2. HIGH-LEVEL WASTE

2.1 INTRODUCTION

High-level waste (HLW) is generated by the chemical reprocessing of spent reactor fuel, irradiated targets, and naval propulsion fuel. HLW generally contains more than 99 wt % 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 wt % of those elements, while HLW from a facility that recovers only uranium contains a residual 0.5 wt % of the uranium and essentially all of the plutonium. Most fission products have short half-lives and therefore quickly decay. HLW older than 10 years contains primarily the fission product radionuclides ^{137}Cs and ^{90}Sr and very small amounts of transuranic (TRU) nuclides, which typically have very long half-lives.

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. Only limited quantities of HLW from the reprocessing of deteriorating SNF are expected to be generated for the immediate future. Future D&D activities of HLW facilities, including the flushing of residual wastes found in reprocessing facilities, must be managed as either mixed low-level waste (MLLW) or as mixed transuranic waste (MTRUW).

When first generated, HLW is a highly radioactive, acidic liquid. This liquid generates heat and must be handled remotely behind heavy shielding in corrosion-resistant vessels. At the Hanford Site (Hanford), HLW was neutralized with caustic soda (sodium hydroxide), and sodium nitrite was then added for corrosion control so that the HLW could be stored in carbon-steel tanks. This practice continued at Hanford, the Savannah River Site (SRS), and the West Valley Demonstration Project (WVDP) because of cost considerations relating to using stainless steel. 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 and Environmental Laboratory (INEEL), however, the waste has always been stored at the Idaho Chemical Processing Plant (ICPP) as an acidic liquid in stainless steel tanks and then converted into a granular solid (calcine) by thermal processing, which drives off water and decomposes nitrate and fluoride salts to stable oxides and calcium fluoride. The calcine is stored in stainless steel bins enclosed in concrete vaults.

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, large quantities of ^{137}Cs and ^{90}Sr were removed from some Hanford HLW and encapsulated in concentrated form as halide salts. Some of these capsules were subsequently leased to non-DOE organizations for beneficial use. All of the leased capsules have now been returned to Hanford.

A new nonaqueous form of HLW will be generated through the operation of an electrometallurgical process for treatment of limited amounts of sodium-bonded fuel at the Argonne National Laboratory–West (ANL–W) facility located on the INEEL site.

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 to safely protect the environment and the health of workers and of the public.

Most of the current U.S. inventory of HLW has resulted from DOE activities. HLW is stored at SRS (Aiken, South Carolina), INEEL (Idaho Falls, Idaho), and Hanford (Richland, Washington). A small amount of HLW was generated by commercial operations and reprocessing of some DOE SNF 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 Act (Pub. 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, INEEL, SRS, and WVDP in ref. 1.

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 exhibits the characteristic of corrosivity because of its acidity, alkalinity, or toxicity because of the presence of heavy metals). Some HLW may also be *listed* mixed waste (i.e., it contains substances managed as hazardous under RCRA because of its source). Mixed wastes must be managed according to RCRA[2] 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. The FFCA exempts the STP requirement if a site already has an enforceable agreement with the host state and EPA that covers the treatment of mixed waste.

Two similar triparty agreements existed before approval of the STPs. One (for Hanford) is among DOE, the U.S. Environmental Protection Agency (EPA), and the state of Washington Department of Ecology. This triparty agreement[5] serves as an STP, is legally enforceable, and requires DOE to undertake specific actions at Hanford on a prescriptive timetable. The other triparty agreement (for SRS) involves DOE, EPA, and the state of South Carolina. However, this Federal Facilities 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 HLWs.

At INEEL, an STP has been executed with the state of Idaho for the treatment of all mixed wastes, including HLW. This STP was published on October 31, 1995; reissued on November 30, 1995; and then subsequently updated on March 20, 1997. The Idaho STP incorporates regulations established in the Settlement Agreement Court Order of 1995,[6] which delineates specific actions and schedules for treating and removing SNF, HLW, and TRUW currently stored at INEEL. The Settlement Agreement was completed on October 17, 1995, among the state of Idaho, DOE, and the U.S. Department of the Navy to resolve issues arising from previous cases in the U.S. District Court.

The state of New York recently approved an STP for HLW at WVDP.

2.3 WASTE CHARACTERIZATION

Characterization of HLW at some sites has been hampered over the years by the use of several different flow sheets 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, INEEL, SRS, and WVDP, extensive sampling of stored HLW.

In previous versions of this report, HLW data were presented by physical form in some detail (e.g., liquid, sludge, slurry, salt cake, and precipitate). Starting with Rev. 11 and continuing in this year's revision, the data are more simply categorized as solid, liquid, or process-generated (canistered) material. Each of these three waste categories requires different storage and processing methods. As HLW pretreatment and vitrification processes proceed, inventories of liquid and solid waste will generally decrease, and canistered material will increase.

Radionuclide compositions and inventories are given for the current and projected HLW at Hanford (Table 2.11), INEEL (Tables 2.12 and 2.22), SRS (Table 2.13); and WVDP (Table 2.14). In addition, chemical compositions are presented for projected HLW final waste form at each site in Tables 2.16–2.19.

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 typically 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 are shown graphically in Fig. 2.2. Historical and projected cumulative volumes of HLW stored or produced at each site are graphically illustrated in Fig. 2.3. The number of waste canisters projected to be produced by each site are depicted in Fig. 2.4.

Current DOE plans are to immobilize and package HLW for disposal in a NRC-licensed, underground geologic repository. Figures 2.5–2.8 show, for each of the four sites, the general treatment processes by which the HLW will be immobilized to a form acceptable to the DOE Office of Civilian Radioactive Waste Management (DOE/RW), which has responsibility for accepting the waste for ultimate emplacement 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. Projected volume, radioactivity, and number of HLW canisters from the new ANL–W process are given separately in Tables 2.21 and 2.22. Canister estimates for SRS [Defense Waste Processing Facility (DWPF)] and WVDP are fairly well established (both projects began radioactive operations in FY 1996), while canister estimates for INEEL and Hanford are less certain because pretreatment and immobilization 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 and projected HLW and associated other wastes for each site is given in Tables 2.11–2.14. Significant changes in any of these tables from the previous IDB report (Rev. 12)[7] 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. As treatment methods or waste forms are modified, current baseline projections for Hanford or INEEL HLW may be superceded. All HLW sites have essentially ceased reprocessing operations, and very little additional HLW will be generated. Major HLW activities will be (a) continued safe storage, (b) pretreatment (c) immobilization, 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 current projected number of HLW canisters for Hanford, INEEL, and SRS is reported in Tables 2.7 and 2.21. For INEEL, the new projections reflect the state of Idaho, Department of the Navy, and DOE Settlement Agreements completed in 1995.

Summary flowsheets of the reference immobilization processes are given for Hanford (Fig. 2.5), INEEL (Fig. 2.6), SRS (Fig. 2.7), and WVDP (Fig. 2.8). 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. The HLW inventory (as of EOFY 1996) consists of 118,800 m^3 considered to be "solid" HLW (salt cake and sludge in single- and double-shell tanks) and 88,460 m^3 of "liquid" HLW (supernatant in single- and double-shell tanks and drainable interstitial liquid in single- and double-shell tanks), for a total of 207,300 m^3. This volume of Hanford solid waste represents a reduction of 24,900 m^3 from the EOCY 1995 value reported in the previous edition of this report (IDB Rev. 12).[7] While part of this reduction is the result of waste evaporation, the majority is an artifact of redefining the reported volume of single-shell tank salt cake to avoid the double accounting of waste interstitial volume.

A total of 2,217 capsules have been manufactured at Hanford, some of which have been leased off-site for beneficial purposes. Of the total 1,577 cesium and 640 strontium capsules, 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) double-shell tanks will continue to receive limited D&D-generated waste, and (3) volume reduction of stored wastes through evaporation will continue.

2.4.2 INEEL

INEEL HLW at the Idaho Chemical Processing Plant (ICPP) is currently being stored as both acidic liquid and calcined solids (calcine). Underground, high-integrity, stainless-steel tanks contain about 6,700 m^3 of acidic liquid waste. [Of this waste, only 1,100 m^3 is actual HLW; the rest is sodium-bearing waste (SBW), which is either MLLW or MTRUW. While it has been managed in the same way as is HLW because of site practice, options described in the ICPP environmental impact statement

(EIS) would allow for other management practices.] Underground stainless-steel bins currently store about 3,800 m^3 of calcine, an interim solid waste form. More than 90% of the total radioactivity is in the calcine.

For INEEL, the HLW projections at ICPP 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. Liquid SBW continues to be generated by fuel storage, waste treatment, and D&D activities. The current reference waste form at the ICPP is a glass. According to the October 17, 1995, Settlement Agreement, the ICPP is to calcine all of the liquid waste currently stored in the tanks by December 31, 2012. All of the HLW must be treated to be converted to the final waste form and be "road ready" by December 31, 2035. It is assumed that radioactive operations and canister production will start in 2020 and continue through 2035 (see Fig. 2.6). The projections reported in Tables 2.1–2.7 reflect this assumption.

In addition to the current INEEL HLW at ICPP described above, Argonne National Laboratory (ANL) has developed an electrometallurgical treatment method for SNFs that are not amendable for direct disposal in a geological repository. This treatment method, which generates small quantities of HLWs, is being demonstrated at the ANL–W facility for SNF from the Experimental Breeder Reactor-II. The reactor fuel contains sodium, a reactive metal, as a thermal bond. The demonstration, which runs through June 1999, is being performed under an environmental assessment (ref. 8). If the demonstration is successful, an environmental impact statement (EIS) will be prepared for applying the technology to other problem fuels. The present demonstration and future operations make use of existing equipment and hot cells, the ANL–W Fuel Conditioning Facility, and the Hot Fuel Examination Facility. The electrometallurgical process is a nonaqueous method using molten salts and liquid metals. It results in two solid HLW products, a zeolite-based ceramic, and a stainless-steel-based metallic waste form. Projected characteristics of the HLW from the treatment of sodium-bonded SNF are provided in Table 2.21. Major radionuclides comprising final HLW forms from the treatment of sodium-bonded SNF are listed in Table 2.22. These values have not been incorporated in Tables 2.4–2.7.

2.4.3 SRS

SRS HLW is stored as alkaline liquid, sludge, salt cake, and precipitate. The current untreated HLW inventory of about 126,500 m^3 is stored in underground, single- and double-shelled carbon-steel tanks. Although reprocessing operations are being phased out, the HLW tank farms are continuing to receive HLW from the canyons as part of cleanout operations and stabilization of damaged fuel elements. Pretreatment of silicate and supernatant portions of HLW is performed in the In-Tank Precipitation Facility, while pretreatment (washing) of the sludge is performed by extended sludge processing. 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 minor changes in composition.

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 two underground tanks. The current HLW inventory of 2,000 m^3 consists of liquid alkaline waste and solid waste (composed of both alkaline sludge and inorganic zeolite ion-exchange material contaminated with ^{90}Sr and ^{137}Cs). The cesium-loaded zeolite was transferred and blended with the sludge and alkaline waste in 1995. A small amount of acidic waste remaining from reprocessing of a thorium fuel was also blended with the alkaline waste in 1995. Immobilization of readily retrievable HLW is expected to be complete in FY 1998, with immobilization of tank heels and other residues expected to be completed by 2002.

2.5 SOLIDIFICATION FOR PERMANENT DISPOSAL

HLW will be processed and immobilized to a form acceptable for permanent disposal in a geologic repository.[9–13] Borosilicate glass has been selected as the reference waste form for all sites.[14] Projections are based on current funding guidance provided to the sites by DOE.

2.5.1 Hanford

The current technical baseline for Hanford is to retrieve and process all (>99 vol %) of the tank wastes using a two-phase approach which will depend on private contractors to design, construct, operate, and finance most of the required processing capability. The demonstration phase (Phase I) facilities for supernatant (liquid) pretreatment and LLW and some HLW immobilization are scheduled to begin operation in June 2002 and may process waste through 2011. HLW sludges will be pretreated in-tank using water washing and caustic leaching as appropriate. Up to 13 vol % of the supernatant and 6 vol % of the sludges will be processed during Phase I. Full-scale production facilities, including out-of-tank sludge pretreatment, are scheduled to begin operating in 2012. These facilities will be sized to complete immobilization of LLW by 2024 and HLW by 2028 in order to meet current triparty agreement milestones.

The pretreatment processes separate the majority of the radioactivity contained in the tank waste into a high-activity stream, which is treated by vitrification and disposed of as HLW, and a low-activity stream, which the NRC has determined can be managed as LLW. The low-activity waste will also be vitrified but disposed of as LLW. The current technical baseline uses settle/decant to separate solids from the liquids, primarily ion exchange to reduce the radioactivity in the supernatants, and caustic leaching to reduce the volume of HLW sludges requiring vitrification. The projected radioactivity and thermal power of the LLW final form, shown in Table 2.11, were derived in support of a performance assessment for LLW disposal at Hanford, which, in turn, provides the basis for classification of the low-activity waste fraction from Hanford site tanks. As such, these values should be considered as bounding. As waste pretreatment processing plans become better defined, these values may be adjusted downward.

An interim storage facility will be built at Hanford with sufficient capacity to store the entire HLW volume of glass produced by the HLW vitrification facility. Storage will continue until the HLW canisters are shipped to a geologic repository. It is assumed for planning purposes that shipment to the repository will commence no sooner than 2035. Thus values for glass volume, curies, watts and number of canisters given in Tables 2.4 through 2.7, respectively, represent the total accumulation of Hanford's HLW canisters.

2.5.2 INEEL

Currently, an EIS is under development to evaluate the HLW processing options for the ICPP at INEEL. The EIS will be issued in 1999 and will result in a Record of Decision made for the preferred option.

