Hanford	INEL	LANL	NTS	ORNL	SRS	Y-12 ^c	All others ^d		
1975 ^e	309.3	352.0	84.6	131.6	8.3	181.5	269.1	58.4	83.9	1,478.9	1,479
1976	14.4	4.1	6.2	8.8	0.0	3.8	8.1	2.7	0.9	49.0	1,528
1977	2.8	10.7	6.6	3.6	0.5	2.4	14.7	1.5	1.1	43.9	1,572
1978	1.9	9.8	5.9	7.5	10.0	2.0	15.5	1.4	3.2	57.2	1,629
1979	1.6	17.5	5.3	4.9	15.8	2.1	18.2	1.1	1.1	67.6	1,697
1980	1.3	10.4	5.1	4.8	13.3	2.0	19.6	1.4	0.7	58.6	1,755
1981	1.5	12.8	3.1	5.5	21.1	1.4	20.1	1.2	1.6	68.3	1,824
1982	2.8	11.7	3.2	4.5	57.0	1.3	22.4	2.2	2.0	107.1	1,931
1983	3.4	17.9	5.5	3.2	12.1	1.8	26.7	3.4	1.7	75.7	2,006
1984	3.5	18.8	3.9	5.4	36.0	2.2	26.1	7.2	10.6	113.7	2,120
1985	0.7	17.0	3.1	6.7	41.7	2.2	30.5	18.7	2.1	122.7	2,243
1986	0	21.1	3.4	4.5	27.9	1.8	30.1	15.0	1.0	104.8	2,348
1987	0	20.3	3.0	3.7	81.1	0.5	28.2	16.2	1.0	154.0	2,501
1988	0	16.8	2.0	4.3	39.1	0.6	30.2	10.6	1.0	104.6	2,606
1989	0	13.7	1.3	6.4	35.0	1.3	26.8	5.7	2.3	92.5	2,699
1990	0	13.4	1.8	4.5	9.1	0.3	26.6	4.4	0.0	60.1	2,759
1991	0	10.6	1.3	5.8	11.6	0.2	23.8	0.3	0.0	53.6	2,812
1992	0	10.9	0.8	2.3	20.1	1.1	13.0	0.0	0.0	48.2	2,860
1993	0	12.1	0.9	2.7	18.6	0.8	15.3	0.1	0.0	50.5	2,911
1994	0	13.7	1.9	1.9	22.9	0.4	11.4	0.0	0.0	52.2	2,963
Total	343.2	615.3	148.9	222.6	481.3	209.7	676.4	151.3	114.2	2,963	

^aNo TRUW included; data from refs. 1 and 5. Slight differences in values shown and those actually reported result from round-off and truncation of numbers.

^bSee Tables 4.8 and 4.13 for breakdown of disposed volumes by physical form.

^cLand disposal of LLW at Y-12 was terminated July 1, 1991. A single exception was made in 1993 when waste was placed in the Bear Creek Burial Ground walk-in pits.

^dIncludes contributions from Ames, BNL, K-25, LLNL, PAD, PANT, PORTS, and SNL/NM.

^eValues for 1975 are cumulative volumes to this date (ref. 3).

Table 4.5. Description of physical forms used to characterize solid LLW from DOE activities^a

Physical form	Description
Debris waste	Waste that is at least 50% by volume solid materials that are intended for disposal and that are either manufactured objects, plant, or animal matter or that are natural geologic materials
Debris—combustible	Waste containing any material that will sustain combustion in air when exposed to an ignition source of 315°C (600°F) for a period of 5 min
Debris—noncombustible and compactible	Waste composed of materials that are capable of undergoing volume reduction or of being compacted and that are not capable of being burned or rapidly oxidized
Debris—noncombustible and combustible mixed	Waste composed of a mixture of materials that can and cannot sustain combustion
Activated metal/equipment/hardware	Waste materials that are contaminated with radionuclides generated through neutron activation of metal, equipment, and/or hardware. Metal waste includes slag generated from removal of dross from molten metal, activated aluminum ingots, and metal generated by the decontamination and decommissioning (D&D) of site structures and equipment. Other examples are activated reactor hardware, glove box parts, dehumidifiers, freezers, engines, pumps, and compressors
Contaminated metal/equipment/hardware	Waste materials that are externally contaminated with radioactive material. Metal waste includes slag generated from removal of dross from molten metal, nonreusable drums, and metal generated by the D&D of site structures and equipment
Filter media	A category of solid waste that includes waste that is primarily (i.e., ≥50% by volume) filters constructed of one (or more than one) type of material. Examples of filter media waste are mechanical filters, cartridge-type filter media, and air filtration filters
Biological waste and carcasses	Waste that consists of any plant or animal material such as shrubs, trees, animal carcasses, animal bedding and litter wastes, including any absorbent material and chemical agents such as lime, animal tissues in vials, and cultures
Asbestos-contaminated waste	Waste that contains about 80% by volume, or more, asbestos or asbestos-based material. The asbestos contained in the waste may be friable or nonfriable asbestos. Friable asbestos is a material that, when dry, may be crumbled, pulverized, or reduced to powder by hand pressure. Nonfriable asbestos is that which is completely encapsulated or fixed in a matrix material that prevents the asbestos fibers from being released upon handling
Soil/sediment/rubble	A category of solid waste estimated to contain about 50% by volume soil and other ground media including, but not limited to, sand, silt, grass, rock, and gravel. The category also includes waste containing sediment which constitutes material in drainage and natural ponds and rubble which comprises waste material from building or demolition processes and concrete chunks and blocks from D&D activities
Solidified liquids/chelates/oils	Wastes that contain liquids, any polydentate ligand that will solubilize metal ions, and oils that have been immobilized or stabilized with agents, such as cement, polymers, and bitumen, and properly cured into a solidified form. The waste should not contain free liquids in excess of 1% of the volume of the waste when the waste is in a disposal container or 0.5% of the volume of the waste processed to a stable form. The waste should be in a form that meets stability requirements
Solidified sludge/resin	Sludge is any solid, semisolid, or liquid waste generated from any of a number of air- or water-treatment processes. Waste with a total suspended/settled solids (TSS) content of >30% is a sludge. The waste may be a mixture of sludge and stabilization agents cured into a solidified form

Table 4.5 (continued)

Physical form	Description
Solidified sludge/resin (continued)	Resin waste includes waste that is primarily (i.e., $\geq 50\%$ by volume) unused or spent inorganic or organic-based resins used in wastewater treatment or other applications. An example of this waste is inorganic/organic ion-exchange resins
Sources	Waste material composed of encapsulated radioactive material whose main purpose is to generate known amounts of radiation. Sealed sources are defined as a category of special-form radioactive material in 10 CFR Part 71.4. Special-form radioactive material is radioactive material which satisfies the following conditions: (1) it is either a single, solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule; (2) the piece or capsule has at least one dimension not less than 5 mm; and (3) it satisfies the test requirements of 10 CFR Part 71.75
Paint waste	Waste that is at least 50% by volume new, used, or removed paint. Examples of waste in this category are dried paint chips; containers filled with dried paint; and opened or unopened cans of heavy, viscous paint. This category does not include waste that is 50% by volume, or more, paint-related solids such as empty paint cans, depressurized spray paint cans, or other painting equipment (brushes, rollers, etc.)
Salt waste	Waste that is at least 50% by volume salts including interstitial liquids, if present. Chloride salts and sulfate salt wastes contain more than (i.e., >1000 ppm) levels of chlorides or other halogens and of sulfur compounds, respectively. Nitrate salts are predominantly (i.e., $>50\%$ by volume of salt) nitrates. Metal oxides/hydroxides waste is predominantly metal oxides or hydroxides
Incinerator ash	An inorganic particulate waste that is primarily (i.e., $\geq 50\%$ by volume) bottom or fly ash resulting from incineration
Activated carbon (charcoal)	An inorganic particulate waste that is primarily (i.e., $\geq 50\%$ by volume) spent or unused activated carbon including any residual liquids. The activated carbon may be in powdered (typically 50 to 100 μm) or granular (typically 0.1 to 1 mm) form
Other inorganic particulates	Waste that is at least 50% by volume inorganic particulates including any residual or absorbed liquids. Examples of other inorganic particulate waste are sandblasting media, inorganic particulate absorbent material (e.g., vermiculite), and ion-exchange media
Other	This category includes solid wastes that are not characterized sufficiently or that do not meet the criteria for assignment into one of the above categories

^aJames A. Turi, DOE Office of Program Integration, Office of Waste Management, Environmental Management, correspondence to DOE field offices and DOE site points of contact, "Low-Level Waste Management Data Call for 1995, Attachment 1, dated May 24, 1995.

Table 4.6. Actual 1994 generation and projected average annual generation of LLW at DOE sites

Physical form	Projections					
	1994 generation		1995		1996-2000	
	Volume (m ³)	Activity (Ci)	Volume (m ³)	Activity (Ci)	Volume (m ³ /year)	Activity (Ci/year)
Debris	11,990	1,439	9,115	418	8,696	423
Combustible	495	5	1,135	2,554	994	2,543
Noncombustible and compactible	4,709	17,416	3,551	27,263	3,712	27,275
Noncombustible and combustible mixed	1,176	150,163	684	198,590	722	299,746
Activated metal/equipment/hardware	6,774	435,858	2,054	85,257	1,843	61,688
Contaminated metal/equipment/hardware	291	4	146	5,057	126	3,419
Filter media (as-is, solidified, dewatered)	50	14	72	22	72	22
Biological waste and carcasses (as-is, solidified)	392	0	144	600,001	147	600,005
Asbestos-contaminated waste (as-is, solidified)	3,478	70	2,986	3	3,141	4
Soil/sediment/rubble (as-is, solidified, dewatered)	352	74,239	169	430,014	175	435,000
Solidified liquids/chelates/oils	1,154	5	1,222	31	777	11
Solidified sludge/resin (dewatered, solidified)	1 ^a	131 ^a	<1 ^b	2,438 ^b	<1 ^c	347 ^c
Sources (sealed sources, devices, and gauges)	1	0	0	0	0	0
Paint waste	138	4	1	0	1	0
Salt waste	40	0	2	0	616	29
Incinerator ash (solidified, as-is)	45	0	177	2	177	2
Activated carbon (charcoal)	822	1,189	68	2	61	2
Other inorganic particulates	6,076	174,002	6,146	268,068	5,901	268,058
Other						
Total	37,984	854,540	27,671	1,619,719	27,161	1,698,575
					25,962	1,468,423

^aEighteen sources with no volume estimate are included in radioactivity value for sources.^bEighty-two sources with no volume estimate are included in radioactivity value for sources.^cForty-six sources with no volume estimate are included in radioactivity value for sources.^dTwenty-seven sources with no volume estimate are included in radioactivity value for sources.

Table 4.7. Actual 1994 cumulative storage inventory and projected average annual storage additions of LLW at DOE sites

Physical form	Cumulative ^b			Projected annual addition ^a			
	Volume (m ³)	Activity (Ci)	Volume (m ³)	1995		1996-2000	
				Volume (m ³)	Activity (Ci)	Volume (m ³ /year)	Activity (Ci/year)
Debris							
Combustible	5,699	43,015	127		22	-3	-8,600
Noncombustible and compactible	265	71	156		16	140	21
Noncombustible and combustible mixed	13,860	498,720	375		172	-387	-77,016
Activated metal/equipment/hardware	1,554	280,028	188		45,030	418	45,100
Contaminated metal/equipment/hardware	11,319	1,572,217	243		31,773	142	5,210
Filter media (as-is, solidified, dewatered)	692	13	8		3	-12	6
Biological waste and carcasses (as-is, solidified)	707	17,250	3		0	3	0
Asbestos-contaminated waste (as-is, solidified)	646	0	19		1	7	5
Soil/sediment/rubble (as-is, solidified, dewatered)	1,646	84	154		-1	268	0
Solidified liquids/chelates/oils	1,309	983,400	-681		-969,990	-1	0
Solidified sludge/resin (dewatered, solidified)	7,447	120	-397		-4	13	0
Sources (sealed sources, devices, and gauges)	4 ^c	344,063 ^c	0 ^d		5 ^d	<1 ^e	101 ^e
Paint waste	1	0	0		0	0	0
Salt waste	161	4	0		0	0	0
Incinerator ash (solidified, as-is)	169	0	2		0	2	0
Activated carbon (charcoal)	82	0	2		0	3	0
Other inorganic particulates	1,561	49	18		0	13	-1
Other							
EM-30 program waste	11,981	186,397	49		0	54	0
EM-40 program waste	67,000 ^{g,h}	i	i		i	i	i
Total	125,890 ^j	3,925,431	268		-892,972	661	-35,175
						782	151

^aNegative values indicate a decrease in stored volume or radioactivity.^bCumulative storage as of December 31, 1994.^cIncluded in radioactivity value for sources are 1,085 sources with no volume estimate.^dIncluded in radioactivity value for sources are 58 sources with no volume estimate.^eIncluded in radioactivity value for sources are 189 sources with no volume estimate.^fIncluded in radioactivity value for sources are 20 sources with no volume estimate.^gFor EM-40 program LLW, data only available for cumulative storage volume for physical form "other." FUSRAP and UMTRAP sites are not included.^hExcludes 10,000 m³ at Fernald and 190,000 m³ at Weldon Spring of 11e(2) by-product material that is in storage. Total shown is rounded to two significant figures.ⁱNot available.^jBased on numerical sum of separate site entries.

Table 4.8. Actual disposal during 1994 and projected average annual disposal of LLW at DOE sites

Physical form	Projections ^{a,b}					
	1994 disposal		1995		1996-2000	
	Volume (m ³)	Activity (Ci)	Volume (m ³)	Activity (Ci)	Volume (m ³ /year)	Activity (Ci/year)
Debris-dry solids	29,182	76,140	24,163	13,743	8,244	13,645
Activated metal/equipment/hardware	1,115	47,513	180	3	180	3
Contaminated metal/equipment/hardware	6,263	13,525	2,484	20,875	1,643	20,875
Filter media (as-is, solidified, dewatered)	41	0	45	0	33	0
Biological waste and carcasses (as-is, solidified)	45	0	68	9	68	9
Asbestos-contaminated waste (as-is, solidified)	73	0	89	600,000	14	600,000
Soil/sediment/rubble (as-is, solidified, dewatered)	2,628	4	54,409	2	17,286	2
Solidified liquids/chelates/oils	6	0	0	0	0	0
Solidified sludge/resin (dewatered, solidified)	147	1	733	0	571	0
Sources (sealed sources, devices, and gauges)	1	122	0	0	0	0
Paint waste	0	0	0	0	0	0
Salt waste	16	0	0	0	0	0
Incinerator ash (solidified, as-is)	0	0	0	0	168	321
Activated carbon (charcoal)	5	0	172	2	172	2
Other inorganic particulates	1,016	1,348	136	0	80	0
Other	11,635 ^c	482,617 ^c	20,641	107,854	8,208	107,626
Total	52,173	621,270	103,120	742,488	36,668	742,483
					15,745	742,482

^aRadioactivity projections unavailable from Hanford. Volume and radioactivity projections unavailable from ORNL. Radioactivity and 2001-2030 volume projections unavailable from NTS.

^bVolume and radioactivity projections do not agree with those in Table 4.17. Projected values, shown in Table 4.17, were estimated for the unavailable data (from Hanford, ORNL, and NTS).

^cIncludes 7,068 m³ and 468,597 Ci of submarine reactor compartments at Hanford.

Table 4.9. Breakdown by physical form of volumes of LLW generated during 1994 at DOE sites

Physical form	Volume, m ³								All others ^b	Total
	Hanford	INEL	K-25	LANL	NR sites ^a	ORNL	SRS	Y-12		
Debris	2,388	0	1,848	477	153	79	5,830	912	303	11,990
Combustible	213	0	11	10	49	3	0	6	203	495
Noncombustible and compactible	83	330	793	417	334	1	422	1,013	1,315	4,709
Noncombustible and combustible mixed										
Activated metal/equipment/hardware	16	0	0	537	297	0	140	0	186	1,176
Contaminated metal/equipment/hardware	1,055	33	4,186	1	203	9	177	804	307	6,774
Filter media (as-is, solidified, dewatered)	0	0	17	41	<1	0	0	61	171	291
Biological waste and carcasses (as-is, solidified)	41	1	0	0	0	1	0	0	8	50
Asbestos-contaminated waste (as-is, solidified)	8	0	143	51	36	3	12	122	17	392
Soil/sediment/rubble (as-is, solidified, dewatered)	119	0	462	118	9	27	2,210	58	474	3,478
Solidified liquids/chelates/oils	<1	0	0	6	4	183	0	0	159	352
Solidified sludge/resin (dewatered, solidified)	4	0	0	29	75	33	0	0	1,014	1,154
Sources (sealed sources, devices, and gauges)	0	0	0	1	<<1	<<1	0	0	0	1
Paint waste	<1	0	0	0	0	0	0	<1	1	1
Salt waste	0	0	0	<<1	0	136	0	1	1	138
Incinerator ash (solidified, as-is)	0	0	38	0	0	0	0	0	2	40
Activated carbon (charcoal)	0	0	<1	0	3	35	0	1	5	45
Other inorganic particulates	569	0	197	0	0	1	0	14	41	822
Other	2	2,301	440	210	405	811	1,700	139	69	6,076
Total	4,498	2,665	8,135	1,898	1,568	1,322	10,491	3,131	4,276	37,984

^aNaval Reactors (NR) sites include KAPL, BAPL, and NRF.^bIncludes Ames, ANL-E, BNL, FNAL, ITRI, KCP, LBL, LLNL, Mound, NTS, PANT, Pinellas, PPPL, RFETS, SLAC, SNL/CA, and WVDP.

Table 4.10. Breakdown by physical form of radioactivity of LLW generated during 1994 at DOE sites

Physical form	Radioactivity, Ci									
	Hanford	INEL	K-25	LANL	NR sites ^a	ORNL	SRS	Y-12	All others ^b	Total
Debris										
Combustible	8	0	c	1,140	<1	0	266	c	25	1,439
Noncombustible and compactible	1	0	c	<1	1	0	0	c	2	5
Noncombustible and combustible mixed	<1	17,147	c	8	24	0	14	c	223	17,416
Activated metal/equipment/hardware	4,840	0	c	8,420	136,891	0	3	c	9	150,163
Contaminated metal/equipment/hardware	1	33,110	c	<1	6	388,220	16	c	14,504	435,858
Filter media (as-is, solidified, dewatered)	0	0	c	<1	1	0	0	c	3	4
Biological waste and carcasses (as-is, solidified)	0	14	c	0	0	0	0	c	0	14
Asbestos-contaminated waste (as-is, solidified)	0	0	c	<1	<1	0	c	c	0	<1
Soil/sediment/rubble (as-is, solidified, dewatered)	3	0	c	<1	1	63	c	c	4	70
Solidified liquids/chelates/oils	0	0	c	<1	<1	1,731	0	c	72,508	74,239
Solidified sludge/resin (dewatered, solidified)	0	0	c	1	2	<1	0	c	3	5
Sources (sealed sources, devices, and gauges)	0	0	c	123	<1	0	0	c	8	131
Paint waste	0	0	c	0	0	0	0	c	0	0
Salt waste	0	0	c	<1	0	4	0	c	0	4
Incinerator ash (solidified, as-is)	0	0	c	0	0	0	0	c	0	0
Activated carbon (charcoal)	0	0	c	0	<1	<1	0	c	0	0
Other inorganic particulates	1,189	0	c	0	0	<1	0	c	1	1,189
Other	0	169,700	c	<1	11	3,620	671	c	0	174,002
Total	6,042	219,971	c	9,692	136,937	393,638	970	c	87,290	854,540

^aNaval Reactors (NR) sites include KAPL, BAPL, and NRF.^bIncludes Ames, ANL-E, BNL, FNAL, ITRI, KCP, LBL, LLNL, Mound, NTS, PANT, Pinellas, PPPL, RFETS, SLAC, SNL/CA, and WVDP.^cUnknown.

Table 4.11. Breakdown by physical form of cumulative volumes of LLW stored at DOE sites^a

Physical form	Volume, m ³										Total
	FEMP	INEL	K-25	Mound	ORNL	RFETS	SRS	WSSRAP	WVDP	Y-12	All others ^b
Debris											
Combustible	0	0	2,293	235	110	2,350	344	0	0	343	24
Noncombustible and compactible	0	0	12	0	0	54	0	0	0	0	199
Noncombustible and combustible mixed	0	9,113	1,632	2,110	59	530	0	0	0	33	381
Activated metal/equipment/hardware	0	0	0	0	0	0	1,240	0	0	0	314
Contaminated metal/equipment/hardware	0	2,257	5,837	0	43	1,000	0	0	1,519	201	461
Filter media (as-is, solidified, dewatered)	0	0	75	0	25	460	0	0	0	<1	132
Biological waste and carcasses (as-is, solidified)	0	685	8	0	2	0	0	0	<1	0	13
Asbestos-contaminated waste (as-is, solidified)	0	0	491	35	3	0	0	0	0	106	11
Soil/sediment/rubble (as-is, solidified, dewatered)	0	0	1,188	0	96	100	0	0	0	44	218
Solidified liquids/chelates/oils	0	0	0	680	628	0	0	0	0	0	1
Solidified sludge/resin (dewatered, solidified)	0	0	1	900	37	720	0	0	5,763	0	27
Sources (sealed sources, devices, and gauges)	0	0	0	0	1	1	0	0	0	0	2
Paint waste	0	0	1	0	<1	0	0	0	0	<1	0
Salt waste	0	0	14	0	145	<1	0	0	0	1	1
Incinerator ash (solidified, as-is)	0	0	158	0	0	1	0	0	0	0	11
Activated carbon (charcoal)	0	0	49	0	31	0	0	0	0	1	0
Other inorganic particulates	0	0	474	0	954	57	0	0	0	13	64
Other ^c											
EM-30 program waste	0	625	2,353	0	1,404	42	0	0	6,992	82	483
EM-40 program waste	27,000 ^d	1,400	0	4,900	0	0	71	0 ^e	0	0	33,416 ^f
Total	27,000	14,080	14,586	8,860	3,538	5,315	1,655	0	14,274	825	35,757
											125,890 ^h

^aCumulative storage as of December 31, 1994.^bIncludes Ames, ANL-E, BNL, ETEC, FNAL, Hanford, ITRI, KCP, LBL, LEHR, LLNL, NTS, PAD, PANT, Pinellas, PORTS, PPPL, RMI, SLAC, and SNL/CA.^cFor EM-40 program LLW, data only available for cumulative storage volume for physical form "other." FUSRAP and UMTAP sites are not included.^dExcludes 10,000 m³ of 11e(2) by-product material that is in storage at Fernald (FEMP).^eExcludes 190,000 m³ of 11e(2) by-product material that is in storage at Weldon Spring (WSSRAP).^fIncludes 25,000 m³ of LLW at Portsmouth (PORTS).^gRounded to two significant figures.^hBased on numerical sum of separate site entries.

Table 4.12. Breakdown by physical form of total gross radioactivity of LLW stored at DOE sites^a

Physical form	Radioactivity, Ci									
	INEL	K-25	Mound	ORNL	RFETS	SRS	WVDP	Y-12	All others ^b	Total
Debris										
Combustible	0	c	43,000	7	3	5	c	c	0	43,015
Noncombustible and compatible	0	c	0	0	<<1	0	c	c	71	71
Noncombustible and combustible mixed	103,488	c	384,000	36	<<1	0	c	c	11,197	498,720
Activated metal/equipment/hardware	0	c	0	0	0	280,000	c	c	28	280,028
Contaminated metal/equipment/hardware	1,097,000	c	0	440,463	3	0	c	c	34,751	1,572,217
Filter media (as-is, solidified, dewatered)	0	c	0	<<1	<1	0	c	c	13	13
Biological waste and carcasses (as-is, solidified)	17,250	c	0	0	0	0	c	c	0	17,250
Asbestos-contaminated waste (as-is, solidified)	0	c	<<1	0	0	0	c	c	0	0
Soil/sediment/rubble (as-is, solidified, dewatered)	0	c	0	81	<1	0	c	c	2	84
Solidified liquids/chelates/oils	0	c	979,000	4,393	0	0	c	c	7	983,400
Solidified sludge/resin (dewatered, solidified)	0	c	3	<1	<<1	0	c	c	117	120
Sources (sealed sources, devices, and gauges)	0	c	0	138,353	c	0	c	c	205,710	344,063
Paint waste	0	c	0	0	0	0	c	c	0	0
Salt waste	0	c	0	4	0	0	c	c	0	4
Incinerator ash (solidified, as-is)	0	c	0	0	c	0	c	c	0	0
Activated carbon (charcoal)	0	c	0	<<1	0	0	c	c	0	0
Other inorganic particulates	0	c	0	40	8	0	c	c	1	49
Other	4,924	c	0	180,170	<<1	0	c	c	1,303	186,397
Total	1,222,662	c	1,406,003	763,547	14	280,005	c	c	253,200	3,925,431

^aTotal gross radioactivity is the total radioactivity, without decay, in storage as of December 31, 1994.^bIncludes Ames, ANL-E, BNL, FNAL, Hanford, ITRI, KCP, LBL, LLNL, NTS, PANT, Pinellas, PPPL, SLAC, and SNL/CA.^cUnknown.

Table 4.13. Breakdown by physical form of volumes of LLW disposed during 1994 at DOE sites

Physical form	Volume, m ³						
	Hanford	INEL	LANL	NTS	ORNL	SRS	Total
Debris-dry solids	3,863	333	901	18,100	5	5,980	29,182
Activated metal/equipment/hardware	51	0	537	0	0	527	1,115
Contaminated metal/equipment/hardware	1,250	54	1	4,770	8	180	6,263
Filter media (as-is, solidified, dewatered)	0	0	41	0	0	0	41
Biological waste and carcasses (as-is, solidified)	41	0	0	3	1	0	45
Asbestos-contaminated waste (as-is, solidified)	10	0	51	0	0	12	73
Soil/sediment/rubble (as-is, solidified, dewatered)	278	0	118	0	22	2,210	2,628
Solidified liquids/chelates/oils	<1	0	6	0	0	0	6
Solidified sludge/resin (dewatered, solidified)	94	0	28	0	25	0	147
Sources (sealed sources, devices, and gauges)	0	0	1	0	0	0	1
Paint waste	<1	0	0	0	0	0	0
Salt waste	0	0	<<1	0	16	0	16
Incinerator ash (solidified, as-is)	0	0	0	0	0	0	0
Activated carbon (charcoal)	0	0	0	0	5	0	5
Other inorganic particulates	1,016	0	0	0	0	0	1,016
Other	7,071 ^a	1,519	210	0	315	2,520	11,635
Total	13,674	1,906	1,894	22,873	397	11,429	52,173

^aIncludes 7,068 m³ of submarine reactor compartments.

Table 4.14. Breakdown by physical form of radioactivity of LLW disposed during 1994 at DOE sites

Physical form	Radioactivity, Ci						
	Hanford	INEL	LANL	NTS	ORNL	SRS	Total
Debris-dry solids	20	23,760	1,148	50,700	0	512	76,140
Activated metal/equipment/hardware	39,067	0	8,429	0	0	17	47,513
Contaminated metal/equipment/hardware	5	12,440	<<1	1,060	2	18	13,525
Filter media (as-is, solidified, dewatered)	0	0	<<1	0	0	0	0
Biological waste and carcasses (as-is, solidified)	0	0	0	<<1	0	0	0
Asbestos-contaminated waste (as-is, solidified)	0	0	<<1	0	0	a	0
Soil/sediment/rubble (as-is, solidified, dewatered)	3	0	<<1	0	<1	a	4
Solidified liquids/chelates/oils	0	0	<<1	0	0	0	0
Solidified sludge/resin (dewatered, solidified)	0	0	1	0	<1	0	1
Sources (sealed sources, devices, and gauges)	0	0	122	0	0	0	122
Paint waste	0	0	0	0	0	0	0
Salt waste	0	0	<<1	0	<<1	0	0
Incinerator ash (solidified, as-is)	0	0	0	0	0	0	0
Activated carbon (charcoal)	0	0	0	0	0	0	0
Other inorganic particulates	1,348	0	0	0	0	0	1,348
Other	468,597 ^b	13,320	<<1	0	13	687	482,617
Total	509,040	49,520	9,700	51,760	15	1,234	621,270

aUnknown.

bIncludes 468,597 Ci of submarine reactor compartments.

Table 4.15. DOE LLW disposed by methods other than shallow-land burial^a

Site	Location	Site use (year)	Waste containers buried ^b	Undecayed radioactive content (Ci)
<i>Atlantic Ocean</i>				
Atlantic	38°30'N 72°06'W	1951–1956; 1959–1962	14,300	74,400 ^c
Atlantic	37°50'N 70°35'W	1957–1959	14,500	2,100
Massachusetts Bay	42°25'N 70°35'W	1952–1959	4,008	2,440
Cape Henry	36°56'N 74°23'W	1949–1967	843	87
Central Atlantic	36°20'N/ 43°49'N 45°00'W	1959–1960	432	480
Subtotal			34,083	79,507
<i>Pacific Ocean</i>				
Farallon Islands (Subsite A)	37°38'N 123°08'W	1951–1953	3,500	1,100
Farallon Islands (Subsite B)	37°37'N 123°17'W	1946–1950; 1954–1956	44,000	13,400
Santa Cruz Basin	33°40'N 119°40'W	1946–1962	3,114	108
Cape Scot	50°56'N 136°03'W 52°25'N 140°12'W	1958–1969	360	124
San Diego	32°00'N 121°30'W	1959–1962	4,415	34
Subtotal (oceans)			55,389	14,766
Total			89,472	94,273
<i>Hydrofracture facility</i>				
ORNL	Bedded Conasauga shale underlying the ORNL site	1959–1965	Small experimental amounts of grout	
		1966–1980 ^d	$8.0 \times 10^3 \text{ m}^3$	600,000
		1982 ^e	$3.8 \times 10^3 \text{ m}^3$	200,000
		1983 ^e	$5.5 \times 10^3 \text{ m}^3$	500,000
Total			$17.3 \times 10^3 \text{ m}^3$	1,300,000

^aRadioactivity is given at time of disposal. Data taken from Table 4.5 of ref. 3.^bEstimated number of containers.^cIncludes approximately 33,000 Ci of induced activity associated with the U.S.S. *Seawolf* reactor vessel.^dRetired after 18 injections.^eNew facility started up with four injections in 1982 and completed campaign with seven injections in 1983.

Table 4.16. Significant revisions and changes in the current values for LLW compared to the values in the previous year

Site	DOE/RW-0006, Rev. 10 (1994)	DOE/RW-0006, Rev. 11 (1995)	Significant revision or net change	Explanation
	Table No.	Table No.		
DOE	4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, 4.12, and 4.14	NA ^a	Tables were removed that reported the breakdown of LLW data by physical and radionuclide characteristics	Data required to complete these tables were not collected
DOE	NA ^a	4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11, 4.12, 4.13, and 4.14	Tables were added that report the breakdown of LLW by physical form	Tables reflect new data collection requirements
ORNL	4.9	4.11	Large decrease in total stored inventory (from 52,659 m ³ to 3,539 m ³)	Previous historical total stored inventory was erroneously reported in units of m ³ when it was actually in units of ft ³
PORTS	4.9	4.11	Large decrease in total stored inventory (from 49,494 m ³ to 25,000 m ³)	Major refinement by site in stored LLW inventory. Previous result was in error

^aNA = not applicable.

Table 4.17. Historical and projected volume, radioactivity, and thermal power characteristics of disposed DOE LLW, except SRS saltstone

End of calendar year	Volume ^{a,b} (10 ³ m ³)		Radioactivity ^{a,b} (10 ³ Ci)		Thermal power (W)	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1990	60.0	2,759	545	13,516	2,013	17,844
1991	53.6	2,812	717	13,277	2,788	18,220
1992	48.3	2,860	1,078	13,401	4,947	20,741
1993	50.5	2,911	894	13,147	3,263	20,398
1994	52.2	2,963	621	12,858	3,463	21,534
1995	103.4	3,066	981	13,109	3,533	23,351
1996	37.0	3,103	840	13,069	3,403	23,791
1997	37.0	3,140	840	13,015	3,403	24,183
1998	37.0	3,177	840	12,948	3,403	24,520
1999	37.0	3,214	840	12,868	3,403	24,790
2000	37.0	3,251	840	12,779	3,403	24,995
2001	37.2	3,289	841	12,684	3,410	25,151
2002	37.2	3,326	841	12,584	3,410	25,256
2003	37.2	3,363	841	12,483	3,410	25,318
2004	37.2	3,400	841	12,382	3,410	25,345
2005	37.2	3,438	841	12,282	3,410	25,343
2006	37.2	3,475	841	12,184	3,410	25,317
2007	37.2	3,512	841	12,090	3,410	25,271
2008	37.2	3,549	841	11,999	3,410	25,209
2009	37.2	3,587	841	11,911	3,410	25,133
2010	37.2	3,624	841	11,828	3,410	25,047
2011	37.2	3,661	841	11,749	3,410	24,952
2012	37.2	3,698	841	11,674	3,410	24,850
2013	37.2	3,736	841	11,604	3,410	24,743
2014	37.2	3,773	841	11,538	3,410	24,632
2015	37.2	3,810	841	11,476	3,410	24,518
2016	37.2	3,847	841	11,418	3,410	24,402
2017	37.2	3,885	841	11,364	3,410	24,285
2018	37.2	3,922	841	11,313	3,410	24,167
2019	37.2	3,959	841	11,267	3,410	24,050
2020	37.2	3,996	841	11,223	3,410	23,932
2021	37.2	4,033	841	11,184	3,410	23,816
2022	37.2	4,071	841	11,147	3,410	23,700
2023	37.2	4,108	841	11,114	3,410	23,586
2024	37.2	4,145	841	11,083	3,410	23,473
2025	37.2	4,182	841	11,056	3,410	23,363
2026	37.2	4,220	841	11,031	3,410	23,254
2027	37.2	4,257	841	11,009	3,410	23,147
2028	37.2	4,294	841	10,989	3,410	23,042
2029	37.2	4,331	841	10,972	3,410	22,940
2030	37.2	4,369	841	10,957	3,410	22,840

^aHistorical (beginning of operations through 1993) annual values of volume and radioactivity (by waste type) for each site are from ref. 5. Similar values for 1994 are from ref. 1. See Tables 4.4, 4.8, 4.13, and 4.14 for more detail. For disposals prior to 1994, radioactivity (by waste type) is decayed from the year of addition using the representative compositions given in Table A.3 of Appendix A. Starting with 1994, compositions provided by the sites in ref. 1 are used to decay radioactivity.

^bBeginning in 1995, projected disposals are estimated for each active disposal site. Estimated values reported in this table may not agree with summary data reported in Table 4.8 because projections were reported as either unknown or unavailable by some sites.

Table 4.18. Projected volume, radioactivity, and thermal power characteristics of DOE LLW saltstone at SRS^a

End of calendar year	Volume (10 ³ m ³)		Radioactivity (10 ³ Ci)		Thermal power (W)	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1995	4.6	27.0 ^b	0.0	0.0	0.0	0.0
1996	58.8	85.8	4.7	4.7	43.5	43.5
1997	58.8	144.7	4.3	7.8	38.8	70.8
1998	58.8	203.5	4.4	10.9	37.8	93.9
1999	58.8	262.4	4.6	14.4	36.8	114.2
2000	58.8	321.2	4.9	18.3	34.5	129.3
2001	58.8	380.1	5.1	22.6	30.9	138.2
2002	58.8	438.9	5.1	27.0	27.3	143.6
2003	58.8	497.8	5.2	31.5	24.6	149.9
2004	58.8	556.6	5.2	36.0	22.9	159.9
2005	58.8	615.5	5.1	40.4	22.1	174.1
2006	58.8	674.3	5.1	44.8	21.7	191.6
2007	58.8	733.2	5.0	49.1	21.7	211.5
2008	58.8	792.0	5.0	53.2	21.8	232.8
2009	58.8	850.8	4.9	57.3	21.9	255.2
2010	58.8	909.7	4.9	61.3	22.1	278.2
2011	58.8	968.5	4.8	65.1	22.3	301.7
2012	58.8	1,027.4	4.8	68.9	22.5	325.5
2013	58.8	1,086.2	4.7	72.6	22.7	349.5
2014	58.8	1,145.1	4.7	76.2	22.9	373.9
2015	58.8	1,203.9	4.6	79.7	23.1	398.5
2016	58.8	1,262.8	4.6	83.2	23.3	423.3
2017	58.8	1,321.6	4.5	86.5	23.5	448.4
2018	58.8	1,380.5	4.5	89.8	23.6	473.7
2019	58.8	1,439.3	4.4	93.1	23.8	499.2
2020	58.8	1,498.2	4.4	96.2	24.0	525.1
2021	58.8	1,557.0	4.4	99.3	24.2	551.2
2022	0.0	1,557.0	0.0	98.1	0.0	553.1
2023	0.0	1,557.0	0.0	96.8	0.0	555.1
2024	0.0	1,557.0	0.0	95.6	0.0	557.0
2025	0.0	1,557.0	0.0	94.4	0.0	559.0
2026	0.0	1,557.0	0.0	93.2	0.0	560.9
2027	0.0	1,557.0	0.0	92.1	0.0	562.9
2028	0.0	1,557.0	0.0	91.0	0.0	564.8
2029	0.0	1,557.0	0.0	89.9	0.0	566.8
2030	0.0	1,557.0	0.0	88.9	0.0	568.8

^aSource: ref. 1 of Chapter 2..

^bReflects disposal, prior to 1995, of 22, 400 m³ from processing of Effluent Treatment Facility concentrate. This volume was not reported in previous IDB reports.

Table 4.19. Historical annual additions and total volume of LLW at commercial disposal sites^a

Year	Volume, m ³						Annual total	Cumulative total
	Beatty ^b	West Valley ^c	Maxey Flats ^d	Richland	Sheffield ^e	Barnwell		
1962	1,861						1,861	1,861
1963	3,512	127	2,206				5,845	7,706
1964	2,836	5,940	3,872				12,648	20,354
1965	1,988	5,192	5,753	668			13,601	33,955
1966	3,533	3,951	5,557	2,402			15,443	49,398
1967	3,206	7,475	7,820	773	2,527		21,801	71,199
1968	3,576	3,490	8,178	1,359	2,713		19,316	90,515
1969	4,526	4,099	10,354	438	2,012		21,429	111,944
1970	5,152	4,906	12,521	423	2,825		25,827	137,771
1971	4,916	7,002	13,173	584	4,430	1,171	31,276	169,047
1972	4,301	9,045	15,578	654	5,956	3,757	39,291	208,338
1973	4,076	7,535	10,074	1,033	8,524	15,839	47,081	255,419
1974	4,103	8,866	8,898	1,411	12,373	18,244	53,895	309,314
1975	4,943	2,243	17,098	1,500	14,116	18,072	57,972	367,286
1976	3,864	427	13,775	2,867	13,480	40,227	74,640	441,926
1977	4,742	351	423	2,718	17,643	45,663	71,540	513,466
1978	8,874	144		7,422	1,735	61,554	79,729	593,195
1979	6,491	138		12,185		63,861	82,675	675,870
1980	12,717	141		24,819		54,723 ^f	92,400	768,270
1981	3,351	216		40,732		39,427 ^f	83,726	851,996
1982	1,505	632		39,606		34,779	76,522	928,518
1983	1,111	1,284		40,458		35,132	77,985	1,006,503
1984	2,067	966		38,481		34,879	76,393	1,082,896
1985	1,388	809		40,135		34,389	76,721	1,159,617
1986	2,668	2,095		18,833		29,612	53,208	1,212,825
1987	9,414			15,765		27,060	52,239	1,265,064
1988	2,645			11,430		26,391	40,466	1,305,530
1989	3,291			11,562		31,242	46,095	1,351,625
1990	1,684			8,362		22,315	32,361	1,383,986
1991	4,539			11,872		22,368	38,779	1,422,765
1992	14,575			11,271		23,518	49,364	1,472,129
1993				5,288		17,145	22,433	1,494,562
1994				3,533		20,783	24,316	1,518,878
Total	137,455	77,074	135,280	358,584	88,334	722,151		1,518,878

^aFor a summary of historical additions (1962–1984), see Table 4.6 in ref. 3. For Beatty, Richland, and Barnwell, the additions for 1985–1993 are from Table 4.18 in ref. 5. Information for 1994 is taken from ref. 7.

^bBeatty ceased accepting LLW Dec. 31, 1992.

^cWest Valley includes a commercial state-licensed facility which opened Nov. 18, 1963, and closed Mar. 11, 1975, and an NRC-licensed facility (for on-site fuel reprocessing wastes) which opened in 1966 and continued to receive only on-site-generated LLW associated with water treatment and site cleanup until late 1986. This license is in abeyance. Disposal operations at the West Valley Demonstration Project (WVDP) have been suspended pending the preparation of an EIS report for the West Valley site closure. The WVDP began in 1982. The LLW volumes reported for 1982 through 1986 are for the WVDP only and are taken from ref. 5. Since the beginning of 1987, LLW generated at the WVDP is stored on-site in engineered facilities pending final disposal (ref. 5).

^dClosed Dec. 27, 1977. Small perturbations in waste volumes have occurred during site cleanup operations but are not included here since they are inconsequential.

^eClosed Apr. 8, 1978. No additional operations have taken place at the site.

^fThese values exclude almost 19,000 m³ (approximately 14,506 in 1980 and approximately 4,279 in 1981) of very low-level-activity settling pond sludge that was not counted against the annual quota.

Table 4.20. Historical annual additions and total undecayed radioactivity of LLW at commercial disposal sites^a

Year	Radioactivity, Ci						Annual total	Cumulative total
	Beatty ^b	West Valley ^c	Maxey Flats ^d	Richland	Sheffield ^e	Barnwell		
1962	f						f	f
1963	5,690	100	22,556				28,346	28,346
1964	6,477	10,400	147,218				164,095	192,441
1965	6,377	22,600	63,828	144			92,949	285,390
1966	11,974	35,400	52,737	1,606			101,717	387,107
1967	10,894	123,100	23,273	5,378	3,850		166,495	553,602
1968	6,808	10,600	45,577	64,432	2,381		129,798	683,400
1969	9,761	36,000	31,028	55,964	2,192		134,945	818,345
1970	12,304	91,900	46,969	52,820	5,427		209,420	1,027,765
1971	4,316	436,700	720,146	23,916	7,895	4,151	1,197,124	2,224,889
1972	5,228	131,300	217,351	31,809	4,857	13,575	404,120	2,629,009
1973	5,704	346,000	118,359	57,037	2,834	48,212	578,146	3,207,155
1974	23,904	6,600	143,656	12,773	3,229	13,557	203,719	3,410,874
1975	18,388	11,600	289,570	113,341	6,103	17,428	456,430	3,867,304
1976	4,493	1,200	211,359	104,306	7,744	90,205	419,307	4,286,611
1977	23,811	900	267,063	7,465	11,147	390,121	700,507	4,987,118
1978	5,685	700		235,548	2,547	652,061	896,541	5,883,659
1979	8,897	400		164,787		314,938	489,022	6,372,681
1980	148,312	300		41,031		143,502	333,145	6,705,826
1981	52,214	229		43,905		183,744	280,092	6,985,918
1982	80,929	293		59,007		273,962	414,191	7,400,109
1983	1,356	255		120,534		383,450	505,595	7,905,704
1984	544	25		215,286		385,079	600,934	8,506,638
1985	453	39		287,849		460,571	748,912	9,255,550
1986	672	13		115,591		116,108	232,384	9,487,934
1987	3,353	0		42,734		211,026	257,113	9,745,047
1988	8,690	0		32,067		218,901	259,658	10,004,705
1989	42,678	0		99,056		725,164	866,898	10,871,603
1990	11,323	0		92,985		444,277	548,585	11,420,188
1991	29,679	0		158,784		611,348	799,811	12,219,999
1992	90,206	0		93,923		815,974	1,000,103	13,220,102
1993				31,422		611,785	643,207	13,863,309
1994				6,078		745,301	751,379	14,614,688
Total	641,120	1,266,654	2,400,690	2,371,578	60,206	7,874,440		14,614,688

^aFor a summary of historical additions (1962–1984), see Table 4.6 in ref. 3. For Beatty, Richland, and Barnwell, the additions for 1985–1993 are from Table 4.19 in ref. 5. Information for 1994 is taken from ref. 7.

^bBeatty ceased accepting LLW Dec. 31, 1992.

^cWest Valley includes a commercial state-licensed facility which opened Nov. 18, 1963, and closed Mar. 11, 1975, and an NRC-licensed facility (for on-site fuel reprocessing wastes) which opened in 1966 and continued to receive only on-site-generated LLW associated with water treatment and site cleanup until late 1986. This license is in abeyance. Disposal operations at the West Valley Demonstration Project (WVDP) have been suspended pending the preparation of an EIS report for the West Valley site closure. The WVDP began in 1982. The LLW radioactivity values reported for 1982 through 1986 are for the WVDP only and are taken from ref. 5. Since the beginning of 1987, LLW generated at the WVDP is stored on-site in engineered facilities pending final disposal (ref. 5).

^dClosed Dec. 27, 1977.

^eClosed Apr. 8, 1978.

^fReported as 296 kg of source material (as defined in Title 10, *Code of Federal Regulations*, Part 40).

Table 4.21. Distribution of total volume and radioactivity, by state, of LLW shipped to commercial disposal sites in 1994^a

State	Volume (m ³)	Radioactivity (Ci)	State	Volume (m ³)	Radioactivity (Ci)
Alabama	401.92	9,034.06	Nebraska	74.60	991.64
Alaska	1.25	4.69	Nevada	7.94	4.39
Arizona	235.04	452.98	New Hampshire	0.00	0.00
Arkansas	177.20	473.05	New Jersey	637.17	5,726.92
California	1,343.88	23,132.46	New Mexico	11.39	5.51
Colorado	498.06	4,520.60	New York	2,338.54	175,843.05
Connecticut	360.67	888.53	North Carolina	869.55	68,213.47
Delaware	10.61	69.29	North Dakota	1.72	6.48
District of Columbia	15.91	345.23	Ohio	330.40	582.68
Florida	339.14	3,279.99	Oklahoma	13.21	63.70
Georgia	550.15	167,310.33	Oregon	911.23	48.34
Hawaii	53.82	50.07	Pennsylvania	1,457.36	93,729.60
Idaho	0.75	93.76	Puerto Rico	0.00	0.00
Illinois	1,733.70	32,136.47	Rhode Island	0.00	0.00
Indiana	45.95	128.92	South Carolina	1,734.72	2,532.01
Iowa	90.02	1,632.89	South Dakota	0.15	7.05
Kansas	56.21	2,297.20	Tennessee	4,369.41	194.18
Kentucky	9.43	284.66	Texas	166.50	4,461.62
Louisiana	442.67	1,877.54	Utah	165.63	80.18
Maine	83.25	16.70	Vermont	81.08	157.85
Maryland	238.46	1,439.69	Virgin Islands	0.00	0.00
Massachusetts	551.80	141,109.85	Virginia	1,429.97	2,402.23
Michigan	0.00	0.00	Washington	1,876.29	1,263.83
Minnesota	54.72	1,738.82	West Virginia	2.32	0.45
Mississippi	201.85	660.06	Wisconsin	166.85	879.26
Missouri	166.98	1,220.21	Wyoming	5.84	5.65
Montana	0.27	0.46			
			Total	24,315.60	751,378.59

^aSource: ref. 7.

Table 4.22. Historical and projected cumulative volume and radioactivity summary of commercial GTCC LLW^a

Category	1993 ^b			2035 ^{c,d}		
	Volume (m ³)		Radioactivity (Ci)	Volume (m ³)		Radioactivity (Ci)
	Unpackaged	ACA packaged ^e		Unpackaged	ACA packaged	
Nuclear utility wastes						
• BWR operations	3.20	1.10	28,200	105.2	36.7	1,155,517
• PWR operations	2.82	0.12	18,300	77.7	10.0	573,510
LWR operations total	6.02	1.22	46,500	182.9	46.7	1,729,027
• BWR decommissioning	6.26	14.48	757,000	115.4	188.8	3,270,412
• PWR decommissioning	3.98	10.32	3,086,500	398.9	570.9	30,548,517
LWR decommissioning total	10.24	24.80	3,843,500	514.3	759.7	33,818,929
Nuclear utility total	16.26	26.02	3,890,000	697.2	806.4	35,547,956
Sealed sources						
• General license	0.007	0.474	1,119	0.123	8.09	18,440
• Specific license	0.125	38.22	354,000	0.87	234	1,560,000
Sealed sources total	0.13	38.69	355,119	0.99	242	1,578,440
DOE-held potential GTCC waste	0	0	0	0	0	0
Other generator waste ^f	46.9	74.2	2,738	235	465	12,680
Total	63.3	138.9	4,247,857	933	1,513	37,139,076

^aBased on the INEL study of ref. 13. Projected data reported represent base-case scenario projections.^bReported cumulative inventory as of December 31, 1993.^cProjected cumulative inventory for end of CY 2035.^dReference 13 also projects quantities of nuclear utility GTCC LLW by the end of CY 2055. For the base case, these include an unpackaged volume of 1,144 m³, an after-concentration-averaged (ACA) packaged volume of 1,347 m³, and an associated radioactivity of 88,400,000 Ci.^eACA packaged waste. This is the packaged volume of waste that is classified as GTCC LLW, after all other waste has been classified as Class A, B, or C LLW using concentration-averaging practices.^fIncludes contributions from ¹⁴C users, irradiation laboratories, sealed source manufacturers, a nuclear fuel fabrication facility, and a university reactor.

**Table 4.23. Breakdown of 1994 low-level radioactive waste
by type, volume, and radioactivity received
by commercial disposal sites^a**

Commercial site	Type of waste	Volume (m ³)	Radioactivity (Ci)
Barnwell	Academic	394	410
	Government	2,849	32,648
	Industrial	7,759	31,507
	Medical	116	452
	Utility	9,665	680,284
		20,783	745,301
Richland	Academic	111	11
	Government	424	380
	Industrial	1,932	20
	Medical	26	3
	Utility	1,040	5,664
		3,533	6,078

^aSource: ref. 7.



Dismantling of a uranium mill facility. Courtesy of the U.S. Department of Energy, Energy Information Administration, Washington, D.C.

5. URANIUM MILL TAILINGS FROM COMMERCIAL OPERATIONS

5.1 INTRODUCTION

Uranium mill tailings are the residual wastes of milled ore that remain after the uranium has been recovered. Mill tailings at licensed sites and tailings that will be produced from meeting future uranium requirements are "commercial" mill tailings, the subject of this chapter. Tailings resulting from uranium milled for defense purposes are not included. Existing tailings at sites that are no longer licensed are classified as "inactive" mill tailings. Inactive tailings are administered under the remedial action projects discussed in Chapter 6.

