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An Evaluation of Commercial Repository Capacity for the Disposal of Defense High-Level Waste

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An Evaluation of Commercial Repository Capacity for the Disposal of Defense High-Level Waste

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PREFACE

The Nuclear Waste Policy Act of 1982 (P.L. 97-425) provides for disposal of defense high-level waste in one or more of the geologic repositories to be developed for permanent isolation of commercial spent fuel and high-level waste. Section 8 of the Act (see page E-1 of this document) requires an evaluation of this Congressional provision by the President prior to January 8, 1985. This report is one analytical input to that evaluation, and is being provided to the President by the Secretary of Energy to assist in executing that mandate.

The scope and approach of the evaluation to place defense high-level wastes in repositories with commercial waste are defined by Section 8 of the act. First, criteria for evaluation are specified: cost efficiency, health and safety, regulation, transportation, public acceptability, and national security. Second, the provision to dispose of defense and commercial waste in the same repositories would be reconsidered only if "the President finds, after conducting the evaluation ..., that the development of a repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only is required, ..."

This report is organized as a comparison, criterion by criterion, of two basic options: separate defense waste and commercial waste repositories and one repository containing both defense and commercial waste. For each criterion, the critical question is whether some condition is discovered that would require the President to conclude that a separate defense waste repository is required. Based on the comparison presented in this report, the only factor that results in a significant advantage for either option is cost efficiency. A substantial cost advantage is to be gained by disposing of defense high-level wastes in repositories designed to accept both commercial and defense waste. The Department recommends this option be implemented.

This report is based on a series of topical studies that were commissioned shortly after P.L. 97-425 became law. To complete this input prior to the President's evaluation, it was necessary to establish and fix repository concepts, geologic media, waste quantities, and other baseline assumptions that would fairly reflect the essential features of likely future repositories and operation, to the extent that the specific purpose of this evaluation could be accomplished.

Because of the rapid evolution of the repository program, some inconsistencies have arisen between assumptions of this study and the latest data and thinking within the repository program concerning such factors as repository design, waste forms, waste packaging concepts, regulatory requirements and costing factors. For example, the cost calculations for the commercial repository are based upon an earlier repository design than that detailed in the Civilian Radioactive Waste Management Mission Plan (DRAFT), which was submitted for public review and comment in April 1984. A comparison with the mission plan repository indicates an increased cost, but it would not change the result of this study.

In addition, the cost analyses contained in this study were based on prior studies by E. T. Lazur "Cost Estimates for Disposal of Defense High-Level Waste in a Defense Only Repository" and R. V. Varadarajan and D. P. Dippold "Cost Estimates for Disposal of DHLW in a Commercial Repository: An Update." The definitions and approaches used to calculate costs varied in these two studies making a line-by-line comparison of costs invalid. However, both approaches represent valid methodology and the total costs computed by both approaches are comparable.

A response document is being prepared that will include comments received during the comment period, and the DOE response. The document will be distributed to all who received the draft report.

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EXECUTIVE SUMMARY

On January 7, 1983, President Reagan signed into law the Nuclear Waste Policy Act of 1982 (P.L. 97-425). Section 8 of this Act states that:

"(a) Atomic Energy Defense Activities--Subject to the provisions of subsection (c), the provisions of this Act shall not apply with respect to any atomic energy defense activity or to any facility used in connection with any such activity.

(b) Evaluation By President--(1) Not later than 2 years after the date of the enactment of this Act, the President shall evaluate the use of disposal capacity at one or more repositories to be developed under subtitle A of title I for the disposal of high-level radioactive waste resulting from atomic energy defense activities. Such evaluation shall take into consideration factors relating to cost efficiency, health and safety, regulation, transportation, public acceptability, and national security.

(2) Unless the President finds, after conducting the evaluation required in paragraph (1), that the development of a repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only is required, taking into account all of the factors described in such subsection, the Secretary shall proceed promptly with arrangement for the use of one or more of the repositories to be developed under subtitle A of title I for the disposal of such waste. Such arrangements shall include the allocation of costs of developing, constructing, and operating this repository or repositories. The costs resulting from permanent disposal of high-level radioactive waste from atomic energy defense activities shall be paid by the Federal Government, into the special account established under section 302.

(3) Any repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only shall (A) be subject to licensing under section 202 of the Energy Reorganization Act of 1973 (42 U.S.C. 5842); and (B) comply with all requirements of the Commission for the siting, development, construction, and operation of a repository.

(c) Applicability To Certain Repositories--The provisions of this Act shall apply with respect to any repository not used exclusively for the disposal of high-level radioactive waste or spent nuclear fuel resulting from atomic energy defense activities, research and development activities of the Secretary, or both."

Scope and Approach

This report is in response to Section 8(b)(1) of the Act as quoted above. It is a comparative study of two geologic disposal options for defense high-level waste with respect to the factors specified. The two disposal options are:

- o Defense high-level waste is disposed of in a commercial geologic repository.
- o Defense high-level waste is disposed of in a defense-only geologic repository.

Ground rules and assumptions (see paragraph 1.3) were established which define a set of reference conditions using information available at the time this report was prepared. Detailed information such as repository and waste package design concepts are subject to continuing study and evaluation. Thus, the concepts used in this report may differ from current and final concepts. It should be noted, however, that these differences are not expected to materially alter the qualitative results of this study.

This report assumes that a reference commercial geologic repository without defense high-level waste has a design capacity for commercial waste of 70,000 metric tons of heavy metal (MTHM). In the case that defense waste is emplaced in a commercial repository, up to 20,000 packages of immobilized defense high-level waste would be emplaced in the repository. The 20,000 packages of defense high-level waste are considered equivalent to approximately

10,000 MTHM.* This is based on the radioactivity (Curie) equivalence of commercial and defense high-level waste.** If 20,000 packages of defense high-level waste are emplaced in a commercial repository, defense high-level waste is expected to require approximately 10 percent of the underground area. Although for purposes of analysis it was assumed that the defense high level waste was placed in a single repository, no policy decision to that effect has been made. If a defense-only repository is not required, the Nuclear Waste Policy Act (Section 8b(2)) directs the use of "one or more" of the commercial repositories for the disposal of defense high-level waste. However, the use of more than one commercial repository for the disposal of defense waste would not be expected to materially alter the qualitative results of this evaluation.

At the end of 1982, approximately 15 percent of the radioactivity in spent fuel and high-level waste in this country originated from atomic energy defense activities. Most of the remainder is contained in commercial spent nuclear fuel. By the year 2000, it is expected that the radioactivity in defense high-level waste will be three percent of the total.

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* It is recognized that under the Nuclear Waste Policy Act of 1982 the combined quantity of commercial waste and defense high level waste in the repository cannot exceed 70,000 MTHM equivalent until after a second repository is placed in operation and the requisite NRC authorization to expand the capacity of the repository is obtained.

** Since EPA has proposed Curie release limits per MTHM charged to a light water reactor, Curie releases and repository loadings in MTHM equivalents were calculated for defense high level waste on a Curie basis.

Defense high-level waste (DHLW) is generated and stored at three DOE sites: the Savannah River Plant, the Idaho National Engineering Laboratory, and the Hanford Reservation. Detailed information concerning the reference plans for permanent disposal of defense high-level waste is contained in the Defense Waste Management Plan. Geologic disposal of immobilized defense high-level waste will satisfy the applicable standards of the Environmental Protection Agency (EPA) and the applicable regulations of the Nuclear Regulatory Commission (NRC).

Comparison of the Geologic Disposal Options

A summary comparison of the two disposal options with respect to cost efficiency, health and safety, regulations, transportation, public acceptability, and national security is presented in Table E-1. The evaluation factors are briefly discussed below.

Cost Efficiency

The cost estimates for construction, operation, and decommissioning of the reference geologic repositories are shown in the table. Using these cost estimates, the construction, operating and decommissioning costs for a single repository containing both commercial and defense high-level waste is estimated to be approximately $1.5 billion dollars less than the costs for two separate repositories.

To the construction, operating and decommissioning costs of the repository must be added the development and evaluation (D&E) costs, which are the costs associated with the technology development, socioeconomic studies, site selection and characterization, licensing procedures, and consultation and cooperation activities. The D&E costs associated with the first commercial repository are estimated to be close to 4 billion dollars. Any additional D&E costs associated with the disposal of defense waste in the commercial repository are expected to be small in comparison (in the 10's of millions of dollars).

Since some of the activities associated with development and evaluation are specified in the Nuclear Waste Policy Act of 1982 for

TABLE E-1

SUMMARY COMPARISON

Evaluation Criteria	Commercial Repository Containing Defense Waste	Separate Defense Waste Repository	Remarks
Cost Efficiency	Billions of 1984 dollars* 6.2 - 7.9**	Billions of 1984 dollars* 2.2 - 3.0 Defense Repository 5.5 - 6.4 Commercial Repository ——— 7.7 - 9.4 Total (Range)	• Section 8 of the Nuclear Waste Policy Act of 1982 requires that if defense waste will be disposed of in a commercial repository, the Secretary's arrangements for its use "shall include the allocation of costs of developing, constructing, and operating this repository or repositories." • Cost efficiency favors disposal of defense waste in a commercial repository.
Health & Safety	Will meet proposed EPA standard 40 CFR 191 (47 FR 58196)	Will meet proposed EPA standard 40 CFR 191 (47 FR 58196)	Health & safety impacts are comparable.
Regulation	• Licensed by NRC under 10 CFR 60 • Procedural rules leading to construction authorization are prescribed by the NWPA-1982	• Licensed by NRC under 10 CFR 60 • Procedural rules in the NWPA that do not apply are: - Recommendation of candidate site for characterization - Site characterization - Site approval and construction authorization - Nuclear waste fund	• Although sections 112-114 of the Nuclear Waste Policy Act of 1982 do not apply to a defense-only repository, similar procedures are required by 10 CFR 60 with respect to site characterization, and construction authorization. It thus may not be possible to have an operational defense-only repository any earlier than a commercial repository. • Regulatory considerations do not favor either option.

*The cost range reflects the dependency of cost on geologic media and the waste packaging requirements.
**This represents the range of costs for a commercial repository plus 20,000 canisters of defense high-level waste.

TABLE E-1 (Concluded)

SUMMARY COMPARISON

Evaluation Criteria	Commercial Repository Containing Defense Waste	Separate Defense Waste Repository	Remarks
Transportation Cost Risks	Millions of 1984 dollars* 110 - 257 Number of accidents are 10^{-4} smaller than predicted from other truck or rail transportation activities during same period	Millions of 1984 dollars* 110 - 257 Number of accidents are 10^{-4} smaller than predicted from other truck or rail transportation activities during same period	• Transportation costs are comparable. • Risks are negligible and comparable.
Public Acceptability	• Low-cost option • May be perceived as most technically complex option • One combined repository may be perceived as more acceptable than two separate repositories	• High-cost option	• Public acceptability is highly uncertain for both options.
National Security	• Interim storage capacity will permit continued defense nuclear material production and waste immobilization operations in the event of repository problems • No need to reveal classified defense information for repository purposes	• Same interim storage and classified information conditions apply	• NRC licensing activities must not interfere with defense nuclear material production, or weapons production. • National security considerations do not favor either option.

*Costs are presented for transport of 20,000 canisters of defense high-level waste.

a commercial repository but not for a defense-only repository, it is expected that the D&E costs for a defense-only repository would be less than 4 billion dollars. The cost advantage of disposal of defense waste in a commercial repository is further enhanced when D&E costs are included in the defense-only repository cost estimates. On the basis of cost efficiency, the total cost of disposal is less when defense high-level waste and commercial waste are placed in the same repository.

Section 8(b)(2) of the Nuclear Waste Policy Act states that arrangements for the use of a commercial repository for defense high-level waste "shall include the allocation of costs of developing, constructing, and operating the repository or repositories." Discussions have begun to determine possible methods for allocating costs; however, a final allocation mechanism has not yet been agreed upon. Whatever final allocation mechanism might be agreed upon, it would not affect the conclusion that it is more economical for the nation to dispose of defense high-level waste in a commercial repository.

Health and Safety

The potential long-term health and safety impacts of the two geologic disposal options were estimated with the understanding that each option must satisfy the requirements of 10 CFR 60 (NRC) and the proposed 40 CFR 191 (EPA). Based upon the evaluations presented in this report, there is no discernible difference between the two disposal options with respect to health and safety impacts. Therefore, health and safety is not a basis for the selection of one of the two disposal options.

Regulation

The Nuclear Waste Policy Act of 1982 specifies certain considerations that apply to both geologic disposal options:

- o Repositories are to be licensed by the Nuclear Regulatory Commission and must comply with all requirements of the Commission for the siting, development, construction, and operation of a repository (Section 8(b)(3)).
- o States and affected Indian Tribes are to be entitled to consultation and cooperation in accordance with Sections 115 through 118 of the Act (Section 101(b)).

In accordance with the Act, however, differences arise in the procedures for establishing a defense-only repository as compared to a commercial repository. For example, a detailed process of nominating, recommending, and selecting sites for characterization of a repository is specified for a commercial repository, but that process is not applicable to a defense-only repository. While procedural differences in the Act appear to give a defense-only repository a schedule and cost advantage, the site characterization procedures of 10 CFR 60, which are similar to those of the Act and must be followed for a defense-only repository, mitigate these advantages. Therefore, regulation is not a basis for the selection of one of the two disposal options.

Transportation

It was assumed that canisters of immobilized defense high-level waste will be shipped to a geologic repository either by truck or by rail. Estimated shipping costs range from $110 million dollars to $257 million dollars depending upon the mode of transport, and the repository location. The total risks associated with shipping defense high-level waste to a defense-only or commercial repository are the same, and in any case are estimated to be a small fraction of the total risks predicted for the United States from all truck or rail transportation.

With respect to any designated defense or commercial repository, the cost of shipping defense high-level waste to that site and the associated risks do not depend on whether the site is a defense-only or a commercial repository. Therefore the transportation considerations are not a basis for the selection of one of the two disposal options.

Public Acceptability

This report has assessed the probable or likely positions that specific segments of the public may take with regard to the two disposal options. In general, the differences in acceptability between the options appear to be minor compared to gaining public acceptance for any high-level waste repository.

National Security

The national security issues with respect to geologic disposal of defense high-level waste are: (1) to avoid interruption of or delay of the defense material production process or nuclear weapons activities and (2) to ensure that there is no disclosure of classified information.

Current plans at DOE facilities include provisions for interim storage of immobilized defense high-level waste to allow defense production and immobilization facilities to continue operation despite possible delays or interruption in repository availability.

The processes used to immobilize defense high-level waste for disposal and the quantity and characteristics of the solidified waste produced are unclassified. Hence, disposal of immobilized waste in a repository will not reveal classified information. In addition, there is no reason foreseen in licensing or regulating a geologic repository to require access to classified defense information.

In addition, DOE foresees no reason for NRC's regulatory process to extend into any part of the defense research and development and production process. However, incomplete knowledge concerning NRC's intentions creates uncertainty about the extent to which the NRC might wish to inquire into the defense production activities, and what the national security implications may be. Section 202(4) of the Energy Reorganization Act of 1974 does not address this point. This concern exists equally for both disposal options. As a result, national security considerations do not form a basis for preference of either option.

Conclusion

Based on the evaluation summarized above, there is no basis for finding that a defense only repository is required. The only factor that results in a significant advantage for either option is cost efficiency. The other factors considered did not provide a basis for suggesting that one option would be preferable to the other. Due to the cost advantage to be gained by disposing of defense wastes in a combined commercial and defense repository, and the fact that there is no compelling requirement for a defense-only repository, the Department recommends that the combined repository option be implemented.

1.0 INTRODUCTION

On January 7, 1983, President Reagan signed into law the Nuclear Waste Policy Act of 1982 (P.L. 97-425). Section 8(b) of the Act states that:

"(1) Not later than 2 years after the date of the enactment of this Act, the President shall evaluate the use of disposal capacity at one or more repositories to be developed under subtitle A of Title I for the disposal of high-level radioactive waste resulting from atomic energy defense activities. Such evaluation shall take into consideration factors relating to cost efficiency, health and safety, regulation, transportation, public acceptability, and national security.

(2) Unless the President finds, after conducting the evaluation required in paragraph (1), that the development of a repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only is required, taking into account all of the factors described in such subsection, the Secretary shall proceed promptly with arrangement for the use of one or more of the repositories to be developed under subtitle A of title I for the disposal of such waste. Such arrangements shall include the allocation of costs of developing, constructing, and operating this repository or repositories. The costs resulting from permanent disposal of high-level radioactive waste from atomic energy defense activities shall be paid by the Federal Government, into the special account established under section 302.

(3) Any repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only shall (A) be subject to licensing under section 202 of the Energy Reorganization Act of 1973 (42 U.S.C. 5842); and (B) comply with all requirements of the Commission for the siting, development, construction, and operation of a repository."

1.1 Management of Defense High-Level Waste

The Executive Office of the President and several Federal departments, agencies, and offices have roles in the disposal of defense high-level radioactive waste. The relationship among them is shown in Figure 1-1. The Department of Energy (DOE) has the lead role and is responsible for developing radioactive waste disposal technologies and for designing, constructing, and operating storage and disposal facilities for its waste. Within DOE, the management of high-level waste resulting from atomic energy defense activities is the responsibility of the Assistant Secretary for Defense Programs. The goal of the DOE with respect to defense high-level waste is to utilize or dispose of it routinely, safely, and effectively. DOE is proceeding with a geologic repository program for the disposal of commercial nuclear waste as called for in the Nuclear Waste Policy Act of 1982. Unless the President finds that a separate repository for defense high-level waste is required, the Office of Civilian Radioactive Waste Management will assume responsibility for permanent disposal of defense high-level waste at a commercial repository .

Close liaison between the defense and commercial waste disposal programs is being maintained to assure technical and schedule compatibility. DOE is cooperating with other agencies, including the Department of the Interior (DOI) and the Department of Transportation (DOT), which manage the public lands and develop and enforce transportation regulations, respectively.

Within the Executive Office of the President, the Office of Management and Budget, (OMB), the National Security Council (NSC), the Office of Science and Technology Policy (OSTP), and the Council of Environmental Quality (CEQ) provide, respectively, oversight of

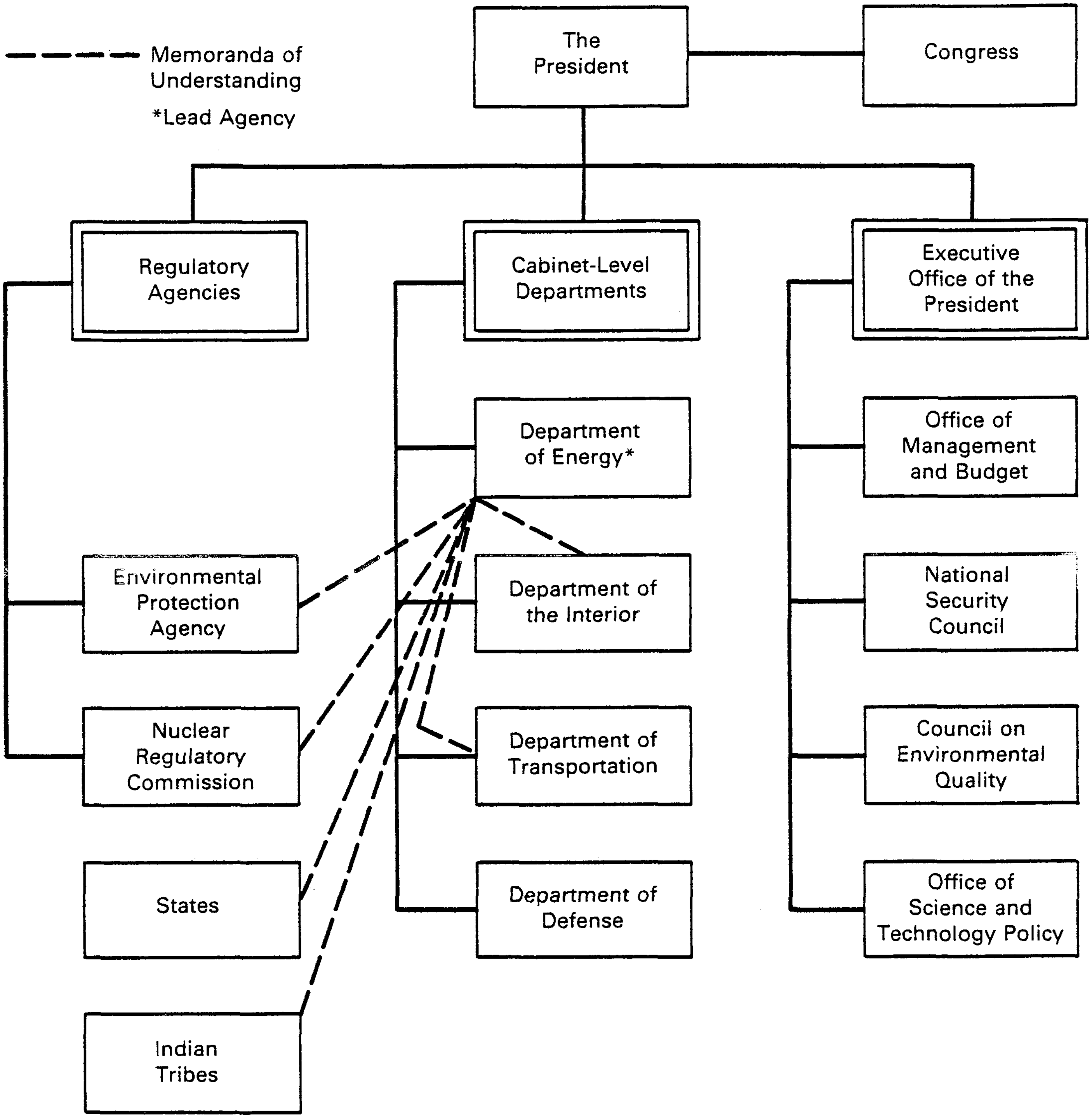

FIGURE 1-1

THE MANAGEMENT OF DEFENSE WASTE: WASTES FROM ATOMIC ENERGY DEFENSE ACTIVITIES ARE MANAGED BY DOE, WORKING WITH OTHER AGENCIES, THE STATES AND INDIAN TRIBES, UNDER THE OVERSIGHT OF THE EXECUTIVE OFFICE OF THE PRESIDENT.

funding and management, national security policy, federal science policy, and guidance on the National Environmental Policy Act.

