GREATER-THAN-CLASS C LOW-LEVEL WASTE CHARACTERIZATION*

Roger R. Piscitella
Idaho National Engineering Laboratory
National Low-Level Waste Management Program
EG&G Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415

ABSTRACT

In 1985, Public Law 99-240 (Low-Level Radioactive Waste Policy Amendments Act of 1985) made the Department of Energy (DOE) responsible for the disposal of greater-than-Class C low-level radioactive waste (GTCC LLW). DOE strategies for storage and disposal of GTCC LLW required characterization of volumes, radionuclide activities, and waste forms. Data from existing literature, disposal records, and original research were used to estimate characteristics, project volumes, and determine radionuclide activities to the years 2035 and 2055. Twenty-year life extensions for 70% of the operating nuclear reactors were assumed to calculate the GTCC LLW available in 2055.

The following categories of GTCC LLW were addressed:

- Nuclear Utilities Waste
- Potential Sealed Sources GTCC LLW
- DOE-Held Potential GTCC LLW
- Other Generator Waste

It was determined that the largest volume of these wastes, approximately 57%, is generated by nuclear utilities. The Other Generator Waste category contributes approximately 10% of the total GTCC LLW volume projected to the year 2035. DOE-Held Potential GTCC LLW accounts for nearly 33% of all waste projected to the year 2035. Potential Sealed Sources GTCC LLW is less than 0.2% of the total projected volume. The base case total projected volume of GTCC LLW for all categories was 3,250 cubic meters. This was substantially less than previous estimates.

GTCC LLW DEFINITION AND REGULATORY HISTORY

In 1983, 10 CFR Part 61 codified disposal requirements for three classes of low-level radioactive waste considered generally suitable for near-surface disposal: A, B, and C, with Class C waste requiring the most rigorous disposal specifications. Waste with concentrations above Class C limits for certain short- and long-lived radionuclides, as defined in Tables 2-1 and 2-2 of 10 CFR Part 61, was identified as greater-than-Class C low-level radioactive waste (GTCC LLW). GTCC LLW was recognized as being generally not suitable for near-surface disposal. In 1983, 10 CFR Part 61 defined the categories of LLW, but it did not relieve the states of their statutory requirement to dispose of such waste.

In 1985, Public Law 99-240 (National Low-Level Waste Policy Amendments Act of 1985) corrected the situation by assigning the states responsibility for disposal of Classes A, B, and C radioactive low-level waste and by making the Federal Government (U.S. Department of Energy) responsible for the disposal of GTCC LLW.

In order for the Department of Energy (DOE) to carry out its responsibilities under this act, characterization of GTCC LLW was a necessary first step. The characterization effort, reported in this paper, supplied necessary information to support the decisions that must be made for storage and disposal of GTCC LLW by the DOE.

PRIOR GTCC LLW ESTIMATES

Information gained in the 1986 Energy Information Administration (EIA) survey (1) was initially planned for use in the waste characterization report. 1250 potential GTCC LLW generators were surveyed. The survey form requested information about GTCC LLW generators, waste-generating activities, current waste inventories, future waste generation (including decommissioning waste), and capabilities of storing the waste.

Analysis of data in this survey revealed incomplete results, and in several cases, inconsistent trends in the data reported by specific generators. Inconsistencies in this data may be attributed to one or all of several factors.

- Generators were not familiar with GTCC *LLW* definitions
- Some generators failed to devote the time or effort necessary to accurately complete the survey
- Some generators lacked detailed information to characterize waste on hand
- Generators have operating procedures that can vary with time.

* Work sponsored by the U.S. Department of Energy, Office of Environmental Restoration and Waste Management, under the DOE Idaho Field Office, Contract No. DE-AC07-76ID01570.

After evaluating these inconsistencies, it was felt that more accurate data could be obtained, and the 1986 survey was augmented with additional research and new data.

Two additional documents were evaluated for use in this report. Those documents were NUREG/CR-0130 (2) and NUREG/CR-O672. (3) The documents were reviewed for data on volumes, activities, and radionuclide concentrations of nuclear utility decommissioning waste. The volume and activity data in these reports are estimated from projections made on a limited number of nuclear reactors.

