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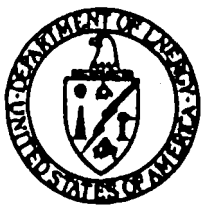
Recommendations for Management of Greater-Than-Class-C Low-Level Radioactive Waste

Report to Congress in Response to Public Law 99-240



U.S. Department of Energy
Assistant Secretary for Nuclear Energy
Washington, D.C. 20585

February 1987

EXECUTIVE SUMMARY

On December 19, 1985, the Congress of the United States passed Public Law 99-240, "The Low-Level Radioactive Waste Policy Amendments Act of 1985" (the Act). The Act was signed into law on January 15, 1986. Under paragraph 3(b)(1) of the Act (Appendix A), the Department of Energy has responsibility for the disposal of the following:

> "(A) low-level radioactive waste owned or generated by the Department of Energy;
>
> "(B) low-level radioactive waste owned or generated by the United States Navy as a result of the decommissioning of vessels of the United States Navy;
>
> "(C) low-level radioactive waste owned or generated by the Federal Government as a result of any research, development, testing, or production of any atomic weapon; and
>
> "(D) any other low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the [Nuclear Regulatory] Commission for Class C radioactive waste [greater-than-Class-C low-level waste], as defined by section 61.55 of title 10, Code of Federal Regulations, as in effect on January 26, 1983."

Section (3)(b)(1)(D) is a new responsibility of the Department of Energy and together with Section 3(b)(3) (Appendix A) is the subject of this report. Section 3(b)(3) of the Act requires that:

> "Not later than 12 months after the date of enactment of this Act, the Secretary [of Energy] shall submit to the Congress a comprehensive report setting forth the recommendations of the Secretary for ensuring the safe disposal of all radioactive waste designated a Federal responsibility pursuant to subparagraph (b)(1)(D). Such report shall include--
>
> > "(A) an identification of the radioactive waste involved, including the source of such waste, and the volume, concentration, and other relevant characteristics of such waste;
> >
> > "(B) an identification of the Federal and nonfederal options for disposal of such radioactive waste;
> >
> > "(C) a description of the actions proposed to ensure the safe disposal of such radioactive waste;
> >
> > "(D) a description of the projected costs of undertaking such actions;
> >
> > "(E) an identification of the options for ensuring that the beneficiaries of the activities resulting in the generation of such radioactive wastes bear all reasonable costs of disposing of such waste; and
> >
> > "(F) an identification of any statutory authority required for disposal of such waste."

At this time there is an estimated total of 120 m^3 of greater-than-Class-C (GTCC) low-level waste in storage. This small volume of GTCC low-level waste is being managed safely under the standards and regulations of the Environmental Protection Agency and the Nuclear Regulatory Commission. The issue, therefore, is not one of safety considerations for continued storage of GTCC low-level waste, but of ultimately providing for safe disposal of such waste. Through the year 2020, the estimated volume to be generated is 2000 m^3. On an annual basis this amount is less than 0.1 percent of the current amounts of Class A, B, and C low-level waste shipped to commercially operated disposal sites. However, the projected amounts of GTCC low-level waste are uncertain at the present time, both because of regulatory uncertainties affecting the definition of high-level radioactive waste and because of the lack of availability of information on the volumes, sources, and characteristics of current and projected GTCC low-level waste. These uncertainties in the types and amounts of GTCC low-level waste prevent a complete discussion of disposal options at this time, although we do in this report discuss many of the issues relating to disposal of GTCC low-level waste. Regulatory uncertainties surrounding NRC licensing and EPA permitting of disposal facilities for GTCC low-level waste further increase the difficulty of discussing and developing realistic disposal options and attendant costs.

Regulatory actions by NRC and EPA would alleviate the regulatory uncertainties affecting GTCC low-level waste types, volumes, disposal licensing, and other waste management activities. Such actions would permit DOE to proceed with identification of disposal options and costs. The needed regulatory actions include the following:

1. Promulgation of NRC licensing guidance for GTCC low-level waste disposal facilities;

2. Promulgation of an EPA general environmental standard for disposal of non-transuranic GTCC low-level waste;

3. A decision by NRC whether or not to proceed with definition of high-level radioactive waste based on radionuclide concentrations (such a definition could change the definition of GTCC low-level waste);

4. (If NRC decides to proceed with a concentration-based definition of high-level waste)-- promulgation of the definition; and

5. Resolution of the inconsistencies between EPA and NRC regulations for management of GTCC low-level radioactive waste that also contains hazardous chemical waste.

This report responds to the requirements specified in Section 3(b)(3) of the Act to the extent possible. DOE plans to carry out its responsibility for safe disposal of GTCC low-level waste when disposal can be implemented by ensuring that such waste in need of disposal is directed to an appropriate facility, Federal or nonfederal, including those administered by States or private entities. Until the time that GTCC

low-level waste can be disposed, DOE plans to accept such waste as necessary, after adoption of appropriate waste acceptance criteria, and to safely manage such waste until disposal options are developed. Such management may include storage and any required treatment, packaging, and transportation prior to disposal. DOE will develop appropriate procedures related to this management and will assess appropriate fees for use of these services.

DOE expects to have a program in place for accepting GTCC low-level waste for storage within 2 years. In the interim, DOE will consider requests for acceptance of GTCC low-level waste on a case-by-case basis. Acceptance of GTCC waste will be contingent on the following:

1. The waste meets DOE acceptance criteria;

2. Generator makes advance arrangements, to facilitate DOE planning;

3. Adequate facilities are available or can be developed;

4. Contractual and financial arrangements can be accomplished;

5. All reasonable costs of storage, subsequent disposal, and associated waste management services such as treatment and transportation are borne by the beneficiaries of the activities resulting in the generation of this waste;

6. Acceptance of the waste will not adversely affect any DOE defense waste activities; and

7. Appropriate National Environmental Policy Act review is completed.

DOE will make every effort to involve interested persons in its program for acceptance and disposal of the GTCC low-level waste and will publish guidelines for generators to use in requesting DOE acceptance of such waste.

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RECOMMENDATIONS FOR MANAGEMENT OF GREATER-THAN-CLASS-C LOW-LEVEL RADIOACTIVE WASTE

1. INTRODUCTION

On December 19, 1985, the Congress of the United States passed Public Law 99-240, the "Low-Level Radioactive Waste Policy Amendments Act" (the Act). The Act was signed into law on January 15, 1986. Under paragraph 3(b)(1) of the Act, the Department of Energy has responsibility for the disposal of the following:

> "(A) low-level radioactive waste owned or generated by the Department of Energy;
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> "(B) low-level radioactive waste owned or generated by the United States Navy as a result of the decommissioning of vessels of the United States Navy;
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> "(D) any other low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the [Nuclear Regulatory] Commission for Class C radioactive waste [greater-than-Class-C low-level waste], as defined by section 61.55 of title 10, Code of Federal Regulations, as in effect on January 26, 1983."

Section (3)(b)(1)(D) is a new responsibility of the Department of Energy and together with Section 3(b)(3) is the subject of this report. Section 3(b)(3) of the Act requires that:

> "Not later than 12 months after the date of enactment of this Act, the Secretary [of Energy] shall submit to the Congress a comprehensive report setting forth the recommendations of the Secretary for ensuring the safe disposal of all radioactive waste designated a federal responsibility pursuant to subparagraph (b)(1)(D). Such report shall include--
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> "(A) An identification of the radioactive waste involved, including the source of such waste, and the volume, concentration, and other relevant characteristics of such waste
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> "(B) An identification of the federal and nonfederal options for disposal of such radioactive waste
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> "(C) A description of the actions proposed to ensure the safe disposal of such radioactive waste
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> "(D) A description of the projected costs of undertaking such actions
>
> "(E) An identification of the options for ensuring that the beneficiaries of the activities resulting in the generation of such radioactive wastes bear all reasonable costs of disposing of such wastes

"(F) An identification of any statutory authority required for disposal of such waste."

The objective of this report is to respond to the above requirements of the Act.

Hereafter, the term "greater-than-Class-C low-level waste" or "GTCC low-level waste" is used to refer only to the waste newly defined as a Federal Government responsibility by subparagraph 3(b)(1)(D) of the Act.

Background

Specific responsibility for disposal of GTCC low-level waste was first assigned to the Federal Government with the passage of the Act. Previously, the 1980 Low-Level Radioactive Waste Policy Act (Public Law 96-573) had assigned to the States responsibility to ensure disposal capacity for all low-level waste, except certain federal low-level waste. The definition of low-level radioactive waste given in Public Law 96-573 excluded transuranic waste.

In 1982, NRC promulgated 10 CFR Part 61, setting forth comprehensive regulations for near-surface disposal facilities for certain "classes" of radioactive waste. The major portion of low-level radioactive waste is classified as Class A, Class B, or Class C under 10 CFR Part 61, based on radionuclide concentrations suitable for disposal within the upper 30 meters of the earth's surface. Class C waste contains the highest radionuclide concentrations permitted to be disposed of routinely by near-surface land disposal methods.

Under 10 CFR Part 61, if waste is of higher concentration than Class C, then it can be disposed in a near-surface facility only on a case-by-case basis with the express permission of NRC or an Agreement State that has authority to regulate disposal of such materials. Limited quantities of waste that would be considered greater-than-Class-C have been disposed of at the three commercial low-level waste disposal facilities that are currently operating.

The Act specifically assigned continued responsibility for ensuring disposal of Class A, B, and C low-level waste to the States. Responsibility for ensuring the safe disposal of GTCC low-level waste not generated by DOE was assigned to the Federal Government.

2. IDENTIFICATION OF GREATER-THAN-CLASS-C LOW-LEVEL WASTE

Information on the volumes and characteristics of GTCC low-level waste, as well as appropriate Federal regulatory requirements, is needed to determine and evaluate the options and costs for disposal of this type of waste. This section summarizes the available information to date. Much of the information on waste characteristics is based on data contained in NRC's recent update of the 10 CFR Part 61 impacts analysis methodology, which in turn compiles data from many other sources (USNRC 1986).

In addition, telephone interviews were conducted with 250 NRC and Agreement-State licensees, not including utilities, selected from groups identified as potential GTCC low-level waste generators (Table 1). The purpose of the interviews was to determine which generators have such waste in storage and the amounts of waste. Fuel testing and fuel fabrication plants, sealed source manufacturers, carbon-14 users, waste service companies, academic and medical institutions, industrial research and development facilities, and non-DOE federal agencies were interviewed (Knecht 1986a, Knecht 1986b, Dressen 1986). The Electric Power Research Institute (EPRI) has performed a written survey of nuclear power plant licensees (Robinson 1986, Daloisio 1986). The data from the telephone interviews and preliminary data from the EPRI survey are incorporated in this section.

A written survey of NRC and Agreement-State licensees identified as potential generators of GTCC low-level waste has also recently been completed by DOE's Energy Information Administration (EIA) to provide information for a comprehensive data base on GTCC low-level waste. The analysis and results of this survey will be available subsequent to submission of this report.

Definition of Greater-Than-Class-C Low-Level Waste

Regulatory Definition

The category of low-level radioactive waste termed GTCC was first defined with the issuance of 10 CFR Part 61, the NRC regulations for near-surface disposal of low-level radioactive waste. Those regulations define three classes of low-level waste (A, B, and C) that are suitable for near-surface land disposal. If low-level waste contains higher concentrations of the radionuclides for which Class C limits are specified (i.e., is greater-than-Class-C), it may be disposed of in a near-surface facility only with the express permission of NRC or an Agreement State.

Thus, the Class C concentration limits in 10 CFR Part 61.55 (shown in Table 2) set a lower bound for low-level waste that is considered greater-than-Class-C. It should be recognized that radionuclides other than those shown in Table 2 may also be present in GTCC low-level waste. While these other radionuclides are not considered in determining the degree of isolation required of the disposal technology, they may be of interest for operational reasons. There is technically no upper limit on the concentrations of radionuclides in GTCC low-level waste, although all low-level waste is defined by the Act to exclude spent nuclear fuel and high-level waste.

TABLE 1. NRC AND AGREEMENT STATE LICENSEES INTERVIEWED BY TELEPHONE

Type of Generator[a]	Number Interviewed	Identified Number of Licensees in Group	Percent of Licensees Interviewed
Fuel testing and fabrication plants	5	5[b]	100
Waste service companies	27	28[b]	96
Sealed source manufacturers	81	198[c]	41
Carbon-14 users	7	7[c]	100
Universities and colleges (non-medical)	73	289[c]	25
Medical institutions	22	529[c]	4
Industrial research and development	21	263[c]	8
Federal agencies (non-DOE)	14	53[c]	26
TOTAL	250	1,372	1[illegible]

a. Nuclear utilities were not included in this survey.

b. Total number of NRC and Agreement State licensees.

c. Includes only those NRC and Agreement State licensees that are known or expected to use radionuclides addressed by the Class C limits.

