CHALLENGES IN CHARACTERIZING LOW-LEVEL RADIOACTIVE WASTE FOR NEW DISPOSAL FACILITIES

R.D. Baird
R. Shuman
G.B. Merrell
V.C. Rogers
Rogers and Associates Engineering Corporation
Salt Lake City, Utah

ABSTRACT

Under the requirements of 10 CFR 61 it is necessary to characterize low-level radioactive waste (LLW) expected to be disposed in new LLW disposal facilities. Analyses are required to demonstrate that the disposal facility will meet 10 CFR 61 performance objectives. Although no regulations exist that define the level of detail required for the waste characterization, the data requirements for the required performance assessments set the standard. Current publicly-available information sources do not provide sufficiently discrete data for LLW waste streams to allow waste to be adequately characterized. Surveys of generators' records may be necessary to provide the necessary information.

INTRODUCTION

In issuing its rules governing the near-surface land disposal of low-level radioactive waste (LLW), the U.S. Nuclear Regulatory Commission (NRC) requires applicants for licenses to dispose LLW to characterize the waste expected to be disposed in sufficient detail to allow assessments of the facility performance to be conducted (1). Only very brief requirements for the information to be included in the waste characterization are stated in 10 CFR 61. In response to the need for additional definition of the information, the NRC issued and revised two documents that state the format and content guidelines for license applications (NUREG-1199, Ref. 2) and declare the procedures that the NRC staff will use to review and evaluate such applications (NUREG-1200, Ref. 3).

In order to characterize the waste as required, existing databases are sought to provide the necessary raw data upon which the characteristics might be defined. Regrettably, existing information sources do not provide the information at a sufficiently discrete level to permit the waste to be adequately characterized.

In the sections that follow, the regulatory requirements for LLW characterization are reviewed, the features of an excellent waste characterization are presented, and current publicly-available information sources are identified and evaluated.

REGULATORY REQUIREMENTS

Under authority of the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA, Ref. 4) the NRC has issued rules which govern the near-surface land disposal of LLW (1). In 10 CFR 61 Subpart B, Licenses, the information that must be included in LLW disposal license applications is listed. The only explicit reference to information requirements for waste characteristics is in 10 CFR 61.11(c)(3) which states that the applicant must include a description of "the types and quantities of radioactive waste to be received, processed, and disposed of". There is no mention of information to be provided on waste characteristics in 10 CFR 61.12, Specific Technical Information.

In 10 CFR 61.13, Technical Analyses, the requirement to conduct and provide results of analyses is stated. In this section, the applicant is directed to demonstrate through analyses that the proposed disposal facility will meet the 10 CFR 61 performance objectives. Specifically, the applicant is required to demonstrate that

- The general population will be protected from releases of radioactivity from the disposal facility,
- Individuals will be protected from inadvertent intrusion,
- Individuals (both occupational workers and the general population) will be protected during operations, and
- The disposal facility will achieve long-term stability without reliance on active maintenance after the facility is closed.

The analyses necessary to demonstrate that the performance objectives are met consist of

- Source term calculations (which estimate the timing and rates of radioactive releases from the disposal facility),
- Migrations calculations (which project how the releases from the facility move through environmental media),
- Uptake calculations (which estimate how humans become exposed to radioactive releases that have migrated from the disposal facilities),
- Occupational radiation exposure estimates (which consider the numbers and natures of individual waste containers received for disposal), and
- Stability calculations (which project when and how waste containers may degrade or otherwise allow

subsidence or other structural instabilities).

In order to conduct the required analyses, the waste to be disposed must be known in discrete detail. For each waste stream disposed in the facility, the following information must be available:

- Radionuclide inventories by waste form,
- Waste volume by waste form, and
- Waste package characteristics by waste form.

The information cited above might be taken through inference to be required by 10 CFR 61. The NRC has, however, provided additional guidance on the information to be provided in license applications through issuance of two documents (2,3). The NRC recommends that individual waste streams that constitute the majority of waste volume and activity should be identified. Further, for each waste stream, the following information should be provided:

- Annual volumes to be disposed,
- Waste class,
- Average concentration of principal radionuclides,
- Chemical and physical form,
- Packaging characteristics, and
- Solidification agent.

