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Report of Task Force for Review of Nuclear Waste Management

February 1978

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U.S. Department of Energy
Directorate of Energy Research
Washington, D.C. 20545

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Washington, D.C. 20585

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MEMORANDUM FOR

DALE D. MYERS
UNDER SECRETARY

FROM: JOHN M. DEUTCH
DIRECTOR, OFFICE OF ENERGY RESEARCH

SUBJECT: TRANSMITTAL OF TASK FORCE REPORT FOR REVIEW OF NUCLEAR WASTE MANAGEMENT

On December 8, 1977, you directed me to form a Task Force to review all nuclear waste management programs of the Department. The attached report presents the findings of the Task Force.

A responsible nuclear waste management policy with an accompanying credible program to implement the policy should be adopted without delay to insure public confidence in the Department of Energy's willingness and ability to deal with nuclear waste. A successful nuclear national waste management policy must reflect the views of other government agencies, Congress, States, industry, and the concerned public, in addition to those of the Department of Energy. Only with broad understanding and acceptance of this policy can a program be successfully developed and implemented that will satisfy public concerns.

This Task Force report is intended to be a first step toward the formulation of an Administration policy. The report presents an assessment of the current nuclear waste management programs, identifies important outstanding issues, and explores alternative courses of action for proceeding. While the report contains significant recommendations, it does not establish new policy or commit the Department to specific new programs or schedules. Rather, it hopefully should serve as the vehicle to stimulate discussion among a wider range of interested parties during the remainder of the policy formulation process.

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The Task Force report raises a number of issues with regard to present nuclear waste management policy and programs. I should like to highlight some of the findings which I consider most significant for management of wastes from commercial power operations.

1. A majority of independent technical experts have concluded that high-level waste (HLW) can be safely disposed in geological media, but validation of the specific technical choices will be an important element of the licensing process.

   Existing technical issues relate to the selection of medium, specific site and repository design and objective research designed to resolve these issues is necessary. An accelerated effort to compile and analyze existing evidence bearing on geological disposal and feasible alternatives is also needed. The licensing process is required in order to open up to public scrutiny and validate the technical approaches taken.

2. Reprocessing is not required for the safe disposal of commercial spent fuel.

   From the point of view of safe disposal, there is no significant difference between spent fuel and reprocessed high-level waste. Since a repository can be designed to accept either spent fuel or commercial HLW, disposal of spent fuel can be pursued initially.

3. Consideration should be given to an early demonstration of the geologic disposal of a limited number of spent fuel assemblies in WIPP.

   This disposal should take place with full licensing, allow R&D, and employ conservative repository design characteristics. The demonstration should take place in WIPP (assumed available in 1985) or in another suitable location.

4. The Spent Fuel Policy announced by President Carter in October 1977 must be integrated with the Waste Management Policy.

   In particular, the methodology that will be used to determine the one-time charge to utilities for the interim storage and subsequent disposal of spent fuel must be developed and integrated with adoption of a detailed scenario for future storage/disposal. The principle of a "one-time" charge is essential, although utilities may be offered various options (bearing different costs) for storage/disposal.

5. The Task Force report highlights the importance of Away from Reactor (AFR) storage that occurs between on-site storage of spent fuel at utilities and ultimate disposal.

   The character and amount of AFR storage required over time is sensitive to installed nuclear power, repository availability, and implementation of the spent fuel policy. Initial AFR storage is needed by 1983. Additional work is needed to define needed future interim storage capacity, including possible private industry financial participation.

6. The target for initial operation in 1985 of a National Waste Repository (NWR) for the permanent disposal of commercial HLW or spent fuel may not be met; this does not affect the early 1980's schedule for WIPP.

   The potential delay in NWR arises from the site selection process and a more realistic assessment of licensing requirements relative to previous plans.

7. The responsibility for the ulitmate disposal for all forms of nuclear waste should be with the Federal Government and long-term waste disposal facilities should be subject to NRC licensing.

   The importance of effective nuclear waste management and the national character of the production and disposal of waste point to the need for an expanded Federal role. A licensing process that allows broad participation will lead to improved public confidence in long-term disposal.

8. The NEPA process is an essential part of the nuclear waste management program and DOE efforts in this regard must be strengthened.

   Clear responsibility is needed to help insure adequate development of the necessary environmental impact analysis among the program office, AS/EV, and GC.

Additional effort is needed on the Impact Statement (GEIS) on Commercially Generated Radioactive Waste because of the major role the GEIS will play in the process leading to disposal of commercial waste.

9. Policy and program management responsibility for Waste Management should be raised to a higher level in DOE.

   At present, the Director of the Waste Management Program reports to the Director of Nuclear Programs in ET as opposed to the AS/ET. Because of the importance of nuclear waste management, the program should report directly to an Assistant Secretary. The responsible Assistant Secretary could be either AS/ET, AS/EV, or AS/RA.

10. There are substantial budgetary impacts of the Task Force recommendations and legislation would be required to carry out many of the suggested changes.

My recommendation is that after internal DOE review, the report be made public and employed as the basis for intensive public and interagency discussion leading to adoption of a nuclear waste management policy.

REPORT OF THE TASK FORCE

FOR REVIEW OF NUCLEAR WASTE MANAGEMENT

TABLE OF CONTENTS

Introduction page 1

Overview page 2

Fundamental Principles page 5

Objectives
Design Criteria
Recommended Approach
Major Technical Judgements

Program Concept page 9

Program Scope
Program Guidelines
Reasonable Assurance
Repository Design Aspects
Characterization of Candidate Sites
Technical Conservatism
Program Timing
Need for a Demonstration

Waste Isolation Pilot Plant (WIPP) page 15

The Function of WIPP
Current Plans for WIPP
Licensing of WIPP
Exhumation of Buried TRU
Demonstration of Spent Fuel Disposal in WIPP
Possible Use of WIPP as a Repository for High Level Defense Waste (HLDW)

Specific Waste Programs page 19

Low Level Waste
DOE Management
Regulatory Approach
DOE Program
Standards and Criteria

TRU Wastes
High Level Defense Waste
West Valley
Responsibility for Waste
Costs
Vitrification R&D
Decontamination and Decommissioning
Uranium Mill Tailings

System Studies page 26

Description of Cases
Results
Conclusions

Spent Fuel Offer page 28

Implementation Issues
Integration of Fuel and Waste Management Policy
Licensing of AFR's
Voluntary Delivery of Fuel
Environmental Impact Statements
Publication of Draft "Charge to Utilities"

Implementation Details page 31

Legislative Requirements
Strengthening the NEPA Process
Generic Environmental Impact Statement (GEIS)
Present Situation
Additional Effort Needed
Next Steps
Organization
Organizational Level
Environmental Aspects
Program Aspects
Personnel Resources
Near Term Budgets
Spent Fuel Storage
Terminal Storage
Waste Operations and Handling
Effluents from DOE Facilities

Publication of the Task Force Report page 38

APPENDICES

A.	Makeup of Task Force	page 39
B.	Low Level Waste (LLW) Disposal Sites	page 40
C.	TRU Waste	page 42
D.	Final Disposal of High Level Waste	page 44
E.	Design Considerations for Geologic Repositories	page 55
F.	Spent Fuel Policy and Charges	page 60
G.	Transportation for Spent Fuel and Waste	page 74
H.	Decontamination and Decommissioning	page 77
I.	Uranium Mill Tailings	page 92
J.	International Programs in Radioactive Waste Management	page 94
K.	Case Studies and Cost Estimates	page 103
L.	Environmental Process	page 148
M.	Current Resources	page 155
N.	Alternatives to Conventional Geologic Disposal	page 159

REPORT OF TASK FORCE

FOR REVIEW OF NUCLEAR WASTE MANAGEMENT

INTRODUCTION

As part of his National Energy Plan, President Carter directed that a review be made of the entire U.S. nuclear waste management program.

A Task Force to review nuclear waste management was established as a first step in this process. The mission of the Task Force study was to construct an information base for the leadership of DOE as a basis for technical discussions and policy formulation among DOE, other Government agencies, and the public. The desired policy, programs and plans cannot be established independently by DOE. They must emerge from this extended process of discussion, identification of issues and alternatives, and consensus development.

In order to ensure effective management of the complex and technically demanding series of tasks, it is essential that interagency cooperation and coordination, realistic time phasing, clear milestones, and measurable tests of progress towards agreed-upon goals be established. The Task Force anticipates that a plan with these characteristics will be generated through an intensive series of interagency and public discussions throughout the remainder of this calendar year.

The scope of the nuclear waste management task and the Task Force review embraces all levels and sources of nuclear waste. The former includes low level, transuranic and high level whether in the form of discharge streams from chemical reprocessing plants or in the form of discarded spent fuel elements; the latter embraces waste from government, defense and research activities, the civilian nuclear power industry, and other private sector activities. The emphasis of this report is on the ultimate disposal of these wastes.

The Appendices to the main body of the report are an integral part of the full presentation of the Task Force effort and should be consulted for a complete understanding of the report. The views, conclusions and recommendations presented in this document are solely those of the Task Force membership.

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OVERVIEW

The Task Force report is the first step toward the formulation of a national policy for the management of nuclear waste. The process being initiated by this review implements a commitment made by President Carter in his National Energy Plan. It follows and is compatible with previous major decisions and statements by the President on nuclear issues involving proliferation, the development of advanced reactors, and chemcial processing.

In developing its recommendations for a national nuclear waste management policy and the programs designed to implement it, the Task Force adopted two basic assumptions:

- Public health and safety must be the primary consideration, and
- The policy and programs must be credible to and accepted by the American public.

The report presents an assessment of the present status of our waste management programs, identifies important unresolved issues, and explores some alternative courses of action. This report is directed to those interested parties both inside and outside of government whose ultimate goal is the development of an acceptable waste management policy.

To provide a focus for both the public and government discussion process, the report is organized around seven topical areas. These areas and the summary of key factors within each area are described here.

1) The Fundamental Principles, which should drive the development of specific plans and programs for the management of nuclear waste include:

   - The objective of waste management planning is to provide reasonable assurance that existing nuclear waste from both military and civilian activities can be adequately isolated from the biosphere and that future nuclear waste in whatever form (including discarded spent fuel) can be similarly disposed;
   - The paramount consideration in a waste management plan is safety;
   - The managerial (but not financial) responsibility for all ultimate disposal activities, should lie with the Federal Government; /1

/1 Excluded from this statement are 1) actions involving interim storage of wastes and 2) waste disposal actions occurring at the point of waste generation (such as routine release of effluents, decommissioning of facilities in place, etc.) which are conducted by the facility generator under regulatory control.

- o All ultimate disposal should be licensed and regulated by the Nuclear Regulatory Commission (NRC);
- o Chemical reprocessing is not required to ensure safety in waste management; and
- o Geologic containment for ultimate disposal is a technically sound basis for planning waste management policies and programs.

2) The Program Concept for any national waste management program which is responsive to the fundamental principles set forth above must contain:

- o The commitment to revise the current program schedule in order to increase assurance that necessary technical outputs will be available prior to identification of and detailed planning for sites for ultimate licensed disposal. The target for initial operation in 1985 of a permanent National Waste Repository (NWR) cannot be met and a new schedule must be adopted. (The NWR is designed for ultimate disposal of high-level waste and spent fuel, as a permanent facility financed on a commercial basis.)
- o Additional effort on developing scientific data, safety analysis and systems models to improve the scientific bases for specific media choice, site selection and repository designs.
- o The principle of technical conservatism which incorporates careful step-by-step approaches with adequate testing and review.

3) The national importance of the Waste Isolation Pilot Plant - WIPP, a near-term demonstration facility, is emphasized together with the key role of this project within the overall program. High priority must be given to:

- o Assuring the technical adequacy of the project;
- o Resolving public and institutional issues concerning it; and
- o Assuring its successful siting, licensing, construction and operation at the earliest feasible date.

The primary use of WIPP are as a geologic ultimate disposal location for transuranic (TRU) wastes from the defense program and as a facility in which to perform R&D with other waste materials in salt. It is inappropriate and premature to decide now whether or not WIPP should be used for the permanent disposal of high-level defense wastes. Authority for such use should not be sought until after further study of the available alternatives, and full discussion with the potentially affected states.

In addition to its use for R&D and TRU disposal, WIPP should be considered for demonstration, on a moderate scale, of the capabilities for ultimate disposal of spent fuel. This might involve about 1% of the potentially available repository acreage, using up to one thousand fuel assemblies.

Emplacement should be on a technically conservative basis to allow removal of the spent fuel from the demonstration if that were subsequently desired within a 15 to 20 year period.

4) The key elements of a number of Specific Waste Management Programs include the steps necessary for the Federal Government to assume total responsibility for ultimate disposal. Legislation will be needed to:

   - Transfer ownership of commercial low-level burial grounds to the Federal Government.
   - Require disposal of commercially generated low-level and TRU wastes at Federally-owned sites.

In addition all Federal disposal of low level and TRU wastes should be made subject to licensing by NRC, including such disposal activities that occur in the future at existing DOE burial grounds.

5) An analytic overview of the technical and economic implications of various alternative approaches is contained in the System Studies. These cover a range of waste generation quantities and timing for the ultimate disposal of such waste. DOE expenditures to conduct such activities through the year 2000 (without consideration of any offsetting revenues from the commercial nuclear power industry) range from about $15 billion to $25 billion. The general nature of materials flows through the waste management system is portrayed in Figure 1.

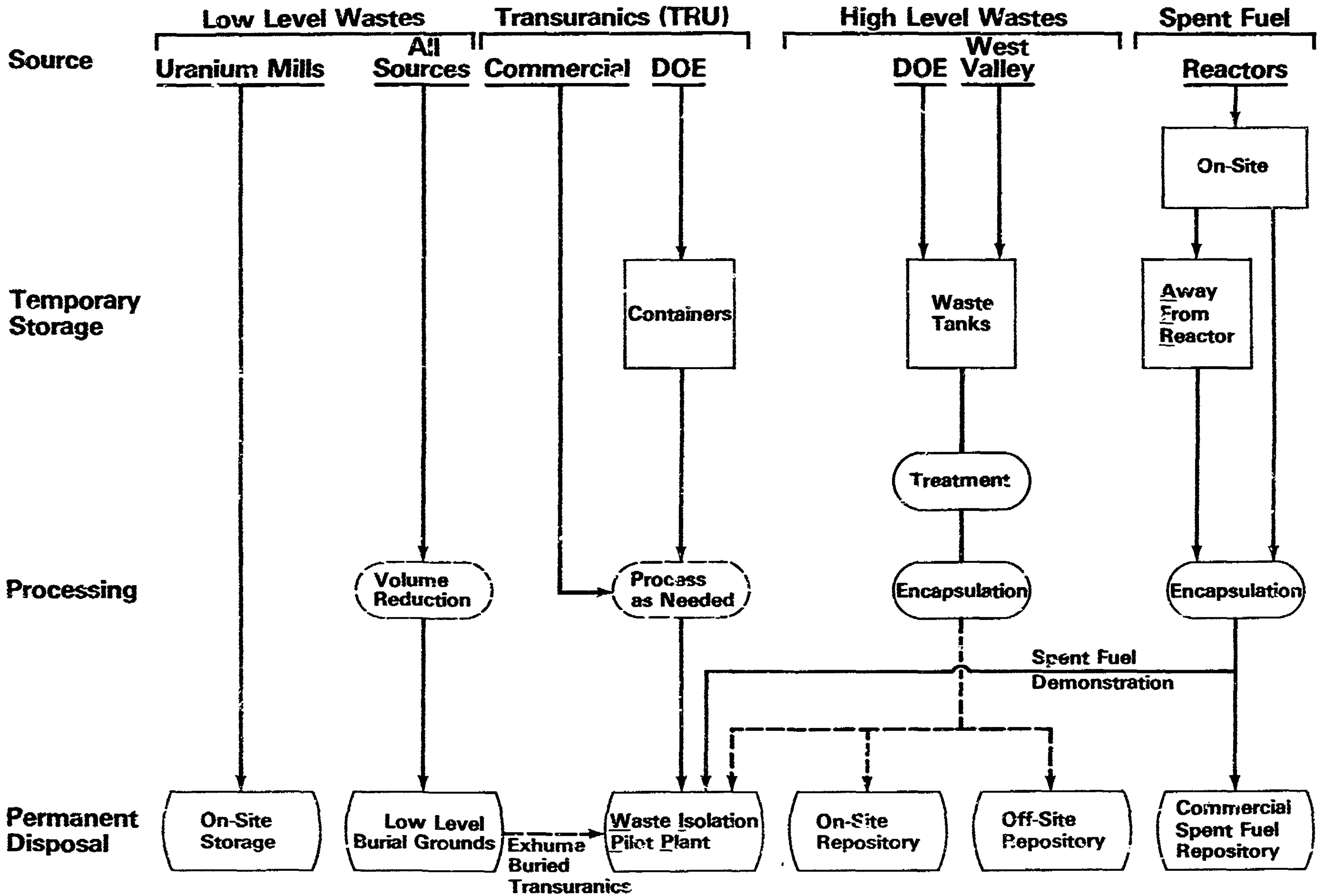
6) Additional attention needs to be given to implementation of the Spent Fuel Offer announced by the President in October 1977. As yet there is no agreed method for determining the one time charge to utilities for interim storage and ultimate disposal of spent fuel. This will necessitate consideration of the interrelationship between future storage and disposal requirements with the waste management plans and programs.

7) Essential areas requiring specific additional Implementation Actions include:

   - Scrupulous adherence to the NEPA process is an essential part of the waste management program and DOE efforts in this regard must be strengthened.
   - Substantial additional work is needed on the Generic Environmental Impact Statement on commercially generated waste.
   - Policy and program management responsibility for waste management should be raised to a higher level in DOE.
   - Potential budgetary impacts are associated with the suggested changes, and legislation is required to carry out many of the Task Force recommendations.

Waste Management By Type and Source

FIGURE 1



FUNDAMENTAL PRINCIPLES

The purpose of the Task Force is to review existing policy, plans, and programs for the ultimate disposal of nuclear wastes. The Task Force review is intended to lay the groundwork for intergovernmental and public discussions of this subject. These discussions should lead to increased consensus on the approach and timing of a credible, broadly accepted nuclear waste management program.

Objectives

The objectives of future waste management planning should be to provide reasonable assurance that:

- o *Existing nuclear wastes from both military and civilian activities will be adequately isolated from the biosphere so as not to pose a significant threat to public health and safety; and*
- o *Future nuclear waste production in whatever form, including spent fuel from the civilian nuclear power cycle will similarly be disposed of in a safe manner.*

The ultimate disposal of low-level wastes from both defense and civilian activities is presently being accomplished, relying on the geologic characteristics of shallow land burial sites. Further actions are needed to achieve successfully the capability for ultimate disposal of:

- o Transuranic (TRU) wastes, primarily from defense activities;
- o High-level wastes (HLW), primarily from defense activities;
- o Spent fuel, from civilian activities.