The Environmental Protection Agency (EPA) sets generally applicable environmental radiation standards for radioactive waste. Although DOE atomic energy defense activities are not under the jurisdiction of the Nuclear Regulatory Commission (NRC), repositories for disposal of high-level radioactive waste resulting from atomic energy defense activities are subject to regulation by NRC under Section 202 of the Energy Reorganization Act of 1974 and the Nuclear Waste Policy Act of 1982.

The States and Indian Tribes also have certain rights of consultation and cooperation with respect to repository siting, as specified in the Nuclear Waste Policy Act of 1982.

Congress oversees defense waste activities through annual authorizations and appropriations and through oversight hearings. The Armed Services and Appropriations Committees in the Senate and in the House of Representatives review defense waste programs at least annually.

1.2 Sources and Quantities of Defense High-Level Waste

Defense high-level waste (DHLW), as defined in DOE Order 5820.2 (and consistent with the Environmental Protection Agency's proposed 40 CFR 191), is the highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic (TRU) waste and fission products in concentrations as to require permanent isolation. Defense high-level waste is generated and stored at three DOE sites: the Savannah River Plant, the Idaho National Engineering Laboratory, and the Hanford Reservation (see Figure 1-2). The following information concerning site reference plans for the Savannah River Plant, the Idaho National Engineering Laboratory and the Hanford Reservation is consistent with policies contained in the Defense Waste Management Plan (U.S. DOE, 1983a).

By the end of 1982, approximately 15 percent of the total curies of radioactivity in spent fuel and high-level waste in this country originated from atomic energy defense activities. Most of the remaining radioactivity is contained in commercial spent nuclear fuel. By 2000, it is expected that the radioactivity in defense high-level waste will be three percent of the total (U.S. DOE 1983b).

At the Savannah River Plant, high-level waste is stored in underground tanks. High-level waste from this site will be immobilized in borosilicate glass in the on-site Defense Waste Processing Facility, the first production scale vitrification plant. This processing facility will produce approximately 500 canisters of borosilicate glass per year beginning in 1989. The immobilized high-level waste will be stored on site until a geologic repository becomes available to receive the waste.

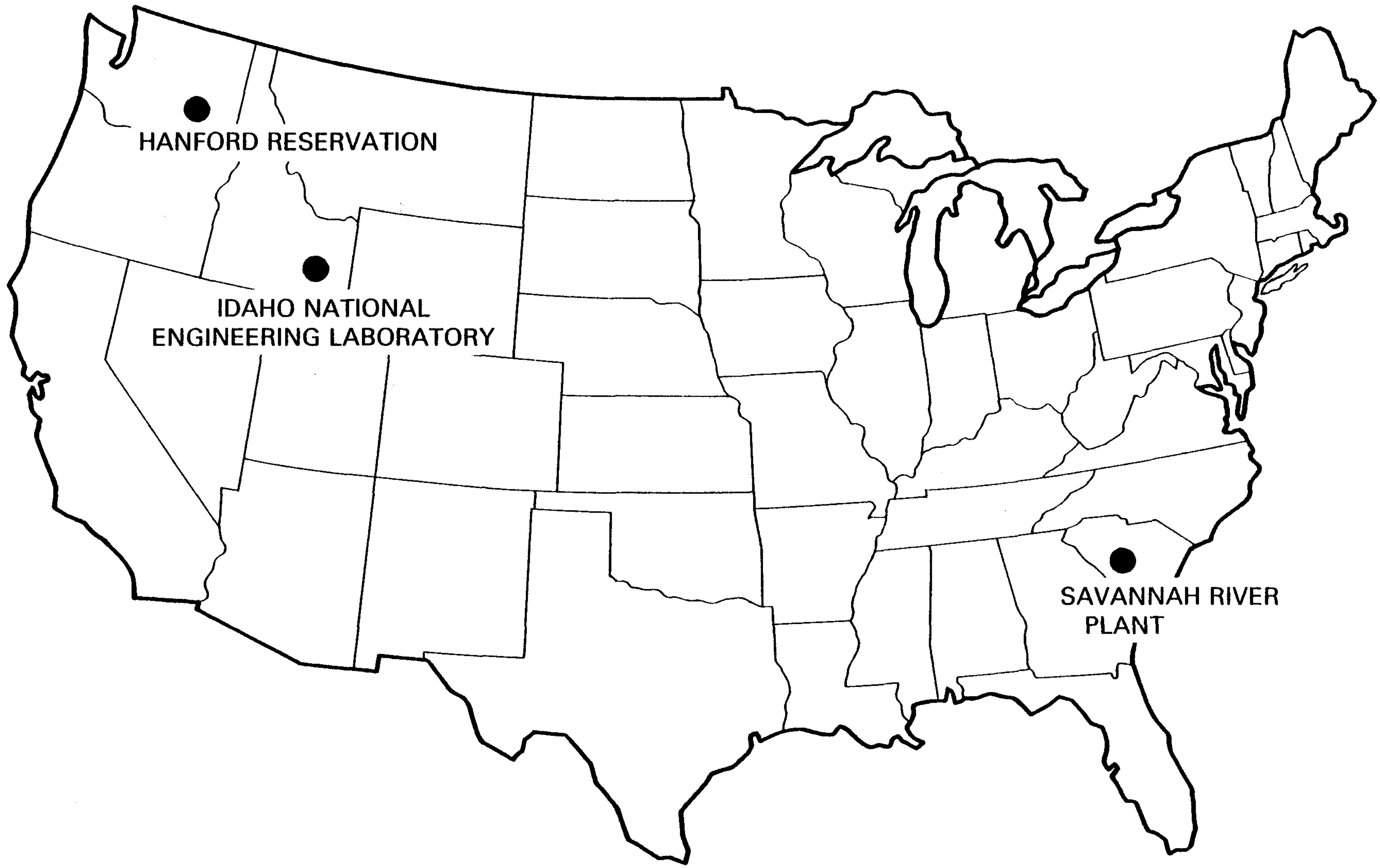

FIGURE 1-2

DEFENSE HIGH-LEVEL WASTE SITES

At the Hanford Reservation, high-level waste is stored in underground tanks. Most of the cesium and strontium has been separated from the stored waste and will be converted to dry cesium chloride and strontium fluoride salts and sealed in double-wall metal capsules by the end of 1985. The capsules will be stored in water basins pending use. Removal of the cesium and strontium has significantly reduced the potential hazard of the stored waste. A PUREX process was started in 1983 to reprocess the inventory of spent N-reactor fuel. In the current DOE reference plan, the PUREX waste and readily retrievable older stored waste will be processed in an immobilization plant beginning in the early 1990's. The production capacity of this facility has not been determined as yet. The early estimate used in this analysis indicates the facility would produce approximately 120 canisters of immobilized waste annually over a 10-year period for disposal in a geologic repository. The immobilized high-level waste will be stored on site until a geologic repository becomes available to receive the waste.

Most of the cesium, strontium and water has been removed from the high-level waste stored in 149 single-shell tanks. The high-level waste remaining in these tanks will be stabilized in place if, after the requisite environmental documentation, it is determined that the short-term risks and costs of retrieval and transportation outweigh the environmental benefits of disposal in a geologic repository. Should it be determined that the benefits of geologic disposal prevail, there will be a substantial increase in the amount of defense high-level waste to be processed and disposed of in a geologic repository.

The Idaho National Engineering Laboratory has been converting high-level liquid waste to a dry calcine and storing it in stainless steel bins which are in underground concrete vaults. While a final decision has not been made, the reference plan anticipates operation of an immobilization facility in 2007. At that time, liquid and calcine wastes will be immobilized for geologic disposal at the rate of 500 canisters per year.

Table 1-1 lists values for the physical characteristics of the high-level waste packages. These values are for design and study purposes and are subject to change based on continuing research and development.

1.3 Scope and Approach

This report is a comparative study of two geologic disposal options for defense high-level waste with respect to factors relating to cost efficiency, health and safety, regulation, transportation, public acceptability and national security, as specified in the Nuclear Waste Policy Act of 1982. The two disposal options are:

- o Defense high-level waste is disposed of in a commercial geologic repository.
- o Defense high-level waste is disposed of in a defense-only geologic repository.

The comparative study was performed using a set of baseline assumptions, which are briefly described below.

TABLE 1-1

HIGH-LEVEL WASTE PACKAGE CHARACTERISTICS

Characteristic	DHLW[a]	CHLW	Spent Fuel (SF) (Typical)
Waste Form	Borosilicate Glass	Borosilicate Glass	Consolidated Spent Fuel Assemblies 6 PWR or 18 BWR Per Waste Package
Canister Size: Diameter x Length (meters)	.61 x 3.0	.324 x 3.0	PWR - .43 x 3.85 BWR - .49 x 4.11
Limiting Temperature During Package Design Life	500°C	500°C	375°C
Limiting Temperature Thereafter	100°C	100°C	TBD
Total Weight of Waste Form (kg)	1470	595	PWR - 3243 BWR - 3737
Total Weight of Canister (kg)	1940	845	N/A
Heat Output (kw)	.423	2.21	PWR - 3.3 BWR - 3.4
Total Radioactivity of Waste (Curies)	1.5×10^5	6.58×10^5	PWR - 2.4×10^6 BWR - 2.5×10^6
Metric Tons of Heavy Metal	0.5[b]	2.28	PWR - 2.77 BWR - 3.4

[a]DHLW varies in characteristics. Table entries are reference values for design purposes.
[b]"Curie Equivalent MTHM" based on the ratio of DHLW to CHLW package radioactivities in curies.

DHLW - Defense High-Level Waste
CHLW - Commercial High-Level Waste
PWR - Pressurized Water Reactor
BWR - Boiling Water Reactor
TBD - To Be Determined
N/A - Not Available

Source: Varadarajan and Dippold, 1984.

These assumptions define a set of reference conditions developed from information available at the time this report was prepared. Detailed information such as repository and waste package design concepts, and repository capacities are subject to continuing study and evaluation. Thus, the concepts used in this report may differ from current and final concepts. It should be noted, however, that these differences are not expected to materially alter the qualitative results of this study.

(1) The study is consistent with data presented in the Defense Waste Management Plan.

(2) The commercial and defense-only repositories are to be located in either salt or hard rock.

(3) A commercial repository will have an inventory of 70,000 metric tons of heavy metal (MTHM), of which 35,000 MTHM is spent nuclear fuel and 35,000 MTHM is commercial high-level waste.*

(4) Up to 20,000 defense waste packages, approximately equivalent to 10,000 MTHM of commercial high-level waste, are to be emplaced in the repository. An additional disposal area for the defense waste will be constructed at the commercial repository site, so that the quantity of defense waste emplaced in the repository will be in addition to the 70,000 MTHM of commercial waste.**

(5) The characteristics of the commercial spent nuclear fuel and high-level waste packages and the defense high-level

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*Although it is recognized that a commercial repository may ultimately accept more than 70,000 MTHM of commercial waste, for purposes of this study, a 70,000 MTHM limit for commercial waste was used as a bounding assumption. MTHM refers to the quantity of fuel before irradiation in a commercial nuclear power plant.

**It is assumed for this report that a second repository will be in operation before the first repository reaches the 70,000 MTHM limit (considering all waste) as specified in Section 114(d)(2) of the Nuclear Waste Policy Act of 1982.

waste packages are those described by Westinghouse (1983a, 1983b), and Baxter (1983), respectively.

(6) Two waste package options for defense high-level wastes are considered: without overpack and with a TiCode-12 overpack. The waste packages for commercial high-level waste and spent nuclear fuel are emplaced with a TiCode-12 overpack.***

(7) Disposal of defense high-level waste will in all cases meet the requirements of applicable standards of the Environmental Protection Agency (EPA) and regulations of the Nuclear Regulatory Commission (NRC).

(8) DHLW is assigned a value of 0.5 MTHM based on the curie equivalence of commercial high-level waste (CHLW) as shown in Table 1-1.

1.4 Organization of this Report

The remainder of this report is organized as follows. Disposal of defense waste in a commercial repository is discussed in Section 2.0 and disposal of defense waste in a defense-only repository is discussed in Section 3.0. For each of these sections, the legislative requirements and design and operational characteristics of the disposal option are presented. Then factors relating to cost efficiency, health and safety, regulation, transportation, public

***An overpack is a container for the waste which is designed to provide an additional containment barrier surrounding the canister containing the waste form.

TiCode-12 refers to a corrosion resistant titanium alloy that forms the outer layer of the overpack.

The need for an overpack, and the overpack material, if one is needed, depends on a variety of factors including waste type, media, and repository characteristics. The options for the waste package used in this analysis was for the purpose of bounding the analysis and does not imply that these are the only options.

acceptability, and national security are discussed. Section 4.0 presents a comparative evaluation of the two disposal options with respect to these factors.

2.0 DISPOSAL OF DEFENSE HIGH-LEVEL WASTE IN A COMMERCIAL REPOSITORY

This section presents a summary of information concerning the disposal of defense high-level waste in a commercial repository. First, a description of the major legislative requirements is presented. Second, a brief description of the design and operational characteristics of a commercial geologic repository is given with emphasis on specific features which will accommodate defense high-level waste. Finally, each of the factors of evaluation is described with respect to this disposal option.

2.1 Legislative Requirements

The following statutes affect the management of defense high-level waste:

- o Atomic Energy Act of 1954 (as amended)
- o Energy Reorganization Act of 1974
- o Department of Energy Organization Act of 1977
- o Federal Land Policy and Management Act of 1976
- o Nuclear Waste Policy Act of 1982

The first three of these laws, among other things, define the roles and responsibilities of the agencies active in nuclear waste management.

Environmental protection is addressed by the Clean Air Act, the Clean Water Act, and the National Environmental Policy Act, among others. Under Executive Order 12088, Federal agencies will take actions to prevent, abate, and control environmental pollution from

Federal facilities under their purview. The EPA* has proposed Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes (40 CFR Part 191, 47 Federal Register 58196 (December 29, 1982)). The NRC** has published its rules governing regulation and licensing of geologic repositories; these rules are entitled "Disposal of High-Level Radioactive Wastes in Geologic Repositories" (10 CFR Part 60, 48 Federal Register 28194 (June 21, 1983) and 46 Federal Register 13971 (February 25, 1981).

The Federal Land Policy and Management Act of 1976 establishes the policy regarding U.S. Government lands. For example, a land withdrawal of over 5,000 acres for a repository site would require Congressional approval.

The Nuclear Waste Policy Act of 1982 places responsibility for the permanent disposal of high-level radioactive waste and spent nuclear fuel with the Federal Government and makes the cost of disposal the responsibility of the generators and owners of the waste and spent fuel. A Nuclear Waste Fund was created by the Act to receive and dispense the fee payments made for disposal services (Section 302(c)). Section 8(b)(2) of the Act states that

> "unless the President finds, after conducting the evaluation required in paragraph (1), that the development of a repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only is required, taking into

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*Under authorities established by the Atomic Energy Act of 1954 and Reorganization Plan No. 3 of 1970.

**Under authorities established by the Atomic Energy Act of 1954, the Energy Reorganization Act of 1974, and the Nuclear Waste Policy Act of 1982.

> account all of the factors described in such subsection, the Secretary shall proceed promptly with arrangements for use of one or more of the repositories to be developed under subtitle A of title I (of the Act) for the disposal of such waste. Such arrangements shall include the allocation of costs of developing, constructing, and operating this repository or repositories. The costs resulting from permanent disposal of high-level radioactive waste from atomic energy defense activities shall be paid by the Federal Government, into the special account established under section 302."

Specific dates are stipulated in the Act for initiation of activities to develop the first two commercial repositories (Section 112(b)(1)). The Act limits the quantity of spent fuel that can be placed in the first repository to 70,000 MTHM, or the waste derived from that quantity, until the second repository is in operation (Section 114(d)).

The Act also requires the Secretary of DOE to provide financial assistance to States and affected Indian Tribes for participation and consultation activities and for mitigation of impacts where a repository is under construction (Section 116(c); Section 118(b)). Financial assistance is to be provided from the Nuclear Waste Fund established in Section 302 of the Act, (Section 116(c)(5); Section 118(b)(6)).

2.2 Design and Operational Characteristics of a Commercial Repository

For the purposes of this report, it was assumed that the commercial geologic repository could receive commercial spent nuclear fuel, commercial high-level waste, and commercial transuranic waste resulting from nuclear fuel containing 70,000 metric tons of heavy metal (MTHM) and up to 10,000 MTHM of defense high-level waste. The Nuclear Waste Policy Act limits to 70,000 MTHM the quantity of waste emplaced only until a second repository is available (Section 114(d)).* Table 1-1 (see Section 1.2) compares some of the physical characteristics of waste packages among the three categories: defense high-level waste, commercial high-level waste, and spent nuclear fuel.

The surface of the repository site will have a waste receiving area; a shipping cask handling area; a lag storage area; several hot cells** to accommodate a non-destructive examination facility, a waste canister overpacking facility (if required) and loading of the waste transfer cask; a heating, ventilation and air conditioning system for surface facilities; accommodations for supporting services such as monitoring and control, maintenance, storage, and administrative offices; and structures and equipment for hoists and underground ventilation. Vertical shafts will provide access to the underground facility from the surface for men and materials, waste, and ventilation air supply and exhaust.

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*The assumptions used in this report are for analysis purpose only. They are not meant to preclude the possibility of disposing of defense waste in more than one repository or of disposing of more than 70,000 MTHM of commercial waste in any single repository. They also do not preclude the use of potential sites with a more limited capacity.

**Hot cells are specially designed rooms to isolate radioactive waste and permit remote handling of the waste.

The underground facility will consist of horizontal tunnels mined out of the salt or rock which function as access corridors, ventilation pathways, and rooms in which the waste is emplaced.

Although it is recognized that different waste emplacement designs are still being evaluated, it has been assumed for purposes of this report that defense high-level waste, commercial high-level waste, remote handled* commercial transuranic waste, and commercial spent fuel will be placed in boreholes drilled into the floor of the repository rooms. Contact handled** commercial transuranic waste will be placed on top of the floor in the rooms. The underground area required to accommodate the commercial waste depends upon the host geologic medium, the quantity of waste emplaced, and on the proportion of each type of commercial waste, i.e., spent fuel and CHLW. A hypothetical representation for the underground layout of a salt repository containing both commercial and defense waste is shown in Figure 2-1.

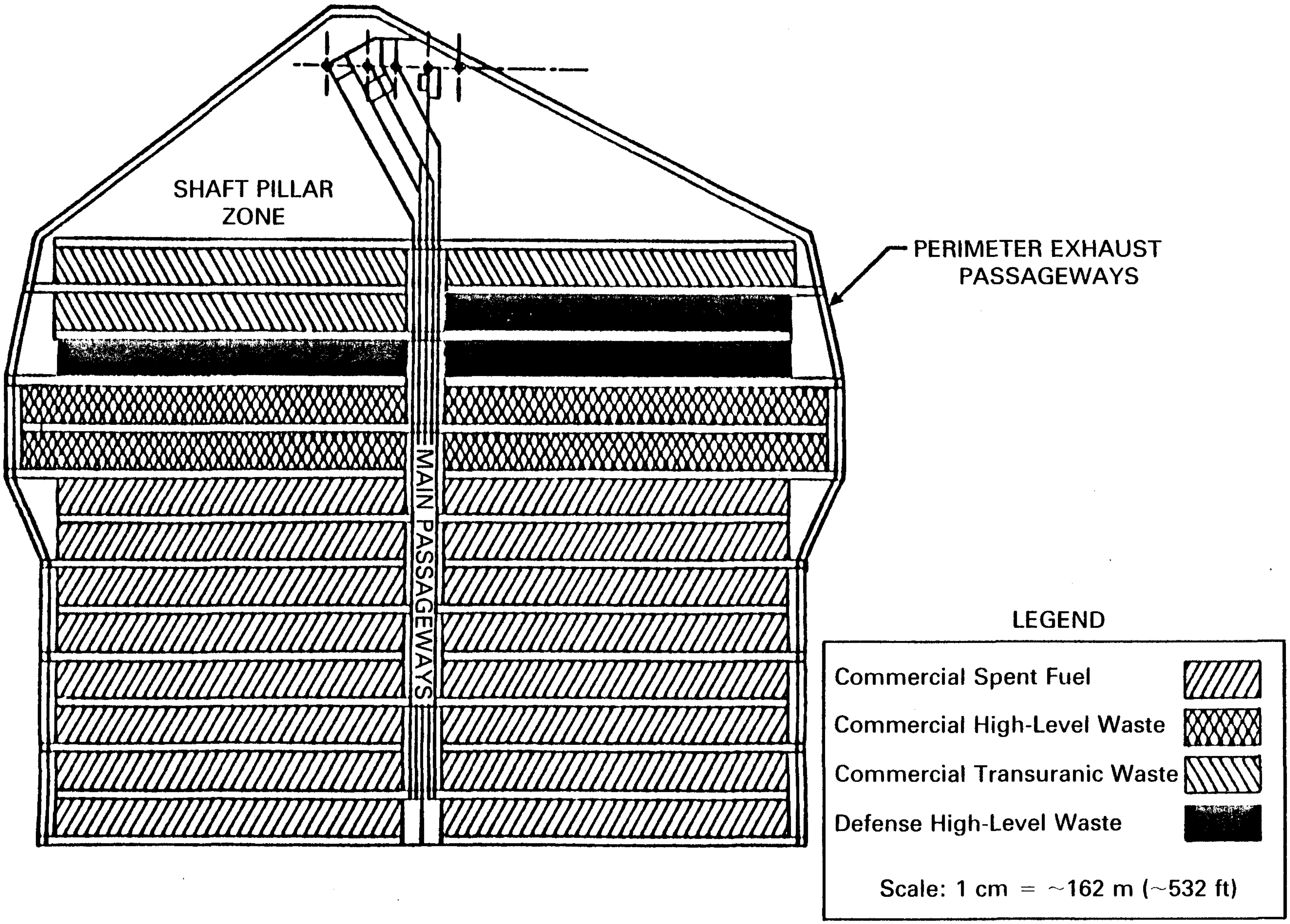
2.3 Characterization with Respect to Areas of Evaluation

The following sections analyze the options for disposal of defense high-level waste in a commercial repository with respect to each of the six factors of evaluation.