The ICPP baseline[15] assumed the New Waste Calcining Facility will operate through 2012 and complete calcining the liquid SBW inventory as required by the Settlement Agreement. A new separations-vitrification facility is planned to be on line by 2020. Newly generated liquid waste and calcine will be processed to separate the high-activity radionuclides from the low-activity waste. In addition, the land disposal restriction (LDR) treatments for the RCRA constituents in the waste will then be made as required. The high-activity waste will be vitrified in a new facility and stored until final disposition after 2035. The separated low-activity waste will be grouted and disposed. All HLW is projected to be processed by December 31, 2035, to meet the Settlement Agreement.

As described in Sect. 2.4.2, treatment of problem SNFs using the electrometallurgical technique at ANL–W is projected to run from 2000–2011 and will result in two HLW forms: a zeolite-based ceramic and a stainless-steel-based metallic waste form (see Table 2.21). Most of the fission products and transuranics, which form chlorides during treatment operations, are stabilized in zeolite, which is then combined with glass frit and processed into a ceramic using a hot isostatic press. The metallic waste form includes noble metal fission products and cladding material after dissolution of the fuel matrix. It is converted into a solid ingot by melting. Both waste forms will be produced using irradiated materials as part of a demonstration of a technology that offers promise in preparing materials for permanent disposal in a geological repository.

2.5.3 SRS

The plan to process SRS HLW into glass is detailed in *High Level Waste System Plan Revision 7(U)*,[16] which was transmitted to DOE November 11, 1996. Briefly, Rev. 7 depicts the completion of the immobilization of the current inventory of HLW in FY 2018.

For SRS, canyon cleanout operations are scheduled to be completed by FY 2002. Additional HLW from canyon cleanout 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 began 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. 2.7).

2.5.4 WVDP

Pretreatment at the WVDP is complete. In May 1988, the pretreatment of liquid HLW was initiated. The alkaline liquid HLW 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. 2.8). 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. The primary vitrification campaign began in July 1996 and will be completed by FY 1998. Tank heels and residual material will then continue to be vitrified through mid-FY 2001. The glass will either be stored on-site until it is transferred to a federal repository or transferred off-site to facilitate accelerated site cleanup activity.

2.5.5 Low-Activity Waste from HLW Immobilization

The HLW immobilization processes described at each of the sites also generate low-activity wastes (LAWs), which contain low concentrations of radioactivity. Table 2.20 gives the historical and projected annual volumes of LAW generated from final HLW form production at each site.

2.6 REFERENCES

1. DOE site HLW data submittal attachments, submitted to the IDB Program during July–October 1997. 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) William J. Taylor, DOE Richland Operations Office, Richland, Washington, correspondence to Kenneth J. Picha, Jr., High-Level Waste Program Manager, DOE-HQ, copy to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, “High-Level Waste (HLW) Information Request for the 1997 Integrated Data Base Report,” 97-WDD-115, dated July 11, 1997.

   b. (INEEL) Clark B. Millet, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho, correspondence to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, “IDB Data Spreadsheet,” dated Sept. 2, 1997.

   c. (SRS) J. R. Hester, Westinghouse Savannah River Company, Aiken, South Carolina, correspondence to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, “DOE Integrated Database,” dated Sept. 2, 1997.

   d. (WVDP) J. J. Hollinden, West Valley Nuclear Services Company, Inc., West Valley, New York, correspondence to Steve Loghry, IDB Program, ORNL, Oak Ridge, Tennessee, “Submittal of High-Level Waste Information for the 1997 Integrated Data Base Report,” WZ:97:0052, dated July 23, 1997.

2. U.S. Congress, Resource Conservation and Recovery Act of 1976, Pub. L. 94–580, 1976, as amended.

3. U.S. Congress, Atomic Energy Act of 1954, Pub. L. 83–703, Aug. 15, 1994.

4. U.S. Congress, The Federal Facility Compliance Act of 1992, Pub. 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. State of Idaho, “Settlement Agreement,” U.S. District Court of Idaho, Civil No. 91-0054-S-EJL (Oct. 16, 1995).

7. U.S. Department of Energy, *Integrated Data Base Report—1995: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*, DOE/RW-0006, Rev. 12, Oak Ridge National Laboratory, Oak Ridge, Tennessee (December 1996).

8. U.S. Department of Energy, *Environmental Assessment Electrometallurgical Treatment Research and Demonstration Project in the Fuel Conditioning Facility at Argonne National Laboratory–West*, DOE/EIA-1148 (May 1996).

9. 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).

10. U.S. Congress, The Nuclear Waste Policy Act of 1982, Pub. L. 97–425, Sect. 8, Jan. 7, 1983, as amended.

11. 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.

12. U.S. Department of Energy, "Civilian Radioactive Waste Management: Calculating Nuclear Waste Fund Disposal Fees for Department of Energy Defense Program Waste; Notice," *Fed. Regist.* **56**(161), 31508 (Aug. 20, 1987).

13. U.S. Congress, The Nuclear Waste Policy Amendments Act of 1987, Pub. L. 100–203, Title V, Subtitle A, Dec. 22, 1987.

14. 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).

15. U.S. Department of Energy, *The INEEL Environmental Management Accelerated Cleanup: Focus on 2006*, PLN-177 (draft), Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho (June 1997).

16. U.S. Department of Energy, *High-Level Waste System Plan Revision 7(U)*, HLW-OVP-96-0083, Savannah River Site, Aiken, South Carolina (Nov. 11, 1996).

Table 2.1. Historical and projected cumulative volume (10^3 m^3) of HLW stored in tanks, bins, and capsules, by site[a,b]

End of year[c]	Hanford	INEEL	SRS	WVDP	Total
1990	227.4	12.0	131.7	1.2	372.3
1991	230.6	10.4	127.9	1.7	370.7
1992	231.1	11.2	126.9	1.6	370.7
1993	233.6	10.5	129.3	2.0	375.4
1994	215.3	11.0	126.3	2.2	354.8
1995	209.6	11.2	126.5	2.2	349.5
1996	207.3	10.5	127.5	2.0	347.3
1997	208.9	9.8	121.9	1.1	341.7
1998	202.1	9.7	116.4	0.5	328.7
1999	198.7	8.8	110.8	0.4	318.7
2000	196.0	8.8	105.3	0.2	310.2
2001	196.1	8.9	99.8		304.7
2002	195.5	8.9	94.2		298.7
2003	194.7	8.9	88.7		292.2
2004	193.6	8.9	83.1		285.6
2005	192.5	8.8	77.6		278.9
2006	191.4	8.6	72.0		272.1
2007	190.3	8.3	66.5		265.2
2008	189.2	8.1	61.0		258.3
2009	188.1	7.6	55.4		251.0
2010	187.0	7.4	49.9		244.2
2011	185.9	7.1	44.3		237.3
2012	184.0	7.1	38.8		229.9
2013	178.0	7.1	33.3		218.3
2014	169.2	7.1	27.7		204.0
2015	156.0	7.1	22.2		185.3
2016	142.9	7.1	16.6		166.6
2017	129.7	7.1	11.1		147.9
2018	116.5	7.1	5.5		129.1
2019	103.3	6.7			110.0
2020	90.2	6.2			96.4
2021	77.0	5.7			82.7
2022	65.5	5.2			70.7
2023	53.9	4.7			58.6
2024	42.4	4.2			46.6
2025	30.8	3.7			34.5
2026	19.3	3.2			22.5
2027	7.8	2.8			10.6
2028	2.0	2.3			4.3
2029	2.0	1.8			3.8
2030	2.0	1.4			3.4
2031	2.0[d]	1.0			3.0
2032	2.0[d]	0.6			2.6
2033	2.0[d]	0.3			2.3
2034	2.0[d]	0.0			2.0
2035	2.0[d]	0.0			2.0

[a]Historical inventories for HLW volume are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 12 (December 1996)]. The inventories for 1996 and the projections through 2035 are taken from ref. 1.

[b]Numbers shown as 0.0 are less than 50 m^3. Values of 0.0 or blank do not imply tank cleanout will be 100%.

[c]Data for 1990 through 1995 are on EOCY basis; data for 1996 through 2035 are on an EOFY basis.

[d]These volumes (2,000 m^3) represent the residual amount (<1.0%) of HLW which will remain in tanks until 2035 or later, as per agreement among DOE, the Washington State Department of Ecology, and the EPA (see ref. 5).

Table 2.2. Historical and projected cumulative decayed radioactivity (10^6 Ci) of HLW stored in tanks, bins, and capsules, by site[a,b]

End of year[c]	Hanford	INEEL	SRS	WVDP	Total
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	49.3	502.2	24.1	915.4
1996	332.1	48.4	492.6	21.7	894.8
1997	324.4	47.6	466.1	9.7	847.8
1998	316.9	46.4	448.2	4.2	815.7
1999	309.6	45.4	422.1	2.9	779.9
2000	302.4	44.3	396.9	1.4	745.0
2001	295.4	43.2	372.7		711.4
2002	288.2	42.2	349.4		679.8
2003	280.8	41.3	327.0		649.1
2004	273.5	40.3	301.9		615.6
2005	266.3	39.3	277.7		583.3
2006	259.3	38.4	251.1		548.8
2007	252.5	37.5	225.4		515.4
2008	245.8	36.7	200.8		483.4
2009	239.4	35.9	177.2		452.5
2010	233.1	35.1	154.5		422.7
2011	226.9	34.2	132.7		393.9
2012	220.4	33.4	111.8		365.6
2013	187.4	32.7	91.8		311.9
2014	153.9	31.9	72.5		258.4
2015	119.2	31.2	54.0		204.5
2016	86.1	30.5	36.3		152.9
2017	76.2	29.8	19.3		
125.32018	66.8	29.1	3.0		98.9
2019	57.7	28.2			86.0
2020	49.1	22.9			72.0
2021	40.8	19.2			60.0
2022	33.7	15.5			49.3
2023	27.0	12.4			39.4
2024	20.5	9.4			29.9
2025	14.4	6.5			20.8
2026	8.5	4.6			13.0
2027	2.8	2.8			5.6
2028	0.1	1.5			1.6
2029	0.1	1.1			1.2
2030	0.1	0.6			0.7
2031	0.1	0.2			0.3
2032	0.1	0.2			0.3
2033	0.1	0.1			0.2
2034	0.1	0.0			0.1
2035	0.1	0.0			0.1

[a]Historical inventories for HLW radioactivity are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 12 (December 1996)]. The inventories for 1995 and the projections through 2035 are taken from ref. 1.

[b]Numbers shown as 0.0 are less than 50,000 Ci. Values of 0.0 or blank do not imply tank cleanout will be 100%.

[c]Data for 1990 through 1995 are on an EOCY basis; data for 1996 through 2035 are on an EOFY basis.

Table 2.3. Historical and projected cumulative decayed thermal power (10^3 W) of HLW stored in tanks, bins, and capsules, by site[a,b]

End of year[c]	Hanford	INEEL	SRS	WVDP	Total
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	142.8	1,406.0	69.7	2,595.2
1996	954.1	143.6	1,387.7	64.8	2,550.2
1997	932.1	141.3	1,318.0	29.3	2,420.6
1998	910.5	137.6	1,275.5	12.7	2,336.3
1999	889.5	134.5	1,207.7	8.9	2,240.6
2000	868.9	131.0	1,141.3	4.3	2,145.6
2001	848.9	128.8	1,076.4		2,054.1
2002	828.0	125.8	1,013.0		1,966.8
2003	806.9	122.7	951.4		1,880.9
2004	785.6	119.6	881.0		1,786.2
2005	764.9	117.5	812.8		1,695.2
2006	744.7	114.2	736.8		1,595.8
2007	725.0	112.2	663.4		1,500.6
2008	705.9	108.8	592.5		1,407.1
2009	687.3	106.4	524.0		1,317.7
2010	669.1	104.2	458.0		1,231.2
2011	651.4	101.7	394.3		1,147.4
2012	632.6	99.8	332.9		1,065.4
2013	541.5	97.6	273.8		912.9
2014	448.7	95.4	216.8		760.8
2015	351.7	93.2	161.9		606.7
2016	258.9	91.1	109.0		459.0
2017	229.5	89.0	58.1		376.6
2018	201.2	87.0	9.0		297.2
2019	174.1	84.5			258.6
2020	148.2	68.7			216.8
2021	123.3	57.4			180.8
2022	102.0	46.6			148.7
2023	81.6	37.2			118.8
2024	62.1	28.1			90.2
2025	43.4	19.5			63.0
2026	25.6	13.8			39.4
2027	8.5	8.5			17.0
2028	0.3	4.7			5.0
2029	0.3	3.3			3.5
2030	0.3	1.9			2.1
2031	0.3	0.8			1.0
2032	0.3	0.5			0.8
2033	0.3	0.2			0.5
2034	0.3	0.0			0.3
2035	0.3	0.0			0.3

[a]Historical inventories for HLW thermal power are taken from the previous edition of this report [i.e., DOE/RW-0006, Rev. 12 (December 1996)]. The inventories for 1995 and the projections through 2035 are taken from ref. 1.

[b]Numbers shown as 0.0 are less than 50 W. Values of 0.0 or blank do not imply tank cleanout will be 100%.

[c]Data for 1990 through 1995 are on an EOCY basis; data for 1996 through 2035 are on an EOFY basis.