Design Criteria

Nuclear Waste Management policy, plans and programs should meet the following criteria:

- o *The paramount consideration should be safety;*
- o Significant attention needs to be given to the existence of uncertainties;
- o The environmental and other social aspects of proposed actions and their costs must be carefully identified and internalized.
- o The basic elements of the approach should be independent of the size of the nuclear industry, and neither seek to subsidize nor economically penalize nuclear power as an energy source.

The definition of safety and what constitutes the assurance of safety is a key designation. Information, relevant to this issue, will be addressed in:

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- o A Generic Environmental Impact Statement for the Management of Nuclear Wastes from Commercial Nuclear Power, now in preparation.
- o The NRC licensing process, required in order to proceed with pilot, demonstration, and production projects.
- o Technical discussions among DOE, other government agencies, and the public in response to this and other reports on waste management.

Recommended Approach

The Federal Government currently has health and safety regulatory responsibility over all the nuclear waste materials considered in this report. *However, the managerial responsibility for ultimate disposal of such material is divided between the Government and the private sector. Because of the significant level of public concerns and the long time periods associated with ultimate disposal, this responsibility should lie with the Federal Government. In addition, all ultimate waste disposal should be subjected to rigorous regulation and to licensing by the NRC.*

In order to implement this approach, the Task Force recommends that legislation be prepared to accomplish the following:

- o DOE have sole responsibility for the provision and management of facilities for the ultimate disposal of commercially-generated low level and TRU wastes.
- o DOE acquires ownership and control of existing burial grounds for commercially-generated low level wastes.
- o DOE facilities for ultimate disposal of low level and TRU wastes be subject to NRC licensing.
- o DOE provide any facilities needed (in addition to those provided by the private sector) for interim storage of spent fuel, and DOE have sole responsibility for the provision and management of facilities for the potential ultimate disposal of such fuel.
- o DOE facilities for interim storage and ultimate disposal of commercially-generated spent fuel be subject to NRC licensing.

Major Technical Judgements

There appears to be a substantive consensus and valid technical basis for the view that present plans and actions should rely on geological containment of wastes which can be achieved in a safe and environmentally acceptable manner.

This view has been promulgated by independent assessments ranging from that of the National Academy of Sciences in 1957 (and subsequent reaffirmations by that body) through a 1977 report of the American Physical Society. Members of the Task Force have also met directly with representatives of the U.S. Geological Survey (USGS) and find them to be in agreement with this statement.

Similar findings have recently been expressed in government-supported reviews in other countries (e.g., West Germany, Sweden, and Canada).

The primary issues for program planning are, therefore, related to the adequacy of technical knowledge for the specific choices of a geologic medium (salt, basalt, shale, granite, etc.), acceptability of an actual site, adequacy of an actual repository design, and the timing for such decisions.

The Federal Government, as an entity, has not formally reached a conclusion on ultimate disposal of high-level wastes because the needed environmental studies are still in preparation. These matters must be given high priority. The status of environmental reviews are discussed in a later section of the report.

For existing wastes, the advantages of moving them from present locations to geologic disposal must be balanced against the safety of their present form and location versus risks inherent in processing them and transporting them to a different location. Each such evaluation needs to be made on a case-by-case basis.

Though ultimate disposal in geologic repositories is the main topic discussed in this report, the investigation of alternatives should continue. These alternatives include 1) disposal in other types of geologic formations, such as the seabed, 2) disposal in space, and 3) elimination of long-lived, radioactive isotopes by transmutation. These and other approaches are discussed in more detail in Appendix N.

A second major judgement is contained in the Task Force conclusion that *no compelling argument could be found that chemical reprocessing of commercial spent fuel is required for safety in waste management.*

President Carter has indefinitely deferred the domestic use of chemical reprocessing and plutonium recycle in light water reactors (LWR's). As a consequence of this action, the nuclear proliferation and other safety aspects of fuel cycles are the subject of both domestic and international reviews.

The Administration's policy raises the question: Should we delay plans for the ultimate disposal of any high-level civilian waste until we know with greater certainty if reprocessing may ultimately be found acceptable? Or, should we emphasize completing the once-through fuel cycle now responsible for about 13 percent of our electric power requirements?

The dilemma is more apparent than real, for much of the knowledge needed to deal with military waste can be applied to civilian reprocessing should we proceed with that approach.

In light of the above, *highest priority should be assigned to demonstrating the capability to place existing military wastes and existing spent fuel from light water reactors into ultimate disposal.*

Many years will go by before large quantities of either material will actually be emplaced. It will take time to select full-scale sites, obtain licenses, and build facilities. Prudent planning and priority emphasis should be placed on dealing with existing systems and problems. If these can be successfully managed, then there will be more public confidence that additional tasks can be managed well.

This approach does not prejudge future decisions concerning reprocessing in the U.S. nor the outcome of international studies of alternative fuel cycles.

PROGRAM CONCEPT

Program Scope

The waste streams discussed in this report can be categorized as follows:

- o Low level waste
- o Transuranic (TRU) waste
- o High level defense waste (HLDW)
- o Discarded spent fuel from commercial power
- o Decontamination and decommissioning waste
- o Uranium mill tailings

Information on present and projected quantities of these wastes and their characteristics are presented in various appendices.

The emphasis of the Task Force review as well as the major driving force for the program concept is the technical aspects of ultimate disposal of TRU, high-level wastes and discarded spent fuel. There is an independent technical consensus that these wastes can be safely placed in geologic media for ultimate disposal. The next step, which is presently underway, is to develop the detailed information which will adequately support the specific choices of geologic medium, site, and repository design.

Past program activities have emphasized the early engineering achievement of disposal. There has been less emphasis on the parallel collection of scientific data that bears on the assessment of site and design specific issues. For example, the Task Force is aware of scientific issues concerning the adequacy of salt as a suitable geologic medium for emplacement of concentrated waste exhibiting high surface temperatures. More attention needs to be paid to these issues and the ongoing scientific work should continue. Current programs should be reviewed to assure the timeliness and adequacy of present efforts (including funding levels). It is recognized that the engineering design bases for a repository must be built upon scientific knowledge.

Safety analyses (identification of potential pathways to releases having undesirable consequences, sensitivity analysis, breadth and depth of situations analyzed) are still in early stages; additional work needs to be done. The current programs should be further reviewed to assure the adequacy of present efforts (including funding levels).

Program Guidelines

The Task Force has identified several concepts which are essential parts of the development of a nuclear waste management program. The overriding concern is the tension between schedule and certainty. The schedule alternatives are discussed in the next section. The following generic concepts are presented in this section because of their intimate relationship to the basic question of program concept and timing.

Reasonable Assurance: Ultimate disposal in geologic containment presumes public confidence in the safety of that action over very long time periods. It is therefore impossible to demonstrate the correctness of such a judgment by experiment. Accordingly, what is involved is the development of a social consensus based upon scientific understandings. This is only likely to be reached by a combination of:

- o Fundamental scientific information;
- o The development and analysis of long-term predictive models;
- o Near-term validation of the elements of such models;
- o Extensive peer review involving the application of independent and objective scientific expertise;
- o Practical experience with initial applications of the disposal approach involving careful monitoring;
- o A capability (over some time period) to take any needed corrective or mitigating actions; and
- o A continuing parallel program of R&D, increasing knowledge and confidence in the prior steps taken, or indicating the direction of any future changes in approach.

Recognition of these features must be built into current R&D activities, program planning, and proposed implementation activities.

Repository Design Aspects: The basic design approach for commercial repositories must continue to reflect the capability of eventually receiving for permanent disposal discarded spent fuel and/or high level waste from reprocessing. However, primary attention must be focused on spent fuel to validate the existing once-through fuel cycle.

Fuel may be placed in underground formations for two entirely different purposes:

- o Storage, with specific features provided to simplify future retrievability for possible value, or
- o Ultimate disposal.

Ultimate geologic disposal should contain no deliberate element of retrievability beyond that required for safety and confidence building, given the current status of the technology. Additional built-in requirements for retrievability could interfere with the main objectives of safe and permanent ultimate disposal (e.g., by requiring the repository to be left open past the time that it could in fact be backfilled and sealed).

The design approaches currently being used with respect to retrievability, both for the WIPP and the planned repository for commercially-generated wastes, need review if the above guidelines are accepted.

Characterization of Candidate Sites: The qualities of actual sites appear extraordinarily important. There can be no relaxation in the effort to identify and characterize specific formations and locations.

The search must, however, be centered in fewer states where the practical probabilities of both technical and institutional success in the near term are the highest.

Satisfactory site selection will require both technical suitability and a good working relationship with State and local governments representing the people of the state. Consequently, press statements and public briefings should focus on local issues, concerns and needs rather than generalized statements released concurrently to all State governors at one time.

Finally, funding should be given to assist states in reviews and evaluations which they may wish to conduct because of DOE activity. DOE should also consider seeking authority from Congress to provide impact aid for state and local services required by location of a repository.

Technical Conservatism: The plan and its implementation should emphasize technical conservatism. Ultimate disposal is a technology field and involves a learning process, building future knowledge upon past experience. Schedules must be reviewed to ensure they do not require leaps forward which could imperil achievement of the ultimate objective. Careful step-wise approaches, built upon greater surety, gaining confidence in the procedures used in each step before taking the next, are most likely to result in success in the long run. On the other hand, delay and lack of priority can impair credibility and confidence. This is why the development of a truly credible and acceptable program involves both technical and institutional judgements. This requires public dialogue and understanding.

Based on what we know today, studies of several geologic media for waste repositories should continue through the R&D phase. More than one design concept and alternative ways of distributing factors of safety (or conservatism) through the system should be considered for each medium. More than one site should be examined for any given medium. Different techniques being pursued by other nations should be carefully evaluated for their particular merits. This program will be more expensive (and perhaps lengthier) than one exclusively pursuing a predetermined single approach. In the end, it may be both more credible and more successful.

Program Timing

The existing Terminal Waste Management Plan, developed under the previous Administration, called for having a long-term waste storage facility operated on a commercial basis in place by 1985. The Task Force finds that this target action for the NWR, however, cannot be achieved for the reasons discussed directly below.

The ERDA program to characterize candidate repository sites throughout 36 states encountered considerable difficulty. It was too ambitious and not well designed for effective Federal/State and local government interaction. Public concerns were aggravated rather than resolved. The earliest possible date for candidate site selection now is late 1979, and even that date could not be achieved without significant change in public climate.

In addition, previous planning as to the procedures for licensing were based on processes and schedules which are not in accord with current NRC views.

Therefore, the earliest date for an operating permanent repository would be 1988, not 1985. /1

Given the basic trade-off referred to earlier between schedule and certainty, the potential significance was examined of the National Waste Repository becoming available within a time frame from 1988 through 1993 (up to a 5 year delay from present unofficial program planning).

Two basically different philosophical approaches are possible:

- o Develop a date for permanent repository operation which allows time for acquiring more scientific data on performance in salt, a stepped up program on other media, more international interaction, etc. Compare the best salt design with the best design in other media. Then choose the preferred medium, and choose between more than one location in that medium.
- o Select an earlier operational date than implied by the first approach. Proceed with a (perhaps smaller) repository in salt which is loaded conservatively from a thermal standpoint. This will provide the potential of retrieval of material emplaced over a time period (probably not in excess of 15 years). Subsequent

/1 This change is schedule is for the National Waste Repository. The schedule for the Waste Isolation Pilot Plant, discussed in the next section, remains unchanged.

decisions can then be taken in either direction (i.e., to remove to another location or to increase the thermal loading) before the repository is finally sealed.

The Task Force believes the first approach to be unnecessarily conservative and favors the second.

In proposing an actual schedule under the second approach, there are again two alternatives:

- Establish a tight, but theoretically "doable" schedule, assuming no major unforeseen delays. This is consistent with maximum program urgency. Difficulties can, of course, upset the best of plans. Thus, candidate site identification, resolution of the adequacy of site-specific technical issues, and final selection of a preferred site can take more time than anticipated. Licensing schedules can change. Problems can be encountered during construction. These could all force future revisions in schedules.
- Establish a longer schedule providing for some of the delays mentioned above, and thus minimize the risk of future changes in the repository operational date. This schedule is a more credible one, in this sense. It (incorrectly) suggests, however, a reduced sense of urgency.

The Task Force was unable to agree on which of these two approaches should be favored.

There was agreement, however, that regardless of the approach to a formal schedule, program managers should adopt as their target the earliest possible completion date consistent with the resolution of technical and environmental issues.

A licensing plan for the commercial repository, including NRC's detailed definition of the process and its information needs through time, should be established at the earliest possible date. When combined with a similarly detailed R&D plan, a realistic schedule for the operation of the commercial repository would be better validated.

Need for a Demonstration

Design, siting, construction, and operation of the commercial repository discussed in the previous section would represent the application of a new technology on a significant scale.

As presently conceived, it could represent the disposal location for about 4000 operating reactor years for 1000 MWe reactors (e.g., 100 such reactors operating for 40 years, 200 such reactors operating for 20 years).

While the NAS suggested the use of salt geology in 1957, no large scale application of this technology has yet occurred. At this time, DOE does not own any pilot facility or location in which R&D involving radioactive material in salt can be conducted. (DOE has conducted radioactive experiments in the past, as in Lyons, Kansas. DOE currently has access to nonsalt media, e.g., basalt, shale, granite, at DOE locations where it can work directly with those types of formations.)

Thus, a facility is vitally needed to perform R&D in salt, concurrent with the selection and licensing of the commercial repository. In addition, it would be useful to demonstrate the emplacement of spent fuel in a monitored facility. Such a facility is WIPP, now being planned for early availability in the program. The next major section of this report discusses this facility and indicates how the Task Force believes its use could be more completely integrated into the overall waste management program.

WASTE ISOLATION PILOT PLANT (WIPP)

The Function of WIPP

The Waste Isolation Pilot Plant is a conceptual facility Detailed engineering specifications have yet to be formulated. The WIPP concept includes its intended use for the geologic ultimate disposal of TRU wastes from the defense program and as a facility in which to perform R&D with other waste materials in salt.

Only a small amount of TRU waste is now being generated by the nuclear power industry and even that may no longer be so classified if the current standard is revised upwards following completion of an ongoing NRC review. No distinction should be made between existing DOE TRU waste and any commercial TRU waste received by DOE in the future.

TRU wastes from DOE operations are now being stored retrievably above ground, mostly at the Idaho National Engineering Laboratory and this is a source of concern to the state.

In 1970, AEC responded positively to requests from Idaho and expressed its plan to being the removal of such wastes from the state by 1980. This plan was predicated on the opening of a geologic repository in salt in Lyons, Kansas. Attempts to develop that repository failed. The earliest available facility for ultimate disposal of TRU wastes will now be the WIPP.

Current Plans for WIPP

A site for WIPP has been proposed near Carlsbad, New Mexico, and is now undergoing detailed geological examination. The current schedule for operation in 1985 at this site is ambitious. It includes a number of complicated steps including legislation for land withdrawal, preparation of environmental reports and licensing. Based on experience with other first-of-a-kind projects, it would not be surprising for delays to be encountered. For this reason it is imperative that management attention be continuously focused on this activity, even in its present phase. Adequate DOE headquarters resources must be made available to ensure prompt responsiveness to issues and difficulties as they emerge. High priority must be given to:

- o Assuring the technical adequacy of the project;
- o Resolving any safety, public and institutional issues concerning it; and
- o Assuring its successful siting, licensing, construction and operation at the earliest feasible date.

Once WIPP is operational, present plans call for an extended schedule for emplacement of TRU material with the result that this material would not have been fully removed from above-ground storage at Idaho until 1995. Since

TRU waste is not a significant heat generator, the proposed schedule in the early years can be accelerated and the requirement for retrievability of TRU waste during initial operation can be removed. Design rate placement should be achieved as soon as feasible to allow more rapid removal of TRU waste from existing surface storage.

Licensing of WIPP

Under current law, the emplacement by DOE of government-generated TRU material in WIPP could be done without seeking a license from NRC. Consistent with the philosophy indicated previously, however, legislation should be sought to bring ultimate disposal of TRU wastes by DOE under regulatory control in the future (including WIPP).

Legislation is also needed to permit land withdrawal for DOE use of WIPP (since other mechanisms would limit land withdrawal to only 20 years, clearly not sensible for an ultimate disposal facility).

The regulatory process and limitations of the license as developed by the NRC should be open to significant input and participation by the State of New Mexico so that local concerns and desired limitations are effectively considered in the process.

Exhumation of Buried TRU

TRU waste has been buried in the past, both at commercial low level burial sites and at DOE sites. Possible exhumation of such wastes for other disposition should be considered in accordance with NEPA procedures. Given the urgency of other elements of the overall waste management program, only moderate priority should be assigned to this particular program element. It should proceed in an expeditious way but not on a "crash" basis.

Demonstration of Spent Fuel Disposal in WIPP

The Task Force recommends that WIPP be considered not only for its present missions as a salt-R&D facility and utlimate disposal of TRU waste, but also as a location for a moderate scale demonstration of the capability for ultimate disposal of spent fuel in salt. This activity would also be licensed and regulated by the NRC.

Licensing and other institutional issues to be faced by a permanent disposal facility would be explored by the process. Base line data could be established and performance of the system monitored in parallel with R&D activity. Obviously, the long term aspects of disposal cannot be achieved in less than geologic time frames; however, the models and analyses used to project such effects could be validated with respect to their near term predictions. This would increase confidence in the analytic techniques and the validity of the underlying experimental work.

The demonstration should be large enough to be meaningful. Up to one-thousand fuel assemblies using less than one percent of the potentially available repository acreage would be involved.

The loading (heat generation per acre) proposed should be technically conservative relative to expectations of what might ultimately be achieved in an operating repository. This is consistent with the recommended approach of techncial conservatism and is also economically acceptable. With conservative heat loadings and despite emplacement in a disposal mode, the spent fuel could, if necessary, be recovered within a 20 year period by remining the passageways. This adds additional confidence that the demonstration facility would present no threat to health and safety. There should be no planning for possible recovery of this fuel for economic value.

It appears likely that any safety issues can be successfully resolved for the demonstration. The total quantity of material is not large. Local temperatures produced by spent fuel are significantly lower than for concentrated high level waste. A conservative underground thermal loading is proposed. The demonstration would be monitored. The capability for removal provides further assurance that the demonstration is under control. The capability for advanced R&D at the same facility means that more extreme conditions in the same geology can be simulated to allow improved confidence through time in the actual status of the demonstration.