Mill tailings are generated during the process of extracting uranium from the ore fed to the mill. Depending on the ore's chemical characteristics, uranium mills use either an acid leach or an alkaline leach process to recover uranium. Currently, all operable U.S. mills are designed to use the acid leach process. Mill tailings from both processes consist of slurries of sands and clay-like particles called slimes; the tailings slurries are pumped to tailings impoundment ponds for disposal.

U.S. uranium production from conventional milling has declined since 1980; as a consequence, the quantity of mill tailings generated each year has declined (see Table 5.1). During 1993 and 1994, there was no uranium production from conventional mills; therefore, no new mill tailings were generated. At the end of 1994, none of the U.S. mills were operational. Six of the 26 mills were on standby status, and the rest were undergoing various stages of decommissioning. The location and status of each of these mills are indicated on the map shown in Fig. 5.1 (ref. 13). The nonutilization of U.S. uranium mill capacity can be attributed, in large part, to nuclear power plant cancellations and deferments. Since the late 1970s, these have led to lower uranium demand which, in turn, has contributed to lower uranium prices and a steady decline in domestic uranium mining. In addition, cost increases for domestic uranium mining and milling have led to increased reliance on imports of less expensive uranium.

In the history of U.S. uranium production, 1993 and 1994 were the only years with no production from conventional milling of ore. Nonconventional concentrate production in 1994 increased to about 1,500 t U_3O_8 , or 9%

above 1993 production.^{1,2} Nonconventional concentrate production includes by-product processing resulting from the mining of phosphate ore as well as the processing of in situ leach mining solutions, heap-leach solutions, mine water, and other solutions from reclamation activities. In situ leaching (ISL) technology has been increasingly applied in recent years to mining operations. Of the total \$80/kg-U uranium reserves estimated by the Energy Information Administration (EIA), the amount for which ISL is the proposed mining method has increased from 42% in 1993 to 43% in 1994. Because ISL mining generally is successful at lower costs compared with conventional mining methods, it could gain even wider use in the near future. ISL and by-product production methods do not generate mill tailings. Residual wastes from nonconventional methods are not considered in this chapter.

The volumes of historical and projected cumulative mill tailings through the year 2005 are shown in Fig. 5.2. This graph is based on the data reported in Table 5.1. The estimates of projected domestic tailings are based on U.S. production of uranium found in projections from ref. 3.

5.2 INVENTORIES

The status of the licensed mills, including their estimated commercial and government-related tailings inventories at the end of 1994, is shown in Table 5.2 (data based on refs. 1–14). For each mill, the amount of tailings generated depends on the amount of ore processed, the ore-feed grade (U_3O_8 assay), and the percentage of U_3O_8 recovered. Table 5.3 lists the annual milling rate, ore grade, and U_3O_8 recovery. The associated mill tailings generated through 1994 are 189.5×10^6 t (118.6×10^6 m³). There were no additions to the tailings pile during 1994.

5.3 WASTE CHARACTERIZATION

Because the amount of uranium (by weight) extracted from the ore during milling is relatively small, the dry

weight of the tailings produced is nearly equal to the dry weight of the ore processed. Dry tailings typically are composed of 70 to 80 wt % sand-sized particles and 20 to 30 wt % finer-sized particles. Acid leaching is preferred for ores with low lime content (12% or less). Those with high lime content require excessive quantities of acid for neutralization and, for economic reasons, are best treated by alkaline leaching. In either leach process, most of the uranium is dissolved, together with the other materials present in the ore (e.g., iron, aluminum, and other impurities). After the ore is leached, the uranium-laden leach liquor is removed from the tailings solids by decantation. After thorough washing, the tailings are pumped as a slurry to a tailings pond. The waste liquid accompanying the tailings solids to the disposal pond is approximately 1 to 1.5 times the weight of the processed ore. Typical characteristics of the tailings solids and liquid are outlined in Table 5.4 (ref. 8).

The tailings pile must have a cover designed to control radiological hazards for a minimum of 200 years and for 1,000 years to the greatest extent reasonably achievable. It must also limit radon (^{222}Rn) releases to 20 pCi/m²/s averaged over the disposal area. Radon release limitation requirements apply to any portion of the tailings disposal site unless radium concentrates do not exceed 5 pCi/g in

the first 15 cm below the surface and 15 pCi/g in layers more than 15 cm below the surface.¹⁴

5.4 PROJECTIONS

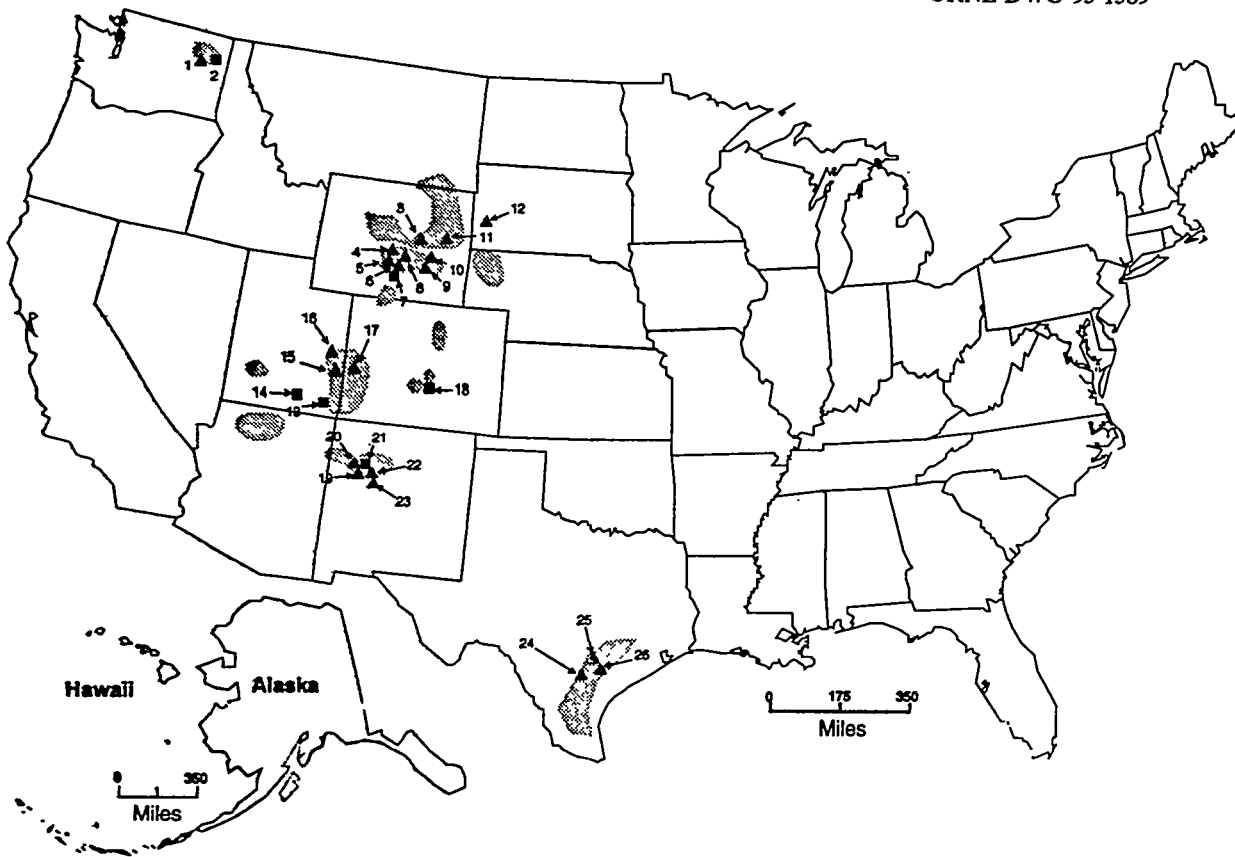
An average tailings density of 1.6 t/m³ was used to calculate mill-tailings volumes resulting from the milling of uranium ore mined by open-pit and underground operations. The quantity of material produced is based on projections of uranium production as reported in the EIA publication, *World Nuclear Outlook 1995*, DOE/EIA-0436(95). These projections were based on uranium requirements associated with the DOE/EIA 1995 Low-Case (formerly called No-New-Orders-Case) scenario and assumed a 2-year lead time from the mining/milling of uranium to its use as a reactor fuel.

The volumes of tailings generated from 1995 through 2010 are estimated based on production schedules for conventional mining/milling operations expected to be operational in this period. Most of the U.S. production is projected to come from nonconventional extraction operations (in situ, by-product, etc.). Imports and U.S. inventory drawdowns, which are projected to make up over 80% of U.S. requirements through 2005, will not add to U.S. tailings buildup.

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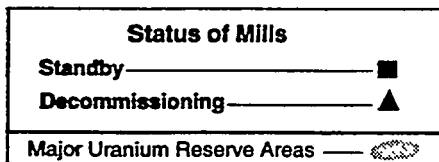
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**Standby**

- 2. Ford
- 7. Sweetwater
- 13. White Mesa
- 14. Shootering
- 18. Canon City
- 21. Ambrosia Lake

Decommissioning

1. Sherwood	15. Lisbon
3. Bear Creek	16. Moab
4. Lucky Mc	17. Uravan
5. Split Rock	19. Bluewater
6. Gas Hills, ANC	20. Churchrock
8. Gas Hill, UMETCO	22. Grants, Homestake
9. Shirley Basin	23. L-Bar
10. Petrotomics	24. Ray Point
11. Highland (Exxon)	25. Falls City
12. Edgemont	26. Panna Maria



Source: Based on U.S. Department of Energy, Grand Junction Project Office (GJPO), National Uranium Resources Evaluation, Interim Report (June 1979) Figure 3.2; GJPO data files; Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1994).

Fig. 5.1. Location and status of uranium mills at the end of 1994.

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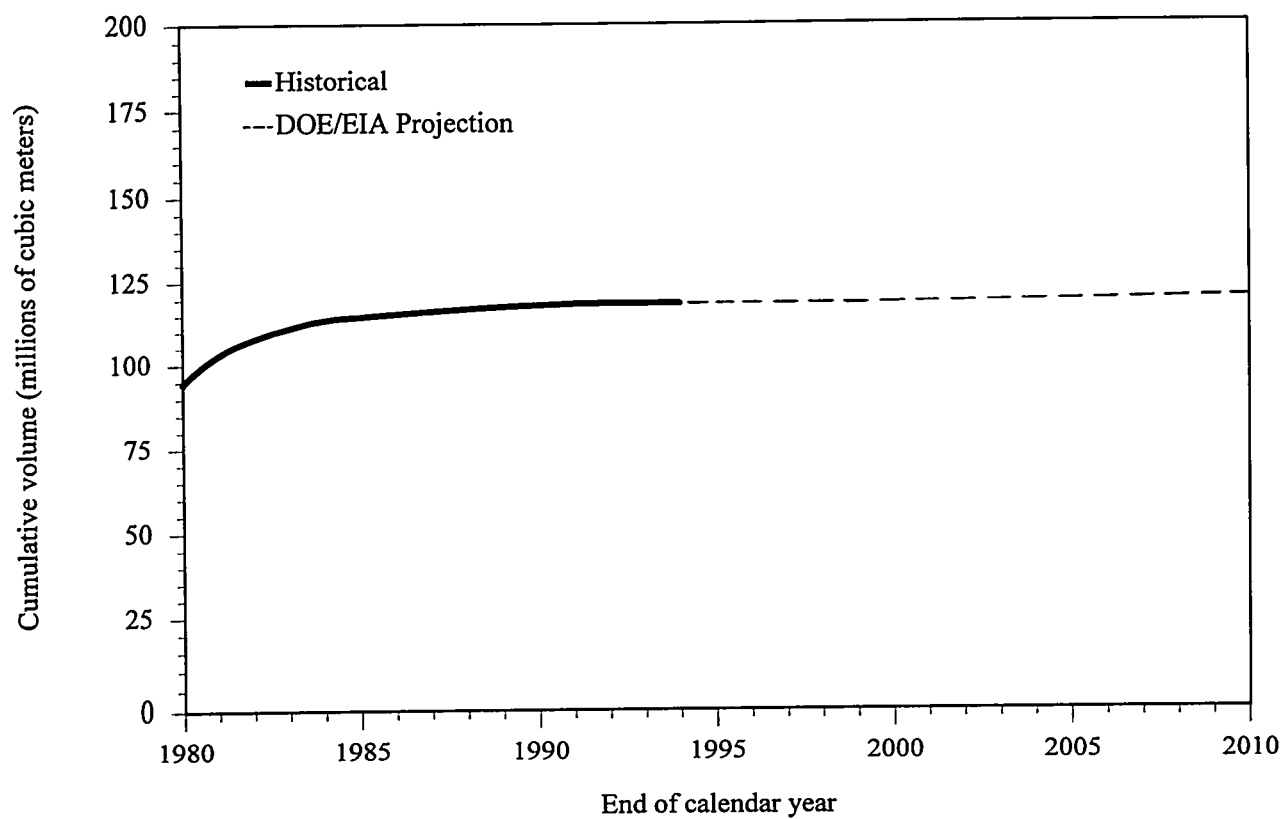


Fig. 5.2. Historical and projected cumulative volume of commercial mill tailings.

Table 5.1. Historical and projected volume of uranium mill tailings^{a,b}

End of calendar year	Volume (10 ⁶ m ³)	
	Annual	Cumulative
Prior to 1978		68.0
1978	7.9	75.8
1979	9.1	84.9
1980	9.5	94.4
1981	8.2	102.7
1982	5.0	107.7
1983	3.4	111.1
1984	2.5	113.6
1985	1.0	114.6
1986	0.7	115.4
1987	0.8	116.2
1988	0.7	116.9
1989	0.7	117.6
1990	0.4	118.0
1991	0.4	118.4
1992	0.2	118.6
1993	0.0	118.6
1994	0.0	118.6
1995	<0.1	118.6
1996	<0.1	118.6
1997	<0.1	118.6
1998	<0.1	118.6
1999	<0.1	118.7
2000	0.1	118.8
2001	0.1	118.9
2002	0.1	119.0
2003	0.2	119.2
2004	0.2	119.4
2005	0.2	119.6
2006	0.2	119.8
2007	0.2	120.0
2008	0.2	120.2
2009	0.2	120.4
2010	0.1	120.5

^aProjections of domestic tailings are generated from estimates of U.S. uranium production under current market conditions described in ref. 3, which is the Lower Reference Case (now referred to by DOE/EIA as the Mid Case).

^bSources: Prior to 1984—U.S. Department of Energy, Grand Junction Project Office data files. From 1984 through 1994—Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey."

Table 5.2. Status of conventional uranium mill sites at the end of 1994^a

Location	Operator	Rated capacity ^b (t/d ore)	Status		Tailings storage area (ha) ^d	Total tailings		
			Operations ^b	Tailings ^c		Volume ^e (10 ⁶ m ³)	Mass (10 ⁶ t)	Government portion ^f (10 ⁶ t)
Colorado								
Canon City	Cotter	1,090	Shut down, 1987		66R ^g	1.3	2.0	0.3
Uravan	Umetco Minerals	1,180 ^h	Decommissioning	Partially stabilized	34R	5.9	9.5	5.2
Subtotal		1,090			100R	7.2	11.5	5.5
New Mexico								
Ambrosia Lake	Quivira Mining	6,350	Shut down, 1985	Fenced	131R	18.8	30.1	9.1
Bluewater	Anaconda	5,440 ^h	Decommissioning	Partially stabilized	199	13.6	21.7	8.0
Church Rock	United Nuclear	2,720 ^h	Decommissioning	i	40R	2.0	3.2	0
Grants	Homestake Mining	3,080 ^h	Decommissioning	Unstabilized	86R	12.7	20.2	10.4
L-Bar	Sohio Western Mining	1,450 ^h	Decommissioning	i	46R	1.2	1.9	0
Marquez	Bokum Resources	1,820 ^{h,j}	New (on standby)	Never operated	0	0	0	0
Subtotal		6,350			502R	48.3	77.1	27.5
South Dakota								
Edgemont	Tennessee Valley Authority	680 ^h	Decommissioning	Partially stabilized	50	1.2	1.8	1.5
Subtotal		0			50	1.2	1.8	1.5
Texas								
Falls City	Continental Oil/ Pioneer Nuclear	3,080 ^h	Decommissioning	i	89	6.5	10.5	0
Panna Maria	Rio Grande Resources	2,720 ^h	Decommissioning	i	101	3.9	5.9	0
Ray Point (Felder Facility)	Exxon	1,000 ^h	Decommissioning	Stabilized ^k	18	0.2	0.4 ^l	0
Subtotal		2,720			208	10.6	16.8	0

Table 5.2 (continued)

Location	Operator	Rated capacity ^b (t/d ore)	Status		Tailsings storage area (ha) ^d	Total tailings		
			Operations ^b	Tailings ^c		Volume ^e (10 ⁶ m ³)	Mass (10 ⁶ t)	Government portion ^f (10 ⁶ t)
Utah								
Lisbon	Rio Algom	680	Decommissioning	i	14	2.2	3.5	0
Moab	Atlas	1,270 ^h	Decommissioning	Unstabilized	>80	6.0	9.6	5.4
Shooting	Plateau Resources	910	New (on standby)	Never operated	28	0	0	0
White Mesa	Energy Fuels	1,810	Shut down, 1990	Partially stabilized	135	1.9	3.2	0
Subtotal		3,400			>257	10.1	16.3	5.4
Washington								
Ford	Dawn Mining	410	Shut down, 1982	Wood chip covering	53R	1.8	2.8	1.1
Sherwood	Western Nuclear	1,810 ^h	Decommissioning	i	17	1.6	2.6	0
Subtotal		410			70R	3.4	5.4	1.1
Wyoming								
Bear Creek	Rocky Mountain Energy	1,810 ^h	Decommissioning	Unstabilized	61	2.7	4.3	0
Gas Hills	American Nuclear	860 ^h	Decommissioning	Unstabilized	47R	3.3	5.4	2.0
Gas Hills	Umetco	1,270 ^h	Decommissioning	Unstabilized	58R	4.6	7.3	1.9
Highland	Exxon	2,900 ^h	Decommissioning	Partially stabilized	116R	6.4	10.3	0
Lucky Mc	Pathfinder	2,540 ^h	Decommissioning	Unstabilized	99R	6.6	10.6	2.6
Petrotomics	Petrotomics	1,360 ^h	Decommissioning	Unstabilized	65	3.9	6.3	0.7
Shirley Basin	Pathfinder	1,630 ^h	Decommissioning	i	105R	4.7	7.4	0
Split Rock	Western Nuclear	1,540 ^h	Decommissioning	Interim stabilization	67R	4.4	7.0	3.0
Sweetwater	Minerals Exploration/ Union Energy Mining	2,720	Shut down, May 1983	Partially stabilized	121	1.3	2.1	0
Subtotal		4,350			739R	37.9	60.7	10.2
1994 total for all sites ^{b,m,n}		18,320 ^o			>1,926R	118.6	189.5	51.2P

(Footnotes on next page.)

Table 5.2 (continued)

^aData based on refs. 1–14. Note: subtotals and totals may not equal sum of components because of independent rounding. Ray Point, Texas (Felder Facility), site was stabilized during 1987 by Exxon Corporation. Historical data are revised based on detailed study of milling data from the Grand Junction Project Office and EIA files. The values shown include all tailings.

^bFrom refs. 1, 5, 9, and 14. Values rounded to nearest 10 t.

^cOn Aug. 15, 1986, EPA issued its final rules on ²²²Rn emissions from tailings piles. Mill owners have 6 years (subject to certain extensions) to phase out the use of large existing tailings piles. New tailings piles may be contained in small impoundments (less than 16 ha) or disposed of continuously by dewatering and burial (i.e., no more than 4 ha are uncovered at any one time). See ref. 7.

^dFrom refs. 6, 12, and 14; 1 ha = 10,000 m² or approximately 2.5 acres.

^eCalculated from reported mass using density = 1.6 t/m³.

^fFrom ref. 5, Table 8.0. These tailings are from government contracts only and are included in the "Total tailings" column.

^gR = revised. From ref. 14.

^hEstimates provided are not included in the total. See column labeled "Operations" under "Status" for reason.

ⁱNot available.

^jMill construction has not been 100% complete.

^kFrom ref. 11.

^lFrom ref. 10.

^mThese values are cumulative totals that may not equal sum of components due to independent rounding. For annual totals see Table 5.3.

ⁿFrom ref. 1.

^oFrom ref. 1.

P Total at the end of government-contracted deliveries in 1970 (ref. 5).

Table 5.3. Uranium ore processed, U₃O₈ recovery rate, and tailings generated through 1994^{a,b}

End of calendar year	Ore processed		U ₃ O ₈		Tailings generated	
	Mass ^c (10 ⁶ t)	Grade (% U ₃ O ₈)	Recovery from ore (%)	Product ^d (10 ³ t)	Mass ^e (10 ⁶ t)	Volume ^f (10 ⁶ m ³)
Prior to 1978	g	g	g	g	108.8	68.0
1978	12.5	0.134	91	15.6	12.6	7.9
1979	14.6	0.113	91	15.3	14.5	9.1
1980	15.3	0.118	93	17.2	15.2	9.5
1981	13.2	0.115	94	14.5	13.2	8.2
1982	7.9	0.119	96	9.9	8.1	5.0
1983	5.4	0.128	97	7.0	5.4	3.4
1984	3.9	0.112	95	4.4	4.0	2.5
1985	1.6	0.161	96	2.8	1.6	1.0
1986	1.2	0.338	97	4.0	1.2	0.7
1987	1.3	0.284	96	3.8	1.3	0.8
1988	1.1	0.288	95	3.2	1.1	0.7
1989	1.1	0.323	95	3.7	1.0	0.7
1990	0.7	0.293	94	2.1	0.7	0.4
1991	0.6	0.188	92	1.2	0.6	0.4
1992	0.2	0.229	96	0.6	0.2	0.2
1993	0.0	0.000	0	0.0	0.0	0.0
1994	0.0	0.000	0	0.0	0.0	0.0
Total ^h					189.5	118.6

^aSources: Prior to 1984—U.S. Department of Energy, Grand Junction Area Office data files.
1984–1994—Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey."

^bThis table has been revised based on a detailed study of milling data from the Grand Junction Project Office and EIA files. The values shown include all tailings.

^cBefore in-process inventory adjustments.

^dConventional U₃O₈ concentrate production.

^eIncludes adjustments to ore-fed amounts for annual mill circuit inventory changes and uranium concentrate production.

^fCalculated assuming that the average density of tailings is 1.6 t/m³ (metric tons per cubic meter).

^gNot available.

^hTotals may not equal sum of components due to independent rounding.

Table 5.4. Typical characteristics of uranium mill tailings^a

Tailings component	Particle size (μm)	Chemical composition	Radioactivity characteristics
Sands	75 to 500	SiO_2 with <1% complex silicates of Al, Fe, Mg, Ca, Na, K, Se, Mn, Ni, Mo, Zn, U, and V; also metallic oxides	0.004 to 0.01% U_3O_8 ^b Acid leaching: ^c 26 to 100 pCi $^{226}\text{Ra}/\text{g}$; 70 to 600 pCi $^{230}\text{Th}/\text{g}$
Slimes	45 to 75	Small amounts of SiO_2 , but mostly very complex clay-like silicates of Na, Ca, Mn, Mg, Al, and Fe; also metallic oxides	U_3O_8 and ^{226}Ra are almost twice the concentration present in the sands Acid leaching: ^c 150 to 400 pCi $^{226}\text{Ra}/\text{g}$; 70 to 600 pCi $^{230}\text{Th}/\text{g}$
Liquids	d	Acid leaching: pH 1.2 to 2.0; Na^+ , NH_4^+ , SO_4^{-2} , Cl^- , and PO_4^{-3} ; dissolved solids up to 1% Alkaline leaching: pH 10 to 10.5; CO_3^{-2} and HCO_3^- ; dissolved solids ~10%	Acid leaching: 0.001 to 0.01% U; 20 to 7,500 pCi $^{226}\text{Ra}/\text{L}$; 2,000 to 22,000 pCi; $^{230}\text{Th}/\text{L}$ Alkaline leaching: 200 pCi $^{226}\text{Ra}/\text{L}$; essentially no ^{230}Th (insoluble)

^aAdapted from information in ref. 8.^b U_3O_8 content is higher for acid leaching than for alkaline leaching.^cSeparate analyses of sands and slimes from the alkaline leaching process are not available. However, total ^{226}Ra and ^{230}Th contents of up to 600 pCi/g (of each) have been reported for the combined sands and slimes.^dParticle size does not apply. Up to 70% of the liquid may be recycled. Recycle potential is greater in the alkaline process.



High-pressure water spraying of the Weldon Spring quarry walls following waste removal. Courtesy of the U.S. Department of Energy, Office of the Deputy Assistant Secretary for Environmental Restoration, Washington, D.C.

6. ENVIRONMENTAL RESTORATION PROGRAM

6.1 INTRODUCTION

The fundamental goal of the DOE Office of Environmental Restoration (DOE/EM-40, or simply EM-40) is to ensure that the risks to the environment and human health and safety posed by inactive and surplus facilities and sites are either eliminated or reduced to prescribed, safe levels. These facilities contain radioactive and chemically hazardous contaminants as a result of previous activities conducted by DOE and its predecessor agencies. Although this goal encompasses all requirements prescribed by applicable federal, state, and local environmental statutes and regulatory requirements, it is not limited to regulatory compliance. DOE's paramount concerns are maintaining and improving human health and safety and protecting the environment.

The DOE environmental restoration program includes a bias for action to expedite actual cleanup wherever and whenever possible. Environmental restoration efforts are proceeding in two major areas: remedial action (RA) and decommissioning. These activities include cleanup of facilities and areas that supported defense-related activities (such as nuclear weapon component fabrication) and nondefense, civilian nuclear power activities (such as the development of heat sources for the space program and the operation of small test reactors).

RAs are concerned with all aspects of the assessment and cleanup of inactive sites at which releases of radioactive and chemically hazardous substances have occurred. These actions are not only limited to those areas directly impacted by the release but also include additional areas to which contaminants may have migrated (e.g., to ground water). A number of DOE installations are on the EPA National Priorities List. RAs include site discovery, preliminary assessment, and site inspection; site characterization, analysis of cleanup alternatives, and selection of remedy; cleanup and site closure; and site compliance monitoring. Although such activities may deal with storage tanks, buildings, and structures, most are concerned with contaminated environmental media such as soil, sediment, and ground water.

The principal regulatory requirements for RAs are derived from the Resource Conservation and Recovery Act

(RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Activities may be subject further to requirements associated with compliance with the National Environmental Policy Act (NEPA) and with regulatory requirements imposed by the states. Other requirements are set forth in various DOE Orders and standards and in other guidance documents.

Decommissioning activities are primarily concerned with the safekeeping of surplus nuclear facilities following shutdown and for either their ensuing decontamination for reuse or their complete dismantlement. Such tasks include surveillance and maintenance, assessment and characterization, environmental review, engineering, specific decommissioning operations, and project closeout. Most decommissioning activities are concerned with facilities such as reactors, hot cells, processing plants, storage tanks, and other structures from which, in general, few releases to the environment have occurred. Approximately 500 contaminated facilities are currently included in the EM-40 inventory for future action. The objectives of decommissioning activities are to decontaminate these facilities and to eliminate any potential hazards to public health and the environment.

Decommissioning activities are carried out under the authority of the Atomic Energy Act (AEA) and according to requirements set forth in various DOE Orders and standards and other guidance documents. In addition, the provisions of RCRA and CERCLA may apply to those facilities from which there either has been a release or there is a potential for release to the environment. State requirements also apply in certain instances. Only those decommissioning activities at facilities currently in the EM-40 program are addressed in this chapter.

Because many RA and decommissioning sites are still in the assessment phase, it is very difficult to project the volumes and types of waste that may be generated. Moreover, detailed information on the specific cleanup activities that may be applied to various contamination problems is not yet available; therefore, the quantity of resultant waste that might be generated cannot be reliably determined. In fact, the plans for many sites are not yet to a stage at which even the broad category of response that will be taken is known. For example, the decision whether

a given contaminated area, such as a waste pit, is to be excavated or stabilized in place is not typically made until after (1) the nature of the problem has been adequately defined, (2) various response alternatives and related impacts have been evaluated in considerable detail, and (3) other agencies (such as the EPA, the impacted state, and the local community) have had a chance to comment on the preferred alternative. Materials regarded as waste would be generated only if the waste pit were excavated; no waste would be generated if the pit were capped in place.

An intensive effort is currently under way to better define waste management requirements for implementing the DOE environmental restoration program. A data collection program was initiated in late 1993 to develop "cradle-to-grave" contaminated media/waste information to allow for better planning of waste treatment and disposal capacity needs.¹ The information provided by the field in response to this data call has been entered into the EM-40 Contaminated Media/Waste Database at Headquarters. This database is the source for most of the information provided in this chapter. In addition to this database, EM-40 developed additional information to meet the needs of the Baseline Environmental Management Report (BEMR) in late 1994. These two data sources are currently being consolidated and updated and represent the two major sources of information in the EM-40 Core Database.

Waste management information currently being compiled by EM-40 includes data on all waste types that may result from environmental restoration activities including radioactive, sanitary, demolition, and hazardous wastes as regulated by RCRA and the Toxic Substances Control Act (TSCA). This information will assist DOE in planning, constructing, and operating appropriate treatment, storage, and disposal facilities to manage the wastes resulting from implementation of the EM-40 program. Waste projections are currently available for only a few sites. Hence, environmental restoration waste volumes are not provided in this report. However, the volumes of contaminated solid environmental media are known at most sites, and these volumes are included in Sect. 6.3.

6.2 OFFICE OF ENVIRONMENTAL RESTORATION

Environmental restoration activities under the auspices of EM-40 are managed in a decentralized manner. That is, much of the responsibility for program implementation rests with the various Operations and project offices. These field offices have the responsibility

for determining the appropriate course of action to take at the various contaminated sites and then directing the remediation activities. The locations of the field offices responsible for directing the DOE environmental restoration program are shown in Fig. 6.1.

The Headquarters element of the EM-40 program is responsible for establishing policy and providing programmatic guidance to the field offices in implementing this program and determining appropriate priorities. In addition, Headquarters is responsible for formulating and executing the EM-40 budget. Other Headquarters responsibilities include tracking progress on environmental restoration activities and responding to information requests from Congress, other federal agencies, and public-interest groups. In addition to serving as an advocate for the EM-40 program, EM-40 Headquarters is responsible for interacting with other EM offices [such as the Office of Waste Management (EM-30), the Office of Technology Development (EM-50), and the Office of Facility Transition (EM-60)] to facilitate transfer of information.

In general, the Operations offices directing the environmental restoration program in the field are the same offices that directed activities at these sites when facilities were operational. For example, energy research and development activities at Ames Laboratory, Argonne National Laboratory, and Brookhaven National Laboratory are directed by the Chicago Operations Office. This Operations office is currently responsible for managing the environmental restoration program at these three laboratories. A listing of the field offices directing the EM-40 program and of the sites for which these offices have responsibility is given in Tables 6.1 and 6.2.

At all sites where environmental restoration activities are conducted, interim actions are used to address urgent risks and remove potential threats before the completion of detailed characterization studies. In 1994, the EM-40 program completed 119 of these actions. In 1995, DOE intends to complete another 100 interim actions, bringing the total to more than 500 since the program was initiated.²

Over half the sites in the EM-40 program are managed under the Uranium Mill Tailings Remedial Action Program (UMTRAP) and the Formerly Utilized Sites Remedial Action Program (FUSRAP). The Albuquerque Operations Office is responsible for implementing UMTRAP, which was authorized in 1978, and involves the stabilization and control of (a) 24 inactive uranium-processing sites and associated vicinity properties located in 10 states and 2 Indian tribal lands and (b) vicinity properties associated with the Edgemont, South Dakota, inactive uranium mill site, which is owned by the Tennessee Valley Authority (see Fig. 6.2). All of the sites are located in the western United States, except for one in

Canonsburg, Pennsylvania. RAs have been completed at 14 of the 24 inactive uranium processing sites. In 1995, RAs will be completed at one site, will continue at three sites, and will be initiated at four sites. RAs will be initiated at the final two sites in 1996. All surface contamination should be remediated by 1997, except for the vicinity properties at Grand Junction.²

The Oak Ridge Operations Office is responsible for implementing FUSRAP, which is primarily concerned with the cleanup of sites that were formerly used to support the activities of the Manhattan Engineer District, established for the Manhattan Project, and the Atomic Energy Commission (AEC). Private firms and institutions were contracted by the federal government in the 1940s and 1950s to develop processes and perform research on radioactive materials. The storage and processing of uranium and thorium ores, concentrates, and residues were often involved. Although these sites were cleaned up to formerly acceptable levels, FUSRAP was established in 1974 to identify, reevaluate, and, if necessary, remediate these sites. Most FUSRAP sites are in the eastern half of the country. Currently, 46 sites have been identified in 14 states; 20 of these sites have already been remediated (see Fig. 6.3). RA at the balance of the FUSRAP sites is planned to be completed by 2016.²

6.3 ENVIRONMENTAL RESTORATION WASTE CHARACTERISTICS

The volumes and types of wastes associated with DOE environmental restoration activities are a direct result of the remedy chosen. Waste associated with remediation of contaminated environmental media would occur only when such media are exhumed. For example, no waste would be produced at a site for which an in situ remedy was selected, such as capping an area containing contaminated soil. If a minimal remedial action were selected (e.g., pumping and treating a small pocket of contaminated ground water followed by construction of lateral barriers to minimize future migration), the site would have relatively small waste volumes. However, if large volumes of contaminated environmental media were removed, treated to provide a more suitable waste form for disposal, and then disposed of in an engineered facility, the site would have very large waste volumes.

Environmental restoration wastes are different from those associated with processing operations in that the former generally have much lower concentrations of radioactive and chemically hazardous substances. Much of the material requiring remediation is a consequence of past activities (e.g., spills, waste disposal, and environmental releases such as liquid discharges to

drainage basins). In addition, operations within structures resulted in the contamination of equipment, walls, and floors from routine material-handling activities and from off-normal incidents such as spills and equipment failure. Decommissioning of these facilities will result in wastes such as wipes, concrete, metal, personal protective clothing, and decontamination solvents that have generally low concentrations of radioactive and chemical contaminants.

Environmental restoration wastes also differ from those resulting from processing operations in that the former are generally highly heterogeneous both in physical form and chemical constituency. For example, remediation of an abandoned waste pit could require the exhumation of all materials previously placed into the pit for disposal. This effort could involve any possible imaginable combination of objects ranging from small pieces of equipment and drums to entire vehicles such as trucks and forklifts. In addition, a full spectrum of contaminants could be associated with these previously disposed materials including those associated with ordnance operations, processing of uranium and thorium ores and concentrates, and the operation of nuclear reactors and associated chemical processing plants. This potential variety is in contrast to waste streams associated with processing activities that have relatively consistent chemical and physical properties.

Because most DOE environmental restoration projects are in the assessment phase of the remedy-selection process, it is not possible to definitively project the wastes that will result from these projects. However, the volumes of radioactively contaminated solid media associated with the various environmental restoration sites are generally known. These volumes, which are based on historical knowledge, monitoring information, and field-characterization results, are given in Table 6.1 for radioactively contaminated soil (including sediment and sludge) and in Table 6.2 for radioactively contaminated debris such as metal, concrete, brick, wood, asphalt, plastic, and rubble. The actual waste volumes that will result from cleanup of some sites may be significantly lower than those given in these two tables, especially for those sites for which minimal RAs are selected. Such minimal activities will likely occur at major DOE installations located in remote areas of the country. In addition, decontamination of metallic items such as hot-cell liners, tanks, and processing equipment could allow for unrestricted release of these items, which would reduce the volume of material requiring disposal.

The volumes of radioactively contaminated media given in Tables 6.1 and 6.2 are limited to solid materials (i.e., contaminated liquids such as surface-water impoundments and ground water are not included). These

data are based on currently available information encompassing those projects for which characterization activities have proceeded to a point which allows for preparation of realistic volume estimates. Some projects have not yet initiated field-characterization activities, and historical records are not available in sufficient detail to allow for volume estimates to be made. The volume estimates for such sites will be larger than those shown in these two tables because not all of the potentially contaminated media would have been addressed.

Three major radioactive waste classes are associated with environmental restoration activities: LLW, TRU waste (TRUW), and 11e(2) by-product material. As defined in DOE Order 5820.2A, LLW is waste that contains radioactivity and is not classified as HLW, TRUW, spent nuclear fuel (SNF), or 11e(2) by-product material. Environmental restoration activities are not expected to generate any HLW or SNF. TRUW is waste contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and at concentrations greater than 100 nCi/g at the time of assay. As defined in Sect. 11e(2) of the AEA of 1954 (P.L. 83-703, as amended), 11e(2) by-product material is tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Materials being managed under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604) are defined as residual radioactive material distinct from 11e(2) by-product material. This residual radioactive material is largely uranium mill tailings (UMT), as well as soil and debris contaminated with UMT. Since this material has the same physical and radioactive properties as 11e(2) by-product material, it is reported in the accompanying tables with 11e(2) by-product material. In addition to radioactive contaminants, these wastes can also be contaminated with hazardous constituents as regulated by RCRA or TSCA; such wastes are considered mixed wastes. Thus, a total of six waste classes are relevant for radioactively contaminated material resulting from environmental restoration activities: LLW, mixed LLW (MLLW), TRUW, mixed TRUW (MTRUW), 11e(2) by-product material, and mixed 11e(2) by-product material.

The relative volumes of these six waste classes for contaminated soil and solid debris for environmental restoration sites are shown in Figs. 6.4 and 6.5, respectively. The two waste classes that constitute the largest volumes of radioactively contaminated soil are LLW and 11e(2) by-product material. The large volume of soil designated as LLW is mainly associated with three sites: NTS, LANL, and Hanford. Together, these three sites account for over 80% of the soil in this waste class. The actual amount of contaminated soil at these three sites

that will eventually be handled as waste is highly uncertain because remedy-selection decisions have yet to be made. The large volume of 11e(2) by-product material is mainly the result of the large volume of residual radioactive material associated with UMT being remediated under UMTRAP.

The volume of radioactively contaminated debris is a very small fraction of that associated with soil. The total volume of contaminated debris is approximately 3,800,000 m³; the total volume of contaminated soil is approximately 73,000,000 m³. Most of this debris is classified as LLW (see Fig. 6.5), which accounts for about 78% of the total volume of radioactively contaminated debris. As with the volume estimates provided for soil, the total amount of debris that will be handled as waste could be lower than that given here if a significant fraction of this debris (e.g., metallic items) can be decontaminated to allow for reuse.

Because environmental restoration information is currently in the initial stages of being compiled at a number of sites, much of the information included in Tables 6.1 and 6.2 is preliminary. In addition, these tables include information only for sites currently in the EM-40 program for which data are available. That is, zero volumes may be reported for areas of a site at which characterization activities have not been initiated, thus resulting in an underestimate of the total volume of radioactively contaminated media. Conversely, overly conservative assumptions may be incorporated into some estimates to ensure the adequate sizing of treatment and disposal facilities. These uncertainties will continue to be reduced with time as characterization and engineering studies become available to refine these volume estimates.

As described earlier, RAs are currently being conducted at a number of sites, especially those associated with the FUSRAP and UMTRAP projects. Many of these RAs are small, interim actions. Wastes resulting from these activities are generally being managed at the site where the RA occurred. However, large volumes of UMT are being relocated (consolidated) for a number of UMTRAP sites. In addition, wastes resulting from RAs at some sites (such as those being remediated under FUSRAP) are being managed at commercial disposal facilities. One such commercial facility currently being utilized is the Envirocare Facility near Clive, Utah. A summary of radioactive wastes resulting from environmental restoration activities disposed of at this facility through the end of 1994 is given in Table 6.3. More than 6,100 m³ of wastes resulting from environmental restoration activities has been disposed of at that site.

The information contained in this chapter is limited to radioactively contaminated environmental media and

wastes, consistent with the scope of this report. The volume estimates given in Tables 6.1 and 6.2 are limited to solid materials. Liquids, such as contaminated surface water and ground water and liquid wastes currently in storage, are not included. It should not be concluded that sites for which no (or minimal) volumes are given in Tables 6.1 and 6.2 have no waste management concerns. Environmental restoration activities at such sites could generate hazardous wastes as regulated by RCRA and TSCA, as well as large volumes of sanitary and demolition wastes. Also, additional characterization activities at these sites may identify areas of radioactive contamination requiring remediation in the future. As it becomes available, such information will be included in future updates of this report.

The volumes of radioactively contaminated soil and debris given in Tables 6.1 and 6.2 are limited to those sites and facilities currently in the EM-40 program. These data are summed across all elements of a site including

environmental media, wastes currently in storage, and radioactively contaminated materials that could result from future decommissioning activities. At a number of sites, wastes resulting from EM-40 RA and decommissioning activities have been transferred to the Office of Waste Management (EM-30) for treatment, storage, and disposal. These wastes are no longer being managed by EM-40 and are therefore not included in this chapter. MLLW currently in storage at EM-40 sites and that projected to result from future RA and decommissioning activities are provided in Chapter 8 of this report.

The DOE Office of Facility Transition (EM-60) is currently preparing a detailed inventory of all facilities that may eventually be transferred to the Office of Environmental Management (EM-1). As facilities are transferred to EM-1, environmental restoration and waste management information will be developed and included in future updates of this report.

6.4 REFERENCES

1. R. P. Whitfield, U.S. Department of Energy, Deputy Assistant Secretary for Environmental Restoration, Washington, D.C., letter to distribution, "Contaminated Media/Waste Data Call Guidance," dated Oct. 8, 1993.
2. U.S. Department of Energy, *Environmental Management 1995, Progress and Plans of the Environmental Management Program*, DOE/EM-0228, Washington, D.C. (February 1995).
3. Al Rafati, Director, Envirocare of Utah, Inc., correspondence to Stephen N. Storch, Integrated Data Base Program, ORNL, Oak Ridge, Tennessee, dated May 24, 1995.

LOCATIONS OF FIELD OFFICES THAT DIRECT THE DOE ENVIRONMENTAL RESTORATION PROGRAM

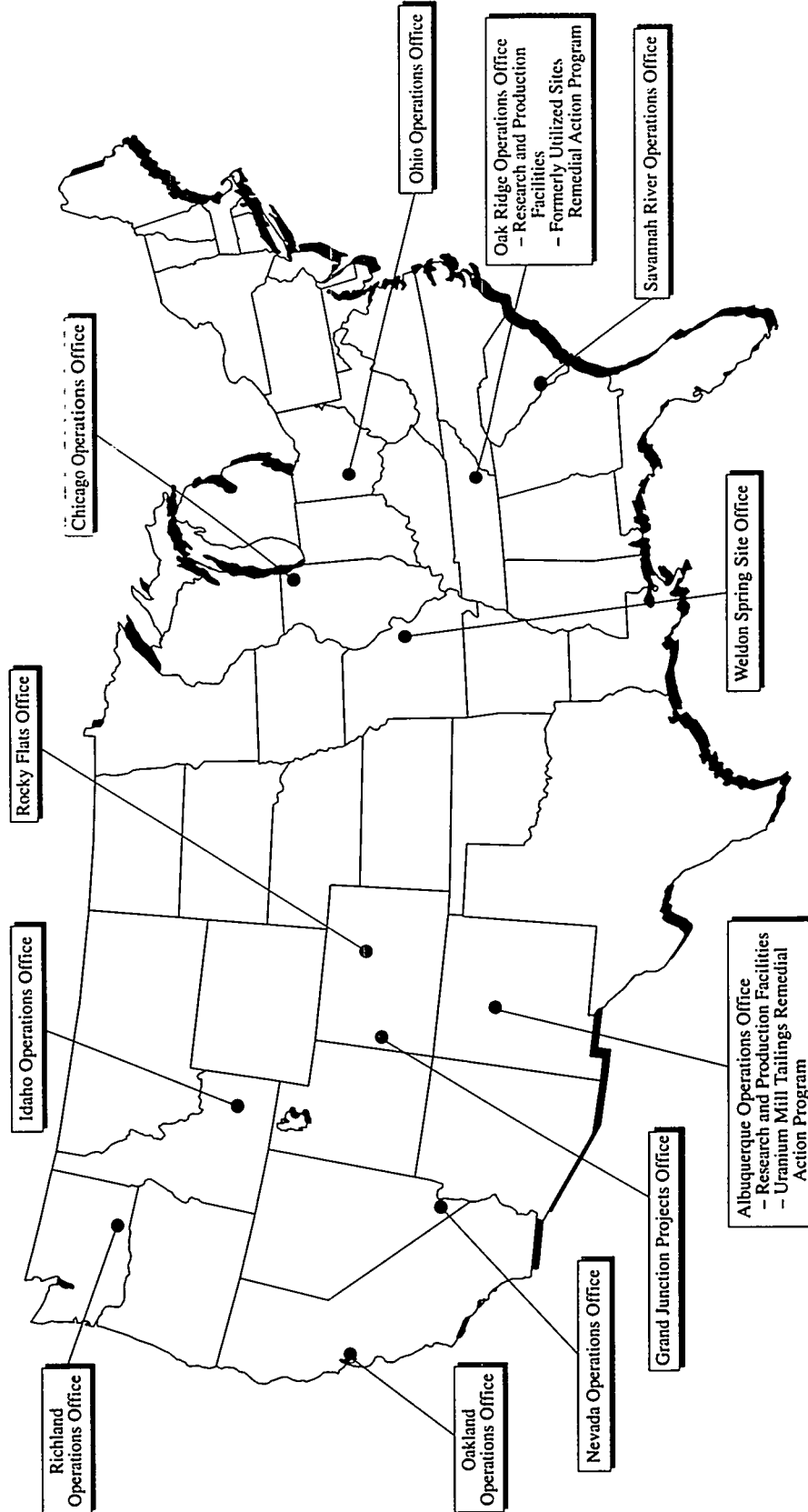


Fig. 6.1. Locations of field offices that direct the DOE environmental restoration program.

ORNL--DWG 95-1595R

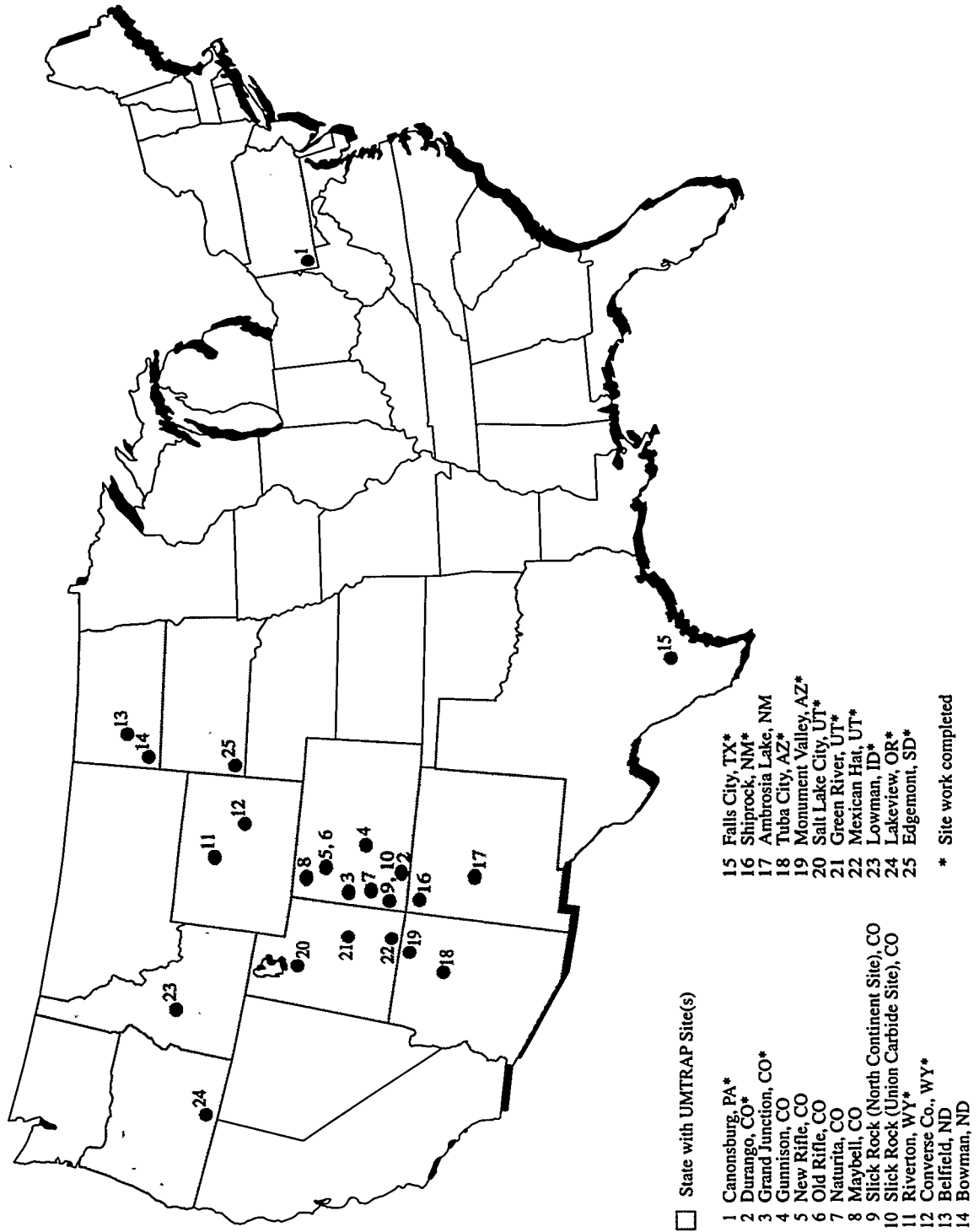


Fig. 6.2. Locations and status of UMTRAP sites.