Research into volumes and radionuclide concentrations of nuclear utility decommissioning waste suggested that the NUREG estimates were greater than observed data from operating commercial nuclear reactors. Packaged waste volumes reported in these documents use very conservative packaging factors, allowing for large void volumes inside the disposal liner and incorporating less waste volume per disposal liner than were used in this study.

Again it was felt that more accurate information could be developed than was available in the NUREG documents. Actual experience with actual waste components was emphasized as the basis of information for this study.

GTCC LLW CHARACTERIZATION REPORT, DOE/LLW-114

The remainder of this paper addresses the details of the current GTCC LLW report, titled "Greater-Than-Class C Low-Level Radioactive Waste Characterization: Estimated volumes, Radionuclide Activities, and Other Characteristics," DOE/LLW-114 (August 1991).

GTCC LLW Generator Types

GTCC LLW was categorized into four main generator types. These major types are shown on Fig. 1 and include Potential Sealed Source GTCC LLW, DOE-Held Potential GTCC LLW, Other Generator Waste, and Nuclear Utility Wastes.

Potential Sealed Source GTCC LLW consists of small capsules, usually stainless steel, that encapsulate relatively high concentrations of a single nuclide. Sealed sources are used in a wide range of applications, including industrial and medical, and become waste when they are no longer usable. Two distinct groups of these sources have been identified in this study: (a) those containing TRU radionuclides and (b) those containing other radionuclides. Typical uses of each category are shown in Fig. 1. The primary source of information for this category of waste was a 1989 U.S. Nuclear Regulatory Commission (NRC) survey of NRC and Agreement State licensees. (4)

DOE-Held Potential GTCC LLW is waste that was accepted by DOE from NRC and Agreement State licensees through contractual arrangements or because of immediate health or safety concerns. This waste is stored by DOE until a disposal facility becomes operational. It is unclear whether all currently inventoried waste in this category will require disposal in a NRC-licensed facility. In some situations, such as receipt of waste for research and development activities, waste may be disposed of at a DOE facility. Listed in Fig. 1 are the DOE facilities that currently store, or plan to store, DOE-Held GTCC LLW.

Other Generator Waste is the name given in this study to waste generated by miscellaneous sources that does not fall in the other three categories. Information on this category was taken from the EIA survey with followup telephone conversations to verify and amend data. Specific generators that fall in this category are listed in Fig. 1.

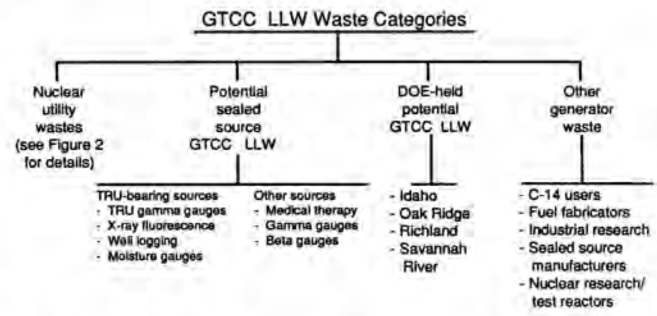

Fig. 1. Sources of GTCC LLW waste, including other generator waste.

Nuclear Utility Wastes constitute the majority of GTCC LLW and for this reason was further subdivided into the categories listed on Fig. 2. Operations Waste and Decommissioning Waste were considered separately because they constituted inherently different waste forms and quantities. Operations Waste was further broken down into Activated Metals, Process Waste, and Dry Contaminated Solids. Examples of the types of waste streams that are included in these subcategories for pressurized water reactor (PWR) and boiling water reactor (BWR) facilities are included in Fig. 2. The primary source of data for Operations Waste comes from actual characterization data used in prepackaging analysis of commercial nuclear power reactor-generated LLW. Decommissioning Waste is comprised primarily of activated metal components. Expected activated metal components for PWR and BWR facilities are listed in Fig. 2. Material volumes for Decommissioning Waste components were taken from engineering drawings, and radionuclide concentrations were calculated using ANISN (5) and ORIGEN2 (6); model results were normalized using surveillance capsule data.