Opportunities should also be sought for RD&D activities with radioactive material in various media prior to the availability of WIPP. The possibilities for international cooperation in this area should be further explored.

Finally, it should be emphasized that the major waste disposal application of WIPP must be associated with TRU wastes. In some cases we have examined, nearly all of the intended WIPP capacity could be required for future TRU waste production from decontamination and decommissioning activities.

Given the proposal to use WIPP as a location for a modest demonstration of spent fuel disposal, activities should continue on characterizing other sites and identifying possible locations for the needed large-scale commercial repository.

<u>Possible Use of WIPP as a Repository for High Level Defense Waste (HLDW)</u>

Under present planning, WIPP is being considered as a potential future repository for HLDW. However, many prior decisions and actions would be required before this could happen. Using Savannah River waste as an example, a decision would first have to be made to go to an off-site geologic repository. A facility would have to be built at Savannah River to prepare the waste for shipment off-site. A further decision would be needed to seek emplacement in WIPP. Finally, a license for that purpose would have to be obtained from NRC (as required under the current law).

The Task Force visualizes that the WIPP Environmental Report submission to NRC would discuss the possibility of the permanent disposal of HLDW in WIPP at some time in the future. The report should analyze the facility proposed to be constructed in terms of such possible future use. We do not visualize seeking or obtaining, at this time, authority to make such a permanent disposal. However, WIPP should be used for R&D on HLDW disposal. Continuing research will develop additional knowledge, either favorable or unfavorable, that will bear on that decision at that later date.

WIPP is conceptually expandable to a 2000 acre repository. However, the facility to be licensed and initially constructed would be for placement of TRU wastes and would be sized accordingly. This mission, together with its use for RD&D means that the value of WIPP as a facility is not dependent on and does not prejudge later decisions on the ultimate disposition of HLDW.

Thus, in summary, WIPP would be used for R&D in salt and ultimate disposal of TRU wastes as originally proposed. The Task Force recommends that this mission be supplemented by a demonstration of spent fuel disposal. These activities should be licensed. Any change in scope or character from this approach will be subject to a licensing revision process involving the opportunity for significant state and public participation.

SPECIFIC WASTE PROGRAMS

The previous sections discussed the waste management program as a whole. In this section a set of particular activities and subsidiary issues is presented which are critical to portions of the program.

Low Level Waste

The management problem is long term, several hundred years for low-level waste placed in shallow land burial. The longevity of management required clearly transcends the durability of most private enterprises. Motivations for R&D, improved disposal methods, alternatives to land burial, and minimization of the number of burial sites are strongest at the national level.

DOE Management: The Task Force recommends that DOE assume responsibility for the ownership and management of the six present commercial low-level waste burial grounds. These are located at Beatty, Nevada; Maxey Flats, Kentucky; West Valley, New York; Hanford, Washington; Sheffield, Illinois; and Barnwell, South Carolina.

There are also five major and nine supplementary Government-owned low-level waste disposal sites now being operated by DOE. The resultant system of 20 sites should be managed as a single complex. Such an approach would permit the strengthening of technical/operating practices, the development of uniform criteria, the minimization of the number of additional sites required in the future, the application of R&D to improve capabilities and practices, the provision for long-term surveillance, and the carrying out of responsibilities inherent in the program.

The Federal Government should receive from the private sector those radioactive waste materials now required by NRC to be placed in disposal. (About 50% of current commercial low-level waste comes from sources other than the nuclear industry.) Charges established by the Government should be on a full-cost recovery basis.

Regulatory Approach: The six commercial low-level waste burial sites are subject to licensing and regulation. One site is regulated directly by NRC, while the others are regulated by the states under "Agreement State" provisions established by NRC. Under DOE ownership and management, the sites should continue to be subject to licensing. Three alternatives are of most interest:

- Continuation of the present regulatory arrangement (but strengthened by the needed establishment of uniform criteria and standards by NRC).

- Central regulation by NRC (but more responsive to state needs, local knowledge and concern through improved mechanisms for state input into NRC regulatory activities).

- An innovative new arrangement designed to seek the best features of both the above.

Federal management of nuclear waste for ultimate disposal cannot take place independently of local concerns. State and local governments have an important role to play in the process. Their viewpoints, and local expertise, must be more effectively integrated into national planning. Additional mechanisms and approaches to achieve this must be developed and put in place.

Selection of the appropriate regulatory approach from among the above alternatives should emerge from discussions involving state and local governments, NRC and the public.

Those operating DOE low level waste burial sites integrated into the proposed system for ultimate disposal should themselves be placed under the same regulatory and licensing mechanisms established above so that all such future activities are licensed. A transition period of several years will be required after the establishment of uniform NRC criteria and standards to bring this process into being so as to minimize disruption of ongoing operations.

DOE Program: Opportunities exist to reduce the waste for future burial through minimization of volume creation at the source and through processing prior to disposition. DOE should pursue these approaches aggressively. Both R&D and institutional approaches (e.g., pricing, support of centralized volume reduction facilities) should be used. Alternatives to shallow land burial (hydrofracturing, deep geologic for some materials) should also be pursued. The centralized management approach recommended here should increase assurance as to the long term management of this national responsibility and improve the overall system operation on an integrated basis.

Standards and Criteria: Finally, as the March 1977, NRC Task Force review, NUREG-0217, pointed out, "there is an urgent need to establish a comprehensive set of standards, criteria and regulations governing low level waste management. An integration and acceleration of on-going efforts to establish such a program is required." The DOE Task Force supports this finding and understands that NRC is moving towards its implementation.

TRU Wastes

At the present time only a small amount of TRU waste is being generated by the nuclear power industry; however, significant quantities of this waste from DOE operations have been accumulated in above-ground interim storage since 1970. The final disposition of this material has been noted earlier as a high priority item and this requirement has been incorporated into the conceptual design of WIPP.

The quantities of TRU requiring ultimate disposal may be affected by the determination of the concentration of TRU in waste that requires measures beyond shallow land burial.

DOE is currently using an internal standard established by the AEC in 1970. Provision was made that wastes containing more than 10 nanocuries of TRU per gram should no longer be placed in low level burial grounds but should rather be stored retrievably pending ultimate disposal by other methods (e.g., deep geologic disposal). One commercial low level burial site at Hanford, Washington is still receiving and burying TRU waste from non-Federal sources.

NRC is reviewing the formerly established AEC standard, which informal indications show may be conservatively low. NRC should expedite completion of this review and establish a revised standard that should be applied uniformly throughout the low level waste system. The anomalous situation at Hanford referred to directly above should also be corrected.

Once this issue is clarified, possible exhumation and alternative disposition of TRU wastes at commercial low level burial sites and at DOE sites should be considered. Given the urgency of other elements of the overall waste management program, high priority should not be assigned to this particular element.

All TRU wastes should be delivered to the Government for ultimate disposal but the definition of such material should be left to the regulatory processes.

High Level Defense Waste

Large volumes of high level defense wastes (HLDW) are stored at DOE facilities in Idaho, South Carolina and Washington. Defense Waste Documents (DWD's) have been published describing reasonably available technical alternatives for their ultimate disposal, preliminary cost estimates, and risk assessments. Some of these alternatives are onsite (bins at Idaho, bedrock at Savannah River, basalt at Hanford); some require construction of major facilities and shipment offsite to deep geologic repositories. Environmental Impact Statements (EIS's) are in preparation on a priority basis for all three sites as input to permit the needed decisions to be made. The above program approach and sense of urgency appear sound.

Present planning is based on an aggressive overall program in which activities at the various sites are given relative priorities. Simultaneous funding of maximum activity at all three sites is unrealistic and not necessary for health and safety reasons. Savannah River has been selected as the lead location based on its generally less favorable environmental characteristics and, therefore, the relatively greater need for ultimate disposal of high level wastes at that site. The Savannah River EIS is scheduled to be available one year ahead of that for the other two locations. The Task Force supports this overall approach and pace.

There is a different reason for expediting R&D and exploratory drilling to characterize basalt at Hanford. This may be the most rapid approach to increase knowledge about the use of basalt as a geologic medium, including its possible use as a commercial repository (whether at Hanford or elsewhere). The work at Hanford should, therefore, be accelerated.

West Valley

The Western New York Nuclear Fuels Services (NFS) Center at West Valley, New York operated from 1966 to 1971 under NRC license as the only commercial nuclear fuel reprocessing plant in the U.S. NFS and New York State are joint holders of the license and responsible for the maintenance of the site and the protection of the public health and safety. The site contains a low level waste burial ground, as was discussed earlier, a spent fuel storage pool, and some 600,000 gallons of high level waste in below-ground tank storage (as compared to 27 million gallons of high level waste in storage at Savannah River and Hanford).

A study requested by Congress on the future use or disposition of the West Valley complex is now in progress. To permit public comment before its submittal to Congress in December, the study is planned for publication in August of this year.

The Task Force does not wish to prejudge the study now in progress and limits its comments here to those elements of the West Valley situation directly connected with waste management.

Responsibility for Waste: Actions involving the low level burial site should be separated from the other circumstances at West Valley and treated as discussed earlier.

DOE should accept responsibility for the high level waste at West Valley, assuming that appropriate financial and other terms can be negotiated with NFS and New York State. Planning for the disposition of this material should then be integrated into total DOE planning for high level wastes at all sites. Negotiation of appropriate terms for assumption of responsibility should include consideration of other DOE waste management objectives such as the characterization of promising geologic formations in New York State as potential sites for a repository. Similarly, other possible applications of the West Valley site to meet future national and state needs should be considered.

Legislation may be required with corresponding need for environmental reviews.

Costs: Costs associated with assumption of Federal responsibilities should be shared by the participants so that all parties have a financial stake in the decisions taken to restore the site to productive use, if this is desired, and in removal of undesired waste materials.

Unrecovered DOE costs for low level burial ground actions should be recovered in charges for future low level services to all customers. Similarly, an allocated share of any unrecovered DOE costs for high level waste (associated with civilian fuel processed at NFS) should be recovered in charges for future commercial fuel or waste disposal services.

Vitrification R&D: The DOE R&D project for the vitrification of future commercial high level waste (currently under construction at Hanford) should be redirected to demonstrate by simulation the processing and vitrification of existing wastes at West Valley and defense sites.

Decontamination and Decommissioning

There is a large uncertainty with respect to the volume of LLW and TRU which might arise from decontamination and decommissioning (D&D) activities (see appendices H and K for further details). The actual quantities of waste and timing of disposal can have an important effect on the magnitude of the need for LLW burial grounds and deep geologic repositories (for TRU).

For the commercial sector, the volume of LLW (no TRU) which might result after the shutdown of a large reactor could vary from 2000 $ft.^3$, under a mothballing procedure, to 800,000 $ft.^3$ for complete removal/ dismantling. Establishing the future costs and obligations of decommissioning and estimating the quantities of waste materials to be managed are concerns of industry, utilities, government (e.g., NRC), and the public. However, commercial D&D activities are not expected to reach a major level until after the year 2000, when presently operating reactors have reached the end of their economic life (30-40 years).

On the other hand, there currently are over 460 surplus DOE facilities, 80 percent of which are located at Hanford. Included are buildings, reactors, reprocessing plants, etc. An additional 100 facilities are expected to become excess over the next few years. The corresponding volumes of waste which might arise from DOE D&D activities could range from 10 to 160 million $ft.^3$ of LLW and 4.5 to 95 million $ft.^3$ of TRU, at an estimated cost of $130 million to $1300 million. A program to establish methods, costs, and priorities for D&D activities was started in 1973. The development of a DOE National Disposition Planning System was initiated in July of 1977 in order to tabulate surplus facilities, document the status and key data pertinent to disposition, and provide a basis for setting priorities for disposition projects. The output from the planning system will be utilized in developing annual budget estimates and five-year plans for the surplus facilities program.

Greater priority should be attached to resolving the above issues so that realistic downstream planning can take place. DOE should then pursue completion of the National Disposition Planning System to establish the scope and timing of actions to be taken on its own facilities.

Uranium Mill Tailings

Uranium mill tailings (Appendix I) contain residual radium which generates radon gas and other daughter products that raise the radiological background in the vicinity of tailings pile to potentially hazardous levels. A study of radiological conditions and practicable remedial alternatives and costs at 22 locations where uranium mills have been closed down is now complete. The general findings are as follows:

- At none of the sites can the tailings be considered adequately stabilized for long-term storage. Contamination usually extends beyond the property boundaries due to wind or water erosion.

- Based on the correlation observed between exposure to radon and other radium daughter products and incidence of lung cancer in uranium miners, the risk of incurring lung cancer is about double the normal to populations living in close proximity to the tailings.

- Most of the mill sites are in potentially favorable locations for alternative uses, and are in demand.

NRC has sought through NEPA to control the disposition of tailings at active, licensed mill sites. However, the Federal Government does not appear to have the authority to require the owners of inactive, non-licensed sites to clean up the tailings. Furthermore, neither the Federal Government nor the states appear to be legally responsible for clean up. Therefore, DOE would require additional legislative authority to participate with the states in a comprehensive remedial action program at these inactive sites. It is estimated that such a program would cost between $80 million and $120 million. DOE is currently conducting a NEPA assessment of the environmental significance of remedial options under consideration for each site.

SYSTEM STUDIES

Description of Cases

The Task Force has conducted independent studies of the nature of potential waste management systems and the related cost consequences to DOE. Details of these studies are presented in Appendix K.

Two basic cases were studied and selective sensitivity analyses were performed:

- Case 1 is designed to minimize the need for low level burial ground acreage and the need and number of centralized geologic repositories for TRU waste, high-level waste and spent fuel. This is accomplished through assumptions which reflect low nuclear capacity levels, volume reduction techniques for low level and TRU wastes, small scale decontamination and decommissioning (D&D) programs for commercial and DOE facilities, and minimization of DOE defense material sent to WIPP.
- Case 2 describes a larger, more decentralized waste management system, structured to maximize burial ground requirements and the need and number of geologic repositories. This is done through assumptions which encompass significant nuclear growth consistent with the National Energy Plan, no volume reduction, a moderate scale D&D program for DOE facilities, and a large commercial D&D program, maximization of material sent to DOE repositories, and more technically conservative repository design assumptions. These assumptions lead to a maximization of the number of both DOE and commercial repositories.

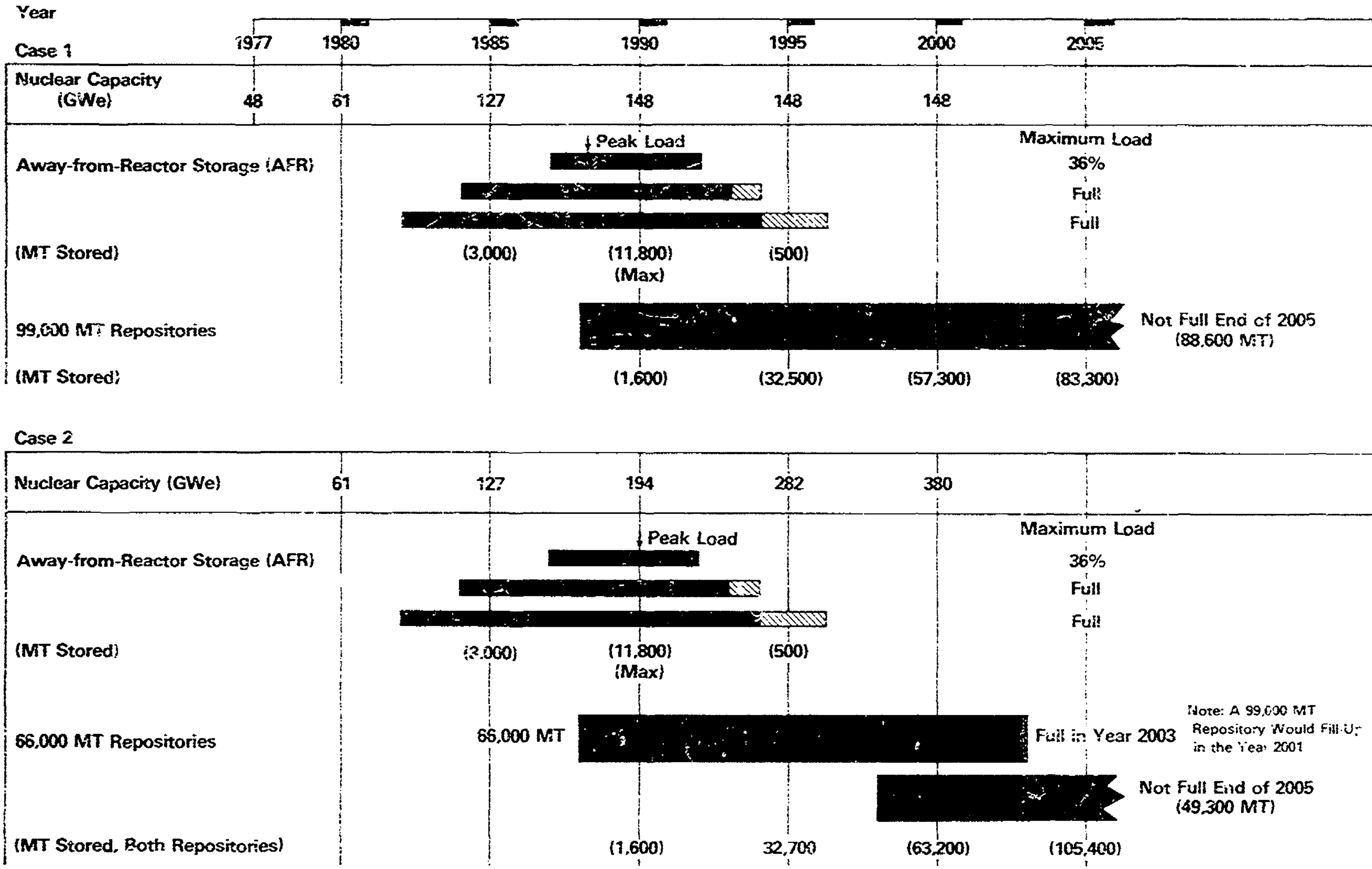
Results

In both cases, any Away from Reactor (AFR) facilities required prior to emplacement of spent fuel in geologic repositories, are emptied as rapidly as possible in order to require the greatest number of commercial repositories. Figure 2 compares the repository and AFR requirements for the two cases, assuming the first repository is available in 1988. The consequences of a 1993 date for the repository are given in Figures 3 and 4 for Cases 1 and 2, respectively.