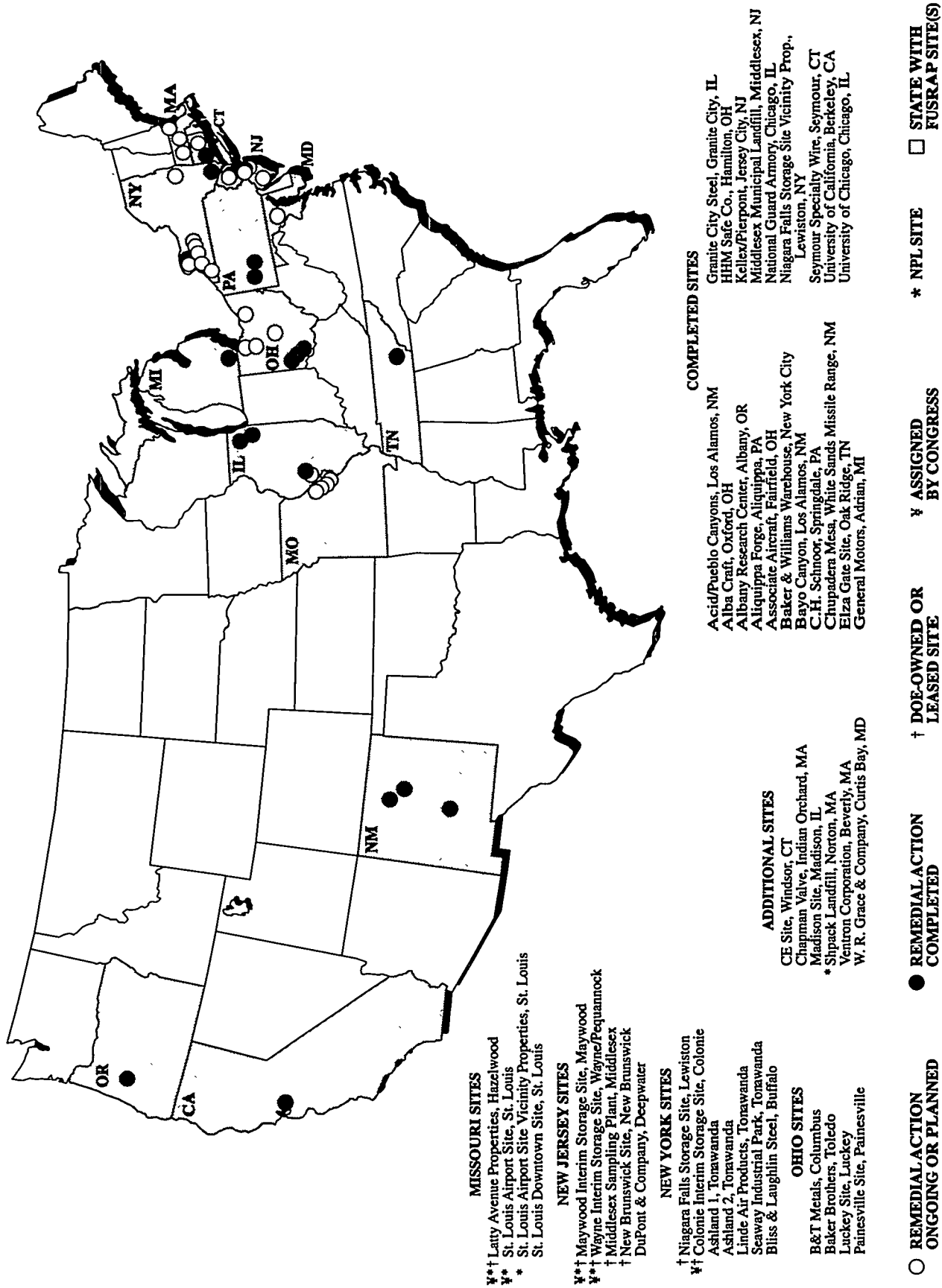


Fig. 6.3. Locations and status of FUSRAP sites.

ORNL DWG 95-8315

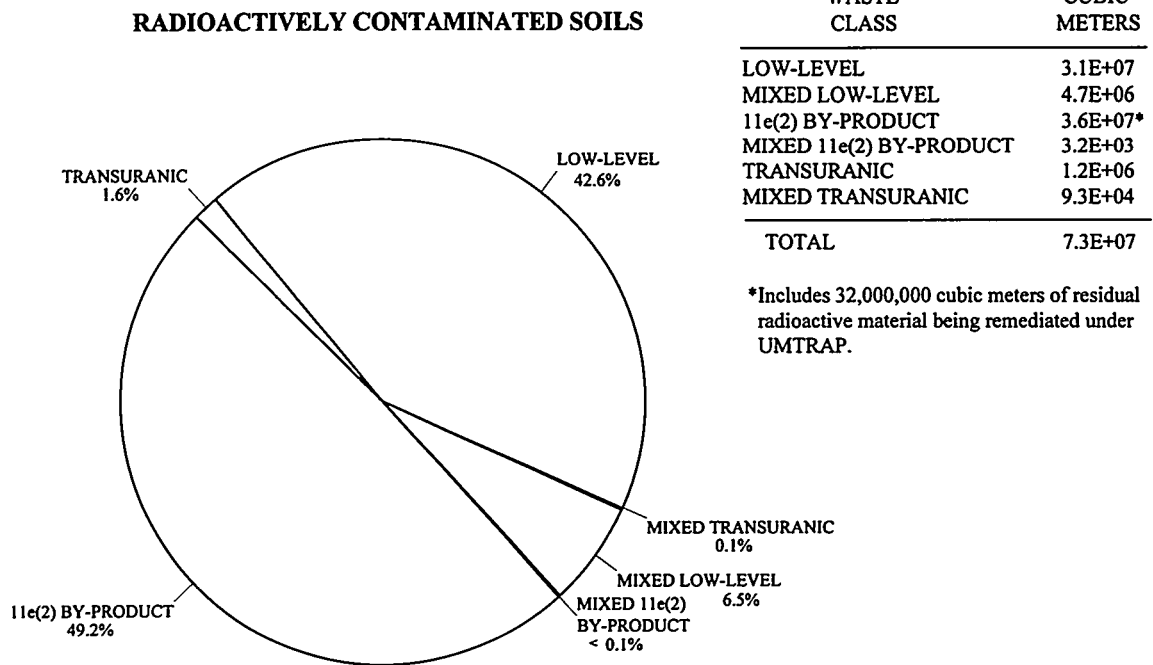


Fig. 6.4. Estimated volumes of radioactively contaminated soils associated with environmental restoration projects.

ORNL DWG 95-8316

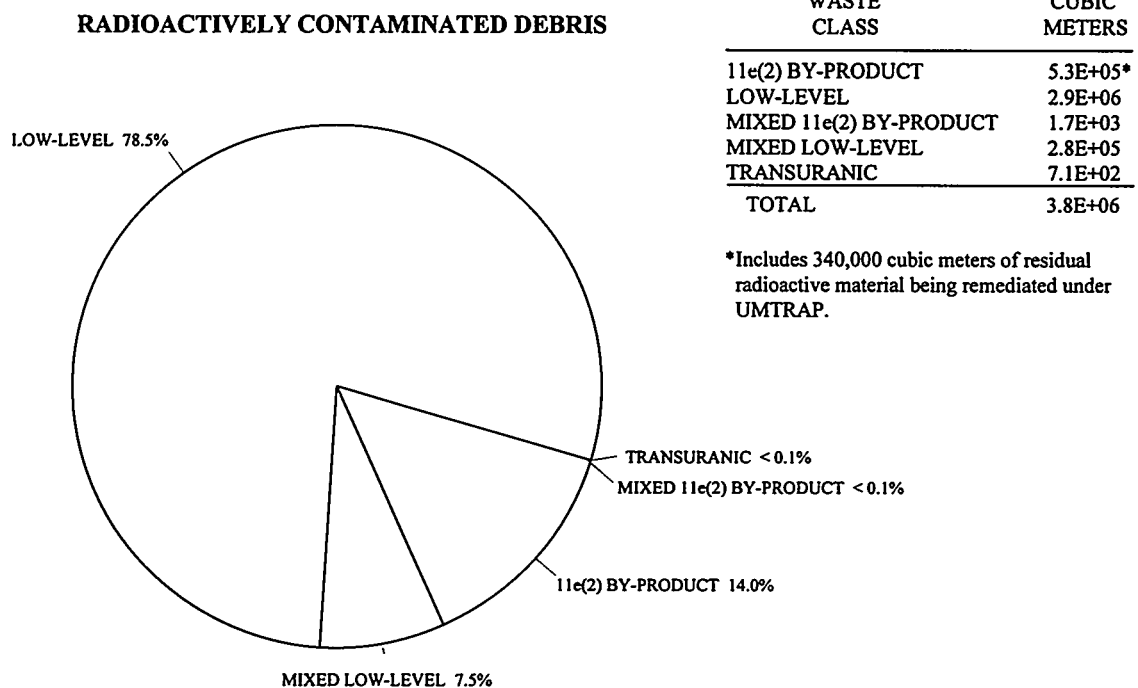


Fig. 6.5. Estimated volumes of radioactively contaminated debris associated with environmental restoration projects.

Table 6.1. Estimated volumes of radioactively contaminated soils associated with environmental restoration projects^{a,b}

Operations office	Volume, m ³				
	LLW	MLLW	11e(2) by-product ^c	Mixed 11e(2) by-product	TRUW
Albuquerque Operations Office					
Research and Production Facilities					
Inhalation Toxicology Research Institute	9,000				
Kansas City Plant					
Los Alamos National Laboratory	8,300,000	1,200,000			93,000 ^d
Pantex Plant					
Pinellas Plant					
Sandia National Laboratories/California					
Sandia National Laboratories/New Mexico	15,000	68,000			
South Valley Superfund Site					
Uranium Mill Tailings Remedial Action Program ^e			32,000,000		
Chicago Operations Office					
Ames Laboratory	1,300				
Argonne National Laboratory-East	7,700	17,000			
Argonne National Laboratory-West	1				
Battelle Columbus Laboratories	640	24			390
Brookhaven National Laboratory	20,000	3,600			
Hallam Site					
Piqua Site					
Princeton Plasma Physics Laboratory					
Separations Process Research Unit	14,000				
Site A/Plot M ^f	4,500	500			36
Grand Junction Projects Office					
Grand Junction Projects Office Site				46	
Monticello Remedial Action Project ^g			35,000		
Idaho Operations Office			2,200,000		
Idaho National Engineering Laboratory	350,000	170,000			170,000
Nevada Operations Office					
Nevada Test Site	14,000,000	460			
Nevada off-site locations ^h	9,500	21,000			
Oak Ridge Operations Office					
Research and Production Facilities					
K-25 Site	3,300	1,700			
					5,000

9,000
0
9,600,000
0
0
0
83,000
0
32,000,000
1,300
25,000
1
1,000
24,000
0
0
0
14,000
5,000
35,000
2,200,000
690,000
14,000,000
30,000
5,000

Table 6.1 (continued)

Operations office	Volume, m ³					Total
	LLW	M LLW	11e(2) by-product ^c	Mixed 11e(2) by-product	TRUW	
Oak Ridge Operations Office (continued)						
Research and Production Facilities (continued)					500	74,000
Oak Ridge National Laboratory	42,000	32,000				100,000
Oak Ridge Reservation (off-site) ⁱ	100,000					540,000
Paducah Gaseous Diffusion Plant	1,800	540,000				9,900
Portsmouth Gaseous Diffusion Plant	7,700	2,200				340,000
Y-12 Plant	960	340,000				
Formerly Utilized Sites Remedial Action Program ^j						
Missouri sites	210,000		500,000			720,000
New Jersey sites	53,000	24,000 ^k	390,000			460,000
New York sites	9,400	12,000	460,000 ^l			480,000
Other sites	91,000	7,200	28,000			130,000
Oakland Operations Office						
General Atomics Site	240	65				300
General Electric Vallecitos Nuclear Center						0
Laboratory for Energy-Related Health Research	620					620
Lawrence Berkeley Laboratory						0
Lawrence Livermore National Laboratory						0
Santa Susana Field Laboratory						0
Stanford Linear Accelerator Center						0
Ohio Operations Office						
Fernald Environmental Management Project	2,600,000	1,300	10,000			2,600,000
Mound Plant	140,000	17,000				150,000
Reactive Metals, Inc., Site	22,000	3,500				25,000
Richland Operations Office						
Hanford Site ^m	3,100,000	760,000				3,900,000
Rocky Flats Office						
Rocky Flats Environmental Technology Site	360	270,000				270,000
Savannah River Operations Office						
Savannah River Site	1,400,000	1,200,000			990,000	3,600,000

Table 6.1 (continued)

Operations office	Volume, m ³				Total
	LLW	M L L W	11e(2) by-product ^c	Mixed 11e(2) by-product	
Weldon Spring Site Office					
Weldon Spring Site Remedial Action Project			520,000	3,200	530,000
Total	31,000,000	4,700,000	36,000,000	3,200	73,000,000

^aEstimated as of December 31, 1994. Includes contaminated soil, sediment, and sludge. Blank entries mean there are no radioactively contaminated soils for the indicated waste class. Additional information on the quantity of mixed waste currently in storage as a result of environmental restoration activities is provided in Chapter 8 of this report.

^bThese volume estimates represent the quantity of in-place contaminated materials; the waste volumes resulting from environmental restoration activities may be larger or smaller depending on the selected remedy and treatment technology utilized. Waste volumes resulting from actions such as capping, monitoring, and certain in situ remedies will be quite small. All values are preliminary and are being updated as site characterization activities proceed. Values are given to two significant figures unless information was reported to only one significant figure. Some totals may not equal sum of components due to independent rounding.

^cBy-product material as defined in Sect. 11e(2) of the Atomic Energy Act of 1954 (P.L. 83-703), as amended. Materials being managed under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604) are defined as residual radioactive material. Since this material has the same physical and radioactive properties as 11e(2) by-product material, it is reported here under 11e(2) by-product material.

^dMixed TRUW.

^eA listing of the sites being addressed under UMTRAP is given in Fig. 6.2. The volume of mill tailings associated with the 14 sites for which RAs have been completed is 21,000,000 m³, leaving 11,000,000 m³ of mill tailings for which RA is currently ongoing or planned.

^fEstimate is very preliminary and includes contaminated debris.

^gIncludes contaminated debris, which will be managed in the same manner as contaminated soil.

^hConsists of Amchitka Island, Alaska; the Rio Blanco and Rulison Test sites in Colorado; the Gnome and Gasbuggy Test sites in New Mexico; the Salmon Test Site in Mississippi; and the Shoal and Central Nevada Test sites in Nevada.

ⁱIncludes contaminated areas in the vicinity of Oak Ridge, Tennessee, beyond the boundaries of the Y-12 Plant, the K-25 Site, and Oak Ridge National Laboratory.

^jA listing of the sites being addressed under FUSRAP is given in Fig. 6.3.

^kLow-level mixed waste soil currently in bulk storage at the Middlesex Site. This storage pile is covered with a tarp.

^lIncludes the 195,000 m³ of soil and residues disposed of in a containment cell at the Niagara Falls Storage Site.

^mDoes not include contaminated soil at the 200 Area of the Hanford Site, which is currently planned to be capped in place. A small percentage of the radioactively contaminated soil at the Hanford Site may be TRUW.

Table 6.2. Estimated volumes of radioactively contaminated debris associated with environmental restoration projects^{a,b}

Operations office	Volume, m ³				
	LLW	M LLW	11e(2) by-product ^c	Mixed 11e(2) by-product	TRUW
Albuquerque Operations Office					
Research and Production Facilities					
Inhalation Toxicology Research Institute	44				
Kansas City Plant					44
Los Alamos National Laboratory	9,000	1,600			0
Pantex Plant					11,000
Pinellas Plant					0
Sandia National Laboratories/California					0
Sandia National Laboratories/New Mexico	2,600	1,500			0
South Valley Superfund Site					4,100
Uranium Mill Tailings Remedial Action Program ^d			340,000		0
Chicago Operations Office					340,000
Ames Laboratory	58				58
Argonne National Laboratory—East	12,000	120,000			140,000
Argonne National Laboratory—West	150				150
Battelle Columbus Laboratories	4,200				4,200
Brookhaven National Laboratory	150	350			490
Hallam Site					0
Piqua Site					0
Princeton Plasma Physics Laboratory					0
Separations Process Research Unit					0
Site A/Plot M ^e	1,400	1.6			1,400
Grand Junction Projects Office					0
Grand Junction Projects Office Site				38	2,200
Monticello Remedial Action Project ^f			2,100		0
Idaho Operations Office					
Idaho National Engineering Laboratory	24,000	2,200			26,000
Nevada Operations Office					
Nevada Test Site	3,800	290			4,100
Nevada off-site locations ^g					0
Oak Ridge Operations Office					
Research and Production Facilities					
K-25 Site	57,000	3,800			60,000

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Table 6.2 (continued)

Operations office	Volume, m ³			
	LLW	MLLW	11e(2) by-product ^c	Mixed 11e(2) by-product
Weldon Spring Site Office				
Weldon Spring Site Remedial Action Project			150,000	1,700
Total	2,900,000	280,000	530,000	1,700
			710	3,800,000

^aEstimated as of December 31, 1994. Includes contaminated metal, concrete, brick, wood, asphalt, plastic, rubble, and other similar materials. Blank entries mean there are no radioactively contaminated debris for the indicated waste class. Additional information on the quantity of mixed waste currently in storage as a result of environmental restoration activities is provided in Chapter 8 of this report.

^bThese volume estimates represent the quantity of in-place contaminated materials; the waste volumes resulting from environmental restoration activities may be larger or smaller depending on the selected remedy and treatment technology utilized. Waste volumes resulting from actions such as capping, monitoring, and certain in situ remedies will be quite small. All values are preliminary and are being updated as site characterization activities proceed. Values are given to two significant figures unless information was reported to only one significant figure. Some totals may not equal sum of components due to independent rounding.

^cBy-product material as defined in Sect. 11e(2) of the Atomic Energy Act of 1954 (P.L. 83-703), as amended. Materials being managed under Title 1 of the Uranium Mill Tailings Radiation Control Act of 1978 (P.L. 95-604) are defined as residual radioactive material. Since this material has the same physical and radioactive properties as 11e(2) by-product material, it is reported here under 11e(2) by-product material.

^dA listing of the sites being addressed under UMTRAP is given in Fig. 6.2. The volume of debris associated with the 14 sites for which RAs have been completed is 260,000 m³, leaving 78,000 m³ of debris for which RA is currently ongoing or planned.

^eContaminated debris volume is included with the contaminated soil volume given in Table 6.1.

^fContaminated debris will be managed in the same manner as contaminated soil. The volume of debris associated with remediation of the Monticello Uranium Mill Tailings Site and vicinity properties is included with the contaminated soil volume given in Table 6.1.

^gConsists of Amchitka Island, Alaska; the Rio Blanco and Rulison Test sites in Colorado; the Gnome and Gasbuggy Test sites in New Mexico; the Salmon Test Site in Mississippi; and the Shoal and Central Nevada Test sites in Nevada.

^hIncludes contaminated areas in the vicinity of Oak Ridge, Tennessee, beyond the boundaries of the Y-12 Plant, the K-25 Site, and Oak Ridge National Laboratory.

ⁱA listing of the sites being addressed under FUSRAP is given in Fig. 6.3.

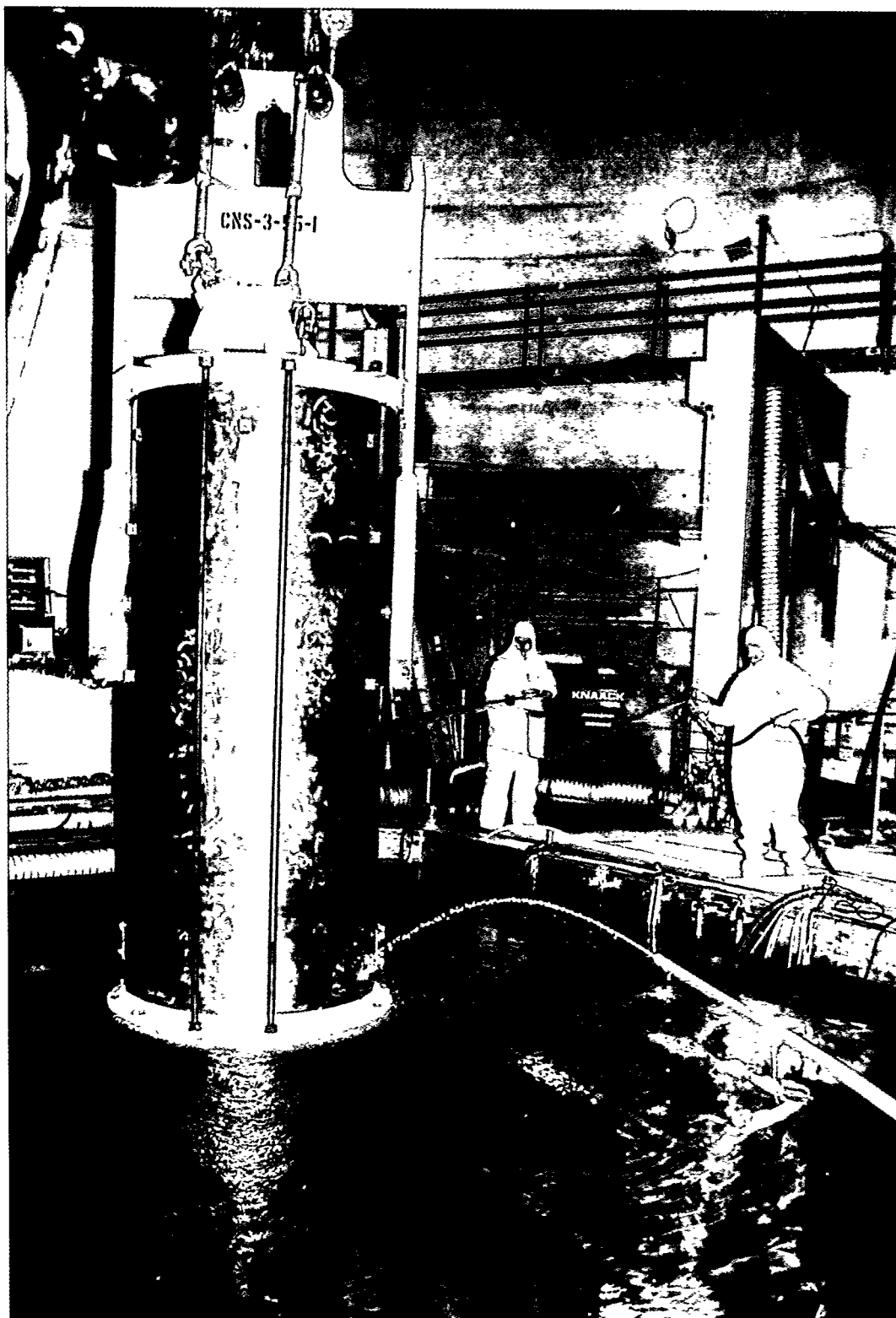
^jA small percentage of the radioactively contaminated debris at the Hanford Site may be TRUW.

Table 6.3. Summary of environmental restoration wastes disposed of at the Envirocare Facility^a

Originating site	Waste class	Volume (m ³)
Alba Craft ^b	LLW	342
Aliquippa Forge ^b	LLW	310
Baker and Williams Warehouse ^b	LLW	8
Baker Brothers ^b	LLW	582
Battelle Columbus Laboratories	LLW	28
C. H. Schnoor ^b	LLW	159
Colonie Interim Storage Site ^b	LLW	31
	MLLW	18
Fernald Environmental Management Project	MLLW	149
Granite City Steel ^b	LLW	1
Maywood Interim Storage Site ^b	11e(2) by-product	3,822
Paducah Gaseous Diffusion Plant	MLLW	4
Portsmouth Gaseous Diffusion Plant	MLLW	53
Reactive Metals, Inc., Site	MLLW	3
Santa Susana Field Laboratory	MLLW	337
Seymour Specialty Wire ^b	LLW	31
Wayne Interim Storage Site ^b	LLW	267
Total	LLW	1,759
	MLLW	564
	11e(2) by-product	3,822
Grand total		6,145

^aCumulative volume of wastes disposed of at the Envirocare Facility through December 31, 1994; most of these wastes were disposed of in 1994. Waste volumes are limited to those originating from environmental restoration activities. Information obtained from ref. 3.

^bSites being addressed under FUSRAP. A complete listing of FUSRAP sites is given in Fig. 6.3.



Handling activities of a cask containing highly radioactive internal components that were removed from the vessel of the Yankee Nuclear Power Station's pressurized-water reactor. *Courtesy of the Yankee Atomic Electric Company, Bolton, Massachusetts.*

7. COMMERCIAL DECOMMISSIONING WASTES

7.1 INTRODUCTION

At the end of their useful life, commercial nuclear facilities must be shut down and decommissioned. This chapter considers the radioactive wastes from the decontamination and decommissioning (D&D) of commercial power reactors and supporting fuel cycle facilities (viz., uranium conversion, enrichment, fuel fabrication, and fuel reprocessing). As described in ref. 1, the U.S. Nuclear Regulatory Commission (NRC) has defined the three major alternative classifications for decommissioning nuclear facilities:

- DECON— “. . . the alternative in which the equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits the property to be released for unrestricted use shortly after cessation of operations.”
- SAFSTOR— “. . . the alternative in which the nuclear facility is placed and maintained in such condition that the nuclear facility can be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use.”
- ENTOMB— “. . . the alternative in which radioactive contaminants are encased in a structurally long-lived material, such as concrete. The entombment structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level permitting the unrestricted release of property.” (This alternative would be allowable for nuclear facilities contaminated with relatively short-lived radionuclides such that all contaminants would decay to levels permissible for unrestricted use within a period on the order of 100 years.)

Table 7.1 lists the major power reactors that have undergone some mode of decommissioning to date (data from refs. 2 and 3). A comprehensive listing of all types of

domestic reactors that have been shut down or dismantled is provided in ref. 2. Those fuel cycle facilities that have been permanently shut down as of the end of 1993 are listed in Table 7.2.

Several studies have been made of the D&D of commercial LWRs and their supporting fuel cycle facilities. Most notable were those prepared and documented by Battelle Pacific Northwest Laboratory (PNL) for the NRC. These included decommissioning analyses for a reference BWR and PWR, documented in refs. 4–6 and refs. 7–9, respectively. In recent years, PNL prepared and issued draft revised decommissioning analyses for both the reference BWR (ref. 10) and reference PWR (ref. 11). These analyses include estimates of the radioactive wastes from D&D, which include low-level waste (LLW) (Class A, B, and C) and some greater-than-Class-C (GTCC) wastes.

Table 7.3 summarizes projections of radioactive wastes from decommissioning reference LWRs and their supporting fuel cycle facilities (data from refs. 10–15). Most of the waste estimates reported assume a 40-year facility operating life. In practice, operating lifetimes can vary significantly, depending on the extent to which a facility's equipment is periodically upgraded or retrofitted. Not shown in Table 7.3 are the radioactive wastes that will result from the decommissioning of research, training, and test reactors.^{16,17} However, the quantities of these wastes are not expected to be significant because such reactors are much smaller than commercial power reactors.

7.2 WASTE CHARACTERIZATION

Radioactive waste from LWR decommissioning can be grouped into three major categories:^{5,8} (1) neutron-activated wastes, (2) contaminated wastes, and (3) miscellaneous wastes.

Neutron-activated materials include the reactor vessel and its internal components (e.g., core shroud, core support assemblies, and control-rod guide tubes) and the inner portion of the biological shield. Contaminated materials include much of the piping and equipment in the

reactor containment, fuel-handling, and auxiliary control buildings. In addition, some concrete surfaces of these buildings are expected to be radioactive and will require removal. The miscellaneous radioactive waste category includes both "wet" and "dry" solids. Wet waste materials result from the processing of chemical decontamination solutions and contaminated water and include spent ion-exchange resins, cartridge filters, and evaporator and concentrator bottoms. Dry radioactive wastes include discarded contaminated items such as rags and wipes, tools, and protective clothing.

Many reactor items with surface contamination can be decontaminated,¹⁸ thereby rendering most of the material nonradioactive and producing a smaller, more concentrated volume of waste containing the radioactivity. Waste decontamination requires the appropriate technology and a defined level of radioactivity at which the contamination level is regarded as acceptable. Depending on available technology and minimum regulatory-level specification, actual quantities of wastes from reactor and fuel cycle facility decommissioning could vary significantly from projected amounts currently reported.

LWR decommissioning operations collect LLW and a small volume of high-activity wastes from the neutron activation of internal parts of the reactor core. Under NRC rules, some of these neutron activation wastes would be classified as GTCC LLW. Some GTCC wastes contain significant concentrations of ⁶⁰Co and long-lived, nontransuranic radioisotopes, such as ⁵⁹Ni, ⁶³Ni, and ⁹⁴Nb. These isotopes are produced by the long-term irradiation (neutron activation) of the stainless steel and other alloys that comprise reactor-core structural components. Because the method of waste disposal for these reactor internals is different from LLW disposal, GTCC wastes are reported separately. Under current NRC regulations,^{19,20} these wastes are considered not generally acceptable for shallow-land disposal. Such wastes must be put into a federal geologic repository unless the NRC approves an alternative disposal in a licensed site. High-activity activation wastes from the DECON decommissioning of LWRs are estimated to make up less than 1% of the total radioactive waste volume, but contain more than 95% of the radioactivity.^{5,8} Most of this radioactivity is in a single reactor component, the stainless steel core shroud that surrounds the reactor fuel.

In recent years, analyses have been made of radioactive wastes from the Shippingport Station D&D and of neutron-activated metal components (GTCC materials) from the internals of other reactors. Waste characterization assessments from studies such as refs. 21 and 22 have thus far indicated the following properties of reactor decommissioning materials:

- All reactor decommissioning materials, except the pressure vessel internals, have the potential for being disposed of as Class-A LLW.
- Fission products and TRU radionuclides are absent.
- Most radioactivity results from neutron-activated products, of which ⁶⁰Co is the principal contributor.

7.3 INVENTORIES AND PROJECTIONS

7.3.1 Commercial Power Reactors

A schedule of historical and projected commercial power LWR shutdowns, based on refs. 2 and 23, is given in Table 7.4. Projections of shutdown capacity listed are based on estimated reactor lifetimes. Actual reactor decommissioning schedules may be significantly different from those indicated in this report if any of the following are implemented:

- reactors are upgraded to extend their operating lifetimes,
- significant radioactivity decay time is allowed before D&D operations begin, or
- the last core of spent nuclear fuel (SNF) is required to remain on-site for a minimum period (possibly several years) before shipment.

Table 7.5 reports quantities of actual wastes shipped from reactor sites that either have completed or are undergoing DECON (dismantlement). Completed DECON projects include the Elk River BWR; the Pathfinder BWR; the sodium reactor experiment at Santa Susana, California; and the Shippingport Station. Specific decommissioning waste characteristics for Elk River, Santa Susana, and Shippingport are given in Tables 7.5, 7.6, and 7.8, respectively, of the IDB Rev. 9 report.²⁴ Table 7.14 of the IDB Rev. 10 report²⁵ gives quantities of disposed decommissioning wastes for the Pathfinder BWR.

Projected volumes and undecayed radioactivity levels of wastes from decommissioning alternatives considered for reference model LWRs are summarized in Table 7.6. The volume estimates given in this table reflect revisions reported by PNL in updated LWR decommissioning analyses recently performed for the NRC.¹⁰⁻¹¹ These revised estimates reflect significant reductions from the quantities previously reported in earlier PNL studies.⁴⁻⁹ The reductions are the result mainly of a large decline in the projected quantities of radioactively contaminated concrete debris resulting from DECON activities and to packaging assumptions that resulted in higher packaging densities for LLW, compared with the earlier PNL studies.

The estimated cumulative volume, decayed radioactivity, and thermal power of radioactive wastes from decommissioning commercial power LWRs shut down during the period 1995–2030 are provided in Table 7.7. These waste projections are based on the results of the PNL reference reactor studies (Table 7.6) and represent additional quantities to those previously reported in Chapter 4 for commercial LLW. This approach is taken because the timing associated with future commercial power reactor D&D activities is uncertain over the long term. Projected waste data shown in Table 7.7 are based on the projected LWR shutdown schedule given in Table 7.4 and decommissioning waste source terms developed from Table 7.6 and refs. 4–11. (The source terms are described in Appendix A.) The projections of Table 7.7 reflect a delayed DECON scenario, which assumes a 10-year period for decommissioning, beginning 6 years after reactor shutdown to allow sufficient preparation for D&D operations and cooling time for the last batch of SNF from the reactor's core. It is further assumed that the D&D wastes will be shipped to a disposal site in equal volumes during each of the 4 years that the facility will be dismantled. (For comparison, it should be noted that the period for disassembly and decontamination used in the PNL studies of refs. 10 and 11 was 1.7 years following the emptying of the SNF pool, not 4 years.)

Radioactive waste inventories and projections are being compiled for several ongoing or recently completed commercial reactor decommissioning projects. Alphabetically listed, the reactors include Dresden–Unit 1 BWR, Fort St Vrain HTGR, Humboldt Bay–Unit 3 BWR, Indian Point–Unit 1 PWR, La Crosse BWR, Rancho Seco PWR, San Onofre–Unit 1 PWR, Saxton PWR, Shoreham BWR, Three Mile Island (TMI)–Unit 2 PWR, Trojan PWR, and Yankee Rowe PWR. Major highlights of the D&D activities at each of these reactor sites follows.

A summary of projected radioactive materials from the SAFSTOR decommissioning of the Dresden–Unit 1 BWR station is given in Table 7.8 (data from ref. 26). These estimates are based on the *Dresden–Unit 1 Decommissioning Plan and Environmental Report*, which was issued by the Commonwealth Edison Company. Commonwealth Edison plans to place the Unit 1 station in a SAFSTOR condition until Dresden–Units 2 and 3 are ready for decommissioning. If an extended-life program for Units 2 and 3 is not initiated, then current utility plans call for all three Dresden units to be decommissioned and dismantled; this would begin in 2017.

Actual inventories (through 1994) of wastes from D&D activities at the Fort St. Vrain HTGR are reported in Table 7.9 (data from ref. 27). In August 1989, the 330-MW(e) Fort St. Vrain reactor was shut down to

replace an inoperable control rod. During this forced outage, stress cracking of the feed-water ring headers to the steam generators was noted. Because of the potential for very large fuel costs due to the cancellation of utility orders for other HTGRs, a decision was made to permanently cease reactor operations. The DECON option was selected as the mode of decommissioning. During 1994, most remaining core internals were removed and disposed of.²⁸ Projections of total wastes from DECON of the Fort St. Vrain reactor are reported in Table 7.10 (data from refs. 29 and 30).

Projections of wastes from decommissioning the 65-MW(e) Humboldt Bay–Unit 3 BWR are reported in Table 7.11 (data from ref. 31). Projections for the Humboldt Bay BWR include wastes from completely dismantling the reactor following a SAFSTOR period of 30 years (i.e., SAFSTOR with delayed DECON).

Table 7.12 (data from ref. 32) reports projections of wastes from the Indian Point–Unit 1 reactor. This 265-MW(e) PWR was shut down in 1974 and later placed in SAFSTOR. The projections of Table 7.12 pertain to a case of dismantlement (DECON) of the Unit 1 station upon completion of its SAFSTOR phase, which will occur when Unit 2 (PWR) is finally shut down.

The La Crosse BWR was shut down in 1987 and placed in SAFSTOR in 1991. Current plans are to dismantle the reactor after a SAFSTOR period of 30 to 50 years. Projected volumes and associated activities of annual waste shipments from this reactor during this period are given in Table 7.13 (data from ref. 33).

The 918-MW(e) Rancho Seco PWR was permanently shut down in 1989. Table 7.14 (data from ref. 34) lists projected volumes of wastes from the dismantlement of this reactor following a SAFSTOR period of about 20 years.

The San Onofre–Unit 1 PWR was shut down in 1992. Estimates of wastes from decommissioning this 436-MW(e) reactor are given in Table 7.15 (data from ref. 35). These projections are reported for a case of DECON following a SAFSTOR period of about 20 years. Dismantlement of San Onofre–Unit 1 is projected to start in 2013.

The Saxton Nuclear Experimental Reactor is a 23.5 MW(t) PWR that was placed in SAFSTOR following its shutdown in 1972. A three-phase decommissioning effort (DECON) was begun in 1986. Phase 1 consisted of the removal of groundwater from reactor support structures and was completed in 1987. Phase 2 involved the decontamination, final survey, and demolition of all structures except the containment vessel (reactor building); this phase was completed in 1992. The final phase will decommission the containment vessel and restore the site for unrestricted use. This phase is scheduled to be

completed in 2000. A summary of projected waste volumes from Saxton decommissioning is provided in Table 7.16 (data from ref. 36).

The 820-MW(e) Shoreham BWR underwent low-power tests until 1989, when the plant's owner, Long Island Lighting Company, agreed to sell the plant to the state of New York for decommissioning. A decommissioning plan³⁷ for the Shoreham plant was approved by the NRC in 1992.³⁸ That same year prompt decontamination and dismantling (DECON) of the Shoreham BWR began, and these activities were completed in 1994. Inventories of wastes from the Shoreham BWR decommissioning are reported in Table 7.17 (data from ref. 39).

Inventories of wastes shipped from the TMI-Unit 2 PWR are summarized in Table 7.18 (data from ref. 40). Removal of core debris from the damaged reactor was begun in January 1986 and completed in April 1990. This resulted in a shipment of 155.9 t of core debris to INEL for R&D testing and storage. TMI-Unit 2 is currently in the Post Defueling Monitored Storage (PDMS) mode after completing preparation activities in December 1993. Criteria for initiating and implementing the PDMS phase were approved through an NRC review of a licensing change request.⁴⁰

Table 7.19 gives projected classification and volumes of radioactive wastes from Trojan PWR decommissioning activities (data from ref. 41). Following its permanent shutdown in January 1993, the Trojan reactor was placed in a short SAFSTOR condition prior to DECON. The projections of Table 7.19 pertain to wastes from both the SAFSTOR and DECON phases of decommissioning. The Large Component Removal Project is currently in progress. As part of this project, concrete blocks were recently removed from the reactor's containment building to form an opening for the future removal of four steam generators and a pressurizer. The current Trojan PWR decommissioning plan includes the removal of these large components and their shipment by barge to the commercial Richland site for disposal. Decontamination and dismantlement of the radioactive contaminated portions of the plant are currently scheduled to be completed by 2001.⁴¹

The 167-MW(e) Yankee Rowe PWR was shut down in 1992, and projections of wastes from its decommissioning are reported in Table 7.19 (data from ref. 42). These projections are reported for two major periods of project decommissioning: component removal (1993–1994), which includes removal of the reactor vessel internal components and steam generator; and final decommissioning (1995–1997, 1999), which includes the remainder of the reactor's components and general plant inventories. Quantities reported for the Component

Removal Project consist of waste disposed prior to the closure of the Barnwell disposal site to Massachusetts LLW generators in 1994. Recently, the final decommissioning project began after the Barnwell facility was reopened to Massachusetts generators in July 1995. Final decommissioning of the Yankee Rowe PWR is expected to be completed in two phases, the first during 1995–1997 and the second in 1999.⁴²

Currently, the total impact of wastes from D&D activities at commercial reactor sites has been small. However, as the projected schedule of Table 7.4 suggests, the impact will become more significant after the year 2000, when more of the older reactors complete their campaign of operation.

7.3.2 Supporting Fuel Cycle Facilities

Table 7.2 lists major facilities that once provided UF₆ conversion, enrichment, fuel fabrication, and fuel reprocessing services for the commercial nuclear fuel cycle. Details of the radioactive waste inventories and projections associated with decommissioning each of these facilities are given below.

Inventories and projections of wastes from decommissioning activities at the Cimarron (Oklahoma) Fuel Fabrication Facility are provided in Table 7.20 (data from ref. 43). Decontamination work at this fabrication plant is scheduled to be completed during 1995. Shut down since 1975, this facility is comprised of two former fabrication plants, one for uranium fuel and one for mixed-oxide fuel.

Table 7.21 (data from ref. 44) presents a summary of the waste inventories and projections from activities at the West Valley Demonstration Project (WVDP), formerly a commercial fuel reprocessing facility. Since startup of this project in 1982, more than 70% of the cell surface areas of the original process building have been decontaminated and released for project reuse.

7.3.3 Noncommercial Facilities

Significant quantities of radioactive wastes have and will also be produced from decommissioning noncommercial facilities. These include wastes from D&D activities performed at various DOE installations, discussed in Chapter 6, and submarine power reactor D&D activities performed for the U.S. Department of Defense. During a period spanning 20 to 30 years, about 100 nuclear-powered submarines of the U.S. Navy may be removed from service and consigned to permanent disposal after removal of the SNF. Current plans are to dispose of the submarine reactor compartments by land burial at the Hanford Site. Each reactor compartment

contains about 1000 t of metal, and it is estimated that about 4 ha (10 acres) will be required to bury 100 reactor compartments.⁴⁵ At the end of 1994, 78 submarines and 4 cruisers had been taken out of active service. In 43 of the submarines, the reactor compartment was first

defueled, then later removed, and disposed of at Hanford. (LLW disposed from these activities is included in the DOE site inventories reported in Chapter 4.) The remaining 39 ships with reactor compartments were being held in protective storage.²

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Table 7.1. List of U.S. civilian reactors shut down or dismantled as of December 31, 1994^a

Reactor facility	Location	Reactor type	Capacity rating		Year of permanent shutdown	Decommissioning alternative selected	Present status of decommissioning alternative
			MW(e)	MW(th)			
Boiling Nuclear Superheater Power Station (BONUS)	Punta Higuera, PR	Boiling-water	37	50	1968	ENTOMB	ENTOMB
Carolinas-Virginia Tube Reactor (CVTR)	Parr, SC	Pressure-tube, heavy-water	17	64	1967	SAFSTOR	SAFSTOR
Dresden Nuclear Power Station—Unit 1	Morris, IL	Boiling-water	200	700	1978	SAFSTOR	SAFSTOR preparation ^b
Elk River Power Station	Elk River, MN	Boiling-water	22	58	1968	DECON	DECON completed ^c
Enrico Fermi—Unit 1	Lagoona Beach, MI	Sodium-cooled, fast	61	200	1972	SAFSTOR	SAFSTOR
ESADA/GE Vallecitos Experimental Superheat Reactor (Empire States Atomic Development Associates and General Electric Company)	Pleasanton, CA	Light-water, moderated	NE ^d	17	1967	SAFSTOR	SAFSTOR
Fort St. Vrain Reactor	Platteville, CO	High-temperature, gas-cooled	330	842	1989	DECON	DECON in progress ^e
General Electric Testing Reactor	Pleasanton, CA	Tank	NE	50	1977	SAFSTOR	SAFSTOR
Hallam Nuclear Power Facility	Hallam, NE	Sodium-cooled, graphite-moderated	75	240	1964	ENTOMB	ENTOMB
Humboldt Bay Power Plant—Unit 3	Eureka, CA	Boiling-water	65	242	1976	SAFSTOR	SAFSTOR ^f
Indian Point Station—Unit 1	Buchanan, NY	Pressurized-water	265	615	1974	SAFSTOR ^g	SAFSTOR

Table 7.1 (continued)

Reactor facility	Location	Reactor type	Capacity rating		Year of permanent shutdown	Decommissioning alternative selected	Present status of decommissioning alternative
			MW(e)	MW(th)			
La Crosse Nuclear Generating Station	Genoa, WI	Boiling-water	48	165	1987	SAFSTOR	SAFSTOR ^h
Pathfinder Atomic Plant	Sioux Falls, SD	Boiling-water	66	192	1967	DECON	DECON ⁱ
Peach Bottom Power Station—Unit 1	Peach Bottom, PA	High-temperature, gas-cooled	40	115	1974	SAFSTOR	SAFSTOR
Piqua Nuclear Power Facility	Piqua, OH	Organic-cooled and moderated	11	46	1966	ENTOMB	ENTOMB
Plum Brook Reactor	Sandusky, OH	Tank	NE	60	1974	SAFSTOR	SAFSTOR
Rancho Seco	Clay Station, CA	Pressurized-water	918	2,915	1989	SAFSTOR	SAFSTOR preparation ^j
San Onofre—Unit 1	San Clemente, CA	Pressurized-water	436	1,347	1992	SAFSTOR	SAFSTOR preparation ^k
Saxton Nuclear Experimental Reactor Project	Saxton, PA	Pressurized-water	3	24	1972	SAFSTOR	DECON in progress ^l
Shippingport Power Station	Shippingport, PA	Pressurized-water	72	236	1982	DECON	DECON completed ^m
Shoreham Reactor	Brookhaven, NY	Boiling-water	820	2,436	1989	DECON	DECON completed ⁿ
Sodium Reactor Experiment	Santa Susana, CA	Sodium-cooled, graphite-moderated	10	30	1964	DECON	DECON completed ^o
Southwest Experimental Fast Oxide Reactor (SEFOR)	Strickler, AR	Sodium-cooled, fast	NE	20	1972	SAFSTOR	SAFSTOR
Three Mile Island—Unit 2 Reactor	Londonderry Township, PA	Pressurized-water	926	2,770	1979	p	p
Trojan—Unit 1 ^q	Rainier, OR	Pressurized-water	1,130	3,411	1992	DECON	DECON

Table 7.1 (continued)

Reactor facility	Location	Reactor type	Capacity rating		Year of permanent shutdown	Decommissioning alternative selected	Present status of decommissioning alternative
			MW(e)	MW(th)			
Vallecitos Boiling-Water Reactor (VBWR)	Pleasanton, CA	Boiling-water	5	33	1963	SAFSTOR	SAFSTOR
Westinghouse Testing Reactor (WTR)	Waltz Mill, PA	Tank	NE	60	1962	SAFSTOR	SAFSTOR
Yankee Rowe-Unit 1 ^f	Rowe, MA	Pressurized-water	167	600	1991	SAFSTOR	SAFSTOR preparation

^aAdapted from refs. 2 and 3.

^bEstimates of decommissioning wastes are reported in Table 7.8.

^cDecommissioning wastes are reported in Table 7.5 of a previous edition of this report (DOE/RW-0006, Rev. 9).

^dNE = no electricity generated by reactor before it was shut down.

^eEstimates of decommissioning wastes are reported in Table 7.10. Actual inventories recovered are reported in Table 7.9.

^fEstimates of decommissioning wastes are reported in Table 7.11.

^gEstimates of decommissioning wastes are reported in Table 7.12.

^hEstimates of decommissioning wastes are reported in Table 7.13.

ⁱEstimates of decommissioning wastes are reported in Table 7.14 of a previous edition of this report (DOE/RW-0006, Rev. 10).

^jDecommissioning wastes are reported in Table 7.14.

^kDecommissioning wastes are reported in Table 7.15.

^lDECON of the Saxton facility started in 1986. Estimates of decommissioning wastes are given in Table 7.16.

^mDecommissioning wastes are reported in Table 7.8 of a previous edition of this report (DOE/RW-0006, Rev. 9).

ⁿDECON of the Shoreham plant started in 1992. Estimates of decommissioning wastes are reported in Table 7.17.

^oDecommissioning wastes are reported in Table 7.6 of a previous edition of this report (DOE/RW-0006, Rev. 9).

^pTMI-Unit 2 has completed defueling and decontamination in selected areas. The plant will be placed in a long-term monitored storage mode and will be decommissioned when TMI-Unit 1 is dismantled. Inventories of decontamination wastes are reported in Table 7.18.

^qDecommissioning wastes are reported in Table 7.19.

^rDecommissioning wastes are reported in Table 7.20.

Table 7.2. List of U.S. nuclear fuel cycle facilities shut down or being decommissioned as of December 31, 1994^a

Facility	Type of installation	Location	Rated capacity	Period of operation	Decommissioning objectives or status
Sequoyah Fuels Corporation Plant	Nuclear fuel conversion plant	Gore, OK	9,090 MTU/year	1970–1993	Complete dismantlement by 2002–2004
Oak Ridge Gaseous Diffusion Plant (K-25 Site)	Uranium enrichment plant	Oak Ridge, TN	7,700 t SWU/year	1945–1985	TBD ^b
Cimarron Fuel Fabrication Facility	Nuclear fuel fabrication plant ^c	Crescent, OK	300 MTU/year	1965–1975	Anticipated completion in 1995
West Valley Demonstration Project	Nuclear fuel reprocessing plant	West Valley, NY	300 MTHM/year	1966–1972	Proceeding ^d

^aExcludes uranium mining and milling facilities being decommissioned. These are indicated in Table 5.2 of Chapter 5.

^bTBD = to be determined.

^cThis facility was comprised of a uranium fuel fabrication plant and a mixed-oxide fuel fabrication plant. The uranium fuel fabrication plant operated from 1965 to 1975 and had a rated capacity of 300 MTU/year. The mixed-oxide fuel fabrication plant operated from 1969 to 1975 and had a rated plutonium product (PuO₂) capacity of 0.5 t/year.

^dMore than 70% of the cell surface areas of the original process building have been decontaminated and released for project reuse.

Table 7.3. Projections of radioactive wastes from decommissioning reference commercial power reactors and fuel cycle facilities^a

Fuel cycle facility	Capacity	Operation		Decommissioning alternative	Waste volume, m ³	
		Period	Lifetime (years)		LLW ^b	GTCC ^c
Boiling-water reactor	1,155 MW(e)		40 ^d	DECON	14,275	7
Pressurized-water reactor	1,175 MW(e)		40 ^d	DECON	6,981	11
Uranium conversion plant (solvent extraction process)	10,000 MTTHM/year		40	DECON	1,260	0
Uranium enrichment plants (gaseous diffusion plants)						
• K-25 site	7,700,000 kg SWU/year	1945–1985	40	DECON	212,466 ^e	0
• Paducah site	11,300,000 kg SWU/year	1954–2005	51	DECON	662,414	0
• Portsmouth site	8,300,000 kg SWU/year	1956–2005	49	DECON	630,093	0
Fuel fabrication plant	1,000 MTTHM/year		40	DECON	1,090	0

^aBased on information reported in refs. 10–15.^bClass-A, Class-B, and Class-C LLW.^cGreater-than-Class-C LLW.^dReactor operations assume a 75%-capacity factor.^eIncludes some liquids (1,849 m³), but mostly solids (mainly in the form of metal equipment and scrap, roofing and construction debris, sludge, and other materials).

Table 7.4. Schedule of actual and projected final shutdown dates for commercial light-water reactors^{a,b}

Calendar year of shutdown	BWR		PWR		Total LWR	
	No.	MW(e)	No.	MW(e)	No.	MW(e)
1963	1	5			1	5
1967	1	66	1	17	2	83
1968	2	39			2	39
1972			1	3	1	3
1974			1	265	1	265
1976	1	65			1	65
1978	1	200			1	200
1979			1	926 ^c	1	926
1982			1	72	1	72
1987	1	48	1	48		
1989	1	820	1	918	2	1,738
1991			1	167	1	167
1992			2	1,566	2	1,566
1994	0	0	0	0	0	0
Actual totals through 1994	8	1,243	9	3,934	17	5,177
2000	1	67			1	67
2007			2	1,226	2	1,226
2008	3	2,691	1	870	4	3,561
2009	1	610	1	470	2	1,080
2010	3	1,952	2	1,175	5	3,127
2011			1	755	1	755
2012	2	1,161	1	781	3	1,942
2013	4	3,376	11	8,728	15	12,104
2014	7	5,498	6	4,689	13	10,187
2015			2	1,853	2	1,853
2016	2	1,832	6	5,231	8	7,063
2017			2	1,875	2	1,875
2018	1	761	2	1,756	3	2,517
2020			3	3,104	3	3,104
2021			4	4,133	4	4,133
2022	2	2,183			2	2,183
2023	1	1,100	2	1,968	3	3,068
2024	4	4,195	3	3,470	7	7,665
2025	2	2,016	6	6,877	8	8,893
2026	4	4,175	2	1,989	6	6,164
2027			5	5,626	5	5,626
2028			3	3,421	3	3,421
2029	1	1,055	1	1,162	2	2,217
2030			3	3,465	3	3,465
Projected totals (1995–2030)	38	32,672	69	64,624	107	97,296

^aData from refs. 2 and 23. Historical data (prior to 1995) are based on ref. 2. Projected shutdown dates are based on utility-projected dates for reactor retirement reported in Table 4 of ref. 23.