Volume and Activity Models

A computer model was developed that took input data and predicted volumes for a number of different scenarios. This process is depicted in Fig. 3 and shows typical input data

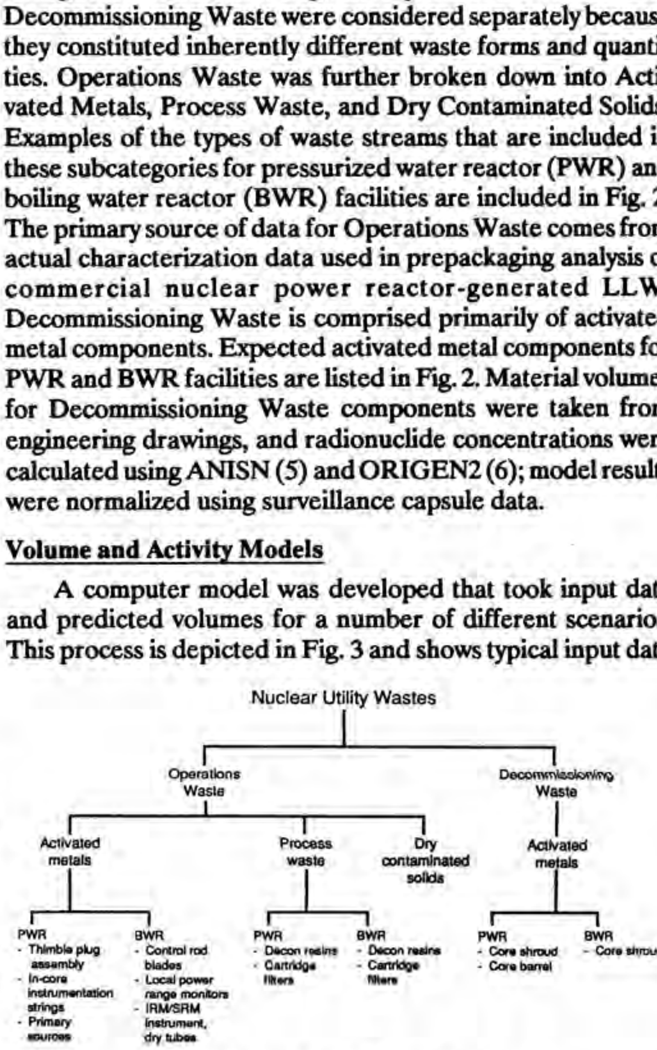

Fig. 2. Nuclear utility waste streams.

that were processed by the computer model into an array of nine possible volumes. The scenario array is composed two sets of assumptions: Unpackaged, Packaged, and Concentration Averaged volumes in columns across the top and High, Base, and Low volumes in rows down the side.

Unpackaged, Packaged, and Concentration Averaged volumes follow the typical sequence of events that occur when a waste component is handled and disposed. Unpackaged volume is the volume of GTCC LLW when first generated. Packaged volume considers any change in volume due to waste processing and the placement in a waste container. Concentration averaging is the practice of placing similar LLW materials together in a container and averaging the radionuclide concentrations of those materials. For example, when GTCC LLW activated metals are combined with Class C activated metals, the resulting packaged waste may meet Class C standards. This practice can reduce the volume of packaged GTCC LLW.

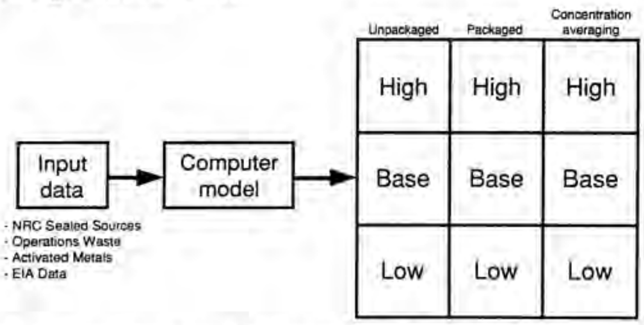

Fig. 3. Input data used to generate high, base, and low cases for GTCC LLW.