Another assumption common to both cases is that the high level waste inventory would be processed and available for disposal in the 1985-2000 period. This and the AFR unloading assumption lead to large transportation requirements. The individual transportation needs for unloading AFR's and for moving high level waste (which require similar equipment) are each comparable in size to the industry requirement to ship spent fuel to the Government in the 1990's.

Transportation is an essential link in the nuclear waste management system and the entire nuclear fuel cycle. There are concerns relating to meeting transportation requirements which encompass public acceptance, hardware availability, the lack of a systems approach, security, and scheduling and economics, which are discussed more fully in Appendix G.

Spent Fuel AFR and Repository Requirements*1/

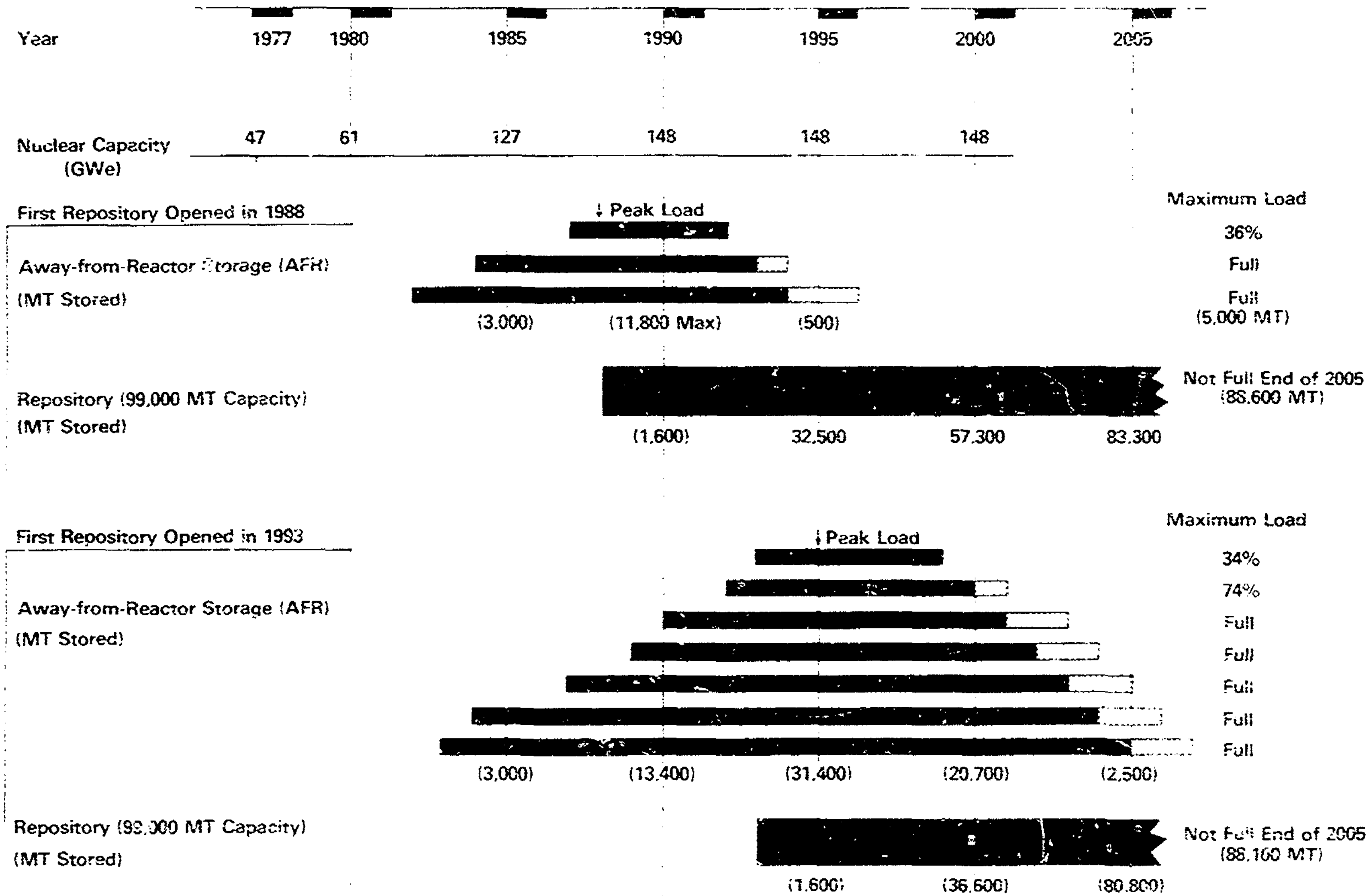


Legend

▨ Storage Kept Open because of Unloading Limits

*1/ Each Bar Represents a Separate Facility of "Standard" Size. Individual Facilities may be Colocated or Dispersed.

Case 1 - Reschedule First Repository from 1983 to 1993 *1/



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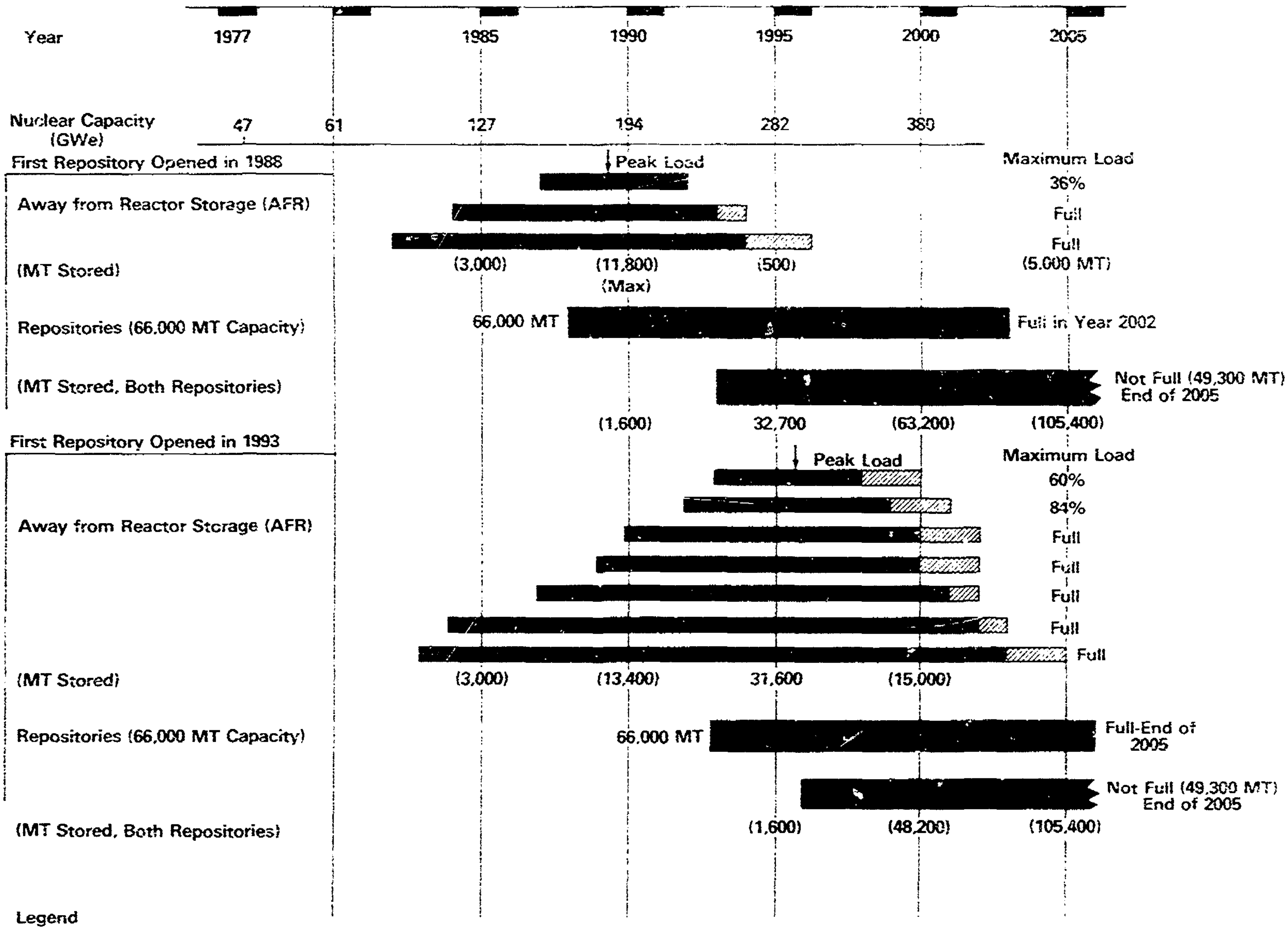
AFR Kept Open because of Unloading Rate Limit

*1/ Each Bar Represents a Separate Facility of "Standard" Size. Individual Facilities may be Colocated or Dispersed.

Case 2- Reschedule First Repository from 1988 to 1993*1/



Legend
Storage Kept Open because of Unloading Limits

*1/Each Bar Represents a Separate Facility of "Standard" Size. Individual Facilities may be Colocated or Dispersed.

Approximate costs to DOE through the year 2000 are $13-17 billion for Case 1 and $18-23 billion for Case 2. The $5-6 billion difference results principally from the larger scale of the nuclear power industry in the second case leading to higher repository and transportation requirements. The other major source of the cost differential is the difference in scale between the D&D programs for DOE facilities assumed under each case.

Conclusions

Conclusions and recommendations throughout previous sections of the report, which emerge from the systems study effort, have already been presented in connection with the specific subject matter.

Additional significant conclusions are as follows:

- The potential magnitude of TRU waste from D&D indicates that WIPP should remain dedicated to the emplacement of TRU waste and possibly solidified HLDW.
- Special attention should be given to transportation as a potential problem area in the waste management system. Near term action should be taken to ensure that casks will be available when needed. Development of dual purpose casks (spent fuel and high level waste) should be considered. The simultaneity of spent fuel and high level waste shipments in the future should be recognized and dealt with from a systems point of view.
- The effects of up to a 5 year delay in repository availability (1988 through 1993 time frame) have been examined. This is particularly important with respect to Case 2, which assumes a continuing growth of nuclear power. The magnitude of the management task clearly increases with delayed repository availability. Nevertheless, the actions required to deal with this situation based on the available analysis appear to be within the reasonable capability of a growing system. Further analysis of this question is desirable.
- It was difficult to assemble and assimilate a consistent set of information for these case studies. More intensive systems analysis is needed and should be made an integral part of the program.

An important contribution of the system studies is the detailed analysis of the material flows through the waste management system, sizing of the facility and transportation requirements, and the calculation of cost estimates. A potential problem has been identified by comparing the structure of the Task Force system to that implied by the Spent Fuel Offer (discussed in the next section).

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SPENT FUEL OFFER

Implementation Issues

Under the Spent Fuel Storage Program, the Government has offered to accept title, to store retrievably for a period of time, and to terminally dispose of spent fuel from commercial power reactors in exchange for a one-time charge.

Implementation details of the spent fuel offer are being developed within DOE. Since the disposal charge must recover future costs, many implementation assumptions are being built into the charge calculations. It is not clear whether these are actual implementation plans or only a convenience for making pricing calculations. These issues arise due to the need for describing the entire future waste management system for civilian fuel through the year 2000 and perhaps beyond. Many items are not compatible with the Task Force view of how the waste management program should evolve over time. Points at issue are the following:

- The calculations from the perspective of the spent fuel offer assume shipment of fuel to AFR interim storage and shipment to geologic storage designed for 25 year retrievability (for economic recovery purposes). This implies both possible removal from underground storage for economic purposes and future shipment to a point of economic use. If fuel is possibly to be reused at a later date, continued interim storage in AFR's would avoid unnecessary transportation and handling and thus would likely be preferred to the proposed scenario. The system described by the charge calculations presupposed a repository design requiring 25 year "economic retrievability" features. This is in conflict with the Task Force view that the repository should be designed for ultimate disposal and should incorporate retrievability only to the degree dictated by safety considerations.
- The waste management considerations outlined above suggest that alternative approaches be considered in the Spent Fuel Offer to better separate storage from disposal. One approach might be to require a determination by the utility at the time of fuel delivery for either:

  a. interim storage for a defined number of years, followed by disposal if an option to recover the fuel is not exercised within that time, or
  b. direct disposal.

  The former service would be more expensive than the latter. Fuel provided under (a) would remain in the AFR's until the disposed date; fuel provided under (b) would remain in AFR's only until the ultimate disposal repository were ready to receive it.

- To minimize transportation needs and to provide additional buffer storage at repository sites, AFR's and repositories should be co-located. This objective could be pursued even to the point of locating an early AFR at a potential repository site which might subsequently be foresaken. Alternatively regional AFR's should be considered.
- The dates, thermal loadings, etc. being used in the calculations are design basis numbers for a conceptual repository. They may not apply to actual sites and may not be sufficiently conservative for at least the initial operating periods of actual repositories.
- Only 15% contingency costs are proposed. No consideration is included in the pricing approach of more costly scenarios and their probabilities. Factors which could increase cost include unloading a repository and reemplacing the material, variations in the dates of repository availability and in AFR construction needs, repository capacities, reduced volume of civilian wastes to be geologically emplaced etc. An alternative approach to the proposed concepts would be to include a greater hedge against uncertainty in the cost algorithm and then, as in the initial nuclear insurance industry approach, provide a future rebate if the actual experience were more favorable. Accordingly, the basic philosophy of dealing with uncertainties in the charge should be treated as a management policy question and given further review.

Resolution of the above issues, which will require additional time and discussion, should be made a matter of high DOE priority.

Integration of Fuel and Waste Management Policy

The waste management and Spent Fuel Offer activities and schedules should be reexamined and integrated to avoid mismatches in the timing of implementation steps.

Licensing of AFR's

AFR's constructed by the Government under the spent fuel offer would substitute directly for private sector interim fuel storage facilities. These private facilities would be licensed by NRC. Accordingly, substitute DOE facilities designed to receive fuel for temporary storage on the way to possible ultimate disposal should be subject to licensing by NRC.

Voluntary Delivery of Fuel

If reprocessing were never to be allowed, fuel would be viewed as a waste material. As such, after some period of time subsequent to its discharge from a reactor, there would logically be a requirement for its mandatory delivery to the Government for ultimate disposal.

Such a requirement does not exist today. This is appropriate because the premise leading to the requirement is not in force. There is no evident safety reason why interim storage of fuel cannot be conducted safely for a number of decades.

At some future time the Government may wish to consider making the delivery of spent fuel to the Government mandatory. Utilities may, however, view the economic risks of "waiting for reprocessing" as being unjustifiable and may prove ready today to arrange for ultimate disposal, without such a requirement, as soon as the Government is prepared to receive the material.

Environmental Impact Statement

Environmental Impact Statements (EIS) and legislation are required to implement the programmatic details of the policy approach. The EIS's under preparation concerned with fuel policy issues are planned to rely on and supplement a Generic Environmental Impact Statement on Management of Commercial Wastes now in preparation. Members of the Task Force have examined the present version of that latter document and believe that substantial additional work is needed to achieve an acceptable Final Statement. This will subsequently be discussed in more detail.

An environmental and policy issue needing further analysis concerns both:

- o The degree of away-from-reactor (AFR) storage by DOE which would be desirable or acceptable (as opposed to continued decentralized storage) and
- o The amount of AFR storage which would actually occur under the proposed Spent Fuel Offer.

There are considerations both pro and con with respect to AFR storage involving transportation volume, vulnerability of centralized versus dispersed facilities, etc. These issues must be resolved in the NEPA process.

Publication of Draft "Charge to Utilities"

The basic methodology being used in the pricing calculations, the policy of full cost recovery, and other generic aspects of the approach are acceptable to the Task Force. The development of the calculations in their present form represents a substantial effort which has been accomplished in a highly competent manner and in a short period of time.

Commitments have been made to publish a proposed draft charge for public comment at an early date. There is value in exposing the existing work to such review promptly. The Task Force recommends, however, that in light of its comments here, the results not yet be described as the proposed "charge to utilities."

IMPLEMENTATION DETAILS

The following is a discussion of the specific details which have emerged from the Task Force analysis of the waste management problem.

Legislative Requirements

Task Force recommendations requiring substantive legislation are:

- o DOE have the sole responsibility for the provision and management of facilities for the ultimate disposal of commercially-generated TRU and low-level radioactive wastes.
- o DOE acquire ownership and control of existing burial grounds for commercially-generated low-level radioactive wastes.
- o DOE be authorized to provide facilities for interim AFR storage of commercially-generated spent fuel and have sole responsibility for the provision and management of facilities for the ultimate disposal of such fuel.
- o DOE facilities for interim storage and ultimate disposal of commercially-generated spent fuel and for ultimate disposal of DOE and commercially-generated TRU wastes be subject to NRC licensing.
- o DOE facilities for the ultimate disposal of DOE and commercially-generated low-level radioactive wastes be subject to licensing by either NRC or the states or through a mechanism involving regulation by both NRC and the states.

The Task Force recommendation that commercially-generated TRU wastes should be delivered to the Federal Government for ultimate disposal can alternatively be accomplished by regulation issued by the Nuclear Regulatory Commission.

Certain actions involving the Western New York Nuclear Fuels Services Center at West Valley, N.Y. may require substantive legislation in addition to that described above. The requirement for such legislation cannot be determined until completion of the DOE study mentioned earlier in the report.

Strengthening the NEPA Process

An attempt has been made to systematize potential future actions in the waste management area by constructing a decision tree for DOE's NEPA strategy in this area. The underlying basis for this strategy is to provide future decisionmakers with timely and reliable environmental information for all reasonably available decision options.

Results are detailed in the attached chart. (Additional details including footnotes to the chart are presented in Appendix L.)

For the set of activities considered on the chart, a maximum of 45 separate environmental reviews are projected as needed. These reviews likely would result in DOE's preparation of 7 EIS's and 14 Environmental Reports (ER's), the latter supporting NRC's preparation of EIS's and resulting licensing decisions. The projected minimum case would be 18 separate environmental reviews likely to result in DOE's preparation of 5 EIS's and 3 ER's.