2.3.1 Cost Efficiency for Disposal of Defense High-Level Waste in a Commercial Repository

The cost of disposal of radioactive waste in a geologic repository will be influenced by numerous variables including, for

*Remote handled waste is material contaminated in such a way that it cannot be directly handled (generally requires shielding).
**Contact handled waste is waste that can be directly handled.



Source: Varadarajan and Dippold, 1984.

FIGURE 2-1

A HYPOTHETICAL UNDERGROUND LAYOUT FOR THE AUGMENTED SALT REPOSITORY WITH 20,000 DEFENSE HIGH-LEVEL WASTE PACKAGES

example, the geologic medium, the geologic location, the quantity of waste, the emplacement method, the type of overpack that is required, and the depth of the repository. Since none of these variables have been definitely established as yet, cost estimates were prepared for a number of different assumptions about these variables to obtain a range of disposal costs. Information in this section is from the report by Varadarajan and Dippold, 1984. The following subsections describe the baseline assumptions used to develop the cost estimates. The cost estimates are then presented in Section 2.3.1.6.

2.3.1.1 Geologic Media. Two categories of geologic media were considered - salt and "hard rock." Basalt, granite, and tuff are considered hard rock media. Sites comprised of these geologic media are currently being considered for nomination for site characterization. A tuff repository design was used to develop the high end of repository cost estimates.

2.3.1.2 Number of Defense High-Level Waste Packages. A total of 20,000 canisters (10,000 MTHM) of defense high-level waste originating from the Savannah River Plant, the Hanford Reservation, and the Idaho National Engineering Laboratory, are to be disposed of in the repository.

2.3.1.3 Type of Overpack The need for an overpack for defense waste depends on the results of an evaluation of the performance of the waste package under specific repository conditions. Two overpack options were considered for defense high-level waste, a corrosion-resistant overpack design consisting of a thick-walled carbon steel cylinder wrapped with a TiCode-12* shell, and no overpack. These options were selected to provide an upper and lower bound to the overpack costs. The corrosion-resistant overpack design, if used, may be different in different media. Various overpack options are still under study. The overpack designs used for the cost estimates are from conceptual waste package design studies performed by Westinghouse (Varadarajan and Dippold, 1984) (See Figures 2-2 and 2-3).

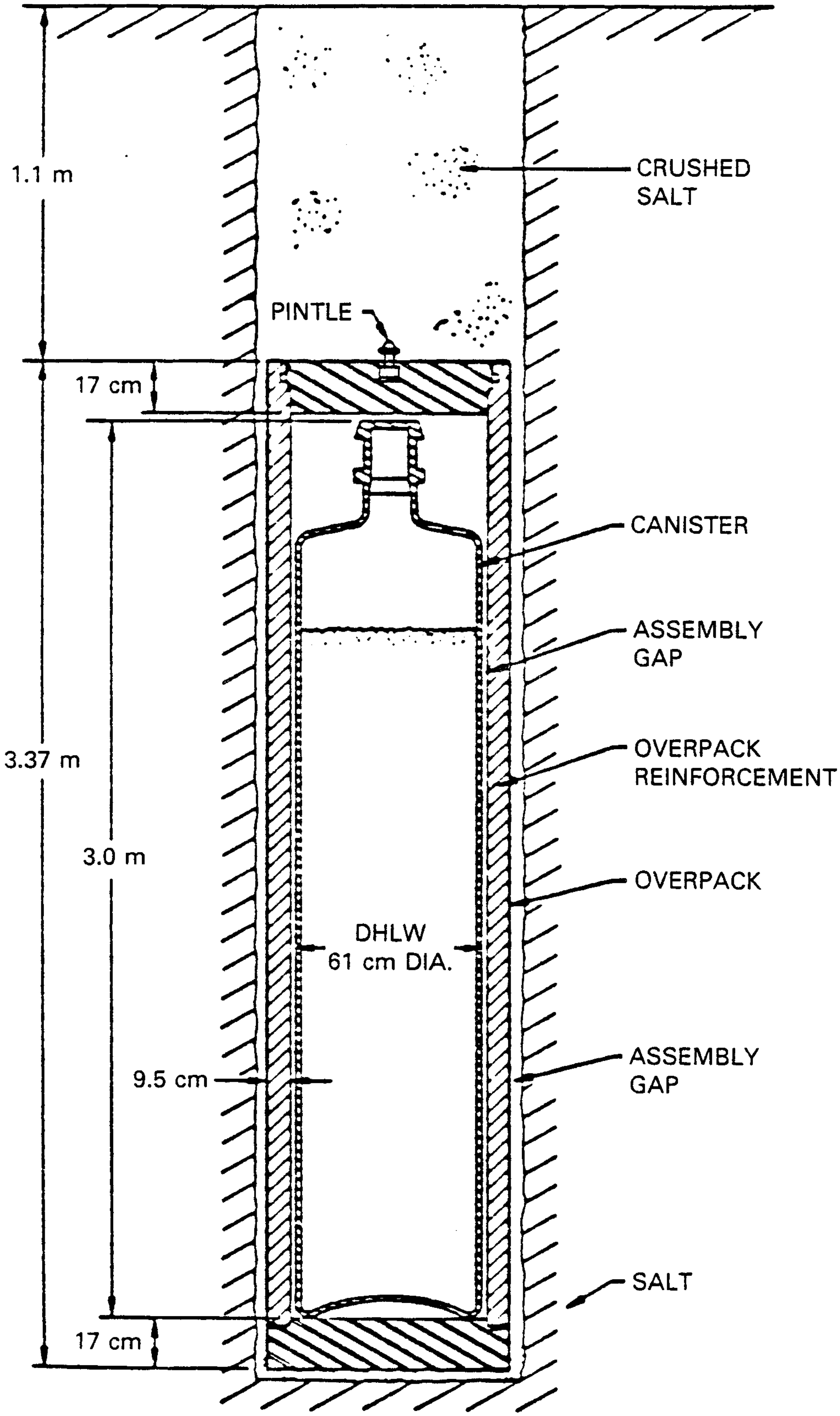
The commercial spent fuel and commercial high-level waste are assumed to have an overpack in all cases (See Figures 2-4, 2-5, 2-6, 2-7, and 2-8).

2.3.1.4 Emplacement Scheme for Defense High-Level Waste. The nominal 70,000 MTHM commercial repository is increased in size to accommodate the defense waste.**

2.3.1.5 Repository Start-up Date. For this study, it was assumed that a commercial repository would be available and could begin to accept defense high-level waste in 1998. If defense wastes are not accepted then, additional costs would be incurred. For example, delayed receipt would necessitate the construction of additional storage capacity at the DOE sites that generate the defense high-level waste. A two-year delay, for example, would

*TiCode-12 is a corrosion-resistant titanium alloy containing 0.8 percent nickel and 0.3 percent molybdenum.

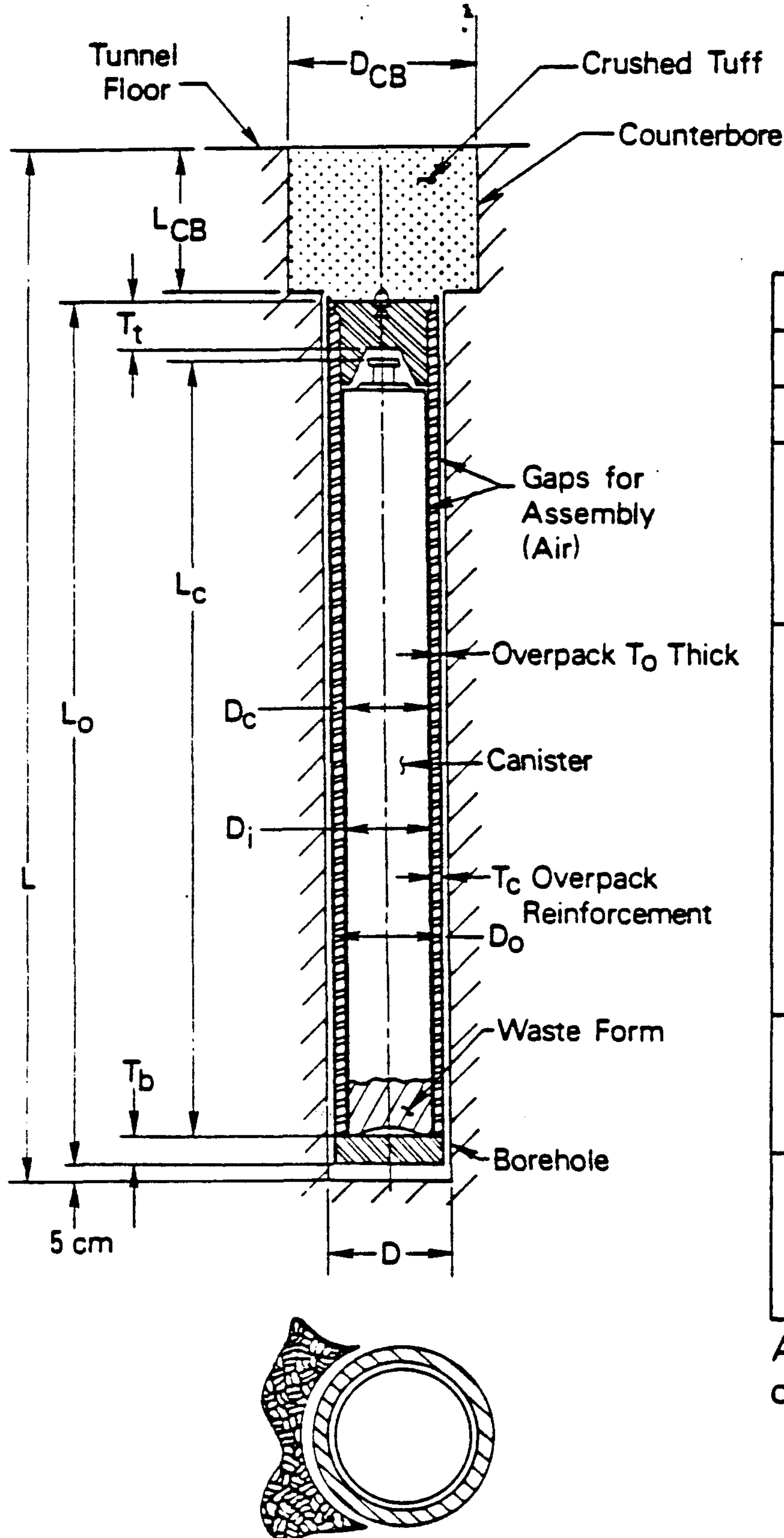
**It is assumed for purposes of this study that a second repository will be in operation before the 70,000 MTHM capacity is reached.



Source: Varadarajan and Dippold, 1984.

FIGURE 2-2

REFERENCE DEFENSE HIGH-LEVEL WASTE PACKAGE DESIGN FOR BOREHOLE EMPLACEMENT IN A SALT REPOSITORY



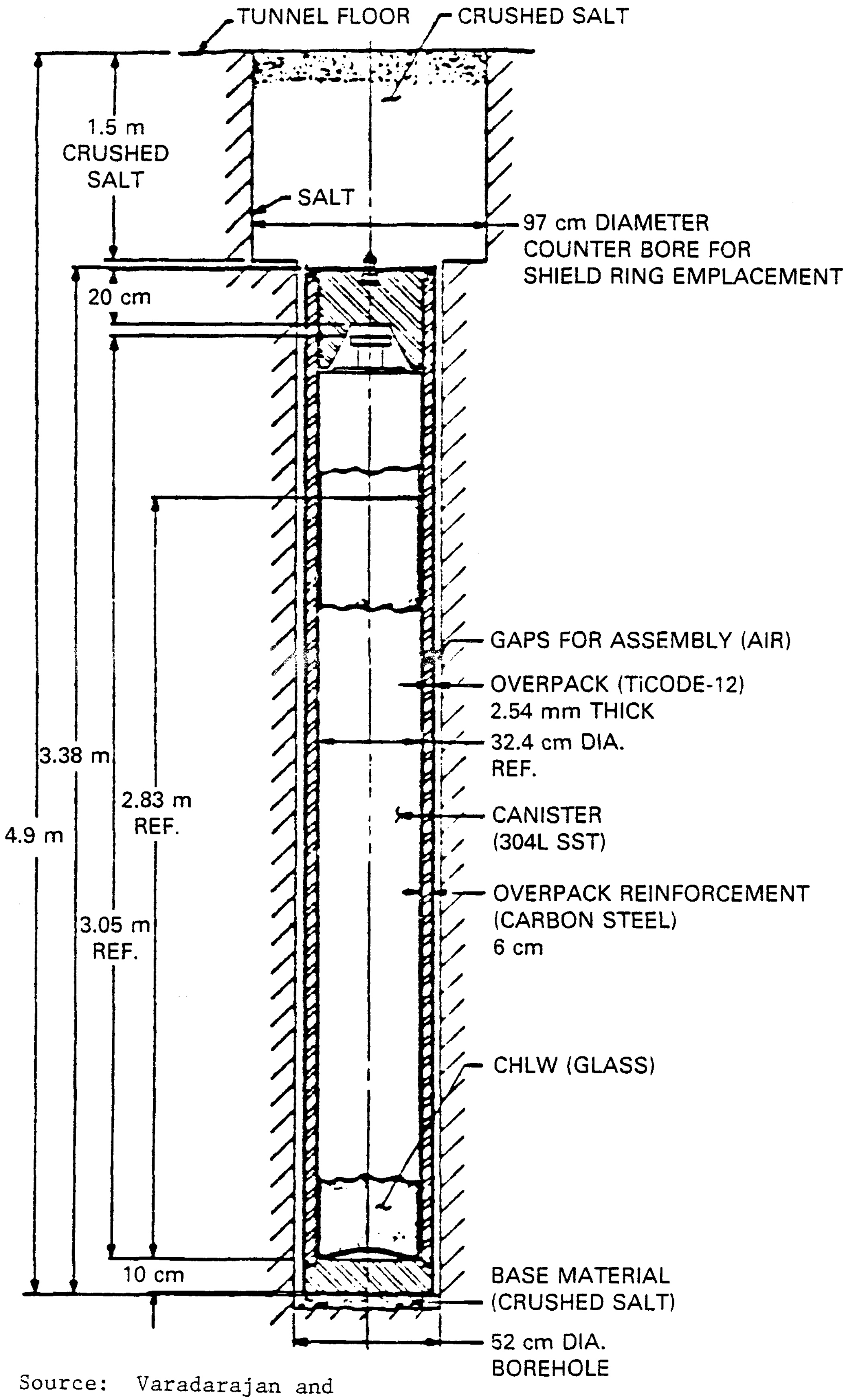
Waste Form	DHLW 1
Concept	Ref.
Power, Watts	423
Waste Form Canister	
D_c	61
L_c	300
Overpack Material	TiCode-12
D_i	63.5
D_o	71.0
L_o	330
T_b	9.0
T_c	3.5
T_t	18.0
T_o	0.25
Borehole	
D	76
L	460
Counterbore	
D_{CB}	101
L_{CB}	120

All dimensions in cm unless otherwise noted.

Source: Varadarajan and Dippold, 1984.

FIGURE 2-3

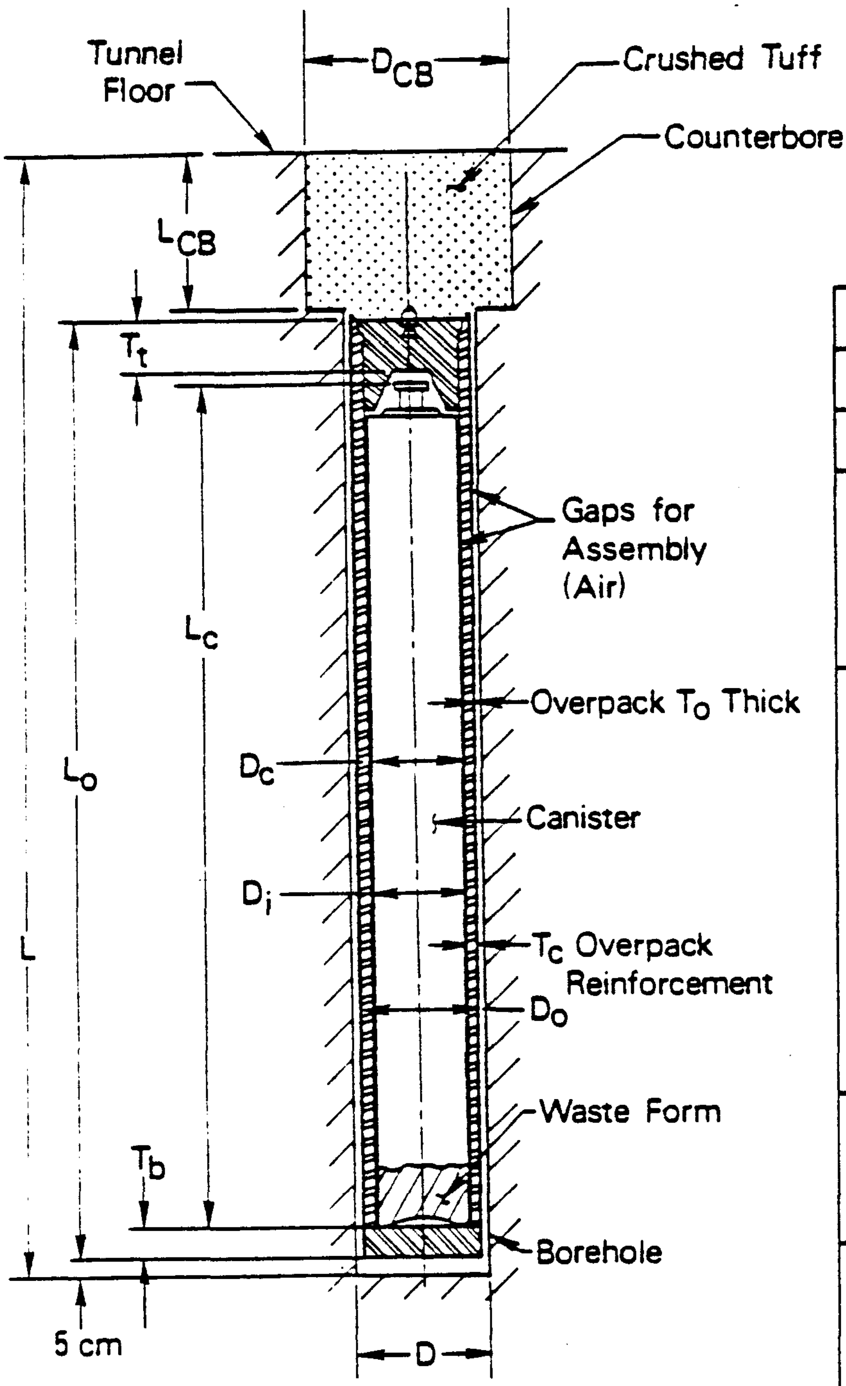
REFERENCE DHLW1 CONCEPTUAL DESIGN FOR BOREHOLE EMPLACEMENT IN A TUFF RESPOSITORY



Source: Varadarajan and Dippold, 1984.

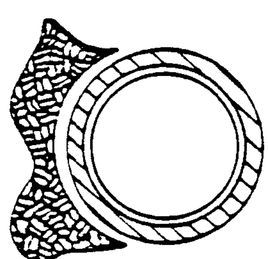
FIGURE 2-4

REFERENCE COMMERCIAL HIGH-LEVEL WASTE PACKAGE DESIGN FOR BOREHOLE EMPLACEMENT IN A SALT REPOSITORY



Waste Form	CHLW
Concept	Ref.
Power, Watts	2210
Waste Form Canister	
D_c	32.4
L_c	305
Overpack Material	TiCode-12
D_i	35
D_o	39
L_o	338
T_b	6
T_c	2
T_t	20
T_o	0.25
Borehole	
D	44
L	493
Counterbore	
D_{CB}	90
L_{CB}	150

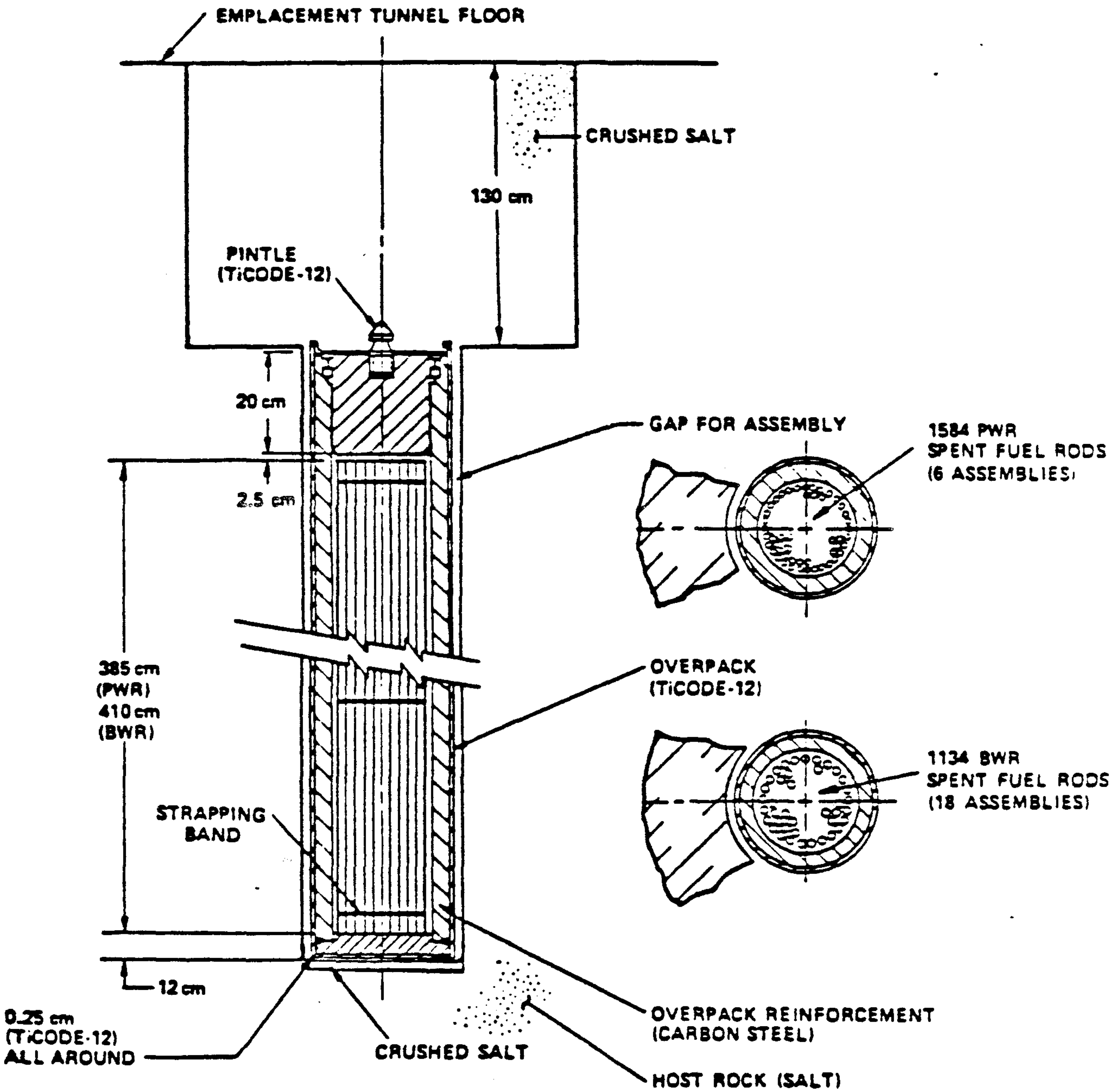
All dimensions in cm unless otherwise noted.