High, Base, and Low volumes address factors, other than packaging, that affect the volume of the waste. The Base case scenario considers the most realistic data available and reflects current operating, decommissioning, and disposal practices for potential GTCC LLW. The High and Low cases account for upper and lower limits of the Base case data. An example of how this works can be seen by examining the High, Base, and Low case for nuclear utility cartridge filters. The Base case for cartridge filters considers no volume reduction and random placement in waste containers. This is the current practice used by the nuclear utilities to handle these waste components. The High volume case considers encapsulation of the filters in a cementation process. This process results in a doubling of the volume. The Low volume case assumes that the filters are shredded and encapsulated. Figure 4 shows schematically how filter volumes would change for the High, Base, and Low case.

Radionuclide activity of waste steams are added to the model and accumulated annually. Radioactive decay is incorporated into the model.

Volume and radionuclide activity of the generator's current inventory and future generation rates were projected to the year 2035. This year represents the point in time when current nuclear power plant life times have expired. Waste generation was also projected to the year 2055 under the assumption that 70% of the operating nuclear reactors would get a 20-year life extension.

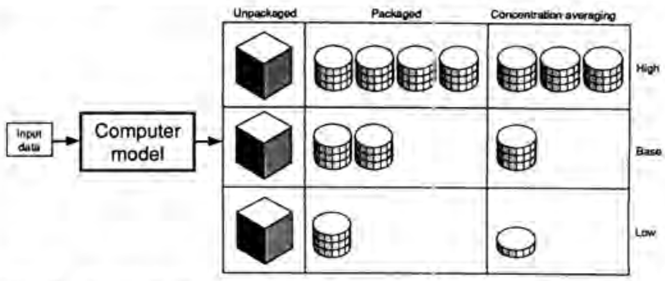

Fig. 4. Predicted volumes for unpackaged, packaged, and concentration averaged GTCC LLW.

GTCC LLW Projections

Results of volume projections through the year 2035 are shown on Fig. 5. It is seen that Nuclear Utility Wastes, composed of both operations and decommissioning waste, makes up the largest projected volume (approximately 57%) of GTCC LLW. This is followed by DOE-Held Potential GTCC LLW (33%), Other Generator Waste (10%), and Potential Sealed Source GTCC LLW (0.2%).

Results of radionuclide activity projections are shown in Fig. 6. Trends in projected activity closely follow the trends in projected volume with the exception of Potential Sealed Source GTCC LLW. Due to this waste's high specific activity,

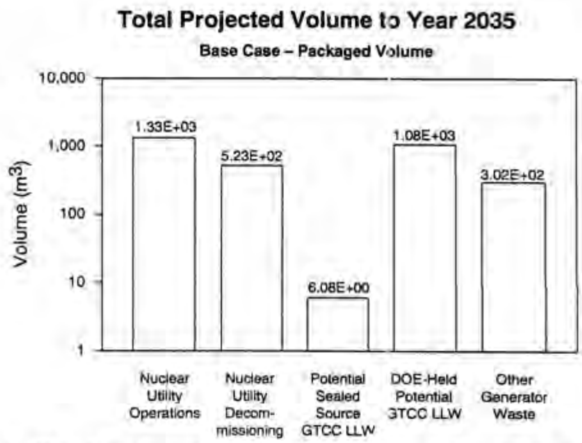

Fig. 5. Total projected volume of GTCC LLW to the year 2035.

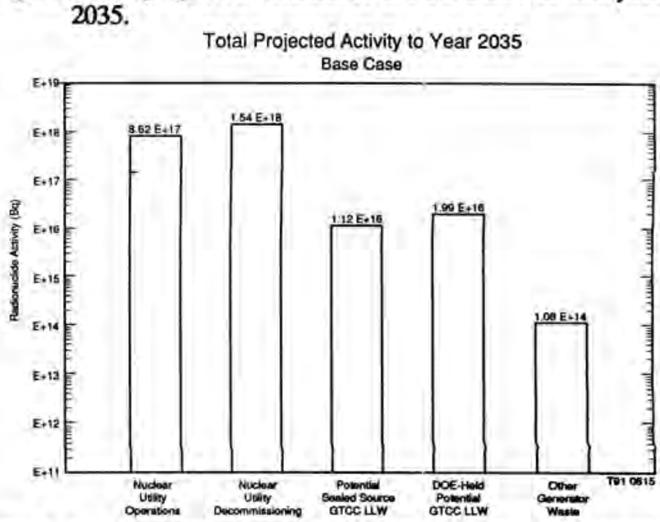

Fig. 6. Total projected activity of GTCC LLW to the year 2035.

the total activity that it represents is much larger than its relative volume.