^bYears in which no reactor shutdown is expected are eliminated.

^cShutdown of Three Mile Island–Unit 2 nuclear power plant due to an accident. Upon completion of the present cleanup campaign, the plant will be placed in a monitored storage mode and will be decommissioned when TMI–Unit 1 is dismantled.

Table 7.5. Quantities of shipped LLW from completed and ongoing reactor decommissioning projects^a

Reactor	Type ^b	Rated capacity [MW(e)]	Year of permanent shutdown	Lifetime electrical generation [MW(e)-years]	Volume of LLW shipped (m ³)
Elk River	BWR	22	1968	58	3,377
Fort St. Vrain ^c	HTGR	330	1989	490	1,914
La Crosse	BWR	48	1987	462	75
Pathfinder	BWR	66	1967	16	562 ^d
Santa Susana	SCGM	10	1964	4	3,863
Saxton	PWR	3	1972	10	1,590
Shippingport	PWR	72	1982	842	6,056
Three Mile Island—Unit 2 ^c	PWR	926	1979	232	9,216
Yankee Rowe	PWR	167	1992	4,030	503
Total		1,644		6,144	27,156

^aInformation as of December 31, 1994, unless indicated otherwise.

^bAbbreviations used: BWR—boiling-water reactor; HTGR—high-temperature, gas-cooled reactor; SCGM—sodium-cooled, graphite-moderated reactor; and PWR—pressurized water reactor.

^cDECON for this reactor is still in progress.

^dVolume of LLW disposed was 303 m³.

Table 7.6. Revised estimates of disposal volumes for radioactive wastes from decommissioning alternatives considered for reference LWRs^{a,b}

Decommissioning alternative ^c	Post-shutdown period ^d (years)	Estimated disposal volume, m ³				
		Total	Class-A LLW	Class-B LLW	Class-C LLW	GTCC LLW ^e
<i>Reference boiling-water reactor [1155 MW(e)]</i>						
DECON	6.3	14,282	13,903	332	40	7
SAFSTOR 1	60	1,117	738	332	40	7
SAFSTOR 2	60	14,282	13,903	332	40	7
ENTOMB 1	60	490	483	0	0	7
ENTOMB 2	60	1,139	760	332	40	7
ENTOMB 3	300	490	483	0	0	7
<i>Reference pressurized-water reactor [1175 MW(e)]</i>						
DECON	8.6	6,992	6,797	154	30	11
SAFSTOR 1	60	763	568	154	30	11
SAFSTOR 2	60	6,992	6,797	154	30	11
ENTOMB 1	60	305	294	0	0	11
ENTOMB 2	60	754	559	154	30	11
ENTOMB 3	300	305	294	0	0	11

^aAdapted from refs. 10 and 11. Before final shutdown, each reactor is assumed to have operated for 40 years with a capacity factor of 0.75.

^bThe classifications listed for LLW are based on the limiting concentrations of long- and short-lived radionuclides given in Tables 1 and 2 of 10 CFR Part 61.55.

^cAs indicated in refs. 10 and 11, the decommissioning alternatives listed have the following major features:

DECON—assumes a period of plant safe storage until the SNF inventory has sufficiently decayed and been completely removed. This is followed by dismantlement of the radioactive portions of the plant; SAFSTOR 1—assumes extended safe storage (<60 years) without any fuel in the reactor storage pool, followed by decontamination and dismantlement of the radioactive portions of the plant and that only the reactor pressure vessel and BWR sacrificial shield or PWR bioshield require disposal as LLW; SAFSTOR 2—same as SAFSTOR 1 except that all radioactive materials are assumed to still exceed unrestricted release levels. No volume reduction from DECON results; ENTOMB 1—assumes no removal of reactor pressure vessel and BWR sacrificial shield or PWR bioshield as these will decay to unrestricted levels; ENTOMB 2—assumes removal of reactor pressure vessel and BWR sacrificial shield or PWR bioshield is required during preparations for entombment to assure license termination within 60 years after final shutdown; and ENTOMB 3—allows for 300 years of radioactive decay after which the reactor pressure vessel and BWR sacrificial shield or PWR bioshield will have decayed to unrestricted release levels.

^dCovers the period of time starting from final reactor shutdown to the completion of plant decommissioning activities.

^eRevised estimates of quantities of GTCC wastes from LWR decommissioning were also developed by Lockheed Idaho Technologies Company (now called Lockheed Martin Idaho Technologies) and are reported in ref. 22. A summary of all GTCC waste estimates reported in ref. 22 is given in Chapter 4.

Table 7.7. Projections of cumulative volume, radioactivity, and thermal power of wastes from decommissioning commercial light-water reactors shut down during 1995–2030^{a,b,c}

Waste type	Volume (m ³)	Activity (Ci)	Thermal power (W)
<i>Boiling-water reactors</i>			
Class-A LLW	393,278	35,559	209
Class-B LLW	9,392	111,078	653
Class-C LLW	1,132	299,754	985
Subtotals	403,802	446,391	1,847
Greater-than-Class-C LLW ^d	194	16,760,009	80,974
Totals for D&D of BWRs	403,996	17,206,400	82,821
<i>Pressurized-water reactors</i>			
Class-A LLW	373,830	132,374	700
Class-B LLW	8,469	162,713	1,473
Class-C LLW	1,650	159,331	1,058
Subtotals	383,949	454,418	3,231
Greater-than-Class-C LLW ^d	605	24,628,168	120,375
Totals for D&D of PWRs	384,554	25,082,586	123,606
<i>Total light-water reactors</i>			
Total LLW	787,751	900,809	5,078
Greater-than-Class-C LLW	799	41,388,177	201,349
Totals for D&D of LWRs	788,550	42,288,986	206,427

^aThe projections in this table are based on a decommissioning scenario (delayed DECON) that spans a total period of 10 years following final reactor shutdown. This scenario assumes an initial 6-year period is needed for spent nuclear fuel from the reactor's last core to sufficiently cool to permit its transfer either to DOE or to a dry on-site storage facility. Active dismantlement of the reactor is assumed to begin following the completion of fuel removal and to take 4 additional years, with radioactive wastes being collected equally over each of the 4 years. In terms of numerical significance, the number of digits used to report these projections are greater than justified. However, this procedure is used for bookkeeping purposes to ensure consistency in the numerical totals reported. Since these projections are based on the reactor shutdown dates reported in ref. 23 and the source terms developed from refs. 4–11 (see Appendix C), each reported number is significant to no more than three figures.

^bThis table refers only to reactors yet to be decommissioned. Historical reactor D&D wastes are included in the institutional/industrial (I/I) waste inventories reported in Chapter 4.

^cThe projections reported for volume, activity, and thermal power are the cumulative levels of wastes from reactor D&D activities (delayed DECON) during the period 1994–2040. For the scenario described in footnote a, the year 2040 is the last year in which wastes are collected from reactors shut down in the year 2030.

^dIncludes contributions from core shroud and other internal core components.

Table 7.8. Projected characteristics of radioactive wastes from Dresden–Unit 1 decommissioning activities^{a,b,c}

Waste category	Reactor component(s)	Volume (m ³)
Radioactive materials	Reactor vessel and internals: ^d	
	Reactor vessel	11
	Bioshield sand and concrete	239
	Thermal shield	2
	Instrumentation support tubes	1
	Bottom core support structure	1
	Other ^e	5
	Subtotal	259
	Solidified decontamination solvents	655
	Reactor station components and materials ^f	6,214
	Total	7,128
Radioactive hazardous materials	Asbestos insulation on contaminated piping and components	409
	Grand total	7,537

^aBased on ref. 26.

^bThe 200-MW(e) Dresden BWR began operation in 1960 and generated about 1,800 MW(e)-years of (gross) electrical energy before it was shut down in 1978. The projections of this table pertain to wastes from the dismantlement of the reactor following a SAFSTOR period of about 30 years.

^cThese projections do not include 32 m³ of LLW from SAFSTOR preparation activities (e.g., materials from cleaning spent fuel pool surfaces, miscellaneous sumps, and other contaminated areas; filters from chemical cleaning system; and miscellaneous dry active trash).

^dThe greatest source of radioactivity in the Dresden containment building is in the reactor vessel and internals. This activity results from neutron activation products in the vessel and shield materials. When the reactor was shut down in 1978, the estimated activity for the vessel and internals was 4,029,000 Ci. By the year 2017, when dismantling of the reactor is to begin, this activity is projected to drop to a level of about 16,000 Ci.

^eOther reactor internal components include steam deflector support, top grid assembly, bottom support grid, control rod guide tubes, and reactor vessel cladding.

^fReactor station components and materials include piping, valves, pumps, heat exchangers, building concrete, and structural steel.

Table 7.9. Actual radioactive waste disposal from the decommissioning of the Fort St. Vrain HTGR^{a,b}

Year	Irradiated hardware			Dry active waste		
	No. of shipments	Volume ^c (m ³)	Activity (Ci)	No. of shipments	Volume ^c (m ³)	Activity (Ci)
1991	6	29.1	8,083.80	20	13.3	1.81
1992 ^d	64	365.8	32,678.49	6	13.4	7.88
1993	113	981.9	26,385.91	7	115.1	8.54
1994 ^e	55	238.7	3,842.47	14	156.4	15.28
Total	238	1,615.5	70,990.67	47	298.2	33.51

^aBased on ref. 27. Includes shipments made by Public Service Company of Colorado and decommissioning contractor and waste processors subsequent to volume reduction.

^bTracking of volume by individual components and/or system is not performed because of mixing of components from various waste streams, void spaces, etc.

^cActual disposal volume which therefore includes void space, filler volume, package volume, etc.

^dNRC Decommissioning Order for Fort St. Vrain became effective on December 8, 1992. Before that date, decommissioning activities were considered to be early dismantlement.

^eQuantities reported for this year have been prorated because irradiated hardware and dry active wastes were shipped together during this time. Resins are assumed to be a dry active waste.

**Table 7.10. Projected characteristics of wastes from DECON
(dismantling) of the Fort St. Vrain HTGR^{a,b}**

Reactor component(s)/waste	Burial volume (m ³)	Activity (Ci)	Projected LLW class
<i>Prestressed concrete reactor vessel (PCR/V) system</i>			
PCR/V concrete	1,174.94	c	A
Control rod drives (CRDs)	97.81	c	A
CRD absorber strings	18.81	c	C
CRD metal clad reflector	4.04	c	C
Boronated stainless steel rods	845.27	c	B
Top cover plates	1.59	c	A
Top head kaowool ^d and liner	13.32	c	A
Core barrel	21.97	c	A
Core support blocks	41.09	c	A
Core support floor kaowool, plates, and liner	6.94	c	A
Metal clad reflector blocks (non-CRD)	28.67	c	C
Dummy fuel blocks	168.28	c	A
Graphite reflector blocks	237.65	c	A, B
Silica insulation blocks	14.27	c	A
Large permeable reflectors	709.32	c	B
Reflector keys	0.57	c	A
Metal shell for large side reflector	0.58	c	A
Radial cover plate, kaowool, and PCR/V liner	55.57	c	A
Region constraint devices	1.42	c	C
Helium purification and regeneration system	30.87	c	A
Helium circulators	4.01	c	A
Steam generators	269.02	c	A, B
PCR/V system total	3,746.01	1.30E+6	
<i>Material handling, treatment, and storage (MHTS) systems</i>			
Fuel handling machine	63.33	c	A
Fuel storage wells	28.48	c	A
Equipment storage wells	2.98	c	A
Auxiliary transfer cask	19.52	c	A
Hot service facility	10.98	c	A
MHTS systems total	125.29	3.88E-2	
<i>Decontamination and waste (DW) systems</i>			
Decontamination	9.57	c	A
Radioactive liquid waste	9.15	c	A
Radioactive gas waste	32.93	c	A
Dry activated and other wastes	153.34	c	A
DW total	204.99	1.33E-4	
Fort St. Vrain HTGR total	4,076.29	1.30E+6	

^aBased on refs. 29 and 30. This table represents the projected radioactive waste disposal volume for the entire DECON project (projected completion in early 1996).

^bThe 330-MW(e) Fort St. Vrain HTGR operated from 1979 until 1989, generating about 490 MW(e)-years of (gross) electrical energy.

^cInformation is not available.

^dKaowool is an insulation material.

**Table 7.11. Projected burial volumes of radioactive wastes
from SAFSTOR (mothballing/delayed dismantling)
of Humboldt Bay—Unit 3 BWR^{a,b,c}**

D&D activity/reactor component	Volume (m ³)
Spent fuel racks	28.3
Nuclear steam supply system removal	
Reactor vessel	66.8 ^d
Reactor vessel internals	19.1 ^e
Other components ^f	17.0
Removal of major equipment	
Asbestos removal program	116.1
Main condensers	24.6
Main turbine/generator	36.4
Disposal of contaminated plant systems	
Condensate system	65.5
Electrical system	30.6
High-pressure steam and feedwater systems	66.7
Radwaste collection and treatment systems	49.2
Reactor cleanup and shutdown	38.8
Turbine system	415.3
Other systems ^g	74.8
Decontamination of site buildings	
Refueling building	216.7
Turbine building	21.3
Yard piping and soil	211.4
Other ^h	14.7
Disposal of contaminated solid waste	16.4
Process liquid waste ⁱ	27.3
Disposal of modified plant seismic and off-gas systems as a result of 1986–1991 capital improvements	20.8
Total	1,577.8

^aBased on the information reported in ref. 31.

^bThe 65-MW(e) Humboldt Bay—Unit 3 BWR operated from 1963 until 1976, generating 545 MW(e)-years of (net) electrical energy. The plant was placed in a SAFSTOR mode in 1988. The projections in this table assume delayed dismantling (DECON) of the reactor begins after a SAFSTOR dormancy period of 30 years. At this time (2018), the current inventory of spent nuclear fuel at the site will have been shipped to a federal repository when the latter is available.

^cExcept where noted, the volumes reported represent estimates for packaged Class-A LLW.

^dIncludes 14.8 m³ of Class-B LLW.

^eIncludes 5.8 m³ of Class-B LLW and 13.3 m³ of Class-C LLW.

^fIncludes removed control rod drive mechanism and inner core instrumentation.

^gIncludes contaminated control rod drive hydraulics, extraction drains and vents, gaseous radwaste, yard piping, seismic equipment, and heating, ventilating, and air-conditioning equipment.

^hIncludes contaminated buildings for hot machine shop and calibration equipment, radwaste treatment, and equipment storage.

ⁱClass-B LLW.

**Table 7.12. Projected volumes of wastes from Indian Point–Unit 1
PWR decommissioning activities^{a,b,c}**

Reactor component(s)	Container (type and number)		
	LSA boxes	Cask liners	Total
Contaminated piping, valves, equipment, and concrete	2,440	0	2,440
Spent nuclear fuel racks	9	0	9
Reactor internals	7	13	20
Reactor vessel	52	0	52
Total containers	2,508	13	2,521
External volume (m ³) of each container (box or liner)	4.694	3.341	
Total container volume (m ³)	11,774	43	11,817

^aBased on ref. 32.

^bThe 265-MW(e) Indian Point–Unit 1 PWR began operation in 1962 and generated about 1,440 MW(e)-years of (gross) electrical energy before it was shut down in 1974. The projections in this table pertain to wastes from the dismantlement of the reactor following a SAFSTOR period of about 40 years.

^cAll Unit 1 systems shared with Unit 2 are credited to Unit 1 waste volume. Significant volume reductions from smelting and off-site decontamination are not factored into estimate. Total induced activity in vessel and vessel internals is approximately 25,000 Ci, projected in year 2013. About 90% of this induced activity is due to ⁶³Ni and about 9% is due to ⁶⁰Co.

Table 7.13. Inventories and projections of low-level radioactive wastes from La Crosse BWR decommissioning activities^{a,b}

Calendar year(s)	Decommissioning mode	Quantity of waste shipped to burial site ^{c,d,e}	
		Volume (m ³)	Undecayed radioactivity (Ci)
<i>Historical annual waste shipments</i>			
1988	SAFSTOR	4.62	70.3
1989 ^f	SAFSTOR	6.74	32.12
1990 ^f	SAFSTOR	4.59	0.74
1991 ^f	SAFSTOR	5.46	0.32
1992 ^f	SAFSTOR	2.61	0.44
1993 ^f	SAFSTOR	3.31	0.24
1994 ^f	SAFSTOR	47.52	1.48
Totals (through 1994)	SAFSTOR	74.85	105.64
<i>Projected waste shipment quantities for certain periods</i>			
1995–1998	SAFSTOR	0.0	0.0
1999–2003	SAFSTOR	6.5	13
2004–2008	SAFSTOR	4.9	7
2009–2013	SAFSTOR	3.6	5
2014–2020	SAFSTOR	0.0	0.0
2021–2025	DECON	3,093	9,303
Projected totals (1995–2025)	SAFSTOR/DECON	3,108	9,328
Historical and projected totals (1988–2025)	SAFSTOR/DECON	3,183	9,434

^aBased on the information reported in ref. 33.

^bThe 48-MW(e) La Crosse BWR began operation in 1968 and generated 462 MW(e)-years of (gross) electrical energy until it was shut down in April 1987. The reactor was placed in SAFSTOR in 1991. The data in this table are based on a SAFSTOR period of 30 years.

^cDuring the SAFSTOR period, the principal types of radioactive solid waste which will be processed and shipped to a suitable disposal facility will be low-level radioactive wastes principally with radioactivity content less than Class C (10 CFR Part 61) wastes. These wastes will include (1) dry active wastes (DAW), normally Class A, unstable; (2) dewatered spent demineralizer resins and filtration media, normally Class A or B, stable; and (3) contaminated or irradiated plant system components, normally Class B or C, stable.

^dContributions from activated core components and structural materials are included in the 2021–2025 estimates.

^eValues are decayed to the time of burial.

^fVolume of waste for this year reflects significant reductions due to treatment. Waste shipments for this year contained DAW and contaminated metal, which were either decontaminated, supercompacted, or both by two Oak Ridge waste treatment companies [(Quadrex Recycle Center and Scientific Ecology Group (SEG), Inc].

**Table 7.14. Projected volumes of wastes from Rancho Seco
PWR decommissioning activities^{a,b,c}**

Reactor component(s)/waste	Volume (m ³)
Spent nuclear fuel racks	359
Reactor vessel	212
Reactor vessel internals	156
Primary system components and piping	1,336
Total for reactor vessel and components	2,063
Secondary and radwaste systems	2,625
Contaminated structures	468
Processed liquid waste	98
Dry active waste	397
Grand total	5,651

^aBased on ref. 34 (extracted from a 1991 decommissioning cost study prepared by TLG Engineering, Inc.).

^bThe 918-MW(e) Rancho Seco—Unit 1 PWR was shut down in 1989. The reactor operated from 1974 until 1989, generating 5,277.3 MW(e)-years of (gross) electrical energy.

^cThe projections in this table pertain to wastes from dismantlement of the reactor following a SAFSTOR period of about 20 years.

Table 7.15. Projected volumes of wastes from San Onofre–Unit 1 PWR decommissioning activities^{a,b}

Activity/reactor facility component or type of waste	Waste volume, m ³				
	Class A	Class B	Class C	GTCC	Total
Annual SAFSTOR maintenance					
Dry activated waste ^c	121.12				121.12
Spent fuel racks	14.39				14.39
Nuclear steam supply system (NSSS) removal					
Reactor coolant piping	86.04				86.04
Pressurizer quench tank	12.94				12.94
Reactor coolant system pumps and motors	49.28				49.28
Pressurizer	56.64				56.64
Steam generators	367.54				367.54
Control rod drive mechanism and incore instrumentation	48.20				48.20
Vessel internals	22.26	13.06	30.81	20.25	86.38
Reactor vessel	147.15	51.94			199.09
NSSS total	790.05	65.00	30.81	20.25	906.11
Plant systems					
Auxiliary feedwater	92.12				92.12
Containment ventilation	42.45				42.45
Contaminated electrical equipment	79.27				79.27
Feedwater sampling	90.28				90.28
Feedwater	338.48				338.48
Gaseous radwaste	54.46				54.46
Letdown demineralizer	3.82				3.82
Letdown and residual heat removal	42.48				42.48
Liquid radwaste	37.72				37.72
Post-accident sampling	5.35				5.35
Pressurizer and relief tank	0.20				0.20
Radwaste drain system	5.21				5.21
Reactor coolant pump seal water system	13.71				13.71
Reactor cool system	3.12				3.12
Reactor cool system sampling system	13.06				13.06
Safety injection	85.70				85.70
Spent fuel cooling	11.98				11.98
Chemical volume and control system	23.93				23.93
Plant systems total	943.34				943.34
Site buildings					
Reactor sphere and enclosure	249.27				249.27
Auxiliary additions	2.04				2.04
Contaminated soil	724.96				724.96
Fuel storage	21.69				21.69
Miscellaneous contaminated buildings	18.49				18.49
Radwaste	13.45				13.45
Reactor auxiliary	5.89				5.89
Storage building	1.42				1.42
Site buildings total	1,037.21				1,037.21

Table 7.15 (continued)

Activity/reactor facility component or type of waste	Waste volume, m ³				
	Class A	Class B	Class C	GTCC	Total
Final waste liquid processing		40.24			40.24
Mixed waste		16.68			16.68
Totals	2,922.79	105.24	30.81	20.25	3,079.09

^aBased on ref. 35. Projections in this table pertain to wastes from reactor dismantlement (DECON) following a SAFSTOR period of 20 years. San Onofre–Unit 1 will be dismantled beginning in 2013.

^bThe 436-MW(e) San Onofre–Unit 1 PWR began operation in 1967 and generated about 6,045 MW(e)-years of (gross) electrical energy before it was shut down in 1992.

^cIncludes 83.94 m³ of dry, activated waste (including protective worker clothing) generated during the latter phase of decommissioning.

Table 7.16. Projected volumes of wastes from future Saxton PWR decommissioning activities^{a,b,c}

Reactor component(s)/waste	Volume (m ³)
Auxiliary system piping and valves	28.32
Containment vessel sump pumps	0.85
Containment ventilation equipment	16.99
Contaminated and activated concrete of containment vessel	240.00
Cooling heat exchangers	16.99
Demineralizers	4.25
Discharge tank drain pumps	0.85
General valves, controllers, and instrumentation	42.48
Low-level waste from disposal operations	33.98
Pressurizer	7.26
Primary coolant pump	2.83
Primary piping	5.66
Reactor vessel, head, and internals	39.64
Relief valve discharge tank	4.25
Shutdown cooling pumps	0.85
Steam generator	8.43
Total volume ^d	453.63

^aBased on the information reported in ref. 36.

^bThe 3-MW(e) Saxton PWR was shut down in 1972 and placed in SAFSTOR. Work on dismantling the reactor site started in 1986. This facility operated from 1961 until 1971, generating 10.4 MW(e)-years of (gross) electrical energy.

^cActivity data are unknown at this time. Saxton reactor decommissioning waste characteristics are still being reviewed, and additional information will be provided in this table in future reports.

^dExcludes 1,590 m³ of contaminated soil (radioactive waste, 5–100 pCi/g) that was shipped to Envirocare of Utah, Inc., in 1994.

Table 7.17. Characteristics of wastes from Shoreham BWR decommissioning activities^{a,b}

(Unless otherwise indicated, all wastes are projected to be LLW Class A)

Category	Containers		Mass (t)	Shipment volume ^c (m ³)	Radioactivity (Ci)	Burial volume (m ³)
	Number	Type				
Items shipped to volume reduction facilities for processing prior to burial ^d						
Reactor recirculation system	e	e	e	e	e	e
Control rod drive system ^f	e	e	e	e	e	e
Residual heat removal system	e	e	e	e	e	e
Core spray system	e	e	e	e	e	e
Reactor water cleanup system	e	e	e	e	e	e
Fuel pool cleanup system	e	e	e	e	e	e
Condensate and demineralizer system	e	e	e	e	e	e
Process sampling system	e	e	e	e	e	e
SNF rack and accessories	e	e	e	e	e	e
Process and dry activated wastes	e	e	e	e	e	e
Demineralizer system and resins/filters	e	e	e	e	e	e
Liquid radwaste system	e	e	e	e	e	e
Mirror insulation	e	e	e	e	e	e
Total	210	g	1,836.93	6,329.38	6.97	61.15
Items shipped directly to burial site (Barnwell)						
Reactor internals ^h						
Control rod blades and drives						
Total	51	i	96.90	79.62	675.79	79.62
Laundry (recycled) ^j	588		125.35	765.91	0.28	0
Miscellaneous equipment (recycled) ^k	87		269.86	598.24	0.23	0
Grand total	936		2,329.06	7,773.15	683.27	140.77

^aBased on ref. 39. As of July 1, 1994.^bThe 820-MW(e) Shoreham BWR underwent low-power tests until 1989, when the Long Island Lighting Company agreed to sell the plant to the state of New York for decommissioning. A total of 865 MW(e)-hours of (gross) electrical energy were generated during the low power tests.^cPrior to treatment and burial.^dVolume reduction facilities include SEG and Quadrex.^eInformation unavailable.^fExcludes control rod blades and drives.^gContainer type: sea land containers, boxes, and high-integrity containers (HICs).^hIncludes some incore instruments, which are projected to be Class B LLW.ⁱCasks and boxes.^jCleaned by Interstate Nuclear Services and recycled.^kEquipment shipped to various reactor sites for salvaging. Such equipment includes traversing incore probe drives and detectors, reactor pressure vessel segments, control rod drives, steam relief valves, local power range monitors, intermediate range monitors, source range monitors, and recirculation pump components.

Table 7.18. Characteristics of wastes from decontamination activities at the Three Mile Island—Unit 2 reactor site^{a,b}

Type of waste	Mass shipped (t)	Total waste shipped from TMI (August 1979 through December 1994)	
		Packaged volume (m ³)	Shipment activity ^c (Ci)
Spent nuclear fuel/core debris ^d	155.9	123.9	6,911,513
Low-level and other wastes ^e			
Dry, activated waste (DAW) ^f		7,492.4	744.7
Wet and solidified waste ^g		320.3	7,787.5
Submerged demineralizer system (SDS) ^h		58.2	673,877.7
EPICOR II system liners ⁱ			
First generation		125.7	77,750
Second generation		947.3	5,066.9
Defueling water cleanup system (DWCS) ^j		8.45	5,886.3
Off-site deconable scrap		138.9	4
Totals	155.9	9,215.5	7,682,630.1

^aThree Mile Island (TMI—Unit 2) is a PWR reactor with the following characteristics: rated capacity—926 MW(e); mass of fuel in core before accident—82 MTIHM; and number of fuel assemblies before accident—177. The reactor began operation in 1978 and generated 231.6 MW(e)-years of (gross) electrical energy before being permanently shut down by an accident in March 1979.

^bBased on information reported in ref. 40.

^cThese activities represent the cumulative sum of curies reported at the time of waste shipment. The values reported are not corrected for decay after the time of shipment.

^dDefueling of the reactor started in January 1986. Fuel-debris shipments were completed in April 1990.

^eOther wastes include those regarded as “abnormal” because their classification is currently uncertain.

^fDry, activated wastes are dry wastes packaged in drums, boxes, and high-integrity containers.

^gIncludes solidified miscellaneous liquids and miscellaneous resin liners and filters from TMI—Unit 2 systems.

^hResin liners and filters from the SDS (for water treatment).

ⁱResin liners and filters from the EPICOR II system that use organic ion-exchange resins and inorganic zeolite media. These include processing high-integrity containers (HICs). The EPICOR II system is a special type of filtering system used at the TMI—Unit 2 site in the final stages of decontaminating large volumes of contaminated water.

^jResin liners and filters from the DWCS that use inorganic zeolite media. These are primarily processing HICs.

Table 7.19. Projected classification and volumes of wastes from Trojan PWR decommissioning activities

Item	Burial volume, m ³				
	Total	Class-A LLW	Class-B LLW	Class-C LLW	GTCC LLW
Plant systems	6,339.8	6,150.1	104.4	85.3	
Plant buildings	637.2	637.2			
Large component removal project (steam generators and pressurizer)	1,557.4	1,557.4			
Reactor vessel internals removal project	325.8	267.2	6.5	42.5	9.6
Total	8,860.2	8,611.9	110.9	127.8	9.6

^aBased on ref. 41.

^bThe 1,130-MW(e) Trojan PWR began operation in 1975 and generated 10,076 MW(e)-years of (gross) electrical energy before it was permanently shut down in January 1993. The projections of this table pertain to several phases of reactor dismantlement (DECON) during 1995–2001.

Table 7.20. Projected characteristics of wastes from Yankee Rowe PWR decommissioning activities^{a,b}

Reactor component	Volume (m ³)	Radioactivity ^c (Ci)
<i>Component Removal Project (1993–1994)</i>		
Main coolant pumps (4)	8.8	11
Pressurizer	19.3	3
Reactor vessel internal components	87.0	132,600
Steam generators (4)	197.0	1,300
Miscellaneous waste	191.0	370
Total (1993–1994)	503.1	134,284
<i>Final decommissioning (1995–1997, 1999)</i>		
Building inventory	410.3	<1
General plant inventory	1,922.8	<500
Reactor core baffle ^d	2.1	1,020,000
Reactor vessel	187.9	4,700
Soil	707.9	<1
Miscellaneous waste	122.5	<50
Total (1995–1999)	3,353.5	1,025,252
Total (1993–1999)	3,856.6	1,159,536

^aBased on ref. 42.

^bThe 167-MW(e) Yankee Rowe–Unit 1 PWR began operation in 1960 and generated about 4,030 MW(e)-years of (gross) electrical energy before it was shut down in 1992.

^cBased on the radioactivity level on January 1, 1994.

^dThe reactor core baffle, the component directly adjacent to the reactor core, was highly activated during plant operations. The baffle's radioactivity exceeds 10 CFR Part 61.55 Class-C LLW requirements for near-surface disposal. DOE is responsible for the disposal of GTCC materials.

Table 7.21. Characteristics of wastes from decommissioning activities at the Cimarron Fuel Fabrication Facility^a

Project area	Type of waste	Total waste removed from Cimarron through December 1994 ^b		Projected waste volume remaining ^c (m ³)
		Volume (m ³)	Activity (Ci)	
Burial ground	LLW (LSA) ^d	1,833.10	5.37	0
Mixed-oxide fuel plant	TRUW	259.34	10.87	0
	LLW (LSA)	463.88	3.25	0
Uranium fuel plant areas				
a. Uranium fuel plant	LLW (LSA)	2,307.30	3.65	12-24
b. North Field	LLW (LSA)	566.26	0.33	0
Liquid process waste evaporation ponds				
a. Mixed-oxide plant pond	LLW (LSA)	104.30	0.000009	0
b. Uranium plant pond	LLW (LSA)	183.73	0.23	0
Sanitary lagoon piping and manholes	LLW (LSA)	1,565.60	2.93	0
Project totals	TRUW	259.34	10.87	0
	LLW (LSA)	7,024.17	15.76	12-24
Total waste		7,283.51	26.63	12-24

^aBased on the information provided in ref. 43.

^bThe LLW inventories are included in the commercial disposal site inventories of Chapter 4. No waste shipments were made from the site during 1994.

^cDecontamination work is anticipated to be completed during 1995. More than 95% of the estimated decontamination requirement has been completed.

^dLSA = low-specific-activity waste.

Table 7.22. Inventories and projections of wastes from various activities at the West Valley Demonstration Project^{a,b}

Waste description	Total wastes as of December 31, 1994 ^c	Projected total wastes upon completion of the project
Spent nuclear fuel remaining ^d		
Mass, MTIHM	27	27
Number of fuel assemblies	125	125
High-level waste generated from reprocessing operations and previtrification treatment ^e		
Volume, m ³	2,180 ^f	240 ^g
Activity, Ci ^h	24,720,000	22,400,000 ⁱ
Transuranic waste generated from presolidification activities and HLW vitrification		
Volume, m ³		
Contact-handled	321	j
Remote-handled	427	j
Activity, Ci		
Contact-handled	j	j
Remote-handled	j	j
Low-level waste generated from presolidification activities and HLW vitrification		
Buried waste (1982–86) volume, m ³	5,786	5,786
Buried waste (1982–86) activity, Ci ^h	625	j
Stored waste volume, m ³	9,506 ^k	j
Stored waste activity, Ci ^h	1	1
Low-level waste incorporated in cement by radwaste treatment system ^m		
Stored waste volume, m ³	4,989	j
Stored waste activity, Ci ^h	j	j
Low-level waste from postsolidification D&D after HLW vitrification		
Volume, m ³	0	4,771
Activity, Ci ^h	0	j
Total low-level summary (buried and stored wastes)		
Volume, m ³	20,281	j
Activity, Ci ^h	j	j

^aBased on data reported in ref. 44.

^bAt the West Valley Demonstration Project (WVDP) site, Nuclear Fuel Services, Inc., operated a reprocessing plant with a rated capacity of 300 MTIHM/year. During its operation from 1966 to 1972, about 640 MTIHM of spent nuclear fuel were reprocessed.

^cWastes generated after 1987 are regarded as stored, not buried or disposed.

^dAt the end of 1994, 125 fuel assemblies (representing 27 MTIHM of spent nuclear fuel) still remained in storage at the WVDP. These assemblies are owned by DOE. The return shipment of all commercially owned spent fuel (625 fuel assemblies) to the owner utilities was completed by the end of 1986. The current SNF inventory at the WVDP consists of 85 BWR assemblies (11.7 MTIHM) and 40 PWR assemblies (15.3 MTIHM).

(Footnotes continued on next page.)

Table 7.22 (continued)

^eCurrently, HLW at the WVDP site is stored in two underground steel tanks. Eventually, this waste will be vitrified and about 300 canisters of glass will be produced. It is assumed that each canister will contain 0.80 m³ of glass.

^fWaste form is liquid, sludge, and zeolite.

^gGlass is the waste form.

^hPrincipal nuclides include ²⁴¹Am, ²⁴¹Pu, ¹³⁷Cs, ⁹⁹Tc, ⁹⁰Sr, and ⁶³Ni.

ⁱDecayed activity for 1998.

^jUnknown.

^kPrevious values reported for this volume included contributions from LLW cement. These contributions are no longer included.

^lInformation currently unavailable. This information will be updated in future updates of this report to include estimated total activity for containerized wastes as the information becomes available.

^mComprised of Class A and Class C LLW. See Table A.6 of Appendix A.



An aerial view of the Envirocare disposal facility near Clive, Utah, where some mixed low-level waste has been disposed. Courtesy of Envirocare of Utah, Inc., Salt Lake City, Utah.

8. MIXED LOW-LEVEL WASTE

8.1 INTRODUCTION

This chapter reports estimated inventories and generation rates of mixed low-level waste (MLLW) from DOE-site and commercial operations. MLLW includes mixtures of low-level radioactive materials and (chemically and/or physically) hazardous wastes. Typically, MLLW at DOE sites includes a variety of contaminated materials, including air filters, cleaning materials, engine oils and grease, paint residues, photographic materials, soils, building materials, and plant equipment being decommissioned. Mixed wastes include other types of radioactive wastes. All high-level wastes (HLWs) are regarded as mixed and are discussed in Chapter 2. Mixed transuranic wastes (MTRUWs) are not included in this chapter, but they are included in the TRUW inventories and projections of Chapter 3.

The radioactive components of mixed wastes are subject to the Atomic Energy Act (AEA), as amended,¹ which, for government sources, is administered by DOE, and, for commercial sources, by NRC (unless a state has obtained agreement-state status). In general, the hazardous components of most mixed wastes are subject to either of two federal statutes that are administered by the U.S. Environmental Protection Agency (EPA) (unless a state has obtained an authorization status): (1) the Resource Conservation and Recovery Act (RCRA), as amended,² and (2) the Toxic Substances Control Act (TSCA).³ Some mixed wastes, particularly spent engine oils, are regulated by state laws. The treatment, handling, and disposal of RCRA- and TSCA-regulated mixed wastes are subject to the regulations of the EPA^{4,5} and NRC (or the authorized and agreement states), or DOE. Table 8.1 (data from ref. 6) lists those states and territories designated by EPA as having mixed waste authorization.

In this report, MLLW is considered separately from the purely radioactive LLW, which is discussed in Chapter 4. This section reports MLLW inventories and projections for two major groups of MLLW. The first comprises wastes containing hazardous components that are RCRA- and/or state-regulated, including RCRA-/state-regulated wastes that are also subject to TSCA. The

summary information reported for these RCRA-/state-regulated wastes are based on the 1995 update to the DOE Mixed Waste Inventory Report (MWIR)⁷ data set. At the time of preparing this IDB report, the updated MWIR data set was undergoing technical review in preparation for official release.

Wastes whose hazardous components are regulated by TSCA comprise the second group of MLLW; inventories and projections of this group are reported in this chapter. Information for the TSCA-regulated wastes was recently provided to the IDB Program by DOE sites.

Unless otherwise noted, the inventories and projections reported for MLLW are separate from those reported for strictly radioactive LLW in Chapter 4. Inventories of MLLW currently stored at DOE sites are being thoroughly characterized. As a result, the waste at some sites could require reclassification, thereby causing significant changes in the inventories that reflect current data.

The Federal Facility Compliance Act (FFCA)⁸ amends RCRA to require (among other things) that DOE develop a Site Treatment Plan (STP) for each site which generates, stores, or treats MLLW. Specifically, Sect. 3021(b) of RCRA, as amended by the FFCA, requires that DOE prepare STPs for developing the technologies and capacities needed to treat MLLWs according to the standards required by EPA in Sect. 3004(m) of RCRA. All STPs are required to be in place by October 1995. These STPs could significantly impact future projections of MLLWs reported in this document for DOE sites.

8.2 WASTE CHARACTERIZATION

MLLWs stored at DOE sites have several common features: (1) such wastes have different blends of hazardous (chemical and/or physical) and radioactive components that dictate precautionary measures; (2) several processes may be involved in generating these wastes; and (3) various methods can be used to treat and prepare these wastes for storage. In recent years, EPA has adopted new toxicity-characteristic leaching procedures

(TCLPs) for identifying some hazardous components of these wastes. Representative data on the chemical and radionuclide compositions of MLLWs will be reported in the 1995 MWIR⁷ and associated data set.

In this chapter, inventories and annual (1994 and projected) generation rates of MLLW are expressed in terms of physical and hazardous categories. RCRA-/state-regulated waste from DOE activities is generally classified into four physical/chemical categories: liquids, solids, specific waste forms, and final waste forms. TSCA-regulated waste from DOE activities is classified into four physical categories: solid, liquid, gas, and sludge, and two hazard categories: PCB and asbestos. MLLW from commercial activities is classified by hazardous categories.

8.3 SUMMARY OF DOE MLLW

Cumulative mass inventories and generation rates are reported in this chapter for most of the DOE sites listed in Table C.3, Appendix C. Some generation rates may vary from current inventory additions because the generation levels reported do not reflect treatment that may take place before the waste is placed in interim storage. DOE site inventories and generation rates are given in both mass [kilograms (kg)] and volume [cubic meters (m³)] units. Most DOE sites track MLLW inventories and generation by volume based on the number of containers. However, MLLW mass information is not always available because the waste may not be weighed.

A breakdown of the MLLW volume inventory by site is graphically described in Fig. 8.1, and a breakdown of the volume-generation level by site is shown in Fig. 8.2. The current total volume inventory of MLLW at DOE sites is about 162,400 m³. About 97,100 m³ of MLLW are estimated to be generated during the period 1994 through 1998.

Summary cumulative inventories and projected cumulative generation for MLLW from DOE site operations are reported in Tables 8.2–8.5. Cumulative inventories of MLLW in interim storage are reported on a mass and volume basis in Tables 8.2 and 8.3, respectively. Projected 5-year mass generation and volume generation of these wastes from DOE site activities are given in Tables 8.4 and 8.5, respectively.

Detailed characteristics of RCRA-/state-regulated wastes from site operations are described in Tables 8.6–8.8. The MWIR documents inventories and generation levels for a wide range of categories of RCRA-/state-regulated wastes. These categories are based on various physical and chemical groupings and are described in Table 8.6 (adapted from ref. 9). Cumulative mass and volume inventories for these physical/chemical

groups are given for each site in Table 8.7 and for the DOE complex in Table 8.8. Projected cumulative 5-year generation levels for each category are given in Table 8.9.

Detailed characteristics of TSCA-regulated MLLW from DOE site operations are reported by physical category (solid, liquid, gas, and sludge) in Tables 8.10–8.13 and by TSCA hazard category [polychlorinated biphenyls (PCBs), asbestos, and other specified materials] in Tables 8.14–8.17.

Cumulative 1994 mass inventories and volume inventories are given in the physical category tables for the TSCA-regulated wastes (Tables 8.10 and 8.11, respectively). Annual mass generation and volume generation of these wastes for 1994 are reported in Tables 8.12 and 8.13, respectively.

The hazardous category tables for TSCA-regulated wastes include information on PCB wastes and asbestos. Other MLLWs regulated by TSCA at each site are also indicated. PCBs are a group of synthetic organic chemicals once widely used in electrical equipment, special hydraulic systems, heat-transfer systems, and other industrial products. They are currently considered a possible carcinogen. Asbestos is a group of magnesium silicate compounds that are mixed with varying amounts of calcium and iron silicates. They are fibrous, noncombustible minerals that have been previously used in the manufacture of many fireproofing and insulating materials. However, such compounds have been found to produce long-term carcinogenic effects; consequently, their use is being phased out.

Cumulative 1994 mass and volume inventories are reported in the hazardous category tables for TSCA-regulated wastes (Tables 8.14 and 8.15, respectively). Annual mass generation and volume generation of these wastes for 1994 are reported in Tables 8.16 and 8.17, respectively.

Historical and annual projections of DOE-site MLLW are reported in Tables 8.18 and 8.19. These tables report annual mass data (Table 8.18) and annual volume data (Table 8.19) on generated TSCA-regulated MLLW from DOE site activities, based on ref. 10.

8.4 SPECIFIC DOE SITE TSCA MLLW

This section highlights the major ground rules and assumptions associated with the DOE site TSCA MLLW information reported in Tables 8.2–8.5 and Tables 8.7–8.19. Most of the information reported in the subsections that follow describes the TSCA MLLW inventory, generation, and projection ground rules and assumptions documented in the specific DOE site submittals of ref. 10. Corresponding site information

associated with RCRA-/state-regulated waste data are reported in the MWIR (ref. 7). Significant changes in DOE TSCA MLLW inventory and characteristics data from that reported in the 1994 edition (1993 data) of this report (Rev. 10) are summarized in Table 8.20.

8.4.1 Ames Laboratory (Ames)

Materials containing radioactively contaminated asbestos comprise the TSCA MLLW inventories and projections for Ames in Tables 8.2, 8.3, 8.10, 8.11, 8.14, 8.15, 8.18, and 8.19. The inventories represent cumulative levels from 1986.

8.4.2 Argonne National Laboratory-East (ANL-E)

As of the end of 1993, ANL-E had no TSCA MLLW inventory. However, 62,400 kg (52 m³) of PCB wastes were generated at ANL-E during 1994. Projections reported in Tables 8.18 and 8.19 include some waste generation during 1995.

8.4.3 Brookhaven National Laboratory (BNL)

Solid asbestos materials comprise the BNL TSCA MLLW inventories reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. These inventories represent cumulative levels from 1990. Projected wastes reported in Tables 8.18 and 8.19 assume that small quantities will continue to be generated as a result of maintenance activities. Decommissioning or environmental restoration activities could result in increased generation of asbestos wastes but are not anticipated at this time. PCB wastes at BNL are reported in the MWIR (ref. 7).

8.4.4 Energy Technology Engineering Center (ETEC)

TSCA MLLW inventories reported for ETEC in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 represent levels accumulated from 1989. Projections reported for generated mass in Table 8.18 and for generated volume in Table 8.19 are based on planned site D&D activities. These projections include quantities of asbestos-containing floor tiles, which are scheduled to be removed during 1998–1999.

8.4.5 Fernald Environmental Management Project (FEMP)

Information for this site is not available.

8.4.6 Grand Junction Projects Office (GJPO)

GJPO TSCA MLLWs are comprised of radioactive PCBs. Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 report cumulative inventories of these wastes from 1990. Projections reported in Tables 8.18 and 8.19 apply to wastes from the remediation of radioactive PCB ballasts. It is assumed that this remediation will subsequently decrease each year.

8.4.7 Hanford Site (Hanford)

PCB wastes comprise the TSCA MLLW inventories reported for Hanford in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. These inventories represent cumulative levels from 1987. Site projections reported in Tables 8.18 and 8.19 are based on Hanford's 30-year solid mixed waste forecast. These projections exclude contributions from off-site generation.

8.4.8 Idaho National Engineering Laboratory (INEL)

Inventories of INEL PCB wastes (solids and liquids) are given in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. The earliest date from which these wastes were accumulated is presently not known. It is likely that PCB wastes will be generated at INEL in the future, however, estimates of specific quantities are not yet available. There are also inventories and projections of asbestos wastes at INEL, however, these are included in the site data for LLW in Chapter 4.

8.4.9 K-25 Site

For the K-25 Site, TSCA MLLW inventories are reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. These inventories represent cumulative levels of waste materials—some of which were produced from the startup of site operations in 1945. Projections of annual TSCA MLLW generation reported in Tables 8.18 and 8.19 are based on 1994 generation levels.

8.4.10 Kansas City Plant (KCP)

Currently, KCP does not have any inventories of TSCA MLLW, and no quantities of TSCA MLLW are anticipated for the future.

8.4.11 Lawrence Berkeley Laboratory (LBL)

LBL TSCA MLLW inventories, representing cumulative levels for 1994 only, are reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. Current

inventories are comprised of PCBs. Significant quantities (1087 kg) of asbestos debris were generated during 1994 as a result of fume hood dismantling, and these were shipped to an off-site facility for treatment, storage, and disposal. Quantities reported for PCB wastes (capacitors and ballasts) are based on an assumed density of 1500 kg/m³, and quantities reported for asbestos debris reflect a density of 400 kg/m³. Projections of LBL generation levels reflect quantities of asbestos from glove boxes and PCBs from the replacement of PCB capacitors and ballasts.

8.4.12 Lawrence Livermore National Laboratory (LLNL)

Inventories of TSCA-regulated MLLW at LLNL are reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. These quantities represent cumulative levels from 1990. No TSCA MLLW is projected from future LLNL activities. Current inventories resulted from either the removal of PCB-containing transformers from service or from renovation/closure of buildings containing asbestos.

8.4.13 Los Alamos National Laboratory (LANL)

Inventories of TSCA MLLW at LANL reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 represent cumulative levels from 1971. These reported inventories are based on limited records kept of asbestos and PCB wastes during the early operating years. A significant increase occurred during 1993 from the addition of contaminated equipment to the asbestos inventory.

8.4.14 Mound Plant (Mound)

TSCA MLLWs are not routinely generated at Mound. TSCA MLLW inventories reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 are cumulative levels of asbestos from 1947. After 1994, no major generation of either PCB or asbestos wastes are anticipated. Projections reported in Tables 8.18 and 8.19 assume a generation rate of two 55-gal drums per year of radioactively contaminated asbestos pipe covers and/or floor tiles. Future generation projections will be affected by changes in site D&D plans and schedules.

8.4.15 Naval Reactor (NR) Sites

Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 report the total inventories of NR sites. These include contributions from the Bettis Atomic Power Laboratory (BAPL), the Knolls, Kesselring (KESS), and Windsor (WIND) sites of

the Knolls Atomic Power Laboratory (KAPL); and six naval shipyards (Charleston, Mare Island, Norfolk, Pearl Harbor, Portsmouth, and Puget Sound). The quantities reported in these tables reflect cumulative amounts from as early as 1982. Projected wastes reported for NR sites in Tables 8.18 and 8.19 are anticipated to result from a variety of site activities, including facility D&D, plant lay-up, ship inactivation, and asbestos removal/replacement.

8.4.16 Nevada Test Site (NTS)

No inventories of TSCA MLLW are presently found at NTS. However, current volumes of radioactive materials in storage are undergoing characterization at the site. It is not known at this time if TSCA MLLW exists among the inventory. Future volumes of TSCA MLLW may be generated from NTS D&D and environmental restoration activities, however no estimates are available at this time.

8.4.17 Oak Ridge National Laboratory (ORNL)

Inventories of TSCA MLLW at ORNL reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 are cumulative levels from 1977. Site-generated projections reported in Tables 8.18 and 8.19 are based on 1994 generation levels.

8.4.18 Oak Ridge Institute of Science and Education (ORISE)

Currently, ORISE does not have any inventories of TSCA MLLW, and no quantities of TSCA MLLW are anticipated for the future.

8.4.19 Paducah Gaseous Diffusion Plant (PAD)

The PAD site TSCA MLLW inventories reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 are cumulative levels from 1980. Projections reported for generated TSCA wastes in Tables 8.18 and 8.19 are based on the following assumptions:

- a routine constant TSCA waste generation of 608 m³/year;
- the mass of a 55-gal (0.21-m³) drum is 159 kg;
- generation levels result from routine site activities, as well as environmental restoration activities, engineering project activities, and D&D activities;
- reported quantities apply to waste solids and liquids, not sludges; and
- reported quantities exclude wastes contaminated by both PCBs and RCRA hazardous materials.

8.4.20 Pantex Plant (PANT)

During 1994, 4500 kg (3 m³) of tritium-contaminated asbestos insulation was generated at PANT as a result of maintenance activities involving the removal of piping containing discharged condensate. This quantity comprises the current site TSCA MLLW inventory. No additional future generation of this waste is anticipated from this maintenance activity. The mass of this asbestos waste reported in Tables 8.2, 8.10, 8.12, 8.14, 8.16, and 8.18 is based on an assumed density of 1500 kg/m³.

8.4.21 Pinellas Plant (Pinellas)

Pinellas currently has no inventories of TSCA MLLW. However, some projected quantities for 1995 are reported in Tables 8.18 and 8.19 as a result of the removal of ductwork containing asbestos.

8.4.22 Portsmouth Gaseous Diffusion Plant (PORTS)

At PORTS, TSCA-regulated MLLW is comprised of both PCBs and asbestos. Inventories of these wastes represent cumulative levels from 1954, and are reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. Projections of generated TSCA wastes from PORTS site activities are reported in Tables 8.18 and 8.19. These forecasts are based on annual historical data and reflect a 10% reduction/year to account for waste minimization. They do not include PCB and asbestos contributions from D&D activities nor final removal of PCB-contaminated equipment (capacitors, transformers, impregnated gaskets, and ventilation ducts).