Source: Varadarajan and Dippold, 1984.

FIGURE 2-5

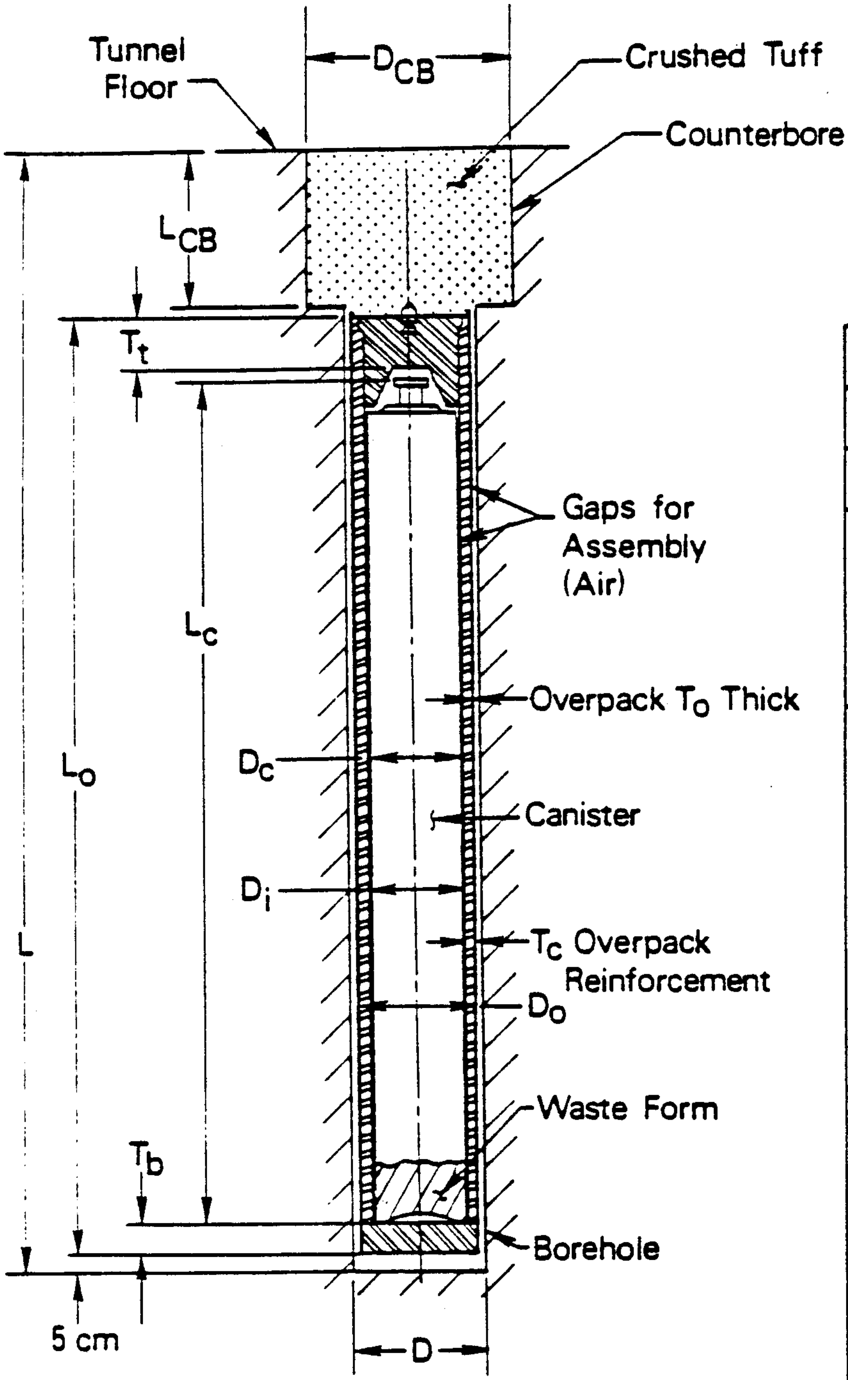
REFERENCE CHLW CONCEPTUAL DESIGN FOR BOREHOLE EMPLACEMENT IN TUFF REPOSITORY



Source: Varadarajan and Dippold, 1984.

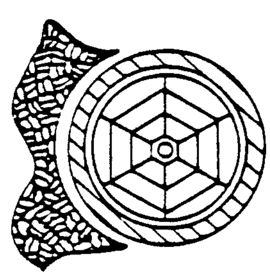
FIGURE 2-6

REFERENCE SF CONCEPTUAL DESIGN FOR BOREHOLE EMPLACEMENT IN A SALT REPOSITORY



Waste Form	SF2(BWR)
Concept	Ref.
Power, Watts	3420
Waste Form Canister	
D_c	55
L_c	410
Overpack Material	TiCode-12
D_i	58
D_o	64.5
L_o	445
T_b	9
T_c	3.0
T_t	20
T_o	0.25
Borehole	
D	70
L	555
Counterbore	
D_{CB}	92
L_{CB}	105

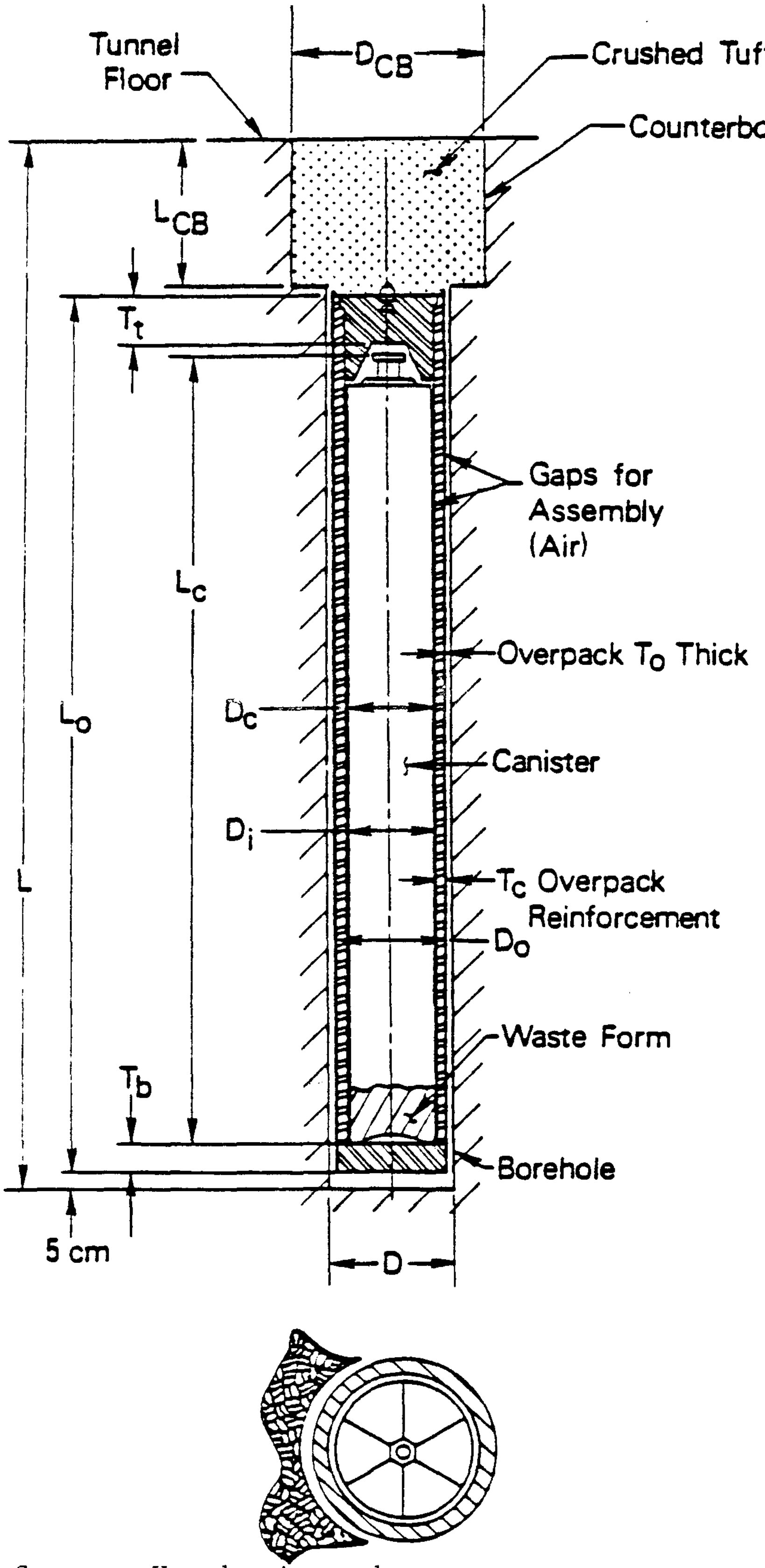
All dimensions in cm unless otherwise noted.



Source: Varadarajan and Dippold, 1984.

FIGURE 2-7

REFERENCE SF-BWR CONCEPTUAL DESIGN FOR BOREHOLE EMPLACEMENT IN A TUFF REPOSITORY



Waste Form	SF2(PWR)
Concept	Ref.
Power, Watts	3300
Waste Form Canister	
D_c	45
L_c	390
Overpack Material	TiCode-12
D_i	48
D_o	53
L_o	420
T_b	8
T_c	2.5
T_t	20
T_o	0.25
Borehole	
D	58
L	555
Counterbore	
D_{CB}	80
L_{CB}	130

All dimensions in cm unless otherwise noted.

Source: Varadarajan and Dippold, 1984.

FIGURE 2-8

REFERENCE SF-PWR CONCEPTUAL DESIGN FOR BOREHOLE EMPLACEMENT IN A TUFF REPOSITORY

require the capital expenditure of an additional $35 million dollars at the Savannah River Plant for the storage of an additional 1,000 canisters of immobilized defense high-level waste (U.S. DOE, 1983a).

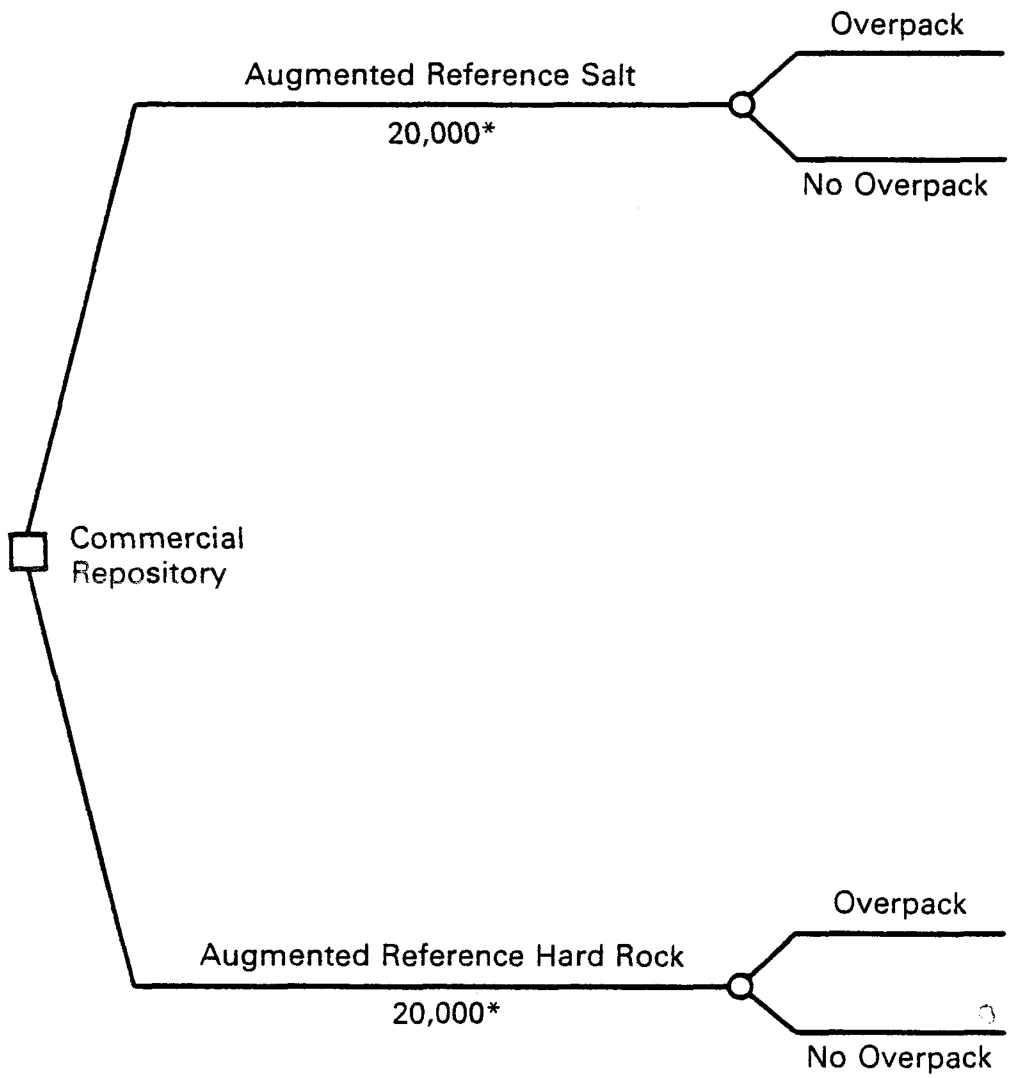
2.3.1.6 Cost Estimates Figure 2-9 schematically illustrates the four disposal scenarios for defense high-level waste in a commercial repository resulting from consideration of the baseline assumptions described above. The resulting cost estimates are presented in Tables 2-1 and 2-2. The total costs shown include allowances for design engineering, project management, and contingency. The costs are summarized in Table 2-3. The tables show that the total cost of a repository in hard rock is higher than one in salt for all cases considered.

The repository construction, operating and decommissioning costs are shown in these tables. The construction and operation cost elements are the primary elements that would be affected by the disposal of defense waste in a commercial repository.

The following factors contribute to a higher cost for a hard rock repository relative to a salt repository:

- Higher unit mining costs for hard rock.
- Lower thermal conductivity of hard rock. This requires waste emplacement at a lower density so that excavated rock volume is higher.
- Ventilation requirements are higher in hard rock because of the lower rate of heat dissipation through the rock.

There are also special factors which tend to offset part of the cost differences introduced above. Salt tends to creep, and, if



*Number of defense high-level waste packages.

FIGURE 2-9

OPTIONS CONSIDERED FOR THE DISPOSAL OF DEFENSE HIGH-LEVEL WASTE IN A COMMERCIAL REPOSITORY

TABLE 2-1

AUGMENTED COMMERCIAL SALT REPOSITORY COST
(Millions of 1984 Dollars)

	Reference Repository Without Defense Waste				Augmented Repository With 20,000 Canisters Defense Waste							
					Without Overpack				With Overpack			
	Cap.	Op.	Decom.	Total	Cap.	Op.	Decom.	Total	Cap.	Op.	Decom.	Total
<u>Waste Preparation System</u>												
Waste Packaging/Receiving Facility and Ventilation Structures	532	1273	87	1892	575	1613	95	2283	575	1613	95	2283
Waste Package Components	--	574	--	574	--	574	--	574	--	1287	--	1287
Subtotal Waste Preparation	532	1847	87	2466	575	2187	95	2857	575	2900	95	3570
<u>Repository System</u>												
Site												
Land and Land Rights	17	0	0	17	17	0	0	17	17	0	0	17
On-Site Improvements	44	38	8	90	44	38	8	90	44	38	8	90
Off-Site Improvements	17	0	2	19	17	0	2	19	17	0	2	19
Shafts	242	209	79	530	250	209	87	546	250	209	87	546
Underground Workings/Rock Handling	245	1034	44	1323	276	1195	47	1518	276	1195	47	1518
Support and Utilities	156	847	19	1022	178	980	20	1178	178	980	20	1178
Subtotal Repository System	721	2128	152	3001	782	2422	164	3368	782	2422	164	3368
<u>Total Cost</u>	1253	3975	239	5467	1357	4609	259	6225	1357	5322	259	6938

Cap. = Capital (Construction)
Op. = Operating
Decom. = Decommissioning

TABLE 2-2

AUGMENTED COMMERCIAL HARD ROCK REPOSITORY COSTS
(Millions of 1984 Dollars)

	Reference Repository Without Defense Waste				Augmented Repository with 20,000 Canisters Defense Waste							
					Without Overpack				With Overpack			
	Cap.	Op.	Decom.	Total	Cap.	Op.	Decom.	Total	Cap.	Op.	Decom.	Total
Waste Preparation System												
Waste Packaging/Receiving Facility and Ventilation Structures	641	1523	106	2270	721	2041	120	2882	721	2041	120	2882
Waste Package Components	-	394	-	394	-	394	-	394	-	822	-	822
Subtotal Waste Preparation	641	1917	106	2664	721	2435	120	3276	721	2863	120	3704
Repository System												
Site												
Land and Land Rights	0	0	0	0	0	0	0	0	0	0	0	0
On-Site Improvements	83	86	14	183	83	86	14	183	83	86	14	183
Off-Site Improvements	240	0	38	278	240	0	38	278	240	0	38	278
Shafts	211	157	24	392	221	157	27	405	221	157	27	405
Underground Workings/ Rock Handling	264	1205	34	1503	292	1409	37	1738	292	1409	37	1738
Support and Utilities	178	1186	22	1386	193	1372	24	1589	193	1372	24	1589
Subtotal Repository System	976	2634	132	3742	1029	3024	140	4193	1029	3024	140	4193
Total Cost	1617	4551	238	6406	1750	5459	260	7469	1750	5887	260	7897

Cap. = Capital (Construction)
Op. = Operating
Decom. = Decommissioning

TABLE 2-3

SUMMARY OF COSTS FOR DISPOSAL OF COMMERCIAL AND DEFENSE HIGH-LEVEL WASTE IN A COMMERCIAL GEOLOGIC REPOSITORY UNDER VARIOUS OPTIONS

Repository Option	Repository Capacity (MTHM)			Cost, millions of 1984 dollars	
	Commercial	Defense	Total	Salt	Hard Rock
Commercial Repository	70,000	--	70,000	5,467	6,406
Augmented Commercial Repository with 20,000 Canisters Defense Waste	70,000	10,000	80,000		
w/o overpack				6,225	7,469
with overpack				6,938	7,897

NOTE: The costs shown above do not include costs for waste transportation or development and evaluation. This cost is assumed to be the same for all the scenarios (see text).

shafts are not lined it is necessary to initially excavate larger shafts and tunnels or else continually re-excavate during operations to maintain required shaft and tunnel size. Thus, the volume of salt mined in a salt repository is higher than it would be without the creep effect. On the basis of expectations, the overpack cost for waste emplaced in salt was assumed to be higher than in hard rock.

The development and evaluation (D&E) activities for the nomination of potentially acceptable sites, the establishment of siting guidelines, and the selection of sites for the first civilian repository include the following activities:

- o Technology Development
- o Socioeconomic Studies
- o Site Identification
- o Site Characterization
- o Site Approval
- o Construction Authorization
- o Consultation and Cooperation

The estimated cost for these activities is approximately $4 billion 1984 dollars for the commercial repository. Any additional D&E costs associated with the disposal of defense waste in the commercial repository are small by comparison and are expected to be within the accuracy of this estimate, therefore, the D&E costs for the combined repository are assumed to be the same as for the commercial repository without defense waste.

2.3.2 Health and Safety Impacts of Disposal of Defense High-Level Waste in a Commercial Repository

This section provides an analysis of the health and safety impacts of disposal of defense high-level waste in a commercial repository. The information in this section was obtained from the report by Kocher, et al. 1984. At the outset, it should be understood that all disposal options must satisfy the requirements of the NRC's 10 CFR 20 and 10 CFR 60 and the EPA's proposed 40 CFR 191 during both the operational and post-closure phases. In the following discussion, both the long-term and short-term effects are discussed.

