DEPARTMENT OF ENERGY TECHNICAL ASSISTANCE TO THE STATES UNDER THE LOW-LEVEL RADIOACTIVE WASTE POLICY AMENDMENTS ACT OF 1985[a]

Joel T. Case and Julie E. Conner
Idaho National Engineering Laboratory
EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

ABSTRACT

The Low-Level Radioactive Waste Policy Amendments Act of 1985 requires the Department of Energy (DOE) to provide technical assistance to the states and compact regions in their efforts to fulfill their responsibilities under the Act. Technical assistance has been defined to include, but is not limited to "...alternative technologies for low-level radioactive waste disposal...." Alternative technologies refer to low-level waste disposal concepts other than traditional shallow-land burial.

The DOE has two ongoing technical assistance projects examining alternative technologies for low-level radioactive waste disposal. The first program is the development of a conceptual design report comparing six low-level waste disposal concepts. The second technical assistance activity is the preparation of technical design reports evaluating licensing aspects of alternative technologies.

This paper presents the status of each activity; it addresses preliminary results of the conceptual design report and information relating to the technical design reports.

BACKGROUND

The Department of Energy Low-Level Radioactive Waste Management Program, through the Idaho National Engineering Laboratory, provides management and technical assistance services to states and regions for the development of new low-level radioactive waste disposal capacity. The Program was formed in response to the passage of the Low-Level Radioactive Waste Act in 1980. This legislation established as Federal policy the responsibility of states for disposal of low-level radioactive waste generated within their borders. Passage of the Low-Level Radioactive Waste Policy Amendments Act of 1985 reaffirmed Congress's intent for state responsibility concerning low-level waste management. The DOE Program has been, since 1980, assisting the states and regions in meeting their responsibilities under both Acts. During the first 5 years of the Program, a major portion of this assistance was in the form of Department of Energy financial assistance, education and analysis of low-level waste provided to support management issues. Table I is a partial list of selected studies funded through program financial assistance grants. Reports that were performed under this grant program are available through the Department's Idaho Operations Field Office.

TABLE I
Examples of National Low-Level Waste Management Program Studies Supported by DOE Grants

Title	Grantee
Interim Report to Governors on Regional LLRW Management	Western Interstate Energy Board
Legislators Guide to Low-Level Waste Management	National Council of State Legislators
A Planners Guide to the Transport of Low-Level Waste	American Planning Association
Prediction & Control of Leachability of Grouts Used in LLRW Management	Purdue Research Foundation
Characteristics of Medically Related Low-Level Radioactive Waste	American College of Nuclear Physicians
Development of a LLRW Disposal Facility in the Central Midwest	Illinois Dept. of Nuclear Safety

As the table shows, a variety of waste management issues have been investigated under the grant concept. The diversity of issues reflects the Program's goal to gather available information on technical and institutional aspects of low-level waste management to provide a comprehensive information base for states/regions to use in developing their approach to low-level waste management.

The focus of the program has changed with the passage of the Low-Level Radioactive Waste Policy Amendments Act of 1985. The Amendments Act outlines a series of milestones the states and compact regions must meet in developing new commercial low-level waste disposal capacity.

The Amendments Act also assigns certain responsibilities to the Department of Energy. Section 7(a) of the Amendments Act requires the Department to provide technical and financial assistance to the states and compact regions for the purposes of meeting their responsibilities under the Act. The Department's current program focuses only on technical assistance to the states and regions in the development of new commercial low-level waste disposal capacity.

The Program has two major technical assistance projects. Both projects are examining low-level waste disposal concepts alternative to traditional shallow-land disposal (SLD), hereafter referred to as alternative technologies. Because of the perceived problems

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associated with SLD, many of the states and regions are considering alternatives to SLD for new low-level waste disposal. Because experience with alternative technologies is limited in the United States, the attributes of these disposal concepts are not fully understood. Issues which need further evaluation include facility performance, licensability, cost, monitoring, closure requirements, etc. The two technical assistance projects underway by the Department addressing some of these issues are "Conceptual Designs of Alternative Technologies in Shallow-Land Burial for Disposal of Low-Level Radioactive Waste" and "Technical Design Review of Alternative Technologies."