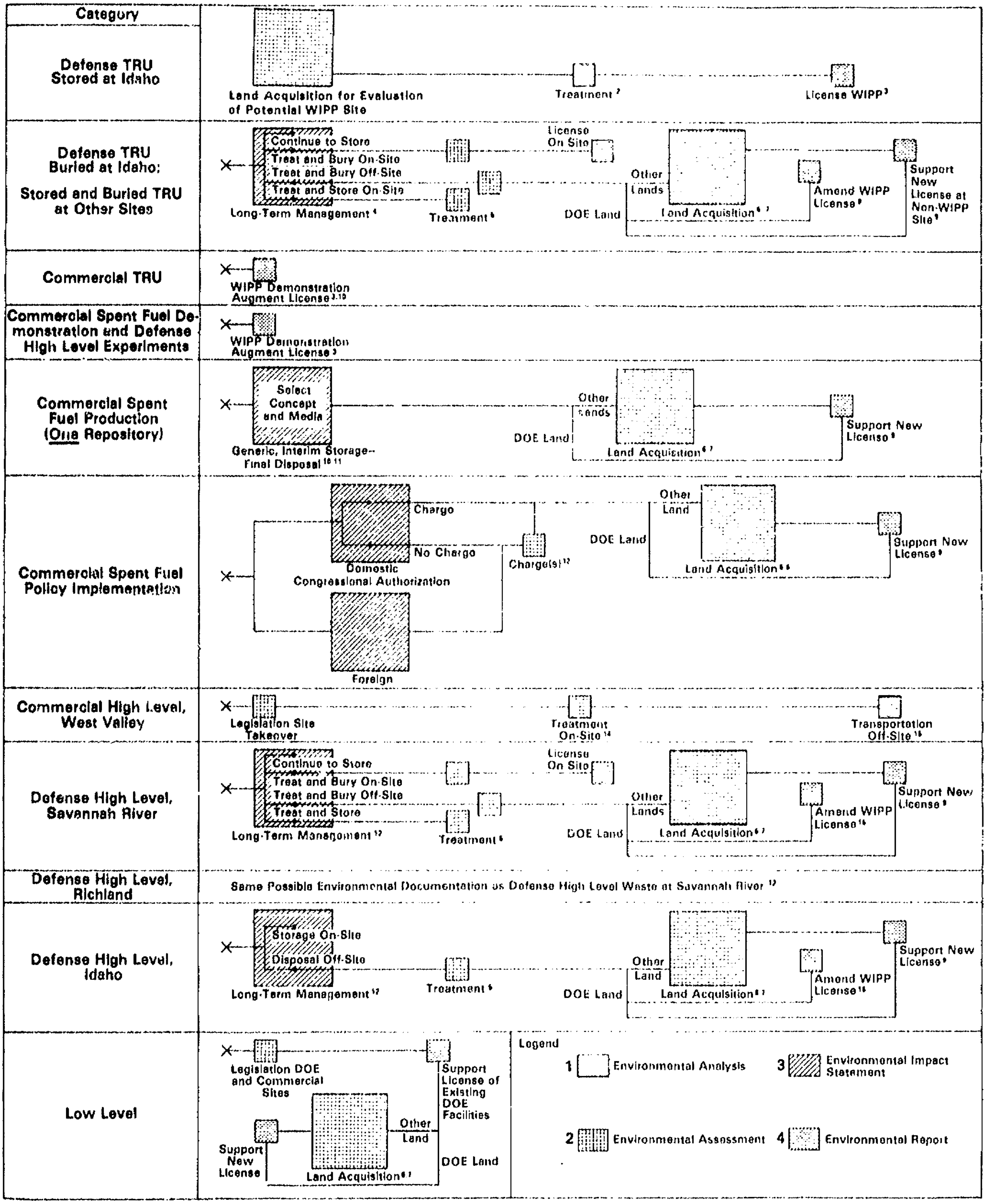
The magnitude, complexity and importance of this task implies the need for significant management attention and for strengthening the environmental analysis capability of the waste management program and the overall NEPA process.

The following broad functions need particular attention:

- Identification of environmental issues and significant potential impacts associated with the program.
- Development of research and development strategy, including the gathering of base-line data to resolve or mitigate such issues and potential impacts.
- Preparation of environmental documentation, including records of environmental review, environmental assessments, negative determinations, environmental impact statements and supplements necessitated by program or project design changes.
- Monitoring of activities to assure that mitigation objectives are achieved during program implementation and system operation.
- Identification and implementation of all environmental and land use-related permits, licenses and certificates necessary for the conduct of program activities.

More specific organizational recommendations are presented in a later section of the report.

Recommended NEPA Strategy for Waste Management Decisions (Assuming Implementation of Task Force Recommendations)



Note that the chart shows alternatives in parallel (e.g., off-site vs. on-site, existing repository such as WIPP vs. new repository) and each such decision requires a NEPA environmental action and appropriate regulatory action, both with full public participation.

Generic Environmental Impact Statement (GEIS)

Present Situation: The first draft of a GEIS on the Management of Commercially-Generated Radioactive Wastes is under review within DOE. Following internal review the document would be published for public comment and formal interagency review. Then, a final statement would be published to provide the basis, under NEPA, for potential programmatic decisions on waste management associated with the four fuel cycles considered in the statement:

- once-through
- uranium recycle
- uranium-plutonium recycle
- deferred isolation or reprocessing

Additional Effort Needed: Review of the preliminary version of the GEIS suggests a number of areas that require further work to bring the GEIS to a level where it can become a more meaningful input to the two key waste management decisions it seeks to support:

- permanent commercial waste isolation, and
- retrievable storage of spent fuel elements.

It should also provide an impetus for additional waste management research and development necessary to resolve areas of uncertainty.

The following comments are designed to assist in identifying some key areas where further effort can profitably be expended:

- Battelle may not yet have been furnished significant technical data necessary for an adequate environmental analysis of geologic media under current program consideration, e.g., salt, basalt, and granite.
- Major issues involved in reaching the two major scope decisions should be more clearly articulated and analyzed (e.g., basis of repository design criteria). Indeed, the document appears to focus more on a description of technological status of the commercial waste management program than on an environmental analysis of waste management control.
- A description is not included concerning generic site selection factors and/or design criteria which would bracket the impacts associated with commercial waste disposal at designed production throughput capacity.
- Inasmuch as this is a generic statement, it should indicate the limitations and/or confidence level of the data and methodology, due to the fact that it uses

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typical, hypothetical disposal sites. This situation particularly applies to accidental release probabilities and resultant inputs.

- Sufficient treatment does not appear to have been given to:

  a. analysis of accidents (physical events or design failures), the consequences, and quantitative probabilities;
  b. the treatment of radiologic dose to both individuals and general population and other environmental consequences, subject to appropriate time constraints;
  c. the fate of fission product gases and other safety/environmental questions about gases;
  d. environmental consequences of scenarios involving unloading and reemplacement at repository(ies) subjected to retrievability requirements; and
  e. monitoring and remedial action requirements at both interim storage and final disposal sites.

- There is work in Sweden and elsewhere involving specific repository design concepts and associated environmental protection philosophies. These concepts should be described and their possible relevance to selection of media, repository design, and environmental consequences for disposal of U.S. waste should be discussed.
- A review is needed of predraft comments on the original outline, the decisions taken then, and the actual treatment in the draft of issues raised at that time.

The foregoing comments are all directed at improving the data base and analysis within the existing scope of the GEIS. While that effort is proceeding, reconsideration might be given to broadening the scope of the GEIS to include commercially-generated low-level waste.

Next Steps: While not complete, the above comments are indicative of the need for greater emphasis and high-level management attention being given to the status of the GEIS document, a critical path item in the development and implementation of waste management policy.

The formal DOE review of the draft is still in progress. If any significant delay is encountered in the availability of a public review draft, the Task Force suggests that the present draft be made publicly available for its information content. This would assist the intergovernmental and public review process which the Task Force anticipates as a follow-on activity. Revision of the draft GEIS could thus proceed in parallel with the larger waste management review.

Organization

Organizational Level: There have been proposals, resulting from both formal studies and draft legislation to establish a separate Federal entity to operate the waste management program. Rather than attempt to evaluate the merits of these proposals, the Task Force has focused instead on the issue of strengthening the program within DOE.

The present waste management program in DOE is located within the Office of Nuclear Energy Programs. The position of Director of the Waste Management Program does not report directly to a DOE Assistant Secretary but rather to the Director of all Nuclear Programs. The program, its management and policy direction are all critical and need increased support and visibility. The Task Force recommends that a program head with policy formulation responsibilities be created, reporting directly to an Assistant Secretary.

Environmental Aspects: The nuclear field is one of significant public controversy with respect to environmental issues. The operation of the entire system within DOE for preparing environmental reviews for the waste management program should be examined in detail and needed remedial actions taken.

The Assistant Secretary for the Environment needs a strong independent and objective overview capability with respect to the waste management program; hence, he should not be selected to operate it. This capability needs significant strengthening.

The Director of the Waste Management Program needs a strong, highly competent, and issue-aware environmental office within the program. This office must centrally manage the full spectrum of environmental assessments, reports, and statements that are required by the program. Significant strengthening is needed here. Strong inputs should be sought at an early stage from other elements of DOE on EIS scopes, strategy and application for the purpose of enhancing the decisionmaking process.

Program Aspects: The present managerial integration of military and civilian waste program management is good. Similarly, there is growing integration of view on low, TRU, high level and spent fuel program needs and issues. These trends should be encouraged and further strengthened.

The interim storage of spent fuel has not been included in the waste program in the past. The discharge of the spent fuel and its storage for possible reprocessing has been considered as associated with the operations of the reactor. However, with the indefinite deferral of reprocessing and the possible need to place spent fuel in deep geologic disposal, the proposed interim storage in AFR's has a direct impact on the nuclear waste management program. Therefore, this function should now be incorporated within it.

Decontamination and Decommissioning (D&D) has not been included in Waste Management. D&D generates nuclear waste that must be ultimately disposed of. The handling of the waste product of D&D must be closely coordinated with the availability of adequate facilities for the disposal of the material. D&D functions should now be incorporated within the waste management program.

Organizationally and programmatically, much greater attention needs to be focused on fuel and waste transportation issues. Present transportation capability for fuel is about 500 tonnes of heavy metal per year whereas actual generation rates now are 1000 tonnes annually. Some 10 to 15 years from now the requirements for repository filling and AFR unloading could reach 10,000 tonnes annually. Numerous transportation issues have been identified by prior task forces. Greater attention to these issues and more evident progress are needed.

Personnel Resources: Current personnel resource levels are viewed as thin for a program involving such significant policy and management issues.

A total of 46 full-time Federal employees (including secretaries) constitutes the DOE headquarters Waste Management Division. In order to minimize DOE headquarters personnel needs, reliance is placed on decisions taken in the field offices and by contractors. Some of these decisions can have significant policy ramifications. Decentralization of implementation responsibilities is desirable. The line between policy implementation and policy formulation needs to be more carefully drawn, however. The balance in this situation warrants review.

Downstream personnel needs will grow as more responsibilities and facilities are undertaken. A detailed analysis of those future needs should be done, and an acceptable staffing plan developed.

Near Term Budgets

A very brief review of the relationship between Task Force recommendations and the FY 1978/9 budgets was undertaken.

Spent Fuel Storage: The FY 1978 and FY 1979 budgets for spent fuel storage provide for analysis of requirements and investigations into suitable financing arrangements. Once determinations have been made on the appropriate approach to providing AFR's, it may be necessary to request a supplemental appropriation to initiate construction of Government AFR's or guarantee financing of AFR's constructed by the private sector. Recommendations of the Task Force do not impact this problem significantly.

Terminal Storage: There are at least three areas requiring further consideration:

- The FY 1979 budget assumes limiting the intensive investigation of salt depositories to two sites. If intensive investigations are required in more than two sites, additional funds would be needed.
- The present allocation of the FY 1979 budget for investigation of alternative geologic types needs further review. To provide for more intensive effort additional funds would be needed.
- Information was not obtained on the adequacy of budgets for safety analysis and for scientific data acquisition. The completion of the review of this area, recommended previously in the report, could indicate the need for additional funds.

Waste Operations and Handling: Budget areas requiring more review are as follows:

- Commercial Low-Level: The FY 1979 budget does not assume DOE assumption of responsibility for commercial burial grounds. If this is implemented, the budget would be inadequate. The extent of the funding required is not known. There may be offsetting revenues.
- West Valley: The FY 1979 budget does not provide for the DOE assumption of responsibility for waste at West Valley. If this is implemented, the budget would be inadequate. The extent of the funding requirement is not known. Again, there may be offsetting revenues.

The Controller's office and the Assistant Secretary for Energy Technology should examine these near term budget questions in more detail and make specific recommendations to the Secretary, as appropriate.

Effluents from DOE Facilities: In future budget years, DOE should give more attention to the magnitude of release of radioactive effluents from its own facilities. In a number of cases, expenditures have been requested but deferred which would have reduced such releases (one form of ultimate disposal of nuclear waste). While such improvements may not always be viewed as matters of the highest priority for limited funds, DOE's own performance is one indicator to the public of the Department's credibility as custodian and manager of nuclear wastes in general.

PUBLICATION OF THE TASK FORCE REPORT

This Task Force Report discusses many sensitive issues. Not all of its views will withstand the judgment of more time for reflection, additional information, and peer review. Its purpose is to make a useful contribution to the resolution of a highly complex problem. If it is viewed as being successful in that regard by DOE management, we urge that it be made available for intergovernmental and public review, expected to take place as the next step in this process.

APPENDIX A

MAKEUP OF TASK FORCE

A DOE Waste Management Task Force was established, under the direction of John Deutch, Director of Energy Research. Makeup of the Task Force is as follows:

Name	Representing Assistant Secretary for
Roger LeGassie, Chairman	Energy Research
Glenn Boyer (Alternate)	Environment
Aaron Edmondson	Controller
Stephen Goldberg	Policy and Evaluation
Stephen Greenleigh	General Counsel
Colin Heath	Energy Technology
Bruce Mercer	General Counsel
Goetz Oertel	Energy Technology
Robert Ramsey	Environment
David Roberts	Energy Research
John Seymour	Institutional Relations
William Sprecher	Policy and Evaluation
Jack Thereault	Energy Technology
Jacob Vreeland (Alternate)	General Counsel

Significant participation and assistance were made available by two ex officio members, John Ahearne of the Office of the Secretary, DOE, and Ted Greenwood of the Office of Science and Technology Policy. Additional inputs were prepared by staff of the Assistant Secretary for International Affairs.

APPENDIX B

LOW LEVEL WASTE (LLW) DISPOSAL SITES

The term LLW covers all wastes that are not "high level" or transuranium-contaminated" (TRU) solids. Current practice is shallow land disposal on-site at 14 active and 2 closed burial grounds at DOE installations, and at 6 commercial burial grounds (4 open, 2 closed) that serve the nation's nuclear power industry and other producers of nuclear wastes such as hospitals and research organizations. Most LLW waste remains radioactive for up to a few hundred years.

Commercial sites accept LLW for fees and according to standards that vary by site. The operators may be licensed by the Nuclear Regulatory Commission (Sheffield, Illinois) or by 'Agreement States" under the Atomic Energy Act of 1954 (all others). DOE sites are subject to overview by an independent DOE organization but not to licensing by NRC or the states.

LLW with more than 10 nCi/g of Pu is termed TRU waste. The dose to humans at that threshold is equivalent to that from radium in naturally occurring ores in the Colorado plateau. NRC is currently developing a new threshold based on a comprehensive analysis of the isolation needs.

Commercial TRU wastes are being accepted and buried as low level solid waste at the commercial site near Richland, Washington, the only site presently accepting commercial TRU wastes. This contrasts with DOE's practice of retrievable storage of TRU wastes at all DOE sites, instituted in 1970 in anticipation of a future decision of the TRU contamination level above which they should be committed to deep geologic disposal. Other burial sites, including several DOE sites and West Valley, contain wastes that are currently not deemed acceptable for continued shallow land disposal. DOE has initiated a land burial technology program to set standards for improved operations and to stabilize existing sites if necessary. The program encompasses DOE sites only, but its results will be available to commercial site operators through an active communications program. Initial criteria will be published this year and finalized in 1980. On-going operations at all DOE sites will meet the initial criteria by 1981. Technology development for long term stabilization of previously buried wastes will be completed by 1981 and applied to all DOE sites, including closed sites, by 1987.

The specific objectives of the land burial technology program are:

- Develop criteria and standards to assure that radioactive waste disposal activities are performed such that the risk of escape of radioacitvity from low level burial sites is minimal and that the dose to man from such escapes will not exceed prescribed limits.

- Define necessary actions to stabilize filled burial grounds at all DOE sites.
- Develop and demonstrate a sufficient theoretical and practical understanding of the near surface geology, hydrology, and transport mechanisms to assure that the objectives can be met.
- Develop and maintain mechanisms to communicate and gain acceptance for technology advances and operational improvements to all U.S. sites.

DOE is considering alternatives to shallow land burial, including volume reduction and disposal in suitable deeper geologic formations. The cost of such alternatives has been estimated to be $60/ft^3 compared to about $3/ft^3 for present practices. Assuming that 275,000 ft^3 can be disposed of per acre, the processing alternative places a "value" of up to $10 million on each acre saved.

Additional DOE burial ground capacity will be required by 1982/1990 depending upon site and decommissioning/decontamination impacts, and by 1990 at the latest, commercial sites (see Section K).

The present DOE land burial program milestones:

1978: Initial criteria issued for LLW shallow land burial operations.

1980: Final criteria issued for LLW shallow land burial operations.

1981: Site improvement program to meet initial criteria completed (upgrading of on-going operations).

1981: Technology development for long-term stabilization completed.

1982: Long-term stabilization of closed burial sites started.

1987: Long-term stabilization of closed burial sites completed.

1987: Sites in compliance with final LLW criteria.

APPENDIX C

TRU WASTE

Background

TRU waste is made up of materials which contain or are contaminated by transuranic elements, with mass numbers higher than uranium, which characteristically emit alpha particles with half-lives measured in thousands of years. Alpha particle radiation requires little shielding but alpha emitters are dangerous if ingested or inhaled. Primary concern comes from the long lifetimes during which they remain radioactive.

The quantities of TRU waste discussed in Section K derive predominantly from defense-related activities. Current production from the commercial sector is low because there is no reprocessing of commercial nuclear fuel. TRU wastes from commercial operations have TRU concentrations that are barely above the 10 nCi/g * threshold.

Early practice allowed disposal of TRU waste in shallow land burial because the threat to health and safety was perceived as small. Concern over long times required for containment and experiences with some leakage and migration resulted in a determination by AEC in 1970 that TRU wastes should not be placed in shallow land burial.

Beginning in 1970, steps were taken to place TRU waste under AEC control, with concentrations higher than 10 nCi/g, on retrievable storage pads pending a later decision on final disposition. The value of 10 nCi/g was used as the cutoff point because this value for Pu is roughly equivalent, in terms of radiation doses to humans, to a naturally occurring radium isotope in high-grade ores found on the Colorado plateau. Materials with concentrations below this level were felt to require no special attention because of their TRU content. Materials with concentrations higher than 10 nCi/g were packaged to provide safe containment for 20 years. A final decision as to what TRU concentrations will require geologic disposal is pending at NRC.