TABLE 2. NRC LIMITS FOR CLASS C LOW-LEVEL RADIOACTIVE WASTE[a]

Long-Lived Radionuclides	
Nuclide (half-life)[b]	Concentration (curies/m^3)
Carbon-14 (5,730 yrs)	8
Carbon-14 in activated metal (5,730 yrs)	80
Nickel-59 in activated metal (75,000 yrs)	220
Niobium-94 in activated metal (20,000 yrs)	0.2
Technetium-99 (214,000 yrs)	3
Iodine-129 (16,000,000 yrs)	0.08
	(nanocuries/gram)
Alpha-emitting transuranics (half-life greater than 5 yrs)	100
Plutonium-241 (14 yrs)[c]	3,500
Curium-242 (162.8 days)[d]	20,000

Short-Lived Radionuclides	
Nuclide (half-life)[b]	Concentration (curies/m^3)
Nickel-63 (100 yrs)	700
Nickel-63 in activated metal (100 yrs)	7,000
Strontium-90 (29 yrs)	7,000
Cesium-137 (30 yrs)	4,600

a. Limits are for single radionuclides; for mixtures of radionuclides limits are obtained by a sum-of-fractions rule separately for long-lived and for short-lived radionuclides. The sum of fractions for either short- or long-lived radionuclides is determined by dividing each nuclide's concentration by its Class C limit and adding the resulting values. If the sum exceeds 1 for either short- or long-lived radionuclides, the waste is greater-than-Class-C.

b. Half-lives are from Lederer (1978).

c. Decays to a long-lived daughter product, neptunium-237 (2,200,000 yrs).

d. Decays to long-lived daughter products, plutonium-238 (90 yrs) and uranium-234 (250,000 yrs).

The Nuclear Waste Policy Act (Section 2(12)) defines high-level radioactive waste as:

(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and

(B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation.

Uncertainty as to the volumes and characteristics of GTCC low-level waste is created by the fact that the definition of high-level waste may change significantly in the next few years. NRC has for several years contemplated a rulemaking to redefine high-level waste based on radionuclide concentrations, in addition to source (i.e., reprocessing of spent fuel). Such a rulemaking would set an upper bound for GTCC low-level waste that is based on concentration limits for specific radionuclides, as is now the case for the lower bound. Absent such a NRC definition of high-level waste, it is impossible to project volumes and characteristics of GTCC low-level waste that are meaningful for the purpose of selecting disposal options and determining costs.

The uncertainty about the types of waste included in the greater-than-Class-C category affects the selection at this time of disposal technologies that would match the waste characteristics. Selection of disposal technologies will, in turn, affect the costs of disposal. For example, if a large part of the cost of disposal is fixed capital investment, smaller waste volumes may mean much higher costs per unit volume of waste. The more capital-intensive the disposal technology that is used, the greater the effect changing volumes are likely to have on the unit price that has to be charged for disposal.

Pending resolution of the definition of the upper bound for GTCC low-level waste, the working definition of GTCC low-level waste used in this report includes all low-level wastes that (a) exceed the Class C limits, (b) are not within the existing legal definition of high-level waste, (c) are not spent fuel or spent fuel hardware, (d) are not owned or generated by the Department of Energy, (e) are not owned or generated by the United States Navy as a result of the decommissioning of vessels of the United States Navy, and (f) are not owned or generated by the Federal Government as a result of any research, development, testing, or production of any atomic weapon. This approach is expected to describe the most likely total amount of GTCC low-level waste for which responsibility for disposal was assigned to the Federal Government by the Act. As noted above, however, the anticipated NRC high-level waste definition could substantially change the total amount of projected GTCC low-level waste.

Categories of GTCC Low-Level Waste

There are three categories of GTCC low-level waste, as follows:

1. Long-lived waste with radionuclide concentrations that exceed only the 10 CFR Part 61 Class limits for long-lived radionuclides such as carbon-14, nickel-59, niobium-94, technetium-99, iodine-129, and transuranic radionuclides with half-lives greater than 5 years (Table 2);

2. High-activity, shorter-lived waste with radionuclide concentrations that exceed only the 10 CFR Part 61 Class C limits for short-lived radionuclides such as nickel-63, strontium-90, and cesium-137 (Table 2);

3. Long-lived waste with high shorter-lived activity. Such waste contains radionuclide concentrations that exceed the 10 CFR Part 61 Class C limits for both short- and long-lived radionuclides.

Figure 1 illustrates the relative differences in the periods of time required for some of the long-lived and short-lived radionuclides contained in GTCC low-level waste to decay.

Mixed Waste

Some GTCC low-level waste is also defined as "mixed waste." Mixed waste is radioactive waste that is also classified as hazardous waste under the definitions of the Resource Conservation and Recovery Act (RCRA) and 40 CFR Part 261. The unique concern with mixed waste is that it is both chemically and radiologically hazardous.

Recent investigations by Brookhaven National Laboratory (Bowerman 1985) have found the following three major categories of mixed waste:

1. Waste containing organic solvents, disposed by all types of generators;

2. Waste containing lead metal, i.e., discarded shielding or lead containers; and

3. Waste containing chromates, i.e., nuclear power plant decontamination waste containing dichromates and waste from cleanup of cooling water in which chromates are used as corrosion inhibitors.

GTCC low-level waste could include all three categories. Considerable overall uncertainty about the hazardous constituents in GTCC low-level waste exists at the present time. The EIA waste generator survey is investigating this question.

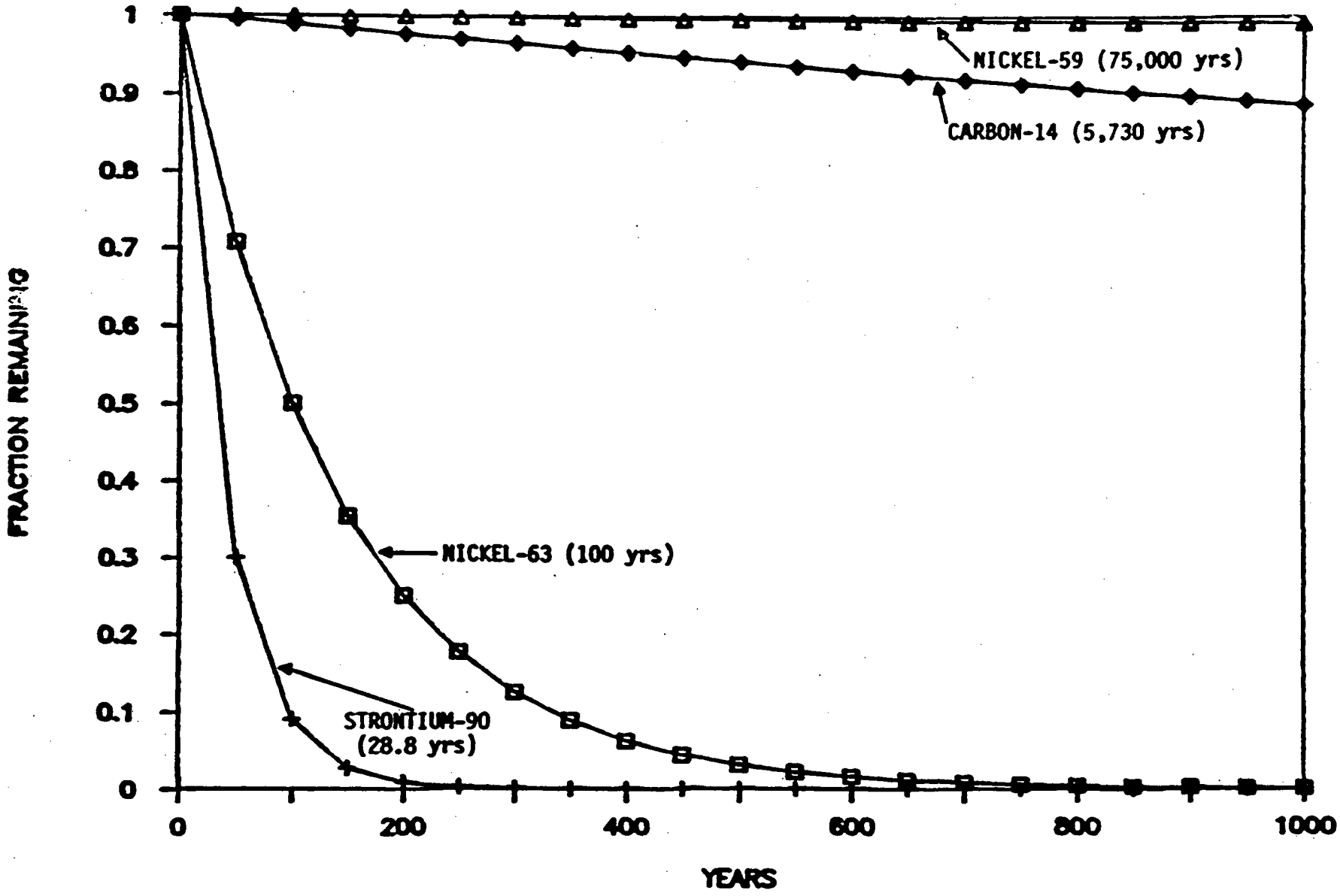

Figure 1. Typical decay curves for short- and long-lived radionuclides.

Overview of Greater-than-Class-C Low-Level Waste Types and Quantities

There are four major categories of generators and/or users of radioactive materials that yield GTCC low-level waste. They include the following:

1. Nuclear utilities;

2. Nuclear fuel testing and burnup evaluation facilities;

3. Sealed source manufacturers and users; and

4. Miscellaneous other entities that produce and use radioactive materials containing the Class C limited radionuclides for academic, medical, and industrial research, development, and other applications.

Table 3 summarizes the information currently available on the volume of GTCC low-level waste in storage and the volume of waste projected to be generated through the year 2020. Detailed descriptions of each of the specific waste types are provided in Appendix B. GTCC waste types are generally similar to those in Class A, B, and C low-level waste.

Currently, there is an estimated total of 120 m^3 (4,200 ft^3) of GTCC low-level waste in storage. Thus, most GTCC low-level waste is yet to be generated. The estimated volume to be generated by the year 2020 is about 2,000 m^3 (71,000 ft^3) or an average of 59 m^3 (2,100 ft^3) per year. For comparison (Figure 2), this annual averaged yearly production is less than 0.1 percent of the current annual generation rate for Class A, B, and C low-level waste shipped for commercial disposal, which is about 75,000 m^3 (2.7 million ft^3) per year. Commercially operated low-level waste disposal facilities routinely receive and dispose of an average annual volume of approximately (a) 34,000 m^3 (1.2 million ft^3) at Barnwell, South Carolina, (b) 39,600 m^3 (1.4 million ft^3) at Richland, Washington, and (c) 1,400 m^3 (50,000 ft^3) at Beatty, Nevada (USDOE 1986a).

Figure 3 illustrates projected total generation of GTCC low-level waste through the year 2020. As shown, volumes will be generated somewhat intermittently. There will be a slightly larger volume initially, representing the backlog of waste stored onsite by generators. A small volume of waste will be generated at a relatively constant rate from sealed source manufacturing, radioisotope use, and operations of nuclear power plants and fuel testing labs. Small variations in waste generation rates will occur from year to year, as non-power plant facilities are decommissioned. After the year 2000, significant increases in waste generation rates are expected as nuclear power plants are decommissioned, with a major peak occurring about 2014, or later. This result is based on the assumption that nuclear power plants have a useful lifetime of approximately 40 years.

Over half of the projected GTCC low-level waste will be classified as such primarily because of high concentrations of short-lived radionuclides, while the remainder will qualify as GTCC low-level waste primarily because of long-lived radionuclides. This breakdown suggests that different disposal methods may be appropriate for various subcategories of GTCC low-level waste, depending on their radionuclide content.

TABLE 3. GREATER-THAN-CLASS-C LOW-LEVEL WASTE CHARACTERISTICS

Waste Source	Physical Form	Estimated Volume in Storage (m^3)	Total Projected Volume by 2020 (m^3)	Mixed Waste	Primary Isotopes of Concern for Disposal
UTILITIES					
Operations	Activated metals, instruments, filters, ion exchange resins, sludges	55[a]	210[b]	Some	Ni-59, Ni-63, Nb-94, TRU
Decommissioning	Activated metals	--	1,200[b]	Some	Ni-63, Nb-94, Ni-59
		55	1,410		
FUEL TESTING LABS					
Burnup Lab Operation	Solidified liquids, metal cuttings, glassware, equipment	<29[d]	75[d]	Some	TRU, Sr-90
Burnup Lab Decommissioning	Solidified liquids, metals, glassware, equipment	--	54[d,e]	Some	TRU, Sr-90
		<29	130		
SEALED SOURCES					
Manufacturer Operations	Trash, metal, foils	30[d]	95[e]	Some	Am-241, Cs-137, Sr-90, C-14, Pu
Manufacturer Decommissioning	Trash, metal, foils	--	270[e]	Some	Am-241, Cs-137, Sr-90, C-14, Pu
Sources Designated as Waste	Sealed sources	<1[d,e]	<1[e,f]	No	Am-241, Cs-137, Pu-238, Pu-239
		<31	370		

TABLE 3. (continued)

Waste Source	Physical Form	Estimated Volume in Storage (m^3)	Total Projected Volume by 2020 (m^3)	Mixed Waste	Primary Isotopes of Concern for Disposal
OTHER					
Carbon-14 Users	Solidified process liquids	1[d]	95[d]	Some	C-14
Test and Research Reactors	Activated metals	<1[d]	<1[d]	No	C-14
Other	Soil, trash	--	14[g]	Unknown	Am-241
		<2	<110		
	TOTAL	<120	2,020		
			Average = 59 m^3/yr (2,100 ft^3/yr)		

a. Based on preliminary data from a survey of nuclear utilities conducted by the Electric Power Research Institute (Robinson 1986, Daloisio 1986).

b. Does not include 255 m^3 of spent fuel hardware in storage and 4,200 to 7,000 m^3 projected by 2020.

c. Highly uncertain volume; assumes no relicensing and immediate dismantling.

d. Based on telephone interviews of licensees conducted by EG & G Idaho, Inc. (Knecht 1986a, Knecht 1986b, Dressen 1986).

e. Based on NRC data (USNRC 1986).

f. Average size of sealed source is 0.000005 m^3 (0.00017 ft^3).

g. Based on NRC estimates (USNRC 1986).