CONCEPTUAL DESIGN PROJECT

The objective of this project is to provide in one report an overview of selected technologies to include functional description, layout, operational considerations, performance assessment, cost analysis and schedule. Six alternative technologies are evaluated in the report. These technologies are the following:

- Shallow-Land Disposal (SLD)
- Intermediate-Depth Disposal (IDD)
- Belowground Vaults (BGV)
- Aboveground Vaults (AGV)
- Modular Concrete Canister Disposal (MCCD)
- Earth-Mounded Concrete Bunker (EMCB).

Each disposal concept is presented in the same level of detail without emphasis on any one of the technologies to allow for inter-technology comparisons.

Design Basis

A standard design basis was used so that each technology could be evaluated under comparable and consistent conditions. All site and waste form requirements of 10 CFR Part 61 are assumed to be satisfied. Each facility is assumed to be located in a site characteristic of the northeastern United States. The capacity of each conceptual design considered in the report is 8.8×10^6 cubic feet of waste with an operational life of 30 years. The average annual disposal rate is 2.9×10^5 cubic feet. These parameters are believed to be fairly representative of the size of facilities anticipated for a preponderance of the states and compact regions.

The radioactive waste source term used to assess the performance is based on information provided in four Nuclear Regulatory Commission documents (1,2,3,4). Class A waste makes up approximately 95 percent of the waste (by volume). Class B and Class C waste components are the remaining 5 percent. Class A waste is assumed to be placed in separate disposal units from those used for Class B and C wastes.

Based upon these common descriptions, each technology is evaluated in the areas of worker industrial safety, worker radiological doses, radiological performance assessment, costs, and schedule.

Industrial Safety

As with any industrial operation, the potential exists for worker injuries and fatalities as a result of accidents during waste disposal operations. Estimates of worker injuries and fatalities for operation of the disposal facilities are based on data collected by the U.S. Atomic Energy Commission (AEC) during the period 1943 - 1970 (5). These data show that maintenance and light construction work result in a lost-time injury accident frequency of 5.4 per 10 E+6 man-hours and a worker fatality rate of 0.03 per 10 E+6 man-hours. Using manpower requirements necessary to perform the waste handling and disposal operations at each facility, an estimate was made of lost-time injury accidents and fatal worker accident risk during the disposal facilities' 30-year operating period. Lost-time injuries and fatal worker accident risk for each technology are provided in Table II.

TABLE II
Lost-Time Worker Injuries and Fatal Accident Risk (30-year period)

Disposal Technology	Lost-Time Injuries	Fatal Accident Risk
Shallow-land disposal	9	0.05
Intermediate-depth disposal	10	0.06
Belowground vault	20	0.11
Aboveground vault	20	0.11
Modular-concrete canisters	19	0.10
Earth-mounded concrete bunker	24	0.13

All the facilities exhibit a low probability for a fatal accident to occur, ranging from five to thirteen percent during the operational period for the facilities. The number of injuries ranges from 9 for shallow land burial to 24 for the earth mounded concrete bunker. These increases are associated primarily with the increased manhours required to construct and operate the alternative technologies.

Worker Radiation Dose

Worker dose calculations are based on the facility source term, waste packaging methods, facility design, and the operational procedures for receipt, inspection, waste emplacement, and disposal unit closure. The WORDRAE computer code was used to calculate worker occupational radiation doses (6). The purpose of the code is to compare annual worker doses from low-level waste disposal operations for alternative disposal technologies. Annual doses were calculated for all disposal facility workers in proximity with radioactive waste during its handling and disposal.

The annual collective doses to workers are summarized in Fig. 1 for the six disposal technologies. The dose estimates are for a reference set of operations for each technology. The annual collective doses to workers fall into two groups: shallow-land and intermediate-depth are the lowest at approximately 14 person-rem/yr, followed by earth-mounded concrete bunker at 23 person-rem/yr. Above and belowground vaults and modular concrete canister disposal range from 26 to 28 person-rem/yr. Changes in operations for any technology could greatly alter its worker dose.