Retrievable storage of TRU wastes from U.S. Government operations since 1970 has primarily been at the Idaho National Engineering Laboratory (INEL) and at the Hanford reservation. In 1970, assurances were given to the Idaho governor and Congressional delegation that AEC would begin transfer of the wastes from Idaho to a geologic repository before 1980. This assurance was based on an AEC plan to seek authority in 1972 to build a geologic repository near Lyons, Kansas.

Development of the Lyons, Kansas facility was not pursued because of problems with that particular site. A program to identify an alternate site in 1973 resulted in preliminary selection of an area in New Mexico. Further evaluation of the area was minimal for two years due to emphasis

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* 10 nanocuries (billionth's of a curie) per gram

on retrievable surface storage. In 1976, the Waste Isolation Pilot Plant (WIPP) project was activated to provide a repository in New Mexico for TRU wastes.

In 1977, a recommendation was made within ERDA that all facilities for the permanent deep geologic isolation of radioactive material, including WIPP, should be subjected to NRC licensing in order to provide a truly independent assessment of the suitability of the site for the repository. The requirement for licensing and the actions required under NEPA resulted in 1985 as the estimated earliest operational date for WIPP.

Most of the site proposed for WIPP is in the public domain under the control of the Bureau of Land Management (BLM). Since current law limits land withdrawal by BLM to 20 years, legislated land withdrawal by the Congress has been proposed.

Secretary of Interior Andrus, previously Governor of Idaho, believes the earlier commitment to Idaho included removal of all currently buried TRU waste as well as retrievable. Andrus desires removal to begin by 1980. There is no permanent isolation site for the material until WIPP becomes available.

Status

TRU waste from DOE operations is now stored retrievably. 1,700,000 ft^3 are now stored. The generation rate from continuing DOE operations is 250,000 ft^3/year. Most of this material is at INEL. The current schedule for WIPP development shows 200,000 ft^3/year going to WIPP for first five years during which WIPP would be in a test phase and wastes could be retrieved. After successful completion of this test phase, input rate could be increased to 1,200,000 ft^3/year. All waste could be retrieved from Idaho pads by 1995.[1/]

An R&D program has been initiated to assess the environmental consequences of recovering previously buried wastes. Experimental recovery and repackaging are in progress as part of that program. Similar programs are in the definition or early development (Richland) phases at other DOE sites and will take advantage of the Idaho experience.

Processing including incineration, immobilization, and packaging may be required to meet the eventual repository acceptance criteria. Technology development is proceeding toward this end.

NRC is currently evaluating the appropriate definition of TRU waste. It is reported that a level of 100 nCi/g will be an acceptable point below which no special attention because of Pu content will be required. Currently only small amounts of TRU waste are coming from the commercial sector.

1/ The Task Force, in the main body of the report, recommends that this schedule by significantly accelerated.

APPENDIX D

FINAL DISPOSAL OF HIGH-LEVEL WASTE

1. High-Level Waste from Reprocessing Operations

High-level waste (HLW) is extracted from irradiated nuclear fuel during reprocessing and contains the bulk of the radioactivity and decay heat.

HLW from nuclear activities in support of national defense are located in the States of Idaho, South Carolina, and Washington. A series of documents entitled "Defense Waste Documents" has been published describing the costs and risks of the technically feasible alternatives for the ultimate disposition of the HLW at these sites. Environmental impact statements analyzing the impact of implementing these alternatives are currently being prepared. Technology development and full-scale equipment testing for likely alternatives are being pursued in parallel to permit prompt project initiation upon completion of the required analyses and a decision as to how to proceed. The FY 1979 budget supports this strategy but delays the start of operations at all sites by one year compared with the most recent defense management plan.

The major alternatives being considered include:

a. Continued interim storage operations

b. Segregation of the more active and/or long-lived wastes and processing to a stable/immobile form for:

   1. on-site surface storage

   2. on-site geological disposal

   3. transportation to off-site geologic disposal

c. Direct disposal in on-site geology

The segregation steps referred to separate sludges and precipitates through centrifugation and filtration. These solids are dried and then washed to remove all water-soluble salts and are then converted to stable solids such as glass or concrete for all cases examined involving off-site disposal. The remaining salt solution is decontaminated by filtration and ion exchange so that the resultant salt cake contains less than 6 nanoCuries/gram of residual activity. At this level it could readily be disposed of in shallow burial grounds.

Risks and costs for each alternative have been identified in the Defense Waste Documents but in each case the calculated risk of each alternative is sufficiently low that any one might be considered acceptable on a risk basis alone. While such calculations are useful in providing insight into the problem for decision-makers, it is most unlikely that the results will be overriding.

It is widely perceived that a decision on a long-term management mode that places minimal demands on future surveillance and maintenance has been deferred for too long, and that permanent isolation in a geologic repository will ultimately be required.

Less than 25% of a typical geologic repository of 2000 acres would be required to dispose of all existing high-level defense wastes (HLDW). If the decision is made to ultimately place all HLDW in a repository, the WIPP site in New Mexico would be a candidate for receipt of this material. No decision to put HLDW in WIPP has been made but the design and licensing of WIPP are currently planned to be conducted in such a way as not to preclude that option.

The programs to provide final treatment and disposal of HLDW at the three sites are deliberately being conducted in a sequential fashion. Based on the environmental characteristics of the site, including local climate and hydrology, Savannah River has been selected as the lead site and preparation of the EIS and implementation of a disposal option will proceed there first. If the same disposal method is selected at other sites, the experience learned at Savannah River will be directly applicable to those sites.

HLW materials are also located at a commercial site at West Valley, New York (see following section).

2. High-Level Waste at West Valley

The Western New York Nuclear Fuel Services Center at West Valley, New York operated from 1966 to 1971 under NRC license as the only commercial nuclear fuel reprocessing plant in the United States. The plant was undergoing repairs, upgrading, and capacity improvements before the operator of the site, Nuclear Fuel Services Corporation (NFS), withdrew its license application for plant expansion in 1976. NFS and the State of New York are joint holders of the license and responsible for the maintenance of the site and the protection of public health and safety. Several leasing agreements between NFS and the State delineate their respective responsibilities and liabilities. The State of New York is believed to be liable for the necessary management of radioactive wastes at the site.

Nuclear wastes at West Valley are contained in high-level waste storage tanks, a burial ground, and a reprocessing plant complex including a spent fuel storage pool. NRC has estimated that the disposal of the high-level wastes could cost from $10M to $540M depending upon the alternative selected. Costs for appropriate action on the other waste situations also depend strongly upon the alternative selected but should be less than for HLW. The facilities at the site may be useful for

- resumed low-level burial operations,
- receipt of additional spent fuel for storage,
- international nuclear fuel cycle project evaluation and waste processing R&D and demonstration.
- geologic disposal of wastes in shale or other suitable formations.

The FY 1978 authorization bill requires that DOE study institutional and technical alternatives for the future of West Valley. The study is scheduled for publication in August 1978. Several technical and programmatic alternatives for each of the waste situations will be described, and the following institutional alternatives evaluated:

- Federal technical and financial aid in support of West Valley decommissioning
- Federal operation of the site for decommissioning, disposing of waste, and demonstration of high-level waste solidification
- Federal ownership and responsibility for all or part of the site

The study will also address the continued use of the site for purposes such as research and development and waste disposal operations.

As part of the National Waste Terminal Storage Program, DOE is evaluating the suitability of the Salina Basin salt beds in Western New York for potential siting of a repository for commercial radioactive wastes including those located at West Valley. A survey of potentially suitable sites is currently underway with a report expected in early 1978. This report will be discussed with State and local officials in New York pending further investigations by corehole drilling. A repository situated in this area could reduce transportation activities required for ultimate disposal of wastes from West Valley.

3. <u>Disposal of Spent Fuel</u>

Initial planning for nuclear power reactors assumed the reprocessing of irradiated fuel elements, a recovery and recycle of uranium and plutonium, and disposal of the residual fission products with small amounts of uranium and plutonium as high-level waste in geologic repositories and TRU wastes in shallow-land burial.

In 1970, the AEC formally imposed a requirement that all high-level waste from reprocessing plants be solidified to a stable form and shipped to a Federal repository for disposal within a fixed period of time.

In May 1976, the Energy Resources Council issued a policy paper (jointly authored by ERDA, EPA, USGS and with consultation by NRC) in which the goal of developing two NRC-licensed repositories in salt formations for operation by 1985 was endorsed. The schedule assumed no licensing action required by NRC prior to construction, only prior to actual receipt of waste. An interagency task force, chaired by the Office of Management and Budget (OMB) was assembled to expedite implementation of those steps necessary to achieve the necessary 1985 schedule.

In October 1976, President Ford directed that ERDA programs should not assume the future reprocessing of spent fuel because of concerns about nuclear proliferation aspects of plutonium recycle. The nuclear waste management program then increased its attention on the alternative of disposal of unreprocessed spent fuel as a primary waste form.

In December 1976, ERDA announced a program to seek sites for geologic repositories in 36 states. The program was to lead to construction of 6 repositories, 2 each in salt, shale and granite, before the year 2000. The first two repositories, in salt formations, were to be in operation by 1985 with site selection announced in 1978. The governors of each state were asked for assistance but were assured that "the project will be terminated if the state raises issues on the project connected with these /site selection/ criteria, and their application, that are not resolved through mutually accepted procedures."

In April 1977, President Carter formally declared an indefinite deferral of reprocessing. The option of disposal of spent fuel elements in geologic formations was given added emphasis in the waste management program.

In October 1977, at the urging of the United States, nations joined together in an International Nuclear Fuel Cycle Evaluation (INFCE) to analyze the various nuclear fuel cycle alternatives in light of concerns about nuclear weapons proliferation. Concurrently DOE is conducting a Nonproliferation Alternative Systems Assessment Program (NASAP) to evaluate alternative fuel cycles which may provide better nonproliferation characteristics, including waste streams that might be produced thereby.

In October 1977, the Department of Energy announced a Spent Fuel Policy whereby utilities will be given the opportunity to deliver spent fuel to DOE in exchange for a one-time fee to cover the costs of temporary storage and eventual geologic disposal. Provisions will be required to handle the anticipated load of spent fuel. Details of this policy and how it might be implemented are discussed further in Appendix F.

The DOE terminal storage program under commercial waste management is continuing to study methods by which spent fuel may be disposed in geologic formations even though no decision has yet been made that commercial spent fuel should be considered as waste. The German government is reported to have taken the position that reprocessing is a necessary step prior to the safe disposal of radioactive waste. However, although there are a number of technical differences in the waste form, primarily associated with the quantity of uranium and plutonium contained in spent fuel, the DOE program has not revealed any generic reason why spent fuel may not be safely disposed of in geologic formations without reprocessing.

Work is also underway to investigate the possibility of using geologic repositories designed and built for terminal disposal as temporary storage facilities pending a future decision as to whether this fuel should be reprocessed for its contained energy value. Periods of up to 25 years during which retrievability of this stored fuel would be maintained are being investigated. Design parameters associated with this storage are discussed in Appendix E.

4. Status of Program for Selection of Sites and Construction of Reporitories

Schedule for Licensing and Construction

Since the time that the goal of a 1985 operating date was established for the first geologic repository for commercial wastes, a number of events and a greater appreciation of the level of outside participation and approval that will be required now suggest that a 1985 goal is unrealistic for a National Waste Repository.

Site exploration activities have been delayed by political resistance and inefficient program management. Scarcity of drilling contractors and drill rigs is now beginning to be a problem because drill rigs are being employed for a number of exploration activities; many also funded by DOE. The earliest possible date for site selection is now considered to be late 1979.

Standards to be released by EPA concerning waste management operations are still in preparation and these are needed for establishment of licensing criteria by NRC.

The degree of site characterization and detailed analysis required by NRC prior to licensing for construction is now a matter of great uncertainty. NRC believes that full EIS review, public hearing and a construction permit will be required before any shafts may be sunk. Shafts may be required to characterize geology. In addition, design studies by architect engineers now indicate that at least 60 months will be required for repository construction.

The elements of the schedule that would have to be met to still achieve the 1985 date are summarized in the attached Table A. No time is available for NRC review prior to start of construction. Given the more clearly defined requirements of the regulation process, an adjusted schedule which allows initial repository operation by 1988 is shown in the attached Table B. Both of these schedules specifically address developing a repository for acceptance of commercial spent fuel or wastes which is separate from the proposed Waste Isolation Pilot Plant (WIPP) in New Mexico. The WIPP facility remains on schedule and is not affected by delays in the schedule for the National Waste Repository.

TABLE A

SUMMARY SCHEDULE REQUIRED TO ACHIEVE 1985 OPERATING DATE FOR A GEOLOGIC REPOSITORY

Milestone	Date
A-E Selected/Title I Design Started	11/78
Identification of Two Suitable Sites for Potential Repository Development	7/79
Single Site Selection	9/79
Start Construction of First Shaft	1/80
Congressional Approval of Construction	10/80
Start Balance of Facility Construction	11/80
Title II Design Complete	7/81
DOE Submits Operating Plan to NRC	9/83
Shaft Construction Complete	12/83
Start Cold Test	10/84
Facility Construction Complete	7/85
NRC Operating License Issued	8/85
Start Hot Operation	10/85

TABLE B

SUMMARY SCHEDULE FOR 1988 OPERATING DATE FOR A GEOLOGIC REPOSITORY

Milestone	Date
A-E Selected/Title I Design Started	11/78
Identification of Candidate Sites for Potential Repository Development	9/79
Single Site Selection	3/80
DOE Tenders Application to NRC for Construction Authorization	7/80
NRC Hearings Begin	10/81
NRC Hearings End	2/82
NRC Permission to Start Construction Start Construction of First Shaft	5/82
Start Balance of Facility Construction	2/83
Title II Design Complete	9/83
Shaft Construction Complete	3/85
DOE Submits Operating Plan to NRC	12/85
Start Cold Test	1/87
Facility Construction Complete	10/87
NRC Operating License Issued	12/87
Start Hot Operation	1/88

The principal objective of the WIPP project has been discussed in Appendix C concerning TRU wastes. Initial WIPP development will cover 200 acres. The potential area that could be developed at each of two different levels is 2000 acres. It has been proposed that, in addition to the principal mission, a limited number of spent fuel elements be placed in WIPP for permanent disposal as a demonstration of closure of the once-through fuel cycle. If 1000 fuel elements, for example, were to be permanently disposed of, they would occupy a total of 20 to 40 acres, depending upon the heat loading per unit area that might be considered acceptable. Adequate space would still remain available for possible placement of defense program solidified HLW and for contaminated equipment from decommissioning and decontamination operations.

Issues - Should a limited demonstration of the permanent disposal of spent fuel be performed in the WIPP facility at an earlier date than the availability of the first commercial repository?

Should the imposition by NRC of detailed licensing requirements prior to shaft sinking at a potential repository site be reexamined?

Repositories in non-salt formations

Granite, basalt and shale are alternate formations potentially suitable for geologic disposal. If long-term retrievability for resource recovery is desired, hard rock repositories could be more suitable. A committee of the American Physical Society (APS) has recommended hard rock development be accelerated in parallel with that in salt.

Suitability of hard rock or shale for disposal is less examined than salt. No test equivalent to Project Salt Vault with radioactive material in hard rock has yet been performed. Groundwater flow through fractures is not well understood. Groundwater is a potential vector for radioisotope migration. Possible fracturing of rock due to thermal load needs investigation. Experimental tests with electrical heaters are currently underway in granite and shale and tests are planned in basalt. These tests will be followed by additional experiments in which spent fuel elements are placed into granite and basalt formations.

Most characterized non-salt geologies are at existing DOE reservations. Hanford has potentially favorable deep basalt beds; the fact that considerable waste currently at Hanford would not need transportation off site if it could be placed in a repository there would offer an advantage. The Nevada Test Site is potentially interesting but the geology there is complex and future weapons testing may preempt possible repository location.

Potentially suitable formations of granite and shale do exist in the continental United States which might be used for construction of repositories. Information on these formations has been compiled, primarily from existing information available through the offices of State Geologists. The current DOE program in these media is limited to that type of survey, however.

Issue - Should additional effort be devoted to accelerating repository development at Hanford?

Design Basis for Repositories

A major issue in designing the terminal storage program is what capacity for receiving solidified HLW, TRU waste or spent fuel elements an individual repository might have. The number of individual repositories that should be developed in parallel to allow for waste volumes generated will have a large impact on the total program scope and cost.

The capacity of an individual repository will be governed by geology type, depth of waste placement, waste form (quantity of Pu contained), possible requirements for retrievability, rate of repository loading, possible need for unloading, and the age since generation in a reactor of the emplaced waste products.

The properties of individual geologies (rock types) will govern total thermal loading per unit acre that will be permissible. Effects in salt are room closure due to creep of salt in the near term and thermal expansion and settling in the long term. Effects in hard rock are possible cracking due to thermal stresses which would increase groundwater circulation through fractures.

Geologic disposal was originally proposed for solidified HLW with low residues of plutonium and uranium. Consideration is being given to either permanent disposal or retrievable storage of spent fuel in geologic formations.

Current program assumptions[1/] are that wastes must be initially placed into repositories on a limited test basis with a capability to remove the wastes if some unforeseen event indicates that it is no longer safe or environmentally acceptable to leave them there. The current assumption is that this limited test phase with retrievability of wastes will last five years. There is no firm basis for this assumption. Recent recommendations have been to expand the initial function of geologic repositories to provide up to 25 years of retrievable storage of unreprocessed spent fuel to allow for a future decision to recover and reprocess this fuel.

1/ The Task Force in the main body of the report recommends that the approach to retrievability be reexamined.

Repository design is significantly affected by thermal loading imposed on the geologic structure by radioactive decay heat. Changes in allowable thermal loading per acre are required to maintain retrievability for significant periods of time. The presence of decay heat from plutonium in spent fuel elements reduces the quantity of fuel that may be emplaced per acre because of long term effects. Further discussion of these impacts may be found in Appendix E.

Technical issues which must be resolved in the licensing of repositories in salt are being identified within the terminal storage program. A vigorous effort to address these issues in a complete and orderly way will be needed to meet desired schedule for NRC licensing action.

Issues - Should multiple sites continue to be sought to increase probability of acceptability of required number? To accommodate initially conservative estimates of repository capacity?

Should sites continue to be sought in both salt and hard rock? Should exploration be accelerated in shales?

Should repositories continue to be designed to receive either HLW or spent fuel?

Should the concept of a limited period of initial operation with potential for retrieval be retained?

Should geologic storage of fuel elements for later recovery continue to be considered?