2.3.2.1 Long-Term Effects. The long term health and safety effects of disposal of spent nuclear fuel and high-level radioactive waste in geologic repositories are limited by EPA's 40 CFR 191 which currently is in proposed form and subject to revision (47 Federal Register 58196). The NRC's 10 CFR Part 60 imposes objectives and criteria for repository performance over the long-term which are designed to assure that the EPA standards will be met. Regardless of whether a repository contains only one type of waste (spent fuel) or several types of waste (spent fuel, commercial HLW or DHLW) it must be demonstrated with reasonable assurance that the objectives and criteria will be met in order for the repository to be licensed by NRC.

The purpose of this analysis is to determine the impact of disposing of defense waste and commercial waste in a repository on demonstrating that the repository performance objectives and criteria will be met. Kocher, Witherspoon, and Smith (1984), evaluated 10 different scenarios for disposal of radioactive waste in a commercial repository in terms of their effect on releases of radionuclides to the accessible environment. The 10 disposal scenarios are listed in Table 2-4. The calculated releases were compared with the proposed EPA release limits for containment requirements. The proposed EPA release limits are shown in Table 2-5.

The quantity and rate of release of radionuclides to the environment from a repository are dependent on a number of repository site and media specific factors, e.g. groundwater flow rate, thermal and mechanical properties, and chemical interactions between the radionuclides and the rock and soil in the path of transport. Since for purposes of this analysis the only concern is the effect of different diposal scenarios on radionuclide releases to the accessible environment and not with the performance of an actual repository, Kocher, et al., took a generic approach and applied what are considered conservative assumptions to a waste isolation system model that calculates releases of radioactive waste from a repository to the environment. The assumptions used are discussed in the following paragraphs.

The commercial high-level waste inventory was calculated by assuming it to be derived from the reprocessing of BWR and PWR spent fuel in the proportion 1.0 MTU PWR to 0.52 MTU BWR (the proportion

TABLE 2-4

DISPOSAL SCENARIOS
FOR WHICH RADIONUCLIDE RELEASES WERE EVALUATED

1,2 - Commercial high-level waste in salt and hard rock, respectively.

3,4 - PWR spent fuel in salt and hard rock, respectively.

5,6 - BWR spent fuel in salt and hard rock, respectively.

7 - Defense high-level waste with minimal overpack in a commercial salt repository.

8 - Defense high-level waste with TiCode-12 overpack in a commercial salt repository.

9 - Defense high-level waste with minimal overpack in a commercial hard rock repository.

10 - Defense high-level waste with TiCode-12 overpack in a commercial hard rock repository.

TABLE 2-5

RELEASE LIMITS IN THE PROPOSED EPA STANDARD (40 CFR 191 (47 FR 58195))*

Radionuclide	Release Limit (Curies per 1,000 MTHM)
Am-241	10
Am-243	4
C-14	200
Cs-135	2,000
Cs-137	500
Np-237	20
Pu-238	400
Pu-239	100
Pu-240	100
Pu-242	100
Ra-226	3
Sr-90	80
Tc-99	10,000
Sn-126	80
Any other alpha-emitting radionuclide	10
Any other radionuclide which does not emit alpha particles**	500

*Cumulative releases to the accessible environment for 10,000 years after disposal.
**Includes I-129

at which the two spent fuel types are assumed to be disposed of in a commercial repository.

All waste packages are assumed to fail simultaneously and completely, whereas containment failure is actually expected to be a gradual process. The model calculates release of waste from the engineered barrier system at a constant rate over a finite time interval, and treats all radionuclides as being released at this one rate. Most investigators expect, however, that releases from an actual repository will occur at rates that will vary over time and differ greatly for different radionuclides. Geosphere transport is treated as occurring at a constant velocity along a single linear flow path of known length. The effects of dispersion are neglected. The model simulates all geochemical interactions with the host rock as ion exchange processes using a retardation factor (R) to calculate delays in radionuclide travel resulting from reversible sorption processes. This method is used to handle geochemical interactions in most groundwater transport models, but it may give erroneous results when applied to interactions that are not due to ion exchange, and it fails to give credit for geochemical interactions (e.g., some precipitation reactions) that may cause contaminants to be retained indefinitely in geologic media. Selection of conservative values for R should prevent any over-estimate of the effectiveness of geochemical processes in retarding radionuclide transport, and will result in overestimates of the transport of most radionuclides.

Two sets of geologic retardation factors (R values) were used to represent the characteristics of salt and "hard rock" (Table 2-6). These factors are considered to be suitably conservative for a generic approach to predicting the performance of conceptual repositories by recognized scientific authorities. The retardation factor R is the ratio of groundwater pore velocity to the net transport velocity of the dissolved substance; a substance which is not retarded by geochemical interactions in a given geologic setting is assigned a retardation factor of 1 for that geologic setting.

Groundwater velocity and the length of the groundwater flow path to the accessible environment are site-specific variables, and it is not reasonable to assign values that are typical of all salt sites or all hard rock sites. Groundwater flux in repository host formations is expected to be quite low, but because associated geologic units may support much larger flows, it is not appropriate to use a velocity typical of the host rock to represent the entire flow path to the accessible environment. The distance to the accessible environment depends on the geometry of the groundwater flow system in and around the site, and on the vertical and horizontal distances to the boundaries of the accessible environment. The NRC Technical criteria for high-level waste disposal (10 CFR 60) require that the pre-emplacement groundwater travel time from the outer boundary of the zone of thermal disturbance to the accessible environment be at least 1000 years. For

TABLE 2-6

RETARDATION FACTORS (R) ASSUMED FOR TRANSPORT OF LONG-LIVED RADIONUCLIDES IN GROUNDWATER

Element	R Value for Hard Rock	R Value for Salt	Source
Carbon	1	1	a,b,c,d
Nickel	1,000	1,000	e
Selenium	50	200	f
Strontium	200	10	f
Zirconium	5,000	1,000	f
Niobium	5,000	1,000	g
Technetium	5	5	f
Palladium	1,000	100	h
Tin	1,000	100	f
Iodine	1	1	a,b,c,d,f
Cesium	500	10	f
Samarium	3,000	1,000	i
Lead	50	20	f
Radium	500	50	f
Actinium	500	1,000	j
Thorium	5,000	1,000	f
Protactinium	500	100	k
Uranium	50	20	f
Neptunium	100	50	f
Plutonium	200	200	f
Americium	500	1,000	f
Curium	500	1,000	e

[a]Smith et al. (1982).
[b]Pepping et al. (1983a).
[c]Siegel and Chu (1983).
[d]Pepping et al. (1983b).
[e]Values based on assumption of geochemical similarity with other transition metals.
[f]National Academy of Science (1983).
[g]Values based on assumption of geochemical similarity with zirconium.
[h]Values based on assumption of geochemical similarity with tin.
[i]Value for hard rock from Rosinger and Tremaine (1980); value for salt is set equal to the highest value recommended for any nuclide in salt by the National Academy of Science (1983).
[j]Values based on assumption of geochemical similarity with americium and curium; see Pepping et al. (1983a, 1983b) and Siegel and Chu (1983).
[k]Value for hard rock based on assumption of geochemical similarity with americium and curium; see Pepping et al. (1983a) and Siegel and Chu (1983). Salt value is based on Pepping et al. (1983b).

Source: Kocher et al. (1983)

this analysis a travel time of exactly 1000 years for both salt and hard rock repository sites, based on a groundwater velocity of 1 m/yr and a flow path 1 km in length was assumed. The assumptions are conservative because actual repository sites are likely to have lower flow velocities and longer flow paths; however, they do meet the NRC's minimum criterion, and quantities of radionuclides released after such a short travel time may indicate potential releases via disruptive events more effectively than if a more realistic travel time were assumed.

10 CFR 60 requires that waste containment be effective for at least 300 years or as long as 1000 years (specific requirements to be set on a case-specific basis) after closure of the repository. This containment criterion is expected to be met by providing waste canisters (or canisters supplemented by overpacks) with the mechanical integrity and corrosion resistance to survive at least 300 to 1000 years in a repository environment; site-specific factors such as dry conditions in the repository could assist in complying with this criterion. For the present analysis, it was assumed that the containment criterion is met solely by the waste package. TiCode-12 overpacks are assumed to be used on all commercial waste packages, as well as on defense waste packages in some options. Though these overpacks are expected to withstand corrosion for much longer than 1000 years in most environments, in this analysis this added margin of safety was disregarded and it was assumed that they provide containment for just 1000 years. Though

integrity of defense waste canisters may be diminished by the higher temperatures and greater mechanical stresses expected in a commercial repository, it is reasonable to assume that these effects are compensated for by supplying sturdier canisters, so that codisposal in a commercial waste repository does not affect containment life of defense waste packages.

A key difference between commercial and defense wastes is the lower leaching rate of defense waste forms, and leaching rate is identified as a factor which will probably be affected by the choice of disposal option for defense high-level wastes. In order to evaluate differences among the different disposal scenarios the waste release rate was treated as a function of the waste form leaching rate alone, while recognizing that other factors (e.g., the performance of backfill materials) also affect release rates and generally result in significantly lower release rates than are calculated from waste form leaching rates alone. Assumed release rates for commercial wastes were set equal to the 10 CFR 60 criterion of 10^{-5} per year.

For the comparison of different waste disposal scenarios, it was assumed that leaching rates vary with the repository temperature at the time of containment failure (i.e., 300 or 1000 years after emplacement). These temperatures were estimated from published repository thermal analyses for salt and tuff. Temperatures for codisposal scenarios are based on the predicted rock temperatures for spent fuel or commercial high-level waste disposal tunnels at

300 and 1000 years after emplacement. Release rates were calculated by assuming that increases in leaching susceptibility at higher temperatures are directly related to the increase in silica solubility at those temperatures. It should be noted that these assumed release rates tend to overstate the differences among defense waste disposal scenarios, as release rates are based on peak temperatures for the release period, whereas actual temperatures and release rates for the codisposal option would decline over time.

All assumptions selected are deliberately intended to be conservative (in that they will usually result in overpredictions of radionuclide releases), while meeting NRC criteria and permitting comparisons among alternate disposal scenarios. Because of the non-site-specific conservative assumptions used in the analysis, the calculated releases cannot be used to demonstrate compliance with the EPA standard, but only for comparing the relative performance of the disposal scenarios.

The analysis showed that even without a corrosion-resistant Ti-Code overpack, defense waste in a commercial repository can be expected to exhibit a lower release of radionuclides to the environment than commercial waste. Recent studies (as yet unpublished) by the DOE Office of Civilian Radioactive Waste Management using more realistic information from potential repository sites, have indicated that there would be no releases of radioactivity from a commercial radioactive waste repository in salt or hard rock during the first 10,000 years following decommissioning of the repository.

It is recognized that the conservative methodology used by Kocher, et al., could be misapplied and lead to an assertion that the potential exists for non-compliance with the proposed EPA standards and 10 CFR 60. However, as stated above, the purpose of this analysis was only to compare the relative effect of the various disposal scenarios and not to demonstrate compliance with any standard. Demonstration of compliance with standards must be accomplished on a site by site basis.

It should be noted that the EPA is circulating for internal review a draft revision to the proposed standard that is referenced in this study. There is nothing in the EPA draft revision that would change the results of the analysis of long term effects presented above.

2.3.2.2 Short-Term Effects. The short-term health and safety impacts of geologic disposal of defense high-level waste are associated with construction and operation of the repository.

The impacts from repository construction and operation will be both radiological and non-radiological and involve the repository labor force and, to a lesser extent, the general population. Radiological impacts occur from the release of radon and its daughter products from exposed rock during underground mining and construction and during radioactive waste disposal operations.

Non-radiological impacts include non-radioactive air pollutant emissions associated with repository construction and operating activities and disabling injuries and fatalities to workers from accidents during construction and operation of the facility.

The estimated health and safety effects during construction for the various disposal options were obtained by normalizing the values obtained for the different conceptual repository designs to one MTHM of disposal capacity. These normalized values were then used to calculate the health and safety effects for the repository capacity used in this analysis. This assumes that the amount of mining required is proportional to the number of MTHM of waste disposed.* Thus, the results show that the estimated number of health and safety impacts are related both to the capacity of the repository and to the particular choice of geologic media but not to whether defense or commercial waste is emplaced in the geologic repository.

Table 2-7 gives estimates of the health and safety impacts expected from construction of a combined repository. The air pollutant emissions result from the burning of various fuels used to power construction equipment. In addition to these pollutants, dust will be generated from surface operations and rock transport to storage. Control techniques will be applied to maintain dust

*This is a good assumption for a repository containing only one type of waste, but if it contains different waste types, the relationship is probably not a direct one. Information for a more detailed analysis does not exist at present.

TABLE 2-7

SHORT-TERM HEALTH AND SAFETY IMPACTS ASSOCIATED WITH CONSTRUCTION OF A COMBINED REPOSITORY

Waste Type and Quantity MTHM		Health Effects										Safety Impacts			
		Non-Radiological					Radiological, man-rems[e]				Non-Radiological[g]			
		Pollutant Emissions, MT[b]					Salt		Hard Rock		Salt		Hard Rock	
Commercial	Defense	CO	HC[c]	NOx	SOx	Part[d]	Workers	Population[f]	Workers	Population[f]	Disabling Injuries[h]	Fatalities[i]	Disabling Injuries[h]	Fatalities[i]
70,000	10,000[a]	13,590	565	2,320	144	144	.28	.011	3400	40	690	14	992	20

[a]Augmented commercial repository with defense waste.
[b]Total metric tons over construction period. Estimated for construction of a spent fuel repository in salt; emissions at a hard rock repository site are estimated to be 20 percent greater.
[c]Hydrocarbons.
[d]Particulates
[e]70-year whole-body dose commitments; based on construction of spent fuel repositories; there are 200 health effects per million man-rem.
[f]Surrounding population out to 80 km is two million persons.
[g]Estimated from data for construction of a spent fuel repository in salt; estimates for hard rock repositories are about 40 percent higher.
[h]Based on rates of 13.6 and 25 injuries per million manhours for construction of surface facilities and underground mining respectively.
[i]Based on rates of 0.17 and 0.53 fatalities per million manhours for construction of surface facilities and underground mining respectively.

Source: Kocher et al., 1983.

concentrations in the air within the applicable standards of the Environmental Protection Agency. It is found that there would be no significant health impacts due to pollutant emissions.

The estimates of safety impacts to workers during construction are based on statistics of injury and fatality rates associated with construction of surface facilities and underground mining operations. Both on-site workers and the surrounding population will be exposed to radioactive radon and its decay products released to the atmosphere during underground mining operations. These emissions are higher from a hard rock repository than from a salt repository by several orders of magnitude. However, even the highest expected exposure to these radiological emissions during construction, shown in Table 2-7, would result in less than one health effect.

Health and safety impacts during the operational phase of the repositories were calculated in a manner similar to that used for the construction phase. Table 2-8 provides the results of those calculations. The total quantities of air pollutants emitted during operation are greater than during construction. However, in the operational phase, pollutant emissions from a hard rock repository are about 40 percent lower than from a salt repository. Nevertheless, the use of standard control techniques will allow air quality standards to be met in both cases, and therefore, no significant health effects are expected from pollutant emissions.

Radiological emissions from radon and its decay products and from occasional decontamination of waste canisters during repository

TABLE 2-8

SHORT-TERM HEALTH IMPACTS ASSOCIATED WITH OPERATIONS
OF A COMBINED REPOSITORY

Waste Type and Quantity (MTHM)		Non-Radiological					Radiological	
		Pollutant Emissions, MT[b]						
Commercial	Defense	CO	HC[c]	NOx	SOx	Part[d]	Total Man-rem[e]	Health Effects[f]
70,000[a]	10,000[a]	4,000	1,360	23,520	15,200	674	7200	1.4

[a] Augmented commercial repository with defense waste.
[b] Total metric tons during operational phase of repository, estimated for operation of a spent fuel repository in salt; emissions at a hard rock repository site would be about 40 percent lower.
[c] Hydrocarbons.
[d] Particulates.
[e] For duration of operational phase (25 years).
[f] Based on one health effect per 5000 man-rem.

Source: Kocher et al., 1983.

operation are not expected to have any appreciable impact on the population (doses to maximally exposed individuals are less than one mrem per year). On-site workers will be exposed to radiation during waste receiving, handling, and emplacement operations. The worker doses reported in Table 2-8 are based on the expected time of operation and permissible exposure limits and, therefore, are independent of the geological medium. Less than two radiological health effects are expected to occur to workers during the operational phase of the repositories.

In addition to the radiological health effects during routine operations, there could be effects from potential accidents. Of the accidents which might occur during repository operations, the dropping of a canister down the repository mine shaft was considered. Estimated occupational doses as a result of this type of accident are independent of the geological medium. The estimated frequency of such an accident is 10^{-5} per year (U.S. Department of Energy, 1980).

2.3.3 Regulation of Disposal of Defense High-Level Waste in a Commercial Repository

Disposal of defense high-level waste in a repository which is not used exclusively for waste resulting from atomic energy defense activities is subject to the Nuclear Waste Policy Act of 1982 and 10 CFR Part 60 "Disposal of High-Level Wastes in Geologic Repositories." The latter regulation is divided into procedural and technical subparts. A sequence of actions which DOE must take to receive authorization to construct a repository and to receive a license to operate a repository is prescribed in both the Nuclear Waste Policy Act and the procedural subparts of 10 CFR 60. The procedure leading to the construction authorization as stated in the Nuclear Waste Policy Act of 1982 and existing regulations is summarized in Table 2-9. (Note that NRC regulations may be revised as necessary in light of the Nuclear Waste Policy Act (48 FR 28195, June 21, 1983)). Criteria for granting the construction authorization and conditions included in it are prescribed in 10 CFR 60.31 and 10 CFR 60.32. Standards for issuance of "a license to receive and possess source, special nuclear or byproduct material at a geologic repository" are prescribed in 10 CFR 60.41. Conditions included in the license are prescribed in 10 CFR 60.42 and 10 CFR 60.43.

The technical subparts of 10 CFR 60 on technical criteria, performance confirmation program, and quality assurance set forth performance objectives and site and design criteria which, if satisfied, would support a finding (by the Commission) of no unreasonable risk to the health and safety of the public. Among the considerations in 10 CFR 60.113(b) to be taken into account is the "generally applicable environmental standard for radioactivity established by the Environmental Protection Agency (EPA)." The EPA has proposed such a standard in 47 Federal Register 58196, 29 December 1982. The proposed rule includes standards of release of radioactive material to the accessible environment from high-level

TABLE 2-9

PROCEDURE FOR ESTABLISHMENT OF A REPOSITORY
FOR COMMERCIAL NUCLEAR WASTE

Activity	Procedural Step	Governing Law or Regulation
Site Selection	o Secretary of DOE issues guidelines	NWPA - Section 112(a)
	o Secretary of DOE nominates at least 5 sites for characterization accompanied by environmental assessment	NWPA - Section 112(b)(1)(A), (E)
	o Secretary of DOE recommends to the President 3 of at least 5 sites for site characterization	NWPA - Section 112(b)(1)(B)
	o President approves or disapproves recommended sites for site characterization	NWPA - Section 112(c)(1)
	o President may delay decision for 6 months	NWPA - Section 112(c)(2)
	o Secretary of DOE submits site characterization plan	NWPA - Section 113(b)(1)
	o NRC prepares site characterization analysis	10 CFR 60.11(d),(e),(f)

TABLE 2-9 (Continued)

Activity	Procedural Step	Governing Law or Regulation
Site Selection (Continued)	o DOE submits semi-annual progress reports to Congress and NRC during site characterization activities	NWPA - Section 113(b)(3) 10 CFR 60.11(g)
	o Secretary of DOE submits recommendation of a site for development of a repository to President accompanied by supporting documentation and an Environmental Impact Statement	NWPA - Section 114(a)(f)
	o President may submit request to Congress to delay recommendation of a site for a repository	NWPA - Section 114(a)(2)(B)
	o President submits recommendation to Congress for the site to be developed as a repository	NWPA - Section 114(a)(2)(A)
	o State or affected Indian Tribe may submit notice of disapproval of site to Congress within 60 days	NWPA - Sections 115(b), 116(b), 118(a)

TABLE 2-9 (Continued)

Activity	Procedural Step	Governing Law or Regulation
Site Selection (Concluded)	o Congress may override disapproval notice within 90 days of continuous session	NWPA - Section 115(c)
	o If first site recommended is not approved, President must submit another recommendation within one year after disapproval	NWPA - Section 114(a)(3)
Construction Authorization and License	o Following site designation and within 90 days after approval by Congress, the Secretary of DOE submits an application for construction authorization to NRC	NWPA - Section 114(b) Section 115
	o NRC submits annual progress reports to Congress on status of application	NWPA - Section 114(c)
	o NRC may adopt environmental impact statement of DOE to fulfill its obligation to prepare same	NWPA - Section 114(f)
	o NRC may approve or disapprove issuance of construction authorization	NWPA - Section 114(d)

TABLE 2-9 (Continued)

Activity	Procedural Step	Governing Law or Regulation
Construction Authorization and License (Concluded)	o NRC must issue final decision on construction authorization within 3 years after application is submitted. Decision may be delayed up to one additional year	NWPA - Section 114(d)
	o A license to receive and process nuclear materials at the geologic repository operations area may be issued by the NRC upon finding that conditions specified in 10 CFR 60.41 are met	10 CFR 60.41
	o The DOE is required to update its application in a timely manner so as to permit Commission review prior to issuance of a license	10 CFR 60.24(b) 10 CFR 60.32(d)
Consultation and Cooperation by States, Affected Indian Tribes, and Public	o States or affected Indian Tribes must be notified and public hearings held prior to site nomination	NWPA - Section 112(b)(1)(H); Section 112(b)(2)
	o The Secretary of DOE must seek to enter into binding written agreement with State or affected Indian Tribe regarding procedures for consultation and cooperation	NWPA - Section 117(c)

TABLE 2-9 (Continued)

Activity	Procedural Step	Governing Law or Regulation
Consultation and Cooperation by States, Affected Indian Tribes, and Public (Continued)	o President or Secretary of DOE must submit notice to State or affected Indian Tribe regarding decisions on sites recommended by DOE for characterization	NWPA - Section 112(c)
	o Secretary of DOE must submit copies of site characterization plan to States or affected Indian Tribe for their review and comment	NWPA - Section 113(b)
	o Secretary of DOE must submit semiannual reports on site characterization activities to State or affected Indian Tribe	NWPA - Section 113(b)(3)
	o DOE must notify State or affected Indian Tribe if site characterization activities are terminated	NWPA - Section 113(c)(3)
	o The Secretary of DOE must conduct public hearings at each site under consideration prior to recommending a site for a repository	NWPA - Section 114(a)(1)

TABLE 2-9 (Continued)

Activity	Procedural Step	Governing Law or Regulation
Consultation and Cooperation by States, Affected Indian Tribes, and Public (Concluded)	o Secretary of DOE must notify State or affected Indian Tribe prior to recommending a site for a repository	NWPA - Section 114(a)(1)
	o State or affected Indian Tribe may submit notice of disapproval of site to Congress	NWPA - Section 116(b) Section 118(a)
	o Site is disapproved unless Congress passes a joint resolution of repository siting approval within 90 days of continuous session	NWPA - Section 115(c)
	o State or affected Indian Tribe must be provided with a copy of the application for construction authorization	NWPA - Section 114(b)
Scheduling	o Secretary of DOE must prepare project decision schedule	NWPA - Section 114(e)(1)
	o Agencies that cannot comply with schedule must so notify Secretary of DOE and Congress	NWPA - Section 114(e)(2)

TABLE 2-9 (Concluded)

Activity	Procedural Step	Governing Law or Regulation
Funding	o All costs paid out of Nuclear Waste Fund	NWPA - Section 116(c)(5), 118(b)(6), Section 302(d)
	o Cost for disposal of defense high-level waste will be paid into Nuclear Waste Fund by Federal Government	NWPA - Section 8(b)(2) Section 302(b)(4)

waste disposal systems during a period of 10,000 years after the repository is permanantly closed. A summary of those sections of 10 CFR 60 most pertinent to comparing the two disposal options in assuring compliance with the proposed standard is presented in Table 2-10.