From Steve Loghry's disk (EXCEL FILE---8/6/97):

1996	976.7	143.6	1387.7	64.8	2572.8
1997	932.1	141.3	1318.0	29.3	2420.6
1998	910.5	137.6	1275.5	12.7	2336.3
1999	889.5	134.5	1207.7	8.9	2240.6
2000	868.9	131.0	1141.3	4.3	2145.6
2001	848.9	128.8	1076.4		2054.1
2002	828.0	125.8	1013.0		1966.8
2003	806.9	122.7	951.4		1880.9
2004	785.6	119.6	881.0		1786.2
2005	764.9	117.5	812.8		1695.2
2006	744.7	114.2	736.8		1595.8
2007	725.0	112.2	663.4		1500.6
2008	705.9	108.8	592.5		1407.1
2009	687.3	106.4	524.0		1317.7
2010	669.1	104.2	458.0		1231.2
2011	651.4	101.7	394.3		1147.4
2012	632.6	99.8	332.9		1065.4
2013	541.5	97.6	273.8		912.9
2014	448.7	95.4	216.8		760.8
2015	351.7	93.2	161.9		606.7
2016	258.9	91.1	109.0		459.0
2017	229.5	89.0	58.1		376.6
2018	201.2	87.0	9.0		297.2
2019	174.1	84.5			258.6
2020	148.2	68.7			216.8
2021	123.3	57.4			180.8
2022	102.0	46.6			148.7
2023	81.6	37.2			118.8
2024	62.1	28.1			90.2
2025	43.4	19.5			63.0
2026	25.6	13.8			39.4
2027	8.5	8.5			17.0
2028	0.3	4.7			5.0
2029	0.3	3.3			3.5
2030	0.3	1.9			2.1
2031	0.3	0.8			1.0
2032	0.3	0.5			0.8
2033	0.3	0.2			0.5
2034	0.3	0.0			0.3
2035	0.3	0.0			0.3

Table 2.4. Historical and projected annual and cumulative volume (10^3 m^3) of HLW glass stored in canisters, by site[a,b]

End of FY	Hanford[c]		INEEL–ICPP[d]		SRS[e]		WVDP[f]		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					0.040	0.040	0.019	0.019	0.059	0.059
1997					0.094	0.134	0.095	0.114	0.189	0.248
1998					0.125	0.259	0.071	0.185	0.196	0.444
1999					0.125	0.384	0.016	0.201	0.141	0.585
2000					0.125	0.509	0.020	0.221	0.145	0.730
2001					0.125	0.635	0.020	0.241	0.145	0.876
2002	0.023	0.023			0.125	0.760		0.241	0.148	1.024
2003	0.046	0.069			0.125	0.885		0.241	0.171	1.195
2004	0.069	0.138			0.156	1.041		0.241	0.225	1.420
2005	0.069	0.207			0.156	1.198		0.241	0.225	1.645
2006	0.069	0.275			0.188	1.386		0.241	0.257	1.902
2007	0.069	0.344			0.188	1.573		0.241	0.257	2.159
2008	0.069	0.413			0.188	1.761		0.241	0.257	2.415
2009	0.069	0.482			0.188	1.949		0.241	0.257	2.672
2010	0.069	0.551			0.188	2.137		0.241	0.257	2.929
2011	0.069	0.620			0.188	2.324		0.241	0.257	3.185
2012	0.069	0.689			0.188	2.512		0.241	0.257	3.442
2013	0.344	1.033			0.188	2.700		0.241	0.532	3.974
2014	0.574	1.607			0.188	2.888		0.241	0.762	4.735
2015	0.918	2.525			0.188	3.076		0.241	1.106	5.841
2016	0.918	3.443			0.188	3.263		0.241	1.106	6.947
2017	0.918	4.361			0.188	3.451		0.241	1.106	8.053
2018	0.918	5.279			0.188	3.639		0.241	1.106	9.158
2019	0.918	6.197	0.004	0.004	0.063	3.702		0.241	0.985	10.143
2020	0.918	7.115	0.054	0.058		3.702		0.241	0.972	11.115
2021	0.918	8.033	0.043	0.101		3.702		0.241	0.961	12.076
2022	0.918	8.951	0.043	0.143		3.702		0.241	0.961	13.037
2023	0.918	9.869	0.043	0.187		3.702		0.241	0.961	13.998
2024	0.918	10.787	0.044	0.230		3.702		0.241	0.962	14.960
2025	0.918	11.705	0.044	0.274		3.702		0.241	0.962	15.921
2026	0.918	12.623	0.049	0.323		3.702		0.241	0.967	16.889
2027	0.918	13.541	0.049	0.373		3.702		0.241	0.967	17.856
2028	0.459	14.000	0.055	0.427		3.702		0.241	0.514	18.370
2029		14.000	0.062	0.490		3.702		0.241	0.062	18.432
2030		14.000	0.062	0.552		3.702		0.241	0.062	18.494

Table 2.4 (continued)

End of FY	Hanford[c]		INEEL–ICPP[d]		SRS[e]		WVDP[f]		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2031			0.059	0.611					0.059	0.611
2032			0.047	0.657					0.047	0.657
2033			0.046	0.704					0.046	0.704
2034			0.040	0.743					0.040	0.743
2035				0.743						0.743

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

[b]See Table 2.7 for the projected number of canisters.

[c]Hanford's reference canister has a diameter of 61 cm and is 450 cm long (about 2 ft in diam by about 15 ft in length). The nominal glass volume is expected to be 1.1 m^3 with a minimum waste oxide loading of 25 vol % (excluding sodium and silicon). Hanford HLW glass volume projections are based on cesium and strontium from capsules being blended with tank wastes during the period 2013 through 2016, assuming that the capsule materials will be declared waste and treated as HLW.

[d]INEEL's canister projections assume the use of a canister containing 0.625 m^3 of glass. For ANL–W projected waste volumes, see Table 2.21.

[e]At SRS, the DWPF canisters are 0.6 m in diam by 3 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 [i.e., 85% of the usable capacity (0.735 m^3)] 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.

[f]For WVDP, it is assumed that 276 canisters 0.6 m in diam by 3 m in length (2 ft in diam by 10 ft in length) are filled with waste glass during 1996–1999 and that each canister contains 0.8 m^3 of glass at the filling temperature. Tank heels and residual materials will continue to be vitrified through mid-FY 2001.

From Steve Loghry's disk (EXCEL FILE---8/6/97):

1996					0.040	0.040	0.019	0.019	0.059	0.059
1997					0.094	0.134	0.095	0.114	0.189	0.248
1998					0.125	0.259	0.071	0.185	0.196	0.444
1999					0.125	0.384	0.016	0.201	0.141	0.585
2000					0.125	0.509	0.020	0.221	0.145	0.730
2001					0.125	0.635	0.020	0.241	0.145	0.876
2002	0.023	0.023			0.125	0.760		0.241	0.148	1.024
2003	0.046	0.069			0.125	0.885		0.241	0.171	1.195
2004	0.069	0.138			0.156	1.041		0.241	0.225	1.420
2005	0.069	0.207			0.156	1.198		0.241	0.225	1.645
2006	0.069	0.275			0.188	1.386		0.241	0.257	1.902
2007	0.069	0.344			0.188	1.573		0.241	0.257	2.159
2008	0.069	0.413			0.188	1.761		0.241	0.257	2.415
2009	0.069	0.482			0.188	1.949		0.241	0.257	2.672
2010	0.069	0.551			0.188	2.137		0.241	0.257	2.929
2011	0.069	0.620			0.188	2.324		0.241	0.257	3.185
2012	0.069	0.689			0.188	2.512		0.241	0.257	3.442
2013	0.344	1.033			0.188	2.700		0.241	0.532	3.974
2014	0.574	1.607			0.188	2.888		0.241	0.762	4.735
2015	0.918	2.525			0.188	3.076		0.241	1.106	5.841
2016	0.918	3.443			0.188	3.263		0.241	1.106	6.947
2017	0.918	4.361			0.188	3.451		0.241	1.106	8.053
2018	0.918	5.279			0.188	3.639		0.241	1.106	9.158
2019	0.918	6.197	0.004	0.004	0.063	3.702		0.241	0.985	10.143
2020	0.918	7.115	0.054	0.058		3.702		0.241	0.972	11.115
2021	0.918	8.033	0.043	0.101		3.702		0.241	0.961	12.076
2022	0.918	8.951	0.043	0.143		3.702		0.241	0.961	13.037
2023	0.918	9.869	0.043	0.187		3.702		0.241	0.961	13.998
2024	0.918	10.787	0.044	0.230		3.702		0.241	0.962	14.960
2025	0.918	11.705	0.044	0.274		3.702		0.241	0.962	15.921
2026	0.918	12.623	0.049	0.323		3.702		0.241	0.967	16.889
2027	0.918	13.541	0.049	0.373		3.702		0.241	0.967	17.856
2028	0.459	14.000	0.055	0.427		3.702		0.241	0.514	18.370
2029		14.000	0.062	0.490		3.702		0.241	0.062	18.432
2030		14.000	0.062	0.552		3.702		0.241	0.062	18.494

Table 2.5. Historical and projected annual and cumulative decayed radioactivity (10^6 Ci) of HLW glass stored in canisters, by site[a,b]

End of FY	Hanford[c]		INEEL–ICPP[d]		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					5.35	5.35	1.90	1.900	7.25	7.25
1997					12.53	17.76	11.50	13.400	24.03	31.16
1998					16.33	33.68	5.30	18.400	21.63	52.08
1999					15.96	48.88	1.20	19.100	17.16	67.98
2000					15.61	63.38	1.40	20.100	17.01	83.48
2001					15.26	77.22	1.40	21.100	16.66	98.32
2002	0.24	0.24			14.93	90.42		20.600	15.17	111.26
2003	0.48	0.72			14.60	103.00		20.100	15.08	123.81
2004	0.70	1.40			17.85	118.56		19.600	18.55	139.56
2005	0.68	2.05			17.47	133.40		19.200	18.15	154.64
2006	0.67	2.67			20.51	150.95		18.700	21.17	172.32
2007	0.65	3.26			20.07	167.68		18.300	20.72	189.24
2008	0.64	3.82			19.64	183.63		17.900	20.27	205.35
2009	0.62	4.35			19.22	198.81		17.500	19.84	220.66
2010	0.61	4.86			18.81	213.26		17.100	19.41	235.22
2011	0.59	5.34			18.41	227.00		16.700	19.00	249.04
2012	0.58	5.80			18.02	240.06		16.300	18.60	262.16
2013	26.84	32.50			17.64	252.47		15.900	44.48	300.87
2014	28.06	59.81			17.27	264.26		15.500	45.33	339.57
2015	30.12	88.55			16.91	275.43		15.200	47.02	379.18
2016	29.42	115.93			16.56	286.03		14.800	45.98	416.76
2017	6.87	120.13			16.21	296.06		14.500	23.09	430.69
2018	6.71	124.08			15.88	305.56		14.200	22.59	443.83
2019	6.56	127.77	0.19	0.19	5.24	304.22		13.800	11.81	445.98
2020	6.41	131.23	4.65	4.83		297.69		13.500	11.05	447.25
2021	6.26	134.47	3.22	7.97		291.31		13.200	9.48	446.95
2022	6.12	137.48	3.14	11.00		285.08		12.900	9.26	446.46
2023	5.97	140.28	2.79	13.50		279.00		12.600	8.76	445.38
2024	5.84	142.88	2.73	15.90		273.07		12.300	8.57	444.15
2025	5.70	145.28	2.67	18.30		267.27		12.000	8.37	442.85
2026	5.57	147.50	1.83	19.60		261.60		11.700	7.40	440.40
2027	5.44	149.54	1.68	20.80		256.07		11.500	7.12	437.91
2028	2.66	148.75	1.31	21.50		250.67		11.200	3.97	432.12
2029		145.32	0.45	21.50		245.39		11.000	0.45	423.21
2030		141.96	0.44	21.40		240.24		10.700	0.44	414.31

Table 2.5 (continued)

End of FY	Hanford[c]		INEEL–ICPP[d]		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2031		e	0.39	21.30		e		e		e
2032		e	0.07	20.80		e		e		e
2033		e	0.07	20.40		e		e		e
2034		e	0.07	20.00		e		e		e
2035		e	0.07	19.60		e		e		e

[a]Taken from data given in ref. 1.

[b]Radioactive decay is taken into account by each site by means of radioisotope generation and depletion codes.

[c]The significant increase in annual radioactivity for the years 2013–2016 reflects the accelerated processing schedule for the strontium and cesium capsules at Hanford (see Sect. 2.5.1). Hanford HLW glass radioactivity projections are based on ^{90}Sr and ^{137}Cs from capsules being blended with tank wastes during the period 2013 through 2016, assuming that the capsule materials will be declared waste and treated as HLW.

[d]For ANL–W radioactivity at FY 2000, see Table 2.22.

[e]Not available.