When will sufficient site-specific information have been accumulated to permit filing of an application for an NRC license for a geologic repository?

APPENDIX E

DESIGN CONSIDERATIONS FOR GEOLOGIC REPOSITORIES

Long-Term Integrity

The engineering design of a geologic repository must minimize perturbations to the existing geology which might lead to a violation of the integrity of the formation. If, for example, the integrity of a salt bed is protected by a layer of material impermeable to water, any disturbances which might crack that layer and allow water to flow through must be avoided.

The development of a repository and the disposal of radioactive waste introduces several impacts on the geologic formation: the mining operation; radioactivity; new chemical elements or materials; and a heat generating source.

With extended experience in mine design and operations, appropriate designs and operating procedures are available to minimize collapse and subsidence which may compromise the geologic integrity.

Radiation from emplaced waste will interact with surrounding minerals and may cause localized radiation damage. Investigations of this phenomenon have shown that this effect will be localized around each waste canister and will not impact the overall geologic integrity.

Chemical elements in the waste form and its packaging could potentially interact with the surrounding minerals and any moisture contained in those minerals. Detailed investigation into the physical chemistry of those potential interactions will be required and work is currently underway. The effects of such interactions are however expected to be localized with minimal impact on the overall geologic integrity. A limit on temperatures in the vicinity of the waste form may result from examination of these interactions. Tentative temperature limits based on current knowledge are given in Table I.

The final factor, heat generation, could potentially cause far-field impacts which could affect geologic stability. Detailed analyses of these effects will be required for any specific geologic site that is considered as a potential repository. It is possible, however, to examine potential effects for a generic site configuration.

As heat is released from a radioactive heat source it will gradually be transferred through the overlying geologic media and be eventually dissipated at the surface. This transfer process will be extremely slow, however, and during this time the total energy stored in a column extending from the surface of the earth to a point four to five times the depth of the repository will increase. The increase in thermal energy within the column will give rise to increased temperatures with accompanying thermal expansion toward the surface. The maximum thermal expansion of this column will determine the maximum strain or uplift which could cause fracturing of upper layers. As the radioactive heat generation decreases and the thermal energy is dissipated, subsidence will occur. Mining experience indicates that subsidence on the order of 5 feet may be acceptable and it is inferred that uplift of the same relative amount will also be acceptable.

Calculations taking into account the above considerations have been performed for a generic configuration of bedded salt with waste emplaced at a depth of 2000 feet. These calculations indicate that solidified HLW could be placed with an initial heat loading of 150 kW/acre if the waste has decayed 10 years since its initial generation in a reactor. Spent fuel elements of the same age could be emplaced at a density of 60 kW/acre. The lower value is required because the cumulative heating over very long periods of time is higher for spent fuel because of the longer decay time and continued heating from contained plutonium in spent fuel. These preliminary values will, of course, change as specific candidate sites are identified and examined. The thermal response will be affected by specific conditions such as: repository depth, presence of aquifers, varying rock strata, waste characteristics and emplacement geometries. More work is required to assess the sensitivity of repository stability to changes in these proposed design parameters.

Operational Requirements

Increases in temperature due to heat generation in the waste will affect conditions during operation of the repository. In salt formations, higher temperatures will increase the rate of creep and open rooms and passages will tend to close. By balancing the thickness of supporting pillars and the allowable increase in temperature the rate of creep can be controlled to permit machinery to enter an open room for the purpose of retrieving emplaced material and returning it to the surface. In non-salt formations, limits on heating and local temperatures will be established to avoid excessive local fracturing.

The capability to retrieve emplaced materials has been proposed for two separate reasons: (1) to allow retrieval for safety considerations during an initial operating period during which measurements confirm design calculations, and (2) to allow recovery of spent fuel for possible reprocessing during a longer storage phase. Periods of 5 years have been proposed for the first reason and 25 years for the second.

In the generic repository configuration, the thermal densities quoted above would permit a 5-year recovery period. Retrievability of spent fuel for 25 years would restrict loading of 10-year old spent fuel to 36 kW/acre.

Using a generic repository configuration, it is possible to compare allowable heat loadings for various geologies and waste types. This comparison is shown in Table II.

All of the tentative specifications and loading limits shown in the tables must be validated by in-situ tests with electrical heaters now underway in granite and shale and those planned in basalt and domed salt and future experiments which will be performed with spent fuel. Many of the complex interactions currently postulated as affecting these parameters can only be checked by actual in-situ testing. The currently planned program will provide the required validation well before final approval is sought for actual emplacement of radioactive waste.

Table I

Tentative Thermal Design Specifications

Close-In (Cannister Scale)		Basis
Salt	260-320°C	Storage Hole stability and heat transfer
Granite	540°C	Storage Hole stability and heat transfer
Basalt	600°C	Storage Hole stability and heat transfer
Shale	200-300°C	Storage Hole stability and heat transfer
Canister	375°C	Corrosion during retrievable period
HLW Glass	500°C	Glass stability
Spent Fuel	200°C	Zr clad stability in absence of oxygen in sealed container
Near Field (Room Scale)		
Salt	36 kW/acre	10-15% closure in 25 yr.
Salt	150 kW/acre	10-15% closure in 5 yr.
Basalt	190 kW/acre	Pillar strength to stress ratio 2 for 5 yr.
Granite	190 kW/acre	Pillar strength to stress ratio 2 for 5 yr.
Shale	130 kW/acre	Pillar strength to stress ratio 2 for 5 yr.
Basalt	100 kW/acre	Pillar strength to stress ratio 2 for 25 yr.
Granite	100 kW/acre	Pillar strength to stress ratio 2 for 25 yr.
Shale	60 kW/acre	Pillar strength to stress ratio 2 for 25 yr.
Far Field (Regional Scale)		
Aquifer	5°C Increase	Aquifer interaction
Earth Surface	0.5°C Increase	Biota effects
Salt	60 kW/acre	a/ 5 ft. uplift in 2000 yr. for 10-yr. old spent fuel disposal
Salt	150 kW/acre	a/ 5 ft. uplift in 200 yr. for 10-yr. old HLW disposal

a/ Time of peak uplift depends on the thermo-mechanical properties of the rocks in the geologic section at the repository site.

Table II

Comparison of Repository Capacities in Generic Configuration at 2000 Foot Depth

Retrieval Period	Host Rock Type	Waste Form	Thermal Loading[a/] kW/acre Near Term[b/]	Long Term[c/] [d/]
5 YR	Salt	Spent Fuel	150[C]	60[U]
5 YR	Salt	HLW (UO_2)	150[C]	150[U]
25 YR	Salt	Spent Fuel	36[C]	60[U]
25 YR	Granite	Spent Fuel	100[R]	190[R]

a/ Controlling design capacity factor

C - Closure U - Uplift R - Rock mass strength adjacent to the room

b/ These numbers are KW per storage acre.

c/ Thermal loadings listed are based on 10-year old material at time of emplacement.

d/ These numbers are KW per gross repository acre including shaft pillar, haulage ways, etc.

APPENDIX F

SPENT FUEL POLICY AND CHARGES[1/]

Spent Fuel Policy

In April 1977, President Carter formally declared an indefinite deferral of reprocessing. The option of disposal of spent fuel elements in geologic formations was given added emphasis.

In October 1977, the Department of Energy announced a Spent Fuel Policy approved by the President whereby utilities will be given the opportunity to deliver spent fuel to DOE in exchange for a one-time fee to cover the costs of temporary storage and eventual geologic disposal. Provisions will be required to handle the anticipated load of spent fuel.

Under the Spent Fuel Policy, the United States Government is proposing to accept and take title to spent nuclear fuel from domestic utilities. The Government will also be prepared to accept a limited amount of foreign spent fuel when such action would contribute to meeting nonproliferation goals. Under this new policy, spent fuel transferred to the United States Government must be delivered to a Government-approved storage site at user expense. A one-time fee will be charged at the time of delivery to cover the full cost to the Government of providing for interim storage and subsequent permanent disposal of the spent fuel. No credit will be included for either the plutonium or uranium contained in the fuel. If, at some time in the future, the United States should decide that commercial reprocessing or other energy recovery methods for spent fuel can be accomplished without serious proliferation risks, the spent fuel could either be returned with an appropriate refund or other suitable compensation provided.

In order to implement this policy, spent fuel storage capability will be required. The possibility of ultimate disposal of spent fuel in a geologic repository has led to the conclusion that maximum use should be made of the geologic facility for interim storage through the concept of retrievability since this would go further toward demonstration of a waste management capability than would above ground storage. In addition, retrievable geologic storage would eliminate the need for further handling to achieve disposal in the event of a permanent no reprocessing decision. Thus, DOE's spent fuel program assumes maximum use of retrievable spent fuel storage in a geologic facility suitable for permanent waste disposal. Toward this objective, the National Waste Terminal Storage Program is directed toward the goal of having such a repository in operation by the end of 1985. To the extent that storage services are required prior to the availability of a geologic facility, interim above ground storage must

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1/ The methodology and assumptions described in this Appendix for determining the charge reflect the approach taken prior to the deliberations of the Task Force. Task Force recommendations on changes in the calculational approach are given in the main report.

also be provided. DOE will seek to contract for any necessary interim above ground storage services with private industry. If private services are not reasonably available, DOE will seek to provide services in Government facilities.

The Spent Fuel Storage Program will provide interim storage for spent fuel while geologic facilities are being developed. It will enable reactors to regain space in their storage basins, thus avoiding restriction of reactor operations. It will also allow costs for the disposition of spent fuel to be confidently considered in energy rate structures.

To estimate the magnitude of the likely demand for storage services, in December 1977, DOE sent letters to U.S. utilities with existing or planned reactors to ascertain their interest in transferring spent fuel to the Government. Also, in December 1977, DOE published a notice in the Commerce Business Daily requesting expressions of interest in providing interim retrievable spent fuel storage services under contract with the Government. Copies of these two requests are attached. The results of these solicitations will permit DOE to determine national needs for both storage and related transportation systems.

This program also provides the activities to implement the Government's policy to provide storage for limited amounts of fuel from foreign power reactors while geologic facilities are being developed. It will assess international needs for both storage and supporting systems. It will offer continued technical assistance and studies of critical foreign fuel storage situations to maximize utilization of spent fuel storage and other facilities at those sites, consistent with the Government's nonproliferation policy and will offer a credible alternative to immediate spent fuel processing abroad.

CHARGES FOR SPENT FUEL STORAGE/DISPOSAL

Under the Spent Fuel Storage Program, the U.S. Government has offered to accept title, to store retrievably for a period of time, and terminally dispose of spent fuel from commercial power reactors in exchange for a one-time charge.

Several key points of the policy are fundamental to the development of this charge. These are:

1. The charge will be a one-time charge - all further liability of the payee will cease at the time of payment.

2. Except for emergencies which will be considered on a case-by-case basis, the fuel shipped to the Government must be cooled a minimum

of five years and notification of intent to transfer must be made at least five years in advance of shipment.

3. No credit will be given for uranium or plutonium contained in the spent fuel.

4. Transfer of fuels to the Government is completely voluntary.

5. If recovery of fuel value is ever permitted, fuel may be either returned or compensation made for net fuel value at the option of the Government.

6. The Government will also accept some spent fuel from foreign countries on a case-by-case basis in support of our nuclear nonproliferation policy.

7. A geologic repository will be provided by the end of 1985 for retrievable storage and ultimate disposal of the fuel.

8. DOE will seek to provide interim storage facilities away-from-reactors (AFR) beginning in 1983.

The one-time charge will be determined to recover the full cost to the U.S. Government for the complete operation including interim storage, transportation from AFR's to repository, encapsulation, retrievable storage and terminal disposal for the fuel elements. All R&D costs will be included. Government indirect costs (added factor) will be included. A contingency, initially assumed to be 15%, will also be included. The fuel owner will pay the cost of transportation to the Government-approved receiving point. Title transfers at the time of delivery. Once the fee has been paid for a given fuel element, no further charge will ever be made for that fuel element.

The charge will be neutral to the size of the nuclear industry neither subsidizing nor penalizing this energy source. Its development should acknowledge and consider the existence of uncertainty in many of the parameters.

Since maximum use of retrievable geologic storage is assumed, for purposes of the charge, the repository will be assumed to be capable of storing 50,000 metric tons of heavy metal in a retrievable mode. Retrievability would be provided for up to 25 years in this mode. The fuel elements placed in AFR's will be unloaded at a reasonable rate into the repository as capacity in excess of annual demand is available. Under reasonable scenarios, this is possible before the year 2000.

Insofar as is practical, the charge calculation will be patterned after that for the uranium enrichment program. A single charge will apply to all customers. Costs will be reviewed annually and the charge will be updated when necessary, thus providing an opportunity to make adjustments for changes and unforeseen considerations. It should be noted that early customers are also later customers so corrections for any over-charges or under-charges made against later customers will apply essentially to the same customers.

The time period over which the charge is calculated and updated is expected to remain through the year 2000 until such time as better data beyond that year are available. Costs will be laid out as cash flows in constant 1978 dollars. These will be discounted at the rate of the cost of money to the Government which currently is 6.5% per year. The expected schedule of demand will also be laid out yearly and discounted at the same rate. The unit charge, then, is determined by dividing the discounted cost by the discounted demand. A contingency of ~15% will be added to the charge.

For purposes of developing the charge, the AFR's are considered to be water basins with a capacity of 5,000 metric tons. The receiving rate will be 2,000 metric tons per year (some rail, some truck). The geologic repository is assumed to be in bedded salt. The repository will have a small (one month surge capacity) water basin and an encapsulation facility at its head end. The receiving rate will be small for the first years and increase to a maximum capability of 10,000 metric tons per year, if required. Mining in the repository will be done as required to meet demand.

Spent Fuel Storage Scenarios

Ultimately the requirements for storage/disposal capacity will be based on actual commitments on the part of utilities to deliver fuel. Initially, however, to assess requirements for storage capacity, recent forecasts of the growth of nuclear power in the U.S. and in foreign non-centrally planned countries were used.

The U.S. forecast assumes the National Energy Plan would be in effect and that nuclear electric generating capacity at the end of year 2000 will be 380 Gwe. Under this forecast, all of the spent fuel discharged from reactors and cooled five years is assumed to be sent to the U.S. Government for storage.

The foreign forecast for countries with non-centrally planned economies assumes 632 Gwe of nuclear power will be installed by the end of the year 2000. Under this forecast, 10% of the spent fuel discharged from reactors and cooled five years is assumed to be sent to the U.S. Government for storage. Table F-1 provides details of the spent fuel discharged from reactors under these forecasts. The first two columns in Table F-2 show by years the cumulated quantities in terms of metric tons of heavy metal that are assumed to require storage. Details of the breakdown between the spent fuel from light water reactors and natural uranium fueled reactors can be determined from Table F-1.

Available Storage

Other crucial assumptions are the availability and loadup rates for the geologic repository and away-from-reactor water basins (AFR's).

The geologic repository is assumed to be available near the end of 1985 and to require a period of two or three years for operational shakedown procedures. The maximum loading rate assumed for the repository is 100 metric tons in 1985, 1,600 metric tons in 1986, 1,600 metric tons in 1987, 5,000 metric tons in 1988, and 6,500 metric tons per year thereafter. This schedule is based on a preliminary study made in connection with conceptual designs currently being made for a repository which is assumed to receive ten year cooled spent fuel and to maintain its retrievability for five years. More precise data is under development.

The first AFR capacity is assumed to be available in 1983. Additional required storage space is assumed to be available when needed. The five-year notification should assure this. The repository loading scheme adopted here is as given above through 1987 (limited to 100, 1,600, 1,600 metric tons in 1985, 1986, and 1987 respectively). Thereafter the repository would be loaded at a rate equal to the annual receipts of five year cooled spent fuel. Any spent fuel unloaded from AFR's into the repository would be in addition to the new receipts. This would probably not occur before 1990 and not exceed the rate of 1,000 metric tons per year as discussed later.

Storage Procedures and Need for AFR's

The spent fuel policy prefers to place spent fuel received directly into the geologic repository, if possible. U.S. fuel would be placed there in preference to foreign fuel. The AFR storage space would be built only to receive spent fuel that the repository would be unable to receive. As can be seen, the loading rate for the repository is a determining factor in the requirement for AFR space.

The analysis given here shows the repository able to accept all spent fuel delivered in 1988 and thereafter. Before that, the need for AFR space is a maximum of 8,900 metric tons of heavy metal through 1987 with 5,100 metric tons needed in 1983. However, these figures include 3,800 metric tons of spent fuel that was already five or more years cooled before the AFR's were available in 1983. Since that quantity had to have been stored somewhere, it is reasonable to assume that most of that fuel would remain where it had been stored and would not be sent to the new AFR facilities. If this were the case, this would reduce the new AFR facilities requirement to 1,300 metric tons in 1983 and 5,100 metric tons in 1987. The figures show the last AFR being needed in 1984 or 1985. The required AFR capacity as a function of several key parameters is graphically portrayed in Figure F-1.

Spent fuel elements could be unloaded from AFR's into the geologic repository beginning in 1988. However, fuel assemblies once loaded into an AFR would probably remain there for some time for economic reasons unless there are other reasons (such as leakages) for removing them.

On the other hand, a reasonable policy to adopt might be to unload from AFR's into the geologic repository that quantity necessary to provide and maintain space for the quantity of newly received spent fuel scheduled to be added to the repository for one year. This would provide a contingency for the possible breakdown of equipment or unforeseen problems. For this paper, 1,000 metric tons per year beginning in 1991 is thought to be a reasonable rate for transfer from AFR to geologic repository.