CONTENTS OF AN EXCELLENT WASTE CHARACTERIZATION

On the basis of the regulatory analysis provided above, the contents of an excellent waste characterization were identified and are presented in the form of an example in Table I. The table shows that each waste stream from each generator should be characterized in terms of its annual volume, waste form, solidification agent used, chelating agent used, container used, individual radionuclide concentrations, and total annual activity. If a waste stream can have components that are processed differently, the components should be separately characterized.

EVALUATION OF EXISTING SOURCES OF WASTE DATA

Knowing what information is required to conduct the analyses whose results are required in an LLW disposal license application, it is possible to identify and evaluate currently available information sources. There are currently at least six major sources of waste data that might provide the needed level of detail. These are :

- Waste Information Management System (including summaries of utility Semi-Annual Effluent and Discharge Reports (5) submitted to the NRC)
- Manifest Information Management System
- NRC waste characterizations
- U.S. Environmental Protection Agency (EPA) waste characterizations
- Electric Power Research Institute (EPRI) waste characterizations
- Surveys of generators' in-house information

Each of these information sources is evaluated in the following sections.

Waste Management Information System

The Waste Information Management System (WIMS) is maintained by EG&G Idaho, Inc (EG&G) at the Idaho National Engineering Laboratory for the U.S. Department of Energy (DOE). This database contains aggregated data and Semi-Annual Effluent and Discharge Reports submitted by utilities to the NRC.

From the WIMS aggregated data it is possible to obtain information such as that depicted generally in Table II. That is, it is possible to obtain total waste volume and total waste activity disposed in a year by state and generator sector form the WIMS aggregated data. Comparing the data available from the WIMS aggregated data to that required in a license application (such as Table I), it is clear that this data source is significantly lacking, particularly because of the lack of any radionuclide information.

Reports of utility data are also available from the WIMS aggregated data. Even though this data presents total waste volume and activity by power plant and year, there is no information available about radionuclides, waste streams, or waste forms. Thus, this data too is inadequate for the purposes of supporting the required analyses for an LLW disposal license application.

The WIMS database also includes Semi-Annual Effluent and Discharge Reports (5) submitted to the NRC by utilities for each power plant. These reports indicate total six-month volume, activity, and radionuclide distribution by

TABLE I
Typical Contents of an Excellent Waste Characterization for a Single Waste Stream

Generator:	GEN 1	GEN 1	GEN 2
Annual Volume (m^3/yr);	600	40	5
Waste Form;	Dewatered	Solidified	Solidified
Solidification Agent;	NA	Cement	Cement
Chelating Agent (gm/L);	None	20	None
Container;	55-gal	55-gal	Small Cask
Nuclide Conc. (Ci/m^3);			
Nuclide 1	1.0E-4	1.0E-3	1.0E-2
Nuclide 2	1.0E-5	1.0E-4	1.0E-5
. . .	. . .	. . .	. . .
Nuclide N	1.0E-7	1.0E-7	1.0E-9
Total	2.4E-3	4.4E-3	6.1E-1
Total Annual Activity (Ci)	1.4E+0	1.7E-1	3.5E+0

TABLE II
Example of Data Available from WIMS Aggregated Database

	STATE			
SECTOR	AK	AL	. . .	WY
Utility	. . .	. . .	. . .	. . .
Industry	. . .	. . .	. . .	. . .
Medical	. . .	. . .	. . .	. . .
Academic	. . .	. . .	. . .	. . .
Government	. . .	. . .	. . .	. . .

The WIMS database also includes Semi-Annual Effluent and Discharge Reports (5) submitted to the NRC by utilities for each power plant. These reports indicate total six-month volume, activity, and radionuclide distribution by six-month period, power plant, and waste category, as

TABLE III

Information Typically Available from Semi-Annual Effluent and Discharge Reports

Power Plant ABC Jan - Jun, 1989

Parameter	Process Waste	Dry Active Waste	Irradiated Components	Other
Volume (m^3)	. . .	. . .	. . .	. . .
Activity (Ci)	. . .	. . .	. . .	. . .
Nuclide				
Activity (%)				
Nuclide 1	. . .	. . .	. . .	. . .
Nuclide 2	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .
Nuclide N	. . .	. . .	. . .	. . .

shown in Table III. The waste categories are

- Process waste,
- Dry active waste,
- Irradiated components, and
- Other.