From Steve Loghry's EXCEL File (8/6/97:

1996					5.35	5.35	1.90	1.90	7.25	7.25
1997					12.53	17.76	11.50	13.400	24.03	31.16
1998					16.33	33.68	5.30	18.400	21.63	52.08
1999					15.96	48.88	1.20	19.100	17.16	67.98
2000					15.61	63.38	1.40	20.100	17.01	83.48
2001					15.26	77.22	1.40	21.100	16.66	98.32
2002	0.24	0.24			14.93	90.42		20.600	15.17	111.26
2003	0.48	0.72			14.60	103.00		20.100	15.08	123.81
2004	0.70	1.40			17.85	118.56		19.600	18.55	139.56
2005	0.68	2.05			17.47	133.40		19.200	18.15	154.64
2006	0.67	2.67			20.51	150.95		18.700	21.17	172.32
2007	0.65	3.26			20.07	167.68		18.300	20.72	189.24
2008	0.64	3.82			19.64	183.63		17.900	20.27	205.35
2009	0.62	4.35			19.22	198.81		17.500	19.84	220.66
2010	0.61	4.86			18.81	213.26		17.100	19.41	235.22
2011	0.59	5.34			18.41	227.00		16.700	19.00	249.04
2012	0.58	5.80			18.02	240.06		16.300	18.60	262.16
2013	26.84	32.50			17.64	252.47		15.900	44.48	300.87
2014	28.06	59.81			17.27	264.26		15.500	45.33	339.57
2015	30.12	88.55			16.91	275.43		15.200	47.02	379.18
2016	29.42	115.93			16.56	286.03		14.800	45.98	416.76
2017	6.87	120.13			16.21	296.06		14.500	23.09	430.69
2018	6.71	124.08			15.88	305.56		14.200	22.59	443.83
2019	6.56	127.77	0.02	0.19	5.24	304.22		13.800	11.81	445.98
2020	6.41	131.23	4.65	4.83		297.69		13.500	11.05	447.25
2021	6.26	134.47	3.22	7.97		291.31		13.200	9.48	446.95
2022	6.12	137.48	3.14	11.00		285.08		12.900	9.26	446.46
2023	5.97	140.28	2.79	13.50		279.00		12.600	8.76	445.38
2024	5.84	142.88	2.73	15.90		273.07		12.300	8.57	444.15
2025	5.70	145.28	2.67	18.30		267.27		12.000	8.37	442.85
2026	5.57	147.50	1.83	19.60		261.60		11.700	7.40	440.40
2027	5.44	149.54	1.68	20.80		256.07		11.500	7.12	437.91
2028	2.66	148.75	1.31	21.50		250.67		11.200	3.97	432.12
2029		145.32	0.45	21.50		245.39		11.000	0.45	423.21
2030		141.96	0.44	21.40		240.24		10.700	0.44	414.31

Table 2.6. Historical and projected annual and cumulative decayed thermal power (10^3 W) of HLW glass stored in canisters, by site[a,b]

End of FY	Hanford[c]		INEEL–ICPP[d]		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					15.02	15.02	5.70	5.70	20.72	20.72
1997					35.44	50.21	34.00	39.50	69.44	89.71
1998					46.47	95.85	15.90	54.60	62.37	150.45
1999					45.68	139.87	3.50	56.90	49.18	196.77
2000					44.89	182.27	4.30	59.90	49.19	242.17
2001					44.08	223.02	4.20	62.80	48.28	285.82
2002	0.74	0.74			43.28	262.14		61.40	44.02	324.28
2003	1.44	2.16			42.48	299.66		60.00	43.92	361.82
2004	2.11	4.22			52.11	346.02		58.70	54.22	408.94
2005	2.06	6.18			51.13	390.45		57.30	53.19	453.94
2006	2.01	8.05			60.19	443.04		56.10	62.20	507.20
2007	1.97	9.84			59.04	493.42		54.80	61.01	558.06
2008	1.92	11.53			57.92	541.67		53.60	59.84	606.80
2009	1.88	13.14			56.82	587.85		52.40	58.69	653.39
2010	1.83	14.67			55.74	632.03		51.20	57.57	697.91
2011	1.79	16.13			54.68	674.30		50.00	56.47	740.42
2012	1.75	17.50			53.64	714.71		48.90	55.39	781.11
2013	73.51	90.61			52.63	753.34		47.80	126.14	891.75
2014	77.38	165.90			51.64	790.25		46.80	129.02	1,002.95
2015	83.76	245.83			50.67	825.51		45.70	134.43	1,117.04
2016	81.83	321.99			49.73	859.17		44.70	131.56	1,225.86
2017	20.77	335.33			48.81	891.32		43.70	69.58	1,270.34
2018	20.29	347.88			47.91	921.99		42.70	68.21	1,312.57
2019	19.83	359.68	0.56	0.56	15.84	920.05		41.80	36.22	1,322.08
2020	19.37	370.76	13.95	14.50		902.37		40.80	33.31	1,328.43
2021	18.92	381.14	9.27	23.90		885.09		39.90	28.19	1,330.02
2022	18.49	390.84	9.05	32.80		868.20		39.00	27.54	1,330.84
2023	18.06	399.90	8.05	40.40		851.70		38.20	26.11	1,330.20
2024	17.65	408.33	7.89	47.70		835.58		37.30	25.54	1,328.91
2025	17.24	416.17	7.72	54.70		819.82		36.50	24.96	1,327.19
2026	16.85	423.43	5.28	58.70		804.43		35.70	22.13	1,322.26
2027	16.46	430.14	4.85	62.50		789.38		34.90	21.31	1,316.93
2028	8.04	428.29	3.77	64.60		774.69		34.10	11.81	1,301.67
2029		418.43	1.29	64.50		760.33		33.40	1.29	1,276.66
2030		408.81	1.26	64.40		746.29		32.70	1.26	1,252.20

Table 2.6 (continued)

End of FY	Hanford[c]		INEEL–ICPP[d]		SRS		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2031		e	1.13	64.00		e		e		e
2032		e	0.02	54.30		e		e		e
2033		e	0.21	61.70		e		e		e
2034		e	0.20	60.50		e		e		e
2035		e	0.20	59.10		e		e		e

[a]Taken from data given in ref. 1.

[b]Thermal power is taken into account by each site by means of radioisotope generation and depletion codes.

[c]The significant increase in annual thermal power for the years 2013–2016 reflects the accelerated processing schedule for the strontium and cesium capsules at Hanford (see Sect. 2.5.1). Hanford HLW thermal power projections are based on ^{90}Sr and ^{137}Cs from capsules being blended with tank wastes during the period 2013 through 2016, assuming that the capsule materials will be declared waste and treated as HLW.

[d]ANL–W thermal power values are not included here. See Table 2.22 for radioactivity values.

[e]Not available.

From Steve Loghry's EXCEL File --8/11/97:

1996					15.02	15.02	5.70	5.70	20.72	20.72
1997					35.44	50.21	34.00	39.50	69.44	89.71
1998					46.47	95.85	15.90	54.60	62.37	150.45
1999					45.68	139.87	3.50	56.90	49.18	196.77
2000					44.89	182.27	4.30	59.90	49.19	242.17
2001					44.08	223.02	4.20	62.80	48.28	285.82
2002	0.74	0.74			43.28	262.14		61.40	44.02	324.28
2003	1.44	2.16			42.48	299.66		60.00	43.92	361.82
2004	2.11	4.22			52.11	346.02		58.70	54.22	408.94
2005	2.06	6.18			51.13	390.45		57.30	53.19	453.94
2006	2.01	8.05			60.19	443.04		56.10	62.20	507.20
2007	1.97	9.84			59.04	493.42		54.80	61.01	558.06
2008	1.92	11.53			57.92	541.67		53.60	59.84	606.80
2009	1.88	13.14			56.82	587.85		52.40	58.69	653.39
2010	1.83	14.67			55.74	632.03		51.20	57.57	697.91
2011	1.79	16.13			54.68	674.30		50.00	56.47	740.42
2012	1.75	17.50			53.64	714.71		48.90	55.39	781.11
2013	73.51	90.61			52.63	753.34		47.80	126.14	891.75
2014	77.38	165.90			51.64	790.25		46.80	129.02	1002.95
2015	83.76	245.83			50.67	825.51		45.70	134.43	1117.04
2016	81.83	321.99			49.73	859.17		44.70	131.56	1225.86
2017	20.77	335.33			48.81	891.32		43.70	69.58	1270.34
2018	20.29	347.88			47.91	921.99		42.70	68.21	1312.57
2019	19.83	359.68	0.56	0.56	15.84	920.05		41.80	36.22	1322.08
2020	19.37	370.76	13.95	14.50		902.37		40.80	33.31	1328.43
2021	18.92	381.14	9.27	23.90		885.09		39.90	28.19	1330.02
2022	18.49	390.84	9.05	32.80		868.20		39.00	27.54	1330.84
2023	18.06	399.90	8.05	40.40		851.70		38.20	26.11	1330.20
2024	17.65	408.33	7.89	47.70		835.58		37.30	25.54	1328.91
2025	17.24	416.17	7.72	54.70		819.82		36.50	24.96	1327.19
2026	16.85	423.43	5.28	58.70		804.43		35.70	22.13	1322.26
2027	16.46	430.14	4.85	62.50		789.38		34.90	21.31	1316.93
2028	8.04	428.29	3.77	64.60		774.69		34.10	11.81	1301.67
2029		418.43	1.29	64.50		760.33		33.40	1.29	1276.66
2030		408.81	1.26	64.40		746.29		32.70	1.26	1252.20
2031			1.13	64.00						
2032			0.22	62.80						
2033			0.21	61.70						
2034			0.20	60.50						
2035			0.20	59.10						

Table 2.7. Historical and projected number of HLW canisters, by site[a]

End of FY	Hanford[b]		INEEL–ICPP[c]		SRS[d]		WVDP[e]		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					64	64	26	26	90	90
1997					150	214	118	144	268	358
1998					200	414	88	232	288	646
1999					200	614	20	252	220	866
2000					200	814	25	277	225	1,091
2001					200	1,014	25	302	225	1,316
2002	20	20			200	1,214		302	220	1,536
2003	40	60			200	1,414		302	240	1,776
2004	60	120			250	1,664		302	310	2,086
2005	60	180			250	1,914		302	310	2,396
2006	60	240			300	2,214		302	360	2,756
2007	60	300			300	2,514		302	360	3,116
2008	60	360			300	2,814		302	360	3,476
2009	60	420			300	3,114		302	360	3,836
2010	60	480			300	3,414		302	360	4,196
2011	60	540			300	3,714		302	360	4,556
2012	60	600			300	4,014		302	360	4,916
2013	300	900			300	4,314		302	600	5,516
2014	500	1,400			300	4,614		302	800	6,316
2015	800	2,200			300	4,914		302	1100	7,416
2016	800	3,000			300	5,214		302	1100	8,516
2017	800	3,800			300	5,514		302	1100	9,616
2018	800	4,600			300	5,814		302	1100	10,716
2019	800	5,400	6	6	101	5,915		302	907	11,623
2020	800	6,200	87	93		5,915		302	887	12,510
2021	800	7,000	68	161		5,915		302	868	13,378
2022	800	7,800	68	229		5,915		302	868	14,246
2023	800	8,600	69	298		5,915		302	869	15,115
2024	800	9,400	70	368		5,915		302	870	15,985
2025	800	10,200	70	438		5,915		302	870	16,855
2026	800	11,000	79	517		5,915		302	879	17,734
2027	800	11,800	79	596		5,915		302	879	18,613
2028	400	12,200	88	684		5,915		302	488	19,101
2029		12,200	99	783		5,915		302	100	19,200
2030		12,200	100	883		5,915		302	100	19,300

Table 2.7 (continued)

End of FY	Hanford[b]		INEEL–ICPP[c]		SRS[d]		WVDP[e]		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2031		12,200	94	977		5,944		302	94	19,423
2032		12,200	75	1,052		5,944		302	75	19,498
2033		12,200	74	1,126		5,944		302	74	19,572
2034		12,200	63	1,189		5,944		302	63	19,635
2035		12,200		1,189		5,944		302		19,635

[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. Canister projections may not be calculated by the site in whole numbers, as presented here. Due to round-off, numbers may not add exactly. The projections reported for Hanford and INEEL 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 61 cm and is 450 cm long (about 2 ft in diam by about 15 ft in length). The nominal glass volume is expected to be 1.1 m^3 with a minimum waste oxide loading of 25 vol % (excluding sodium and silicon).

[c]INEEL canister projections assume the use of a canister containing 0.625 m^3 of glass. For projected ANL–W canisters, see Table 2.21.

[d]Canisters are 0.6 m in diam by 3 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 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.

From Steve Loghry's EXCEL File (8/11/97):

1996					64	64	26	26	90	90
1997					150	214	118	144	268	358
1998					200	414	88	232	288	646
1999					200	614	20	252	220	866
2000					200	814	25	277	225	1091
2001					200	1014	25	302	225	1316
2002	20	20			200	1214		302	220	1536
2003	40	60			200	1414		302	240	1776
2004	60	120			250	1664		302	310	2086
2005	60	180			250	1914		302	310	2396
2006	60	240			300	2214		302	360	2756
2007	60	300			300	2514		302	360	3116
2008	60	360			300	2814		302	360	3476
2009	60	420			300	3114		302	360	3836
2010	60	480			300	3414		302	360	4196
2011	60	540			300	3714		302	360	4556
2012	60	600			300	4014		302	360	4916
2013	300	900			300	4314		302	600	5516
2014	500	1400			300	4614		302	800	6316
2015	800	2200			300	4914		302	1100	7416
2016	800	3000			300	5214		302	1100	8516
2017	800	3800			300	5514		302	1100	9616
2018	800	4600			300	5814		302	1100	10716
2019	800	5400	6	6	101	5915		302	907	11623
2020	800	6200	87	93		5915		302	887	12510
2021	800	7000	68	161		5915		302	868	13378
2022	800	7800	68	229		5915		302	868	14246
2023	800	8600	69	298		5915		302	869	15115
2024	800	9400	70	368		5915		302	870	15985
2025	800	10200	70	438		5915		302	870	16855
2026	800	11000	79	517		5915		302	879	17734
2027	800	11800	79	596		5915		302	879	18613
2028	400	12200	88	684		5915		302	488	19101
2029		12200	100	783		5915		302	100	19200
2030		12200	100	883		5915		302	100	19300
2031		12442	94	977				302	94	13721
2032		12442	74	1052				302	74	13796
2033		12442	74	1126				302	74	13870
2034		12442	63	1189				302	63	13933
2035		12442		1189				302		13933

Table 2.8. Current volume (10^3 m^3) of HLW in storage by site through FY 1996[a]

Site	Tank waste		Capsules		Canister material	Total
	Liquid[b]	Solid[c]	Sr	Cs		
Hanford	88.46	118.8	0.0011	0.0024		207.3
INEEL	6.74	3.80				10.5
SRS	83.3[d]	65.0			0.040	148.3
WVDP[e]	2.0				0.019	2.0
Total	180.5	187.6	0.0011	0.0024	0.059	368.1

[a]Taken from ref. 1.

[b]Liquid tank waste consists of free tank supernatant and drainable interstitial liquid.

[c]Solid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate. Hanford salt cake volume has been adjusted to exclude the pore volume occupied by drainable interstitial liquid, which is reported as part of the liquid waste volume.

[d]SRS liquid tank waste consists of free supernate and drainable interstitial liquid. The actual physical volume of all tank waste at SRS is 127,500 m^3, which is reported in Table 2.1.

[e]WVDP liquid waste includes sludge and zeolite.