8.4.23 Rocky Flats Environmental Technology Site (RFETS)

Both radioactive PCBs and asbestos are included in the RFETS TSCA MLLW inventories reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. These inventories represent cumulative levels from 1987. Projections reported in Tables 8.18 and 8.19 are based on separate assumptions pertaining to PCBs and asbestos. PCB generation rates assume that historical PCB spill sites will be funded for remediation during 1995–2000, and that these sites will contain only low-level radioactivity. Asbestos generation rates assume funding for asbestos abatement projects, no significant changes in regulations affecting encapsulation and abatement, and increases in waste generation from building usage transition and D&D activities.

8.4.24 Sandia National Laboratory/New Mexico (SNL/NM)

Radioactive asbestos comprises the SNL/NM TSCA MLLW inventories reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15. These inventories are levels cumulative from 1989. Future TSCA MLLWs cannot be estimated at this time. These wastes are expected to be mostly asbestos from building D&D activities. Some older SNL/NM buildings slated for D&D are known to contain radiologically contaminated asbestos. PCBs are expected to comprise a much smaller portion of future-generated SNL/NM TSCA MLLW.

8.4.25 Sandia National Laboratory/California (SNL/CA)

Current inventories of TSCA MLLW at SNL/CA are based on small quantities of asbestos removed during 1994. These are reported in Tables 8.2, 8.3, and 8.10–8.17. As indicated in Tables 8.18 and 8.19, no quantities of additional TSCA MLLW are anticipated.

8.4.26 Savannah River Site (SRS)

SRS TSCA MLLW inventories reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 represent cumulative levels from 1986. Most of the SRS TSCA wastes are asbestos materials whose mass was estimated from site-reported volume data using an assumed density of 500 kg/m³. This density was also used to estimate the TSCA MLLW mass generation rates reported in Tables 8.12, 8.16, and 8.18. The projections reported in Tables 8.18 and 8.19 assume a reduction of 80% in levels of annual generation previously reported in this document. At SRS, programs are either being developed or under development to reduce the generation of radioactively contaminated asbestos.

8.4.27 West Valley Demonstration Project (WVDP)

TSCA MLLW inventories reported for WVDP in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 are cumulative quantities of asbestos from 1982. Projections reported in Tables 8.18 and 8.19 also pertain solely to asbestos and assume a 20% annual reduction through 1999. WVDP inventories and projections for radioactively contaminated PCBs are contained in the MWIR (ref. 7). The estimates reported for asbestos generation are based on actual generation levels achieved during January–April 1995. All masses reported for asbestos include contributions from asbestos, debris contaminated with asbestos, and piping still having asbestos on it.

8.4.28 Y-12 Plant (Y-12)

Y-12 Plant TSCA MLLW inventories reported in Tables 8.2, 8.3, 8.10, 8.11, 8.14, and 8.15 represent cumulative levels from 1982. These wastes are PCBs regulated by TSCA. Contributions from asbestos are not reported because asbestos is considered to be a sanitary waste at the Y-12 Plant. Waste volumes reported were estimated from site-reported waste mass information using an assumed density of 1500 kg/m³ for solids and 1000 kg/m³ for liquids. For Tables 8.18 and 8.19, projected TSCA MLLW generation rates for the Y-12 Plant reflect an anticipated stand-down of site operations during 1994–1996. TSCA MLLW generation is expected to increase following the anticipated resumption of site operations after 1996. However, this assumes that funding will be available for future D&D of existing site facilities.

8.5 COMMERCIAL MLLW

In recent years, the NRC and EPA co-sponsored a survey study to compile a national profile of the volumes, characteristics, and treatability of commercially generated MLLW. Such a profile was designed to provide the following:

- states and compacts with information to assist in planning and developing adequate disposal capacity for low-level radioactive waste, including MLLW, as mandated by the Low-Level Radioactive Waste Policy Amendments Act;¹¹
- private developers with a clearer idea of the characteristics and volumes of mixed waste and the technical capability and capacity needed to treat this waste; and
- a reliable national data base of the volumes, characteristics, and treatability of commercial mixed waste.

In addition, the data were collected to provide a basis for possible federal actions that would effectively manage and regulate the treatment and disposal of mixed waste. Results from this investigation are documented in ref. 12 and summarized in this report.

The study identified the types and volumes of MLLW generated from five groups of facilities: nuclear utilities, medical facilities, academic institutions, industrial facilities, and NRC-licensed government facilities. The study selected a random sample of 1323 facilities out of a total target population of 2936 facilities. Data from the 1016 completed mixed waste survey questionnaires (77% response rate) received and the use of appropriate

weighting factors indicate that approximately 3950 m³ of MLLW—of which 72% was liquid scintillation fluids—were generated in the United States in 1990.

The study divided the MLLW into several hazardous stream categories, including the following:

- Liquid scintillation fluids from laboratory counting activities.
- Waste oil from various pumps, equipment, and maintenance activities.
- Chlorinated or fluorinated organics and chlorinated fluorocarbons, including sludges and contaminated filters from dry cleaning, refrigeration, degreasing, and decontamination operations. Chloroform and a number of pesticides are also included.
- Other organics, including miscellaneous solvents, reagents, expired products, and other organic compounds (or materials like rags, wipes, etc., contaminated with such) from research and manufacturing activities, experimental procedures, and laboratory and process equipment cleaning.
- Lead wastes, including lead shielding and lead solutions for research and industrial facilities.
- Mercury wastes, including equipment and debris contaminated with mercury.
- Chromate wastes, including chromium-contaminated solutions for research, maintenance, and waste treatment (ion exchange) operations.
- Cadmium wastes from decontamination activities.
- Aqueous corrosive wastes, including inorganic acids, or, in some instances, bases from cleanup and decontamination activities.
- Other hazardous materials, including materials (a) either not readily assignable to any one of the previous categories or (b) containing a number of different hazardous materials.

Summaries of estimated generation rates, amounts in storage, and amounts treated for each of the five facility categories and each of the hazardous waste stream categories are shown in Tables 8.21 and 8.22, respectively (data from ref. 12). Upper and lower bounds were also set for the volume of mixed waste that is untreatable under current technologies by making the simplifying assumption that liquid scintillation fluids, oil, nonhalogenated organics, and corrosive wastes are treatable. Deducting their total contribution from the estimated total mixed waste generation rate leaves residues of about 524 m³. This upper bound for untreatable mixed waste is about 13% of

the estimated 1990 national generation rate of 3950 m³. However, it was noted that the capacity to treat *all* of the so-called treatable mixed waste may not be available.

8.6 REFERENCES

1. U.S. Congress, Atomic Energy Act of 1954, Pub. L. 83-703, Aug. 15, 1954.
2. U.S. Congress, Resource Conservation and Recovery Act of 1976, Pub. L. 94-580, Oct. 21, 1976, as amended by the Hazardous and Solid Waste Amendments Acts of 1984, Pub. L. 98-616, Nov. 9, 1984.
3. U.S. Congress, Toxic Substances Control Act of 1976, Pub. L. 94-469, Oct. 11, 1976.
4. U.S. Environmental Protection Agency, "Identification and Listing of Hazardous Waste," *Code of Federal Regulations*, 40 CFR Parts 260-271 (1986).
5. U.S. Environmental Protection Agency, "Subchapter R—Toxic Substances Control Act," *Code of Federal Regulations*, 40 CFR Parts 700-799 (1988).
6. Susan Jones, DOE Office of Program Integration, Germantown, Maryland, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, dated July 3, 1995, containing the updated respective EPA mixed waste authorization statuses for states and U.S. territories as of May 31, 1995.
7. U.S. Department of Energy, Office of Environmental Management, *1995 Mixed Waste Inventory Report* (to be issued).
8. U.S. Congress, Federal Facility Compliance Act of 1992, Pub. L. 102-386, Oct. 6, 1992.
9. U.S. Department of Energy, Office of Waste Management, *DOE Waste Treatability Group Guidance*, DOE/LLW-217, Rev. 0 (January 1995).
10. DOE site TSCA-regulated MLLW data submittal attachments, submitted to the IDB Program during May–August 1995. The following TSCA MLLW submittals were received and reviewed by the IDB Program before analysis and integration. Preceding each submittal is the site (in parentheses) to which it refers.
 - a. (Ames) Lowell K. Mathison, Ames Laboratory, Ames, Iowa, correspondence to Gaile A. Higashi, DOE Chicago Operations Office, Ames Laboratory Management Office, Argonne, Illinois, "1995 Integrated Data Base (IDB) Request for TSCA LLW," dated June 2, 1995.
 - b. (ANL-E) M. A. Sodaro, Argonne National Laboratory, Argonne, Illinois, correspondence to S. N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Department of Energy Site Toxic Substances Control Act Mixed Low-Level Waste Information Request for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," dated June 15, 1995.
 - c. (ANL-W) Information not available.
 - d. (BNL) Carson L. Nealy, DOE Brookhaven Area Office, Upton, New York, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Department of Energy (DOE) Site Toxic Substance Control Act Mixed Low-Level Waste Information Request for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," dated June 14, 1995.

- e. (ETEC) Kevin Hartnett, DOE Oakland Operations Office, Oakland, California, correspondence to Steve Storch, IDB Program, ORNL, "Department of Energy Toxic Substance Control Act Low-Level Waste (LLW) Information Request for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," dated June 20, 1995.
- f. (FNAL) Andrew E. Mravca, DOE Batavia Area Office, Batavia, Illinois, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "DOE Site TSCA Mixed Low-Level Waste Information Request for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," dated Apr. 26, 1995.
- g. (FEMP) Information not available.
- h. (GJPO) Jolene Stelmach, DOE Grand Junction Projects Office, Grand Junction, Colorado, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Toxic Substances Control Act Mixed Low-Level Waste Information Request for the 1995 Integrated Data Base Report," dated June 14, 1995.
- i. (Hanford) Mike Coony, Westinghouse Hanford Company, Richland, Washington, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, submitting updated TSCA MLLW information for Hanford, dated Aug. 7, 1995.
- j. (INEL) R. R. Piscitella, Idaho National Engineering Laboratory, Idaho Falls, Idaho, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Idaho National Engineering Laboratory (INEL) Input to Toxic Substances Control Act (TSCA) Information Request for the 1995 Integrated Data Base (IDB)," RRP-11-95, dated June 15, 1995.
- k. (ITRI) Joe L. Mauderly, Lovelace Biomedical and Environmental Research Institute, Inc., Albuquerque, New Mexico, correspondence to Stephen Storch, IDB Program, ORNL, Oak Ridge, Tennessee, transmitting ITRI TSCA/MLLW data attachment, dated June 12, 1995.
- l. (K-25) A. L. Rivera, Lockheed Martin Energy Systems, Oak Ridge, Tennessee, correspondence to S. N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Integrated Database (sic) Data Call for TSCA-Rad Waste," dated July 31, 1995.
- m. (KCP) Margaret E. Stockdale, DOE Kansas City Area Office, Kansas City, Missouri, personal communication with Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, dated July 17, 1995.
- n. (LANL) I-Li Chen, Los Alamos National Laboratory, Los Alamos, New Mexico, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "1995 Integrated Data Base (IDB) Report," CST14-95-290, June 7, 1995.
- o. (LBL) Jack Bartley, DOE Oakland Operations Office, Lawrence Berkeley Laboratory, Berkeley, California, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Lawrence Berkeley Laboratory (LBL) Integrated Data Base Report (IDB) of 1995," WM-95-123, dated June 7, 1995.
- p. (LLNL) Roy Kearns, DOE San Francisco Operations Office, Oakland, California, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Transmittal of the Lawrence Livermore National Laboratory Toxic Substances Control Act Low-Level Waste Information Request for the 1995 Integrated Data Base Report (DOE/RW-0006, Revision 11)."
- q. (Mound) Robert Rothman, DOE Miamisburg Area Office, Miamisburg, Ohio, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "1995 Integrated Data Base Call for TSCA MLLW," dated June 20, 1995.

- r. (NR sites) R. B. Haemer, DOE Office of Naval Reactors (NE-60), Arlington, Virginia, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, transmitting updated TSCA MLLW information for NR sites, dated June 12, 1995.
- s. (NTS) Carl P. Gertz, DOE Nevada Operations Office, Las Vegas, Nevada, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Toxic Substances Control Act Mixed Low-Level Waste Information Request for the 1995 Integrated Data Base (DOE/RW-006 [sic], Rev. 11)," dated May 11, 1995.
- t. (ORISE) Tom Wantland, Oak Ridge Associated Universities, Oak Ridge, Tennessee, personal communication with Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, July 17, 1995.
- u. (ORNL) A. L. Rivera, Lockheed Martin Energy Systems, Oak Ridge, Tennessee, Oak Ridge, Tennessee, correspondence to S. N. Storch, IDB Program, ORNL, "Integrated Database (sic) Data Call for TSCA-Rad Waste," dated July 31, 1995.
- v. (PAD) Jimmie C. Hodges, DOE Paducah Site Office, Paducah, Kentucky, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Department of Energy (DOE) Site Toxic Substance Control Act (TSCA) Mixed Low-Level Waste (LLW) Information Request for the 1995 Integrated Data Base Report (DOE/RE-0006[sic], Revision 11)," dated June 14, 1995.
- w. (PANT) Jerry S. Johnson, DOE Amarillo Area Office, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Department of Energy Site Toxic Substances Control Act Mixed Low-Level Waste Information Request for 1995 Integrated Data Base Report," dated July 11, 1995.
- x. (Pinellas) Gary Schmidtke, DOE Pinellas Area Office, Largo, Florida, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Pinellas Plant TSCA/LLW Information Request," dated June 15, 1995.
- y. (PORTS) Terry Acox, Lockheed Martin Energy Systems, Inc., Portsmouth, Ohio, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Data Call for TSCA-Related Wastes," dated July 25, 1995.
- z. (PPPL) H. Allen Wrigley, DOE Princeton Area Office, Princeton, New Jersey, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Data Call - TOSCA HW," dated May 10, 1995.
- aa. (RFETS) Scott Ludwig, DOE Rocky Flats Office, Golden, Colorado, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, transmitting updated TSCA MLLW information, dated Aug. 1, 1995.
- ab. (SLAC) Kevin Hartnett, DOE Oakland Operations Office, Oakland, California, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Department of Energy Toxic Substance Control Act Low-Level Waste Information Request for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," dated June 14, 1995.
- ac. (SNL/CA) Sarah O'Connor, Lockheed Martin Sandia Corporation, correspondence to Stephen N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, submitting SNL/CA TSCA MLLW information, dated July 18, 1995.
- ad. (SNL/NM) Maureen J. Lincoln, Sandia National Laboratory/New Mexico, Albuquerque, New Mexico, correspondence to Ted Pietrok, DOE Kirtland Area Office, Albuquerque, New Mexico, "IDB Data Base Update," dated July 15, 1994.
- ae. (SRS) Paul D. Hunt, Westinghouse Savannah River Company, Aiken, South Carolina, correspondence to Steven N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "SRS 1995 Integrated Data Base Report Input (U)," SWE-95-0303, dated June 15, 1995.

- af. (WVDP) John J. Hollinden, West Valley Nuclear Services Company, Inc., West Valley, New York, correspondence to Steven N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Submittal of the Department of Energy Site Toxic Substance Control Act Mixed Low-Level Waste Information for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev.11)," WZ:95:0095, dated June 15, 1995.
 - ag. (Y-12) A. L. Rivera, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee, correspondence to Steve Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Integrated Database (sic) Data Call for TSCA-Rad Waste," dated July 31, 1995.
11. U.S. Congress, Low-Level Radioactive Waste Policy Amendments Act of 1985, Pub. L. 99-240, Jan. 15, 1986.
 12. J. A. Klein, et al., *National Profile on Commercially Generated Low-Level Radioactive Mixed Waste*, prepared by Oak Ridge National Laboratory, Oak Ridge, Tennessee, for U.S. Nuclear Regulatory Commission and U.S. Environmental Protection Agency, NUREG/CR-5938, Oak Ridge National Laboratory-6731 (December 1992).

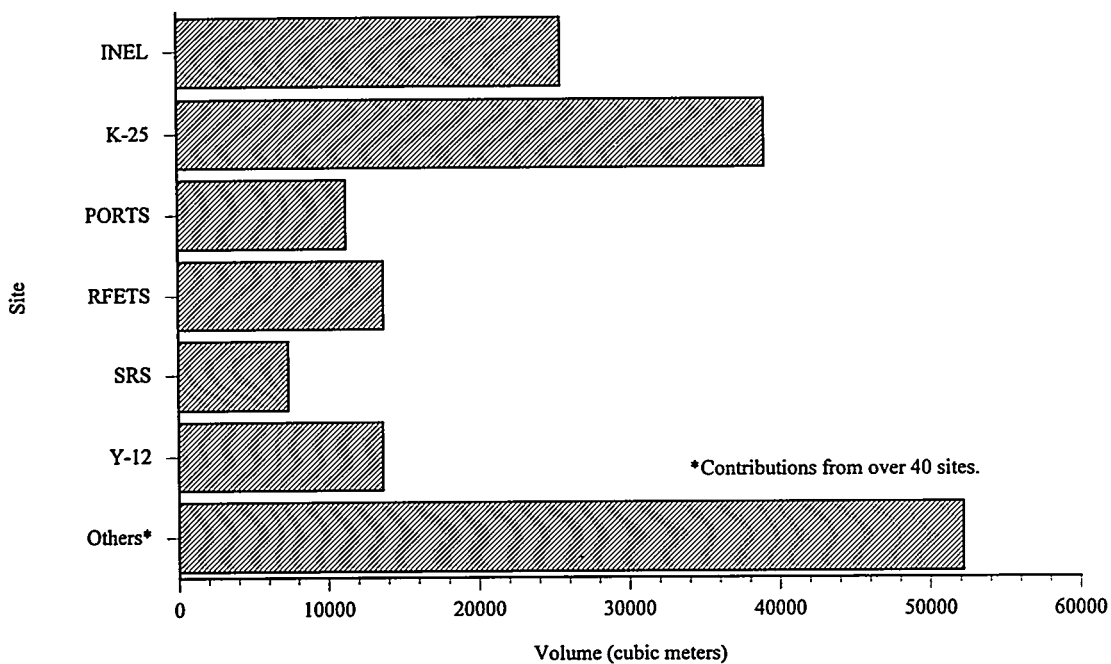


Fig. 8.1. Total volume inventory of all DOE MLLW.

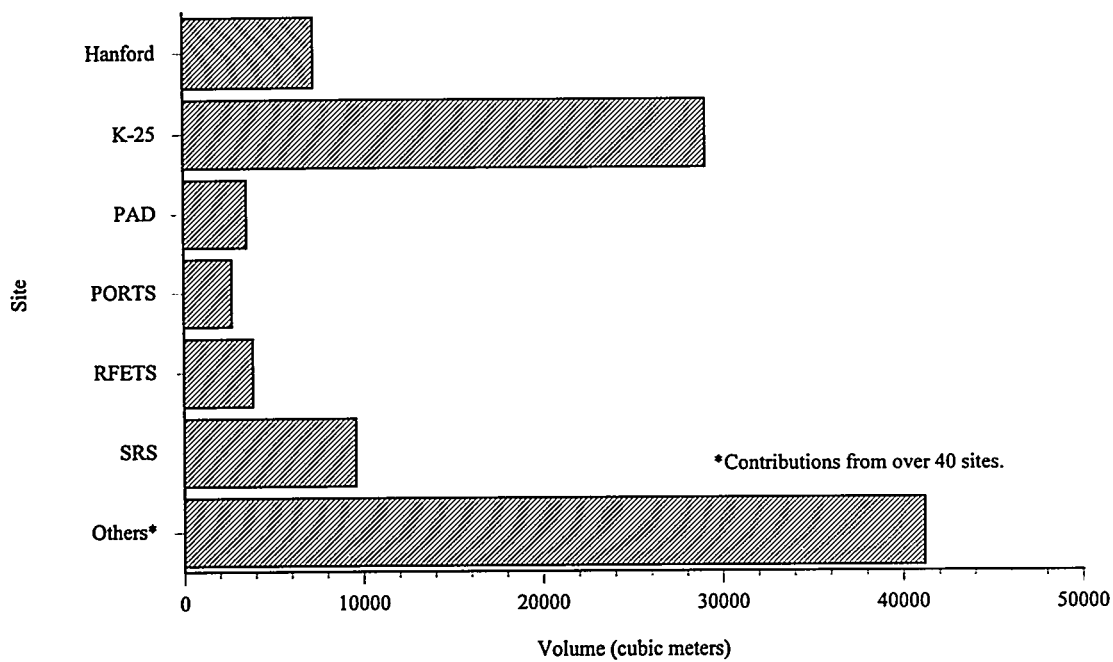


Fig. 8.2. Projected cumulative volume generation of all DOE MLLW during 1994-1998.

Table 8.1. Thirty-eight states and territories with EPA mixed waste authorization^a

State/territory	Effective date	State/territory	Effective date
Alabama	11/23/93	Montana	03/21/94
Arizona	01/22/93	Nebraska	12/03/88
Arkansas	05/29/90	Nevada	06/29/92
California	08/01/92	New Hampshire	11/14/94
Colorado	11/07/86	New Mexico	07/25/90
Connecticut	12/31/90	New York	05/07/90
Florida	02/12/91	North Carolina	11/21/89
Georgia	09/26/88	North Dakota	08/24/90
Guam	10/10/89	Ohio	06/30/89
Idaho	04/09/90	Oklahoma	11/27/90
Illinois	04/30/90	Oregon	05/29/90
Indiana	09/30/91	South Carolina	09/13/87
Kansas	06/25/90	South Dakota	06/17/91
Kentucky	12/19/88	Tennessee	08/11/87
Louisiana	10/26/91	Texas	03/15/90
Michigan	12/26/89	Utah	03/07/89
Minnesota	06/23/89	Vermont	08/06/93
Mississippi	05/28/91	Washington	11/23/87
Missouri	03/12/93	Wisconsin	04/24/92

^aBased on ref. 6. Information as of May 31, 1995.

Table 8.2. Cumulative mass (kg) inventories of MLLW from DOE site activities^a

Site	RCRA/state ^b	TSCA ^{c,d}	Total
Ames	154	2,600	2,754
ANL-E	e	62,400	62,400
ANL-W	587,334	e	587,334
BNL	24,573	1,000	25,573
ETEC	191	4,320	4,511
FEMP	e	e	e
FNAL	e	0	e
GJPO	395	69,705	70,100
Hanford ^f	420	109,387	109,807
INEL ^g	13,153,364	797	13,154,161
ITRI	e	0	e
K-25	41,138,289	6,381,168	47,519,457
KCP	116	0	116
LANL	e	2,504,237	2,504,237
LBL	e	214	214
LLNL	457,190	2,094	459,284
Mound	e	4,113	4,113
NR sites ^h	58,843	10,843	69,686
NTS	455,189	0	455,189
ORISE	e	0	e
ORNL	3,276,027	18,278	3,294,305
PAD	515,706	3,001,953	3,517,659
PANT	38,726	4,500	43,226
Pinellas	0	0	0
PORTS	7,200,966	2,076,200	9,277,166
PPPL	e	0	e
RFETS	1,536,428	38,610	1,575,038
RMI	20,354	e	20,354
SLAC	8,072	0	8,072
SNL/CA	62	2	64
SNL/NM	2,738	68	2,806
SRS	4,171,684	70,636	4,242,320
WVDP	104,323	10,850	115,173
Y-12	18,235,195	204,544	18,439,739
Others ⁱ	100,788	e	100,788
Total	91,087,127 ^j	14,578,519 ^k	105,665,646 ^k

^aMaterials may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bBased on the MWIR, ref. 7.

^cIn general, densities of 500 kg/m³ for compressed gases, 1,000 kg/m³ for liquids, and 1,500 kg/m³ for solids and sludges were assumed to estimate masses when site did not report mass data.

^dBased on the DOE site data submittals of ref. 10. Inventories as of December 31, 1994.

^eInformation not available or unknown.

^fIncludes contributions from PNL.

^gIncludes contributions from the Naval Reactors Facility (NRF).

^hIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), and Windsor (WIND).

ⁱIncludes contributions from Battelle Columbus Laboratories Decommissioning Project, Colonic Interim Storage Site, General Atomics facility, Laboratory for Energy-Related Health Research, Middlesex Sampling Plant, University of Missouri, Weldon Spring Site Remedial Action Project, and 6 naval shipyards (Charleston, South Carolina; Mare Island, California; Norfolk, Virginia; Pearl Harbor, Hawaii; Portsmouth, Maine; and Puget Sound, Washington).

^jMass values not reported for all streams; the values shown reflect only those which were reported.

^kExcludes contributions from sites that did not report complete mass data.

Table 8.3. Cumulative volume (m³) inventories of MLLW from DOE site activities^a

Site	RCRA/state ^b	TSCA ^c	Total
Ames	<0.1	3.4	3.5
ANL-E	34.4	52.0	86.4
ANL-W	391.5	d	391.5
BNL	26.6	2.1	28.7
ETEC	1.2	11.3	12.5
FEMP	2,150.6	d	2,150.6
FNAL	d	0	d
GJPO	0.6	46.5	47.1
Hanford ^e	6,331.0	95.6	6,426.6
INEL ^f	25,440.0	1.8	25,441.8
ITRI	0.0	0	0.0
K-25	29,472.9	9,493.3	38,966.2
KCP	0.2	0	0.2
LANL	608.6	5,992.5	6,601.1
LBL	6.2	0.1	6.3
LLNL	457.2	1.7	458.9
Mound	98.0	15.6	113.6
NR sites ^g	47.5	22.1	69.6
NTS	297.5	0	297.5
ORISE	d	0	d
ORNL	3,020.1	14.7	3,034.8
PAD	1,028.4	4,359.4	5,387.8
PANT	127.7	3.0	130.7
Pinellas	0	0	0
PORTS	7,514.5	3,669.8	11,184.3
PPPL	0.0	0	0.0
RFETS	13,550.1	112.0	13,662.1
RMI	23.5	d	23.5
SLAC	5.9	0	5.9
SNL/CA	0.4	0.2	0.6
SNL/NM	74.7	0.4	75.1
SRS	7,200.2	142.0	7,342.2
WVDP	86.3	43.9	130.2
Y-12	13,465.1	150.2	13,615.3
Others ^h	26,682.6	d	26,682.6
Total	138,143.6	24,233.6	162,377.2

^aMaterials may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bBased on the MWIR, ref. 7. Mass (kg) values were reported for only a portion of the streams.

^cBased on the DOE site data submittals of ref. 10. Inventories as of December 31, 1994.

^dInformation not available or unknown.

^eIncludes contributions from PNL.

^fIncludes contributions from the Naval Reactors Facility (NRF).

^gIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), and Windsor (WIND).

^hIncludes contributions from Battelle Columbus Laboratories Decommissioning Project, Colonie Interim Storage Site, General Atomics facility, Laboratory for Energy-Related Health Research, Middlesex Sampling Plant, University of Missouri, Weldon Spring Remedial Action Project, and 6 naval shipyards (Charleston, South Carolina; Mare Island, California; Norfolk, Virginia; Pearl Harbor, Hawaii; Portsmouth, Maine; and Puget Sound, Washington).

Table 8.4. Projected 5-year (1994–1998) cumulative mass (kg) generation of MLLW from DOE site activities

Site	RCRA/state ^a	TSCA ^{b,c,d}	Total
Ames	220	100	320
ANL-E	5,574	69,600	75,174
ANL-W	10,580	e	10,580
BNL	2,288	216	2,504
ETEC	e	13,400	13,400
FEMP	e	e	e
FNAL	e	0	e
GJPO	60	820	880
Hanford ^f	e	1,075,247	1,075,247
INEL ^g	1,069,473	164	1,069,637
ITRI	63,980	0	63,980
K-25	1,332,408	10,829,500	12,161,908
KCP	e	0	e
LANL	e	201,272	201,272
LBL	e	5,755	5,755
LLNL	e	1,165	1,165
Mound	e	2,414	2,414
NR sites ^h	1,105,243	305,070	1,410,313
NTS	4,339,981	d	4,339,981
ORISE	e	0	e
ORNL	685,996	91,390	777,386
PAD	e	2,284,826	2,284,826
PANT	719,432	4,500	723,932
Pinellas	e	1,850	1,850
PORTS	e	339,690	339,690
PPPL	e	0	e
RFETS	e	100,370	100,370
RMI	5,416	e	5,416
SLAC	e	0	e
SNL/CA	e	2	2
SNL/NM	e	e	e
SRS	1,900,729	170,050	2,070,779
WVDP	45,193	28,926	74,119
Y-12	1,829,276	153,140	1,982,416
Others ⁱ	32,773,112	e	32,773,112
Total	45,888,961 ^j	15,679,467 ^k	61,568,428 ^k

^aBased on the MWIR, ref. 7. RCRA/state projections for five sites [Ames Laboratory (Ames), Argonne National Laboratory–East (ANL–E), Portsmouth Gaseous Diffusion Plant (PORTS), Reactive Metals, Inc., Titanium Extrusion Plant (RMI), and Savannah River Site (SRS)] may include contributions from DOE environmental restoration (EM-40) wastes.

^bSpecific site information is provided in Sect. 8.4.

^cIn general, densities of 500 kg/m³ for compressed gases, 1,000 kg/m³ for liquids, and 1,500 kg/m³ for solids and sludges were assumed to estimate masses when site did not report mass data.

^dBased on the DOE site data submittals of ref. 10.

^eInformation not available or unknown.

^fIncludes contributions from PNL.

^gIncludes contributions from the Naval Reactors Facility (NRF).

^hIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), and Windsor (WIND).

ⁱIncludes contributions (if any) from BCLDP, Colonie Interim Storage Site (CISS), General Atomics (GA) facility, LEHR, Middlesex Sampling Plant, University of Missouri (MURR), and Weldon Spring Site Remedial Action Project (WSSRAP), and 6 naval shipyards (Charleston, South Carolina; Mare Island, California; Norfolk, Virginia; Pearl Harbor, Hawaii; Portsmouth, Maine; and Puget Sound, Washington).

^jMass (kg) values were provided for only a limited amount of the projected waste.

^kExcludes contributions from sites that did not report complete mass data.

Table 8.5. Projected 5-year (1994–1998) cumulative volume (m³) generation of MLLW from DOE site activities

Site	RCRA/state ^a	TSCA ^{b,c}	Total
Ames	<0.1	<0.2	<0.3
ANL–E	71.6	58.0	129.6
ANL–W	13.6	d	13.6
BNL	2.1	1.1	3.2
ETEC	d	31.1	31.1
FEMP	d	d	d
FNAL	d	0	d
GJPO	<0.1	1.9	2.0
Hanford ^e	6,559.8	716.8	7,276.6
INEL ^f	801.7	0.6	802.3
ITRI	77.1	0	77.1
K-25	1,076.1	27,934.0	29,010.1
KCP	d	0	d
LANL	84.3	396.6	480.9
LBL	5.6	14.0	19.6
LLNL	1,412.0	0.8	1,412.8
Mound	d	8.8	8.8
NR sites ^g	1,119.0	851.6	1,970.6
NTS	2,535.0	d	2,535.0
ORISE	d	0	d
ORNL	572.9	65.5	638.4
PAD	d	3,509.0	3,509.0
PANT	887.3	3.0	890.3
Pinellas	d	3.0	3.0
PORTS	1,648.0	1,035.9	2,683.9
PPPL	8.2	0	8.2
RFETS	3,623.4	220.0	3,843.4
RMI	7.7	d	7.7
SLAC	d	0	d
SNL/CA	4.1	0.2	4.3
SNL/NM	28.0	d	28.0
SRS	9,232.9	340.1	9,573.0
WVDP	29.8	19.3	49.1
Y-12	1,550.9	114.6	1,665.5
Others ^h	30,381.3	d	30,381.3
Total	61,732.6	35,326.1	97,058.7

^aBased on the MWIR, ref. 7. RCRA/state projections for five sites [Ames Laboratory (Ames), Argonne National Laboratory–East (ANL–E), Portsmouth Gaseous Diffusion Plant (PORTS), Reactive Metals, Inc., Titanium Extrusion Plant (RMI), and Savannah River Site (SRS)] include contributions from DOE environmental restoration (EM-40) wastes.

^bSpecific site information is provided in Sect. 8.4.

^cBased on the DOE site data submittals of ref. 10.

^dInformation not available or unknown.

^eIncludes contributions from PNL.

^fIncludes contributions from the Naval Reactors Facility (NRF).

^gIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), and Windsor (WIND).

^hIncludes contributions (if any) from BCLDP, Colonie Interim Storage Site (CISS), General Atomics (GA) facility, LEHR, Middlesex Sampling Plant, University of Missouri (MURR), Weldon Spring Remedial Action Project (WSSRAP), and 6 naval shipyards (Charleston, South Carolina; Mare Island, California; Norfolk, Virginia; Pearl Harbor, Hawaii; Portsmouth, Maine; and Puget Sound, Washington).

Table 8.6. Treatability group matrix parameter categories used to characterize RCRA- and state-regulated MLLW from DOE activities^a

Matrix parameter category	Description
<i>Liquids^b</i>	
Aqueous liquids/slurries	Liquids and slurries containing less than 1% total organic carbon (TOC)
Organic liquids	Liquids and slurries containing $\geq 1\%$ TOC
Unknown/other liquids	Liquids and slurries which can not be categorized as aqueous liquids/slurries or organic liquids because it is not known if the TOC level is less, or greater than 1%
<i>Solids^c</i>	
Inorganic homogeneous solids	Wastes that are at least 50 vol % inorganic homogeneous solids. Homogeneous solids are defined as solid waste materials, excluding soil/gravel, that do not meet the Environmental Protection Agency (EPA) land disposal restrictions (LDR) criteria for classification as debris. Inorganic homogeneous solids are further defined as those with sufficient inorganic solids content such that a minimum of approximately 20 wt % would remain as residue (i.e., ash/solids) following incineration
Organic homogeneous solids	Wastes that are at least 50 vol % organic homogeneous solids. Homogeneous solids are defined as solid waste materials, excluding soil/gravel, that do not meet the EPA LDR criteria for classification as debris. Organic homogeneous solids are further defined as those with a base structure that is primarily organic such that a maximum of approximately 20 wt % would remain as residue (i.e., ash/solids) following incineration
Unknown/other homogeneous solids	Wastes that are at least 50 vol % homogeneous solids, but: - are insufficiently characterized to enable categorization as either inorganic or organic homogeneous solids, or - do not meet the criteria for categorization as either inorganic or organic homogeneous solids
Soil/gravel	Wastes that are at least 50 vol % soil, including sand and silt or rock and gravel, that do not meet EPA LDR criteria for classification as debris
Inorganic debris	Wastes that are at least 80 vol % inorganic materials that meet the EPA LDR criteria for classification as debris. Examples include scrap metal, concrete, glass, and brick
Organic debris	Wastes that are at least 80 vol % organic materials that meet the EPA LDR criteria for classification as debris. Examples include plastic, rubber, wood, paper, cloth, and biological materials
Heterogeneous debris	Wastes that are at least 50 vol % debris materials that meet the EPA LDR criteria for classification as debris but are not dominant (i.e., at least 80 vol %) in either inorganic or organic debris materials
Unknown/other debris	Wastes that are at least 50 vol % materials that meet the EPA LDR criteria for classification as debris but lack adequate characterization information to enable categorizing as inorganic, organic, or heterogeneous debris
Unknown/other solids	Wastes with physically solid matrices for which insufficient characterization information exists to enable categorizing as a homogeneous solid, soil/gravel, or debris

Table 8.6 (continued)

Matrix parameter category	Description
<i>Specific waste forms^d</i>	
Lab packs	Wastes packaged in lab pack configurations. A lab pack configuration is defined as two or more waste containers packaged within a larger outer container. Typically, the inner containers are surrounded by absorbent materials. If present, the absorbents can be homogeneous solids or debris materials
Reactive metals	Reactive metal wastes that meet the criteria for classification as water-reactive or ignitable-reactive per the Third Third LDR rule (55 FR 22545 and 22553). Typically, this waste is sodium metal or sodium metal alloys, but can also include particulate fines of aluminum, uranium, zirconium, or other pyrophoric materials
Explosives/propellants	Wastes consisting of substances which undergo rapid chemical transformations that produce large amounts of gases and heat. The gases rapidly expand at velocities exceeding the speed of sound (due to the heat of reaction), which creates a shock wave and explosion. Waste that meets this definition is categorized as an explosive/propellant regardless of the specific physical form
Compressed gases/aerosols	Wastes consisting of pressurized gas cylinders or aerosol cans
Elemental mercury	Wastes that are bulk, pourable liquid mercury. The liquid mercury may be packaged in a lab pack configuration
Elemental hazardous metals	Wastes that are at least 50 vol % solid, bulk elemental hazardous metals that meet the EPA LDR size criteria for classification as debris. Typical examples of solid elemental hazardous metals are lead and cadmium
Beryllium dust	Wastes that are subject to the metal recovery treatment standard for beryllium dust as specified in the Third Third LDR rule (55 FR 22545)
Batteries	Wastes consisting of lead acid, cadmium, or other batteries. The batteries may be packaged with absorbent materials
Unknown/other matrix	Wastes for which insufficient characterization information is known to enable categorization as a liquid or solid or as one of the specific waste forms
<i>Final waste forms^e</i>	
Immobilized forms	Wastes that have been immobilized. This includes waste considered to be either micro- or macro-encapsulated
Decontaminated solids	Waste that has been decontaminated and is ready for disposal or recycling
Other final forms	Final waste forms other than immobilized forms and decontaminated solids

^aBased on ref. 9.

^bThis category addresses wastes that are liquid, including slurries, and are packaged in bulk, free form (i.e., excludes lab packs). Slurries are defined as liquids with a total suspended/settled solids (TSS) content of $\geq 1\%$ and $\leq 30\%$.

^cThis category addresses waste with physically solid matrices, including sludges. Sludges are defined as having a TSS $> 30\%$. Certain waste with physically solid matrices are excluded from this category (see the "specific waste forms" and "final waste forms" categories above).

^dThis category addresses lab packs and other specific waste forms. The other specific waste forms include waste that (a) is inherently hazardous (i.e., the bulk material itself is RCRA hazardous), or (b) presents unique treatment or management concerns.

^eThis category addresses waste that is in final form and meets applicable disposal criteria, including applicable LDR and PCB treatment standards.

Table 8.7. Cumulative mass and volume inventories of RCRA- and state-regulated MLLW at each DOE site^a

Site	Category ^b	Inventory		
		Date(s) ^c	Mass (kg)	Volume (m ³)
Ames	Aqueous liquids/slurries		100	0.05
	Elemental hazardous metals		50	0.01
	Lab packs		4	0.01
	Ames total	02/01/95–04/01/95	154	0.07
ANL–E	Aqueous liquids/slurries		d	0.02
	Elemental hazardous metals		d	17.53
	Inorganic debris		d	0.67
	Inorganic homogeneous solids		d	5.10
	Lab packs		d	9.36
	Organic debris		d	0.79
	Reactive metals		d	0.53
	Soil/gravel		d	0.40
	ANL–E total	06/01/95	d	34.40
ANL–W	Aqueous liquids/slurries		537	0.42
	Heterogeneous debris		599	3.08
	Inorganic homogeneous solids		177	0.42
	Organic debris		1,799	0.57
	Organic liquids		42	0.08
	Reactive metals		584,180	386.99
	ANL–W total	04/30/95	587,334	391.56
BNL	Elemental hazardous metals		385	0.44
	Elemental mercury		238	0.45
	Heterogeneous debris		386	1.03
	Inorganic homogeneous solids		7,200	6.20
	Lab packs		469	0.57
	Organic liquids		15,895	17.95
	BNL total	06/01/95	24,573	26.64
ETEC	Elemental mercury		d	0.10
	Inorganic homogeneous solids		159	0.99
	Organic liquids		32	0.15
	Reactive metals		d	e
	ETEC total	03/01/95–06/01/95	191	1.24
FEMP	Aqueous liquids/slurries		d	869.80
	Batteries		d	5.00
	Compressed gases/aerosols		d	0.40
	Elemental hazardous metals		d	2.00
	Elemental mercury		d	0.20
	Heterogeneous debris		d	26.60
	Immobilized forms		d	33.40
	Inorganic debris		d	17.40
	Inorganic homogeneous solids		d	706.20
	Lab packs		d	0.40

Table 8.7 (continued)

Site	Category ^b	Inventory		
		Date(s) ^c	Mass (kg)	Volume (m ³)
FEMP (contd.)	Organic debris		d	21.20
	Organic homogeneous solids		d	78.20
	Organic liquids		d	374.80
	Reactive metals		d	2.60
	Soil/gravel		d	11.20
	Unknown/other debris		d	0.80
	Unknown/other solids		d	0.40
	FEMP total	10/01/94	d	2,150.60
FNAL		d	d	d
GJPO	Aqueous liquids/slurries		18	0.03
	Inorganic homogeneous solids		191	0.19
	Lab packs		59	0.22
	Organic debris		5	0.01
	Organic liquids		119	0.12
	Soil/gravel		3	e
	GJPO total	05/01/94–05/01/95	395	0.57
Hanford ^f	Batteries		d	1.65
	Elemental hazardous metals		d	210.81
	Elemental mercury		d	1.46
	Heterogeneous debris		d	629.69
	Inorganic debris		d	491.35
	Inorganic homogeneous solids		d	2,655.57
	Lab packs		420	264.91
	Organic debris		d	1,587.26
	Organic homogeneous solids		d	1.90
	Organic liquids		d	0.21
	Reactive metals		d	8.50
	Soil/gravel		d	459.06
	Unknown/other matrix		d	18.63
	Hanford total	12/31/94–05/01/95	420	6,331.00
INEL ^g	Aqueous liquids/slurries		11,050	12.29
	Elemental hazardous metals		871,676	445.55
	Heterogeneous debris		1,063,830	2,954.49
	Inorganic debris		3,582,300	9,302.00
	Inorganic homogeneous solids		4,040,955	3,929.34
	Lab packs		1,455	4.08
	Organic debris		1,817,593	5,404.64
	Organic homogeneous solids		4,244	6.08
	Organic liquids		10,119	12.86
	Reactive metals		694	0.93
	Soil/gravel		217,747	222.31
	Unknown/other homogeneous solids		200	0.64
	Unknown/other solids		1,531,501	3,144.79
	INEL total	12/31/94–4/30/95	13,153,364	25,440.00

Table 8.7 (continued)

Site	Category ^b	Inventory		
		Date(s) ^c	Mass (kg)	Volume (m ³)
ITRI		d	d	d
K-25	Aqueous liquids/slurries		445,285	442.19
	Batteries		24,345	16.23
	Beryllium dust		259	0.17
	Compressed gases/aerosols		6,943	5.76
	Elemental hazardous metals		135,551	90.37
	Elemental mercury		5,473	5.04
	Explosives/propellants		119	0.08
	Heterogeneous debris		153,910	102.99
	Inorganic debris		237,675	158.45
	Inorganic homogeneous solids		38,581,756	27,484.14
	Lab packs		23,273	21.85
	Organic debris		186,857	124.73
	Organic homogeneous solids		482,174	334.91
	Organic liquids		350,589	348.13
	Reactive metals		118	0.08
	Soil/gravel		407,451	271.63
	Unknown/other matrix		96,511	66.16
	K-25 total	12/31/94	41,138,289	29,472.90
KCP	Inorganic debris	01/01/95	116	0.21
LANL	Aqueous liquids/slurries		d	3.34
	Compressed gases/aerosols		d	1.68
	Elemental hazardous metals		d	133.95
	Heterogeneous debris		d	6.32
	Inorganic homogeneous solids		d	269.51
	Organic debris		d	42.14
	Organic liquids		d	55.42
	Reactive metals		d	6.03
	Soil/gravel		d	49.85
	Unknown/other debris		d	7.82
	Unknown/other matrix		d	32.54
	LANL total	09/30/94	d	608.60
LBL	Aqueous liquids/slurries		d	2.16
	Elemental hazardous metals		d	0.43
	Elemental mercury		d	0.11
	Heterogeneous debris		d	0.11
	Lab packs		d	0.15
	Organic liquids		d	3.30
	LBL total	08/01/94–05/01/95	d	6.26
LLNL	Elemental mercury		90	0.09
	Heterogeneous debris		62,400	62.40
	Inorganic debris		19,100	19.10
	Inorganic homogeneous solids		253,200	253.20
	Lab packs		6,300	6.30

Table 8.7 (continued)

Site	Category ^b	Inventory		
		Date(s) ^c	Mass (kg)	Volume (m ³)
LLNL (contd.)	Organic homogeneous solids		1,200	1.20
	Organic liquids		92,800	92.80
	Reactive metals		5,400	5.40
	Soil/gravel		16,700	16.70
	LLNL total	01/01/95	457,190	457.19
MOUND	Batteries		d	0.85
	Elemental hazardous metals		d	5.00
	Elemental mercury		d	0.02
	Inorganic homogeneous solids		d	0.23
	Lab packs		d	43.47
	Organic debris		d	0.02
	Organic liquids		d	28.50
	Unknown/other matrix		d	19.90
	Mound total	05/01/94	d	97.98
NR sites ^h	Aqueous liquids/slurries		25,532	26.13
	Elemental hazardous metals		24,699	7.76
	Elemental mercury		192	0.02
	Heterogeneous debris		1,202	4.28
	Inorganic debris		180	1.02
	Inorganic homogeneous solids		538	0.92
	Lab packs		102	0.09
	Organic debris		72	0.74
	Organic homogeneous solids		4,095	3.57
	Organic liquids		1,000	1.46
	Reactive metals		205	0.03
	Soil/gravel		1,025	1.47
	NR sites total	12/01/94	58,843	47.49
NTS	Elemental hazardous metals		52,296	4.90
	Inorganic homogeneous solids		364,744	260.00
	Organic homogeneous solids		2,144	1.51
	Organic liquids		153	0.21
	Soil/gravel		35,852	30.91
	NTS total	11/01/93–04/01/95	455,189	297.53
ORISE		d	d	d
ORNL	Aqueous liquids/slurries		3,003,608	2,799.37
	Batteries		1,269	1.02
	Beryllium dust		11	0.01
	Compressed gases/aerosols		i	d
	Elemental hazardous metals		221	0.15
	Elemental mercury		773	0.76
	Explosives/propellants		14	0.01
	Heterogeneous debris		3,234	2.17
	Inorganic debris		4,107	2.71

Table 8.7 (continued)

Site	Category ^b	Inventory		
		Date(s) ^c	Mass (kg)	Volume (m ³)
ORNL (contd.)	Inorganic homogeneous solids		102,915	68.93
	Lab packs		37,028	35.91
	Organic debris		3,529	2.35
	Organic homogeneous solids		475	0.32
	Organic liquids		61,384	61.21
	Reactive metals		601	0.40
	Soil/gravel		8,162	5.44
	Unknown/other liquids		2,105	2.10
	Unknown/other matrix		34,152	28.45
	Unknown/other solids		12,439	8.75
	ORNL total	12/31/94	3,276,027	3,020.06
PAD	Aqueous liquids/slurries		50,071	61.43
	Batteries		3,039	4.99
	Compressed gases/aerosols		4,951	15.40
	Elemental hazardous metals		5,172	4.25
	Elemental mercury		159	0.52
	Explosives/propellants		13	0.21
	Heterogeneous debris		1,538	4.02
	Inorganic debris		133,582	538.78
	Inorganic homogeneous solids		81,331	86.95
	Lab packs		4,432	7.70
	Organic debris		36,025	78.71
	Organic homogeneous solids		15,068	20.97
	Organic liquids		152,257	173.21
	Soil/gravel		5,923	5.01
	Unknown/other matrix		22,147	26.25
	PAD total	12/31/94	515,706	1,028.40
PANT	Aqueous liquids/slurries		1,677	1.75
	Batteries		21	0.05
	Compressed gases/aerosols		1	e
	Elemental hazardous metals		22	0.06
	Heterogeneous debris		1,260	3.80
	Inorganic debris		4,230	11.20
	Inorganic homogeneous solids		3,675	18.90
	Lab packs		1,929	7.29
	Organic debris		24,793	82.01
	Organic liquids		1,118	2.60
	PANT total	03/01/95	38,726	127.66
Pinellas		d	d	d
PORTS	Aqueous liquids/slurries		76,956	113.33
	Batteries		91,600	80.00
	Compressed gases/aerosols		1,899	7.00
	Elemental mercury		880	2.20
	Heterogeneous debris		434,703	842.33
	Inorganic debris		63,950	101.70
	Inorganic homogeneous solids		535,201	655.75
	Lab packs		13,590	29.20

Table 8.7 (continued)

Site	Category ^b	Inventory		
		Date(s) ^c	Mass (kg)	Volume (m ³)
PORTS (contd.)	Organic debris		151,104	280.44
	Organic homogeneous solids		213,319	273.60
	Organic liquids		175,164	250.79
	Reactive metals			0.60
	Soil/gravel		5,442,600	4,877.60
	PORTS total	12/01/94	7,200,966	7,514.54
PPPL		d	d	d
RFETS	Aqueous liquids/slurries		293	533.26
	Beryllium dust		1,028	3.15
	Elemental hazardous metals		27,838	34.69
	Heterogeneous debris		1,785	6.66
	Inorganic debris		14,162	170.66
	Inorganic homogeneous solids		561,396	10,975.96
	Lab packs		d	47.38
	Organic debris		588,326	1,241.53
	Organic liquids		d	130.80
	Soil/gravel		341,600	406.05
	RFETS total	10/01/94	1,536,428	13,550.14
RMI	Aqueous liquids/slurries		2,221	2.43
	Inorganic debris		6,122	6.40
	Inorganic homogeneous solids		4,686	4.16
	Organic debris		1,308	3.53
	Organic liquids		6,017	7.00
	RMI total	03/01/95	20,354	23.52
SLAC	Aqueous liquids/slurries		12	0.01
	Elemental hazardous metals		8,060	5.90
	SLAC total	11/01/94–03/01/95	8,072	5.91
SNL/CA	Lab packs	05/01/95	62	0.40
SNL/NM	Aqueous liquids/slurries		d	0.02
	Elemental hazardous metals		131	0.04
	Elemental mercury		3	e
	Heterogeneous debris		d	4.37
	Inorganic debris		1,450	9.70
	Inorganic homogeneous solids		1	0.01
	Organic debris		1,098	28.60
	Organic liquids		3	2.91
	Reactive metals		53	0.06
	Unknown/other debris		d	29.00
	SNL/NM total	05/01/95	2,738	74.71
SRS	Aqueous liquids/slurries		158,140	157.70
	Elemental hazardous metals		129,386	82.20
	Elemental mercury		5,369	2.70

Table 8.7 (continued)

Site	Category ^b	Inventory		
		Date(s) ^c	Mass (kg)	Volume (m ³)
SRS (contd.)	Heterogeneous debris		385,250	3,013.60
	Immobilized forms		2,270	0.30
	Inorganic debris		105,809	89.60
	Inorganic homogeneous solids		3,039,362	2,724.20
	Lab packs		7,476	8.40
	Organic debris		4,950	13.90
	Organic liquids		108,381	139.00
	Reactive metals		318	0.80
	Soil/gravel		23,568	16.80
	Unknown/other debris		201,405	951.00
	SRS total	09/01/94–10/01/94	4,171,684	7,200.20
WVDP	Aqueous liquids/slurries		1,593	0.71
	Batteries		86	0.06
	Elemental hazardous metals		14,297	1.26
	Elemental mercury		6	e
	Heterogeneous debris		67,888	68.89
	Inorganic debris		2,603	1.74
	Inorganic homogeneous solids		966	0.44
	Lab packs		286	0.30
	Organic homogeneous solids		70	0.07
	Organic liquids		4,094	4.51
	Unknown/other debris		12,394	8.26
	Unknown/other matrix		39	0.03
	WVDP total	09/01/94	104,323	86.26
Y-12	Aqueous liquids/slurries		40,187	40.13
	Batteries		6,376	4.25
	Beryllium dust		7	e
	Compressed gases/aerosols		831	0.80
	Elemental hazardous metals		7,385	4.92
	Elemental mercury		160	0.13
	Explosives/propellants		1	e
	Heterogeneous debris		49,791	33.72
	Inorganic debris		23,542	15.71
	Inorganic homogeneous solids		7,781,626	6,475.92
	Lab packs		278	0.26
	Organic debris		80,862	54.04
	Organic homogeneous solids		57,845	46.21
	Organic liquids		313,716	313.68
	Reactive metals		1,012	0.68
	Soil/gravel		9,793,441	6,421.72
	Unknown/other liquids		2,258	2.26
	Unknown/other matrix		42	0.03
	Unknown/other solids		75,835	50.62
	Y-12 total	12/31/94	18,235,195	13,465.07
Others ^j	Aqueous liquids/slurries		36,040	43.98
	Batteries		39	3.50
	Elemental hazardous metals		4,118	28.90
	Elemental mercury		d	0.40

Table 8.7 (continued)

Site	Category ^b	Inventory		
		Date(s) ^c	Mass (kg)	Volume (m ³)
Others ^j (contd.)	Heterogeneous debris		21,149	647.03
	Immobilized forms		d	2.54
	Inorganic debris		18,017	1,011.87
	Inorganic homogeneous solids		7,851	73.12
	Lab packs		i	4.48
	Organic debris		12,648	320.44
	Organic homogeneous solids		d	2.27
	Organic liquids		17	60.68
	Reactive metals		d	0.20
	Soil/gravel		d	24,481.42
	Unknown/other debris		100	0.23
	Unknown/other liquids		542	0.55
	Unknown/other matrix		d	0.21
	Unknown/other solids		267	0.67
	Others total	03/01/94–05/01/95	100,788	26,682.49
	Grand total (DOE complex)	11/01/93–06/01/95	91,087,127	138,143.60

^aBased on MWIR, ref. 7.