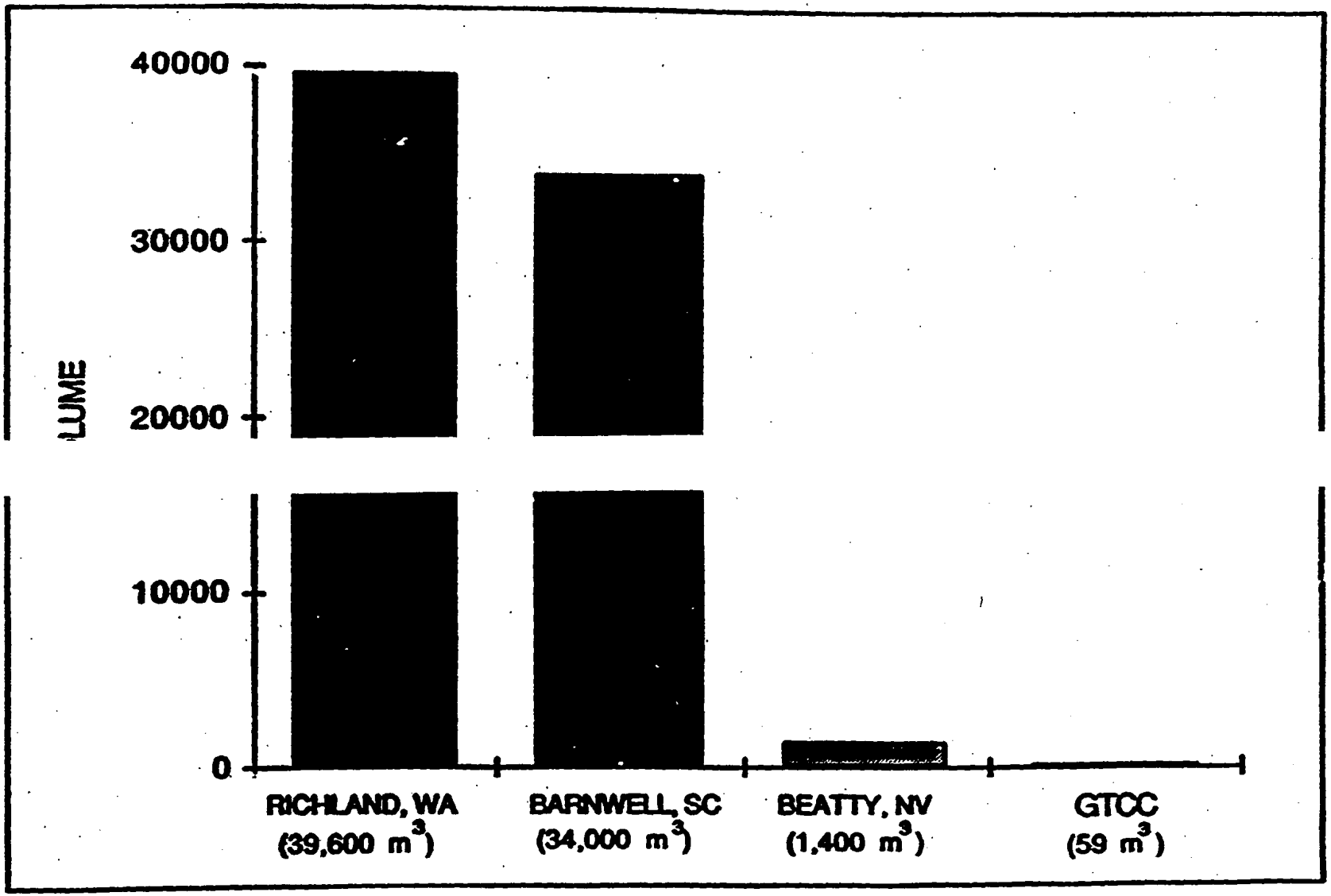

Figure 2. Projected average annual GTCC low-level waste volumes, as compared with Class A, B, and C low-level waste disposed of annually at commercial sites.

Source: USDOE 1986a

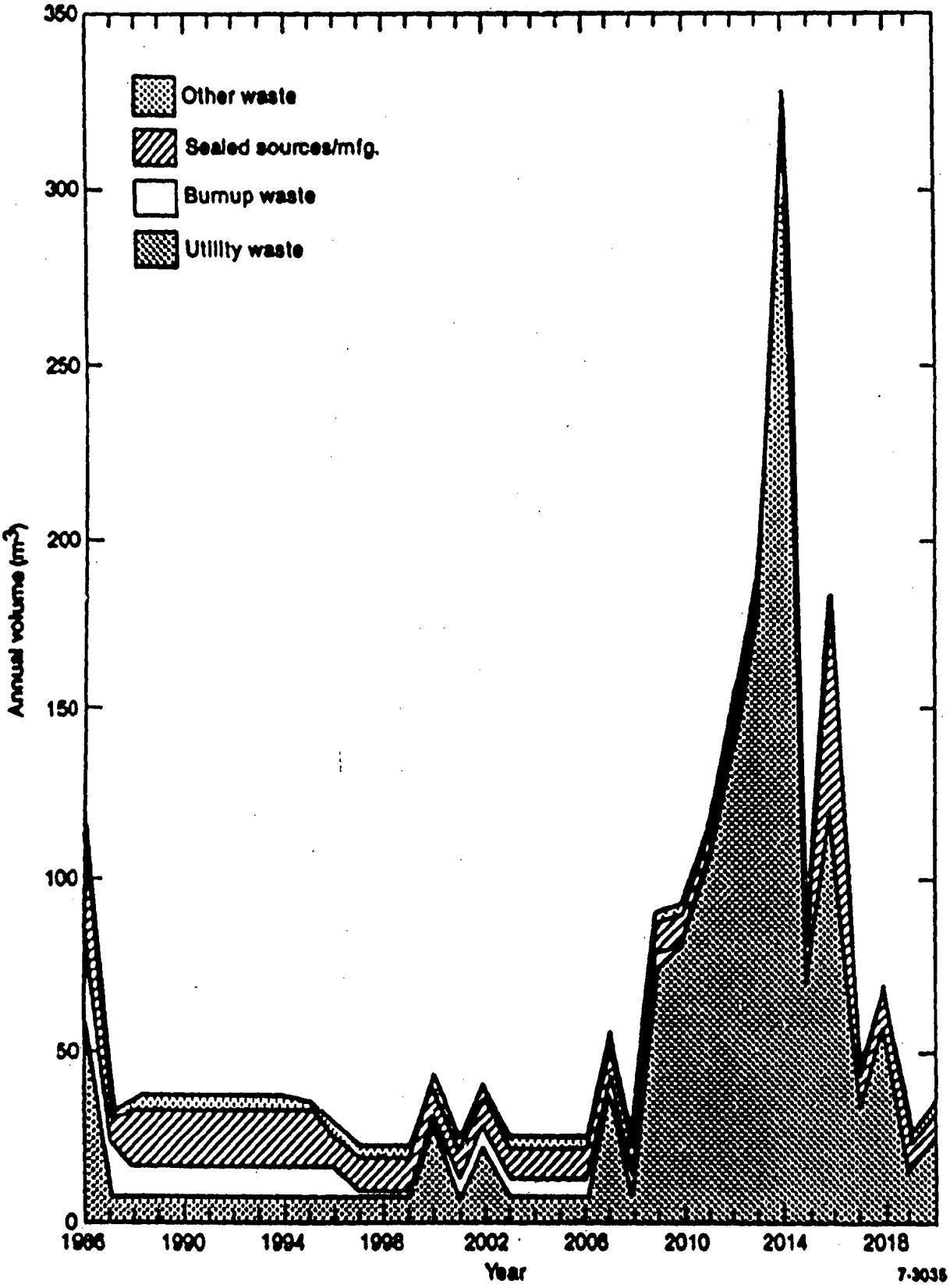

Figure 3. Projected average annual generation rates for GTCC low-level waste.

3. REGULATORY NEEDS AND LEGISLATIVE AUTHORITIES

This section examines existing federal legislation, regulations and authorities for the management of GTCC low-level waste and identifies one need for additional regulatory guidance. Several issues are identified that preclude recommendation of specific disposal options at this time. This section provides the basis, in part, for the actions proposed in Section 4.

Regulatory Needs

Several regulatory uncertainties preclude identification of feasible federal and nonfederal GTCC low-level waste disposal options and costs at this time. The most important of the regulatory uncertainties is the potential change to the definition of GTCC low-level waste that would result from an anticipated NRC regulatory definition of lower-bound radionuclide concentration limits for high-level waste, as discussed previously. The additional uncertainties are described below.

EPA Waste Disposal Standard

For several years, EPA has been developing environmental protection standards for radioactive waste. A standard (40 CFR Part 191) for disposal of spent fuel, high-level, and transuranic wastes was issued in 1985. This standard defines transuranic waste (Part 191.02 (i)) as: "waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes with half-lives greater than 20 years per gram of waste, except for...wastes that the Department has determined, with the concurrence of the Administrator, do not need the degree of isolation required by this part or...wastes that the Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61."

Work is underway on an EPA standard for disposal of low-level waste. This standard will cover all low-level waste, including GTCC, but excluding the transuranic waste covered by 40 CFR Part 191. Such a standard covering nontransuranic GTCC low-level waste would assist development of NRC-licensed disposal capability for GTCC low-level waste, and would enhance confidence in the technical disposal planning and licensing decisions.

NRC Licensing Guidance

The Act [Section 3(b)(2)] requires that "All radioactive waste designated a Federal responsibility...that results from activities licensed by the Nuclear Regulatory Commission under the Atomic Energy Act of 1954, as amended, shall be disposed in a facility licensed by the Nuclear Regulatory Commission that the Commission determines is adequate to protect the public health and safety." NRC's 10 CFR Part 61 sets forth performance objectives for low-level waste disposal that are applicable to all methods of land disposal, excluding geologic repositories, and for all low-level waste, excluding transuranic waste. Technical criteria are also promulgated in 10 CFR Part 61, but are specific only to disposal of Class A, B, and C wastes at depths within 30 meters of the surface.

Technical criteria for facilities using disposal methods specific to GTCC low-level waste are not currently available. Performance objectives and technical criteria for those wastes exceeding transuranic waste limits, which also fall into the current definition of GTCC low-level waste, are needed as well. Development of such specific criteria will be required for site and technology selection and preparation of a license application.

Mixed Waste Requirements

Mixed waste is defined by the NRC as "materials that are both hazardous waste as defined under 40 CFR Part 261 and low-level radioactive waste according to 10 CFR Part 61" (Bowerman 1985) and may be regulated by (a) NRC as part of its historic responsibility for radioactive waste, (b) EPA under its responsibility for hazardous waste regulation assigned by the Resource Conservation and Recovery Act (RCRA), (c) the States, under EPA-delegated authority over the hazardous waste portions of mixed waste (USEPA 1986), or (d) a combination of the three.

Clarification of the regulatory responsibilities of NRC, EPA, and the States with regard to the DOE-generated mixed GTCC low-level waste is needed. Such clarification will enable disposal planning that fully complies with regulatory requirements for facility design, operations, monitoring, and other factors.

Resolution of these regulatory disparities is essential to storage, treatment and disposal planning for mixed GTCC low-level waste, to ensure that facilities can be operated in compliance with the relevant NRC, EPA, and State requirements. DOE is communicating and working with NRC and EPA on this issue.

Legislative Authorities

The Act [Section 3(b)(1)] provides that "the Federal Government shall be responsible for the disposal of [GTCC low-level waste]." A question is whether the Act actually designates DOE as the responsible Federal agency for assuring safe disposal of GTCC low-level waste. This is presumed, since this section of the Act also lists as federal responsibilities three other categories of low-level radioactive waste all within DOE's existing responsibility; Section 3(b)(3) requires the Secretary to submit the report on waste above Class C; and section 3(b)(4) appears to assume that DOE is the responsible agency, since it prohibits the "Secretary [of Energy]" from disposing of the subject waste until 90 days after providing Congress with the requisite report. While DOE recognizes that the Act is not explicit on this point, DOE considers that -- based on the entire context of the Act -- DOE is the agency responsible for disposal. Accordingly, no additional legislative authorization is required at this time.