Table 2.9. Current radioactivity (10^6 Ci) of HLW in storage by site through FY 1996[a]

Site	Tank waste		Capsules		Canister material	Total
	Liquid[b]	Solid[c]	Sr	Cs		
Hanford	66.9	122.4	43.9	98.9		332.1
INEEL	2.6	45.8				48.4
SRS	260.8	231.8			5.4	498.0
WVDP[d]	21.7				1.9	23.6
Total	352.0	400.0	43.9	98.9	7.3	902.1

[a]Taken from ref. 1.

[b]Liquid tank waste consists of free tank supernatant and drainable interstitial liquid.

[c]Solid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate. Hanford salt cake volume has been adjusted to exclude the pore volume occupied by drainable interstitial liquid, which is reported as part of the liquid waste volume.

[d]WVDP liquid waste includes sludge and zeolite.

Table 2.10. Current thermal power (10^3 W) of HLW in storage by site through FY 1996[a]

Site	Tank waste		Capsules		Canister material	Total
	Liquid[b]	Solid[c]	Sr	Cs		
Hanford	162.9	404.6	146.8	239.8		954.1
INEEL	7.6	136.0				143.6
SRS	550.6	837.1			15.0	1,402.7
WVDP[d]	64.8				5.7	70.5
Total	785.9	1,377.7	146.8	239.8	20.7	2,570.9

[a]Taken from ref. 1.

[b]Liquid tank waste consists of free tank supernatant and drainable interstitial liquid.

[c]Solid tank waste consists of sludge, salt cake, zeolite, calcine, and precipitate. Hanford salt cake volume has been adjusted to exclude the pore volume occupied by drainable interstitial liquid, which is reported as part of the liquid waste volume.

[d]WVDP liquid waste includes sludge and zeolite.

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 emissions
^{3}H[e]					
^{14}C	4.573E+03		9.110E−02	4.420E+00	4.507E+03
^{90}Sr	5.812E+07	2.194E+07	2.543E+07	1.693E+06	
^{90}Y	5.812E+07	2.194E+07	2.543E+07	1.693E+06	
^{99}Tc	3.210E+04		2.247E+03	2.955E+04	
^{129}I	2.980E−01		5.959E−06	2.891E−04	2.948E−01
^{137}Cs	3.686E+07	5.078E+07	1.504E+07	2.532E+06	
^{137m}Ba	3.491E+07	4.809E+07	1.424E+07	2.398E+06	
^{151}Sm	1.050E+06		7.713E+05	4.875E+04	
^{238}Pu	1.404E+03		9.913E+02	9.823E+01	
^{239}Pu	2.635E+04		2.393E+04	2.371E+03	
^{240}Pu	6.691E+03		6.061E+03	6.005E+02	
^{241}Pu	8.878E+04		1.730E+04	1.714E+03	
^{242}Pu	2.802E−01		2.547E−01	2.523E−02	
^{241}Am	1.037E+05		9.358E+04	7.032E+03	
^{242}Am	6.218E+01		4.997E+01	3.724E+00	
Total	1.893E+08	1.427E+08	8.105E+07	8.405E+06	4.507E+03

[a]Data taken from ref. 1(a).

[b]As of Sept. 30, 1996.

[c]As of Sept. 30, 2028.

[d]Radionuclide distribution and decay power in LLW glass and emissions out of system are undefined, pending flowsheet development and regulatory decisions.

[e]Estimate of the EOFY 1996 inventory for ^{3}H is currently unavailable.

4.420E+00
1.693E+06
1.693E+06
2.955E+04
2.891E-04
2.532E+06
2.398E+06
4.875E+04
9.823E+01
2.371E+03
6.005E+02
1.714E+03
2.523E-02
7.032E+03
3.724E+00

Table 2.12. Major radionuclides comprising HLW and associated wastes at INEEL–ICPP[a]

Radionuclides	Radioactivity, Ci, by waste category			
	Interim forms[b]		Final forms[c]	
	Liquid	Calcine	Glass	Grout
^{3}H	d	d	d	d
^{14}C	d	d	d	d
^{60}Co	d	d	d	d
^{63}Ni	d	d	d	d
^{90}Sr	6.09E+05	1.07E+07	4.52E+06	4.52E+02
^{90}Y	6.09E+05	1.07E+07	4.52E+06	4.52E+02
^{99}Tc	d	d	d	d
^{106}Ru	1.51E+02	9.34E+02	1.03E−09	1.03E−09
^{106}Rh	1.51E+02	9.34E+02	1.03E−09	1.03E−09
^{125}Sb	4.43E+02	5.00E+02	4.26E−02	4.26E−06
^{129}I	d	d	d	d
^{134}Cs	3.21E+03	2.71E+04	6.66E−02	6.66E−06
^{137}Cs	7.17E+05	1.23E+07	5.35E+06	5.35E+02
^{137m}Ba	6.80E+05	1.16E+07	5.07E+06	5.07E+02
^{144}Ce	6.52E+02	2.95E+03	3.49E−12	3.49E−16
^{144}Pr	6.52E+02	2.95E+03	3.49E−12	3.49E−16
^{147}Pm	d	4.73E+04	1.70E+00	1.70E−04
^{154}Eu	3.83E+03	4.40E+04	2.09E+03	2.09E−01
^{155}Eu	1.50E+03	2.44E+03	1.79E+01	1.79E+01
^{232}Th	d	d	d	d
^{233}U	d	2.06E−06	2.06E−06	2.06E−10
^{234}U	4.99E+00	5.55E+01	1.16E+02	1.16E−02
^{235}U	3.33E−01	3.80E−01	8.02E−01	8.02E−05
^{236}U	3.41E−01	9.01E–01	1.87E+00	1.87E−04
^{238}U	1.39E−01	2.15E−02	4.55E−02	4.55E−06
^{237}Np	4.30E+00	5.61E+00	1.43E+01	1.43E−03
^{238}Pu	7.06E+03	1.11E+05	9.04E+04	9.04E+00
^{239}Pu	5.20E+02	1.09E+03	8.33E+02	8.33E−02
^{240}Pu	3.71E+02	7.69E+02	1.71E+02	1.71E−02
^{241}Pu	4.44E+03	1.73E+05	2.65E+04	2.65E+00
^{242}Pu	1.22E−01	3.10E+00	3.10E+00	3.10E−04
^{241}Am	3.00E+03	1.54E+03	2.24E+03	2.24E−01
^{243}Am	d	1.43E+01	1.42E+01	1.42E−03
^{242}Cm	d	3.01E−01	1.57E−27	1.57E−31
^{244}Cm	d	6.16E+02	1.39E+02	1.39E−02
Total	2.64E+06	4.58E+07	1.96E+07	1.96E+03

[a]Data taken from ref. 1(b). See Table 2.22 for projected radionuclides in ANL–W HLW at FY 2000.
[b]As of Sept. 30, 1996.
[c]As of Sept. 30, 2035.
[d]Unknown.

d
2.06E-10
1.16E-02
8.02E-05
1.87E-04
4.55E-06
1.43E-03
9.04E+00
8.33E-02
1.71E-02
2.65E+00
3.10E-04
2.24E-01
1.42E-03
1.57E-31
1.39E-02

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

Radionuclides	Radioactivity, Ci, by waste category			
	Interim form[b]	Final forms[b]		
	Tank waste	Canister material	Saltstone (LLW)	Outfall
^{3}H	9.62E+04	1.04E+03	4.02E−02	c
^{14}C	2.00E+01	2.16E−01	8.36E−06	c
^{90}Sr	1.06E+08	1.15E+06	4.42E+01	c
^{90}Y	1.06E+08	1.15E+06	4.42E+01	c
^{99}Tc	2.57E+04	2.78E+02	1.07E−02	c
^{129}I	4.16E+01	4.50E−01	1.74E−05	c
^{137}Cs	1.34E+08	1.45E+06	5.59E+01	c
^{137m}Ba	1.27E+08	1.37E+06	5.29E+01	c
^{238}Pu	1.73E+06	1.87E+04	7.21E−01	c
^{239}Pu	3.64E+04	3.94E+02	1.52E−02	c
^{240}Pu	1.66E+04	1.79E+02	6.92E−03	c
^{241}Pu	7.52E+05	8.14E+03	3.14E−01	c
^{242}Pu	2.84E+01	3.07E−01	1.19E−05	c
^{241}Am	9.61E+05	1.04E+04	4.01E−01	c
^{242m}Am	7.24E+01	7.83E−01	3.02E−05	c
^{232}Th	1.47E+00	1.59E−02	6.15E−07	c
^{233}U	1.08E+02	1.17E+00	4.53E−05	c
^{234}U	3.01E+01	3.25E−01	1.26E−05	c
^{237}Np	7.04E+01	7.62E−01	2.94E−05	c
^{244}Cm	2.60E+03	2.81E+01	1.09E−03	c
Total[d]	4.76E+08	5.15E+06	1.99E+02	c

[a]Data taken from ref. 1(c).
[b]As of Sept. 30, 1996.
[c]Negligible contribution.
[d]Totals listed pertain only to the contributions from the radionuclides listed and do not indicate the total radioactivity of the particular waste category.

From Steve Loghry's EXCEL File (8/28/95):

3.25E+03	8.27E-01
7.63E-01	1.94E-04
4.66E+06	1.18E+03
4.66E+06	1.18E+03
8.69E+02	2.21E-01
1.41E+00	3.57E-04
4.53E+06	1.15E+03
4.28E+06	1.09E+03
6.59E+04	1.68E+01
1.39E+03	3.54E-01
6.32E+02	1.61E-01
3.02E+04	7.67E+00
1.08E+00	2.76E-04
8.97E+02	2.28E-01
2.45E+00	6.22E-04
5.62E-02	1.43E-05
4.13E+00	1.05E-03
1.15E+00	2.92E-04
2.69E+00	6.83E-04
9.92E+01	2.52E-02

8.53E+04
2.00E+01
1.22E+08
1.22E+08
2.28E+04
3.68E+01
1.19E+08
1.12E+08
1.73E+06
3.64E+04
1.66E+04
7.91E+05
2.84E+01
2.35E+04
6.41E+01
1.47E+00
1.08E+02
3.01E+01
7.04E+01
2.60E+03

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

Radionuclides	Radioactivity, Ci, by waste category	
	Interim form[b]	Final form[b]
	Tank waste	Canister material
^{63}Ni	7.6E+03	5.8E+02
^{90}Sr	5.3E+06	4.4E+05
^{90}Y	5.3E+06	4.4E+05
^{93}Zr	2.6E+02	2.0E+01
^{93m}Nb	1.9E+02	1.4E+01
^{99}Tc	1.6E+03	1.2E+02
^{137}Cs	5.7E+06	5.2E+05
^{135}Cs	1.5E+02	1.4E+01
^{137m}Ba	5.4E+06	5.0E+05
^{151}Sm	7.5E+04	5.7E+03
^{238}Pu	7.4E+03	5.7E+02
^{239}Pu	1.5E+03	1.2E+02
^{240}Pu	1.1E+03	8.7E+01
^{241}Pu	5.5E+04	4.2E+03
^{242}Pu	1.5E+00	1.2E+01
^{241}Am	5.0E+04	3.8E+03
^{242}Am	2.6E+02	2.0E+01
^{243}Am	3.2E+02	2.5E+01
^{244}Cm	5.5E+03	4.2E+02
Total	2.2E+07	1.9E+06

[a]Data taken from ref. 1(d).
[b]As of Sept. 30, 1996.

7.6E+03	5.8E+02
5.3E+06	4.4E+05
5.3E+06	4.4E+05
2.6E+02	2.0E+01
1.9E+02	1.4E+01
1.6E+03	1.2E+02
5.7E+06	5.2E+05
1.5E+02	1.4E+01
5.4E+06	5.0E+05
7.5E+04	5.7E+03
7.4E+03	5.7E+02
1.5E+03	1.2E+02
1.1E+03	8.7E+01
5.5E+04	4.2E+03
1.5E+00	1.2E+01
5.0E+04	3.8E+03
2.6E+02	2.0E+01
3.2E+02	2.5E+01
5.5E+03	4.2E+02

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
		Hanford Site		
Number of canisters	See Table 2.7	Canister production schedule updated	See Table 2.7	
Tank waste volume	See Table 2.8	Tank waste volume adjustment	See Table 2.8	The single-shell tank salt cake component of solid waste volume is adjusted ("compressed") to account for interstitial liquid being reported separately as part of the liquid category
		Idaho National Engineering and Environmental Laboratory		
Number of canisters	See Table 2.7	Canister volume changed to be consistent with SRS. Data added for HLW generated from stabilizaion of sodium-bonded fuel at ANL–W	See Table 2.7	Based on current funding guidance from DOE and the INEEL Focus on 2006 draft report (see ref. 15)
		Savannah River Site		
Number of canisters	See Table 2.7	Canister production schedule updated	See Table 2.7	Based on current funding guidance from DOE and the SRS *High-Level Waste System Plan Revision 7(U)* (see ref. 16)
		West Valley Demonstration Project		
Volume, radioactivity, and thermal power	See Tables 2.8–2.10	Values reported are for liquid, sludge, and zeolite	See Tables 2.8–2.10	Wastes have been blended prior to vitrification

[a]Data are for Dec. 31, 1995. See tables and text cited in Chapter 2 of ref. 6 (DOE/RW-0006, Rev. 12).
[b]Data are for Sept. 30, 1996, as reported in this document (DOE/RW-0006, Rev. 13).

Table 2.16. Proposed representative chemical composition of future HLW glass to be generated at Hanford[a]

Component	Wt %	Component	Wt %
Al_2O_3	9.31	Na_2O	11.79
B_2O_3	7.02	Na_2SO_4	0.10
Bi_2O_3	1.15	NiO	1.08
CaO	0.83	P_2O_5	1.56
Ce_2O_3	1.13	PbO_2	0.14
Cr_2O_3	0.36	SiO_2	46.11
Fe_2O_3	4.49	SrO	0.18
K_2O	0.17	ThO_2	0.01
La_2O_3	0.11	UO_3	6.69
Li_2O	2.01	ZrO_2	3.79
MnO_2	1.17	Other	0.17
NaF	0.63		
		Total	100.00

[a]Data taken from ref. 1(a).