^bAs described in Table 8.6.

^cAs reported in the MWIR, different categories of MLLW for a site may have different inventory dates. Thus, a range of dates may be reported for a site's MLLW inventory. Each date is specified by the numbering system used for month/day/calendar year.

^dInformation not available.

^eValue <0.005 m³.

^fIncludes contributions from PNL.

^gIncludes contributions from the Naval Reactors Facility (NRF).

^hIncludes contributions (if any) from Bettis (BAPL), Knolls, (KAPL), Kesselring (KESS), and Windsor (WIND).

ⁱValue <0.5 kg.

^jIncludes contributions from Battelle Columbus Laboratories Decommissioning Project, Colonie Interim Storage Site, General Atomics facility, Laboratory for Energy-Related Health Research, Middlesex Sampling Plant, University of Missouri, Weldon Spring Site Remedial Action Project, and 6 naval shipyards (Charleston, South Carolina; Mare Island, California; Norfolk, Virginia; Pearl Harbor, Hawaii; Portsmouth, Maine; and Puget Sound, Washington).

Table 8.8. Cumulative mass and volume inventories, by physical/chemical matrix category, of RCRA- and state-regulated MLLW from DOE site activities^a

Category ^b	Mass ^c (kg)	Volume (m ³)
Liquids		
Aqueous liquids/slurries	3,853,320.96	5,110.56
Organic liquids	1,292,901.32	2,082.38
Unknown/other liquids	4,904.83	4.91
Solids		
Heterogeneous debris	2,248,924.00	8,417.58
Inorganic debris	4,216,943.93	11,950.26
Inorganic homogeneous solids	55,367,931.09	56,656.34
Organic debris	2,910,967.26	9,287.65
Organic homogeneous solids	780,633.67	770.81
Soil/gravel	16,294,071.28	37,277.58
Unknown/other debris	213,899.41	997.11
Unknown/other homogeneous solids	199.58	0.64
Unknown/other solids	1,620,040.95	3,205.23
Specific waste forms		
Batteries	126,774.31	117.59
Beryllium dust	1,304.81	3.33
Compressed gases/aerosols	14,625.31	31.04
Explosives/propellants	146.63	0.30
Elemental hazardous metals	1,281,286.31	1,081.11
Elemental mercury	13,343.80	14.21
Lab packs	97,164.48	492.72
Reactive metals	592,582.29	413.83
Final waste forms	2,270.00	36.24
Uncategorized matrix	152,890.71	192.19
Grand total (DOE complex)	91,087,127	138,143.6

^aBased on the MWIR, ref. 7. Detailed site data for these categories are also reported in this reference.

^bAs described in Table 8.6.

^cMass values were not reported for all streams. The values shown reflect only those that were reported.

Table 8.9. Projected 5-year (1994–1998) cumulative mass and volume generation, by physical/chemical matrix category, of RCRA- and state-regulated MLLW from DOE site activities^a

Category ^b	Mass ^c (kg)	Volume (m ³)
Liquids		
Aqueous liquids/slurries	3,929,174.20	8,401.97
Organic liquids	828,666.04	2,100.98
Unknown/other liquids	22,440.00	22.44
Solids		
Heterogeneous debris	792,545.50	3,797.89
Inorganic debris	526,992.46	3,616.65
Inorganic homogeneous solids	2,138,302.40	4,532.64
Organic debris	488,520.48	4,575.32
Organic homogeneous solids	61,008.00	161.60
Soil/gravel	4,405,487.00	3,396.37
Unknown/other debris	49,061.02	55.54
Unknown/other homogeneous solids	3,440.00	4.28
Unknown/other solids	34,381.60	26.02
Specific waste forms		
Batteries	13,579.40	19.78
Compressed gases/aerosols	2,220.00	5.31
Explosives/propellants	4.00	d
Elemental hazardous metals	512,115.35	407.47
Elemental mercury	20,706.16	8.61
Lab packs	26,729.05	934.27
Reactive metals	10,037.92	13.50
Final waste forms	32,020,874.00	29,603.24
Uncategorized matrix	2,676.00	48.70
Grand total (DOE complex)	45,888,961	61,732.6

^aBased on the MWIR, ref. 7. Detailed site data for these categories are also reported in this reference.

^bAs described in Table 8.6.

^cMass values were not reported for all streams. The values shown reflect only those that were reported.

^dValue <0.005 m³.

Table 8.10. Cumulative mass (kg) inventories through 1994, by physical category, of TSCA-regulated MLLW from DOE site activities^{a,b}

Site	Solid	Liquid	Gas ^c	Sludge	Total
Ames	2,600	0	0	0	2,600
ANL-E	0	0	0	62,400	62,400
ANL-W	d	d	d	d	d
BNL	1,000	0	0	0	1,000
ETEC	4,320	0	0	0	4,320
FEMP	d	d	d	d	d
FNAL	0	0	0	0	0
GJPO	69,705	0	0	0	69,705
Hanford ^e	109,387	0	0	0	109,387
INEL ^f	232	565	0	0	797
ITRI	0	0	0	0	0
K-25	6,231,540	135,768	0	13,860	6,381,168
KCP	0	0	0	0	0
LANL	2,504,237	0	0	0	2,504,237
LBL	214	0	0	0	214
LLNL	1,637	434	0	23	2,094
Mound	4,113	0	0	0	4,113
NR sites ^g	10,714	129	0	0	10,843
NTS	0	0	0	0	0
ORISE	0	0	0	0	0
ORNL	10,749	7,473	0	56	18,278
PAD	2,930,037	71,916	0	0	3,001,953
PANT	4,500	0	0	0	4,500
Pinellas	0	0	0	0	0
PORTS	2,020,300	55,900	0	e	2,076,200
PPPL	0	0	0	0	0
RFETS	33,680	4,930	0	0	38,610
SLAC	0	0	0	0	0
SNL/CA	2	0	0	0	2
SNL/NM ^h	68	0	0	0	68
SRS	70,636	0	0	0	70,636
WVDP	10,850	0	0	0	10,850
Y-12	163,130	41,414	0	e	204,544
Total	14,183,651	318,529	0	76,339	14,578,519

^aBased on the DOE site data submittals of ref. 10. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bIn general, densities of 500 kg/m³ for compressed gases, 1,000 kg/m³ for liquids, and 1,500 kg/m³ for solids and sludges were assumed to calculate masses when the site did not report mass data.

^cStored in cylinders.

^dInformation not available or unknown.

^eIncludes contributions from PNL.

^fExcludes contributions from ANL-W.

^gIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

^hInformation for CY 1993. Information for CY 1994 not available.

Table 8.11. Cumulative volume (m³) inventories through 1994, by physical category, of TSCA-regulated MLLW from DOE site activities^{a,b}

Site	Solid	Liquid	Gas ^c	Sludge	Total
Ames	3.4	0.0	0.0	0.0	3.4
ANL-E	0.0	0.0	0.0	52.0	52.0
ANL-W	d	d	d	d	d
BNL	2.1	0.0	0.0	0.0	2.1
ETEC	11.3	0.0	0.0	0.0	11.3
FEMP	d	d	d	d	d
FNAL	0.0	0.0	0.0	0.0	0.0
GJPO	46.5	0.0	0.0	0.0	46.5
Hanford ^e	95.6	0.0	0.0	0.0	95.6
INEL ^f	0.8	1.0	0.0	0.0	1.8
ITRI	0.0	0.0	0.0	0.0	0.0
K-25	9,340.2	138.2	0.0	14.9	9,493.3
KCP	0.0	0.0	0.0	0.0	0.0
LANL	5,992.5	0.0	0.0	0.0	5,992.5
LBL	0.1	0.0	0.0	0.0	0.1
LLNL	1.2	0.4	0.0	<0.1	1.7
Mound	15.6	0.0	0.0	0.0	15.6
NR sites ^g	21.9	0.2	0.0	0.0	22.1
NTS	0.0	0.0	0.0	0.0	0.0
ORISE	0.0	0.0	0.0	0.0	0.0
ORNL	7.2	7.5	0.0	~0.0	14.7
PAD	4,280.3	79.1	0.0	0.0	4,359.4
PANT	3.0	0.0	0.0	0.0	3.0
Pinellas	0.0	0.0	0.0	0.0	0.0
PORTS	3,574.0	95.8	0.0	e	3,669.8
PPPL	0.0	0.0	0.0	0.0	0.0
RFETS	104.0	8.0	0.0	0.0	112.0
SLAC	0.0	0.0	0.0	0.0	0.0
SNL/CA	0.2	0.0	0.0	0.0	0.2
SNL/NM ^h	0.4	0.0	0.0	0.0	0.4
SRS	142.0	0.0	0.0	0.0	142.0
WVDP	43.9	0.0	0.0	0.0	43.9
Y-12	108.8	41.4	0.0	0.0	150.2
Total	23,795.0	371.6	0.0	67.0	24,233.6

^aBased on the DOE site data submittals of ref. 10. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bIn general, densities of 500 kg/m³ for compressed gases, 1,000 kg/m³ for liquids, and 1,500 kg/m³ for solids and sludges were assumed to calculate masses when the site did not report mass data.

^cStored in cylinders.

^dInformation not available or unknown.

^eIncludes contributions from PNL.

^fExcludes contributions from ANL-W.

^gIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

^hInformation for CY 1993. Information for CY 1994 not available.

Table 8.12. 1994 mass (kg) generation, by physical category, of TSCA-regulated MLLW from DOE site activities^{a,b}

Site	Solid	Liquid	Gas ^c	Sludge	Total
Ames	0	0	0	0	0
ANL-E	0	0	0	62,400	62,400
ANL-W	d	d	d	d	d
BNL	91	0	0	0	91
ETEC	3,600	0	0	0	3,600
FEMP	d	d	d	d	d
FNAL	0	0	0	0	0
GJPO	720	0	0	0	720
Hanford ^e	4,997	0	0	0	4,997
INEL ^f	164	0	0	0	164
ITRI	0	0	0	0	0
K-25	2,030,331	125,460	0	10,109	2,165,900
KCP	0	0	0	0	0
LANL	59,272	0	0	0	59,272
LBL	1,151	0	0	0	1,151
LLNL	1,165	0	0	0	1,165
Mound	2,054	0	0	0	2,054
NR sites ^g	123,517	0	0	0	123,517
NTS	0	0	0	0	0
ORISE	0	0	0	0	0
ORNL	15,625	2,643	0	10	18,278
PAD	292,999	119,265	0	0	412,264
PANT	4,500	0	0	0	4,500
Pinellas	0	0	0	0	0
PORTS	85,570	5,920	0	0	91,490
PPPL	0	0	0	0	0
RFETS	8,280	250	0	0	8,530
SLAC	0	0	0	0	0
SNL/CA	2	0	0	0	2
SNL/NM ^h	0	0	0	0	0
SRS	6,050	0	0	0	6,050
WVDP	6,726	0	0	0	6,726
Y-12	19,701	7,439	0	0	27,140
Total	2,666,515	260,977	0	72,519	3,000,011

^aBased on the DOE site data submittals of ref. 10. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bIn general, densities of 500 kg/m³ for compressed gases, 1,000 kg/m³ for liquids, and 1,500 kg/m³ for solids and sludges were assumed to calculate masses when the site did not report mass data.

^cStored in cylinders.

^dInformation not available or unknown.

^eIncludes contributions from PNL.

^fExcludes contributions from ANL-W.

^gIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

^hInformation for CY 1993. Information for CY 1994 not available.

Table 8.13. 1994 volume (m³) generation, by physical category, of TSCA-regulated MLLW from DOE site activities^{a,b}

Site	Solid	Liquid	Gas ^c	Sludge	Total
Ames	0.0	0.0	0.0	0.0	0.0
ANL-E	0.0	0.0	0.0	52.0	52.0
ANL-W	d	d	d	d	d
BNL	0.4	0.0	0.0	0.0	0.4
ETEC	8.1	0.0	0.0	0.0	8.1
FEMP	d	d	d	d	d
FNAL	0.0	0.0	0.0	0.0	0.0
GJPO	1.5	0.0	0.0	0.0	1.5
Hanford ^e	3.3	0.0	0.0	0.0	3.3
INEL ^f	0.6	0.0	0.0	0.0	0.6
ITRI	0.0	0.0	0.0	0.0	0.0
K-25	5,438.9	137.0	0.0	10.9	5,586.8
KCP	0.0	0.0	0.0	0.0	0.0
LANL	166.6	0.0	0.0	0.0	166.6
LBL	2.8	0.0	0.0	0.0	2.8
LLNL	0.8	0.0	0.0	0.0	0.8
Mound	6.8	0.0	0.0	0.0	6.8
NR sites ^g	344.5	0.0	0.0	0.0	344.5
NTS	0.0	0.0	0.0	0.0	0.0
ORISE	0.0	0.0	0.0	0.0	0.0
ORNL	10.4	2.7	0.0	~0.0	13.1
PAD	931.7	129.1	0.0	0.0	1,060.8
PANT	3.0	0.0	0.0	0.0	3.0
Pinellas	0.0	0.0	0.0	0.0	0.0
PORTS	242.2	17.7	0.0	0.0	259.9
PPPL	0.0	0.0	0.0	0.0	0.0
RFETS	35.0	1.0	0.0	0.0	36.0
SLAC	0.0	0.0	0.0	0.0	0.0
SNL/CA	0.2	0.0	0.0	0.0	0.2
SNL/NM ^h	0.0	0.0	0.0	0.0	0.0
SRS	12.1	0.0	0.0	0.0	12.1
WVDP	4.5	0.0	0.0	0.0	4.5
Y-12	13.1	7.5	0.0	0.0	20.6
Total	7,226.5	295.0	0.0	62.9	7,584.4

^aBased on the DOE site data submittals of ref. 10. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bDensities of 500 kg/m³ for compressed gases, 1,000 kg/m³ for liquids, and 1,500 kg/m³ for solids and sludges were assumed to calculate masses when the site did not report mass data.

^cStored in cylinders.

^dInformation not available or unknown.

^eIncludes contributions from PNL.

^fExcludes contributions from ANL-W.

^gIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

^hInformation for CY 1993. Information for CY 1994 not available.

Table 8.14. Cumulative mass (kg) inventories through 1994, by hazard category, of TSCA-regulated MLLW from DOE site activities^a

Site	PCB	Asbestos	Other	Total
Ames	0	2,600	0	2,600
ANL-E	62,400	0	0	62,400
ANL-W	b	b	b	b
BNL	0	1,000	0	1,000
ETEC	0	4,320	0	4,320
FEMP	b	b	b	b
FNAL	0	0	0	0
GJPO	69,705	0	0	69,705
Hanford ^c	109,387	b	b	109,387
INEL ^d	797	0	0	797
ITRI	0	0	0	0
K-25	6,129,696	249,865	1,607	6,381,168
KCP	0	0	0	0
LANL	2,010,033	494,204	0	2,504,237
LBL	214	0	0	214
LLNL	475	1,619	0	2,094
Mound	0	4,113	0	4,113
NR sites ^e	10,843	0	0	10,843
NTS	0	0	0	0
ORISE	0	0	0	0
ORNL	14,897	3,312	69	18,278
PAD	2,807,972	193,981	0	3,001,953
PANT	0	4,500	0	4,500
Pinellas	0	0	0	0
PORTS	1,886,000	190,200	0	2,076,200
PPPL	0	0	0	0
RFETS	36,240	2,370	0	38,610
SLAC	0	0	0	0
SNL/CA	0	2	0	2
SNL/NM ^f	0	68	0	68
SRS	636	70,000	0	70,636
WVDP	0	10,850	0	10,850
Y-12	204,544	0	0	204,544
Total	13,343,839	1,233,004	1,676	14,578,519

^aBased on the DOE site data submittals of ref. 10. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bInformation not available or unknown.

^cIncludes contributions from PNL.

^dExcludes contributions from ANL-W.

^eIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

^fInformation for CY 1993. Information for CY 1994 not available.

Table 8.15. Cumulative volume (m³) inventories through 1994, by hazard category, of TSCA-regulated MLLW from DOE site activities^a

Site	PCB	Asbestos	Other	Total
Ames	0.0	3.4	0.0	3.4
ANL-E	52.0	0.0	0.0	52.0
ANL-W	b	b	b	b
BNL	0.0	2.1	0.0	2.1
ETEC	0.0	11.3	0.0	11.3
FEMP	b	b	b	b
FNAL	0.0	0.0	0.0	0.0
GJPO	46.5	0.0	0.0	46.5
Hanford ^c	95.6	b	b	95.6
INEL ^d	1.8	0.0	0.0	1.8
ITRI	0.0	0.0	0.0	0.0
K-25	8,130.1	1,356.3	6.9	9,493.3
KCP	0.0	0.0	0.0	0.0
LANL	2,100.7	3,891.8	0.0	5,992.5
LBL	0.1	0.0	0.0	0.1
LLNL	0.5	1.2	0.0	1.7
Mound	0.0	15.6	0.0	15.6
NR sites ^e	22.1	0.0	0.0	22.1
NTS	0.0	0.0	0.0	0.0
ORISE	0.0	0.0	0.0	0.0
ORNL	12.4	2.2	>0.1	14.7
PAD	3,952.6	406.8	0.0	4,359.4
PANT	0.0	3.0	0.0	3.0
Pinellas	0.0	0.0	0.0	0.0
PORTS	3,507.8	162.0	0.0	3,669.8
PPPL	0.0	0.0	0.0	0.0
RFETS	71.4	40.6	0.0	112.0
SLAC	0.0	0.0	0.0	0.0
SNL/CA	0.0	0.2	0.0	0.2
SNL/NM ^f	0.0	0.4	0.0	0.4
SRS	2.0	140.0	0.0	142.0
WVDP	0.0	43.9	0.0	43.9
Y-12	150.2	0.0	0.0	150.2
Total	18,145.8	6,080.8	7.0	24,233.6

^aBased on the DOE site data submittals of ref. 10. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bInformation not available or unknown.

^cIncludes contributions from PNL.

^dExcludes contributions from ANL-W.

^eIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

^fInformation for CY 1993. Information for CY 1994 not available.

Table 8.16. 1994 mass (kg) generation, by hazard category, of TSCA-regulated MLLW from DOE site activities^a

Site	PCB	Asbestos	Other	Total
Ames	0	0	0	0
ANL-E	62,400	0	0	62,400
ANL-W	b	b	b	b
BNL	0	91	0	91
ETEC	0	3,600	0	3,600
FEMP	b	b	b	b
FNAL	0	0	0	0
GJPO	174	546	0	720
Hanford ^c	4,997	b	b	4,997
INEL ^d	164	0	0	164
ITRI	0	0	0	0
K-25	2,059,870	104,790	1,240	2,165,900
KCP	0	0	0	0
LANL	14	59,258	0	59,272
LBL	64	1,087	0	1,151
LLNL	14	1,151	0	1,165
Mound	0	2,054	0	2,054
NR sites ^e	886	122,631	0	123,517
NTS	0	0	0	0
ORISE	0	0	0	0
ORNL	10,580	5,656	2,042	18,278
PAD	224,470	187,794	0	412,264
PANT	0	4,500	0	4,500
Pinellas	0	0	0	0
PORTS	79,990	11,500	0	91,490
PPPL	0	0	0	0
RFETS	7,460	1,070	0	8,530
SLAC	0	0	0	0
SNL/CA	0	2	0	2
SNL/NM ^f	0	0	0	0
SRS	0	6,050	0	6,050
WVDP	0	6,726	0	6,726
Y-12	27,140	0	0	27,140
Total	2,478,223	518,506	3,282	3,000,011

^aBased on the DOE site data submittals of ref. 10. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bInformation not available or unknown.

^cIncludes contributions from PNL.

^dExcludes contributions from ANL-W.

^eIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

^fInformation for CY 1993. Information for CY 1994 not available.

Table 8.17. 1994 volume (m³) generation, by hazard category, of TSCA-regulated MLLW from DOE site activities^a

Site	PCB	Asbestos	Other	Total
Ames	0.0	0.0	0.0	0.0
ANL-E	52.0	0.0	0.0	52.0
ANL-W	b	b	b	b
BNL	0.0	0.4	0.0	0.4
ETEC	0.0	8.1	0.0	8.1
FEMP	b	b	b	b
FNAL	0.0	0.0	0.0	0.0
GJPO	0.1	1.4	0.0	1.5
Hanford ^c	3.3	b	b	3.3
INEL ^d	0.6	0.0	0.0	0.6
ITRI	0.0	0.0	0.0	0.0
K-25	5,349.0	232.2	5.6	5,586.8
KCP	0.0	0.0	0.0	0.0
LANL	0.2	166.4	0.0	166.6
LBL	<0.1	2.7	0.0	2.8
LLNL	~0	0.8	0.0	0.8
Mound	0.0	6.8	0.0	6.8
NR sites ^c	2.2	342.3	0.0	344.5
NTS	0.0	0.0	0.0	0.0
ORISE	0.0	0.0	0.0	0.0
ORNL	7.9	3.8	1.4	13.1
PAD	286.1	774.7	0.0	1,060.8
PANT	0.0	3.0	0.0	3.0
Pinellas	0.0	0.0	0.0	0.0
PORTS	250.0	9.9	0.0	259.9
PPPL	0.0	0.0	0.0	0.0
RFETS	31.5	4.5	0.0	36.0
SLAC	0.0	0.0	0.0	0.0
SNL/CA	0.0	0.2	0.0	0.2
SNL/NM ^f	0.0	0.0	0.0	0.0
SRS	0.0	12.1	0.0	12.1
WVDP	0.0	4.5	0.0	4.5
Y-12	20.6	0.0	0.0	20.6
Total	6,003.6	1,573.8	7.0	7,584.4

^aBased on the DOE site data submittals of ref. 10. Material may be in interim storage awaiting treatment. Specific site information is provided in Sect. 8.4.

^bInformation not available or unknown.

^cIncludes contributions from PNL.

^dExcludes contributions from ANL-W.

^eIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

^fInformation for CY 1993. Information for CY 1994 not available.

Table 8.18. Historical and projected annual mass (kg) generation rates for TSCA-regulated MLLW from DOE site activities^a

Site	1994 ^b	1995	1996	1997	1998	1999	2000–2030 ^c
Ames	0	50	50	d	d	d	d
ANL–E	62,400	7,200	0	0	0	0	0
psANL–W	d	d	d	d	d	d	d
BNL	91	60	30	20	15	15	10
ETEC	3,600	9,000	0	0	800	1,600	0
FEMP	d	d	d	d	d	d	d
FNAL	0	0	0	0	0	0	0
GJPO	720	50	20	20	10	10	<10
Hanford ^e	4,997	255,900	292,800	252,000	269,550	418,650	670,100
INEL ^f	164	d	d	d	d	d	d
ITRI	0	0	0	0	0	0	0
K-25	2,165,900	2,165,900	2,165,900	2,165,900	2,165,900	2,165,900	2,165,900
KCP	0	0	0	0	0	0	0
LANL	59,272	37,000	37,000	37,000	31,000	28,000	28,000
LBL	1,151	1,151	1,151	1,151	1,151	1,151	1,151
LLNL	1,165	0	0	0	0	0	0
Mound	2,054	90	90	90	90	90	90
NR sites ^g	123,517	46,509	50,878	42,083	42,083	41,183	8,055
NTS	0	0	d	d	d	d	d
ORISE	0	0	0	0	0	0	0
ORNL	18,278	18,278	18,278	18,278	18,278	18,278	18,278
PAD	412,264	469,034	464,934	467,584	471,010	463,510	460,810
PANT	4,500	0	0	0	0	0	0
Pinellas	0	1,850	0	0	0	0	0
PORTS	91,490	72,000	65,000	58,500	52,700	47,400	50,000
PPPL	0	0	0	0	0	0	0
RFETS	8,530	33,640	19,400	19,400	19,400	19,400	32,000
SLAC	0	0	0	0	0	0	0
SNL/CA	2	0	0	0	0	0	0
SNL/NM	d	d	d	d	d	d	d
SRS	6,050	41,000	41,000	41,000	41,000	41,000	55,000
WVDP	6,726	7,500	6,000	4,800	3,900	3,150	1,050
Y-12	27,140	27,000	27,000	36,000	36,000	36,000	d
Total	3,000,011	3,193,212	3,189,531	3,143,826	3,152,887	3,285,337	3,490,454

^aBased on the DOE site data submittals of ref. 10. Specific site information is provided in Sect. 8.4.

^bActual data.

^cAverage annual generation rate anticipated for this period.

^dInformation not available or unknown.

^eIncludes contributions from PNL.

^fExcludes contributions from ANL–W.

^gIncludes contributions (if any) from Bettis (BAPL), Knolls, (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

Table 8.19. Historical and projected annual volume (m³) generation rates for TSCA-regulated MLLW from DOE site activities^a

Site	1994 ^b	1995	1996	1997	1998	1999	2000–2030 ^c
Ames	0.0	<0.1	<0.1	d	d	d	d
ANL–E	52.0	6.0	0.0	0.0	0.0	0.0	0.0
ANL–W	d	d	d	d	d	d	d
BNL	0.4	0.3	0.2	0.1	0.1	0.1	0.1
ETEC	8.1	22.0	0.0	0.0	1.0	2.0	0.0
FEMP	d	d	d	d	d	d	d
FNAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GJPO	1.5	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Hanford ^e	3.3	170.6	195.2	168.0	179.7	279.1	461.0
INEL ^f	0.6	d	d	d	d	d	d
ITRI	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K-25	5,586.8	5,586.8	5,586.8	5,586.8	5,586.8	5,586.8	5,586.8
KCP	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LANL	166.6	60.0	60.0	60.0	50.0	45.0	45.0
LBL	2.8	2.8	2.8	2.8	2.8	2.8	2.8
LLNL	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Mound	6.8	0.5	0.5	0.5	0.5	0.5	0.5
NR sites ^g	344.5	127.2	154.5	112.7	112.7	109.7	17.9
NTS	0.0	0.0	d	d	d	d	d
ORISE	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ORNL	13.1	13.1	13.1	13.1	13.1	13.1	13.1
PAD	1,060.8	612.6	610.3	611.8	613.5	609.3	607.8
PANT	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Pinellas	0.0	3.0	0.0	0.0	0.0	0.0	0.0
PORTS	259.9	225.0	203.0	183.0	165.0	149.0	65.0
PPPL	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RFETS	36.0	76.0	36.0	36.0	36.0	36.0	62.0
SLAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SNL/CA	0.2	0.0	0.0	0.0	0.0	0.0	0.0
SNL/NM	d	d	d	d	d	d	d
SRS	12.1	82.0	82.0	82.0	82.0	82.0	110.0
WVDP	4.5	5.0	4.0	3.2	2.6	2.1	0.7
Y-12	20.6	20.0	20.0	27.0	27.0	27.0	d
Total	7,584.4	7,013.1	6,968.6	6,887.1	6,872.9	6,944.6	6,972.8

^aBased on the DOE site data submittals of ref. 10. Specific site information is provided in Sect. 8.4.

^bActual data.

^cAverage annual generation rate anticipated for this period.

^dInformation not available or unknown.

^eIncludes contributions from PNL.

^fExcludes contributions from ANL–W.

^gIncludes contributions (if any) from Bettis (BAPL), Knolls (KAPL), Kesselring (KESS), Windsor (WIND), and six naval shipyards.

Table 8.20. Significant revisions and changes in historical inventory data for TSCA MLLW compared to inventory data reported previously

Site	Waste characteristics	Values in previous report ^a	Values in current report ^b	Significant revisions and changes	Explanation
BNL	Cumulative quantities of asbestos	2 kg (Table 8.14) (Trace) m ³ (Table 8.15)	1,000 kg (Table 8.14) 2.1 m ³ (Table 8.15)	+998 kg +2.1 m ³	Waste was not transferred to site waste management department until May 1994 and thus not tracked in the waste data base until that time
PAD	Cumulative quantities of asbestos	45,798 kg (Table 8.14) 179.7 m ³ (Table 8.15)	193,981 kg (Table 8.14) 406.8 m ³ (Table 8.15)	+148, 183 kg +227.1 m ³	Large increase from asbestos in a special area (Munter's Fill). These quantities were inadvertently left off previously
PORTS	Cumulative quantities of solids	1,692,401 kg (Table 8.10) 3,318.0 m ³ (Table 8.11)	2,020,000 kg (Table 8.10) 3,574.0 m ³ (Table 8.11)	+327,599 kg +256.0 m ³	Includes contributions from PCB sludges
	Cumulative quantities of sludges	665,510 kg (Table 8.10) 458.0 m ³ (Table 8.11)	Unknown (Table 8.10) Unknown (Table 8.10)	Unknown Unknown	Site unable to confirm quantities of sludge

^aDOE/RW-0006, Rev. 10 (December 1994).^bDOE/RW-0006, Rev. 11 (September 1995).

**Table 8.21. National commercially generated MLLW profile
volume summary, by facility category^a**

Facility category	Waste volume, m ³		
	Generated in 1990	Stored as of Dec. 31, 1990 ^b	Treated in 1990 ^c
Academic	820.7	154.2	1,581.9
Government	750.4	78.9	612.5
Industrial	1,428.0	1,197.3	1,115.1
Medical	563.6	63.1	466.3
Nuclear power plants	385.8	622.5	216.9
Total ^d	3,948.5	2,116.0	3,992.6

^aBased on ref. 12.

^bThis is not the amount of mixed waste requiring disposal. Some of this waste was being accumulated for treatment.

^cTreated wastes may include mixed wastes generated in years prior to 1990.

^dTotal reported in this table may not equal the sum of component entries because of round-off and truncation of numbers.

Table 8.22. National commercially generated MLLW profile volume summary, by hazardous waste stream^a

Hazardous stream	Waste volume, m ³		
	Generated in 1990	Stored as of Dec. 31, 1990 ^b	Treated in 1990 ^c
Organics			
Liquid scintillation fluids	2,837.2	363.4	3,371.8
Waste oil	148.9	178.1	139.4
Chlorinated organics	70.9	27.0	23.2
Fluorinated organics	0	3.5	0
Chlorinated fluorocarbons (CFCs)	113.2	254.7	3.7
Other organics	274.6	117.9	258.9
Total organics ^d	3,444.8	944.6	3,797.0
Metals			
Lead	81.6	138.7	6.1
Mercury	12.5	81.1	1.5
Chromium	28.4	53.3	3.9
Cadmium	0.3	745.2	0.1
Total metals ^d	122.8	1,018.3	11.6
Aqueous corrosives	80.4	12.2	2.6
Other hazardous materials	300.5	141.0	181.4
Grand totals ^d	3,948.5	2,116.0	3,992.6

^aBased on ref. 12.

^bThis is not the amount of mixed waste requiring disposal. Some of this waste was being accumulated for treatment.

^cTreated wastes may include mixed wastes generated in years prior to 1990.

^dTotals reported in this table may not equal the sum of component entries because of round-off and truncation of numbers.

**APPENDIX A. WASTE FLOWSHEETS, SOURCE TERMS,
AND CHARACTERISTICS**

APPENDIX A. WASTE FLOWSHEETS, SOURCE TERMS, AND CHARACTERISTICS

A.1 DISCUSSION

In this report, a number of engineering estimates, assumptions, and ground rules are used to determine radioactive waste and spent nuclear fuel projections through the year 2030. Many of these involve parameters that characterize certain types of waste (e.g., see Table A.1). In other instances, estimates were made of the waste volume generated per unit of product throughput for each step in the fuel cycle. This appendix is a compilation of generic flowsheets and source terms used for making waste projections. Source terms are used to describe quantitative and qualitative characteristics of radioactive wastes. As used in this report, the source term for a particular waste is comprised of two components unique to that waste: (1) the number of curies of radioactivity expressed either per unit of facility production or per unit of waste volume or mass and (2) a listing of the relative radioactivity contributions of component radioisotopes.

The source terms used in the analysis of this report are based on reported historical data, engineering estimates, calculations, and/or experimental data. Documentation of the source terms and key waste-modeling parameters is provided in the following sets of figures and tables (based primarily on refs. 1 through 9). Detailed information on how these source terms and modeling parameters were derived is available, mainly in ref. 1 and its update (ref. 2). Figures A.1 and A.2 were adapted from refs. 3 and 4, respectively. The mass, radioactivity, and thermal power of the nuclides contained in all stored domestic commercial LWR spent nuclear fuel as of December 31, 1994, are listed in Table A.2.

Representative DOE LLW radionuclide compositions are described in Table A.3 (based on ref. 1). Average concentrations for representative radionuclides in LLW disposed of at commercial sites are given in Table A.4. This information was adapted from ref. 5. Table A.5 gives a summary of major sources and estimated characteristics of commercial greater-than-Class-C LLW (data from refs. 6 and 7). Information on the LLW to be incorporated in cement as a result of future operations by the West Valley Demonstration Project Radwaste Treatment System is presented in Table A.6, which is taken from ref. 8.

A.2 REFERENCES

1. C. W. Forsberg, W. L. Carter, and A. H. Kibbey, *Flowsheets and Source Terms for Radioactive Waste Projections*, ORNL/TM-8462, Oak Ridge National Laboratory, Oak Ridge, Tennessee (March 1985).
2. S. L. Loghry, A. H. Kibbey, H. W. Godbee, A. S. Icenhour, and S. M. DePaoli, *Low-Level Radioactive Waste Source Terms for the 1992 Integrated Data Base*, ORNL/TM-11710, Oak Ridge National Laboratory, Oak Ridge, Tennessee (January 1995).
3. R. I. Smith, *Revised Analyses of Decommissioning for the Reference Boiling Water Reactor Power Station*, draft report, NUREG/CR-6174, PNL-9975, Vols. 1 and 2, U.S. Nuclear Regulatory Commission, Washington, D.C. (September 1994).
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5. G. W. Roles, *Characteristics of Low-Level Radioactive Waste Disposed During 1987 Through 1989*, NUREG-1418, U.S. Nuclear Regulatory Commission, Washington, D.C. (December 1990).
6. U.S. Department of Energy, *Recommendations for Management of Greater-than-Class-C Low-Level Radioactive Waste*, DOE/NE-0077, Washington, D.C. (February 1987).
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8. John J. Hollinden, West Valley Nuclear Services Company, Inc., West Valley, New York, correspondence to Steven N. Storch, IDB Program, ORNL, Oak Ridge, Tennessee, "Submittal of the Department of Energy Site Toxic Substance Control Act Mixed Low-Level Waste Information Request for the 1995 Integrated Data Base Report (DOE/RW-0006, Rev. 11)," WZ:95:0095, dated June 15, 1995.

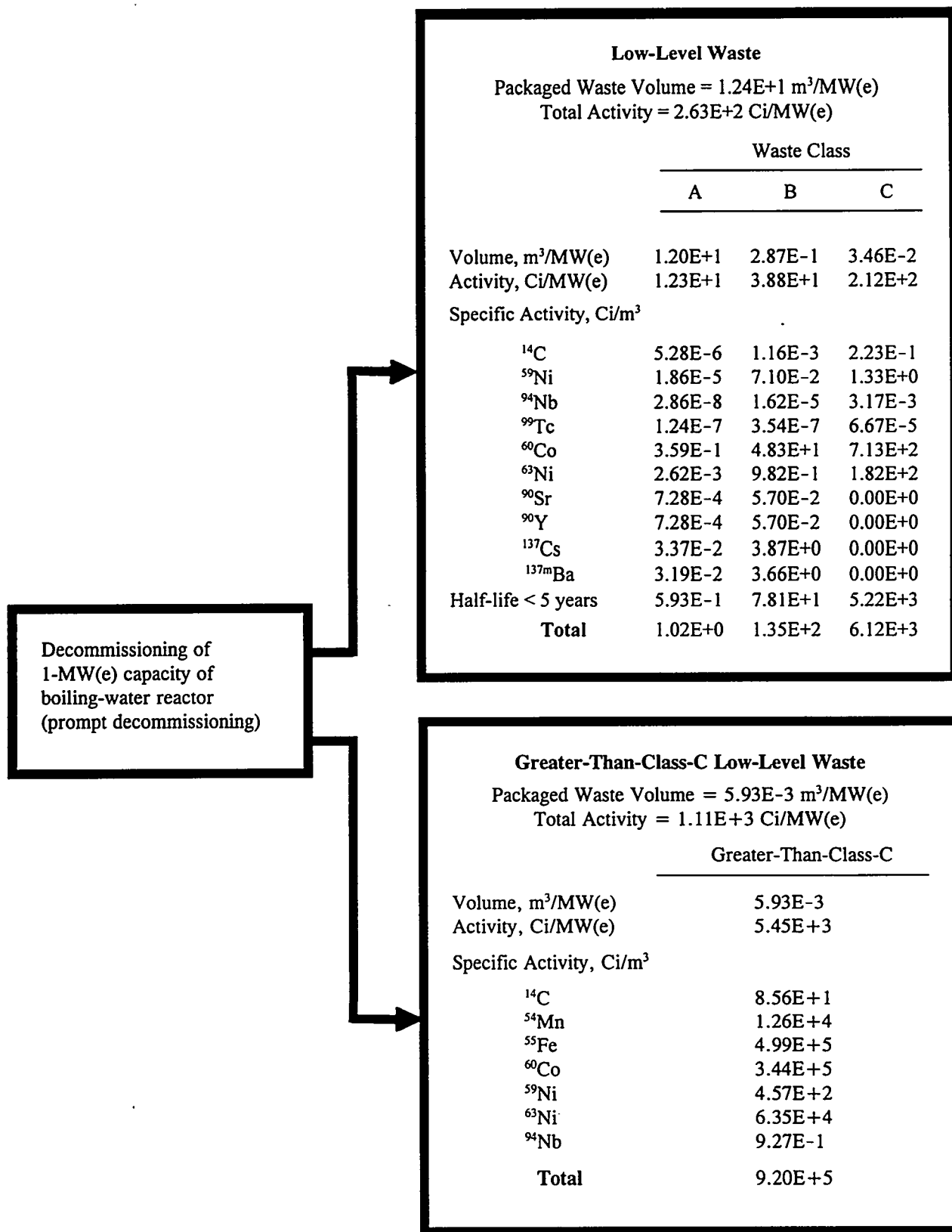


Fig. A.1. Boiling-water reactor decommissioning wastes per 1-MW(e) capacity.

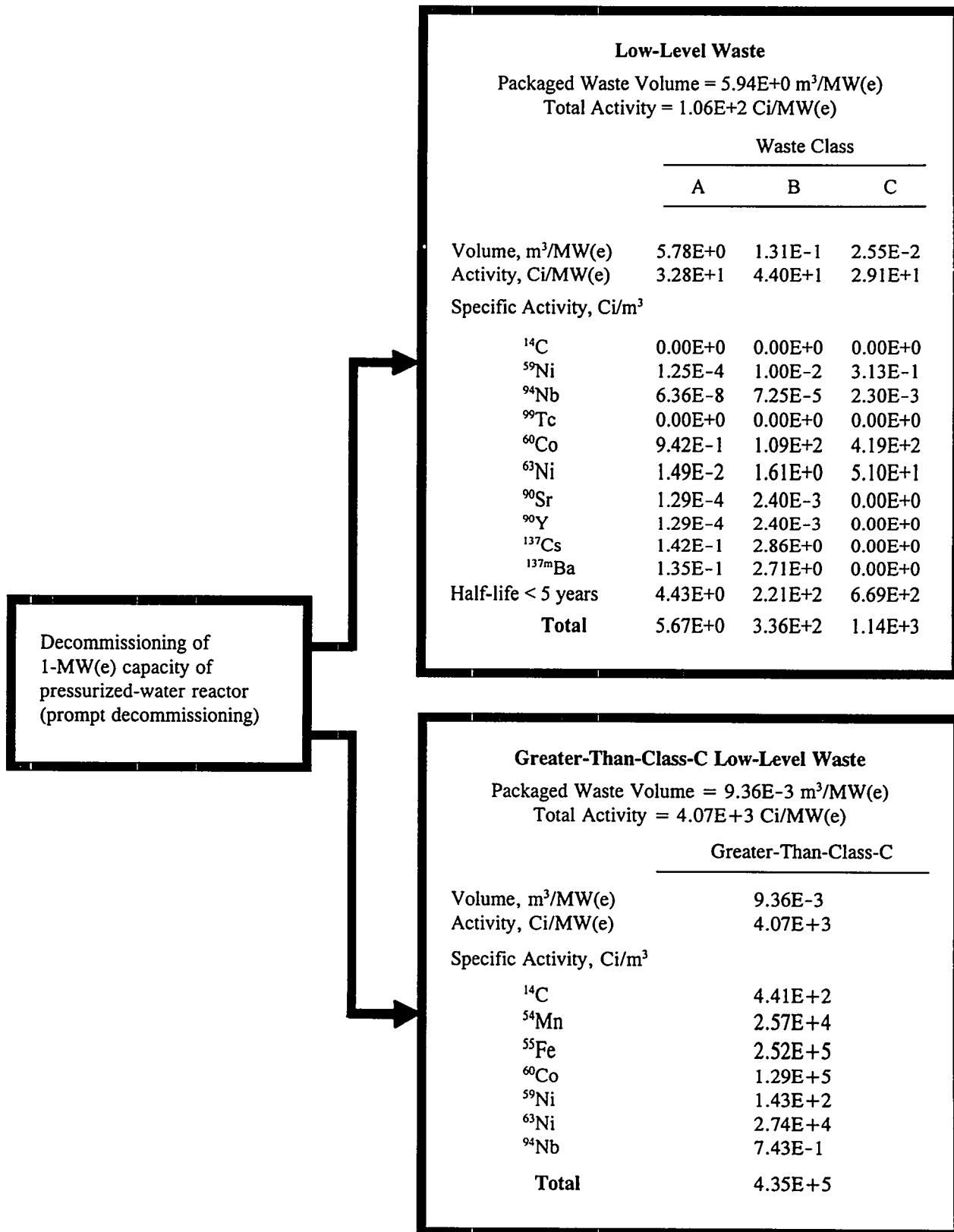


Fig. A.2. Pressurized-water reactor decommissioning wastes per 1-MW(e) capacity.

Table A.1. Estimated representative unit activity and thermal power characteristics of various types of radioactive materials and wastes

Radioactive material/ waste type	Unit activity (Ci/m ³)	Unit thermal power (W/m ³)
Spent nuclear fuel ^a		
BWR	1,000,000–10,000,000	3,500–40,000
PWR	2,000,000–20,000,000	7,500–65,000
High-level waste	1,500–15,000	5–50
Transuranic waste		
Remote-handled, stored	1,000	1–2
Contact-handled, stored	25–50	0.5–1.5
Buried	0.25–0.50	0.005–0.010
Low-level waste ^b		
DOE sites	9–27	0.012–0.054
Commercial sites ^c	4.6–6.4	0.30–1.60
Class A	0.5–0.7	0.03–0.10
Class B	55–60	14–15
Class C	0.1–>7,000 ^d	0.003–115 ^d
GTCC ^e	>0.1–No limit	>0.003–No limit
Uranium mill tailings	0.010	0.00020

^aLower-bound levels are based on cumulative spent nuclear fuel discharged; upper-bound levels are based on annual discharges.

^bBased on 1986–1988 Solid Waste Information Management System (SWIMS) and the national Low-Level Waste Management Program (LLWMP) data access system, both of which were maintained by EG&G, Idaho, Inc., Idaho Falls, Idaho.

^cWaste classification is defined by the NRC in 10 CFR Part 61.55 on the basis of concentration of certain long- and short-lived radionuclides. The classification system is designed to minimize potential exposures in both the short and long term. The gross Ci/m³ shown above are representative of typical LLW shipped to commercial disposal sites. Nuclear power plant wastes account for most of the radioactivity (~96%) and include Class A, B, and C. Essentially all medical wastes are Class A. Industrial wastes are largely Class A, but they contain some Class B and C.

^dMaximum for ⁶³Ni in activated metal or ⁹⁰Sr. There is no limit on concentration of ³H, ⁶⁰Co, or nuclides with half-lives < 5 years. The maximum thermal power shown is based on the highest reported gross Ci/m³ analysis for irradiated core components (1986–1988) and assumes all the activity is due to ⁶⁰Co, which would yield the greatest heat output. If the activity is due to activation products, such as ⁵⁴Mn, ⁵⁸Co, etc., the Ci/m³ could be much higher for individual shipments, and the total W/m³ could exceed the value shown.

^eIn temporary storage. The concentration of actinides and ¹²⁹I determines the lower activity boundary. There is no limit on concentrations of ³H, ⁶⁰Co, or nuclides with half-lives < 5 years.