4. PROPOSED ACTIONS TO ENSURE THE SAFE MANAGEMENT OF GREATER-THAN-CLASS-C LOW-LEVEL WASTE

Background for Proposed Actions

The relatively small volume of GTCC low-level waste that currently exists is being stored and controlled in a safe manner under the regulations of the Environmental Protection Agency and the Nuclear Regulatory Commission. Long-term storage of this type of waste is possible but subject to increasing costs and risks of future safety problems. The policy established by the Low-Level Radioactive Waste Policy Act (1980) and again stated in the Low-Level Radioactive Waste Policy Amendments Act of 1985 is that low-level radioactive waste should be disposed. Long-term storage of this waste was not addressed by either of these laws.

The goal of this report, as assigned in Section 3(b)(3) of the Act, is to make recommendations that ensure the safe disposal of GTCC low-level waste. In a preliminary analysis of the safety, licensability, feasibility, cost, and schedule implications of a range of federal and nonfederal options for such disposal, the Department identified several factors that make it impossible to recommend specific federal or nonfederal disposal options at this time. These factors include the following:

1. Additional regulatory guidance necessary to evaluate and select alternative disposal technologies for GTCC low-level waste. The licensability of various disposal options cannot be evaluated at this time because of (a) the lack of comprehensive and specific NRC licensing guidance for GTCC low-level waste disposal facilities, (b) the current lack of an EPA general environmental standard defining allowable radiation dose to a member of the public from disposal of GTCC low-level radioactive waste, other than transuranic waste, (c) anticipated changes in the regulatory definition of GTCC low-level waste, and (d) evolving regulations applicable to mixed radioactive/hazardous waste.

2. Inadequate information on the volumes, sources, and characteristics of GTCC low-level waste. This inadequacy is due, in part, to (a) anticipated changes in the NRC definition of high-level waste, which may effectively define the upper limit of radionuclide concentrations in GTCC low-level waste, (b) incomplete generator characterization of potential GTCC low-level waste, and (c) lack of experience upon which to base projections of waste that may be generated from future facility decommissioning. More reliable data are essential to evaluate which disposal technologies are appropriate and to determine the economic viability of potential disposal options.

As outlined in Section 7, steps are being taken to resolve and eliminate these constraints, but that process is expected to take several years. An additional period of time (as much as 8 to 10 years) could then be required to fully implement any permanent, licensed disposal option that

requires a new facility. In the interim, DOE is willing to accept GTCC low-level waste for disposal and to store such waste in accordance with applicable regulations until disposal capacity is available. Such waste would be accepted upon the request of the generator if DOE waste acceptance criteria are met and costs to the Federal Government for this service are paid.

Actions Proposed to Ensure the Safe Disposal of GTCC Low-Level Waste

DOE will develop a program to accept for disposal GTCC low-level waste, after adoption of appropriate waste acceptance criteria, and will safely manage such waste until such time as disposal facilities are available commercially or can be provided by DOE. Such management may include storage and any required treatment, packaging, and transportation prior to disposal. DOE will not begin to accept waste on a regular basis under the Act until it has developed a program for acceptance that will require that:

1. The waste meets DOE acceptance criteria;

2. Generator makes advance arrangements, to facilitate DOE planning;

3. Adequate facilities are available or can be developed;

4. Contractual and financial arrangements can be accomplished;

5. All reasonable costs of storage, subsequent disposal, and associated waste management services such as treatment and transportation are borne by the beneficiaries of the activities resulting in the generation of this waste;

6. Such waste acceptance will not adversely affect any DOE defense waste activities; and

7. Appropriate National Environmental Policy Act review is completed.

DOE plans to proceed with additional studies towards the implementation of such a program following the submission of this report. Cost estimates for any waste acceptance will be made on a case-by-case basis and will of necessity include costs of contingencies to minimize risk of underpayment. These contingencies would include estimated costs for waste treatment and repackaging and use of highest cost estimates for all cost elements. For example, estimated costs of disposal in a high-level waste repository could be used for such early waste acceptance, rather than some lower-cost disposal method that may be specifically tailored to the specific GTCC low-level waste being tendered for acceptance.

The activities required to implement this recommendation are outlined in Section 7.

5. SYSTEMS CONSIDERATIONS FOR WASTE DISPOSAL

The disposal system for GTCC low-level waste includes storage, treatment, packaging, transportation, and disposal. Requirements for each part of the system will place certain constraints on other parts. These constraints are discussed in detail in Appendix C.

These systems considerations are significant for the management of GTCC low-level waste. Many of these considerations are not quantifiable at this time. However, the proposed implementation plan in Section 7 outlines steps to be taken to resolve such uncertainties.

6. FUNDING OPTIONS

The Act specifies that options should be identified "for ensuring that the beneficiaries of the activities resulting in the generation of [GTCC low-level] waste bear all reasonable costs of disposing of such wastes..." The purpose of this section is to explore funding options through a discussion of the underlying principles of alternative funding mechanisms, the influence of uncertainties on future costs and revenues, and the advantages and disadvantages of the options.

DOE will develop cost estimates for safe disposal of GTCC low-level waste, using conservative assumptions, when sufficient data on waste volumes, characteristics, and beneficiaries become available. DOE will then determine required revenues and select funding mechanisms and set fee schedules to recover disposal costs. Fees and funding mechanisms will be reevaluated periodically. A combination of funding options may best meet the needs of DOE and the GTCC low-level waste generators.

Principles of Funding

The underlying principle of financing safe GTCC low-level waste disposal, based on the language contained in the Act, appears to be implementation of a self-financing program. Although early program planning and development costs may have to be provided through Congressional appropriations, planning will include later reimbursement through the selected funding mechanism.

Funding schemes and fee schedules that are selected must include contingencies for reduction of risk related to uncertainties in costs and revenues. A mechanism such as an escrow account would need to be instituted to carry over collected funds from year to year and, through investment of the funds, to ensure protection of the worth of such funds from losses due to inflation.

Funding Options

A range of mechanisms could be established to allocate the costs of waste disposal to the generators. Two alternative funding mechanisms that bracket this range are discussed below and the advantages and disadvantages of each are described. The two funding mechanisms considered are (a) an advance fee, and (b) a charge upon waste receipt.

Both funding mechanisms rely on estimates of waste volumes and types, and costs upon which a fee is based. In addition, both can be administered so that any Congressional appropriations required for program start-up costs can be reimbursed. Both funding mechanisms can be adjusted as uncertainties are resolved and costs and schedules are more accurately estimated.

Advance Funding Option

An advance fee, similar to that for the Nuclear Waste Fund, established under the Nuclear Waste Policy Act, could be developed to set aside monies to cover the total costs of disposal of some GTCC low-level waste. Under this funding option, generators would pay into the fund before the waste is generated or shipped for disposal. Payments might be based on a special fee on identified beneficiaries, a tax on manufacturers of radioactive materials that will become GTCC low-level waste, a fee on other generators of GTCC low-level waste, or a combination of these. In order to implement this mechanism, there would need to be predictable waste generators, waste types, volumes, and rates of shipment, as well as sufficient contingencies to protect DOE from financial liability.

Advantages of this funding option include the following:

1. For waste sources and types that are relatively predictable (e.g., users of carbon-14), advance payments could start quickly. This would minimize, but not eliminate, the need for federal appropriations for initial programmatic and development costs.

2. For any one generator, payment over a long term, and repeated fee adjustment as uncertainties are diminished, would smooth and spread the cost burden.

However, this funding option has the following disadvantage:

For the majority of waste sources, types, and volumes that are not readily predictable, an advance fee would be difficult to set and assess. For example, many operating nuclear utilities are not able to predict generation of GTCC low-level waste and do not have any GTCC low-level waste in storage, even though they have operated for many years. Advance funding may not be suitable for such non-routine waste generation.

Charge Upon Waste Receipt Option

A second funding mechanism would be to assess a fee at the time waste is delivered for disposal. This approach is similar to that used at the commercial disposal sites for Class A, B, and C low-level waste. If a federal disposal option were selected, this funding mechanism might require federal appropriations for early development and construction costs, because no revenues would be produced until wastes were delivered. However, the fee would be designed to reimburse such federal costs.

The advantage of this option is that it is more readily tailored to wastes that are not easily predicted, for which there would be more certainty about waste characteristics and the required services at the time of shipment.

The disadvantages of the charge upon waste receipt option also need to be recognized. The following items summarize some of the shortcomings:

1. No revenues could be assumed to be available to cover early programmatic and facility development costs, so full federal appropriations would be necessary, although eventually there would be repayment of all costs to the Federal Government.

2. For any one generator's waste, there could be less opportunity for collected funds to be adjusted to meet, but not exceed, future uncertain costs.

7. REQUIREMENTS FOR IMPLEMENTATION

For DOE to ensure safe disposal of GTCC low-level waste, a number of preparatory steps will need to be taken. These steps include regulatory, technical, institutional, and fiscal activities, as described below. The proposed schedule and partial estimated costs for these activities are presented in Section 8.

Required Regulatory Guidance

The actions needed to obtain the required regulatory guidance include the following:

1. Resolution of the definition of GTCC low-level waste. Case-by-case analysis of waste management requirements can be done for the small amounts of waste expected initially. For longer-range planning, however, expeditious NRC resolution of the definition of high-level radioactive waste, which may change the definition of GTCC low-level waste, is needed. The resulting definition will allow accurate characterization of GTCC low-level waste and permit planning for needed waste management capacity. The definition will also affect the selection of preferred waste management options.

2. Promulgation of an EPA standard for environmental protection for disposal of non-transuranic GTCC low-level waste.

3. Development of NRC regulatory guidance specific to licensing of disposal facilities for GTCC low-level waste, enabling the waste to be categorized, disposal options to be evaluated for licensability, and a schedule to be developed.

4. Resolution of the uncertainty in regulatory responsibility for storage, treatment, and disposal of mixed hazardous/radioactive GTCC low-level waste. EPA and NRC should provide clear guidance on licensing and permitting requirements for management of such waste. The applicability of other EPA technical requirements (i.e., opening hazardous waste containers for analysis upon receipt at storage facilities, which could require expensive remote sampling and analysis capabilities) should be clarified for storage, treatment, and disposal.

Required Technical Activities

Based on the final definition of GTCC low-level waste, technical criteria should be developed for the entire system, including (a) waste acceptance,(b) storage, (c) waste treatment and packaging, and (d) environmental monitoring and safety needs.

Specific technical activities DOE plans to undertake could include:

1. Detailed determination of the sources, quantities, and characteristics of GTCC low-level waste requiring disposal. Specific waste characterization information will be used to develop facility designs, waste acceptance criteria, storage, treatment, packaging, transportation, and disposal requirements, and cost analyses.

2. Examination of the effects of differing waste definitions on the waste disposal system, e.g., how design requirements would vary if a significant portion of the waste was removed from or added to the GTCC low-level waste category.

3. Evaluation of the available storage, treatment, packaging, transportation, and disposal technologies for costs and applicability specifically to the quantities and characteristics of GTCC low-level waste. The results will be incorporated in waste acceptance criteria, facility design criteria, and fee-setting.

4. Evaluation of the health, safety, and environmental risks of the recommended approaches to select specific options for waste management technologies and facility locations.

5. Assessment of waste storage, treatment, packaging, transportation and system requirements. Availability and capacity of federal and nonfederal facilities and operations that may be suitable for management of GTCC low-level waste must be evaluated, as well as the needed capacity and technical requirements for handling mixed hazardous/radioactive GTCC low-level waste that would meet DOE acceptance criteria. Existing EPA-permitted facilities must be identified or EPA permits obtained to manage such mixed waste.

6. Evaluation of the costs and risks of transporting GTCC low-level waste to and from waste management facility(ies).

7. Definition of technical criteria and a process to be used to select disposal site(s), if needed. Selection of potential disposal site(s), detailed characterization of the geology, hydrology, biota, and other features of the site(s).

8. Preparation or modification, as appropriate, of disposal facility designs, operating procedures, environmental monitoring and safety protection systems, closure plans, and other technical features of the facility.

9. Definition of facility waste acceptance criteria for waste form and packaging.

10. Preparation of environmental documentation and review procedures needed to comply with the National Environmental Policy Act or equivalent state requirements.

11. Submission of applications for NRC licensing, EPA hazardous waste permits, and other appropriate permits, and support for their regulatory review.

12. Construction or modification of the disposal facility(ies), purchase of equipment, and hiring and training of staff.

Required Institutional and Fiscal Activities

The Act specifies that DOE should identify options for ensuring that the beneficiaries of the activities resulting in the generation of GTCC low-level waste bear all reasonable costs of waste disposal. The steps proposed to accomplish this include the following:

1. Identification of the beneficiaries of the activities resulting in the generation of GTCC low-level waste.

2. Development of estimated total costs for the disposal program, including any required storage, treatment, packaging, and transportation.

3. Definition of unit charges for disposal using improved estimates of GTCC low-level waste volumes.

4. Recommendation of a mechanism for funding the disposal system.

5. Request for Congressional appropriations, as needed, for the initial costs of planning, technical evaluations, and other associated activities.