Table 2.17. Proposed representative chemical composition of future HLW glass to be generated at INEEL[a]

Chemical compound	Glass, wt %, formed from high-activity fraction from		
	Dissolved Zr calcine	Dissolved Al calcine	Na-bearing-waste
Al_2O_3	0.5	12.7	17.2
AMP[b]	0.8	6.6	
B_2O_3	12.2	8.1	11.3
CaF_2	14.5		
CaO	0.4		
Cs_2O		0.1	
Fe_2O_3		0.1	0.1
Na_2O	12.9	18.0	13.8
P_2O_5	0.1		
SiO_2	56.8	54.4	57.6
ZrO_2	1.8		
Total	100.0	100.0	100.0

[a]Data taken from ref. 1(b); flowsheet estimate, not verified by laboratory tests. Compositions are not available of future ceramic and metal waste forms generated by treatment of sodium-bonded fuel at ANL–W.

[b]Ammoniummolybdophosphate.

Table 2.18. Proposed representative chemical composition of future HLW glass to be generated at SRS[a]

Component	Wt %	Component	Wt %
Al_2O_3	3.9	MgO	2.0
B_2O_3	7.3	MnO	1.2
CaO	0.6	Na_2O	8.7
$Ca_3(PO_4)_2$	1.1	NiO	0.1
Cr_2O_3	0.2	SiO_2	53.4
CuO	0.4	TiO_2	0.3
FeO	1.1	U_3O_8	0.9
Fe_2O_3	11.1	ZnO	0.1
K_2O	2.4	Other	0.4
Li_2O	4.8		———
		Total	100.0

[a]Data taken from ref. 1(c).

Table 2.19. Proposed representative chemical composition of future HLW glass to be generated at WVDP[a]

Component	Wt %	Composition	Wt %
Al_2O_3	6.00	Nd_2O_3	0.14
B_2O_3	12.89	NiO	0.25
BaO	0.16	P_2O_5	1.20
CaO	0.48	PdO	0.03
Ce_2O_3	0.31	Pr_6O_{11}	0.04
CoO	0.02	Rh_2O_3	0.02
Cr_2O_3	0.14	RuO_2	0.08
Cs_2O	0.08	SO_3	0.23
CuO	0.03	SiO_2	40.98
Fe_2O_3	12.02	Sm_2O_3	0.03
K_2O	5.00	SrO	0.02
La_2O_3	0.04	ThO_2	3.56
Li_2O	3.71	TiO_2	0.80
MgO	0.89	UO_3	0.63
MnO	0.82	Y_2O_3	0.02
MoO_3	0.04	ZnO	0.02
Na_2O	8.00	ZrO_2	1.32
		Total	100.00

[a]Data taken from ref. 1(d).

Table 2.20. Historical and projected annual and cumulative volume (10^3 m^3) of LAW generated from final HLW waste form production at each site[a]

End of FY	Hanford		INEEL[b]		SRS[c]		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
1996					0.5	22.8	d	d	0.5	22.8
1997					2.0	24.8	d	d	2.0	24.8
1998					26.9	51.7	d	d	26.9	51.7
1999					40.3	92.0	d	d	40.3	92.0
2000					29.9	121.9	d	d	29.9	121.9
2001					25.8	147.7			25.8	147.7
2002	3.088	3.088			25.3	173.0			28.4	176.1
2003	3.088	6.176			26.1	199.1			29.2	205.3
2004	3.088	9.264			24.6	223.7			27.7	233.0
2005	3.088	12.352			27.0	250.7			30.1	263.1
2006	3.088	15.440			26.0	276.7			29.1	292.2
2007	3.088	18.528			27.2	303.9			30.3	322.5
2008	3.088	21.616			25.9	329.8			29.0	351.4
2009	3.088	24.704			27.4	357.2			30.5	381.9
2010	3.088	27.792			25.2	382.4			28.3	410.2
2011	3.088	30.880			25.4	407.8			28.5	438.7
2012	14.330	45.210			27.0	434.8			41.3	480.0
2013	21.740	66.950			25.0	459.8			46.7	526.8
2014	21.740	88.690			25.2	485.0			46.9	573.7
2015	21.740	110.430			26.4	511.4			48.1	621.9
2016	21.740	132.170			24.1	535.5			45.8	667.7
2017	21.740	153.910			24.9	560.4			46.6	714.3
2018	21.740	175.650			24.4	584.8			46.1	760.5
2019	21.740	197.390	0.25	0.25	0.1	584.8			22.1	782.6
2020	21.740	219.130	2.32	2.57		584.8			24.1	806.6
2021	21.740	240.870	1.64	4.21		584.8			23.4	830.0
2022		240.870	1.64	5.85		584.8			1.6	831.6
2023		240.870	1.69	7.54		584.8			1.7	833.3
2024		240.870	1.70	9.24		584.8			1.7	835.0
2025		240.870	1.71	10.95		584.8			1.7	836.7

Table 2.20 (continued)

End of FY	Hanford		INEEL[b]		SRS[c]		WVDP		Total	
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative
2026		240.870	2.06	13.01		584.8			2.1	838.8
2027		240.870	2.07	15.08		584.8			2.1	840.9
2028		240.870	2.40	17.48		584.8			2.4	843.3
2029		240.870	2.87	20.34		584.8			2.9	846.2
2030		240.870	2.87	23.21		584.8			2.9	849.1
2031		240.870	2.71	25.92		584.8			2.7	851.8
2032		240.870	2.14	28.07		584.8			2.1	853.9
2033		240.870	2.13	30.20		584.8			2.1	856.0
2034		240.870	1.82	32.02		584.8			1.8	857.8
2035		240.870		32.02		584.8				857.8

[a]Based on refs. 1a–1d.
[b]LLW grout.
[c]LLW saltstone.
[d]Negligible quantity.

Table 2.21. Projected characteristics of HLW generated at ANL–W from the treatment of sodium-bonded SNF[a]

End of FY	Volume, m^3		Number of canisters[b]	
	Ceramic waste	Metal waste	Annual	Total
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	3.6	0.08	5	5
2001	3.6	0.08	6	11
2002	3.6	0.08	6	17
2003	3.6	0.08	6	23
2004	3.6	0.08	6	29
2005	3.6	0.08	6	35
2006	3.6	0.08	6	41
2007	3.6	0.08	6	47
2008	3.6	0.08	6	53
2009	3.6	0.08	6	59
2010	3.6	0.08	6	65
2011	3.6	0.08	6	71
2012–2030	0	0	0	0
Total	43.2	0.96		

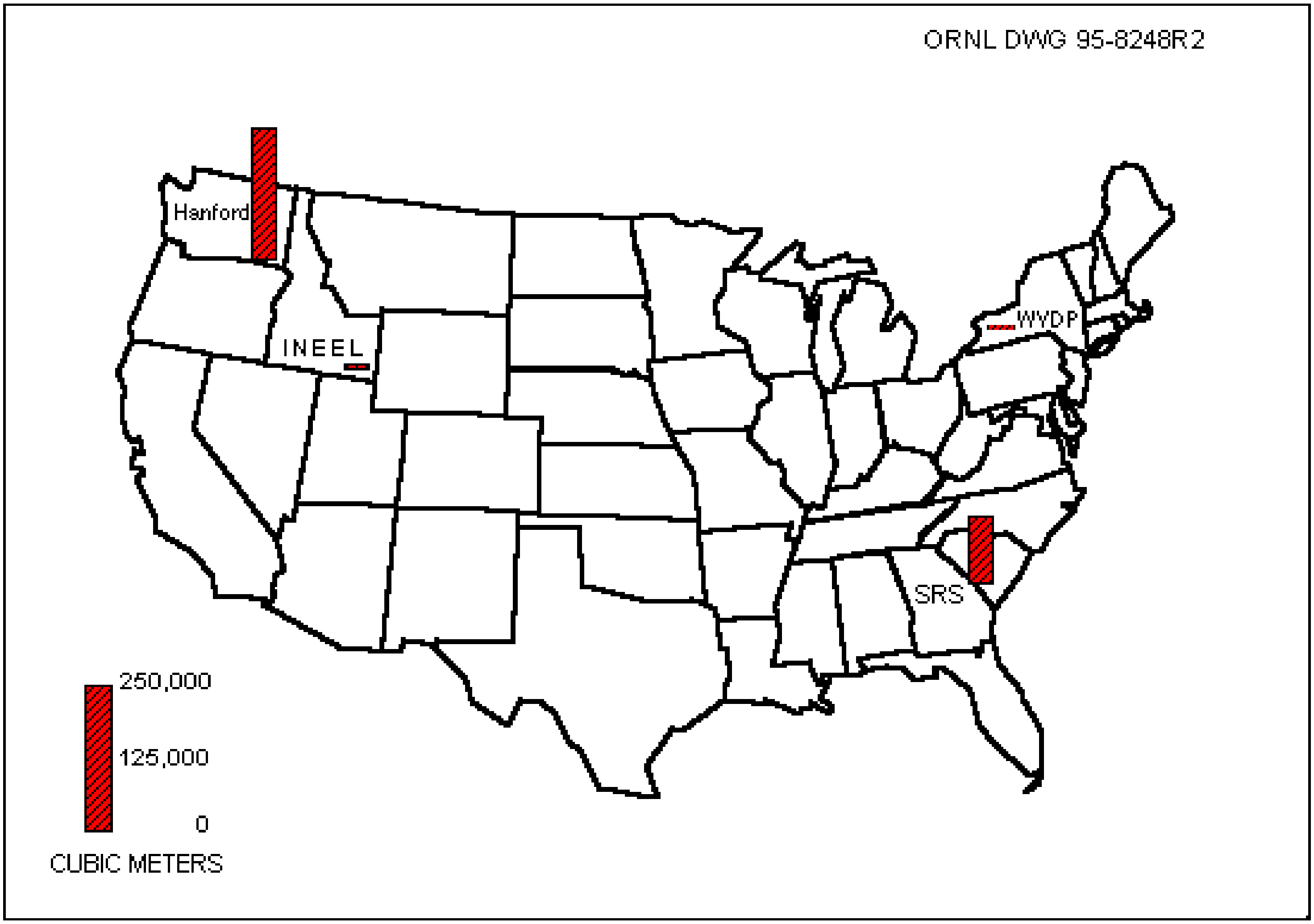
[a]Based on ref. 1(b).

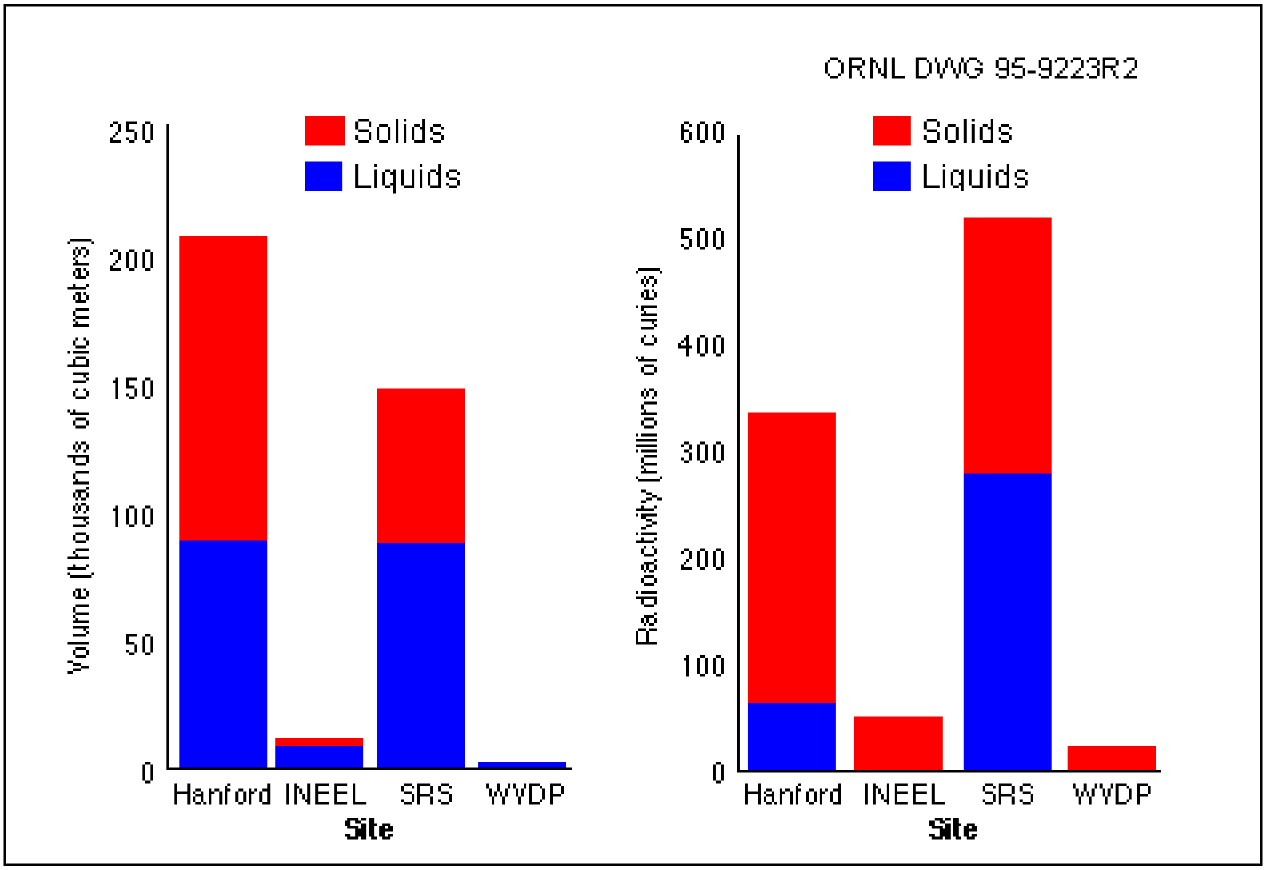
[b]Based on the SRS Reference Canister, which is assumed to contain 0.625 m^3 of glass.