Regulatory Assessment

The Nuclear Regulatory Commission (NRC) regulations governing disposal of low-level radioactive waste are contained in 10 CFR Part 61. These regulations contain several sections that pertain to disposal facility design. Pertinent sections of the regulation

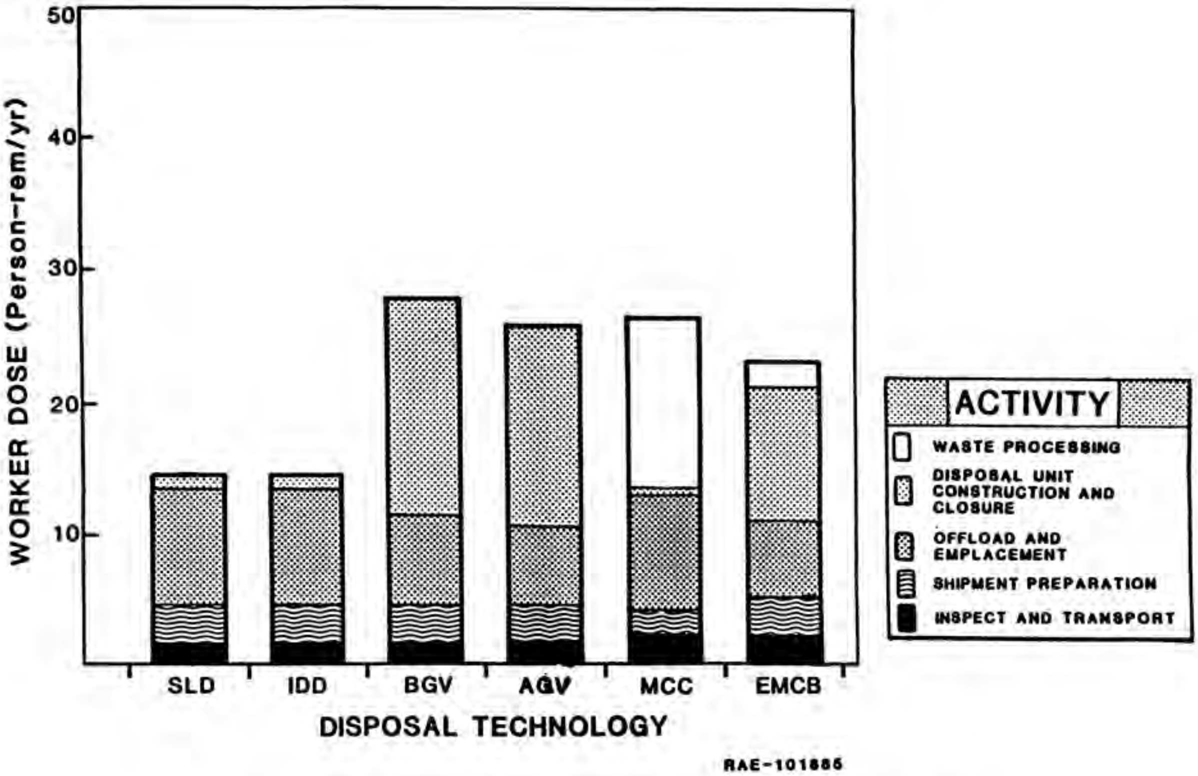

Fig. 1. Worker Dose Comparisons for the Disposal Technologies.

relating to facility performance objectives and design requirements are summarized in Table III.

A qualitative evaluation of each technology against these performance objectives was conducted. A summary of this evaluation is presented in Table IV.