For federal disposal options, a program may be required to involve appropriately State and tribal government in selection of a location for disposal of GTCC low-level waste. DOE will make every effort to involve interested persons in the program discussed in this report and will publish guidelines for generators to use in requesting DOE acceptance of GTCC low-level waste. A mechanism would also be needed for continuing consultation with affected government and public entities, as well as GTCC low-level waste generators. For nonfederal disposal options, some or all of these institutional activities may also be needed for DOE to ensure the safe disposal of GTCC low-level waste.

Required Legislation

No legislation is required to initiate a program for DOE acceptance of GTCC low-level waste for disposal and for provision of interim storage for such waste. If federal disposal options are to be used, no legislation will be required initially. Authorization may be needed to provide funds for the initial costs of development and implementation of the disposal program. Authority and appropriations for design, construction, operation, and decommissioning of required waste management facilities, or modifications and operations may be required for a federal disposal option. For a new federal disposal facility, DOE may need authority to select and acquire land as well. If nonfederal disposal options are selected, any needed legislation would be assessed at the time of selection.

8. SCHEDULE AND COST

Schedule

Implementation of plans to safely manage GTCC low-level waste involves technical, regulatory, and institutional activities for the elements of a waste disposal system, as shown in Figure 4.

A number of preliminary activities, for which DOE cannot now project time requirements, should take place before technical efforts to assess safe disposal options can begin. The need and schedule for these preliminary activities if nonfederal facility(ies) are used are uncertain. These preliminary activities would include resolution of the GTCC low-level waste definition and clarification of mixed waste requirements. Ensuring the existence of performance objectives and technical criteria for disposal of all GTCC low-level waste is a key milestone.

The activities leading to provision of disposal capability for GTCC low-level waste may require considerable additional lead time. After regulatory guidance on disposal requirements has been issued, specific disposal technologies can be selected and DOE criteria for waste acceptance can be finalized.

If new, independent facility(ies) or new facility(ies) collocated with other existing disposal facility(ies) are required, it will be necessary to define siting criteria, select and characterize site(s), and prepare facility designs. Based on the site and facility design, environmental compliance requirements must be met and a license must be obtained or amended. The facility(ies) can then be constructed and disposal charges can be defined. Depending on the disposal technology selected, this process could require 7 to 9 years in addition to the time required for preliminary activities, for nonfederal or federal options.

If existing federal or nonfederal facility(ies) or facility(ies) under development can be used for disposal of GTCC low-level waste, disposal services may be provided sooner, depending upon availability.

In parallel with the disposal development activities, efforts to ensure adequate capabilities for storage, treatment, repackaging, and shipping waste from storage to licensed disposal will be needed, also depicted in Figure 4. These tasks will include evaluating waste shipping requirements and procedures, evaluating existing packaging and transportation containers, and negotiating with private carriers to ship waste from storage to disposal, as appropriate. As much as two years may be required to provide for federal storage, if necessary, including activities to define waste acceptance criteria, select storage, treatment, and packaging technologies and locations, perform any necessary construction, write operating procedures, and define the fees to be paid by users of the waste management services. In this regard, Figure 4 should be considered a planning guide and not necessarily an actual schedule for program implementation.

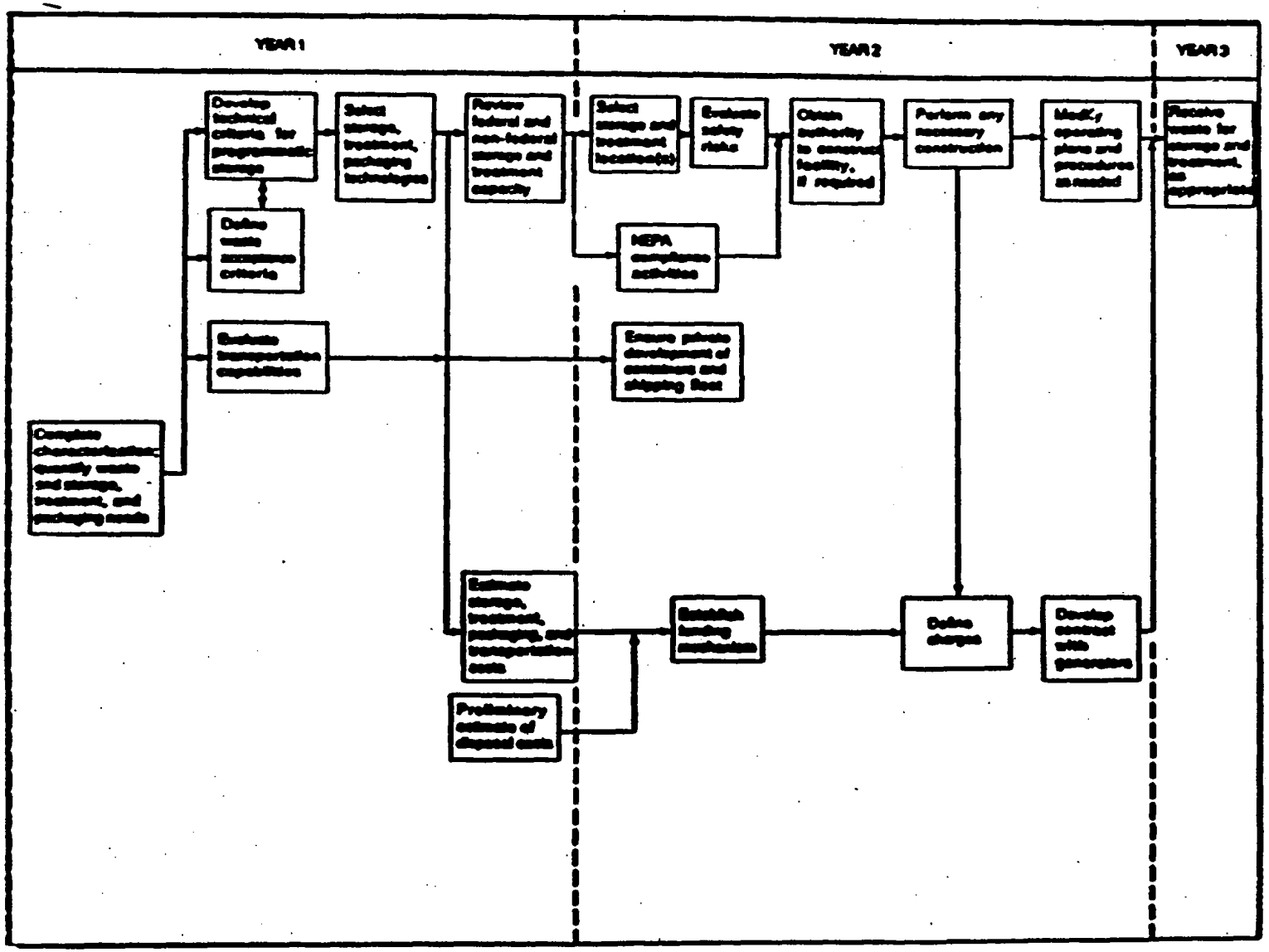

Figure 4. Schedule for associated GTCC low-level waste management activities.

Cost

The total program costs will include those for disposal, storage, treatment, repackaging, and transportation, as well as programmatic costs. Some preliminary estimates of the ranges of potential storage and transportation costs in constant 1986 dollars are presented in Table 4. Disposal, treatment, repackaging, and programmatic cost estimates cannot be determined until federal or nonfederal options and disposal technologies are selected.

Programmatic Costs

Under federal waste management options, programmatic costs may include federal agency staff requirements, technical support from outside contractors, and technology development, as well as the expenses incurred by regulatory agencies such as NRC and EPA. Technical support costs for new, independent facility(ies) would be relatively high because of the need for a complete facility design, EIS, and NRC license application. Use of existing or already planned federal or nonfederal disposal facility(ies) would require only amendments to the existing design and license applications and compliance with NEPA and other environmental requirements, so the related technical support costs could be lower. The costs of disposal or treatment technology development cannot be estimated until uncertainties about the regulatory requirements have been resolved.

Storage Costs

Preliminary estimates of storage costs are shown in Table 4 for three representative storage concepts to address both low-activity waste that would be contact-handled and high-activity waste that would be remote-handled. One concept employs an above-ground building for storage of contact-handled waste. For remote-handled waste, use of lined augered holes and concrete casks on concrete pads are addressed. For each of the three concepts, the preliminary cost estimates include (a) preoperational costs (land improvement, design, and construction), (b) waste acceptance inspection, and (c) operational costs (waste handling, monitoring, and retrieval) over a 20-year period. As shown in Table 4, estimated costs for storage will vary widely, from about $\$200/ft^3$ to $\$2,000/ft^3$ (constant 1986 dollars), depending on the design concept and the need for remote handling.

It is assumed that the storage concepts noted above would be implemented at existing DOE facility(ies). It is assumed that the storage facilities, when vacated, would be re-used and, therefore, closure costs would not need to be considered.

Transportation Costs

The two major variables influencing transportation costs to a disposal site are distance and shipping container requirements. Data on costs for defense transuranic waste transportation were examined to assess the

TABLE 4. PRELIMINARY ESTIMATES OF STORAGE AND TRANSPORTATION (constant 1986 dollars)

Storage Costs at Existing DOE Facility	
Above-ground building (contact-handled waste)	$180/ft^{3} [a]
Lined augered holes (remote-handled waste)	$440/ft^{3} [b]
Concrete casks on concrete pad (remote-handled waste)	$1,900/ft^{3} [c]
Transportation Costs	$32-$77/ft^{3} [d]

a. Based on data from Bird 1986; Richardson Engineering Services 1986; Bower 1986.

b. Based on data from Rucker 1986.

c. Based on data from Ayers 1986.

d. Based on data from USDOE (USDOE 1986b, USDOE 1983, USDOE 1980).

potential range of costs for shipping GTCC low-level waste (USDOE 1986b, USDOE 1980). Waste with relatively high levels of radioactivity (i.e., high-activity, remote-handled GTCC low-level waste) must be transported in shielded containers; the transportation costs shown in Table 4 are based on published data for transporting shielded low-level waste distances comparable to those in the defense transuranic waste analyses (USDOE 1983).

Disposal Cost

Costs for disposal of GTCC low-level waste cannot be determined until the uncertainties surrounding the waste definition, implementation of disposal regulations, quantities and characteristics of the waste, and selected technologies have been resolved. As a rough basis for comparison of the upper end of the range of potential disposal costs, however, the cost of disposing of defense high-level wastes in a repository is estimated at about $\$6{,}800/ft^3$. This cost is based on a projected total handling cost of $3.4 billion, in constant 1985 dollars (USDOE 1986c), for a total of 16,000 defense high-level waste canisters (USDOE 1986d).

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APPENDIX A

PUBLIC LAW 99-240
SECTION 3(b)

SECTION 3

"(b)(1) The Federal Government shall be responsible for the disposal of—

"(A) low-level radioactive waste owned or generated by the Department of Energy;

"(B) low-level radioactive waste owned or generated by the United States Navy as a result of the decommissioning of vessels of the United States Navy;

"(C) low-level radioactive waste owned or generated by the Federal Government as a result of any research, development, testing, or production of any atomic weapon; and

"(D) any other low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the Commission for class C radioactive waste, as defined by section 61.55 of title 10, Code of Federal Regulations, as in effect on January 26, 1983.

"(2) All radioactive waste designated a Federal responsibility pursuant to subparagraph (b)(1)(D) that results from activities licensed by the Nuclear Regulatory Commission under the Atomic Energy Act of 1954, as amended, shall be disposed of in a facility licensed by the Nuclear Regulatory Commission that the Commission determines is adequate to protect the public health and safety.

"(3) Not later than 12 months after the date of enactment of this Act, the Secretary shall submit to the Congress a comprehensive report setting forth the recommendations of the Secretary for ensuring the safe disposal of all radioactive waste designated a Federal responsibility pursuant to subparagraph (b)(1)(D). Such report shall include—

"(A) an identification of the radioactive waste involved, including the source of such waste, and the volume, concentration, and other relevant characteristics of such waste;

"(B) an identification of the Federal and non-Federal options for disposal of such radioactive waste;

"(C) a description of the actions proposed to ensure the safe disposal of such radioactive waste;

"(D) a description of the projected costs of undertaking such actions;

"(E) an identification of the options for ensuring that the beneficiaries of the activities resulting in the generation of such radioactive wastes bear all reasonable costs of disposing of such wastes; and

"(F) an identification of any statutory authority required for disposal of such waste.

"(4) The Secretary may not dispose of any radioactive waste designated a Federal responsibility pursuant to paragraph (b)(1)(D) that becomes a Federal responsibility for the first time pursuant to such paragraph until ninety days after the report prepared pursuant to paragraph (3) has been submitted to the Congress.

APPENDIX B

GREATER-THAN-CLASS-C LOW-LEVEL WASTE TYPES AND QUANTITIES

APPENDIX B

GREATER-THAN-CLASS-C LOW-LEVEL WASTE TYPES AND QUANTITIES

Four major categories of generators and users of radioactive materials are potential generators of greater-than-Class-C (GTCC) low-level waste. They include the following:

1. Nuclear utilities;

2. Nuclear fuel testing and burnup evaluation facilities;

3. Sealed source manufacturers and users; and

4. Miscellaneous other entities that produce and use radioactive materials containing the Class C limited radionuclides for academic, medical, and industrial research, development, and other applications.