Table 2.22. Major radionuclides comprising final HLW forms at ANL–W from the treatment of sodium-bonded SNF

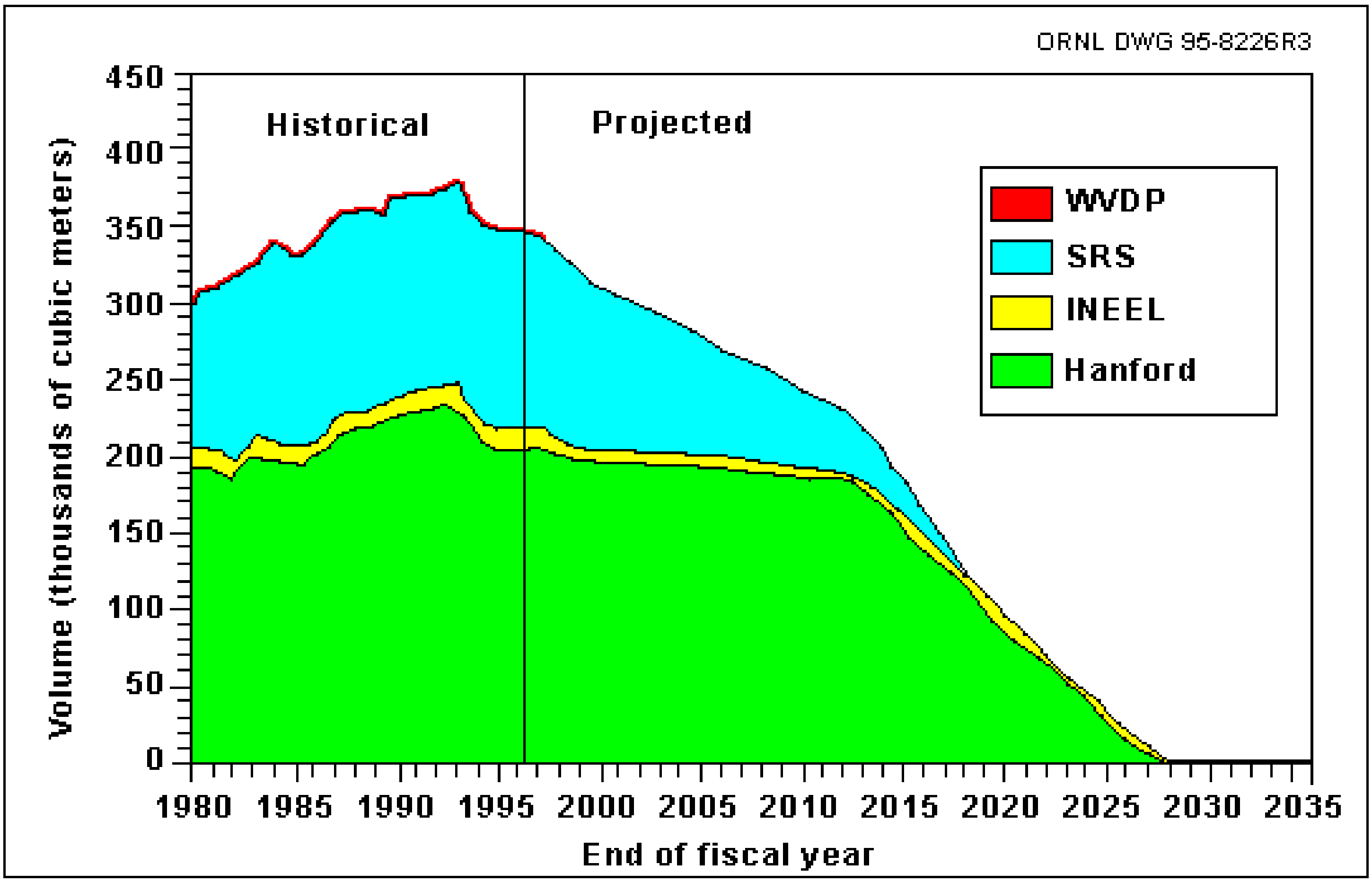
Radionuclide	Radioactivity,[a] Ci		Radionuclide	Radioactivity,[a] Ci	
	Ceramic waste	Metal waste		Ceramic waste	Metal waste
^{14}C		4.3E+00	^{233}U	2.0E−04	5.8E−05
^{60}Co		3.2E+03	^{234}U	2.8E+00	7.7E−01
^{63}Ni		4.1E+02	^{235}U	8.8E−02	2.5E−02
^{90}Sr	7.1E+05		^{236}U	6.3E−02	1.8E−02
^{90}Y	7.1E+05		^{238}U	2.8E−01	9.7E−02
^{99}Tc		1.3E+02	^{237}Np	1.3E+00	2.4E−05
^{106}Rh		2.1E+04	^{238}Pu	1.0E+03	1.8E−02
^{106}Ru		2.1E+04	^{239}Pu	4.7E+04	9.3E−01
^{126}Sn		2.8E+00	^{240}Pu	4.2E+03	8.1E−02
^{125}Sb		1.4E+04	^{241}Pu	3.0E+04	5.4E−01
^{129}I	3.4E−01		^{242}Pu	3.4E−01	5.6E−06
^{134}Cs	7.9E+03		^{241}Am	1.6E+03	3.1E−02
^{135}Cs	1.6E+01		^{242}Am	1.4E+01	2.7E−04
^{137}Cs	8.5E+05		^{243}Am	2.8E−01	4.8E−06
^{137m}Ba	8.0E+05		^{242}Cm	1.2E+01	2.3E−04
^{144}Ce	4.9E+04		^{243}Cm	1.6E−01	3.0E−06
^{144}Pr	4.9E+04		^{244}Cm	1.9E+00	3.1E−05
^{147}Pm	4.5E+05		^{245}Cm	6.8E−05	1.1E−09
^{154}Eu	2.1E+03		^{246}Cm	4.2E−07	7.1E−12
^{155}Eu	1.9E+04		^{247}Cm	2.4E−13	4.0E−18
^{226}Ra	3.0E−05		^{248}Cm	2.6E−14	4.4E−19
^{232}U	2.6E−03	1.2E−04			
			Total	3.7E+06	6.0E+04

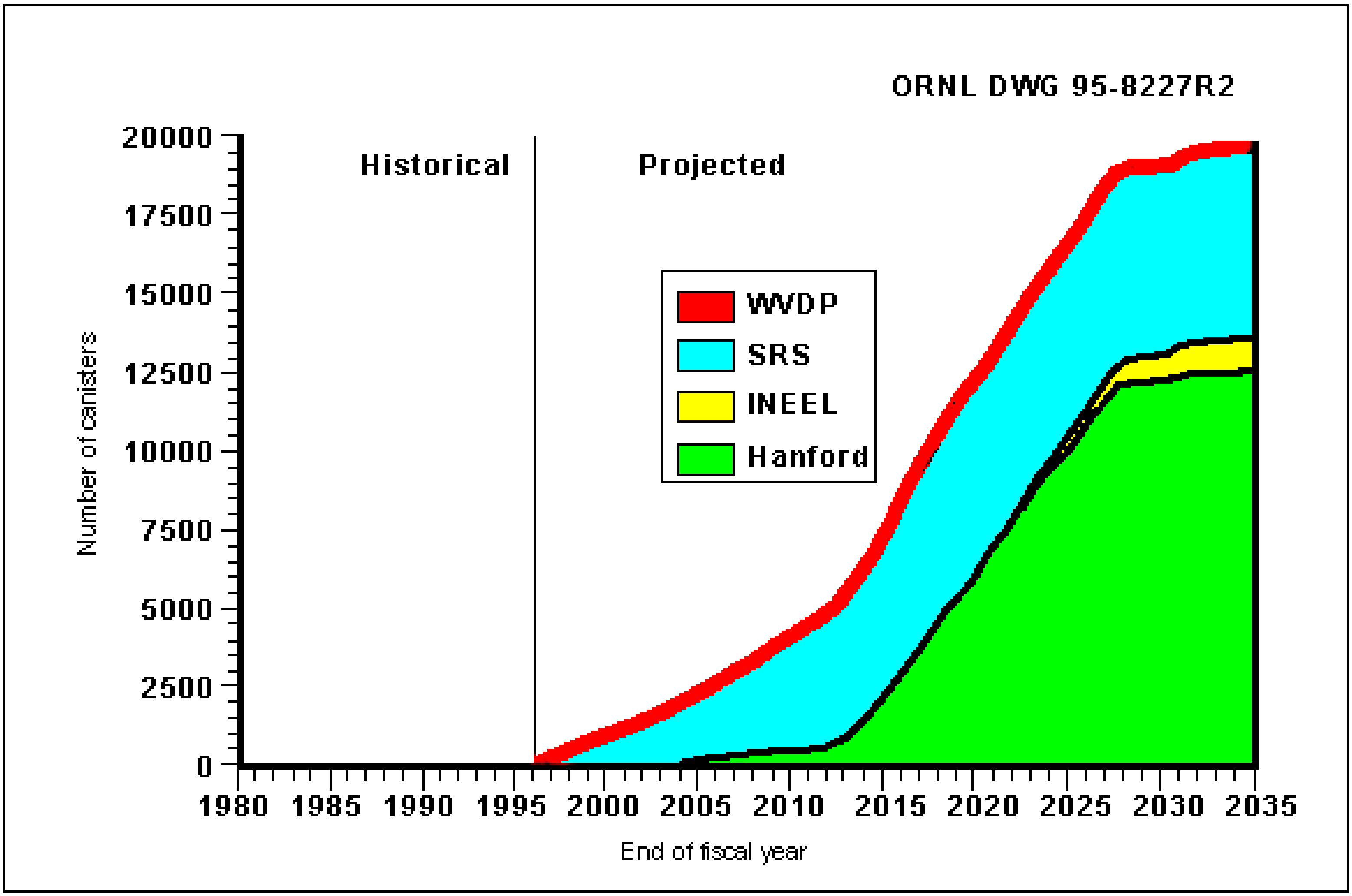
[a]Based on ref. 1(b). Radioactivity levels reported are decayed to FY 2000 and reflect totals for the treatment of all sodium-bonded fuel.