Total projected base case GTCC LLW volume for all waste categories is 3.25E + 03 m^3. This is substantially less than previously projected volumes (7) that were as high as 1.70E + 04 m^3. The projected total activity for all waste categories is 2.43E + 18 Bq (6.58E + 07 Ci).

Uncertainties with GTCC LLW Projections

A number of assumptions were made during the development of the report and uncertainties remain with some of the assumptions upon which the GTCC LLW projections were based. Major uncertainties, which may cause the projected volumes and activities to increase or decrease, are briefly discussed below.

Interpretations of the Standard Contract (10 CFR 961) may result in larger or smaller quantities of GTCC LLW. Terms defined in Appendix E of this CFR have been and continue to be points of much discussion and interpretation. If the final definition of "Nonfuel Components" covers a wide range of in-core components, then the quantity of GTCC LLW may decrease. If the definition is very narrow, GTCC LLW volumes may increase.

The degree to which concentration averaging is allowed in LLW disposal sites will affect the quantities of GTCC LLW. Each regional compact and unaffiliated state may establish different rules governing concentration averaging. This adds a large uncertainty factor to the final GTCC LLW that will be generated.

Current measurement and analysis methods, used to calculate metal activation inside decommissioned reactor vessels, are not accurate enough to firmly predict whether or not decommissioning waste will be GTCC LLW. Decommissioning components such a core barrels represent large volumes of potential waste that may or may not be GTCC LLW.

Some DOE-Held Potential GTCC LLW has been placed on the GTCC LLW inventory without a rigorous legal determination of their waste classification. Some of this waste may not qualify as commercially owned waste and could be removed from the inventory.

CONCLUSIONS

Volumes and radionuclide activities that are presented in DOE/LLW-114 represent a major step toward improved understanding of existing and projected GTCC LLW. In order to increase the accuracy in predicting GTCC LLW, this study emphasized the use of actual data from actual waste streams. This emphasis gives these GTCC LLW projections, particularly in the area of Nuclear Utility Wastes, a much stronger basis than the previous estimates.

Based on the analysis of GTCC LLW in this study, the projected volume of GTCC LLW is much lower than previously estimated. This lower value will form the basis upon which decisions on storage and disposal of GTCC LLW will be based.

Uncertainties still exist with the projections of GTCC LLW. Work is planned in the upcoming year to refine estimates in the area of DOE-Held Potential GTCC LLW and activation analysis of decommissioning components. Developments in the interpretation of the Standard Contract and concentration averaging will also be followed and changes that occur in these areas will be incorporated into the estimates of GTCC LLW.

REFERENCES

1. Energy Information Administration, "Greater-Than-Class C Low-Level Radioactive Waste and Radioactive Waste Data Form," NE-869, OMB No. 1901-0290 (July 1986).
2. Nuclear Regulatory Commission, "Technology, Safety, and Cost of Decommissioning a Reference Pressurized Water Reactor Power Station," NUREG/CR-0130 (June 1978).
3. Nuclear Regulatory Commission, "Technology, Safety, and Cost of Decommissioning a Reference Boiling Water Reactor Power Station," NUREG/CR-0672 (June 1984).
4. S. L. BAGGETT and T. W. RICH, "Above Class C Source/Device Inventory Survey, Division of Industrial and Medical Nuclear Safety," U.S. Nuclear Regulatory Commission (November 1989).
5. W. E. ENGLE, JR., "A Users Guide for ANISN, A One-Dimensional Discrete Ordinates Transport Code with Anisotropic Scattering," ORNL/K-1693 (March 1967).
6. A. G. CROFF, "A Users Manual for the ORIGEN2 Computer Code," ORNL/TM-7175 (1980).
7. Nuclear Regulatory Commission, "Update of Part 61 Impacts Analysis Methodology," NUREG/CR-4370 (January 1986).