The GTCC low-level waste generated by each of these categories of generators is described below.

NUCLEAR UTILITY WASTE

Nuclear utilities may generate GTCC low-level waste during both operation and decommissioning of nuclear power plants. Figure B-1 shows the locations of the operating and planned reactors in the U.S.

Operational wastes from nuclear utilities may include two waste streams. The first includes non-fuel reactor core components such as control rods (Figure B-2), control rod channels, control assemblies, thimbles, in-core instrumentation, fuel channels, shim rods, poison curtains, and flux wires. These are composed mainly of stainless steel, inconel, and other high-grade metals. This waste stream is likely to be GTCC mainly because of the nickel-59, nickel-63, and niobium-94 concentrations.

The other operational GTCC low-level waste stream from nuclear utilities includes neutron sources, fission chambers, spent ion-exchange resins, and sludges containing transuranic radionuclides from periodic reactor decontamination and fuel pool cleanup. Some decontamination wastes may contain chromium in sufficient quantities to be mixed waste.

When power plants are decommissioned at the end of their useful lives, some GTCC low-level waste may also be generated. It is difficult to project decommissioning wastes because of the lack of experience in decommissioning, uncertainty about when decommissioning will take place, and questions about the relationship between the amount of waste to be generated and the size of the power plant. The difficulty has increased with recent consideration by some utilities of the feasibility of plant life extension beyond the original plan of 40 years (Beyer 1985). Longer operating periods would increase the degree of activation in metals exposed to a neutron flux, and, thus, would increase the potential amount of GTCC low-level waste.

Nuclear Power Reactors In The United States

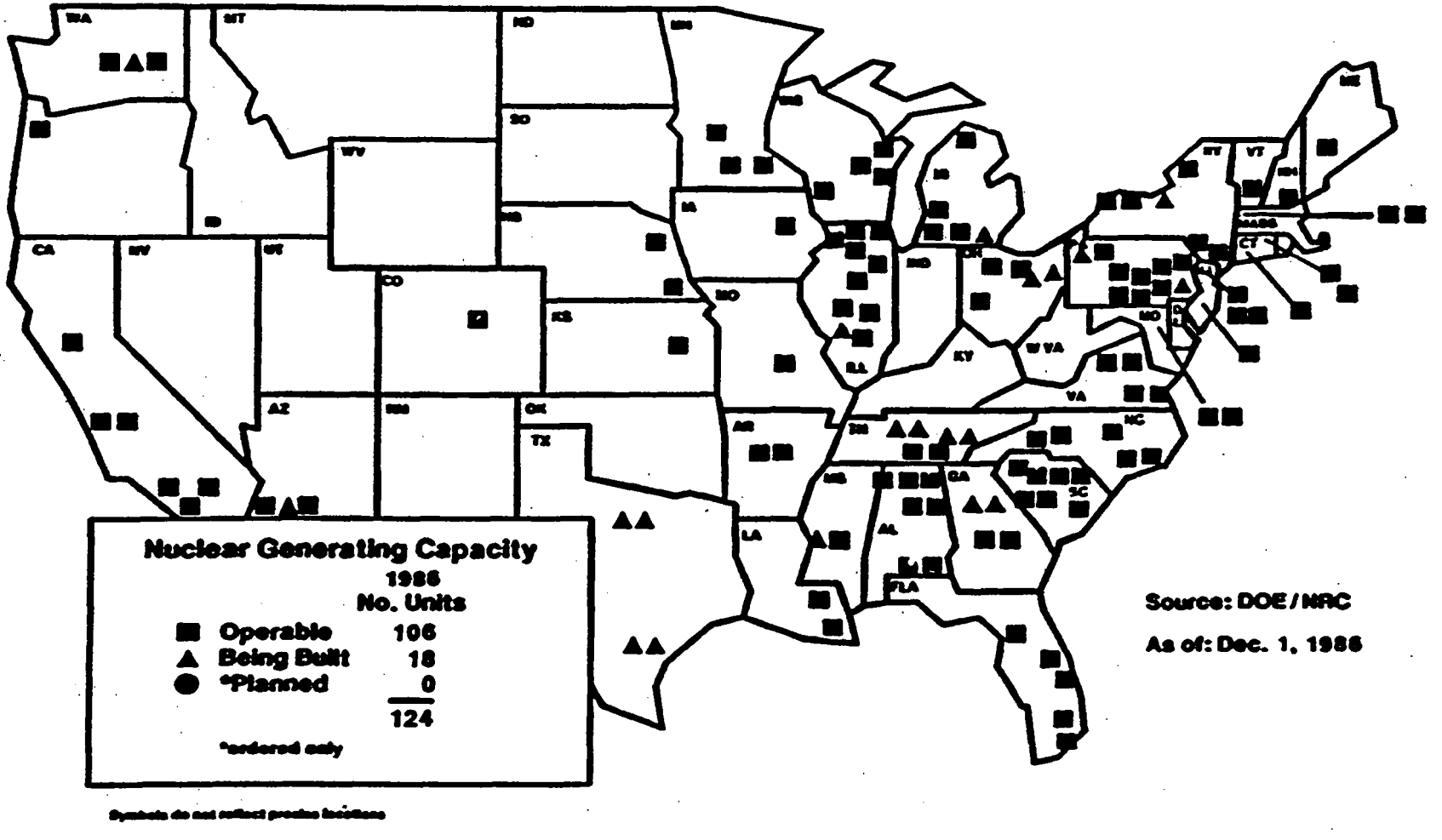


Figure 8-1

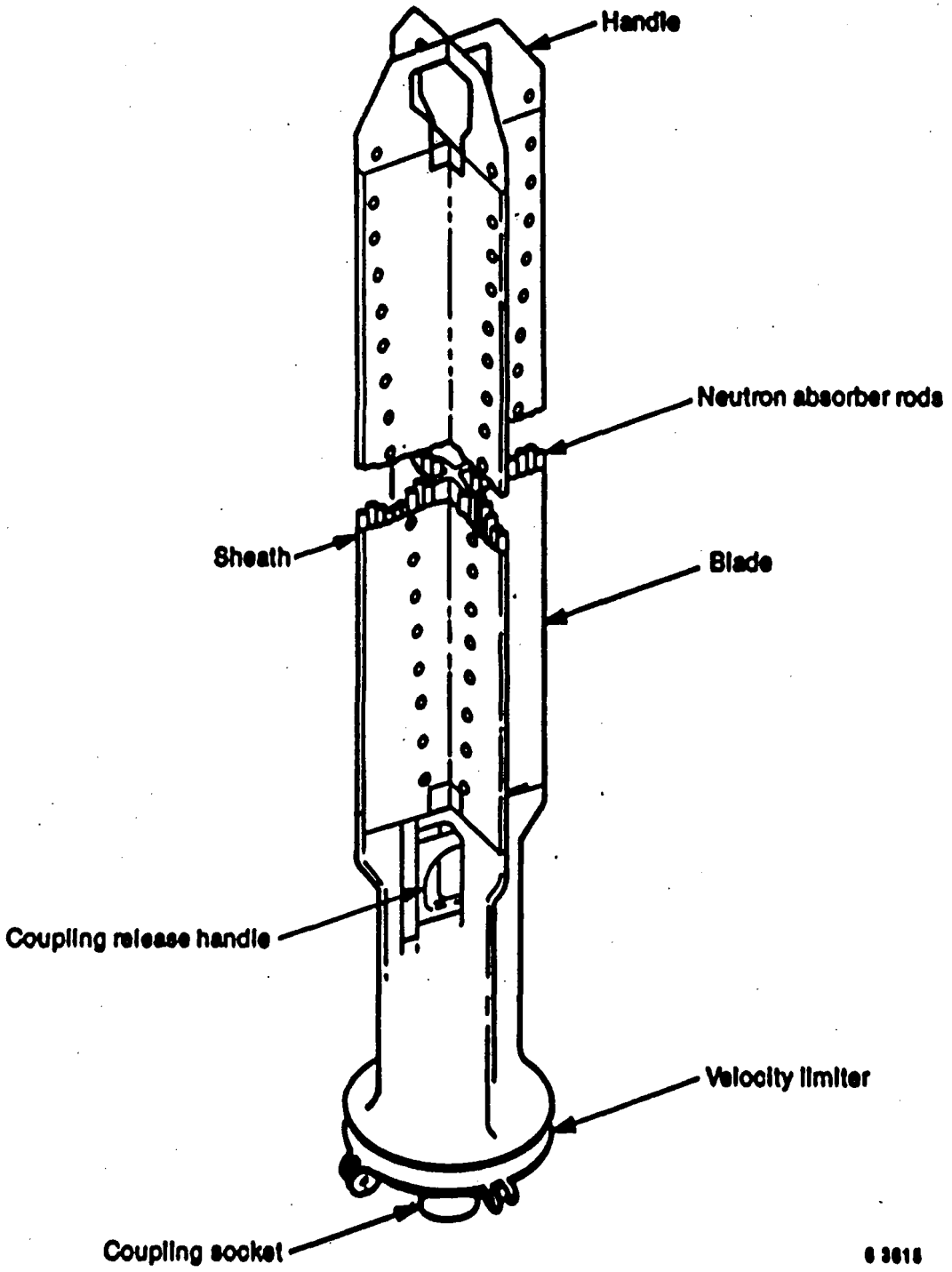


Figure B-2. Example of control rod for a boiling water reactor (Luksic 1986a).

If nuclear power plants are dismantled rather than mothballed or entombed for decommissioning, waste is expected to include stainless steel core shrouds (sleeves separating the reactor core from the reactor vessel) in which component elements are activated (USNRC 1986, Luksic 1986a). Some reactors may have operated for short enough periods that very little or no GTCC low-level waste will result from decommissioning. In other reactors, the core shrouds may be greater-than-Class-C, primarily due to niobium-94, nickel-59, nickel-63, and carbon-14 (Luksic 1986b). Decommissioning activities can also generate spent resins, sludges, and other materials that will be greater-than-Class-C, largely due to transuranics. However, it is expected that some of these materials could be maintained within the Class C limits through appropriate process controls.

Until there is further experience in reactor decommissioning, there is a high degree of uncertainty about volume and classification of decommissioning waste. For purposes of this report, only the core shrouds from decommissioning are included in the projections, assuming no plant life extension and early dismantling as the decommissioning method.

Based on preliminary data from a recent EPRI survey (Daloisio 1986), there may be about 55 m^3 (1,900 ft^3) of operational GTCC low-level waste in storage at nuclear power plants. There is, however, uncertainty if some of this waste is actually greater-than-Class-C, because measurements needed for waste classification have not been completed.

Projections of volumes and characteristics of future utility GTCC low-level waste to be disposed are difficult to make. In particular, volumes of nonfuel reactor core components are difficult to project because the components are replaced infrequently and there is great uncertainty about the trace amounts of several of the Class C limited nuclides formed by neutron activation. Other operational wastes are also generated infrequently. Assuming that the amount of waste may be generally related to the years of reactor operation and the type of reactor, however, a rough estimate of the projected waste from utility operations was developed by prorating the amount of GTCC low-level waste currently in storage over the projected number of reactor years of operation through 2020. Based on this calculation, 210 m^3 (7,400 ft^3) of operational utility waste would be generated by 2020.

For nuclear power plants that are decommissioned by immediate dismantling, GTCC core shrouds will be generated at a rate depending on the size, capacity factor, power rating, and age of the plant to be decommissioned. There has been limited experience with smaller-scale decontamination operations on which to base projections of decommissioning and decontamination wastes. Based on NRC data (USNRC 1986), it is estimated that a maximum of 1,200 m^3 (42,000 ft^3) of this waste stream could be generated by the year 2020.

Thus, the total volume of GTCC low-level waste from nuclear power plants in storage and projected through 2020 is about 1,500 m^3 (53,000 ft^3). Most of this waste will consist of activated metals in which the radionuclides are tightly bound in the metal matrix.

FUEL TESTING AND BURNUP FACILITIES

Currently, there are three commercial facilities that perform radiochemical studies and irradiation experiments (fuel burnup analyses) on reactor fuel in hot cells (General Electric, Vallecitos, CA; Babcock and Wilcox, Lynchburg, VA; Battelle Memorial Institute, Columbus, OH) as shown in Figure B-3. Operations at these facilities result in solidified liquids and solid waste, such as metal cuttings, cladding, glassware, and contaminated equipment, that are GTCC primarily due to transuranic elements (Figure B-4). This waste is also likely to contain hazardous chemicals. Additional GTCC low-level waste will result when fuel testing and burnup facilities are decommissioned. The decommissioning waste will probably have the radiological characteristics of the operational waste and also contain chemically hazardous constituents.

Currently, there is estimated to be less than 29 m^3 (1,000 ft^3) of GTCC low-level waste in storage from operation of fuel testing facilities (Dressen 1986). Approximately 75 m^3 (2,600 ft^3) of this type of GTCC low-level waste is projected to be generated by 2020 (Dressen 1986). An additional 54 m^3 (1,900 ft^3) is projected from decommissioning of these facilities (Dressen 1986, USNRC 1986). Thus, a total of about 160 m^3 (5,600 ft^3) of GTCC low-level waste is in storage or projected to be generated by fuel testing and burnup facilities through 2020.