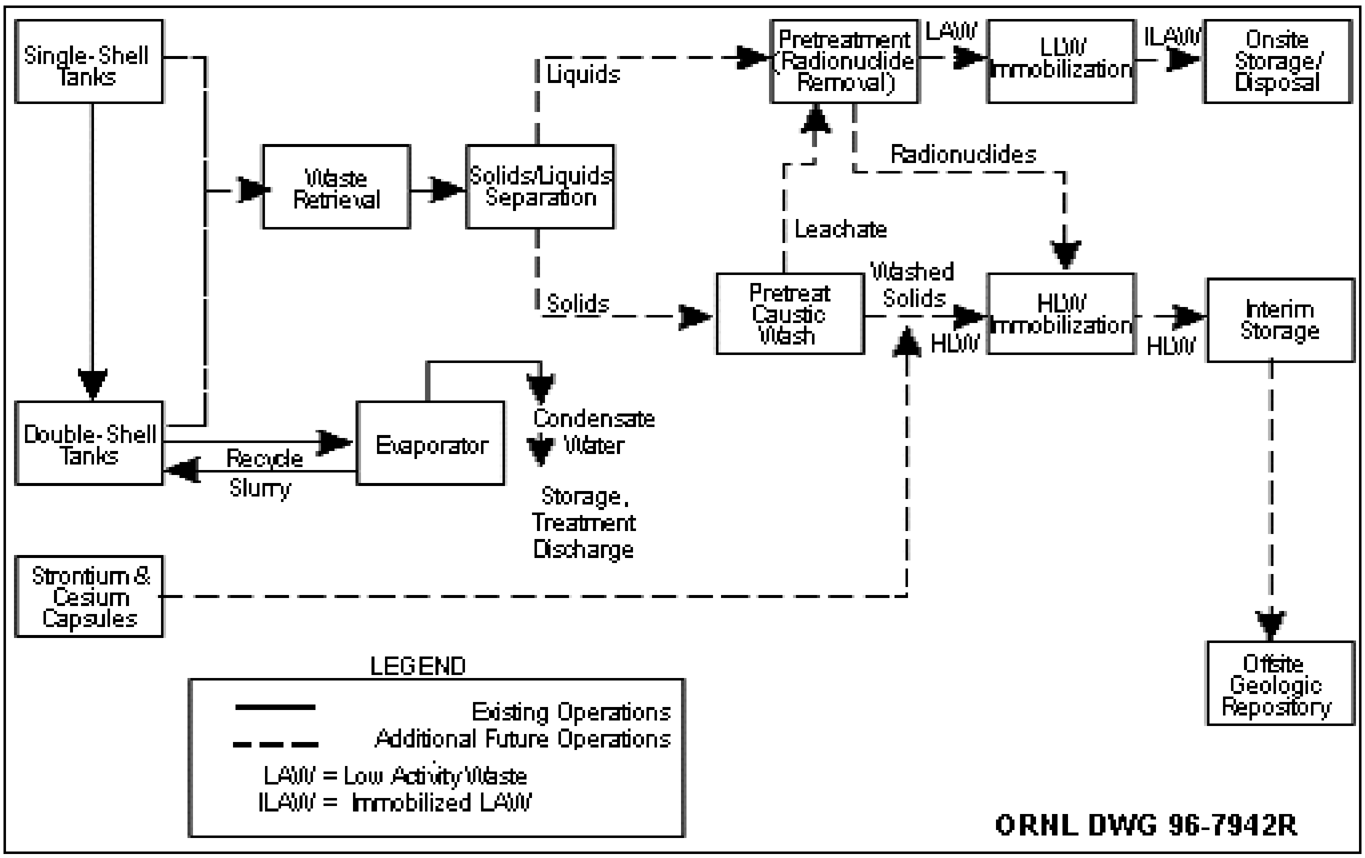

ORNL DWG 95-8248R2
Hanford
INEEL
WVDP
SRS
250,000
125,000
0
CUBIC METERS

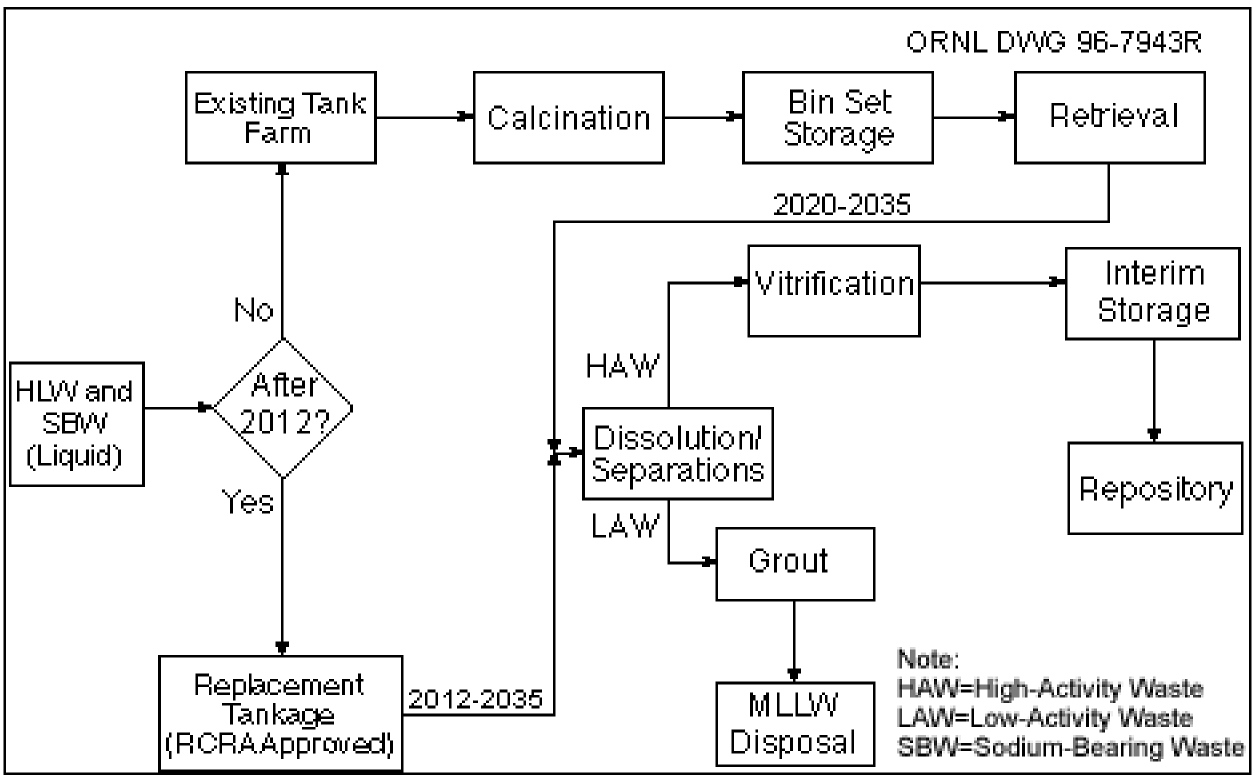


ORNL DWG 95-9223R2
Solids
Liquids
Volume (thousands of cubic meters)
250
200
150
100
50
0
Hanford
INEEL
SRS
WVDP
Site
Radioactivity (millions of curies)
600
500
400
300
200
100
0

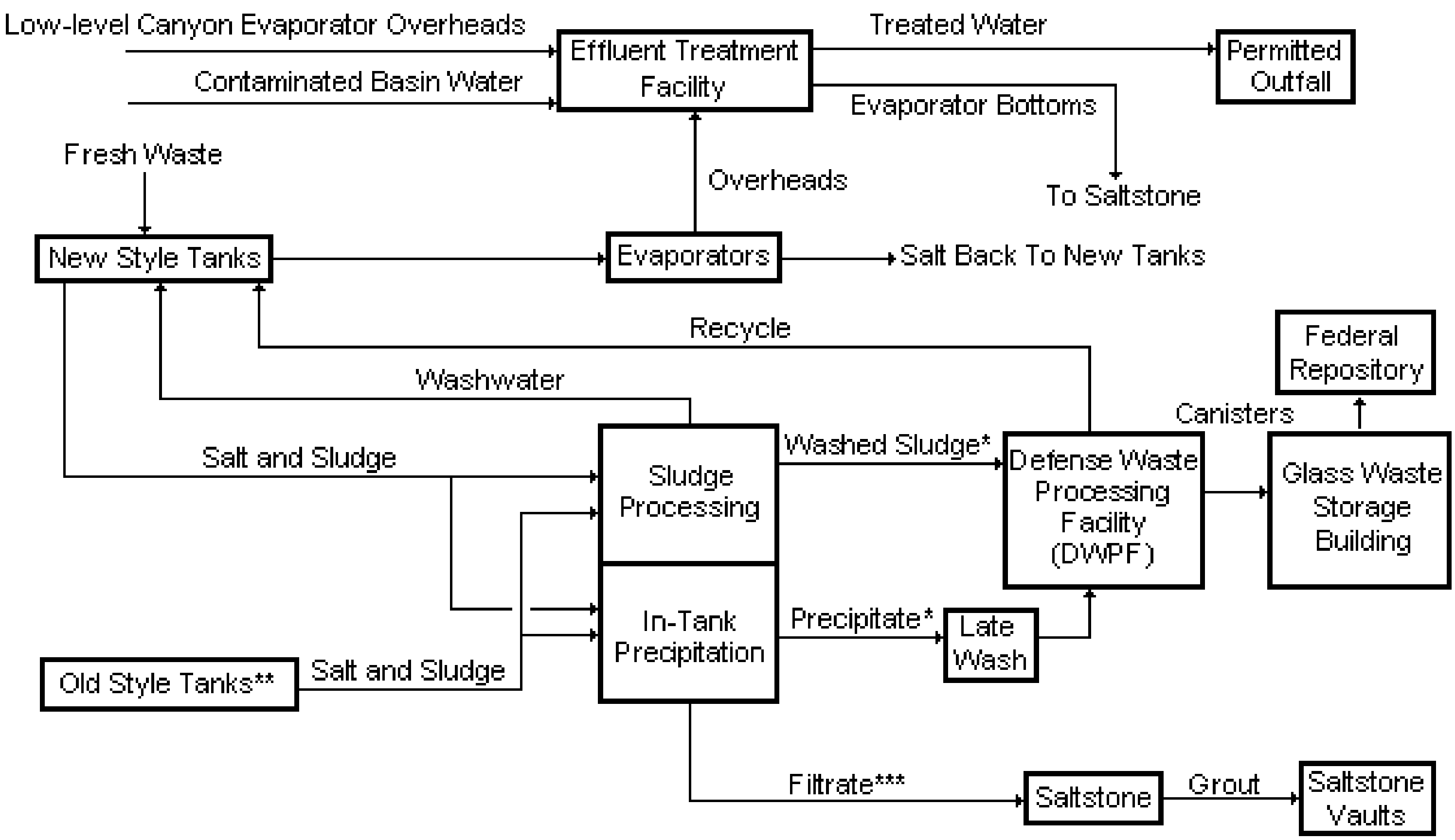

ORNL DWG 95-8226R3
Historical
Projected
WVDP
SRS
INEEL
Hanford
Volume (thousands of cubic meters)
0
50
100
150
200
250
300
350
400
450
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
End of fiscal year


ORNL DWG 95-8227R2
Historical
Projected
WVDP
SRS
INEEL
Hanford
Number of canisters
0
2500
5000
7500
10000
12500
15000
17500
20000
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
End of fiscal year

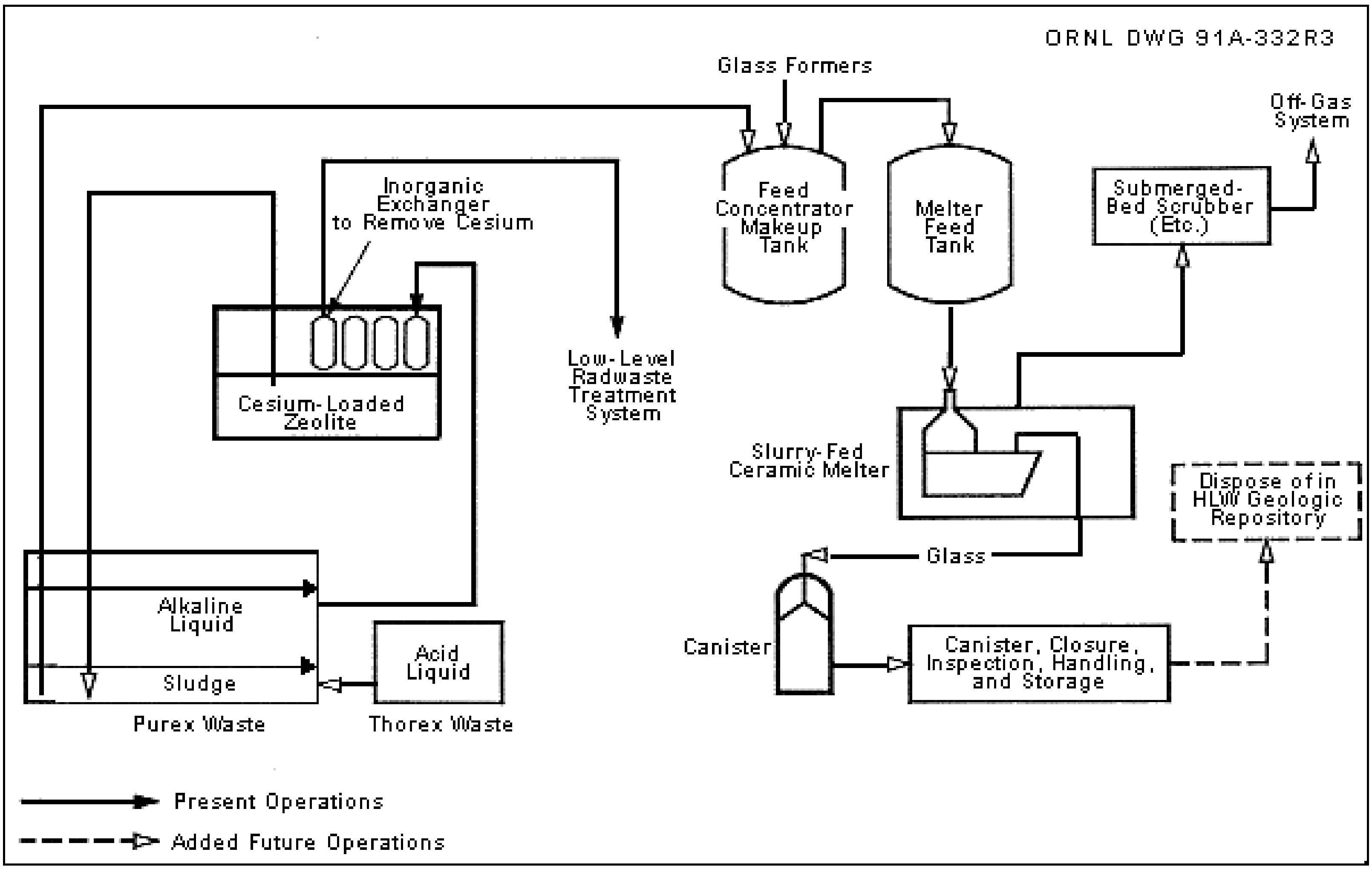

Single-Shell Tanks
Waste Retrieval
Solids/Liquids Separation
Liquids
Pretreatment (Radionuclide Removal)
LAW
LLW Immobilization
ILAW
Onsite Storage/ Disposal
Radionuclides
Leachate
Solids
Pretreat Caustic Wash
Washed Solids
HLW
HLW Immobilization
HLW
Interim Storage
Double-Shell Tanks
Recycle
Slurry
Evaporator
Condensate Water
Storage, Treatment Discharge
Strontium & Cesium Capsules
Offsite Geologic Repository
LEGEND
Existing Operations
Additional Future Operations
LAW = Low Activity Waste
ILAW = Immobilized LAW
ORNL DWG 96-7942R


ORNL DWG 96-7943R
Existing Tank Farm
Calcination
Bin Set Storage
Retrieval
2020-2035
No
HLW and SBW (Liquid)
After 2012?
Yes
Replacement Tankage (RCRA Approved)
2012-2035
Vitrification
Interim Storage
HAW
Dissolution/ Separations
LAW
Grout
Repository
MLLW Disposal
Note:
HAW=High-Activity Waste
LAW=Low-Activity Waste
SBW=Sodium-Bearing Waste

ORNL DWG 96-7145R



*High-activity waste stream
**Do not meet current DOE and regulatory criteria for secondary containment
***Low-activity waste stream


ORNL DWG 91A-332R3
Glass Formers
Off-Gas System
Inorganic Exchanger to Remove Cesium
Feed Concentrator Makeup Tank
Melter Feed Tank
Submerged-Bed Scrubber (Etc.)
Cesium-Loaded Zeolite
Low-Level Radwaste Treatment System
Slurry-Fed Ceramic Melter
Dispose of in HLW Geologic Repository
Glass
Alkaline Liquid
Acid Liquid
Canister
Canister, Closure, Inspection, Handling, and Storage
Sludge
Purex Waste
Thorex Waste
Present Operations
Added Future Operations