The Semi-Annual Effluent and Discharge Reports appear promising in the characterization of waste from power plants. However, they have significant deficiencies which cannot currently be rectified so that this database can be truly useful. These include:

- Radionuclides are not consistently reported (i.e., the same radionuclides are not reported even though they are almost certainly consistently present and the precision of reported values are disparate).
- Use of "Other" as a radionuclide (significant fractions of the total waste activities appear with this designation).
- Use of plant-specific or generic scaling factors is not known and may influence the way the data should be interpreted.
- Use of lower limits of detection for important but difficult to measure radionuclides may significantly overstate concentrations and inventories.
- Unusual and infrequent volumes and activities are not identified.
- Container types, solidification agents, and chelating agents are not identified.
- Information is available only for the utility generator sector.

Because of the first two deficiencies in particular, the Semi-Annual Effluent and Discharge Reports do not offer the hope that utility waste can be characterized with an acceptable degree of confidence.

Manifest Information Management System

The Manifest Information Management System is also maintained by EG&G for DOE. This database consists of disposal data for waste disposed from 1986 through 1988 at the three currently operating LLW disposal facilities in the U.S.: Barnwell, SC; Hanford, WA; and Beatty, NV. Total volume and total activity for each shipment received for disposal are available for all 1986 and 1987 shipments and for shipments to Barnwell in 1988. Disposal data for waste sent to Hanford and Beatty in 1988 are presented for each container of waste. All waste is designated as being shipped

either directly by the generator or by a broker/processor (broker in this paper) for a generator.

The information available in the MIMS database for direct-shipped waste includes the following:

- Generator Identification Code
- State of origin
- Generator type (e.g., Industry, Medical, etc.)
- Date received for disposal
- Shipment total volume
- Volume by 10 CFR 61 waste class
- Shipment total activity
- Shipment activity by radionuclide

Unfortunately, waste stream information is not provided, only limited waste form information (e.g., DOT designations such as Class A Unstable or Class B Stable) is available, and no information is provided on the presence of solidification or chelating agents. Because waste stream information is lacking. the most discrete definition possible for waste to be disposed would be for an entire sector of generators. Since the waste processing (and hence waste form) differ among generators, this source of data is insufficient to allow adequate characterization of waste expected for disposal.

The information available for MIMS for broker-shipped waste is essentially the same, except that no radionuclide information is available and total shipment activity may not be available. This additional deficiency underscores to conclusion that data from the MIMS database is insufficient for supporting the preparation of an LLW disposal license application.

U.S. Nuclear Regulatory Commission Waste Characterizations

The NRC has characterized waste streams that are expected to be disposed in order to support the development and promulgation of 10 CFR 61 (6,7). These waste stream characterizations have been widely used and are presented in sufficient detail that they adequately support the preparation of an LLW disposal license application. There are, however, problems associated with the use of this data.

Use of the NRC waste stream characterizations would force the assumption that all waste to be disposed at a proposed disposal facility possesses the same radiological characteristics as the NRC waste streams. Since the NRC waste stream characterizations are based on data from generators throughout the nation, this assumption can be deeply flawed. Even though adjustments for individual waste volume generation rates can be made, there can be several orders of magnitude variations in the radiological characteristics. Thus, confidence in projected disposal inventories may not be justified.

The NRC waste stream characterizations are based on relatively old data. Originally, the waste streams were characterized with data from the late 70's and early 80's (7). These were updated in 1986 (6) but the data was still from earlier years. Because of major adjustments in operating procedures and equipment used by generators over the past few years, there is reason to question the adequacy of using these waste stream characterizations in new LLW disposal license applications.

U.S. Environmental Protection Agency Waste Characterizations

In support of its development of environmental protection standards for LLW disposal, the EPA has utilized NRC waste stream characterizations (8). Recently the EPA has updated these characterizations to incorporate more recent disposal information (9). The most recent characterizations of LLW by the EPA updated the magnitudes of radionuclide concentration, based on recent disposal data. In general, relative radionuclide concentrations were based on the updated NRC characterizations of LLW waste streams, with adjustments made for certain radionuclides, based on recent information from EPRI (10).

Although the EPA waste stream characterizations have the same fundamental deficiencies that the NRC characterizations do, they are improved by the incorporation of more recent information. The major deficiency of using EPA waste characteristics is the implied assumption that the waste expected for disposal is radiologically identical to waste from the nation as a whole. This assumption may induce significant errors for particular waste streams in a given region.