Table A.2. Mass, radioactivity, and thermal power of nuclides in domestic commercial LWR spent nuclear fuel at the end of calendar year 1994^a

Atomic number	Element	Mass number of nuclide	Mass, g		Radioactivity, Ci		Thermal power, W	
			Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1	Hydrogen	Stable ^b	8.97E+03	1.41E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Hydrogen	3	1.69E+02	1.55E+03	1.63E+06	1.50E+07	5.48E+01	5.04E+02
2	Helium	Stable	5.62E+03	7.15E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	Lithium	Stable	2.05E+03	3.26E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	Beryllium	Stable	2.18E+00	2.77E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	Boron	Stable	1.90E+03	2.98E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	Carbon	Stable	3.39E+05	5.34E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Carbon	14	9.54E+02	1.18E+04	4.25E+03	5.27E+04	1.25E+00	1.55E+01
7	Nitrogen	Stable	2.32E+05	3.68E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	Oxygen	Stable	2.54E+08	4.02E+09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	Fluorine	Stable	2.01E+04	3.19E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	Neon	Stable	8.80E-01	1.16E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	Sodium	Stable	2.82E+04	4.46E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Sodium	24	1.66E-04	1.66E-04	1.45E+03	1.45E+03	4.01E+01	4.01E+01
12	Magnesium	Stable	3.84E+03	6.06E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	Aluminum	Stable	1.54E+05	2.43E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	Silicon	Stable	9.00E+05	1.43E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	Phosphorus	Stable	4.27E+05	6.73E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Phosphorus	32	3.02E-01	3.02E-01	8.63E+04	8.63E+04	8.74E+02	8.74E+02
16	Sulfur	Stable	5.02E+04	7.96E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	Chlorine	Stable	9.21E+03	1.48E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	Argon	Stable	8.38E+02	1.11E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	Potassium	Stable	3.64E+00	4.79E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	Calcium	Stable	3.76E+03	5.95E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	Scandium	Stable	2.37E-01	3.13E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	Titanium	Stable	1.57E+05	2.49E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	Vanadium	Stable	3.62E+04	5.10E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Vanadium	50	1.15E+02	1.59E+03	2.05E-11	2.85E-10	2.26E-13	3.14E-12
24	Chromium	Stable	2.06E+07	3.26E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Chromium	51	7.65E+01	7.65E+01	7.07E+06	7.07E+06	1.51E+03	1.51E+03
25	Manganese	Stable	1.71E+06	2.72E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Manganese	54	1.71E+02	3.30E+02	1.33E+06	2.55E+06	6.61E+03	1.27E+04
26	Iron	Stable	6.26E+07	9.92E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Iron	55	4.92E+03	1.99E+04	1.23E+07	4.98E+07	4.16E+02	1.68E+03
	Iron	59	2.93E+00	2.94E+00	1.44E+05	1.45E+05	1.11E+03	1.12E+03

Table A.2 (continued)

Atomic number	Element	Mass number of nuclide	Mass, g		Radioactivity, Ci		Thermal power, W	
			Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
27	Cobalt	Stable	1.46E+05	2.35E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Cobalt	58	8.52E+01	8.82E+01	2.71E+06	2.81E+06	1.62E+04	1.68E+04
	Cobalt	60	1.39E+04	8.73E+04	1.57E+07	9.87E+07	2.42E+05	1.52E+06
28	Nickel	Stable	1.91E+07	3.03E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Nickel	59	1.28E+05	1.64E+06	9.74E+03	1.24E+05	3.87E-01	4.93E+00
	Nickel	63	2.28E+04	2.68E+05	1.40E+06	1.66E+07	1.42E+02	1.67E+03
29	Copper	Stable	3.34E+04	5.27E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Copper	65	7.58E+04	1.20E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Zinc	Stable	1.98E+01	3.27E+01	1.63E+05	2.69E+05	5.72E+02	9.42E+02
31	Gallium	Stable	6.96E+01	9.19E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Germanium	Stable	1.33E+03	1.65E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Arsenic	Stable	4.13E+02	5.20E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
34	Selenium	Stable	1.04E+05	1.28E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Selenium	79	1.24E+04	1.54E+05	8.66E+02	1.07E+04	2.16E-01	2.66E+00
	Bromine	Stable	4.52E+04	5.59E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35	Krypton	Stable	7.16E+05	8.75E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Krypton	81	5.09E-02	5.97E-01	1.07E-03	1.26E-02	1.32E-07	1.55E-06
	Krypton	85	4.85E+04	4.05E+05	1.90E+07	1.59E+08	2.85E+04	2.38E+05
37	Rubidium	Stable	2.09E+05	2.55E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Rubidium	86	3.50E+00	3.50E+00	2.85E+05	2.85E+05	1.29E+03	1.29E+03
	Rubidium	87	5.19E+05	6.34E+06	4.54E-02	5.55E-01	3.79E-05	4.64E-04
38	Strontium	Stable	7.43E+05	9.07E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Strontium	89	9.47E+03	9.54E+03	2.75E+08	2.77E+08	9.51E+05	9.59E+05
	Strontium	90	1.12E+06	1.17E+07	1.52E+08	1.60E+09	1.77E+05	1.85E+06
39	Yttrium	Stable	9.22E+05	1.11E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Yttrium	90	2.83E+02	2.94E+03	1.54E+08	1.60E+09	8.55E+05	8.87E+06
	Yttrium	91	1.72E+04	1.74E+04	4.21E+08	4.28E+08	1.51E+06	1.54E+06
40	Zirconium	Stable	6.55E+08	1.04E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Zirconium	93	1.77E+06	2.17E+07	4.45E+03	5.45E+04	5.17E-01	6.33E+00
	Zirconium	95	3.25E+04	3.33E+04	6.99E+08	7.16E+08	3.54E+06	3.62E+06
41	Niobium	Stable	9.67E+05	1.53E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Niobium	93m	1.56E+00	6.31E+01	4.42E+02	1.78E+04	7.84E-02	3.16E+00
	Niobium	94	1.36E+04	1.69E+05	2.55E+03	3.17E+04	2.59E+01	3.23E+02
42	Niobium	95	2.76E+04	2.86E+04	1.08E+09	1.12E+09	5.19E+06	5.36E+06
	Niobium	95m	1.41E+01	1.44E+01	5.38E+06	5.50E+06	7.48E+03	7.64E+03
	Molybdenum	Stable	7.57E+06	9.43E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
43	Technetium	99	1.63E+06	2.04E+07	2.76E+04	3.45E+05	1.38E+01	1.73E+02

Table A.2 (continued)

Atomic number	Element	Mass number of nuclide	Mass, g		Radioactivity, Ci		Thermal power, W	
			Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
44	Ruthenium	Stable	4.63E+06	5.69E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ruthenium	103	1.31E+04	1.31E+04	4.23E+08	4.24E+08	1.42E+06	1.42E+06
	Ruthenium	106	2.37E+05	5.06E+05	7.94E+08	1.69E+09	4.72E+04	1.01E+05
45	Rhodium	Stable	8.57E+05	1.12E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Rhodium	103m	1.17E+01	1.18E+01	3.82E+08	3.83E+08	8.79E+04	8.81E+04
	Rhodium	106	2.23E-01	4.76E-01	7.94E+08	1.69E+09	7.62E+06	1.62E+07
46	Palladium	Stable	2.22E+06	2.64E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Palladium	107	4.71E+05	5.88E+06	2.42E+02	3.03E+03	1.44E-02	1.79E-01
	Palladium	107	1.59E+05	2.04E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
47	Silver	Stable	3.11E-09	2.51E-08	2.29E+00	1.84E+01	8.52E-03	6.87E-02
	Silver	108	9.86E-01	7.95E+00	2.57E+01	2.07E+02	2.49E-01	2.01E+00
	Silver	110	1.87E-05	3.05E-05	7.82E+04	1.27E+05	5.61E+02	9.15E+02
48	Silver	110m	1.24E+03	2.02E+03	5.88E+06	9.58E+06	9.81E+04	1.60E+05
	Silver	111	2.51E+01	2.51E+01	3.97E+06	3.97E+06	8.89E+03	8.89E+03
	Silver	111	2.81E+05	3.38E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
49	Cadmium	Stable	6.98E-01	1.78E+00	1.80E+03	4.60E+03	2.09E-01	5.35E-01
	Cadmium	109	5.38E+02	4.93E+03	1.17E+05	1.07E+06	1.96E+02	1.80E+03
	Cadmium	113m	2.22E+01	2.23E+01	5.65E+05	5.68E+05	2.11E+03	2.12E+03
50	Indium	Stable	2.56E+03	3.25E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Indium	114	8.09E-05	8.14E-05	1.11E+05	1.12E+05	5.30E+02	5.34E+02
	Indium	114m	5.03E+00	5.06E+00	1.16E+05	1.17E+05	1.64E+02	1.65E+02
51	Indium	115	4.38E+03	6.74E+04	2.72E-08	4.19E-07	3.91E-11	6.02E-10
	Indium	115m	4.36E-02	4.36E-02	2.76E+05	2.76E+05	5.51E+02	5.51E+02
	Indium	115m	1.07E+07	1.70E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
52	Tin	Stable	1.51E+01	1.51E+01	1.20E+06	1.20E+06	2.23E+03	2.23E+03
	Tin	117m	3.08E+03	4.97E+03	1.33E+07	2.22E+07	7.14E+03	1.15E+04
	Tin	119m	5.18E+01	5.68E+02	3.06E+03	3.36E+04	6.14E+00	6.73E+01
53	Tin	121m	4.00E+02	4.78E+02	3.29E+06	3.93E+06	1.03E+04	1.23E+04
	Tin	123	1.06E+01	1.06E+01	1.15E+06	1.15E+06	7.62E+03	7.62E+03
	Tin	125	5.70E+04	7.20E+05	1.62E+03	2.04E+04	2.02E+00	2.55E+01
54	Tin	126	4.38E+04	5.58E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Antimony	Stable	3.73E+01	3.80E+01	6.53E+05	6.64E+05	8.67E+03	8.82E+03
	Antimony	124	3.03E+04	1.29E+05	3.13E+07	1.34E+08	9.77E+04	4.18E+05
55	Antimony	125	1.34E+00	1.34E+00	1.12E+05	1.12E+05	2.07E+03	2.07E+03
	Antimony	126	1.09E+01	1.09E+01	2.92E+06	2.92E+06	1.73E+04	1.73E+04
	Antimony	127	9.90E+05	1.23E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
56	Tellurium	Stable	2.83E+01	3.06E+02	8.23E-09	8.90E-08	8.34E-13	9.02E-12
	Tellurium	123						

Table A.2 (continued)

Atomic number	Element	Mass number of nuclide	Mass, g		Radioactivity, Ci		Thermal power, W	
			Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
53	Tellurium	123 m	2.72E+00	3.12E+00	2.41E+04	2.76E+04	3.51E+01	4.03E+01
	Tellurium	125 m	4.10E+02	1.80E+03	7.39E+06	3.24E+07	6.21E+03	2.72E+04
	Tellurium	127	4.90E+00	5.40E+00	1.29E+07	1.42E+07	1.75E+04	1.92E+04
	Tellurium	127 m	1.10E+03	1.24E+03	1.03E+07	1.17E+07	5.56E+03	6.29E+03
	Tellurium	129	3.52E-01	3.52E-01	7.38E+06	7.38E+06	2.64E+04	2.64E+04
	Tellurium	129 m	3.63E+02	3.63E+02	1.09E+07	1.09E+07	1.92E+04	1.92E+04
	Tellurium	132	9.84E+01	9.84E+01	2.99E+07	2.99E+07	5.92E+04	5.92E+04
	Iodine	Stable	1.12E+05	1.41E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
54	Iodine	129	3.77E+05	4.74E+06	6.65E+01	8.37E+02	3.08E-02	3.87E-01
	Iodine	131	4.35E+02	4.35E+02	5.40E+07	5.40E+07	1.83E+05	1.83E+05
	Xenon	Stable	1.10E+07	1.36E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Xenon	129 m	3.74E-03	3.74E-03	4.73E+02	4.73E+02	6.62E-01	6.62E-01
	Xenon	131 m	1.75E+01	1.75E+01	1.47E+06	1.47E+06	1.41E+03	1.41E+03
	Xenon	133	4.31E+02	4.31E+02	8.06E+07	8.06E+07	8.64E+04	8.64E+04
	Cesium	Stable	2.34E+06	2.94E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Cesium	134	2.26E+05	7.45E+05	2.93E+08	9.65E+08	2.98E+06	9.82E+06
55	Cesium	135	7.31E+05	8.36E+06	8.42E+02	9.63E+03	2.81E-01	3.21E+00
	Cesium	136	6.96E+01	6.96E+01	5.10E+06	5.10E+06	6.96E+04	6.96E+04
	Cesium	137	2.51E+06	2.66E+07	2.18E+08	2.31E+09	2.42E+05	2.56E+06
	Barium	Stable	2.95E+06	3.56E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Barium	136 m	3.12E-06	3.12E-06	8.41E+05	8.41E+05	1.02E+04	1.02E+04
	Barium	137 m	3.84E-01	4.07E+00	2.07E+08	2.19E+09	8.12E+05	8.60E+06
	Barium	140	1.94E+03	1.94E+03	1.41E+08	1.41E+08	3.94E+05	3.94E+05
	Lanthanum	Stable	2.59E+06	3.19E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
57	Lanthanum	138	1.15E+01	1.48E+02	2.21E-07	2.84E-06	1.62E-09	2.08E-08
	Lanthanum	140	2.94E+02	2.94E+02	1.64E+08	1.64E+08	2.74E+06	2.74E+06
	Cerium	Stable	2.59E+06	3.16E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Cerium	141	1.22E+04	1.22E+04	3.47E+08	3.48E+08	5.09E+05	5.09E+05
	Cerium	142	2.40E+06	2.95E+07	5.77E-02	7.08E-01	0.00E+00	0.00E+00
	Cerium	144	4.54E+05	8.22E+05	1.45E+09	2.62E+09	9.61E+05	1.74E+06
	Praseodymium	Stable	2.30E+06	2.81E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Praseodymium	143	2.10E+03	2.10E+03	1.41E+08	1.41E+08	2.64E+05	2.64E+05
59	Praseodymium	144	1.92E+01	3.47E+01	1.45E+09	2.62E+09	1.06E+07	1.93E+07
	Praseodymium	144 m	9.58E-02	1.73E-01	1.74E+07	3.15E+07	5.95E+03	1.08E+04
	Neodymium	Stable	5.63E+06	7.01E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Neodymium	144	2.44E+06	3.36E+07	2.89E-06	3.97E-05	0.00E+00	0.00E+00
	Neodymium	147	5.80E+02	5.80E+02	4.66E+07	4.66E+07	1.13E+05	1.13E+05

Table A.2 (continued)

Atomic number	Element	Mass number of nuclide	Mass, g		Radioactivity, Ci		Thermal power, W	
			Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
61	Promethium	147	2.39E+05	1.03E+06	2.22E+08	9.54E+08	7.95E+04	3.42E+05
	Promethium	148	6.34E+01	6.34E+01	1.04E+07	1.04E+07	8.03E+04	8.03E+04
	Promethium	148m	4.00E+02	4.01E+02	8.55E+06	8.57E+06	1.08E+05	1.09E+05
62	Samarium	Stable	9.00E+05	1.14E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Samarium	147	1.66E+05	4.48E+06	3.78E-03	1.02E-01	5.18E-05	1.40E-03
	Samarium	148	3.86E+05	4.34E+06	1.17E-07	1.31E-06	1.39E-09	1.56E-08
	Samarium	149	5.41E+03	8.25E+04	1.30E-09	1.98E-08	0.00E+00	0.00E+00
	Samarium	151	2.54E+04	3.38E+05	6.68E+05	8.90E+06	7.83E+01	1.04E+03
63	Europium	Stable	2.28E+05	2.81E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Europium	152	6.90E+01	6.29E+02	1.19E+04	1.09E+05	9.03E+01	8.23E+02
	Europium	154	8.49E+04	6.14E+05	2.29E+07	1.66E+08	2.05E+05	1.48E+06
	Europium	155	2.94E+04	1.67E+05	1.37E+07	7.78E+07	9.95E+03	5.66E+04
	Europium	156	4.79E+02	4.79E+02	2.64E+07	2.64E+07	2.73E+05	2.73E+05
	Gadolinium	Stable	1.24E+06	1.89E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
64	Gadolinium	152	6.31E+01	2.46E+03	1.38E-09	5.36E-08	1.79E-11	6.99E-10
	Gadolinium	153	1.42E+02	2.38E+02	5.01E+05	8.40E+05	4.52E+02	7.59E+02
65	Terbium	Stable	2.26E+04	2.89E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Terbium	160	1.88E+02	1.94E+02	2.12E+06	2.19E+06	1.73E+04	1.79E+04
	Terbium	161	1.38E+00	1.38E+00	1.62E+05	1.62E+05	3.24E+02	3.24E+02
81	Thallium	Stable	2.30E-09	2.51E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Thallium	206	3.45E-22	3.45E-22	7.53E-14	7.53E-14	6.80E-16	6.80E-16
	Thallium	207	7.06E-12	4.55E-10	1.35E-03	8.66E-02	3.95E-06	2.54E-04
	Thallium	208	1.04E-08	5.29E-07	3.06E+00	1.56E+02	7.20E-02	3.67E+00
	Thallium	209	2.08E-14	1.57E-13	8.49E-06	6.44E-05	1.41E-07	1.07E-06
82	Lead	Stable	1.86E+03	2.94E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Lead	204	2.59E+01	4.10E+02	3.24E-13	5.13E-12	4.99E-15	7.91E-14
	Lead	205	6.81E-02	8.99E-01	3.96E-06	5.23E-05	1.15E-10	1.52E-09
	Lead	209	2.04E-10	7.73E-10	9.28E-04	3.51E-03	1.07E-06	4.04E-06
	Lead	210	1.06E-07	1.75E-05	8.10E-06	1.34E-03	1.88E-09	3.09E-07
	Lead	211	5.47E-11	3.52E-09	1.35E-03	8.69E-02	4.04E-06	2.60E-04
	Lead	212	6.12E-06	3.12E-04	8.51E+00	4.33E+02	1.62E-02	8.25E-01
	Lead	214	1.79E-12	2.72E-10	5.87E-05	8.92E-03	1.87E-07	2.84E-05
	Bismuth	Stable	7.53E+02	1.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Bismuth	208	1.09E-02	1.44E-01	5.08E-05	6.74E-04	8.00E-07	1.06E-05
83	Bismuth	210	1.31E-05	1.31E-05	1.63E+00	1.63E+00	3.75E-03	3.75E-03
	Bismuth	210m	6.47E-02	8.54E-01	3.67E-05	4.85E-04	1.15E-06	1.52E-05
	Bismuth	211	3.22E-12	2.08E-10	1.35E-03	8.69E-02	5.38E-05	3.46E-03

Table A.2 (continued)

Atomic number	Element	Mass number of nuclide	Mass, g		Radioactivity, Ci		Thermal power, W	
			Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
84	Bismuth	212	5.81E-07	2.96E-05	8.51E+00	4.33E+02	1.45E-01	7.37E+00
	Bismuth	213	2.03E-11	1.54E-10	3.93E-04	2.98E-03	1.65E-06	1.25E-05
	Bismuth	214	1.33E-12	2.02E-10	5.87E-05	8.92E-03	7.53E-07	1.14E-04
	Polonium	210	8.19E-03	1.01E-02	3.68E+01	4.53E+01	1.18E+00	1.45E+00
	Polonium	211	3.96E-17	2.55E-15	3.78E-06	2.43E-04	1.70E-07	1.09E-05
	Polonium	212	3.07E-17	1.57E-15	5.45E+00	2.78E+02	2.89E-01	1.47E+01
	Polonium	213	3.05E-20	2.31E-19	3.85E-04	2.92E-03	1.95E-05	1.48E-04
	Polonium	214	2.35E-19	2.78E-17	7.56E-05	8.93E-03	3.51E-06	4.15E-04
	Polonium	215	4.58E-17	2.95E-15	1.35E-03	8.69E-02	6.02E-05	3.88E-03
	Polonium	216	2.44E-11	1.24E-09	8.50E+00	4.33E+02	3.48E-01	1.77E+01
85	Polonium	218	2.08E-13	3.15E-11	5.88E-05	8.92E-03	2.13E-06	3.23E-04
	Astatine	217	2.44E-16	1.85E-15	3.93E-04	2.98E-03	1.68E-05	1.27E-04
86	Radon	218	1.14E-17	1.14E-17	1.68E-05	1.68E-05	7.24E-07	7.24E-07
	Radon	219	1.04E-13	6.67E-12	1.35E-03	8.69E-02	5.60E-05	3.60E-03
87	Radon	220	9.21E-09	4.70E-07	8.50E+00	4.33E+02	3.23E-01	1.65E+01
	Radon	222	3.82E-10	5.80E-08	5.88E-05	8.92E-03	1.95E-06	2.96E-04
88	Francium	221	2.22E-12	1.68E-11	3.93E-04	2.98E-03	1.52E-05	1.15E-04
	Francium	223	5.19E-13	3.14E-11	2.01E-05	1.22E-03	5.22E-08	3.16E-06
89	Radium	222	1.26E-14	1.26E-14	1.68E-05	1.68E-05	6.66E-07	6.66E-07
	Radium	223	2.63E-08	1.70E-06	1.35E-03	8.69E-02	4.81E-05	3.09E-03
90	Radium	224	5.33E-05	2.72E-03	8.50E+00	4.33E+02	2.92E-01	1.49E+01
	Radium	225	9.19E-09	7.52E-08	3.61E-04	2.95E-03	2.53E-07	2.07E-06
89	Radium	226	5.98E-05	9.04E-03	5.92E-05	8.94E-03	1.71E-06	2.58E-04
	Radium	228	3.45E-11	5.30E-09	8.07E-09	1.24E-06	6.22E-13	9.56E-11
89	Actinium	225	6.77E-09	5.13E-08	3.93E-04	2.98E-03	1.37E-05	1.04E-04
	Actinium	227	2.01E-05	1.22E-03	1.46E-03	8.82E-02	7.05E-07	4.27E-05
90	Actinium	228	5.94E-12	6.49E-12	1.33E-05	1.46E-05	1.15E-07	1.26E-07
	Thorium	226	6.27E-13	6.27E-13	1.68E-05	1.68E-05	6.43E-07	6.43E-07
90	Thorium	227	4.45E-08	2.80E-06	1.37E-03	8.61E-02	5.00E-05	3.14E-03
	Thorium	228	1.02E-02	5.25E-01	8.39E+00	4.31E+02	2.74E-01	1.41E+01
90	Thorium	229	1.47E-03	1.36E-02	3.12E-04	2.90E-03	9.56E-06	8.89E-05
	Thorium	230	3.31E+00	1.51E+02	6.69E-02	3.04E+00	1.89E-03	8.61E-02
90	Thorium	231	6.93E-05	1.01E-03	3.68E+01	5.35E+02	2.07E-02	3.00E-01
	Thorium	232	5.75E-01	2.72E+01	6.31E-08	2.99E-06	1.53E-09	7.23E-08
90	Thorium	233	9.99E-12	9.99E-12	3.65E-04	3.65E-04	9.23E-07	9.23E-07
	Thorium	234	2.57E-02	4.11E-01	5.95E+02	9.52E+03	2.41E-01	3.86E+00

Table A.2 (continued)

Atomic number	Element	Mass number of nuclide	Mass, g		Radioactivity, Ci		Thermal power, W	
			Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
91	Protactinium	231	6.96E-01	9.22E+00	3.29E-02	4.36E-01	9.91E-04	1.31E-02
	Protactinium	232	1.26E-05	1.26E-05	5.43E+00	5.43E+00	3.55E-02	3.55E-02
	Protactinium	233	3.35E-02	3.84E-01	6.96E+02	7.97E+03	1.58E+00	1.81E+01
	Protactinium	234	3.92E-07	6.19E-06	7.83E-01	1.24E+01	1.13E-02	1.78E-01
	Protactinium	234m	8.65E-07	1.39E-05	5.95E+02	9.52E+03	2.94E+00	4.70E+01
92	Protactinium	235	6.54E-17	6.54E-17	2.17E-09	2.17E-09	6.06E-12	6.06E-12
	Uranium	230	6.15E-10	6.15E-10	1.68E-05	1.68E-05	5.97E-07	5.97E-07
	Uranium	231	5.88E-09	5.88E-09	7.91E-04	7.91E-04	6.54E-07	6.54E-07
	Uranium	232	1.34E+00	2.65E+01	2.87E+01	5.68E+02	9.20E-01	1.82E+01
	Uranium	233	2.75E+00	5.92E+01	2.67E-02	5.74E-01	7.75E-04	1.67E-02
	Uranium	234	3.48E+05	5.17E+06	2.18E+03	3.23E+04	6.27E+01	9.30E+02
	Uranium	235	1.40E+07	2.44E+08	3.04E+01	5.29E+02	7.96E-01	1.38E+01
	Uranium	236	8.30E+06	1.02E+08	5.37E+02	6.62E+03	1.46E+01	1.79E+02
	Uranium	237	5.39E+02	5.40E+02	4.41E+07	4.41E+07	8.34E+04	8.35E+04
	Uranium	238	1.77E+09	2.83E+10	5.95E+02	9.52E+03	1.51E+01	2.41E+02
	Uranium	239	1.44E-02	1.44E-02	4.80E+05	4.80E+05	1.29E+03	1.29E+03
	Uranium	240	2.25E-04	2.25E-04	2.08E+02	2.08E+02	1.71E-01	1.71E-01
	Neptunium	235	6.97E-03	1.50E-02	9.78E+00	2.10E+01	5.68E-04	1.22E-03
	Neptunium	236	8.77E-01	9.60E+00	1.16E-02	1.27E-01	2.33E-05	2.55E-04
	Neptunium	236m	1.02E-04	1.02E-04	6.00E+01	6.00E+01	4.74E-02	4.74E-02
	Neptunium	237	9.89E+05	1.13E+07	6.97E+02	7.97E+03	2.13E+01	2.44E+02
94	Neptunium	238	2.33E+01	2.33E+01	6.04E+06	6.04E+06	2.89E+04	2.89E+04
	Neptunium	239	1.44E+03	1.44E+03	3.35E+08	3.35E+08	8.09E+05	8.10E+05
	Neptunium	240	3.41E-04	3.41E-04	4.11E+03	4.11E+03	4.36E+01	4.36E+01
	Neptunium	240m	2.00E-06	2.00E-06	2.11E+02	2.11E+02	1.22E+00	1.22E+00
	Neptunium	241	1.11E-13	1.11E-13	5.42E-06	5.42E-06	1.51E-08	1.51E-08
	Plutonium	236	2.34E+00	9.23E+00	1.24E+03	4.91E+03	4.33E+01	1.71E+02
	Plutonium	237	1.96E-02	1.97E-02	2.37E+02	2.38E+02	8.75E-02	8.79E-02
	Plutonium	238	3.36E+05	3.43E+06	5.76E+06	5.87E+07	1.91E+05	1.94E+06
	Plutonium	239	9.41E+06	1.45E+08	5.85E+05	9.00E+06	1.80E+04	2.77E+05
	Plutonium	240	4.53E+06	6.14E+07	1.03E+06	1.40E+07	3.21E+04	4.36E+05
	Plutonium	241	2.42E+06	2.42E+07	2.50E+08	2.49E+09	7.74E+03	7.72E+04
	Plutonium	242	1.03E+06	1.23E+07	3.95E+03	4.69E+04	1.17E+02	1.39E+03
	Plutonium	243	2.07E-01	2.07E-01	5.39E+05	5.39E+05	6.22E+02	6.22E+02
	Plutonium	244	6.50E+01	6.68E+02	1.15E-03	1.19E-02	3.34E-05	3.44E-04
	Plutonium	245	2.46E-06	2.46E-06	2.97E+00	2.97E+00	7.05E-03	7.05E-03
	Plutonium	246	5.42E-07	5.42E-07	2.65E-02	2.65E-02	2.23E-05	2.23E-05

Table A.2 (continued)

Atomic number	Element	Mass number of nuclide	Mass, g		Radioactivity, Ci		Thermal power, W	
			Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
95	Americium	239	3.71E-09	3.71E-09	4.09E-03	4.09E-03	9.90E-06	9.90E-06
	Americium	240	1.63E-05	1.63E-05	4.20E+00	4.20E+00	2.75E-02	2.75E-02
	Americium	241	1.29E+05	1.07E+07	4.43E+05	3.69E+07	1.47E+04	1.23E+06
	Americium	242	5.47E-01	7.38E-01	4.42E+05	5.97E+05	5.02E+02	6.78E+02
	Americium	242 ^m	1.54E+03	1.76E+04	1.50E+04	1.71E+05	5.91E+00	6.75E+01
	Americium	243	2.22E+05	2.38E+06	4.43E+04	4.75E+05	1.43E+03	1.53E+04
	Americium	244	1.57E-02	1.57E-02	1.99E+04	1.99E+04	1.04E+02	1.04E+02
	Americium	244 ^m	1.39E-04	1.39E-04	4.12E+03	4.12E+03	1.25E+01	1.25E+01
	Americium	245	5.80E-07	5.80E-07	3.58E+00	3.58E+00	6.65E-03	6.65E-03
	Americium	246	8.68E-10	8.68E-10	2.66E-02	2.66E-02	2.14E-04	2.14E-04
	Curium	242	1.47E+04	1.91E+04	4.86E+07	6.32E+07	1.79E+06	2.33E+06
	Curium	243	8.87E+02	7.81E+03	4.58E+04	4.03E+05	1.68E+03	1.48E+04
96	Curium	244	7.10E+04	5.55E+05	5.74E+06	4.49E+07	2.01E+05	1.57E+06
	Curium	245	2.84E+03	2.63E+04	4.88E+02	4.51E+03	1.62E+01	1.50E+02
	Curium	246	4.12E+02	3.48E+03	1.27E+02	1.07E+03	4.14E+00	3.51E+01
	Curium	247	4.40E+00	3.48E+01	4.08E-04	3.23E-03	1.30E-05	1.03E-04
	Curium	248	2.63E-01	1.95E+00	1.12E-03	8.30E-03	1.39E-04	1.03E-03
	Totals		2.90E+09	4.60E+10	1.10E+10	2.67E+10	4.61E+07	1.00E+08

^aIncludes contributions from nuclides in the fuel, cladding, and fuel assembly structural material.^bThe term *stable* represents a group of nonradioactive nuclides of a particular element.

Table A.3. Representative DOE LLW radionuclide composition by percent activity^a

Uranium/thorium		Fission product		Induced activity		Alpha, <100 nCi/g		Other	
Nuclide	Composition	Nuclide	Composition	Nuclide	Composition	Nuclide	Composition	Nuclide	Composition
²⁰⁸ Tl	0.0017	⁶⁰ Co	0.08	⁵¹ Cr	4.95	²³⁸ Pu	2.62	³ H	1.22
²¹² Pb	0.0045	⁹⁰ Sr	7.77	⁵⁴ Mn	38.10	²³⁹ Pu	0.20	¹⁴ C	0.06
²¹² Bi	0.0045	⁹⁰ Y	7.77	⁵⁸ Co	55.40	²⁴⁰ Pu	0.70	⁵⁴ Mn	6.76
²¹² Po	0.0029	⁹⁵ Zr	1.27	⁹⁹ Tc	0.49	²⁴¹ Pu	96.4	⁵⁸ Co	6.24
²¹⁶ Po	0.0045	⁹⁵ Nb	2.83	⁶⁰ Co	0.87	²⁴¹ Am	0.004	⁶⁰ Co	18.03
²²⁴ Ra	0.0045	⁹⁹ Tc	0.02	⁶⁵ Zn	0.19	²⁴² Cm	0.056	⁹⁰ Sr	8.48
²²⁸ Ra	0.0269	¹²⁵ Sb	2.93			²⁴⁴ Cm	0.020	⁹⁰ Y	8.48
²²⁸ Ac	0.0269	^{125m} Te	0.73		100.00			⁹⁹ Tc	0.12
²²⁸ Th	0.0045	¹⁰⁶ Ru	6.39				100.000	¹³⁴ Cs	13.98
²³¹ Th	0.0259	¹⁰⁶ Rh	6.39					¹³⁷ Cs	18.45
²³² Th	0.273	¹³⁴ Cs	0.38					^{137m} Ba	17.45
²³⁴ Th	33.197	¹³⁷ Cs	17.31					²³⁸ U	0.73
^{234m} Pa	33.197	^{137m} Ba	16.38						
²³⁴ Pa	0.0034	¹⁴⁴ Ce	14.67						100.00
²³⁵ U	0.0258	¹⁴⁴ Pr	14.67						
²³⁸ U	33.197	¹⁴⁷ Pm	0.06						
		¹⁵¹ Sm	0.11						
	100.0000	¹⁵² Eu	0.09						
		¹⁵⁴ Eu	0.09						
		¹⁵⁵ Eu	0.06						
			100.00						

^aBased on ref. 1.

Table A.4. Average concentrations for representative radionuclides in LLW at commercial disposal sites^a

Radionuclide	Half-life ^b	Concentration (Ci/m ³)
³ H	1.228E+01 y	1.083E+00
¹⁴ C	5.730E+03 y	5.079E-03
²⁶ Al	7.300E+05 y	2.980E-10
³² Si	1.000E+02 y	3.725E-11
³² P	1.428E+01 d	9.292E-04
³⁵ S	8.751E+01 d	2.208E-03
³⁶ Cl	3.010E+05 y	6.143E-06
⁴⁰ K	1.280E+09 y	1.766E-07
⁵¹ Cr	2.770E+01 d	7.137E-02
⁵⁴ Mn	3.122E+02 d	3.895E-01
⁵⁵ Fe	2.730E+00 y	3.112E+00
⁵⁹ Fe	4.445E+01 d	5.081E-03
⁵⁸ Co	7.092E+01 d	2.047E-01
⁶⁰ Co	5.271E+00 y	2.242E+00
⁵⁹ Ni	7.500E+04 y	1.364E-03
⁶³ Ni	1.001E+02 y	2.692E-01
⁶⁵ Zn	2.441E+02 d	1.174E-01
⁸⁵ Kr	1.072E+01 y	8.147E-04
⁸⁹ Sr	5.055E+01 d	6.032E-03
⁹⁰ Sr	2.850E+01 y	6.987E-02
⁹⁰ Y	2.671E+01 d	6.987E-02
⁹¹ Y	5.851E+01 d	8.859E-03
⁹⁵ Zr	6.402E+01 d	1.036E-02
⁹⁴ Nb	2.030E+04 y	1.659E-05
⁹⁵ Nb	3.497E+01 d	1.916E-02
⁹³ Mo	3.500E+03 y	9.273E-12
⁹⁹ Tc	2.130E+05 y	1.949E-04
¹⁰³ Ru	3.925E+01 d	5.900E-04
^{108m} Ag	1.300E+02 y	5.534E-06
^{110m} Ag	2.498E+02 d	3.600E-02
¹¹³ Cd	9.000E+15 y	4.223E-12
¹²⁴ Sb	6.020E+00 d	2.621E-03
¹²⁵ Sb	2.730E+00 y	1.901E-02
¹²³ Te	1.300E+13 y	5.710E-07
¹²⁵ I	6.014E+00 d	4.570E-04
¹²⁹ I	1.570E+07 y	2.101E-05
¹³¹ I	8.040E+00 d	5.299E-03
¹³⁴ Cs	2.062E+00 y	8.661E-02
¹³⁵ Cs	3.000E+06 y	1.105E-05
¹³⁷ Cs	3.017E+01 y	2.431E-01
^{137m} Ba	2.552E+00 min	2.300E-01
¹⁴¹ Ce	3.250E+01 d	1.649E-03
¹⁴⁴ Ce	2.849E+02 d	1.463E-02

Table A.4 (continued)

Radionuclide	Half-life ^b	Concentration (Ci/m ³)
¹⁴⁴ Pr	1.728E+01 min	1.463E-02
¹⁴⁴ Nd	2.100E+15 y	1.689E-10
¹⁴⁷ Pm	2.623E+00 y	1.317E-02
¹⁵⁷ Tb	1.100E+02 y	1.012E-10
¹⁵⁸ Tb	1.800E+02 y	3.768E-10
¹⁷⁵ Hf	7.000E+01 d	1.427E-03
¹⁸¹ Hf	4.240E+01 d	3.235E-03
¹⁸⁷ Re	4.100E+10 y	1.772E-11
²⁰⁹ Po	3.253E+00 h	1.284E-10
²²⁶ Ra	1.600E+03 y	2.852E-04
²²⁹ Th	7.340E+03 y	1.310E-10
²³⁰ Th	7.540E+04 y	1.721E-08
²³² Th	1.405E+10 y	8.482E-03
²³¹ Pa	3.276E+04 y	1.016E-10
²³³ U	1.592E+05 y	2.308E-07
²³⁴ U	2.454E+05 y	5.368E-05
²³⁵ U	7.037E+08 y	3.179E-05
²³⁶ U	2.432E+07 y	7.886E-07
²³⁸ U	4.468E+09 y	9.970E-03
²³⁷ Np	2.140E+06 y	2.210E-07
²³⁹ Pu	2.413E+04 y	1.021E-05 ^c
²⁴⁰ Pu	6.563E+03 y	2.504E-06 ^c
²⁴² Pu	3.763E+05 y	6.148E-07 ^c
²⁴¹ Am	4.322E+02 y	4.053E-05
²⁴³ Am	7.380E+03 y	1.398E-08
²⁴⁸ Cm	3.400E+05 y	6.220E-07
Total		8.380E+00

^aAdapted from ref. 5.^by = years; d = days; h = hours; min = minutes; and s = seconds.^cIsotopes of plutonium are omitted when this list is applied to waste disposed at Barnwell, South Carolina, because this site has not permitted disposal of plutonium (even though traces of plutonium could have entered with other wastes).

Table A.5. Estimated sources and characteristics of commercial Greater-Than-Class-C LLW^a

Waste source	Physical form	Primary isotopes of concern for disposal
Utilities		
Reactor operations	Activated metals, instruments, filters, ion-exchange resins, sludges	⁵⁹ Ni, ⁶³ Ni, ⁹⁴ Nb, and TRU isotopes
Reactor decommissioning	Activated metals	⁵⁹ Ni, ⁶³ Ni, and ⁹⁴ Nb
Fuel testing labs		
Burnup lab operation	Solidified liquids, metal cuttings, glassware, equipment, ion-exchange resins	⁹⁰ Sr and TRU isotopes
Burnup lab decommissioning	Solidified liquids, metals, glassware, equipment	⁹⁰ Sr and TRU isotopes
Sealed sources		
Manufacturer operations	Trash, metal, foils	¹⁴ C, ⁹⁰ Sr, ¹³⁷ Cs, ²⁴¹ Am, and Pu isotopes
Manufacturer decommissioning	Trash, metal, foils	¹⁴ C, ⁹⁰ Sr, ¹³⁷ Cs, ²⁴¹ Am, and Pu isotopes
Sources designated as waste	Sealed sources	¹³⁷ Cs, ²³⁸ Pu, ²³⁹ Pu, and ²⁴¹ Am
Other		
¹⁴ C users	Solidified process liquids	¹⁴ C
Test and research reactors	Activated metals	⁵⁹ Ni, ⁹⁴ Nb, and TRU isotopes
Other	Soil, trash	²⁴¹ Am

^aGleaned from information given in refs. 6 and 7.

Table A.6. Historical and projected number and volume of drums and classes of LLW incorporated in cement to be generated in the WVDP Low-Level Radwaste Treatment System^{a,b,c,d}

End of calendar year	Number of drums			Total volume of drums (m ³)
	Class A ^e	Class B	Class C ^e	
1987	726 ^f	g	—	189
1988	—	g	2,009	523
1989	—	g	4,523	1,177
1990 ^h	—	g	3,862	1,055
1991	—	g	0	0
1992	1,268	g	268	399
1993	2,387	g	1,298	959
1994	—	g	2,641	687
1995	—	g	1,632	425
Total number	4,381	g	16,238	
Total volume, m ³	1,140	g	4,225	5,414

^aThe so-called square drums used are parallelepipeds of square cross sections (~0.6 m × 0.6 m × 0.8 m) with a volume of 71 gal (0.27 m³).

^bThe classes are in accordance with the Classes (A, B, or C) as set by requirements of the NRC in 10 CFR Part 61.55.

^cTaken from ref. 8.

^dAlkaline HLW liquid is processed (see Chapter 2) to yield a loaded ion-exchange material (zeolite), which is HLW, and an effluent, which is LLW. This effluent is solidified with cement.

^eStored in a shielded drum cell.

^fGenerated in 1987 during equipment testing campaigns.

^gNo Class-B LLW is expected to be generated with the effluent mentioned in footnote d.

^hProcessing of alkaline HLW liquid was completed in November 1990, leaving a 1,090-m³ heel of liquid in the alkaline HLW waste (liquid plus sludge) storage tank.

APPENDIX B. CHARACTERISTICS OF IMPORTANT RADIONUCLIDES

APPENDIX B. CHARACTERISTICS OF IMPORTANT RADIONUCLIDES

B.1 DISCUSSION

The following Table B.1 lists radionuclides whose characteristics are most often referenced in the variety of studies and evaluations discussed in Chapters 1–7. It includes isotopes for HLW, TRUW, LLW, and UMT as defined by EPA,¹ NRC,^{2,3} and DOE.^{4,5} The data in Table B.1 were obtained from refs. 6–9.

B.2 REFERENCES

1. U.S. Environmental Protection Agency, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," *Code of Federal Regulations*, 40 CFR Part 191 (July 1, 1995).
2. U.S. Nuclear Regulatory Commission, "Licensing Requirements for Land Disposal of Radioactive Waste," *Code of Federal Regulations*, 10 CFR Part 61 (Jan. 1, 1995).
3. U.S. Nuclear Regulatory Commission, "Biomedical Waste Disposal," *Fed. Regist.* 46(47), 16230–16234 (Mar. 11, 1981).
4. U.S. Department of Energy, DOE Order 5820.2A, *Radioactive Waste Management*, Washington, D.C., Sept. 26, 1988.
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Table B.1. Characteristics of important radionuclides^a

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
³ H	1	1.233E+01 y	β		0.00568		5.68E-03	3.37E-05	9.650E+03	³ He
¹⁴ C	6	5.730E+03 y	β		0.0495		4.95E-02	2.93E-04	4.457	¹⁴ N
²⁶ Al	13	7.2E+05 y	EC		0.4451	2.6758	3.079	1.825E-02	1.91E-02	²⁶ Mg
³² Si	14	650 y	β		0.0647		2.10E-01	1.245E-03	1.719E+01	³² P
³² P	15	14.282 d	β		0.6947		6.95E-01	4.12E-03	2.853E+05	³² S
³⁵ S	16	87.51 d	β		0.0486		4.86E-02	2.88E-04	4.263E+04	³⁵ Cl
³⁶ Cl	17	3.01E+05 y	β (98.1%); EC (1.9%)		0.2460		2.460E-01	1.458E-03	3.299E-02	³⁶ Ar, ³⁶ S
⁴⁰ K	19	1.277E+09 y	β (89.33%); EC (10.67%)		0.4545	0.1559	6.104E-01	3.62E-03	6.983E-06	⁴⁰ Ca; ⁴⁰ Ar
⁴⁵ Ca	20	163.8 d	β		0.0770		7.70E-02	4.56E-04	1.780E+04	⁴⁵ Sc
⁴⁶ Sc	21	83.83 d	β	0.1120	2.0095		2.122	1.257E-02	3.381E+04	⁴⁶ Ti
⁵¹ Cr	24	27.704 d	EC		0.0031	0.0325	3.56E-02	2.11E-04	9.240E+04	⁵¹ V
⁵⁴ Mn	25	312.20 d	EC		0.0034	0.8360	8.394E-01	4.975E-03	7.738E+03	⁵⁴ Cr
⁵⁵ Fe	26	2.73 y	EC		0.0038	0.0016	5.4E-03	3.2E-05	2.500E+03	⁵⁵ Mn
⁵⁹ Fe	26	44.496 d	β		0.1174	1.1882	1.3056	7.741E-03	4.918E+04	⁵⁹ Co
⁵⁷ Co	27	271.77 d	EC		0.0176	0.1252	1.428E-01	8.464E-01	8.456E+03	⁵⁷ Fe
⁵⁸ Co	27	70.92 d	EC		0.0336	0.9758	1.0094	5.99E-03	3.181E+04	⁵⁸ Fe
⁶⁰ Co	27	5.271 y	β		0.0958	2.5058	2.6016	1.541E-02	1.131E+03	⁶⁰ Ni
^{60m} Co	27	10.47 min	IT (99.75%); β (0.25%)		0.0536	0.0066	6.02E-02	3.57E-04	2.993E+08	⁶⁰ Co; ⁶⁰ Ni
⁵⁹ Ni	28	7.5E+04 y	EC		0.0043	0.0024	6.72E-03	3.98E-05	8.079E-02	⁵⁹ Co
⁶⁵ Ni	28	1.001E+02 y	β		0.0171		1.71E-02	1.01E-04	6.168E+01	⁶⁵ Cu

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
⁶⁵ Zn	30	244.1 d	EC		0.0066	0.5838	5.90E-01	3.51E-03	8.237E+03	⁶⁵ Cu
⁶⁷ Ga	31	3.261 d	EC		0.0333	0.1549	1.882E-01	1.115E-03	5.975E+05	⁶⁷ Zn
⁷⁵ Se	34	119.77 d	EC		0.0134	0.3924	4.06E-01	2.41E-03	1.453E+04	⁷⁵ As
⁷⁹ Se	34	<6.5E+04 y			0.0529		5.29E-02	3.13E-04	6.966E-02	⁷⁹ Br
⁸⁵ Kr	36	1.072E+01 y	β		0.2505	0.0022	2.53E-01	1.50E-03	3.923E+02	⁸⁵ Rb
⁸⁶ Rb	37	18.66 d	β		0.6670	0.0945	7.62E-01	4.52E-03	8.138E+04	⁸⁶ Sr
⁸⁸ Sr	38	50.55 d	β		0.5829	0.0001	5.83E-01	3.46E-03	2.905E+04	⁸⁸ Y
⁹⁰ Sr	38	2.85E+01 y	β		0.1958		1.96E-01	1.16E-03	1.364E+02	⁹⁰ Y
⁹⁰ Y	39	2.671 d	β		0.9332		9.33E-01	5.54E-03	5.441E+05	90Zr
⁹¹ Y	39	58.51 d	β		0.6039	0.0036	6.07E-01	3.60E-03	2.452E+04	⁹¹ Zr
⁹³ Zr	40	1.53E+06 y	β		0.0471	0.0018	4.89E-02	2.90E-04	2.513E-03	⁹³ Nb
⁹⁵ Zr	40	64.02 d	β		0.1200	0.7337	8.54E-01	5.06E-03	2.148E+04	⁹⁵ Nb
^{93m} Nb	41	1.36E+01 y	IT		0.0281	0.0018	2.99E-02	1.77E-04	2.826E+02	⁹³ Nb
⁹⁴ Nb	41	2.03E+04 y	β		0.1454	1.5715	1.7169	1.018E-02	1.873E-01	⁹⁴ Mo
⁹⁵ Nb	41	34.97 d	β		0.0435	0.7643	8.078E-01	4.788E-03	3.910E+04	⁹⁵ Mo
⁹³ Mo	42	3500 y	EC		0.0051	0.0107	1.58E-02	9.37E-05	1.10	⁹³ Nb
⁹⁹ Mo	42	2.748 d	β		0.4076	0.2723	6.799E-01	4.028E-03	4.796E+05	⁹⁹ Tc
⁹⁹ Tc	43	2.13E+05 y	β		0.0846		8.46E-02	5.01E-04	1.695E-02	⁹⁹ Ru
^{99m} Tc	43	6.006 h	IT		0.0142	0.1240	1.382E-01	8.186E-04	5.271E+06	⁹⁹ Tc
¹⁰³ Ru	44	39.254 d	β		0.1105	0.4851	5.96E-01	3.53E-03	3.227E+04	¹⁰³ Rh
¹⁰⁶ Ru	44	1.020 y	β		0.1004		1.004E-01	5.951E-04	3.346E+03	¹⁰⁶ Rh
^{103m} Rh	45	56.12 min	IT		0.0375	0.0017	3.92E-02	2.32E-04	3.253E+07	¹⁰³ Rh
¹⁰⁶ Rh	45	2.17 h	β		0.3144	2.8826	3.197	1.894E-02	3.560E+09	¹⁰⁶ Pd

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
¹⁰⁷ Pd	46	6.5E+06 y	β			0.0093	9.3E-03	5.5E-05	5.143E-04	¹⁰⁷ Ag
¹¹⁰ Ag	47	24.6 s	β (99.70%); EC (0.30%)		1.1842	0.0316	1.216	7.208E-03	4.169E+09	¹¹⁰ Cd; ¹¹⁰ Pd
^{110m} Ag	47	249.76 d	β (98.64%); IT (1.36%)		0.0755	2.7392	2.815	1.669E-02	4.750E+03	¹¹⁰ Cd; ¹¹⁰ Ag
¹¹³ Cd	48	9.3E+15 y	β		0.0933		9.13E-02	5.412E-04	3.402E-13	¹¹³ In - 13
^{113m} Cd	48	1.37E+01 y	β (99.9%); IT (0.1%)			0.1834	1.83E-01	1.08E-03	2.168E+02	¹¹³ In; ¹¹³ Cd
^{115m} Cd	48	44.6 d	β		0.6029	0.0329	6.36E-01	3.76E-03	2.546E+04	¹¹⁵ In
¹¹¹ In	49	2.807 d	EC		0.0340	0.4053	4.393E-01	2.604E-03	4.157E+05	¹¹¹ Cd
^{113m} In	49	1.658 h	IT		0.1340	0.2555	3.89E-01	2.31E-03	1.673E+07	¹¹³ In
^{114m} In	49	49.51 d	IT (95.7%); EC (4.3%)		0.1431	0.0943	2.37E-01	1.40E-03	2.313E+04	¹¹⁴ In; ¹¹⁴ Cd
¹¹³ Sn	50	115.09 d	EC		0.1394	0.2808	4.20E-01	2.48E-03	1.004E+04	¹¹³ In
^{117m} Sn	50	13.61 d	IT		0.1613	0.1580	3.19E-01	1.89E-03	7.969E+04	¹¹⁷ Sn
^{119m} Sn	50	293.0 d	IT		0.0783	0.0114	8.97E-02	5.32E-04	4.478E+03	¹¹⁹ Sn
^{121m} Sn	50	5.5E+01 y	IT (77.6%); β (22.4%)		0.0352	0.0050	4.02E-02	2.43E-04	5.912E+01	¹²¹ Sn; ¹²¹ Sb
¹²³ Sn	50	129.2 d	β		0.5222	0.0069	5.29E-01	3.14E-03	8.219E+03	¹²³ Sb
¹²⁵ Sn	50	9.64 d	β		0.8110	0.3124	1.123	6.656E-03	1.084E+05	¹²⁵ Sb
¹²⁶ Sn	50	~1E+05 y	β		0.1249	0.0573	1.82E-01	1.08E-03	2.837E-02	¹²⁶ Sb
¹²⁴ Sb	51	60.20 d	β		0.3897	1.8523	2.242	1.329E-02	1.749E+04	¹²⁴ Te
¹²⁵ Sb	51	2.73 y	β		0.1257	0.4434	5.69E-01	3.37E-03	1.032E+03	¹²⁵ Te
¹²⁶ Sb	51	12.4 d	β		0.3527	2.7496	3.102	1.839E-02	8.360E+04	¹²⁶ Te
^{126m} Sb	51	19.0 min	β (86%); IT (14%)		0.6323	1.5484	2.181	1.292E-02	7.854E+07	¹²⁶ Te; ¹²⁶ Sb
^{123m} Te	52	119.7 d	IT		0.1020	0.1482	2.502E-01	1.482E-03	8.870E+03	¹²³ Te
^{125m} Te	52	58 d	IT		0.1106	0.0361	1.467E-01	8.690E-04	1.801E+04	¹²⁵ Te
¹²⁷ Te	52	9.35 h	β		0.2248	0.0048	2.30E-01	1.36E-03	2.639E+06	¹²⁷ I

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
^{127m} Te	52	109 d	IT (97.6%); β (2.4%)		0.0821	0.0111	9.32E-02	5.52E-04	9.432E+03	¹²⁷ Te; ¹²⁷ I
¹²⁹ Te	52	1.160 h	β		0.5422	0.0624	6.05E-01	3.58E-03	2.094E+07	¹²⁹ I
^{129m} Te	52	33.6 d	IT (64%); β (36%)		0.2663	0.0370	3.03E-01	1.80E-03	3.013E+04	¹²⁹ Te; ¹²⁹ I
¹²³ I	53	13.2 h	EC		0.0276	0.1729	2.005E-01	1.188E-03	1.940E+06	¹²³ Te
¹²³ I	53	60.14 d	EC		0.0179	0.0423	6.02E-02	3.57E-04	1.737E+04	¹²³ Te
¹²⁹ I	53	1.57E+07 y	β		0.0556	0.0248	8.04E-02	4.77E-04	1.765E-04	¹²⁹ Xe
¹³¹ I	53	8.040 d	β		0.1913	0.3826	5.74E-01	3.40E-03	1.240E+05	¹³¹ Xe
¹³³ Xe	54	5.245 d	β		0.1363	0.0459	1.82E-01	1.08E-03	1.872E+05	¹³³ Cs
¹³⁴ Cs	55	2.062 y	β		0.1639	1.5555	1.719	1.019E-02	1.294E+03	¹³⁴ Ba
¹³³ Cs	55	3.0E+06 y	β		0.0563		5.63E-02	3.32E-04	1.151E-03	¹³³ Ba
¹³⁷ Cs	55	3.017E+01 y	β (94.6%); β (5.4%)			0.1708	1.71E-01	1.01E-03	8.698E+01	^{137m} Ba; ¹³⁷ Ba
¹³³ Ba	56	1.054E+01 y	EC		0.0547	0.4045	4.592E-01	2.722E-03	2.500E+02	¹³³ Cs
^{137m} Ba	56	2.552 min	IT		0.0652	0.5991	6.64E-01	3.94E-03	5.379E+08	¹³⁷ Ba
¹⁴¹ Ce	58	32.50 d	β		0.1707	0.0770	2.48E-01	1.47E-03	2.848E+04	¹⁴¹ Pr
¹⁴⁴ Ce	58	284.9 d	β		0.0918	0.0192	1.11E-01	6.58E-04	3.190E+03	¹⁴⁴ Pr
¹⁴³ Pr	59	13.58 d	β		0.3156		3.16E-01	1.87E-03	6.731E+04	¹⁴³ Nd
¹⁴⁴ Pr	59	17.28 min	β		1.2091	0.0289	1.238	7.338E-03	7.555E+07	¹⁴⁴ Nd
^{144m} Pr	59	7.2 min	IT (99.96%); β (0.04%)		0.0464	0.0121	5.85E-02	3.43E-04	1.814E+08	¹⁴⁴ Pr; ¹⁴⁴ Nd
¹⁴⁶ Pm	61	5.53 y	EC (66.1%); β (33.9%)		0.0928	0.7542	8.47E-01	5.02E-03	4.428E+02	¹⁴⁶ Nd; ¹⁴⁶ Sm
¹⁴⁷ Pm	61	2.6234 y	β		0.6196		6.20E-02	3.67E-04	9.270E+02	¹⁴⁷ Sm
¹⁴⁸ Pm	61	5.370 d	β		0.7235	0.5747	1.298	7.691E-03	1.643E+05	¹⁴⁸ Sm
^{148m} Pm	61	41.29 d	β (95.4%); IT (4.6%)		0.1695	1.9861	2.156	1.278E-02	2.136E+04	¹⁴⁸ Sm; ¹⁴⁶ Pm