In general, all technologies are compatible with the NRC requirements in 10 CFR Part 61, with the possible exception of aboveground vaults. The analysis indicates that aboveground technology would have difficulty meeting the long-term stability and inadvertent intruder requirements. The ability of the vault to deter intruders for up to 500 years, as required for Class C waste, has a high degree of uncertainty. The dependence of aboveground vaults on man-made materials, the continual exposure of those materials to the environment, and the requirement that the disposal facility provide adequate containment for the long term indicates that active maintenance on the facility will be required after facility closure. This is inconsistent with the long-term stability requirement in 10 CFR Part 61 to minimize active maintenance.

Radiological Performance Assessment

Exposure to the public from the release of radioactive materials contained in each facility was evaluated. The exposure scenarios considered in this analysis included the following:

- Groundwater transport in an adjacent farm

Inadvertent Intrusion Scenarios

- Intruder-explorer
- Intruder-construction
- Intruder-agriculture.

TABLE III
NRC Facility Performance and Design Requirements Influencing Disposal Technology

Technical Requirement	10 CFR 61 Paragraph
Protect the general population from releases of radionuclides	61.41
Protect individuals from inadvertent intrusion	61.23(c), 61.42, 61.52(a)(2)
Protect workers during operations	61.43
Site stability after closure	61.7(c)(2), 61.23(e), 61.44, 61.51(a)(1)
Minimize contact of waste by water	61.51(a)(4), 61.51(a)(6)
Fill void spaces between packages	61.52(a)(4), 61.52(a)(5)
Restrict surface gamma radiation doses to acceptable levels	61.52(a)(6)
Stability of Class B and Class C wastes	61.7(b)(2), 61.56(b)
Segregate Class A wastes from other wastes	61.7(b)(2), 61.52(a)(1)

TABLE IV
Qualitative Assessment of Disposal Technologies for Meeting Regulatory Standards

Regulatory Regulatory Requirement	Disposal Technology					
	SLD	IDD	BGV	AGV	MCCD	EMCB
Protect the general population from releases of radionuclides	+	+	+	+-	+	+
Protect individuals from inadvertent intrusion	+	+	+	-	+	+
Protect workers during operation	+	+	+-	+-	+-	+
Site stability after closure	+	+	+	-	+	+-
Minimize contact of waste by water	+	+	+	+-	+	+
Fill void spaces between packages	+	+	+	+	+	+
Surface gamma radiation doses restricted to acceptable levels	+	+	+	+-	+	+
Stability of Class B and Class C wastes	+	+	+	+-	+	+
Segregate Class A waste from other wastes	+	+	+	+	+	+

\+ meets the requirements
+- probably meets the requirements
\- difficulty in meeting requirements

Exposures resulting from each of the scenarios were modeled for a period of 1000 years following site closure. Three computer codes were used in modeling the disposal technologies. Onsite transport pathways were modeled using PATHRAE (7). Groundwater flow in the unsaturated zone beneath the site was simulated using a modified version of UNSAT-H (8). Offsite transport pathways were modeled using PRESTO-CPG (9).

The maximum annual doses for the adjacent farm scenario and the maximum inadvertent intrusion scenario are presented in Table V.

TABLE V
Peak Annual Doses
(mrem/y)

Disposal Technology	Adjacent Farmer Scenario	Inadvertent Intrusion Scenario
SLB	22	22
IDD	18	18
BGV	16	16
AGV	150	95
MCCD	19	19
EMCB	14	14

The peak annual dose to the adjacent farmer is similar for all technologies except aboveground vault. This difference is attributed to the fact that, for all technologies except aboveground vault, groundwater dominates dose. For aboveground vault, surface water dominates the doses to the adjacent farmer, resulting in a higher peak dose than through the groundwater pathway.

For the inadvertent intrusion scenarios, the inadvertent-agriculture scenario dominates the doses for all technologies except for aboveground vault. For this technology, the intruder-explorer scenario gives the highest annual doses, because it is assumed that soil conditions on failed aboveground vaults will not support the growth of agricultural crops. For all technologies, the peak doses are dominated by ingestion of I-129 and C-14.