The concept of several different types of barriers to radionuclide release to assure isolation from the accessible environment is described in both the proposed EPA standard (47 Federal Register 58196) and the Commission regulations (10 CFR 60.102(e)). Performance requirements of these barriers in 10 CFR 60.113 include some flexibility because it was recognized that the characteristics of the waste form, such as thermal release, specific radionuclide content, surface radiation levels, and the immediate environment in which the waste is emplaced, would affect repository performance and could influence the selection of technical measures required to achieve performance objectives.

An important factor influencing specification of the performance requirements for the geologic repository system and corresponding technical measures required to meet those requirements is the repository temperature. Substantially complete containment of nuclides is required during the first several hundred years following permanent closure of a geological repository, when radiation and thermal levels are high and the uncertainties in assessing repository performance are large (60.102(e)(1)). In most cases, high repository temperatures can hasten radionuclide release

TABLE 2-10

PERFORMANCE REQUIREMENTS FOR A GEOLOGIC REPOSITORY AS SPECIFIED IN NUCLEAR REGULATORY COMMISSION REGULATION 10 CFR PART 60

Paragraph	Performance Requirement
60.113(a)(1)	Engineered Barrier System - Containment of the high-level waste within the engineered barrier system must be substantially complete during the period when radiation and thermal conditions in the engineered barrier system are dominated by fission products decay. Containment of high-level waste within the waste package must be substantially complete for a period of between 300 and 1,000 years as determined by the NRC for individual cases according to factors specified in 60.113(b).
	Any release of radionuclides shall be a gradual process of small fractional releases to the geologic setting over long periods of time. For disposal in the saturated zone, both partial and complete filling with groundwater of available void spaces in the underground facility shall be appropriately considered and analyzed among the anticipated processes and events in designing the engineered barrier system.
	The release rate for any radionuclide shall not exceed 10^{-5} per year of its inventory calculated to be present 1,000 years after permanent closure (60.113(a)(1)(ii)(B). This requirement does not apply to any radionuclide which is released at a rate less than 0.1% of the calculated total release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000 per year of the inventory of radioactive waste originally emplaced in the underground facility, that remains after 1,000 years of radioactive decay. Other fractional release limits may be specified by NRC for individual cases (60.113(b)).
60.113(a)(2)	Geologic Setting - The repository shall be located so that pre-waste-emplacement groundwater travel time from the disturbed zone to the accessible environment shall be at least 1,000 years, or other travel time approved or specified by the Commission (60.113(b)).

TABLE 2-10 (Continued)

PERFORMANCE REQUIREMENTS FOR A GEOLOGIC REPOSITORY
AS SPECIFIED IN NUCLEAR REGULATORY COMMISSION
REGULATION 10 CFR PART 60

60.113(b)	On a case-by-case basis the Commission may approve or specify some other radionuclide release rate, designed containment period or pre-waste-emplacement groundwater travel time, provided that the overall system performance objective as it relates to anticipated processes and events, is satisfied. Among the factors that the Commission may take into account are: - age and nature of waste as well as design of the underground facility, particularly with respect to the time when the thermal pulse is dominated by the decay heat of fission products - geochemical characteristics of the host rock, surrounding strata and groundwater - particular sources of uncertainty in predicting the repository performance.
60.131	General design criteria for the geologic repository operations area.
60.131(a)	Radiological Protection - The geologic repository operation area shall be designed to maintain radiation doses, levels, and concentrations of radioactive material in air in restricted* areas within the limits specified in 10 CFR 20**.
60.131(b)	Structures Systems and Components Important to Safety - The repository system must include the following protective features: - protection against anticipated natural phenomena and environmental conditions

*A restricted area is any area, access to which is controlled, for purposes of protection of individuals from exposure to radiation.

**10 CFR 20 establishes standards for protection against radiation hazards from licensed activities. Standards are established to protect both the workers and the general public.

TABLE 2-10 (Concluded)

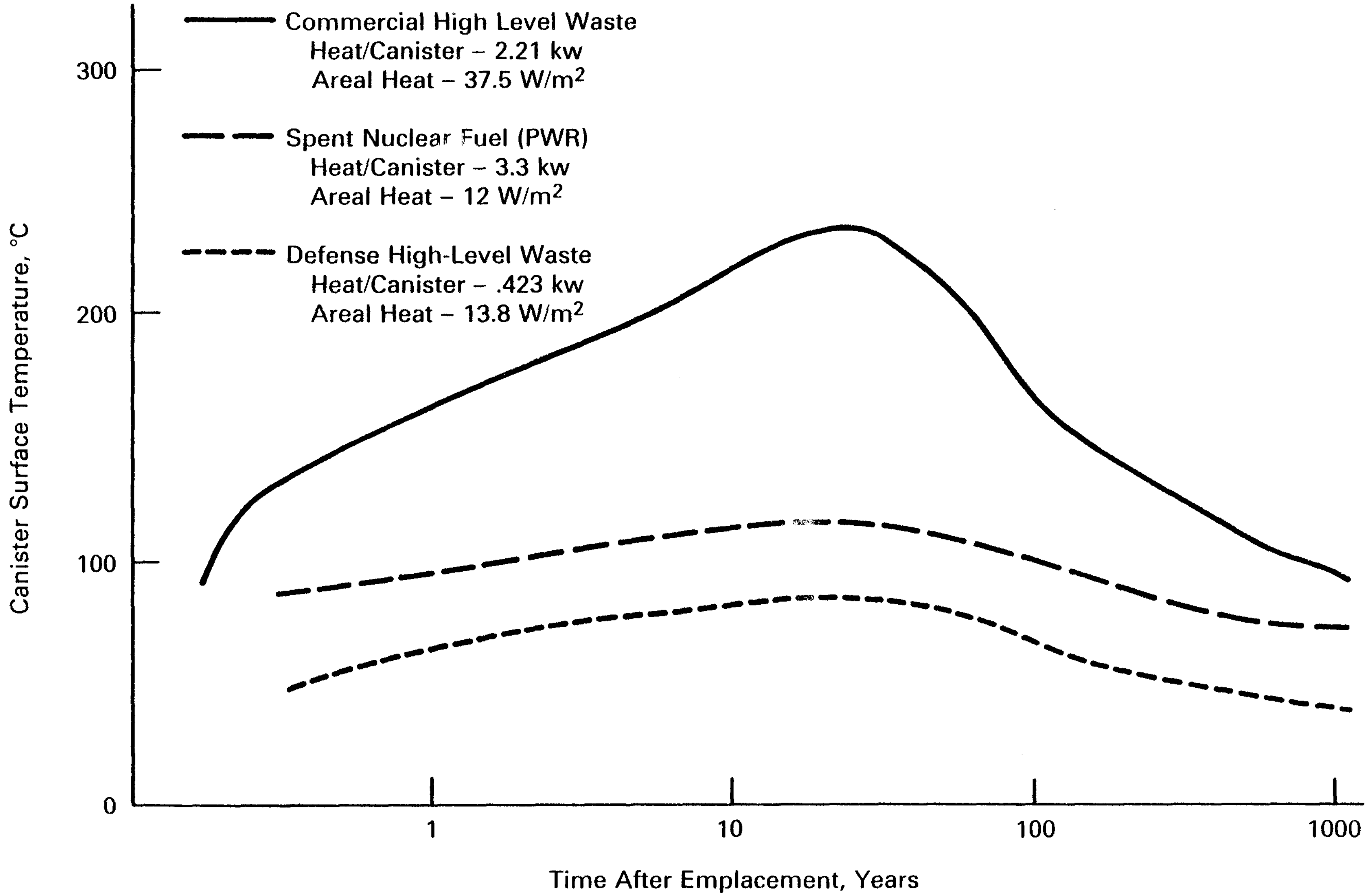
PERFORMANCE REQUIREMENTS FOR A GEOLOGIC REPOSITORY
AS SPECIFIED IN NUCLEAR REGULATORY COMMISSION
REGULATION 10 CFR 60

Paragraph	Performance Requirement
60.131(b) (Concluded)	- protection against dynamic effects of equipment failure and similar events
	- protection against fires and explosions
	- emergency capability
	- utility services under normal and accident conditions
	- periodic inspection testing and maintenance
	- control against criticality conditions under normal and accidental conditions
	- instrumentation and control systems
	- compliance with mining regulations
	- safe shaft conveyances for radioactive waste handling

by increasing solubility of the waste form and reducing the sorbtive capacity of the repository media. High temperature also accelerates corrosion of the waste container (Westinghouse (1983a)).

The spacing of nuclear waste in the repository is limited by one of three considerations: the maximum allowable temperature of the host geologic medium, the maximum allowable temperature in the waste form, or the structural limitations of the underground facility. The determining consideration differs for different types of waste. Figure 2-10 shows the thermal history of the waste container surface that would be expected in salt repositories for commercial high-level waste, spent fuel, and defense high-level waste. In each case, the waste packages are emplaced as close together as permitted by the limiting consideration, and there is no commingling of waste categories. Waste package characteristics on which the thermal histories are based may not represent current or future values. However, the curves do illustrate the characteristic difference in thermal history that could be expected from the different wastes although the absolute values on the curves may be different for actual waste.

In a combined repository containing several kinds of waste, the defense waste could be subjected to a higher temperature environment than would exist in a defense-only repository. However, this temperature differential should not present a technical problem for defense waste and can be adjusted, if necessary, by repository design (spacing of emplacement holes) if desired. Acceptable



Source: Adapted from Westinghouse, 1983a.

FIGURE 2-10

THERMAL HISTORY OF WASTE CATEGORIES AFTER EMPLACEMENT IN A SALT REPOSITORY WITH NO COMMINGLING

containment performance can be assured by appropriate selection of waste package design and repository design.

2.3.4 Transportation of Defense High-Level Waste to a Commercial Repository

Two Federal agencies have regulatory authority for the transportation and packaging of radioactive waste; the Department of Transportation (DOT) and the Nuclear Regulatory Commission (NRC) respectively. The DOT has jurisdiction over all aspects of the transportation required. The NRC prescribes procedures to be followed by NRC licensees and establishes packaging standards to protect the public health and safety.

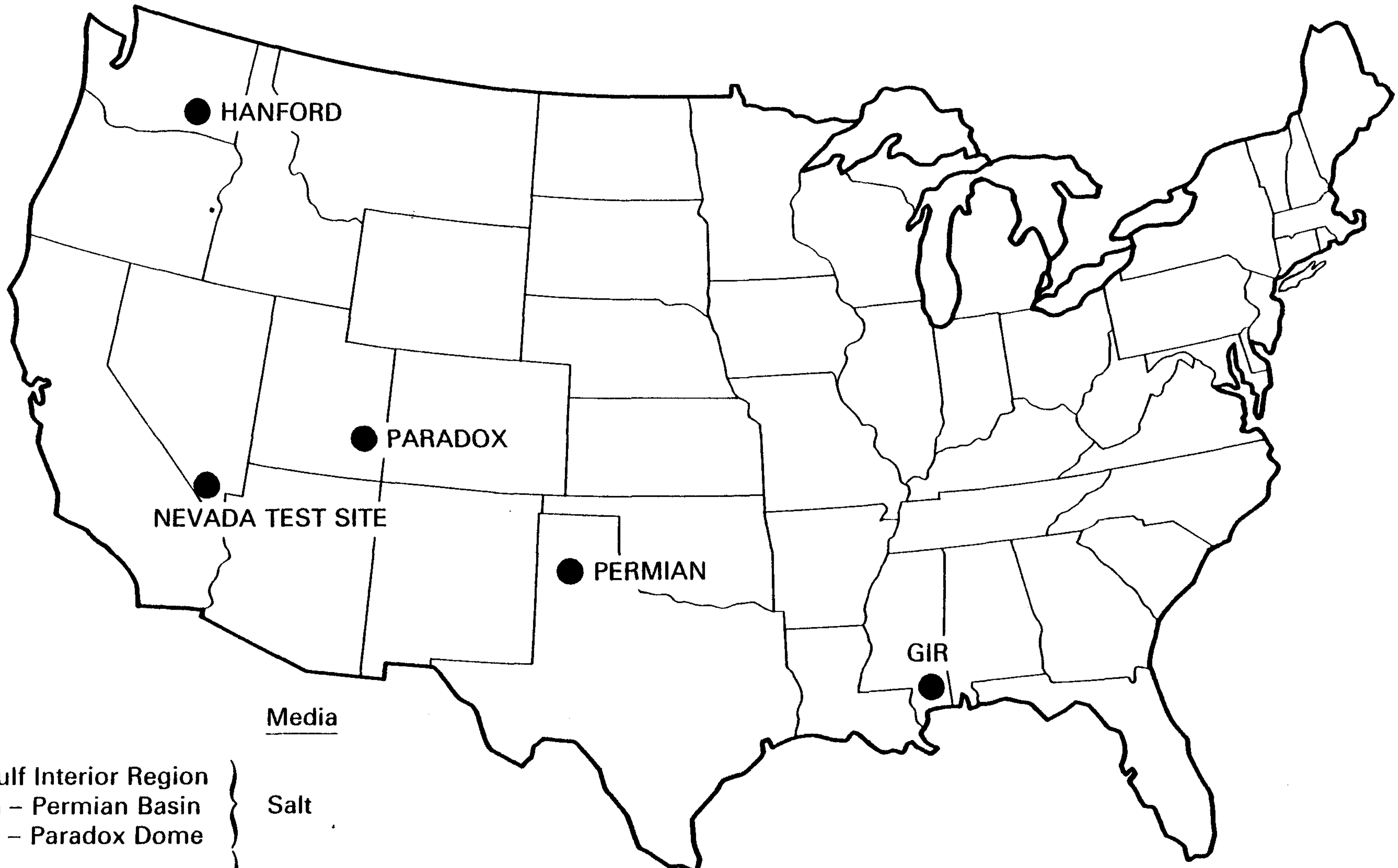
In accordance with the NWPA, all shipments of commercial HLW and spent fuel will be the responsibility of the Office of Civilian Radioactive Waste Management (OCRWM), and will comply with the applicable DOT regulations and NWPA provisions. In addition, under a Procedural Agreement, the DOE has agreed to ship all commercial HLW and spent fuel under the NWPA in NRC certified shipping casks to the extent that such casks are available.

While shipments of DHLW are subject to the DOT regulations, the DOE, under the provisions of the Atomic Energy Act, has the authority to certify its own packagings or casks for the shipment of DOE-owned radioactive materials and waste. The DOE has voluntarily accepted the NRC packaging standards as the basis for their certified program to assure equivalent protection of the public health and safety.

Accordingly, the Department has adopted the policy that any shipments of high-level waste or spent fuel managed by OCRWM will be subject to DOT regulations and will be shipped in NRC certified packagings or casks to the extent they are available. DOE shipment of defense waste managed by the Assistant Secretary for Defense Programs will comply with applicable DOT regulations and will be shipped in DOE certified packagings or casks under existing Departmental procedures.

The cost of transportation of defense high-level waste to a repository site and the risks associated with that transport depend on both the quantity of the waste and the distance that the waste must travel. There are three DOE sites from which defense high-level waste will be shipped: The Savannah River Plant, the Hanford Reservation, and the Idaho National Engineering Laboratory. The repository site to which the waste will be transported has not yet been selected. However, the five potential repository regions, shown in Figure 2-11, have been identified for site specific investigations.

The analysis assumes that a total of 20,000 canisters will be transported from three DOE sites. These wastes will be received on a mutually agreed to schedule such that the rate of receipt of commercial wastes at the repository will not be altered. The information presented below was obtained from the reference by Joy, et al., 1983.



Region		Media
GIR – Gulf Interior Region Permian – Permian Basin Paradox – Paradox Dome	}	Salt
Hanford Nevada Test Site	}	Hard Rock

FIGURE 2-11

LOCATION OF POTENTIAL REPOSITORY REGIONS

Two separate transportation analyses were performed for shipments to each repository region: one assumed that all shipments are made by rail, and a second assumed that all shipments are made by truck. It was assumed that rail transport casks can accomodate five high-level waste canisters and truck casks can accommodate one high-level waste canister.

The total transportation costs for defense high-level waste include the capital and maintenance costs for the casks and carrier transportation charges. The capital and maintenance costs depend on the number of casks required which, in turn, depends on the transportation distance, travel time, cask turnaround time at the repository, the number of canisters transported per trip, and the annual rate of waste transport to the repository. Carrier transportation charges depend on the distance traveled, the weight of the cargo, the mode of transport, and any expenses associated with handling hazardous cargo.

Truck distances were calculated using a computerized routing model (HIGHWAY) which is designed to simulate routes on the highway system in the U.S. under conditions of interest. Routes that might be used for general commerce were used. No routing restrictions were assumed.* The truck routes are symmetric, i.e., the return trip for the empty cask uses the same route as the loaded cask.

*In actual practice, routes selected for transport of defense high-level waste to a specific repository site would have to conform with DOT's final rule on highway routing of large quantity radioactive material shipments (DOT Docket HM-164).

Rail distances were calculated using a railroad routing model (INTERLINE) which is designed to simulate routing on the railroad system. No routing restrictions were imposed. All rail shipments were assumed to travel as general freight between the origin and destination. In general, rail routes are not symmetrical because the originating railroad tries to maximize the distance traveled on its own right of way.

Assumptions used in the calculation were as follows:

- o The canisters will be shipped in a heavily shielded cask. The truck cask weighs 50,000 lbs loaded and 45,500 lbs empty. The rail cask weighs 200,000 lbs loaded and 177,500 lbs empty.
- o Truck shipments travel at an average speed of 35 mph. Rail shipments average 3 mph for short hauls and 12 mph across country.
- o The total time for loading a cask at the generating site and unloading the cask at the repository is five days for rail casks and three days for truck casks.
- o Shipping casks are available 300 days per year.
- o The annual shipping rate will ultimately approximate the annual rate of production at defense facilities.

The routing and logistic analysis showed that the number of truck casks required ranges from 21 to 24, depending on location of the repository. In the case where only rail transport is used, the number of rail casks required ranges from 16 to 18.

Transportation costs for either all rail or all truck transport are summarized in Table 2-11. The table shows that the mode of transport has a significant effect on the total transportation

TABLE 2-11

SUMMARY OF COSTS OF TRANSPORTING DEFENSE HIGH-LEVEL WASTE TO A REPOSITORY SITE

Destination	Cost*, Millions of 1984 Dollars	
	20,000 Canisters	
	Truck	Rail
Hanford	162	257
Nevada Test Site	148	257
Paradox Basin	138	219
Permian Basin	105	223
Gulf Interior Region	110	203

*Assumes use of a single mode of transport, all truck or all rail.

cost. Transport by rail is more costly, varying between 1.6 and 2.0 times the cost of truck transport to the same location. This is due mainly to much slower rail speeds and more constraints on routing.

There are two categories of risk associated with the transport of high-level waste: (1) the nonradiological risks which occur independent of the nature of the waste; and (2) the radiological risks which are determined by the nature of the waste and its packaging.

The nonradiological risks include the health impacts to the general population from pollutant emissions, e.g., emissions from diesel engines, and impacts to both the public and the workers from transportation related accidents. The radiological risks are the health impacts to workers and the general population from potential exposure to radiation during transport or in the event of an accident.

Table 2-12 presents the nonradiological impacts expected from transportation of defense high-level waste for the scenarios considered. Accidents, resulting in fatalities and injuries, account for nearly all of the nonradiological fatalities. In general, the number of nonradiological fatalities due to transport of high-level waste to a repository over the 25 years of its operating life is less than 10^{-4} of the truck and rail fatalities predicted in the United States from other activities during this period of time. In 1980 there were 2,528 truck fatalities and 1,242

TABLE 2-12

ESTIMATED NONRADIOLOGICAL IMPACTS FOR TRANSPORTATION OF DEFENSE HIGH-LEVEL WASTE

Destination	Waste Quantity (MTHM)	TRUCK					RAIL				
		Workers		Population			Workers		Population		
		Accident Related		Pollution Related	Accident Related		Accident Related		Pollution Related	Accident Related	
		Injuries	Fatalities	Fatalities	Injuries	Fatalities	Injuries	Fatalities	Fatalities	Injuries	Fatalities
Gulf Interior Region	10,000	1.8	0.9	0.07	53	3.3	3.3	0.02	0.02	0.6	0.3
Permian Basin	10,000	2.1	1.0	0.08	59	3.7	3.9	0.03	0.03	0.7	0.4
Paradox Basin	10,000	2.3	1.2	0.09	65	4.1	3.9	0.03	0.03	0.7	0.3
Nevada Test Site	10,000	2.7	1.4	0.1	77	4.8	4.8	0.04	0.03	0.8	0.4
Hanford	10,000	2.8	1.4	0.1	80	5.0	4.9	0.04	0.03	0.9	0.4

rail fatalities; at this rate there would be over 94,000 fatalities in a 25-year period of which fewer than 10 would be related to transport of high-level waste to a repository.