SEALED SOURCE MANUFACTURERS AND USERS

Sealed sources are small sealed capsules, usually stainless steel, containing radioactive material (Figure B-5). These sources are used as calibration standards, medical irradiators, industrial irradiation devices (such as thickness gauges), well logging sources, radiography sources, static eliminators, and so on. A typical sealed source is only about 1.5 inches long and 0.5 inches in diameter, occupying a volume of 0.000005 m^3 (0.00017 ft^3) or about 5 cc (those sealed sources that are GTCC may be somewhat larger). While sealed sources are very small in volume, the radioactivity is so concentrated that many may qualify as GTCC low-level waste.

GTCC low-level waste is also generated in the manufacture of sealed sources. This waste consists of a variety of materials contaminated with americium-241, cesium-137, strontium-90, carbon-14, and plutonium. When the sealed source manufacturing facilities are decommissioned, additional GTCC low-level waste may be generated. The amount and characteristics of the waste are difficult to project, because they will depend on the design and size of the facility and the extent of contamination. Locations of sealed source manufacturers that may be producing GTCC low-level waste are shown in Figure B-6.

There are estimated to be less than 2,000 sealed sources (approximately 0.3 ft^3) in storage that are GTCC low-level waste. Sealed source manufacturers also have an additional 30 m^3 (1,100 ft^3) of other forms of GTCC low-level waste in storage (Knecht 1986a).

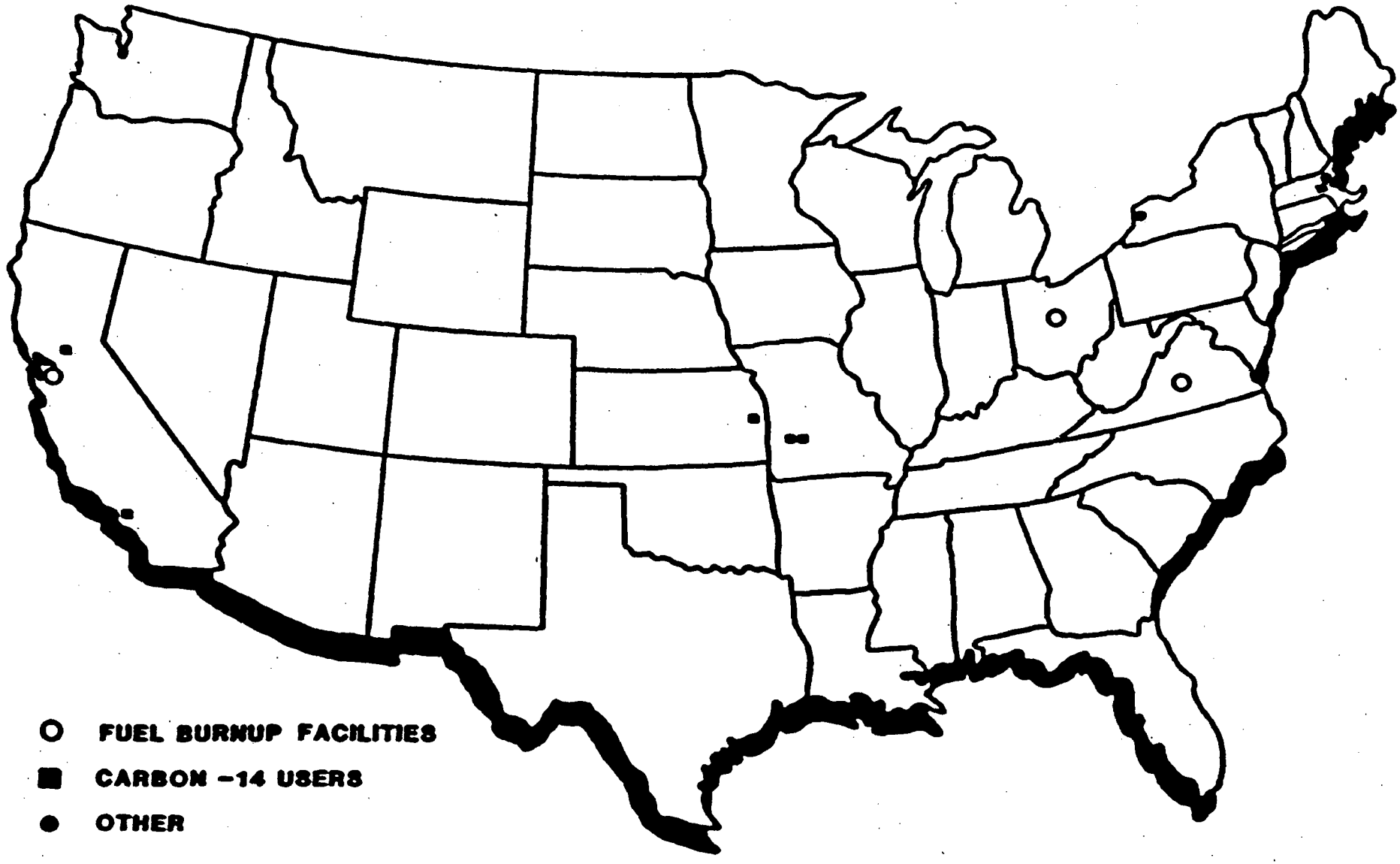
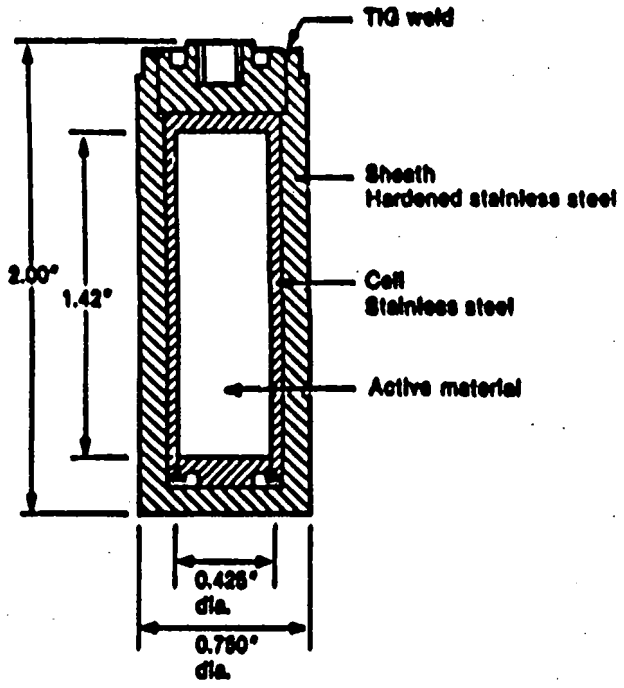


Figure B-3. Locations of non-nuclear power plant GTCC low-level waste sources.

Typical Oil Well Logging Source

Americium—241/Beryllium
Neutron Source



Typical Low-Energy Gamma Source

Americium—241

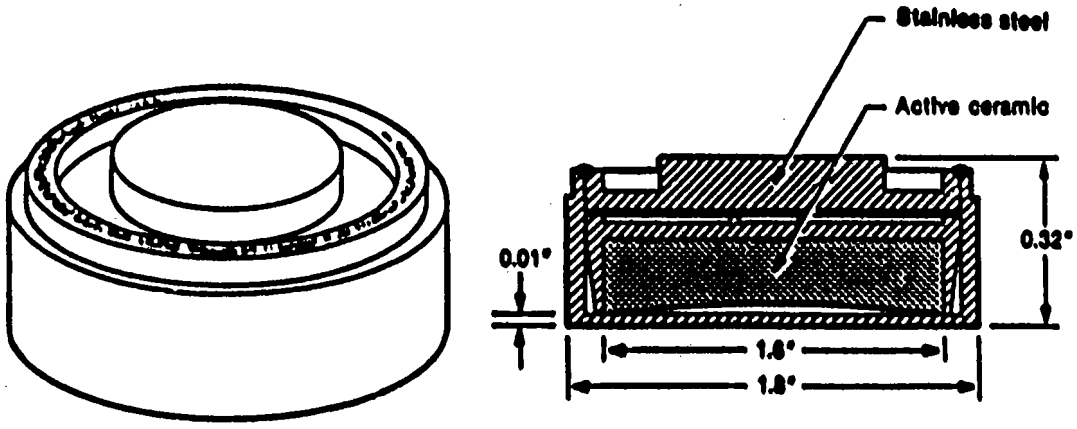


Figure B-4. Example of sealed source.

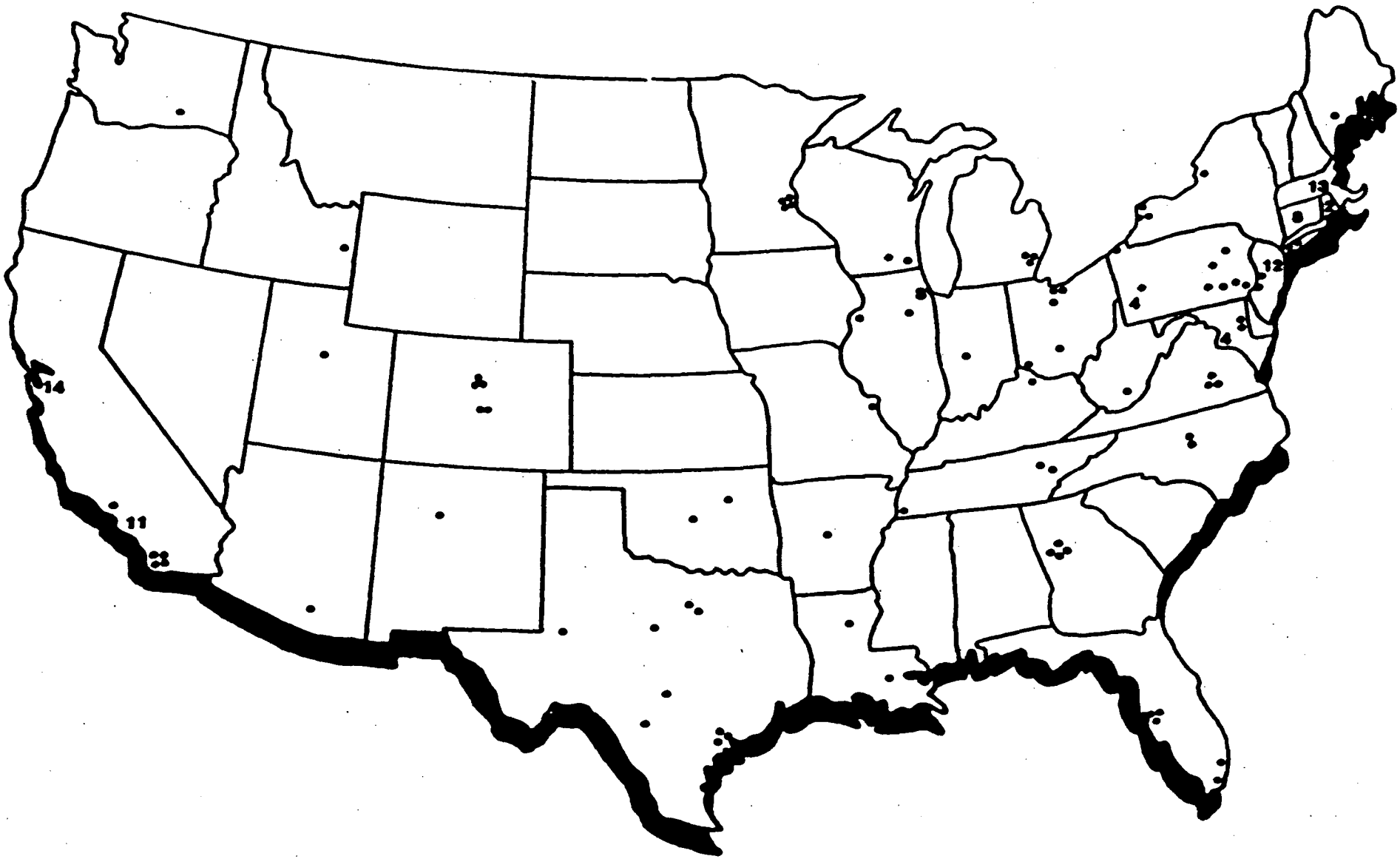


Figure B-5. Locations of sealed source manufacturers that may produce GTCC low-level waste.

For several reasons, it is difficult to estimate how many of the sealed sources currently in use will become GTCC low-level waste. Many of these sealed sources can be returned to the manufacturer and the radioactive materials may be recycled into new sources. It is also difficult to predict when users will decide to dispose of the source rather than retain it in storage pending some future use. The total volume of sealed sources projected to be disposed of as GTCC low-level waste through the year 2020 is less than 0.02 m^3 (0.7 ft^3) (USNRC 1986, USNRC 1984). If lead shielding required for shipping and storage were considered, the total waste volume might increase by approximately 4 m^3 (140 ft^3).