Electric Power Research Institute Waste Characterizations

EPRI has developed excellent databases for characterizing waste from nuclear power plants. These databases were developed through surveys of its member utilities (11,12) and major research projects which involved detailed characterization of typical waste streams (10).

The EPRI waste generation database includes the volume, activity, and waste form of waste generated by individual power plants, by year, and by waste type (e.g., process waste and dry active waste). Radionuclide information is lacking, except through reference to studies of radiological characteristics of waste streams by reactor type.

Although the EPRI database are useful to those who have access to them, they do not provide a coordinated

representation of all waste characteristics, particularly radionuclide characteristics.

Generator Surveys

To the extent that LLW generators properly analyze the characteristics of the waste they produce and maintain records of this information, they are excellent sources of the data necessary to support the preparation of an LLW disposal license application. Generally, this is the case. However, generators do not normally maintain their records in a form that conveniently supports the needs of a thorough survey. Therefore, significant effort may be required to obtain the necessary data directly from generators. In addition to a site visit, much time may be spent reviewing records of previous disposal shipments and extracting the useful data.

Survey questionnaires must be carefully prepared if they are to properly solicit the needed information from generators. Even when questionnaires are properly prepared, it is most likely necessary to visit major generators' facilities in order to obtain important understandings that cannot result the filling out of a survey form.

An additional factor that complicates the acquisition of data directly from generators is the fact that commercial generators are usually involved in profit generating activities or at least have an objective of minimizing operating costs. This being the case, they may not be motivated to take time to provide the information and understanding necessary to properly characterize the waste generated at their facilities.

SUMMARY AND CONCLUSION

Despite the availability of several public sources of LLW information, they are uniformly deficient in their ability to provide the data necessary to adequately characterize LLW expected to be disposed at proposed LLW disposal facilities. Although it may be possible to use several information sources to improve the characterization of LLW, it is not possible to fully characterize LLW with these sources alone so that the necessary performance analyses can be conducted. In order to obtain the most complete data, it is probably necessary to work with major LLW generators and to extract the data from their records, rather than relying of publicly-available sources of information.

REFERENCES

1. U.S. Nuclear Regulatory Commission, "Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR Part 61)," Federal Register, Vol. 47, No. 248, pp 57463-57477, December 27, 1982.
2. U.S. Nuclear Regulatory Commission, "Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility; Safety Analysis Report," NUREG-1199, Rev. 1, January 1988.
3. U.S. Nuclear Regulatory Commission, "Standard Review Plan for the Review of a License Application for Low-Level Radioactive Waste Disposal Facility; Safety Analysis Report," NUREG-1200, Rev. 1, January 1988.
4. "Low-Level Radioactive Waste Policy Amendments Act," PL 99-240, January 1986.
5. U.S. Nuclear Regulatory Commission, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Tight-Water-Cooled Nuclear Reactors," Regulatory Guide 1.21, Revision 1, June 1974.
6. Oztunali, O.I., and G.W. Roles, "Update of Part 61 Impacts Analysis Methodology; Methodology Report," Envirosphere Company for U.S. Nuclear Regulatory Commission, NUREG/CR-4370, January 1986.
7. Wild, R.E., et al., "Data Base for Radioactive Waste Management, Volume 2, Waste Source Options Report," Dames & Moore for U.S. Nuclear Regulatory Commission, NUREG/CR-1759, November 1981.
8. "Low-Level Radioactive Waste: Draft Background Information Document," U.S. Environmental Protection Agency, Office of Radiation Programs.
9. Baird, R.D., "Radiological Risk Assessment of Low-Level Radioactive Waste Disposal Alternatives," Rogers and Associates for U.S. Environmental Protection Agency, RAE-8829/6-1, in preparation.
10. Best, W.T., and A.D. Miller, "Updated Scaling Factors in Low-Level Radwaste," Impell Corporation for Electric Power Research Institute, NP-5077, March 1987.
11. Daloisio, G.S., and C.P. Deltete, "Radwaste Generation Survey Update, Volume 1: Boiling Water Reactors (BWRs)," Analytical Resources, Inc. for Electric Power Research Institute, in preparation as of 1987.
12. Daloisio, G.S., and C.P. Deltete, "Radwaste Generation Survey Update, Volume 2: Pressurized Water Reactors (PWRs)," Analytical Resources, Inc. for Electric Power Research Institute, in preparation as of 1987.