The radiological impacts of the transportation scenarios were also considered. Impacts to the crew depend on the number of crew members, the distance between the crew and the waste package, package dimension, velocity of travel, and exposure rate. Impacts to the population are calculated by combining impacts to people at places where a shipment stops, in vehicles sharing the transport route with a shipment, and within 800 meters surrounding the transport route while a shipment is moving. Impacts to both pedestrians and persons in buildings along the route while the transport is moving and while stopped are also included.

Impacts from accidents depend on the probability of an accident per mile of travel, the number of miles traveled, the quantity of radioactivity involved, the severity of the accident, and the accident location. Only very severe accidents would result in any exposure at all. Because transportation casks are designed to survive extremely severe accidents without serious consequences, the probability of accidents resulting in health effects is very small as seen in Table 2-13.

2.3.5 Public Acceptability of Disposal of Defense High-Level Waste in a Commercial Repository

The issue of public acceptability of disposal of defense high-level waste in a commercial repository has been discussed in

TABLE 2-13

ESTIMATED NUMBER OF RADIOLOGICAL HEALTH EFFECTS[(a)]
FROM TRANSPORTATION OF DEFENSE HIGH-LEVEL WASTE

Destination	Waste Quantity (MTHM)	TRUCK			RAIL		
		Normal		Accident	Normal		Accident
		Workers	Population	Population	Workers	Population	Population
Gulf Interior Region	10,000	0.2	1.1	0.001	0.001	3.7	0.002
Permian Basin	10,000	0.3	1.2	0.001	0.001	3.9	0.002
Paradox Basin	10,000	0.3	1.3	0.001	0.001	4.3	0.002
Nevada Test Site	10,000	0.3	1.6	0.002	0.001	5.3	0.003
Hanford	10,000	0.4	1.7	0.004	0.001	5.4	0.003

(a) Based on 200 health effects per million person-rem of exposure the U.S. Congress. From the Congressional record and other sources of opinions of the public on this issue, one may only speculate on the potential reaction of the public. This would be based on a knowledge of public interests and positions that would influence the acceptability of the disposal option. The actual stand that the public takes may also be influenced by the manner in which the Federal Government deals with the institutions and public segments involved in the repository development program.

This analysis has assessed the probable or likely positions that specific segments of the public will take with regard to this disposal option. The analysis is based on the information presented by Nealy, et al. (1983). The public institutions and groups that have been examined are:

- o Federal Agencies
- o States (Governors and Legislatures) and Indian Tribes
- o Local Officials
- o Nuclear Utilities and Pro-Nuclear Groups
- o Nuclear Critics
- o Citizen Groups and the General Public

A major concern within the Federal Government will be that sufficient technical information exists to make sound regulatory and licensing decisions. The attention of regulatory agencies will be focused on the question of whether colocation meets all applicable standards. This disposal option may be seen as one more complicating factor, especially if the packaging and emplacement techniques differ for defense and commercial wastes. Questions may also be raised about the level of confidence which can be placed on the technical analysis supporting licensing decisions. Several Federal agencies may favor this disposal option as the low cost option. However, if added complexity would cause delay in establishment of a repository, some Federal agencies may not favor it.

It is difficult to generalize about State, local government and Indian Tribe attitudes concerning the disposal of defense waste in a commercial repository. The officials in whose jurisdiction the commercial repository resides will assess their perceived gains and losses before taking a position on the issue.

These officials may be particularly concerned about the relative economic impacts and benefits to their jurisdiction as well as the perception of increased health and safety risks to the local populace posed by the addition of defense waste to a commercial repository. If the addition of defense waste to the repository results in more waste shipments through the area, it may cause increased traffic congestion and increase the potential for accidents to occur; thereby increasing the health and safety risks to the public. There may be concern about the possibility of groups holding disruptive demonstrations with attendant negative publicity. On the other hand, economic benefits would include additional jobs, impact assistance, and increased business activity.

Nuclear utilities and other pro-nuclear groups may be opposed to delay in establishing a repository. In addition, the utilities may be concerned about the fairness of the cost allocation arrangements. The issue of placing defense waste in the commercial repository can be perceived as another complicating factor which is likely to cause delay in establishing a repository. The possibility of demonstrations against transportation of defense waste may also be of concern.

Nuclear critics will give careful scrutiny to any repository proposal. They may be expected to litigate for the lowest risk option even if all options comply with standards. Thus, the issue of disposal of defense high-level waste in a commercial repository may become a focus for activities which would delay the licensing process because of the multiple waste forms and the perception of greater complexity even though the heat levels and radioactivity levels of defense waste may be lower than commercial waste.

Among citizen groups and the general public, the issue of colocation of defense waste in a commercial repository may create confusion and misunderstanding since two types of waste are involved. Concerns will be voiced about safe management and about the increase in the number of waste shipments passing through their locality on the way to the repository. Local citizens may also raise the question of geographic equity. They may ask: "Why should we accept both commercial and defense wastes? Why shouldn't other regions do their share?" Similar concerns may be expressed by State and local officials. These concerns may be heightened if those near the repository site perceive that they gain few benefits from commercial or defense nuclear activities.

2.3.6 National Security for Disposal of Defense High-Level Waste in a Commercial Repository

This section addresses two key national security issues and the analysis of those issues that have arisen in the consideration of the disposal of defense high-level waste in a commercial geologic repository.

The issues which have been addressed are:

- o There must be no interruption of or delay or NRC involvement in the defense material production process or nuclear weapons activities.
- o There must be no disclosure of classified information.

Each of these is discussed below.

Interruption or shutdown of a defense production or utilization facility because of waste buildup problems could develop if the opening of the repository were delayed, if the repository accepted high-level waste at less than the expected rate, or if the repository were to be closed for regulatory or technical reasons. Shutdown or interruption of defense production or utilization facilities could also occur because of in-plant regulatory requirements and/or inspections imposed by geologic repository requirements on waste form preparation. There is also concern that

NRC regulation of a disposal system at a geologic repository might reflect back into the production system to create an interruption or shutdown of production operations.

The following two courses of action are being considered to avoid the possibility of an interruption or shutdown. First, sufficient interim waste storage would be provided to permit continued operation of production or immobilization facilities in the event of shutdowns or delays in the operation of the geologic repository. Interim storage for defense high-level waste has been provided at the three DOE generating sites. At the Savannah River Plant, the Defense Waste Processing Facility (DWPF), scheduled for operation in 1989, will include interim storage for immobilized glass waste forms. The designs of immobilization plants at the other DOE sites also include provision for interim storage capacity. It may be possible to anticipate future interim storage requirements and, if necessary, additional storage capacity could be made available if the geologic repository was delayed.

Second, DOE and NRC will engage in a thorough technological exchange during all stages of waste form and repository developments. DOE has initiated and continues contact with the NRC staff to ensure that the NRC has a full understanding of and opportunities to review DOE defense plans to produce immobilized glass waste forms.

It should be made quite clear that Section 202(4) of the Energy Reorganization Act of 1974 does not authorize any NRC involvement in nuclear defense activities.

Disclosure of classified defense information during the disposal of defense high-level waste is the other issue that could adversely affect national security. The processes used to immobilize defense high-level waste for disposal and the quantity and characteristics of the solidified waste produced are unclassified. A small percentage of the defense waste in storage tanks is classified. There will probably be classified waste in the future. All classified waste will be handled separately and appropriately until mixed with other wastes resulting in a composition that is unclassified prior to vitrification.

Data on the amount and composition of current defense materials production programs are usually classified. However, the time delay between the creation of waste materials and vitrification and the act of mixing waste streams from several points in the process into large waste storage tanks creates a mixture that is unclassified. Information on the composite inventories of wastes at each of the three DOE high-level waste sites is updated annually in an unclassified report on radioactive waste inventories (DOE, 1983b).

Since the waste inventory is unclassified and the subsequent immobilization steps at each of the three DOE sites will be unclassified, immobilized waste destined for a repository will not reveal classified information. In addition, DOE foresees no reason for the licensing or regulating of a geologic repository to require access to classified defense information.

3.0 DISPOSAL OF DEFENSE HIGH-LEVEL WASTE IN A DEFENSE-ONLY REPOSITORY

This section presents a summary of information concerning the disposal of defense high-level waste in a defense-only repository. First, a description of the major legislative requirements is presented. Second, a brief description of the design and operational characteristics of a defense-only repository is given. Finally, each of the factors of evaluation are described with respect to this disposal option.

3.1 Legislative Requirements

The statutes which affect the management of defense high-level waste are:

- Atomic Energy Act of 1954 (as amended)
- Energy Reorganization Act of 1974
- Department of Energy Organization Act of 1977
- Federal Land Policy and Management Act of 1976
- Nuclear Waste Policy Act of 1982

The first four statutes were discussed earlier in Sections 1.1 and 2.1 and, therefore, will not be discussed further. The part of the last statute which deals explicitly with a defense-only repository is discussed below.

Section 8(b)(3) of the Nuclear Waste Policy Act of 1982 states that

> "any repository for the disposal of high-level radioactive waste resulting from atomic energy defense activities only shall (A) be subject to licensing under section 202 of the Energy Reorganization Act of 1974 (42 USC 5842); and

(B) comply with all requirements of the (Nuclear Regulatory) Commission for the siting, development, construction, and operation of a repository."

The Act also states that before proceeding with any site-specific investigations for a defense-only repository, the Secretary of Energy shall notify the Governor and legislature of the State in which such repository is proposed to be located, or the governing body of the affected Indian Tribe on whose reservation such repository is proposed to be located, as the case may be, of the decision to develop such a repository (Section 101(a)). Following the notification, the State or Indian Tribe involved is entitled to the same rights of consultation and cooperation as in the case of development of a commercial repository (Section 101(b)). Financial assistance to an affected State or Indian Tribe for consultation and cooperation activities and for impact mitigation is to be made from amounts appropriated to the Secretary of Energy for that purpose (Section 101(b)). Procedures for site selection and characterization leading to a license for a commercial repository as stated in Sections 112 through 114 of the Act do not apply to a defense-only repository. However, 10 CFR 60 contains procedures for site characterization that are similar to those of the Act and these do apply to a defense-only repository.

The Act also specifically states that "Nothing in this Act shall require the release or disclosure to any person or to the Commission of any classified national security information" (Section 7).

3.2 Design and Operational Characteristics of a Defense-Only Repository

The design and operational characteristics of a defense-only repository will, in most respects, be similar to those of a commercial repository. Differences are that a defense-only repository would be smaller in size since it would contain a smaller quantity of waste, and it would not handle transuranic waste because defense transuranic waste will be disposed of in the Waste Isolation Pilot Plant authorized by Congress under Public Law 96-164.

3.3 Characterization with Respect to Areas of Evaluation

The following sections analyze the option for disposal of defense high-level waste in a defense-only repository with respect to each of the six factors of evaluation.

3.3.1 Cost Efficiency for Disposal of Defense High-Level Waste in a Defense-Only Repository

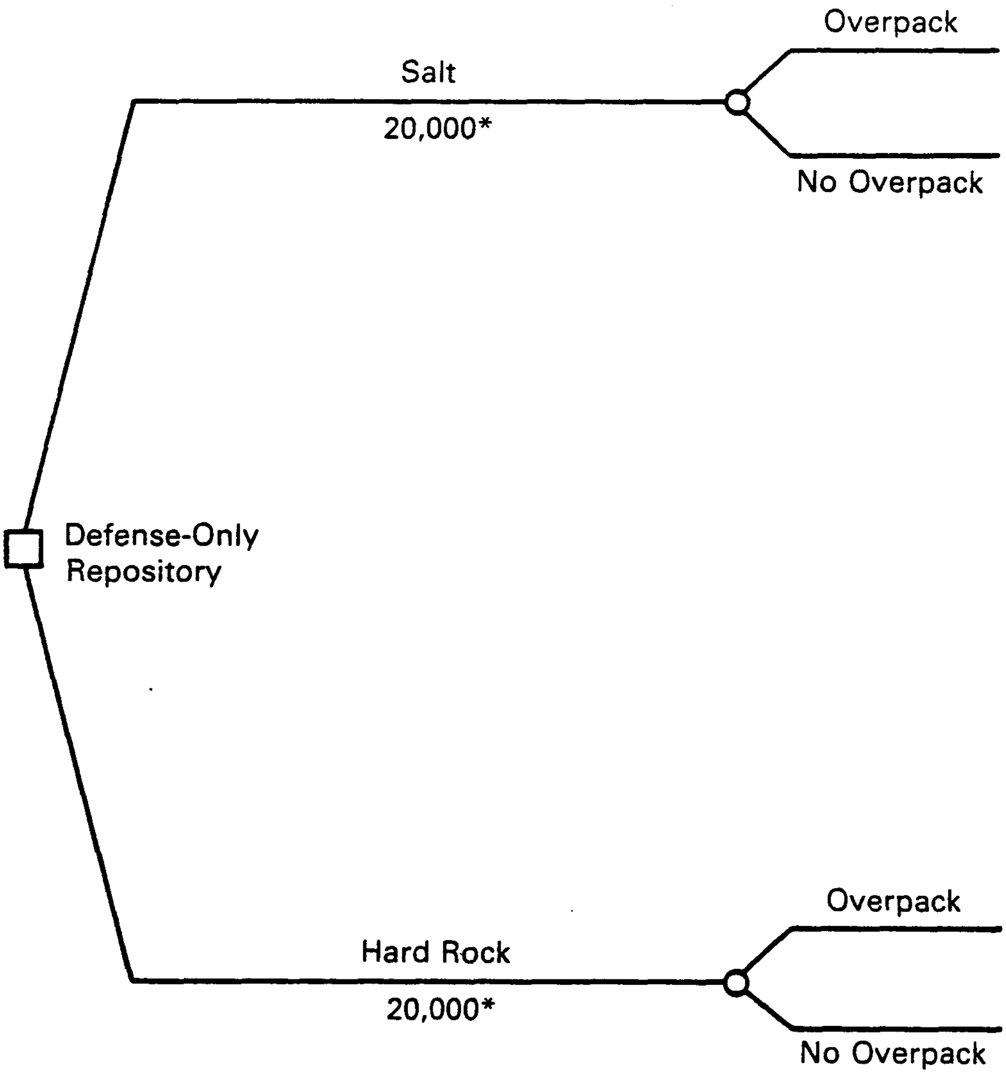
The same variables were considered for disposal in a defense-only repository as in a commercial repository, and similar considerations govern the cost estimates. Information in this section was obtained from the reference by Lazur, 1983. A cost estimating model for mining operations was used to calculate the capital cost of a defense-only repository, including engineering, project management, and contingency. The capital cost model was calibrated using known cost data for similar facilities.

Operating costs were based on estimated manpower requirements and wages for similar operations at other defense facilities. Total operating costs were assumed to be twice the labor cost. Decommissioning costs were assumed to be a fixed 20 percent of initial capital costs. Site acquisition and improvement costs were made consistent with the costs used for the commercial repository cost estimates.

Costs were developed for each of four disposal options for defense high-level waste in a defense-only repository. These options are depicted schematically in Figure 3-1. The resulting cost estimates are presented in Table 3-1. The costs for disposal of defense high-level waste in a defense-only repository are summarized in Table 3-2.

The tables show that for the no overpack option, the cost of a salt repository is less than the cost of a hard rock repository. However, if an overpack is required, the less expensive overpack required in hard rock reduces the cost of a defense only hard rock repository to slightly below that of a salt repository.

Some of the development and evaluation activities associated with a defense-only repository are the same as those associated with a commercial repository. The D&E cost for a defense-only repository would be less than for a commercial repository because some provisions in the NWPA do not apply to a defense-only repository, e.g. site nomination procedures. However, similar costs would be incurred for site characterization and State and Indian Tribe



*Number of defense high-level waste packages

FIGURE 3-1

OPTIONS CONSIDERED FOR THE DISPOSAL OF DEFENSE HIGH-LEVEL WASTE IN A DEFENSE-ONLY REPOSITORY

TABLE 3-1

DEFENSE-ONLY REPOSITORY COSTS
(Millions of 1984 Dollars)

	Hard Rock Repository With 20,000 Canisters								Salt Repository With 20,000 Canisters							
	without overpack				with overpack				without overpack				with overpack			
	Cap.	Op.	Decom.	Total	Cap.	Op.	Decom.	Total	Cap.	Op.	Decom.	Total	Cap.	Op.	Decom.	Total
Waste Preparation System																
Waste Packaging/Receiving Facility and Ventilatiion Structures	427	-	86	-	441	-	89	-	427	-[a]	86	-	441	-	89	-
Waste Package Components[b]	-	-	-	-	-	438	-	-	-	-	-	-	-	714	-	-
Subtotal Waste Preparation	427	-	86	-	441	-	89	-	427	-	86	-	441	-	89	-
Repository System																
Site																
Land and Land Rights	0	-	-	-	0	-	-	-	17	-	-	-	17	-	-	-
On-Site Improvements	83	-	-	-	83	-	-	-	44	-	-	-	44	-	-	-
Off-Site Improvements	240	-	-	-	240	-	-	-	17	-	-	-	17	-	-	-
Shafts	77	-	-	-	77	-	-	-	104	-	-	-	104	-	-	-
Underground Workings/ Rock Handling	195	-	-	-	195	-	-	-	168	-	-	-	168	-	-	-
Support and Utilities	29	-	-	-	29	-	-	-	29	-	-	-	29	-	-	-
Subtotal Repository System	624	-	87	-	624	-	88	-	379	-	87	-	379	-	87	-
Total Cost	1051	1244	173	2468	1065	1720	177	2962	806	1244	173	2223	820	2037	176	3033

Cap. = Capital (Construction)
Op. = Operating
Decom. = Decommissioning

[a] Separate value not determined, amount included in total cost line unless otherwise noted
[b] An operating cost only; cost incurred only if overpack is used.

TABLE 3-2

SUMMARY OF COSTS FOR DISPOSAL OF DEFENSE HIGH-LEVEL WASTE IN A DEFENSE-ONLY REPOSITORY UNDER VARIOUS SCENARIOS

		(Cost, Millions of 1984 Dollars)	
		Geologic Media	
Repository Capacity No. of Waste Canisters	Packaging Option	Salt	Hard Rock
20,000	Without overpack	2,223	2,468
20,000	With overpack	3,033	2,962

NOTE: The costs shown above do not include costs for waste transportation or development and evaluation. This cost is assumed to be the same for all the scenarios (see text).

participation and consultation activities which are the same for development of any repository.

3.3.2 Health and Safety Impacts of Disposal of Defense High-Level Waste in a Defense-Only Repository

This section provides an analysis of the health and safety impacts of disposal of defense high-level waste in a defense-only repository. As is the case for a commercial repository, a defense-only repository must satisfy the requirements of the NRC's 10 CFR 20 and 10 CFR 60 and EPA's proposed 40 CFR 191 during both the operational and post-closure phases. The health and safety impact analysis for the defense-only repository was performed using the same methodology described in Section 2.3.2 for the commercial repository. The reader is referred to the report by Kocher, et al., 1984 for further information. Therefore, the detailed discussion of the assumptions underlying the analysis will not be repeated here. Both long-term and short-term health and safety impacts of disposal of defense high-level waste in a defense-only repository are addressed in the following discussion.

3.3.2.1 Long-Term Effects. The long-term health impacts of disposal of defense high-level waste in a defense-only repository were evaluated for the no overpack option. The reason for this is that temperatures in the defense-only repository are essentially stable after the assumed 300-year life of the defense waste package without an overpack. The major reason for requiring an overpack is to assure containment of the waste during the period of thermal instability which may be up to 1,000 years in the commercial repository. The temperature in the defense-only repository after 300 years is expected to be between 50 and 60^{o}C. The potential release rate of the defense waste due to water leaching in this temperature range would be approximately 10^{-6} year^{-1}.

The analysis showed that defense waste in a defense-only repository can be expected to exhibit a lower release of radionuclides to the environment than defense waste in a commercial repository. However, differences among the defense waste disposal scenarios in this regard were never larger than a factor of 5, and are largely attributable to assumed differences in waste release rates due to leaching at different temperatures. Those differences are much less than uncertainties that would be associated with a realistic repository performance assessment, particularly if one is comparing the health and safety aspects of disposal at two different sites. Since, as stated in Section 2.3.2.1, it has been shown that under more realistic assumptions there would be no releases of radioactivity from a commercial repository during the first 10,000 years following repository decommissioning, the health and safety impacts of disposal of defense high-level waste in a defense-only repository can be considered to be the same as for disposal of defense waste in a commercial repository.

3.3.2.2 Short-Term Effects. Table 3-3 gives estimates of the health and safety impacts expected from construction of a defense-only repository. No significant health impacts should result from non-radiological pollutant emissions if dust emissions are controlled. No health effects from released radionuclides are expected to occur to workers or the surrounding population from construction of the defense-only repository.

Table 3-4 gives estimates of the health and safety impacts of operation of a defense-only repository. Except for carbon monoxide emissions, the total quantities of air pollutants emitted during operation are greater than during construction. However, it is assumed that air quality standards are met, and therefore, no health effects are expected from pollutant emissions.

Radiological emissions from radon and its decay products and from occasional decontamination of waste canisters during repository operation are not expected to have any appreciable impact on the population. Worker exposure to radiation during waste receiving, handling, and emplacement is small, and as a result, less than one radiological health effect is expected among workers over the operating life of the repository.