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
¹⁵¹ Sm	62	9.0E+01 y	β		0.1251		1.25E-01	7.41E-04	2.631E+01	¹⁵¹ Eu
¹⁵² Eu	63	1.333E+01 y	EC (72.08%); β (27.92%)		0.1275	1.1628	1.290	7.646E-03	1.729E+02	¹⁵² Sm; ¹⁵² Gd
¹⁵⁴ Eu	63	8.8 y	β		0.2794	1.2531	1.532	9.081E-03	2.699E+02	¹⁵⁴ Gd
¹⁵⁵ Eu	63	4.96 y	β		0.0650	0.0633	1.28E-01	7.59E-04	4.651E+02	¹⁵⁵ Gd
¹⁵³ Gd	64	241.6 d	EC		0.0399	0.1015	1.414E-01	8.381E-04	3.526E+03	¹⁵³ Eu
¹⁵⁷ Tb	65	150 y	EC		0.0031	0.0050	8.10E-03	4.802E-05	1.519E+01	¹⁵⁷ Gd
¹⁵⁸ Tb	65	150 y	EC (82%) β (18%)				9.02E-01	5.347E-03	1.508E+01	¹⁵⁸ Gd; ¹⁵⁸ Dy
¹⁶⁰ Tb	65	72.3 d	β		0.2535	1.1271	1.381	8.186E-03	1.129E+04	¹⁶⁰ Dy
¹⁶⁹ Yb	70	32.02 d	EC		0.1117	0.3121	4.238E-01	2.512E-03	2.414E+04	¹⁶⁹ Tm
¹⁷⁵ Hf	72	70.0 d	EC		0.0439	0.3646	4.085E-01	2.422E-03	1.066E+04	¹⁷⁵ Lu
¹⁸¹ Hf	72	42.39 d	β		0.1943	0.5441	7.54E-01	4.47E-03	1.702E+04	¹⁸¹ Ta
¹⁸² Ta	73	115.0 d	β		0.2073	1.3011	1.508	8.940E-03	6.253E+03	¹⁸² W
¹⁸⁷ Re	75	4.6E+10 y	β		0.0007		2.59	1.535E-02	3.823E-08	¹⁸⁷ Os
¹⁹² Ir	77	73.831 d	β (95.4%); EC (4.6%)		0.2162	0.8137	1.030	6.105E-03	9.211E+03	¹⁹² Pt; ¹⁹² Os
²⁰¹ Tl	81	3.046 d	EC		0.0481	0.0924	1.40E-01	8.30E-04	2.132E+05	²⁰¹ Hg
²⁰⁷ Tl	81	4.77 min	β		0.4931	0.0022	4.95E-01	2.93E-03	1.904E+08	²⁰⁷ Pb
²⁰⁸ Tl	81	3.053 min	β		0.5979	3.3742	3.972	2.354E-02	2.945E+08	²⁰⁸ Pb
²⁰⁹ Pb	82	3.253 h	β		0.1980		1.98E-01	1.17E-03	4.544E+06	²⁰⁹ Bi
²¹¹ Pb	82	36.1 min	β		0.4523	0.0678	5.20E-01	3.083E-03	2.468E+07	²¹¹ Bi
²¹² Pb	82	10.64 h	β		0.1752	0.1453	3.20E-01	1.90E-03	1.389E+06	²¹² Bi
²¹¹ Bi	83	2.14 min	α (99.727%); β (0.273%)	6.5505	0.0099	0.0467	6.607	3.916E-02	4.184E+08	²⁰⁷ Tl; ²¹¹ Po

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
²¹² Bi	83	1.0092 h	α (35.94%); β (64.06%)	2.1740	0.5025	0.1061	2.783	1.649E-02	1.465E+07	²⁰⁸ Tl; ²¹² Po
²¹³ Bi	83	45.59 min	α (2.16%); β (97.84%)	0.1268	0.4563	0.0825	6.66E-01	3.95E-03	1.934E+07	²⁰⁹ Tl; ²¹³ Po
²⁰⁹ Po	84	102 y	α (99.74%); EC (0.26%)				4.9645	2.943E-01	1.68E+01	²⁰⁵ Pb; ²⁰⁹ Bi
²¹² Po	84	2.98E-07 s	α	8.7844			8.784	5.207E-02	1.774E+17	²⁰⁸ Pb
²¹³ Po	84	4.2E-06 s	α	8.3757			8.375	4.964E-02	1.261E+16	²⁰⁹ Pb
²¹⁵ Po	84	1.780E-03 s	α	7.3864			7.386	4.378E-02	2.948E+13	²¹¹ Pb
²¹⁶ Po	84	1.50E-02 s	α	6.7785			6.779	4.018E-02	3.482E+11	²¹² Pb
²¹⁷ At	85	3.23E-02 s	α	7.0657		0.0002	7.066	4.189E-02	1.610E+12	²¹³ Bi
²¹⁹ Rn	86	3.96 s	α	6.8122	0.0064	0.0560	6.875	4.076E-02	1.301E+10	²¹⁵ Po
²²⁰ Rn	86	55.6 s	α	6.2878		0.0005	6.288	3.727E-02	9.223E+08	²¹⁶ Po
²²¹ Rn	86	3.825 d	α	5.4892		0.0004	5.490	3.255E-02	1.538E+05	²¹⁸ Po
²²¹ Fr	87	4.9 min	α	6.3571	0.0084	0.0277	6.393	3.789E-02	1.772E+08	²¹⁷ At
²²³ Fr	87	21.8 min	β		0.3805	0.0542	4.35E-01	2.85E-03	3.868E+07	²²³ Ra
²²³ Ra	88	11.43 d	α	5.6972	0.0731	0.1348	5.905	3.500E-02	5.121E+04	²¹⁹ Rn
²²⁴ Ra	88	3.66 d	α	5.6751	0.0022	0.0103	5.688	3.372E-02	1.593E+05	²²⁰ Rn
²²⁵ Ra	88	14.2 d	β		0.1057	0.0137	1.19E-01	7.08E-04	3.920E+04	²²⁵ Ac
²²⁶ Ra	88	1.600E+03 y	α	4.7741	0.0035	0.0067	4.784	2.836E-02	9.887E-01	²²² Rn
²²⁸ Ra	88	5.75 y	β		0.0116		1.16E-02	6.88E-05	2.340E+02	²²⁸ Ac
²²⁵ Ac	89	10.0 d	α	5.7501	0.0257	0.0176	5.793	3.434E-02	5.803E+04	²²¹ Fr
²²⁷ Ac	89	2.177E+01 y	β (98.62%); α (1.38%)	0.0673	0.0125	0.0002	8.00E-02	4.74E-04	7.233E+01	²²⁷ Th; ²²³ Fr
²²⁸ Ac	89	6.13 h	β		0.4292	0.9269	1.356	8.038E-03	2.242E+06	²²⁸ Th
²²⁷ Th	90	18.718 d	α	5.9022	0.0543	0.1113	6.068	3.597E-02	3.073E+04	²²³ Ra
²²⁸ Th	90	1.913 y	α	5.3992	0.0201	0.0034	5.423	3.214E-02	8.196E+02	²²⁴ Ra
²²⁹ Th	90	7.340E+03 y	α	4.8620		0.0343	4.896	2.902E-02	2.127E-01	²²⁵ Ra
²³⁰ Th	90	7.54E+04 y	α	4.6651		0.0004	4.665	2.765E-02	2.109E-02	²²⁶ Ra

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
²³¹ Th	90	1.0633 d	β	0.1732		0.0295	2.03E-01	1.21E-03	5.316E+05	²³¹ Pa
²³² Th	90	1.405E+10 y	α	4.0056		0.0002	4.006	2.375E-02	1.097E-07	²²⁸ Ra
²³⁴ Th	90	24.10 d	β		0.0158	0.0094	2.52E-02	1.49E-04	2.316E+04	²³⁴ Pa
²³¹ Pa	91	3.276E+04 y	α	4.9230	0.0483	0.0399	5.011	2.970E-02	4.723E-02	²²⁷ Ac
²³² Pa	91	27.0 d	β		0.1941	0.2042	3.98E-01	2.36E-03	2.075E+04	²³³ U
^{234m} Pa	91	1.17 min	β (99.87%); IT (0.13%)		0.8227	0.0121	8.35E-01	4.95E-03	6.868E+08	²³⁴ U; ²³⁴ Pa
²³² U	92	6.89E+01 y	α	5.3065		0.0002	5.307	3.146E-02	2.140E+01	²²⁸ Th
²³³ U	92	1.592E+05 y	α	4.8141	0.0055	0.0013	4.821	2.857E-02	9.680E-03	²²⁹ Th
²³⁴ U	92	2.454E+05 y	α	4.7732		0.0001	4.773	2.829E-02	6.248E-03	²³⁰ Th
²³⁵ U	92	7.037E+08 y	α	4.3785	0.0426	0.1561	4.577	2.713E-02	2.161E-06	²³¹ Th
²³⁶ U	92	2.342E+07 y	α	4.4793	0.0108	0.0015	4.492	2.662E-02	6.469E-05	²³² Th
²³⁸ U	92	4.468E+09 y	α	4.1945	0.0095	0.0013	4.205	2.492E-02	3.362E-07	²³⁴ Th
²³⁶ Np	93	1.550E+05 y	EC (91%); β (8.9%); α (0.20%)		0.1967	0.1411	3.38E-01	2.00E-03	1.317E-02	²³⁶ U; ²³⁶ Pu; ²³² Pa
²³⁷ Np	93	2.140E+06 y	α	4.7604	0.0640	0.0327	4.857	2.879E-02	7.049E-04	²³³ Pa
²³⁹ Np	93	2.355 d	β		0.2521	0.1740	4.26E-01	2.53E-03	2.320E+05	²³⁹ Pu
²³⁶ Pu	94	2.851 y	α	5.7521	0.0126	0.0020	5.767	3.418E-02	5.313E+02	²³² U
²³⁸ Pu	94	8.774E+01 y	α	5.4871	0.0099	0.0018	5.499	3.2593E-02	1.712E+01	²³⁴ U
²³⁹ Pu	94	2.411E+04 y	α	5.1011		0.0001	5.101	3.024E-02	6.216E-02	²³⁵ U
²⁴⁰ Pu	94	6.563E+03 y	α	5.1549			5.155	3.056E-02	2.279E-01	²³⁶ U
²⁴¹ Pu	94	1.44E+01 y	β	0.0001		0.0052	5.3E-03	3.2E-05	1.030E+02	²⁴¹ Am
²⁴² Pu	94	3.763E+05 y	α	4.8901	0.0081	0.0014	4.900	2.904E-02	3.818E-03	²³⁸ U
²⁴⁴ Pu	94	8.26E+07 y	α (99.875%); SPF (0.125%)	4.5751	0.0007	0.0001	4.576	2.712E-02	1.774E-05	²⁴⁰ U; (fission products)
²⁴¹ Am	95	4.327E+02 y	α	5.4801	0.0304	0.0287	5.539	3.283E-02	3.432	²³⁷ Np
²⁴² Am	95	16.01 h	β (82.7%); EC (17.3%)		0.1781	0.0180	1.96E-01	1.16E-03	8.084E+05	²⁴² Cm; ²⁴² Pu

Table B.1 (continued)

Nuclide	Atomic number	Half-life ^b	Principal mode(s) of decay ^c	Major radiation energies ^d (MeV/dis)			“Q” value ^e		Specific activity (Ci/g)	Daughter(s)
				α	ϵ	γ and X	(MeV/dis)	(W/Ci)		
^{242m} Am	95	1.41E+02 y	IT (99.55%); α (0.45%)	0.0232	0.0403	0.0049	6.84E-02	4.05E-04	9.718	²⁴² Am; ²³⁸ Np ²³⁹ Np
²⁴³ Am	95	7.380E+03 y	α	5.2656		0.0481	5.3137	3.1496E-02	1.993E-01	
²⁴² Cm	96	162.94 d	α	6.0434	0.0090	0.0018	6.0542	3.5886E-02	3.306E+03	²³⁸ Pu
²⁴³ Cm	96	2.85E+01 y	α (99.76%); EC (0.24%)	5.8380	0.1129	0.1316	6.083	3.605E-02	5.162E+01	²³⁹ Pu; ²⁴³ Am
²⁴⁴ Cm	96	1.811E+01 y	α	5.7965		0.0016	5.798	3.437E-02	8.090E+01	²⁴⁰ Pu
²⁴⁵ Cm	96	8.5E+03 y	α	5.3631	0.1342	0.1178	5.615	3.329E-02	1.717E-01	²⁴¹ Pu
²⁴⁶ Cm	96	4.73E+03 y	α	5.3764	0.0072	0.0014	5.385	3.192E-02	3.072E-01	²⁴² Pu
²⁴⁷ Cm	96	1.56E+07 y	α	4.9475		0.3152	5.263	3.119E-02	9.278E-05	²⁴³ Pu
²⁴⁸ Cm	96	3.40E+05 y	α (91.74%); SPF (8.26%)	4.6524			4.6524	2.7577E-02	4.251E-03	²⁴⁴ Pu; (fission products)
²⁵³ Cf	98	2.645 y	α (96.908%); SPF (3.092%)	5.9308	0.0051	0.0011	5.9370	3.5191E-02	5.378E+02	²⁴⁸ Cm; (fission products)

^aBased on refs. 6-9.^by—years; d—days; h—hours; min—minutes; and s—seconds.^c α —alpha decay; β —negative beta decay; EC—electron capture; IT—isoimetric transition (radioactive transition from one nuclear isomer to another of lower energy); and SPF—spontaneous fission.^d α —alpha decay; ϵ —total electron emissions; and γ and X—gamma and X-ray photons.^eThe sum of the average energies for different radiation types in MeV/disintegration or W/Ci (includes alpha and beta particles, discrete electrons, and photons). The “value” indicates the amount of energy (heat) that could be deposited in a radioactive material from each decay event if none of the radiation escaped from the material. Neutrinos are not included.

APPENDIX C. REFERENCE SITES AND FACILITIES

APPENDIX C. REFERENCE SITES AND FACILITIES

This appendix provides information on the major DOE and commercial sites and facilities discussed in this report. The DOE operations and special site offices are identified in Table C.1, along with the sites for which they have responsibility. This is followed by Table C.2, which lists DOE Naval Reactors Program (NE-60) offices and sites. Table C.3 lists major DOE sites and facilities referred to in this report, and major commercial radioactive waste disposal sites are given in Table C.4. For each site or facility listed in Tables C.3 and C.4, additional information is provided, including reference symbol or label, location, operations contractor, and, for DOE sites, the supervisory DOE operations and area office.

Table C.1. DOE operations and special site offices

DOE office	Symbol/label	General mailing address (Phone number) ^a	Radioactive waste sites for which DOE office has responsibility
Albuquerque Operations Office ^b	DOE/AL	P.O. Box 5400 Albuquerque, NM 87115-5400 (505/845-4154)	Grand Junction Projects Office sites Inhalation Toxicology Research Institute Kansas City Plant Los Alamos National Laboratory Pantex Plant Pinellas Plant Sandia National Laboratories/California Sandia National Laboratories/New Mexico Uranium Mill Tailings Remedial Action Program sites Waste Isolation Pilot Plant
Chicago Operations Office ^c	DOE/CH	Building 201 9800 South Cass Avenue Argonne, IL 60439 (708/252-2001)	Ames Laboratory Argonne National Laboratory—East Argonne National Laboratory—West Battelle Columbus Laboratories Decommissioning Project Brookhaven National Laboratory Fermi National Accelerator Laboratory Princeton Plasma Physics Laboratory Reactive Metals, Inc., Extrusion Plant
Idaho Operations Office	DOE/ID	785 DOE Place Idaho Falls, ID 83402 (208/526-0111)	Idaho National Engineering Laboratory
Nevada Operations Office	DOE/NV	P.O. Box 98518 Las Vegas, Nevada 89193-8518 (702/295-1212)	Nevada Test Site
Oakland Operations Office	DOE/OAK	1301 Clay Street Oakland, CA 94612-5208 (510/273-6383)	Energy Technology Engineering Center (Santa Susana Field Laboratory) Laboratory for Energy-Related Health Research (Institute of Toxicology and Environmental Health) Lawrence Berkeley Laboratory Lawrence Livermore National Laboratory Stanford Linear Accelerator Center

Table C.1 (continued)

DOE office	Symbol/label	General mailing address (Phone number) ^a	Radioactive waste sites for which DOE office has responsibility
Oak Ridge Operations Office ^d	DOE/OR	P.O. Box 2001 Oak Ridge, TN 37831 (423/576-5454)	Formerly Utilized Sites Remedial Action Program (FUSRAP) sites Oak Ridge Institute for Science and Education Oak Ridge K-25 Site Oak Ridge National Laboratory Oak Ridge Y-12 Plant Paducah Gaseous Diffusion Plant Portsmouth Gaseous Diffusion Plant Weldon Spring Site Remedial Action Project
Ohio Field Office	DOE/OH	P.O. Box 3020 Miamisburg, OH 45343-3020 (513/865-3977)	Fernald Environmental Management Project Mound Plant West Valley Demonstration Project
Richland Operations Office	DOE/RL	P.O. Box 550 825 Jadwin Avenue Richland, WA 99352 (509/376-7411)	Hanford Site Pacific Northwest Laboratory
Rocky Flats Office	DOE/RF	P.O. Box 928 Golden, CO 80401-0928 (303/966-7000)	Rocky Flats Environmental Technology Site
Savannah River Operations Office	DOE/SR	P.O. Box A Aiken, SC 29802 (803/725-6211)	Savannah River Site

^aAccess to main organizations.^bThe Albuquerque Operations Office also has the following area offices (monitoring activities of the sites indicated) under its purview: Amarillo (Pantex Plant), Grand Junction (Grand Junction Projects Office), Kansas City (Kansas City Plant), Los Alamos (Los Alamos National Laboratory), and Pinellas (Pinellas Plant).^cThe Chicago Operations Office has the following area offices (monitoring activities of the sites indicated) under its purview: Argonne (Argonne National Laboratory-East), Batavia (Fermi National Accelerator Laboratory), Upton (Brookhaven National Laboratory), and Princeton (Princeton Plasma Physics Laboratory).^dThe Oak Ridge Operations Office has a separate site office located at the following: Oak Ridge K-25 Site, Oak Ridge National Laboratory, Oak Ridge Y-12 Plant, Paducah Gaseous Diffusion Plant, Portsmouth Gaseous Diffusion Plant, and the Weldon Spring Site Remedial Action Project.

Table C.2. DOE Naval Reactors Program offices and sites

DOE office	Symbol/label	General mailing address (Phone number) ^a	Radioactive waste sites for which DOE office has responsibility
DOE/HQ, Office of Naval Reactors	DOE/HQ/NE-60	Route Symbol NE-60 2521 Jefferson Davis Hwy Arlington, VA 22202 (703/603-7321)	Oversees Pittsburgh and Schenectady area offices and their sites; oversees the following shipyards: • Charleston Naval Shipyard, Charleston, SC • Mare Island Naval Shipyard, Mare Island, CA • Norfolk Naval Shipyard, Norfolk, VA • Pearl Harbor Naval Shipyard, Pearl Harbor, HI • Portsmouth Naval Shipyard, Portsmouth, ME • Puget Sound Naval Shipyard, Puget Sound, WA
Pittsburgh Naval Reactors Offices	DOE/PNRO	P.O. Box 109 West Mifflin, PA 15122-0109 (412/476-5000)	Bettis Atomic Power Laboratory Naval Reactors Facility (Idaho Falls, ID)
Schenectady Naval Reactors Office	DOE/SNRO	P.O. Box 1069 Schenectady, NY 12301-1069 (518/395-4000)	Knolls Atomic Power Laboratory

^aAccess to main organizations.

Table C.3. Major DOE sites and facilities referred to in this report

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations office (Phone number) ^a
Ames Laboratory	Ames	Iowa State University Spedding Hall Pammel Drive Ames, IA 50011-3020 (515/294-2680)	Chicago (708/252-2001)
Argonne National Laboratory-East	ANL-E	University of Chicago 9700 South Cass Avenue Argonne, IL 60439 (708/252-2000)	Chicago Argonne Area Office (708/252-2001)
Argonne National Laboratory-West ^b	ANL-W	University of Chicago Idaho Site P.O. Box 2528 Idaho Falls, ID 83403-2528 (208/533-7000)	Chicago (708/252-2001)
Battelle Columbus Laboratories Decommissioning Project	BCLDP	Battelle Memorial Institute 505 King Avenue Columbus, OH 43201-2693 (614/424-3989)	Chicago (708/252-2001)
Brookhaven National Laboratory	BNL	Associated Universities, Inc. 16 South Railroad Street Upton, NY 11973-2310 (516/282-2123)	Chicago Brookhaven Area Office (516/282-3427)
Colonie Interim Storage Site	CISS	Beechtel National, Inc. P.O. Box 5169 Albany, NY 12205 (518/482-0237)	Oak Ridge (423/576-5454)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations office (Phone number) ^a
Energy Technology Engineering Center (Santa Susana Field Laboratory)	ETEC (SSFL)	Rockwell International Rocketdyne Division 6633 Canoga Avenue P.O. Box 1449 Canoga Park, CA 91304 (818/586-5326)	Oakland (510/273-6383)
Fermi National Accelerator Laboratory	FNAL	University Research Association P.O. Box 500 Batavia, IL 60510 (708/840-3000)	Chicago Batavia Area Office (708/840-3281)
Fernald Environmental Management Project	FEMP	Fluor Daniels Fernald Environmental Restoration Management Corporation P.O. Box 398704 7400 Wiley Road Cincinnati, OH 45239-8704 (513/738-6200)	Ohio Field Office Fernald Area Office (513/648-3119)
Grand Junction Projects Office	GJPO	Chem-Nuclear Geotech, Inc. P.O. Box 14000 Grand Junction, CO 81502-5504 (303/248-6200)	Albuquerque (505/845-4154)
Hanford Site	Hanford	Westinghouse Hanford Company, Inc. P.O. Box 1970 Richland, WA 99352 (509/376-7411)	Richland (509/376-7411)
Idaho National Engineering Laboratory	INEL	Lockheed Martin Idaho Technologies P.O. Box 1625 Idaho Falls, ID 83415-4201 (208/526-0111)	Idaho (208/526-0111)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations office (Phone number) ^a
Inhalation Toxicology Research Institute	ITRI	Lovelace Biomedical and Environmental Research Institute, Inc. P.O. Box 5890 Albuquerque, NM 87185 (505/845-1037)	Albuquerque (505/845-4154)
Kansas City Plant	KCP	Allied-Signal Aerospace Company Kansas City Division Bannister Federal Complex Kansas City, MO 64141 (816/997-2000)	Albuquerque Kansas City Area Office (816/997-3348)
Laboratory for Energy-Related Health Research (Institute of Toxicology and Environmental Health)	LEHR (ITEH)	University of California-Davis Old Davis Road Davis, CA 95616-8615 (916/752-1340)	Oakland (510/273-6383)
Lawrence Berkeley Laboratory	LBL	University of California One Cyclotron Road Berkeley, CA 94720 (510/486-4000)	Oakland Lawrence Berkeley Laboratory Site Office (510/486-4363)
Lawrence Livermore National Laboratory	LLNL	University of California 7000 East Avenue P.O. Box 808, L-1 Livermore, CA 94550 (510/422-1100)	Oakland (510/273-6383)
Los Alamos National Laboratory	LANL	University of California P.O. Box 1663 Los Alamos, NM 87545 (505/667-5061)	Albuquerque Los Alamos Area Office (505/667-5061)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations office (Phone number) ^a
Mound Plant	Mound	EG&G Mound Applied Technologies P.O. Box 3000 Miamisburg, OH 45343-3000 (513/865-4020)	Ohio Field Office Miamisburg Area Office (513/865-3271)
Naval Reactors Program Facilities Bettis Atomic Power Laboratory	BAPL	Westinghouse Electric Corporation P.O. Box 79 West Mifflin, PA 15122-0079 (412/476-5000)	DOE/HQ Office of Naval Reactors (NE-60) Pittsburgh Naval Reactors Office (412/476-5000)
Knolls Atomic Power Laboratory	KAPL	General Electric Company P.O. Box 1072 Schenectady, NY 12301-1072 (518/395-4000)	DOE/HQ Office of Naval Reactors (NE-60) Schenectady Naval Reactors Office (518/395-4000)
Naval Reactors Facility (INEL)	NRF	Westinghouse Electric Corporation P.O. Box 2068 Idaho Falls, ID 83403-2068 (208/526-5526)	DOE/HQ Office of Naval Reactors (NE-60) Pittsburgh Naval Reactors Office (412/476-5000)
Nevada Test Site	NTS	Reynolds Electrical & Engineering Company, Inc. P.O. Box 98521 Mail Stop 738 Las Vegas, NV 89193-8521 (702/295-9060)	Nevada (702/295-1212)
Oak Ridge Institute for Science and Education	ORISE	Oak Ridge Associated Universities 246 Laboratory Road P.O. Box 117 Oak Ridge, TN 37831-0117 (423/576-3000)	Oak Ridge (423/576-5454)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations office (Phone number) ^a
Oak Ridge K-25 Site	K-25	Lockheed Martin Energy Systems, Inc. P.O. Box 2003 Oak Ridge, TN 37831-7358 (423/576-5454)	Oak Ridge (423/576-5454)
Oak Ridge National Laboratory	ORNL	Lockheed Martin Energy and Environment Sector P.O. Box 2008 Oak Ridge, TN 37831-6235 (423/576-5454)	Oak Ridge (423/576-5454)
Oak Ridge Y-12 Plant	Y-12	Lockheed Martin Energy Systems, Inc. P.O. Box 2009 Oak Ridge, TN 37831-8010 (423/576-5454)	Oak Ridge (423/576-5454)
Pacific Northwest Laboratory ^c	PNL	Battelle Memorial Institute Battelle Boulevard P.O. Box 999 Richland, WA 99352 (509/375-2121)	Richland (509/376-7411)
Paducah Gaseous Diffusion Plant	PAD	Lockheed Martin Utility Systems, Inc. P.O. Box 1410 Paducah, KY 42001 (502/441-6000)	Oak Ridge Paducah Site Office (502/441-6800)
Pantex Plant	PANT	Mason & Hanger—Silas Mason Company, Inc. P.O. Box 30020 Amarillo, TX 79177 (806/477-3000)	Albuquerque Amarillo Area Office (806/477-3000)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations office (Phone number) ^a
Pinellas Plant	Pinellas	Lockheed Martin Specialty Components, Inc. P.O. Box 2908 Largo, FL 34649-2908 (813/541-8001)	Albuquerque Pinellas Area Office (813/541-8196)
Portsmouth Gaseous Diffusion Plant	PORTS	Lockheed Martin Utility Systems, Inc. P.O. Box 628 Piketon, OH 45661 (614/897-2331)	Oak Ridge Portsmouth Site Office (614/897-2331)
Princeton Plasma Physics Laboratory	PPPL	Princeton University P.O. Box 451 Princeton, NJ 08543 (609/243-2000)	Chicago Princeton Area Office (609/243-3700)
Reactive Metals, Inc., Extrusion Plant	RMI	RMI Titanium Company P.O. Box 579 Ashtabula, OH 44004 (216/992-7442)	Chicago RMI Decommissioning Project Office (216/992-7442)
Rocky Flats Environmental Technology Site	RFETS	EG&G Rocky Flats, Inc. P.O. Box 464 Golden, CO 80401-0464 (303/966-7000)	Rocky Flats Office (303/966-7000)
Sandia National Laboratories California	SNL/CA	Lockheed Martin Sandia Corporation P.O. Box 969 Livermore, CA 94551-0969 (510/294-3000)	Albuquerque (505/845-4154)
New Mexico	SNL/NM	Lockheed Martin Sandia Corporation P.O. Box 5800 Albuquerque, NM 87185-5800 (505/844-5678)	Albuquerque (505/845-4154)

Table C.3 (continued)

Site/facility	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^a	DOE operations office (Phone number) ^a
Savannah River Site	SRS	Westinghouse Savannah River Company P.O. Box 616 Aiken, SC 29802 (803/725-6211)	Savannah River (803/725-6211)
Stanford Linear Accelerator Center	SLAC	Stanford University P.O. Box 4349 Palo Alto, CA 94309 (415/926-3300)	Oakland Stanford Site Office (415/926-3208)
Three Mile Island—Unit 2 Reactor	TMI—Unit 2	General Public Utilities P.O. Box 480 Middletown, PA 17057 (717/944-7621)	Idaho Three Mile Island Site Office (717/944-7621)
Waste Isolation Pilot Plant	WIPP	Westinghouse Electric Corporation WIPP Project Office P.O. Box 2078 Carlsbad, NM 88221 (505/885-7500)	Albuquerque Carlsbad Area Office (505/234-7327)
Weldon Spring Site Remedial Action Project	WSSRAP	Jacobs Engineering Group, Inc. MK-Ferguson Company 7295 Highway 94 South St. Charles, MO 63304 (314/441-8978)	Oak Ridge Weldon Spring Site Office (314/441-8978)
West Valley Demonstration Project	WVDP	Westinghouse Electric Corporation West Valley Nuclear Services Company, Inc. 10282 Rock Springs Road P.O. Box 191 West Valley, NY 14171-0191 (716/942-3235)	Ohio Field Office West Valley Area Office (716/942-4313)

^aPhone number for access to main organization.^bPart of the Idaho National Engineering Laboratory Reservation.^cPart of the Hanford Site.

Table C.4. Major commercial radioactive waste disposal sites included in this report^a

Site	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^b
Barnwell	BARN	Chem-Nuclear Systems, Inc. 140 Stoneridge Drive Columbia, SC 29210 (803/256-0450)
Beatty	BETY	U.S. Ecology, Nuclear P.O. Box 578 Beatty, NV 89003 (702/553-2203)
Envirocare ^c	ENVR	Envirocare of Utah, Inc. 46 West Broadway Suite 240 Salt Lake City, Utah 84101 (801/532-1330)
Maxey Flats	MFKY	Commonwealth of Kentucky ^d Department of Environmental Protection/Superfund Branch Maxey Flats Project 14 Reilly Road Frankfort, KY 40601-1190 (502/564-6716) <u>Site address:</u> Maxey Flats Project Route 2 P.O. Box 238A Hillsboro, KY 41049 (606/784-6612)
Richland	RICH	U.S. Ecology, Nuclear P.O. Box 638 Richland, WA 99352 (509/377-2411)
Sheffield	SHEF	U.S. Ecology, Nuclear P.O. Box 158 Sheffield, IL 61361 (815/454-2342)
West Valley	WVNY	Westinghouse Electric Corporation West Valley Nuclear Services Company, Inc. 10282 Rock Springs Road P.O. Box 191 West Valley, NY 14171-0191 (716/942-3235)

Table C.4 (continued)

Site	Symbol/label	Principal contractor(s) for site operations and mailing address (Phone number) ^b
West Valley (contd.)	WVNY	New York State Energy Research and Development Authority 2 Rockefeller Plaza Albany, NY 12223 (518/465-6251)

^aDoes not include uranium mill tailings sites. See Table 5.2.

^bPhone number for access to main organizations.

^cAlso contains disposed wastes from DOE site activities.

^dThe Commonwealth of Kentucky assumed operating contractor responsibilities for the Maxey Flats site in 1992.

**APPENDIX D. INTEGRATED DATA BASE DOCUMENT
ACCESS ON THE INTERNET**

APPENDIX D. INTEGRATED DATA BASE DOCUMENT ACCESS ON THE INTERNET

A copy of this document (IDB Rev. 11) will be accessible via the Internet on the DOE Office of Environmental Management World Wide Web (EM WWW) Server at the Universal Resource Locator (URL) via the following path: **<http://www.em.doe.gov/idb95>** .

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APPENDIX E. INTEGRATED DATA BASE READER COMMENT FORM

APPENDIX E. INTEGRATED DATA BASE READER COMMENT FORM

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GLOSSARY OF TERMS

This glossary gives definitions of some terms commonly used in the main body of this report. A more detailed glossary of waste terms, applicable to the DOE complex, is being developed by the DOE Office of Environmental Management and will be issued for use by DOE and DOE contractors in the near future.

Actinides: Elements with atomic numbers from 89 (actinium) or 90 (thorium) to 103 (lawrencium) inclusive.

Activation product: A radioactive material produced by bombardment with neutrons, protons, or other nuclear particles.

Agreement State: A state that has entered into an agreement with the U.S. Nuclear Regulatory Commission (as specified by the Atomic Energy Act of 1954) and has authority to regulate the disposal of low-level radioactive waste under such an agreement. This term is used in the Low-Level Radioactive Waste Policy Act (Public Law 99-240).

Alpha decay: Radioactive decay in which an alpha particle (^4He nucleus) is emitted.

Beta decay: Radioactive decay in which a beta particle (negative or positive electron) is emitted.

Borosilicate glass: A type of glass containing at least 5% boric oxide. It is used in glassware that resists heat and is a leading candidate for use in high-level waste immobilization and disposal.

Branching ratio: In branching radioactive decay, the fraction of nuclei that disintegrates in a specific way. (It is usually expressed as a percentage.)

Burnup, specific: The total energy released per initial unit mass of reactor fuel as a result of the fission process occurring. The unit commonly used for specific burnup is megawatt-days per metric ton of initial heavy metal, MWd/MTIHM.

By-product material: (1) Any radioactive material (except special nuclear material) yielded in, or made

radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material. For purposes of determining the applicability of the Resource Conservation and Recovery Act of 1976 to any radioactive waste, the term "any radioactive material" refers only to the actual radionuclides dispersed or suspended in the waste substance. The nonradioactive hazardous waste component of the waste substance will be subject to regulation under the Resource Conservation and Recovery Act; (2) the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction operations and which remain underground do not constitute by-product material.

Calcine: A form of high-level waste produced from defense reactor fuel reprocessing waste (at the Idaho Chemical Processing Plant) by heating to a temperature below the melting point to bring about loss of moisture and nonradioactive volatile oxides, thus producing a chemically stable granular powder.

Canister: A metal container used for the storage or disposal of heat-producing, solid, high-level radioactive waste.

Capacity factor, plant: The ratio of the electrical energy actually supplied by a power plant in a given time interval to the electrical energy that could have been produced at continuous full-power operation during the same time period.

Capsules: Encapsulated strontium and cesium high-level wastes produced from defense reactor fuel reprocessing at the Hanford Site. For purposes of this report, inventories of encapsulated strontium and cesium are included in a separate table in the high-level waste section (Chapter 2).

Cladding: A corrosion-resistant tube (commonly aluminum, zirconium alloy, or stainless steel) surrounding the reactor fuel pellets which provides protection from a chemically reactive environment and containment of fission products.

Code of Federal Regulations: A documentation of the general rules by the executive departments of the federal government. The code is divided into 50 titles that represent broad areas subject to federal regulation. Each title is divided into chapters that usually bear the name of the issuing agency. Each chapter is further subdivided into parts covering specific regulatory areas.

Control rod: A movable part of the reactor core that is adjusted to regulate the degree of fuel fissioning in the core.

Conversion, fuel: Chemical treatment of yellowcake (U_3O_8) to uranium hexafluoride (UF_6) in preparation for enrichment.

Core, nuclear reactor: That part of the reactor which contains the nuclear fuel and in which most or all of the nuclear fissions occur.

Daughter product(s): The nuclide(s) formed by the radioactive decay of the parent radionuclide.

Decay, radioactive: The transition of a nucleus from one energy state to a lower one, usually involving the emission of a photon, electron, neutron, or alpha particle.

Decay chain, radioactive: A series of nuclides in which each member decays to the next member of the chain through radioactive decay until a stable nuclide has been formed.

Decommissioning: Activities taken to reduce the potential health and safety impacts of commercial and DOE-contaminated facilities, including removing a unit from operation, decontamination, entombment, dismantlement, or conversion of the site to another use.

Decommissioning wastes: Wastes (generally low-level) collected or resulting from facility decommissioning activities.

Decontamination: Activities taken to remove unwanted (typically radioactive) material from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other (treatment) techniques.

Deep bed plant: A boiling-water reactor facility using a demineralizer vessel for water purification which contains an ion-exchange resin that is 3 ft or more deep.

Disintegration energy (Q-value): The amount of energy released in a particular nuclear disintegration. This is usually expressed in MeV/disintegration.

DOE waste: Radioactive waste produced from activities supported by the Department of Energy and/or U.S. government defense programs.

Double-shell tank wastes: High-level wastes, generated from defense reactor fuel reprocessing at Hanford, which are stored in double-shelled tanks. These wastes consist of a mixture of liquid and suspended solids referred to as slurry. See also "single-shell tank wastes."

Electron capture: Radioactive decay in which an orbital electron is captured by the nucleus of the radionuclide.

Enrichment, fuel: A nuclear fuel cycle process which increases the concentration of fissionable uranium (i.e., ^{235}U) in uranium ore above its natural level of 0.71%. (The method currently used in the United States is gaseous diffusion.)

Environmental Impact Statement: A report that documents the information required to evaluate the environmental impact of a project. Such a report informs decision-makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the environment.

Environmental restoration: Cleanup and restoration of sites contaminated with radioactive and/or hazardous substances during past production, accidental releases, or disposal activities.

Equilibrium cycle: An assumed nuclear fuel cycle in which the feed and waste materials of a facility have constant compositions. In a reactor this condition typically results after the third or fourth fuel-loading schedule.

Fabrication, fuel: Conversion of enriched uranium hexafluoride (UF_6) into pellets of ceramic uranium dioxide (UO_2). These pellets are then sealed into corrosion-resistant tubes of zirconium alloy or stainless steel. The loaded tubes, called fuel elements or rods, are then mounted into special assemblies for loading into the reactor core.

Fertile nuclide: A nuclide capable of being transformed into a fissile nuclide by neutron capture.

Filter/demineralizer plant: A facility that combines filtration and ion-exchange processing using non-regenerable powered resins.

Fissile nuclide: A nuclide capable of undergoing nuclear fission with thermal neutrons.

Fission, nuclear: The division of a heavy atomic nucleus into two or more isotopes, usually accompanied by the emission of neutrons and gamma radiation.

Fission products: Nuclides produced either by fission or by the subsequent decay of the nuclides thus formed.

Fission, spontaneous: Nuclear fission that occurs without the addition of particles or energy to the nucleus.

Formerly utilized site: A site contaminated with radioactive wastes which was previously used for supporting nuclear activities of the DOE's predecessor agencies, the Manhattan Engineer District (Manhattan Project) and the Atomic Energy Commission.

Fuel assembly: A grouping of nuclear fuel rods that remains integral during the charging and discharging of a reactor core.

Fuel cycle, nuclear: The complete series of steps involved in supplying fuel for nuclear reactors. It includes mining, refining, UF_6 conversion, enrichment, fabrication of fuel elements, use in a reactor, and management of radioactive waste. It may also involve chemical processing to recover the fissionable material remaining in the spent nuclear fuel, reenrichment of the fuel material, and/or refabrication of new fuel elements.

Generation (electricity): The process of producing electric energy from other forms of energy; also, the amount of electric energy produced, commonly expressed in kilowatt-hours (kWh) or megawatt-years [MW(e)-years].

Generation (gross): The total amount of electric energy produced by the generating units in a generating station or stations, measured at the generator terminals.

Generation (net): Gross generation less the electric energy consumed at the generating station for station use.

Generation (waste): The origination of new wastes from various facility operations (including production, rework, decontamination and decommissioning, and environmental restoration), including the recovery of pre-1970 transuranic-produced wastes, should their recovery be determined necessary.

Glass frit: A fusible ceramic mixture used to make glass for use in the immobilization and disposal of high-level wastes.

Greater-than-Class-C low-level waste: Waste from commercial sources containing concentrations of radionuclides that exceed U.S. Nuclear Regulatory Commission limits for Class C low-level radioactive waste, as defined in 10 CFR Part 61.55.

Grout: A mortar or cement mixture used to immobilize radioactive wastes.

Half-life, radioactive: For a single radioactive decay process, the time required for the activity to decrease to one-half of its initial value by that process.

Hazardous waste: Nonradioactive waste that has at least one of the following characteristics: (1) is listed as a hazardous waste in Subpart D of 40 CFR Part 261, (2) exhibits any of the characteristics identified in Subpart C of 40 CFR Part 261, or (3) contains PCB-containing wastes subject to regulation under the Toxic Substances Control Act and 40 CFR Parts 702-799.

High-level waste: As defined by the Nuclear Waste Policy Act, high-level waste is (1) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including the liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations and (2) other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule to require permanent isolation.

Hydrofracture: A process formerly used for permanent disposal of low-level (approximately 0.25 Ci/L) liquid waste at the Oak Ridge National Laboratory. The process involved mixing the waste with a blend of cement and other additives with the resulting grout being injected into shale at a depth of 200 to 300 m. The injected grout hardened into thin, horizontal sheets several hundred meters wide.

Industrial waste: Commercial low-level waste resulting from nonnuclear fuel cycle sources. These include the commercial producers of radiochemicals and radiopharmaceuticals, luminous dial manufacturers, and instruments that incorporate sealed source components (e.g., smoke detectors).

Institutional waste: Commercial low-level waste resulting from bioresearch, medical, and certain nonbioresearch sources. Bioresearch wastes include wastes from animal studies at universities. Medical wastes include those generated from diagnostic and therapeutic procedures on humans at hospitals. Nonbioresearch wastes include research reactor wastes; small-volume, sealed radiation sources; and accelerator targets.

Leaching: The process of removal or separation of soluble components from a solid by percolating water or other liquids through the solid.

Low-level waste: As specified in the Low-Level Radioactive Waste Policy Amendments Act of 1985 (Public Law 99-240), radioactive waste not classified as high-level waste, spent nuclear fuel, or by-product material specified as uranium or thorium tailings and waste.

Mill tailings, uranium: Earthen residues that remain after the extraction of uranium from ores. Tailings may also contain other minerals or metals not extracted in the process.

Mixed low-level waste: Waste that satisfies the definition of low-level radioactive waste (LLW) in the Low-Level Radioactive Waste Policy Amendments Act of 1985 and that contains hazardous waste that has at least one of the following characteristics: (1) is listed as a hazardous waste in Subpart D of 40 CFR Part 261, (2) exhibits any of the hazardous waste characteristics identified in Subpart C of 40 CFR Part 261, or (3) contains PCB-containing wastes subject to regulation under the Toxic Substances Control Act and 40 CFR Parts 702–799.

Mixed-oxide fuel: Nuclear reactor fuel composed of plutonium and uranium in oxide form.

Mixed waste: Waste that includes concentrations of both radionuclides and hazardous chemicals.

Moderator: A material used to reduce neutron energy (for fissioning if in a reactor) by elastic scattering.

MRS facility: A proposed facility for the monitored retrievable storage of spent nuclear fuel from commercial power plants. Such a facility would permit continuous monitoring, management, and maintenance of these wastes and provide for their ready retrieval for further processing or disposal.

Naturally occurring or accelerator-produced radioactive material: Any radioactive material that can be considered naturally occurring and is not source, special nuclear, or by-product material or that is produced in a charged particle accelerator.

Neutron activation: The process of irradiating a material with neutrons so that the material itself is transformed into a radioactive nuclide.

Nonfuel components: Nuclear reactor core parts and hardware, excluding the nuclear fuel itself. Such components include shrouds, control rods, fuel channels, in-core chambers, support tubes, and dummy fuel rods.

Parent: A radionuclide that upon decay yields a specified nuclide (the daughter) either directly or as a later member of a radioactive decay series.

Pressure vessel, reactor: A strong-walled container housing the core of most types of power reactors. It usually also contains other core components such as the moderator and control rods.

PUREX™ process: A solvent extraction process that may be used in the reprocessing of uranium/plutonium-based nuclear fuels.

Radioactivity: The property possessed by certain nuclides of spontaneously emitting alpha or beta particles and, sometimes, gamma radiation by the disintegration of atomic nuclei. The units for the rate of decay of radioactive nuclides are the curie, Ci (3.7×10^{10} disintegrations per second exactly), or, in SI units, the becquerel, Bq (1 disintegration per second).

Reactor, boiling-water: A light-water reactor in which water, used as both coolant and moderator, is allowed to boil in the core. The resulting steam is used directly to drive a turbine.

Reactor, breeder: A reactor that produces more fissionable fuel than it consumes. The new fissionable material is created by a process (breeding) in which fission neutrons are captured in fertile materials.

Reactor, fast flux: A reactor in which fission is induced predominantly by fast neutrons.

Reactor, high-temperature, gas-cooled: A nuclear reactor that uses an inert gas (helium) as the primary coolant and graphite as the moderator.

Reactor, light-water: A nuclear reactor that uses light water (H_2O) as the primary coolant and moderator and slightly enriched uranium as the fuel. There are two types of commercial light-water reactors: boiling-water and pressurized-water.

Reactor, naval propulsion: A reactor used to power a U.S. Navy vessel.

Reactor, pressurized-water: A light-water reactor in which heat is transferred from the core to a heat exchanger via water kept under high pressure, so that high temperatures can be maintained in the primary coolant system without boiling the water. Steam is generated in a secondary circuit.

Reactor, production: A reactor whose primary purpose is to produce fissile or other materials or to perform irradiations on an industrial scale. Unless otherwise specified, the term usually refers to either a tritium- or plutonium-production facility used to produce materials for nuclear weapons.

Reactor, research: A reactor whose nuclear radiations are used primarily as a tool for basic or applied research. Typically, it has a thermal power of 10 MW(t) or less and may include facilities for testing reactor materials.

Reactor, test: A reactor associated with an engineering-scale test program conducted to develop basic design information or demonstrate safety characteristics of nuclear reactor systems.

Reinserted fuel: Irradiated reactor fuel that is discharged in one cycle and inserted into the same reactor during a subsequent refueling. In a few cases, fuel discharged from one reactor has been used to fuel a different reactor.

Repository, geologic: A facility that has an excavated subsurface system for the permanent disposal of spent nuclear fuel and high-level waste.

Reprocessing, fuel: The chemical/mechanical processing of irradiated nuclear reactor fuel to remove fission products and recover fissile and fertile material.

Salt cake: A salt form of high-level waste stored in tanks, which is produced from neutralizing acidic liquid waste from defense reactor fuel reprocessing with an alkaline agent (caustic soda).

Saltstone: A low-level waste by-product from the solidification of high-level waste at the Savannah River Site. Saltstone is retained in trenches at the Savannah River Site.

Sea-bed disposal: Placement of waste packages in deep ocean sediments.

Sea dumping (disposal): The practice of periodically dumping shiploads of drummed, solidified waste into the ocean at specified locations. (No longer performed.)

Separative work unit: The standard measure of enrichment services. The separative work unit (SWU) is expressed as a unit of mass. For example, 1 kilogram of separative work is expressed as 1 kg SWU.

Single-shell tank wastes: High-level wastes, generated from defense reactor fuel reprocessing at Hanford, which are stored in single-shelled tanks that contain liquid, sludge, and salt cake. See also "double-shell tank wastes."

Slurry, high-level waste: A watery mixture of highly radioactive, insoluble matter.

Solvent extraction: The separation of materials of different chemical types by exploiting the relative chelating ability of different chemicals which preferentially dissolve in one of the two phases. In spent nuclear fuel reprocessing, liquid-liquid contact of two immiscible solvents (one aqueous, one organic) permits recovery and separation of uranium and plutonium in one phase and fission products in the other phase.

Source term (IDB Program usage): A set of qualitative and quantitative features used to describe the origin and concentration of radioactive waste. The qualitative features include a flowchart of waste streams generated by a facility or an activity. Quantitative features include (1) the number of curies of radioactivity expressed either per unit of facility production or per unit of waste volume or mass and (2) a listing of the relative concentrations of component radioisotopes per curie of waste activity.

Special nuclear material: Plutonium or uranium enriched to a higher-than-natural assay.

Spent nuclear fuel: Nuclear fuel that has been permanently discharged from a reactor after it has been irradiated. Typically, spent nuclear fuel is measured in terms of either the number of discharged fuel assemblies or the quantity of discharged fuel mass. The latter is measured either in metric tons of heavy metal (i.e., only the heavy-metal content of the spent nuclear fuel is considered) or in metric tons of initial heavy metal (essentially, the initial heavy-metal mass of the fuel before irradiation). The difference between these two quantities is the weight of the fission products produced during irradiation.

Thermal power: A measure of the rate of heat-energy emission that results from the radioactive decay of a material. A unit of thermal power commonly used is the watt (W).

THOREX process: A solvent extraction process developed to reprocess thorium-based nuclear fuels.

Transuranic waste: As defined and used by the U.S. Department of Energy (DOE Order 5820.2A), radioactive waste that, at the time of assay, contains more than 100 nCi/g of alpha-emitting isotopes with atomic numbers greater than 92 and half-lives greater than 20 years.

Transuranic waste acceptance criteria: A set of requirements/criteria that must be satisfied prior to transport to and emplacement in the Waste Isolation Pilot Plant for disposal.

Transuranic waste certification: The process for verifying that waste meets the applicable requirements/criteria for transport to and emplacement in a repository for disposal.

Transuranic waste, contact-handled: Transuranic waste with a surface dose rate of less than 200 mrem/h.

Transuranic waste nondestructive assay/nondestructive examination: Nondestructive test procedures performed on suspect transuranic wastes to determine their transuranic isotope concentration. From these tests such wastes can be properly classified (certified) as transuranic or low-level.

Transuranic waste, remote-handled: Transuranic waste with a surface dose rate of greater than 200 mrem/h.

Vitrification: The conversion of high-level waste materials into a glassy or noncrystalline solid for subsequent disposal.

Waste Isolation Pilot Plant: A facility, located near Carlsbad, New Mexico, to be used for demonstrating the safe disposal of transuranic wastes from DOE defense-related activities.

Yellowcake: A uranium oxide concentrate that results from milling (concentrating) uranium ore. It typically contains 80 to 90% U_3O_8 .

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