Cost and Schedules

Costs for each facility were based on four life-cycle operating periods: pre-operating costs; operating costs; closure costs and postclosure costs. A summary of the estimated costs for the six conceptual disposal facilities is given in Table VI.

TABLE VI
Comparison of Cost Estimates for Six Conceptual Disposal Facilities

Operating Period	Costs (Millions - 1986 Dollars)					
	SLD	IDD	BGV	AGV	MCCD	EMCB
Pre-operating period	21	22	25	26	30	36
Operating period	155	162	256	319	245	356
Closure period	6	6	7	6	8	10
Postclosure period	34	34	40	69	52	73
Total costs	215	224	327	420	335	474

The construction periods for the conceptual disposal facilities were estimated to range from about 14 months for shallow-land disposal to 23 months for aboveground vaults.

TECHNICAL DESIGN REVIEW

The overall objective of this project is to evaluate design features of specific low-level waste alternative disposal technologies to the performance objectives and technical requirements of 10 CFR Part 61. Each design evaluation will be submitted by the DOE to the NRC in a license application format.

The project is the result of interaction between the Program, the states and regions, and the NRC. Many of the states and regions have specifically prohibited traditional shallow-land disposal as an option for new low-level waste disposal capacity. However, current U.S. experience is limited to shallow-land disposal technology. The technical design review project will provide information to the states and regions on alternative disposal technologies. The issues which will be examined by the study include what is accomplished by using improved design features, interaction of these design features with site characteristics, and identification of desirable design features. The license application process in the design report format will be similar to a license application. This will help states and compact regions prepare their own license applications, as no new low-level waste disposal facilities have been licensed under 10 CFR Part 61.

Two alternative disposal technologies have been selected for evaluation. These design concepts are earth-mounded concrete bunker and below grade vault. These technologies were selected because they possess many of the design components inherent in the alternative technologies under consideration for new commercial low-level waste disposal capacity. A third design, abovegrade vault (ABV), will be evaluated at a later date to address those concerns unique to the disposal of low-level waste abovegrade.

Each design review report consists of three components. These components are:

- Design basis document
- Preliminary design report
- Technical evaluation.

The design basis document shall provide the design criteria necessary for a detailed disposal unit design. The design criteria will be developed for a humid site environment. The disposal unit for both designs is to be sized for 250,000 cubic feet per year for a facility life of 30 years.

The preliminary design report will outline the components of the disposal unit in sufficient detail to objectively evaluate these components relative to NRC licensing issues.

The major component of each design review report is the technical evaluation of the disposal unit designs. This evaluation shall respond to the applicable requirements outlined in the NRC Branch Technical Position on Standard Format and Content of License Applications for Near-Surface Disposal of Radioactive Waste. The intent of the technical evaluation is to analyze the design features of each alternative technology to the performance objectives of 10 CFR Part 61. Specific areas to be examined in the evaluation include:

- Facility operations; the effect of the disposal unit design on waste receipt, waste handling, waste disposal, and environmental monitoring and surveillance
- Site closure and institutional controls; the effect of the disposal unit design on site stabilization, decontamination and decommissioning, and postclosure monitoring.
- Safety assessment; the effect of the disposal unit design on radioactivity release, infiltration, pathway analysis, and occupational exposure
- Long-term stability of the disposal unit
- Intruder protection.

Each report will be reviewed by an independent review group made up of representatives from the DOE, the DOE-sponsored Alternative Technology Coordinating Committee, the Environmental Protection Agency and other appropriate entities. The objective of this review is to provide an independent technical evaluation of the designs by experts in the low-level waste management field. Upon completion of the review and acceptance of the reports by the DOE, the Department will submit each design report to the Nuclear Regulatory Commission for review. NRC comments will be compiled by the Program and both the design reports and report comments made available to interested parties.

The schedule for completion of the design reports is driven in part by the milestones in the Amendments Act. The two design reports are scheduled for completion by early 1988 with NRC reviews to be completed within three to six months of this time. This schedule will provide those states and regions developing new commercial LLW disposal sites both performance data and guidance on licensing alternative design concepts.

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