Based on an examination of several of the largest manufacturers (McGraw 1985a, McGraw 1985b, Kempf 1984a, Kempf 1984b), NRC projections give a minimum of 95 m^3 (3,400 ft^3) of other GTCC low-level waste containing americium-241 from sealed source manufacturing through 2020 (USNRC 1986). NRC made no projections for other radionuclides. However, telephone interviews with sealed source manufacturers (Knecht 1986a, Knecht 1986b) found waste already in storage that is believed to be GTCC due to cesium-137, strontium-90, carbon-14, and plutonium, as well as americium-241. While the NRC projection seems reasonable for americium-241, a more detailed data base on other radionuclides is needed to project the total GTCC low-level waste from sealed source manufacturers. NRC estimated that decommissioning of sealed source manufacturing facilities will generate about 270 m^3 (9,500 ft^3).

Thus, a total of less than 400 m^3 (14,000 ft^3) of GTCC low-level waste related to sealed source manufacturing and use is in storage or projected through 2020.

OTHER WASTE SOURCES

Other sources of GTCC low-level waste may include carbon-14 users, test and research reactors, and bankrupt/out-of-business facilities. The locations of these other identified facilities are shown in Figure B-3.

Carbon-14 Users

Industrial users of carbon-14 currently have about 1 m^3 (35 ft^3) of GTCC low-level waste containing that element in storage (Knecht 1986c). These facilities are projected to generate another 95 m^3 (3,400 ft^3) of GTCC low-level waste containing carbon-14 through 2020 (Knecht 1986c).

Test and Research Reactors

Currently there are 66 NRC-licensed research reactors in the U.S. There are eight licensed (seven by NRC and one by a state) test reactors in the U.S. All but one of the eight (National Bureau of Standards Test Reactor) are in safe storage with an amended license, awaiting decommissioning (USDOE 1985). The research reactors are primarily all-aluminum construction and will result in little or no GTCC low-level waste. In recent telephone interviews with operators of the research reactors, only the Massachusetts Institute of Technology (Figure B-3)

identified any activated metal inventory (0.09 m^3 or 3.2 ft^3) that resulted from irradiation of fission chambers and control rods (Knecht 1986b). However, in most cases even these components are aluminum (Hickman 1986).

Waste from decommissioning of the eight test reactors that are currently shut down is difficult to project. Decommissioning data (Konzek 1982) do not indicate that any of the waste will qualify as greater-than-Class-C.

Other Sources

Miscellaneous future sources of GTCC low-level waste may include operations that will have gone out of business before decommissioning. Based on cleanup of similar contaminated commercial facilities in the past, decommissioning of such facilities is expected to generate less than 14 m^3 (500 ft^3) of GTCC low-level waste, primarily soil and trash contaminated with americium-241 (Bradley 1986, Roles 1986a, Seeman 1986). Possible future sources of small amounts of GTCC low-level waste in this category may also be expected to occur from accidental releases (e.g., rupture of americium-241 sealed source during well logging operation) (Roles 1986b).

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APPENDIX C

DESCRIPTIONS OF SYSTEMS CONSIDERATIONS FOR WASTE DISPOSAL

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DESCRIPTIONS OF SYSTEMS CONSIDERATIONS FOR WASTE DISPOSAL

The disposal system for GTCC low-level waste includes storage, treatment, packaging, transportation, and disposal. Requirements for each part of the system will place certain constraints on other parts. These constraints are discussed below.

STORAGE

There has been considerable experience in the U.S. and throughout the world with design of radioactive waste facilities for up to 50 years of interim storage. Several viable concepts for storage of GTCC low-level waste exist and can be generically classified into four categories: (a) shielded storage buildings, (b) shielded storage modules/vaults (Figure C-1), (c) shielded casks, and (d) unshielded facilities. For GTCC low-level waste, there probably will be a need for both shielded (for remote-handled waste) and unshielded (for contact-handled waste) storage areas.

The specific facility features required for storage depend upon the specific characteristics and volumes of the waste to be stored. That information determines (a) how much storage capacity is needed, (b) what kind of facility(ies) should be used, (c) where the storage facility(ies) should be located, (d) if treatment of the wastes will be necessary before storage, and (e) how the wastes and packages will perform during the storage period.

The volume of waste to be accepted for disposal and requiring DOE storage is expected to be rather small in the near term, so it will be desirable to plan the storage facility(ies) for infrequent, intermittent waste receipt. Collocation of the storage facility(ies) with other similar activities would facilitate such operation by allowing sharing of labor and equipment. Advance scheduling of waste shipments would be required in such an operation to ensure availability of required labor, equipment, and facilities.

TREATMENT AND PACKAGING

The purpose of treating a waste stream is to alter one or more of its physical and/or chemical characteristics to (a) reduce volume, (b) improve structural stability, or (c) otherwise improve the waste form and long-term performance in storage or disposal. Volume reduction methods applicable to GTCC low-level waste include shredding, compaction, melting of metallics, evaporation, and incineration. Waste form improvements include incineration to remove hazardous organics and combustibles, followed by solidification, or solidification alone. Structural stability and barriers to release of radiologically and chemically hazardous materials from waste can be improved by both treatment and packaging.

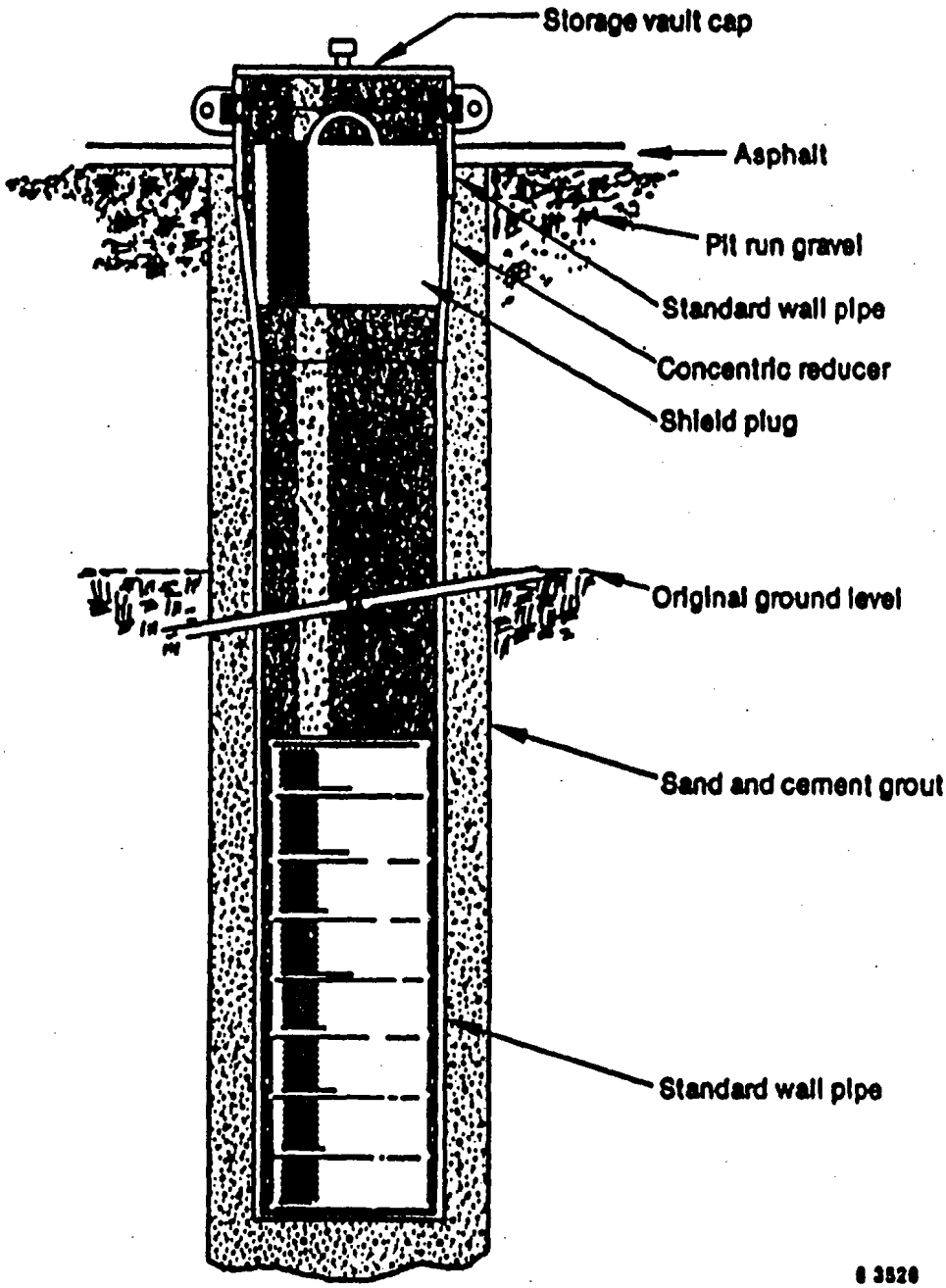

Figure C-1. Example of typical shielded storage vault.

The first step in evaluating treatment and packaging needs for GTCC low-level waste is to obtain more detailed information on the waste characteristics. This will enable an evaluation of the hazards, structural stability, volume reduction potential, and other features of the waste as generated. The types of storage, treatment, and packaging technologies that may be required can then be evaluated and, finally, technical criteria for waste form and packaging of waste delivered for storage can be developed. Waste packaging will be required to comply with Department of Transportation (DOT), EPA, and NRC regulations, and will be in accordance with policies, procedures, and standards stated in DOE Order 5480.3.

The above steps are straightforward. However, the key concerns are (a) container and/or waste form integrity must be maintained for the storage and transportation period, and (b) waste form and packaging requirements may differ for a disposal technology that is to be selected at some point in the future. Both of these concerns generate a question that the waste might need further treatment or repackaging before shipment to a disposal facility.

Investigations by Brookhaven National Laboratory (Siskind 1985) have identified areas of concern for extended storage of low-level waste in general. Such concerns include radiolytic gas generation, biodegradation, container corrosion, degradation of waste form properties, and loss of strength from freeze-thaw fluctuations. Most of these concerns can be avoided by acceptance specifications on waste form and packaging. Some of the containers could require venting to prevent buildup of gases during storage, transportation, and disposal. In addition, the package design should address potential adverse radiation effects from compounded radiation fields from adjacent packages. These efforts should collectively minimize the need for future treatment or repackaging of the waste because of changes to the waste form or container during storage. A DOE program of 20-year storage of similar waste has shown such extended storage to be feasible (USDOE 1979).

Steps to be taken to prepare for such treatment and repackaging include the following:

1. Specification of waste acceptance criteria based on DOT shipping requirements, maximum expected time of storage, and the best currently available treatment and packaging technologies;

2. Evaluation of the potential for GTCC low-level waste to be treated further; and

3. Development of a best estimate of the potential costs if future treatment or repackaging become necessary. Identification of the contingency to be included in fees charged the generator to cover such treatment or repackaging.

TRANSPORTATION

The radiologic and nonradiologic risk of radioactive waste transportation has been shown to be directly related to the number of shipments and the miles traveled (Wolff 1984, Neuhauser 1984). DOE can take several steps to minimize the transportation mileage and associated risk. First, when detailed information on the amounts and locations of waste to be shipped to DOE is known, discussions can be initiated with private brokers on the feasibility of consolidating small shipments. Through advance scheduling of shipments, DOE can serve as a clearinghouse of information for consolidation of shipments. Furthermore, in selecting the storage and disposal location(s), proximity to waste generators should be one of the considerations. When it is feasible for the generators, shipment to DOE will be their responsibility. After detailed waste characterization information is available, planning to ensure adequate shipping capacity can be conducted. It is assumed that private industry will be used to transport GTCC low-level waste to the maximum extent possible. DOE will arrange for transportation from DOE storage to the disposal facility, again using private industry when feasible.

A study should be conducted to determine if there are sufficient suitable containers for shipping GTCC low-level waste. Similarly, detailed information should be collected on the expected quantity or size of large activated metal pieces and the ability of generators to perform any size reduction that may be needed to place these into shipping containers. DOE should assist, if necessary, in ensuring that suitable casks and metal shredding equipment exist to allow packaging and transportation of the waste.

Transporting GTCC low-level waste is not expected to be a problem. The average volume of waste expected to be shipped per year is less than 0.1 percent of the Class A, B, and C low-level waste volumes being shipped every year to commercial disposal sites. This volume is also small compared to the spent fuel projected to be shipped to a repository. Small amounts of GTCC low-level waste have been sent to commercial low-level waste disposal sites in the recent past, so some transportation capability already exists.

DISPOSAL

Potential needs for further waste treatment and repackaging to meet waste form and container requirements for disposal were discussed previously. In addition, the time required to develop disposal capacity will determine the length of the storage period required, the required capacity of the storage facility(ies), and the need for transportation equipment to move the stored waste to disposal. However, until a disposal option is selected, it will be difficult to project the time required to

bring a disposal facility into operation. Therefore, it will be necessary to select and design storage facility(ies) to provide flexibility for a range of storage periods and waste volumes.

Because of the relationship of transportation risks and costs to the distance shipped and the number of shipments, costs and risks for shipment of waste to and from DOE facility(ies) will need to be analyzed.

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