As in a commercial repository, the most severe accident which might occur in the defense-only repository is the dropping of a canister down the repository mine shaft. The frequency of such accident, 10^{-5} per year, however, is considered low.

TABLE 3-3

SHORT-TERM HEALTH AND SAFETY IMPACTS ASSOCIATED WITH CONSTRUCTION OF A DEFENSE-ONLY REPOSITORY

Quantity of Waste (MTHM)	Health Impacts									Safety Impacts			
	Non Radiological					Radiological (person-rem)[d]				Non Radiological[f]			
	Pollutant Emissions, MT[a]					Salt		Hard Rock		Salt		Hard Rock	
	CO	HC[b]	NO_x	SO_x	Part[c]	Workers	Population	Workers	Population[e]	Disabling	Fatalities[h]	Disabling[g]	Fatalities[h]
10,000	1,550	71	290	18	18	0.035	0.0014	420	5.0	86	1.7	124	2.5

(a) Total metric tons over construction period. Estimated for construction of a spent fuel repository in salt; emissions at a hard rock repository are estimated to be 20 percent greater.
(b) Hydrocarbons.
(c) Particulates.
(d) 70-year whole-body dose commitments; based on construction of spent fuel repositories, there are 200 health effects per million person-rem.
(e) Surrounding population out to 80 km is two million persons.
(f) Estimated from data for construction of a spent fuel repository.
(g) Based on rates of 13.6 and 25 injuries per million person hours for construction of surface facilities and underground mining respectively.
(h) Based on rates of 0.17 and 0.53 fatalities per million person hours for construction of surface facilities and underground mining respectively.

TABLE 3-4

SHORT-TERM HEALTH IMPACTS ASSOCIATED WITH OPERATION OF A DEFENSE-ONLY REPOSITORY

Waste Quantity MTHM	Non Radiological					Radiological	
	Pollutant Emissions, MT[a]						
	CO	HC[b]	NO	SO	Part[c]	Total Person-Rem[d]	Health Effects[e]
10,000	500	170	2,940	1,900	84	900	0.18

[a]Total metric tons during operational phase of repository, estimated for operation of a repository in salt; emissions at a hard rock repository site would be about 40 percent lower

[b]Hydrocarbons

[c]Particulates

[d]For duration of operational phase (25 years).

[e]Based on one health effect per 5000 man-rem.

3.3.3 Regulation of Disposal of Defense High-Level Waste in a Defense-Only Repository

A defense-only repository will be subject to the same NRC regulations (10 CFR 60) as the commercial repository. Also, the Nuclear Waste Policy Act of 1982 specifies several additional procedural rules for establishment of a defense-only repository. However, these are much fewer in number and detail than for establishment of a repository for commercial nuclear waste. A summary of the procedural rules for establishment of a defense-only repository is presented in Table 3-5.

As stated in Section 2.3.3, the technical part of the NRC regulation permits adjustment of the engineered barrier system and geologic setting requirements to account for the effect of waste characteristics and the repository ambient conditions. For example, the thermal characteristics of defense high-level waste are such that regulatory considerations may allow use of a lower cost overpack or no overpack for defense waste in a defense-only repository. However, the applicable regulations on repository performance can be met in either a defense-only repository or in a combined repository.

3.3.4 Transportation of Defense High-Level Waste to a Defense-Only Repository

The costs and health and safety impacts of transporting defense high-level waste to five prospective regions for a commercial geologic repository have been described in Section 2.3.4. Since there are no assumed differences in regulatory requirements or

TABLE 3-5

PROCEDURAL RULES FOR ESTABLISHMENT OF A DEFENSE-ONLY REPOSITORY

Activity	Procedural Step	Governing Law or Regulation
Decision to establish a defense-only repository	o President conducts evaluation and finds that development of a defense-only repository is required	NWPA - Section 8(b)(2)
Site selection	o At least 3 sites representing two geologic media, at least one of which is not salt must be characterized for purposes of comparative evaluation to satisfy NEPA	10 CFR 51.40(d)
	o DOE submits site characterization report to NRC prior to site characterization	10 CFR 60.11
	o NRC prepares site characterization analysis and submits same to DOE	10 CFR 60.11(d)(e)
	o DOE submits semi-annual progress reports to NRC during site characterization	10 CFR 60.11(g)
Construction authorization and license	o Following site characterization and selection of a site for the repository, the Secretary of DOE submits an application for a license accompanied by an environmental report	10 CFR 60.22

TABLE 3-5 (Continued)

PROCEDURAL RULES FOR ESTABLISHMENT OF A DEFENSE-ONLY REPOSITORY

Activity	Procedural Step	Governing Law or Regulation
Construction authorization and license (Concluded)	o NRC prepares environmental impact statement in conjunction with review and consideration of the application	10 CFR 51.5(a)(11)
	o NRC may authorize construction	10 CFR 60.31
	o The DOE is required to update its application in a timely manner so as to permit Commission review prior to issuance of a license	10 CFR 60.24(b) 10 CRF 60.32(d)
	o A license to receive and possess nuclear materials at the geologic repository operations area may be issued by the NRC upon finding that conditions specified in 10 CFR 60.41 are met	10 CFR 60.41
Consultation and cooperation by States, affected Indian Tribes, and public	o The Secretary of DOE must seek to enter into binding written agreement with State or affected Indian Tribe regarding procedures for consultation and cooperation	NWPA - Section 101(b) Section 117(c)

TABLE 3-5 (Continued)

PROCEDURAL RULES FOR ESTABLISHMENT OF A DEFENSE-ONLY REPOSITORY

Activity	Procedural Step	Governing Law or Regulation
Consultation and cooperation by States, affected Indian Tribes, and public (Concluded)	o Secretary of DOE must notify State or affected Indian Tribe* prior to proceeding with site specific investigations	NWPA - Section 101(a)
	o NRC must notify affected State and locality or affected Indian Tribe upon receipt of site characterization report and provide opportunity for consultation	10 CFR 60.11(c),(e) 10 CFR 60.61
	o State or affected Indian Tribe may submit notice of disapproval of site to Congress	NWPA - Sections 101(b), 115(b), 116(b), 118(a)
	o Congress may override disapproval notice by joint resolution, otherwise disapproval stands	NWPA - Section 101(b) Section 115(c)
	o The license application and accompanying reports are to be made publicly available. Public hearings may be held on any Environmental Impact Statement prepared by NRC in connection with its consideration of the application	10 CFR 51.52

*Notification is to be made to "The Governor and legislature of the State in which such repository is proposed to be located, or the governing body of the affected Indian Tribe on whose reservation such repository is proposed to be located ..."

TABLE 3-5 (Concluded)

PROCEDURAL RULES FOR ESTABLISHMENT OF A DEFENSE-ONLY REPOSITORY

Activity	Procedural Step	Governing Law or Regulation
Scheduling	o State or affected Indian Tribe may submit notice of disapproval of site to Congress within 60 days	NWPA - Sections 101(b), 115(b), 116(b), 118(a)
	o Congress may override disapproval notice within 90 days of continuous session	NWPA - Section 101(b) Section 115(c)
Funding	o Financial assistance to States and Indian Tribes to be paid from funds appropriated to Department of Energy	NWPA - Section 101(b)

transport distances for transportation to a defense-only repository located in any of these same regions, the same transportation costs and impacts apply to a defense-only repository.

3.3.5 Public Acceptability of Disposal of Defense High-Level Waste in a Defense-Only Repository

As in the case of disposal of defense high-level waste in a commercial repository (see Section 2.3.5), the probable positions that specific segments of the public will take with regard to the disposal of defense high-level waste in a defense-only repository have been assessed. This analysis is based on the information presented by Nealy, et al. (1983). The public institutions and groups that have been examined are:

- Federal Agencies
- States (Governors and Legislatures) and Indian Tribes
- Local Officials
- Nuclear Utilities and Pro-Nuclear Groups
- Nuclear Critics
- Citizen Groups and the General Public

As in the case of the colocation option, a major concern within the Federal Government will be that sufficient technical information exists to make sound regulatory and licensing decisions. A valid concern is that a combined repository has multiple waste forms, i.e., defense high-level waste, commercial high-level waste and spent fuel, whereas a defense-only repository has just one waste form, defense high-level waste. It is possible that the defense-only option will be perceived as presenting the least technical challenge, especially if the differences in defense and commercial high-level waste are clearly highlighted. This may make the licensing process less complex. Fewer questions may also be raised about the level of confidence which can be placed on the technical analysis supporting licensing decisions. Several Federal agencies may not favor this disposal option on the basis of cost.

It is difficult to generalize about State and Indian Tribe attitudes concerning disposal of defense waste in a defense-only repository. As in Section 2.3.5, States or Indian Tribes will carefully examine the risks and any economic impacts and benefits they may derive before taking a position on the issue.

If there is a strong likelihood of some kind of geologic repository being established in the locale, then the defense-only repository might be seen as having a lower impact because of its smaller size and lower total radioactivity content.

Nuclear utilities and other pro-nuclear groups, opposed to delay in establishing a commercial repository, may support a defense-only repository in the belief that it will keep defense waste out of the commercial repository, thereby possibly removing an obstacle to the establishment of the commercial repository.

Nuclear critics may give careful scrutiny to any repository proposal. As in the colocation option, they may be expected to litigate for the lowest risk option even if all options comply with standards. If they perceive that the standards for a defense-only repository are less stringent than for a commercial repository, this option may become a focus for activities which could delay the licensing process.

Among citizen groups and the general public, concerns may be voiced about safe management and about differences in standards. As expressed in Section 2.3.5, local citizens may also raise the question of geographic equity. They may ask: "Why should we accept defense wastes? Why shouldn't other regions do their share?" Similar concerns may be expressed by State and local officials.

3.3.6 National Security for Disposal of Defense High-Level Waste in a Defense-Only Repository

The two key national security issues that arise in consideration of disposal of defense high-level waste in a defense-only repository are the same as discussed previously in Section 2.3.6, namely:

- There must be no interruption or shutdown of a defense production or utilization facility because of regulatory or technical difficulties related to the repository.
- There must be no disclosure of classified information.

For a full discussion and analysis of the issues, the reader is referred to Section 2.3.6.

It was concluded that there need be no difference from a national security standpoint as to whether defense high-level waste is disposed of in a defense-only repository or in a commercial repository.

4.0 COMPARISON OF THE DISPOSAL OPTIONS

This section presents a comparison of the two disposal options with respect to the six factors of the evaluation.

4.1 Cost Efficiency

The range of estimated costs for the various repository types and capacities is shown in Table 4-1.

The development and evaluation costs for the repositories are not included in the cost estimates. These costs are estimated to be $4 billion dollars for the commercial repository. The D&E costs for the commercial repository will not change significantly if defense waste is disposed of in the repository. The D&E costs for a defense-only repository are expected to be less than for a commercial repository because some activities required for a commercial repository by the Nuclear Waste Policy Act of 1982 are not required for a defense-only repository.

The table shows that a single repository containing both commercial radioactive waste and defense high-level waste has a lower cost than two separate repositories, one of which contains commercial radioactive waste only, and the second of which contains defense high-level waste only. A single repository containing both commercial and defense high-level waste is shown to have construction, operating and decommissioning costs on the order of $1.5 billion dollars less than two separate repositories. When D&E costs are considered, the cost advantage of disposing of defense waste in

TABLE 4-1

SUMMARY COMPARISON OF COSTS FOR GEOLOGIC DISPOSAL OF HIGH-LEVEL WASTE

Repository Type and Capacity	Total Cost,[a] billions of 1984 dollars Minimum	Maximum
Reference Commercial Repository, (70,000 MTHM)[b,c]	5.5	6.4
Reference Defense-Only Repository, (10,000 MTHM)	2.2	3.0
Commercial Repository Containing Defense Waste (80,000 MTHM)[b,c]	6.2	7.9
Two Separate Repositories, One Solely for Commercial Waste and One solely for Defense Waste (80,000 MTHM Combined Capacity)[b,c]	7.7	9.4

[a] Costs shown represent the minimum and maximum total costs estimated for a variety of scenarios which considered two types of geologic medium, hard rock and salt; and two containment options for defense waste, overpack and no overpack. The costs shown are limited to the combined costs of construction, operation, and decommissioning of a geologic repository facility which has an on-site packaging capability. D&E and waste transportation costs are not included.

[b] The limit of 70,000 MTHM, as specified in Section 114(d)(2) of the Nuclear Waste Policy Act of 1982, must be observed until a second repository is available.

[c] The Mission Plan for the Commercial Waste Program is currently under development. Revised cost estimates may result. However, the revised costs should not change the relative cost benefit of the combined repository compared to two separate repositories.

a commercial repository is enhanced. Therefore, on the basis of cost efficiency, there is a clear cost advantage to be gained by disposing of defense wastes in a combined commercial and defense repository.

Should it be determined that the benefits of geologic disposal of high-level waste stored in 149 single-shell tanks at the Hanford Reservation prevail, there would be a substantial increase in the amount of defense high-level waste to be processed and disposed of in a geologic repository. The resultant larger quantity would cause an increase in the capital and operating cost of either a combined respository or a defense-only repository. To the extent these increases might be experienced equally by both disposal options, their relative costs would not be affected. No differential cost impact (affecting one option more than the other) has been identified that would lead to the conclusion that a defense-only repository is required.

Section 8(b)(2) of the Nuclear Waste Policy Act states that arrangements for the use of the commercial repository for defense high-level waste "shall include the allocation of costs of developing, constructing, and operating this repository or repositories." Since, at this time, an allocation formula has not been agreed upon to define how the costs of a commercial repository containing defense high-level waste will be shared among the two categories of waste, it is not possible to estimate the pro-rata share of the cost for disposal of defense waste in a commercialrepository. Whatever final allocation mechanism is agreed upon, it will not affect the cost efficiency conclusion above.

4.2 Health and Safety

The potential health and safety impacts of the two disposal options were compared with the understanding that any disposal option must conform to the requirements of 10 CFR 20 (NRC) on radiation protection standards, 10 CFR 60 (NRC) on HLW disposal, and the proposed 40 CFR 191 (EPA) on HLW disposal.

Based upon the evaluations presented in this report, there is no discernible difference between the two disposal options with respect to health and safety impacts. Therefore health and safety is not a basis for the selection of one of the two disposal options.

4.3 Regulation

Both options for disposal of defense high-level waste must comply with 10 CFR 60 which governs the licensing of any Department of Energy geologic repository. The regulation specifies numerical performance standards for each of the major elements of such a geologic repository system, i.e., the waste package, the underground facility, and the geologic setting. The numerical standard for the waste package is specified as a range rather than a single numerical value and the NRC, on a case-by-case basis, may approve some other numerical performance standard. Numerical standards for other features of the repository system may also be modified on a case-by-case basis by the NRC so long as the overall system performance objectives are met. Thus, it is possible that the numerical performance standards for a defense-only repository could be different than for a commercial repository containing defense high-level waste. For example, the thermal characteristics of defense high-level waste are such that the numerical standard specified for the period of time during which radionuclides must be contained may be different for a defense-only than for a combined repository. A shorter containment time period may satisfy the performance requirements in a defense-only repository. A shorter time period for waste containment may allow the use of a less expensive overpack on the defense waste or eliminate the need for an overpack altogether. The applicable regulations are met for either disposal option.

The procedures for acquiring a construction authorization and license from the NRC are somewhat different for the two disposal options. These differences occur because the procedures for establishing a commercial repository, as specified in the Nuclear Waste Policy Act of 1982, are more detailed than those for a defense-only repository. For example, a detailed process of nominating, recommending, and selecting sites for characterization of a repository is specified for a commercial repository, but that process is not applicable to a defense-only repository. Also, a schedule for repository activities is specified for the commercial repository, but not for a defense-only repository. However, a similar process may be followed to select a site for a defense-only repository. Additionally, some procedures leading to construction authorization in 10 CFR 60, which must be followed for a defense-only repository, are similar to those specified in the Nuclear Waste Policy Act for a commercial repository. A three year schedule for obtaining construction authorization from the NRC is specified in the Act for a commercial repository (4 years if a one year extension is obtained) but the regulatory process for licensing a geologic repository is untried, and the actual time required to obtain a construction authorization and license for either disposal option is unknown at this time.

An important consideraton to defense programs is that there is no need for NRC's regulatory jurisdiction to extend into any part of the defense research and development or production process. This is discussed in more detail in Section 4.6. Because of the uncertainties involved, regulation cannot be considerd as a basis for the selection of one of the two disposal options.

4.4 Transportation

With respect to any designated repository, the cost for shipping defense high-level waste to that site does not depend on whether the site is a defense-only or a commercial repository. Since shipping costs and cask fleet requirements for either transport mode are strongly influenced by the total distance traveled and vehicle speed, the actual repository location will have an effect on the total transportation costs. For example, for shipments by truck the cost ranges between $110 and $162 million dollars.

As in the case of costs, the risk associated with shipping defense high-level waste to any designated repository site does not depend on whether the site is a defense-only or a commercial repository. The total risks associated with shipping defense high-level waste to a repository are also influenced by the total distance traveled. Thus, there is a variation in risk when comparing one potential repository site with another. In general, these risks are extremely small. Therefore, the transportation considerations are not a basis for the selection of one of the two disposal options.

4.5 Public Acceptability

The issue of disposal of defense high-level waste in either a commercial repository or a defense-only repository has been discussed in the U.S. Congress. From the Congressional Record and other sources of public opinions on this issue, one may only speculate on potential public reactions. This would be based on a knowledge of public interests and positions that could influence the acceptability of the disposal option. The actual stand that the public takes may also be influenced by how the Federal Government deals with the institutions and public segments involved in the repository program.

A major concern within the Federal Government will be whether there is sufficient technical information to make sound regulatory and licensing decisions. The attention of regulatory agencies will be focused on the question of whether disposal options meet all applicable standards. The disposal of defense high-level waste in a commercial repository may be seen as a complicating factor, especially if the packaging and emplacement techniques differ for defense and commercial wastes. Several Federal agencies may favor the colocation option as the low cost option. However, if added complexity is seen as a possible cause of delay in establishment of a repository, some Federal agencies may favor the defense-only option.

The utilities and pro-nuclear groups may support a defense-only repository in the belief that it will remove a potential obstacle to the establishment of a commercial repository. These groups will be opposed to delay in establishing a commercial repository. The utilities may support the placing of defense wastes in a commercial repository under the expectation that allocating the costs for the disposal of defense wastes will lower the cost to the utilities for disposing of their waste.

Other groups may be primarily interested in assurances that public health and safety will not be compromised. These groups will insist that their health and safety concerns be adequately addressed, regardless of where defense high-level waste is to be disposed. They may seriously object to any suggestion that licensing standards for one disposal option are less stringent than those for another.

In general, the differences in acceptability between the options appear to be minor compared to gaining public acceptance for any high-level waste repository.

4.6 National Security

Two key national security issues have been considered:

- There must be no interruption of or delay or NRC involvement in the defense material production process or nuclear weapons activities.

- There must be no disclosure of classified information.

Each of these is discussed below.

Interruption or shutdown of a defense production or utilization facility because of waste buildup problems could develop if the opening of the repository were delayed, if the repository accepted high-level waste at less than the expected rate, or if the repository were to be closed for regulatory or technical reasons. Shutdown or interruption of defense production or utilization facilities could also occur because of in-plant regulatory requirements and/or inspections imposed by geologic repository requirements on waste form preparation. There is also concern that NRC regulation of a disposal system at a geologic repository might reflect back into the production system to create an interruption or shutdown of production operations.

The following two courses of action are being considered to avoid the possibility of an interruption or shutdown.

First, sufficient interim waste storage would be provided to permit continued operation of production or immobilization facilities in the event of shutdowns or delays in the operation of the geologic repository. Interim storage for defense high-level waste has been provided at the three DOE generating sites. At the Savannah River Plant, the Defense Waste Processing Facility (DWPF), scheduled for operation in 1989, will include interim storage for production of immobilized glass waste forms. The designs of immobilization plants at the other DOE sites will also include provisions for interim storage capacity. It may be possible to anticipate future interim storage requirements, and if necessary, additional interim storage capacity could be made available if the geologic repository were delayed.

Second, DOE and NRC will engage in a thorough technological exchange during all stages of development of both the waste form and the repository. DOE has initiated and continues contact with the NRC staff to ensure that NRC has a full understanding of and opportunity to review DOE defense plans to produce immobilized glass waste forms.

There is also concern that disclosure of classified defense information during the disposal of defense high-level waste could adversely affect national security. The process used to immobilize defense high-level waste for disposal and the quantity and characteristics of the solidified waste produced are unclassified. A small percentage of the defense waste in storage tanks is classified. There will probably be classified waste in the future. All classified waste will be handled separately and appropriately until mixed with other wastes resulting in a composition that is unclassified prior to vitrification.

Data on the amount and composition of current defense materials production programs are usually classified. However, the time delay between the creation of waste materials and vitrification and the act of mixing various waste streams from several points in the process into large waste storage tanks creates a mixture that is unclassified. Information on the composite inventories of wastes at each of the three DOE high-level waste sites is updated annually in an unclassified report on radioactive waste inventories.

Since the waste inventory is unclassified, and the subsequent immobilization steps at each of the three DOE sites will be unclassified, immobilized waste destined for a repository will not reveal classified information. DOE foresees no reason for the licensing or regulating of a geologic repository to require access to classified defense information.

As mentioned earlier, however, the regulatory process for licensing a geologic repository is untried at this time. Incomplete knowledge about NRC's information requirements creates uncertainty about the extent to which the NRC may wish to inquire into the defense production activities, and what the national security implications may be. This concern exists equally for both disposal options. As a result, national security considerations do not form a basis for preference of either option.

4.7 Conclusion

The analysis of the factors of cost efficiency, health and safety, regulation, transportation, public acceptability, and national security with respect to the disposal options did not provide a basis for finding that a defense only repository is required. The only factor that results in a significant advantage for either option is cost efficiency. The other factors do not provide a basis for preferring one disposal option over the other. Taking into account all the factors specified for the evaluation, the Department finds no compelling basis to require that defense high-level waste be disposed of in a separate defense repository.

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