TABLE F-1 1/

Spent Fuel Discharged from Reactors
(Metric tons of heavy metal)

YEAR	U.S. Reactors: Annual	U.S. Reactors: Cumulated	Foreign Reactors: LWR	Foreign Reactors: Nat & Other	Foreign Reactors: Sum	Foreign Reactors: Cumulated	10% of Foreign
1975		1300	430	3600	4000	4000	400
1976	600	1900	340	1800	1200	6200	600
1977	1000	2900	500	2000	2500	8700	900
1978	1100	4000	540	2200	2700	11400	1100
1979	1300	5300	870	2300	3200	14600	1500
1980	1300	6600	1030	2400	3400	18000	1800
1981	1400	8000	1200	2500	3700	21700	2200
1982	1600	9600	1400	2500	3900	25600	2600
1983	1900	11500	1800	2600	4400	30000	3000
1984	2200	13700	2100	2700	4800	34800	3500
1985	2700	16400	2500	2800	5300	40100	4000
1986	2900	19300	3000	3000	6000	46100	4600
1987	3400	22700	3500	3100	6600	52700	5300
1988	3600	26300	4200	3300	7500	60200	6000
1989	3900	30200	4800	3500	8300	68500	6800
1990	4200	34400	5400	3600	9000	77500	7800
1991	4600	39000	5900	3800	9700	87200	8700
1992	4900	43900	6700	4100	10800	98000	9800
1993	5200	49100	7400	4300	11700	109700	11000
1994	5700	54800	8000	4600	12600	122300	12200
1995	6000	60800	8700	4800	13500	135800	13600

1/ Excludes 400 mt currently stored at Morris, Illinois and West Valley, New York

TABLE F-2

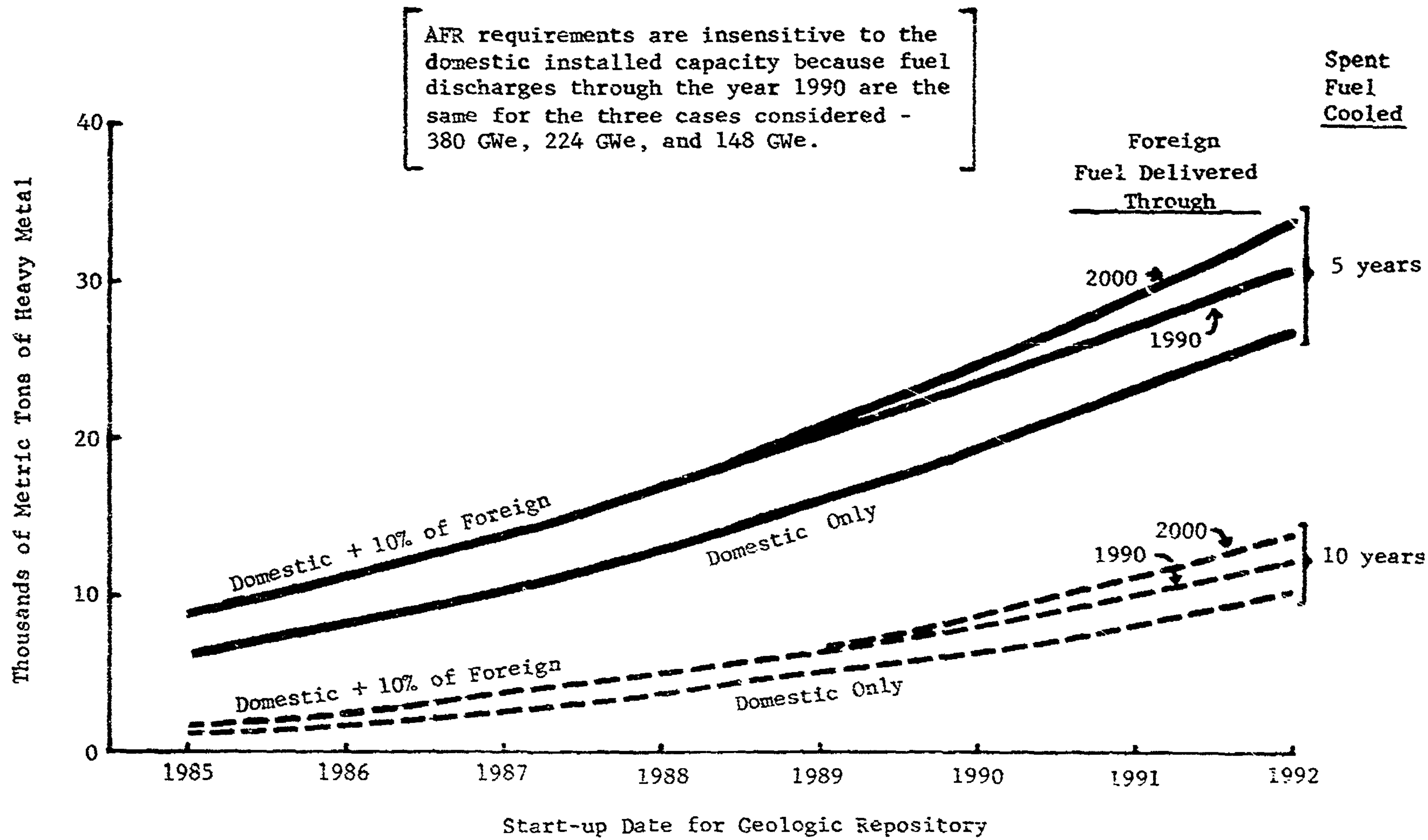
Spent Fuel Storage (Maximum)

(Metric tons of heavy metal)

Year	5-Year Cooled Spent Fuel: U.S.	5-Year Cooled Spent Fuel: 10% Foreign	Additions to Geologic: U.S.	Additions to Geologic: Foreign	Use of Geologic Repository	Use of AFR Storage: U.S.	Use of AFR Storage: Foreign	Use of AFR Storage: Total
1980		400						
1981	2,000	600						
1982	3,000	900						
1983	4,000	1,100				4000	1100	5100
1984	5,300	1,500				5300	1500	6800
1985	6,600	1,800	100	-	100	6500	1800	8300
1986	8,000	2,200	1400	200	1,700	6500	2000	8500
1987	9,600	2,600	1600	-	3,300	6500	2400	8900
1988	11,500	3,000	1900	400	5,600	6500	2400	8900
1989	13,700	3,500	2200	500	8,300	6500	2400	8900
1990	16,400	4,000	2700	500	11,500	6500	2400	8900
1991	19,300	assume no further deliveries	2900	0	14,400	Begin to unload AFR's so that they can be available for contingencies i.e., to take fuel if repository is tied up.		
1992	22,700		3400	0	17,800			
1993	26,300		3600	0	21,400			
1994	30,200		3900	0	25,300			
1995	34,400		4200	0	29,500			
1996	39,000		4600	0	34,100			
1997	43,900		4900	0	39,000			
1998	49,100		5200	0	44,200			
1999	54,800		5700	0	49,900			
2000	60,800		6000	0	55,900			

FIGURE F-1

AFR CAPACITY REQUIREMENTS
FOR SPENT UNREPROCESSED FUEL STORAGE



Department of Energy
Washington, D.C. 20545

DEC 2 0 1977

The purpose of this letter is to determine the interest of the United States utilities in transferring spent nuclear fuel to the Federal Government under certain terms and conditions.

On April 7, 1977, President Carter announced that the United States would defer indefinitely all civilian processing of spent nuclear fuel. Other countries were also asked to join the United States in deferring use of this technology in order to evaluate alternative fuel cycles and processes which may reduce the risk of nuclear weapons proliferation. This deferral, however, will require increased capacity for storage of spent nuclear fuel to be discharged from reactors.

On October 18, 1977, the Department of Energy (DOE) announced a new spent nuclear fuel policy, approved by the President, whereby the United States Government is proposing to accept and take title to spent nuclear fuel from the United States utilities. The United States will also be prepared to store limited foreign spent fuel when such action would contribute to meeting nonproliferation goals. Under this new policy, spent fuel transferred to the United States Government must be delivered to a Government approved storage site at user expense. A one-time storage fee will be made to cover the full cost to the Government of providing for interim storage and subsequent permanent disposal of the spent fuel should that be required. No credit will be included for either the plutonium or uranium contained in the fuel. If, at some time in the future, the United States should decide that commercial reprocessing or other energy recovery methods for spent fuel can be accomplished economically and without serious proliferation risks, the spent fuel could either be returned with an appropriate storage charge refund or compensation provided for the net fuel value.

In order to implement this policy, DOE will require retrievable spent fuel storage capability. It is DOE's intention to ultimately provide retrievable spent fuel storage in a geologic facility suitable for permanent waste disposal. DOE has a National Waste Terminal Storage Program with an objective of having such a repository in operation by the end of 1985. To the extent that storage services are required prior to the availability of a geologic facility, interim retrievable storage must be provided. DOE will seek to contract for any necessary interim retrievable storage services with private industry. If private services are not reasonably available, DOE will seek to provide services in Government facilities.

To facilitate utility consideration of the Government proposal, the following possible acceptance guidelines and criteria are provided. These guidelines and criteria are for initial planning purposes only and are subject to change.

1. Five years advance notice of intent to transfer spent fuel to the Government would be required. An exception might be granted, at DOE's option, in emergency cases where transfer prior to that time is necessary to maintain discharge capability.

2. Fuel should be cooled for a minimum of five years except in emergency situations noted in (1) above.

3. The storage/disposal fee range for preliminary considerations of this proposal is estimated in 1977 dollars at $150 - 250/KG of total mass of heavy metal. Approximately 60 percent of the total charge may be considered as applicable to interim water basin storage of the spent fuel assemblies and transportation thereafter of the assemblies to the geologic repository. The remaining approximately 40 percent may be considered as applicable to storage in the geologic repository.

4. Fuel would be transferred, at owner expense and in owner provided casks, to a Government approved storage site.

5. If reprocessing or other alternate recovery of the residual energy potential contained in the spent fuel is approved, the Government would offer the domestic utility the election of retrieving the spent nuclear fuel and receiving a refund of the portion of the storage fee attributable to permanent storage or having a credit of such amount applied toward charges for later permanent isolation of wastes resulting from reprocessing of such spent nuclear fuel. If the domestic utility elected not to retrieve the fuel, the Government thereafter would have no obligation to return the spent nuclear fuel or make any payment or credit therefor.

6. Fuel transfers would be voluntary.

To carry out the Government's spent nuclear fuel policy, DOE would need information on the spent fuel storage capacity it may be required to provide. Should your company be interested in a program such as that outlined above, DOE would accordingly need from your company information such as that outlined below. Please understand that any information you furnish will not commit your company or DOE in any manner whatsoever.

Any information in your response which you consider to be proprietary should be clearly identified as such, with reasons therefor. DOE reserves the right to make any information, including any proprietary information contained therein, available to personnel of DOE, its contractors, consultants, or other Government agencies for the sole purpose of assisting DOE in its evaluations.

1. A calendar year by calendar year estimate through 1990, if practicable, of spent fuel discharges from each of your nuclear reactors, specified in metric tons, number of assemblies, and type of assemblies respectively, such as boiling water reactor, or pressurized water reactor types.

2. Calendar year cumulative totals, as of December 31 of each respective year, through 1990, if practicable, of spent fuel on hand which has been cooled for at least five years, specified in both metric tons and number and type of fuel assemblies.

3. Estimated transfers to the Government, described in both metric tons and number and type of fuel assemblies for the same annual and cumulative periods specified in (1) and (2) above. When preparing your estimates, assume that adequate Government approved spent reactor fuel storage will be available on a timely basis to receive your estimated transfers to the Government.

4. A statement of the need for any fuel transfer prior to five years notice and cooling.

5. Comments on the acceptance guidelines and criteria provided for consideration.

6. Comments on time and form of fee payment proposed above.

7. Any other comments.

We will appreciate your providing the requested information within 30 days, if practical, to:

U. S. Department of Energy
Eric S. Beckjord, Acting Director
Division of Nuclear Power Development
Mail Stop F-305
Washington, D.C. 20545

Please note that this request for information is not a request for proposal (RFP) and does not commit the Government to contract with any party or to pay any costs incurred in connection with preparing and submitting any response.

Sincerely,

George W. Cunningham
Acting Program Director
for Nuclear Energy

COMMERCE BUSINESS DAILY

Issue No. PSA-6966 December 6, 1977

Page 2

A--EXPRESSIONS OF INTEREST-SPENT NUCLEAR FUEL STORAGE SERVICES. On 7 Apr 77, President Carter announced that the US would defer indefinitely all civilian reprocessing of spent nuclear fuel. Other countries were also asked to join the U.S. in deferring use of this technology in order to evaluate alternative fuel cycles and processes which may reduce the risk of nuclear weapons proliferation. This deferral, however, will required increased capacity for storage of spent nuclear fuel to be discharged from reactors.

On 18 Oct 77, the Department of Energy announced a new spent nuclear fuel policy, approved by the President, whereby the U. S. Government is proposing to accept and take title to spent nuclear fuel from United States utilities. The United States will also be prepared to store limited foreign spent fuel when such action would contribute to meeting non-proliferation goals. Under this new policy, spent fuel transferred to the U. S. Government must be delivered to a Government-approved storage site at user expense. A one-time storage fee will be made to cover the full cost to the Government of providing for interim storage & subsequent permanent disposal of the spent fuel should that be required. No credit will be included for either the plutonium or uranium contained in the fuel. If, at some time in the future, the U.S. should decide that commercial reprocessing or other energy recovery methods for spent fuel can be accomplished economically and without serious proliferation risks, the spent fuel could either be returned with an appropriate storage charge refund or compensation provided for the net fuel value. It is the Department of Energy's intention to provide retrievable spent fuel storage in geologic repositories suitable for permanent waste disposal. The Department of Energy has a National Waste Terminal Storage Program with an objective of having such a repository in operation by the end of 1985. The Department of Energy is currently contacting domestic utilities to determine their interest in transferring spent fuel to the Government. To the extent that spent fuel storage must be provided prior to the availability of the geologic repository interim retrievable storage would have to be provided. The Department of Energy is interested in contracting for interim spent fuel storage services. The purpose of this notice is to request that all organizations interested in providing interim retrievable storage services in either existing or new facilities inform DOE of their interest. The magnitude of this proposed effort cannot be assessed until the utility response is evaluated.

Interested organizations are requested to provide the following information in the fullest degree possible: 1. The amount and timing of interim retrievable storage capacity that would be made available expressed in both metric tons and respective numbers of assemblies from Pressurized Water Reactors and Boiling Water Reactors. 2. A brief description of the facilities that would be used to provide interim retrievable storage services, including location (existing or possible) size, receiving capabilities, and licensing status. 3. Preliminary estimates of proposed charges for such storage services, if possible. 4. Any other relevant comments that these organizations may care to provide. Expressions of interest should be submitted within 30 days of the publication of this request. This invitation is not a Request for Proposals and does not commit the Government to contract with any party or to pay any costs incurred in connection with preparing and submitting any response. A decision to request proposals will depend on an assessment of the overall storage requirements, and the potential for reasonable attainment of private storage services to meet interim storage requirements.

Any information in your response to this request which you consider to be proprietary should be clearly identified as such, with reasons therefor. DOE reserves the right to make any information, including any proprietary information contained therein, available to personnel of DOE, its contractors, consultants, or other Government agencies for the sole purpose of assisting DOE in its evaluation. Five copies of responses to this notice should be submitted. (P336)

Manager Savannah River Operations Office
Department of Energy, PO Box A,
Aiken, SC 29801

CORRECTION

COMMERCE BUSINESS DAILY

Issue No. PSA-6970 December 12, 1977

Page 2

A--EXPRESSIONS OF INTEREST-SPENT NUCLEAR FUEL STORAGE SERVICES. CORRECTION. Five copies of responses to this notice should be submitted to Michael Lawrence, Acting Asst. Director for Spent Fuel Storage, Div. of Nuclear Power Development, U.S. Dept. of Energy, Washington, DC 20545; and send one copy to address below.

Correction to PSA 6966. (P342)

Manager Savannah River Operations Office
Department of Energy, PO Box A,
Aiken, SC 29801

APPENDIX G - TRANSPORTATION FOR SPENT FUEL AND WASTE

Background

Transportation of nuclear materials is an essential link for each of the steps in the nuclear fuel cycle. Historically shipments of fuel cycle materials have moved with relative ease for a small fraction of the cost of nuclear power. More recently, concern has been expressed regarding future transport of nuclear materials. These concerns are related to meeting the requirements for shipping spent reactor fuel, transuranium materials and radioactive wastes. There are no special requirements for transporting low level waste.

Status

There is a growing backlog of nuclear materials to be shipped, including spent fuel, transuranic waste from Government programs and high level DOE waste. Transportation of these materials is fast becoming the limiting factor in both current operations and in maintaining the option of nuclear energy. Expressions of transportation concerns have developed in various forms: Congressional legislation ; state and local jurisdictions developing restrictive transport regulations ; heightened public concern ; the paucity of container manufacturing capability ; licensing reviews; and the need for Government decisions on system operations and parameters. The costs of nuclear shipments are increasing rapidly. These costs are both direct and indirect. Direct costs include use charges, while indirect costs include operational delays, public hearings and litigation, and the need for procedures, reliable forecasts and matching equipment.

Special Issues

1. Public Acceptance - The safety of transporting nuclear materials has been questioned. There is a need to put the relatively low transportation risks in perspective with other risks through an adequate program for (a) informing the public on the subject and (b) restoring public confidence in the federal safety regulatory system. Recent full-scale crash tests of shipping casks have been completed and are reassuring. The testing program should be expanded to include tests of current generation equipment.

2. Hardware - At present there is a serious lack of availability of containers for spent fuel, transuranium waste, and high level waste. The current commercial cask inventory can transport only about one-third of the spent fuel output from reactors and there are no industry commitments to build more. One conceptual design exists for a high level waste cask but none has been built, and no safety analysis has been prepared. Transuranium waste is now shipped only in DOE-owned railcars; these are neither licensed for nor available to industry. Their numbers are very limited (about 10). To transport the current inventory of transuranium waste stored retrievably, from INEL to WIPP, would take over 12 years if started now, using the best equipment currently available (ATMX railcars). To transport the transuranium waste predicted to be stored by 1985 to WIPP, it would take over 28 years using all of the ATMX railcars available.

spent fuel and high level waste). Standardization offers many advantages: efficiency in handling, maintenance, decontamination, testing; lower capital costs for casks and handling hardware; increased safety in handling; shorter turnaround times and lower labor costs; and better public acceptance. There is a need to provide incentives to expeditiously restore a national capability to fabricate large casks.

5. Security - There are increasing questions of a need for guards for spent fuel casks and transuranium container shipments. Based on container integrity tests and the lack of defined threats, the NRC, DOT, and DOE position is that guards are not necessary.

6. Need to define problems - There are several good recent studies by Battelle Northwest (PNL 2457 and BNWL 2066) and by AGNS (Y/OWI-SUB-77/42513). The results need to be disseminated and digested. A 1977 DOE internal task force also studied and defined problems; a final report has not yet been issued.

Shipment Characteristics

At present, about 90% of the spent fuel shipped is done by rail (4 casks) with the balance transported by truck (9 casks). This split is assumed to apply to spent fuel, as well as high level waste, over the 1977 to 2000 timeframe. Transuranic wastes will continue to be shipped using ATMX railcars. The capacity, "turnaround time", and estimated cost characteristics of the various shipment modes are summarized in Table G-1. Since spent fuel and HLW casks are expected to be very similar, identical cost and in-service characteristics are assumed. Development costs have not been included.

Table G-1 - Spent Fuel and Waste Shipment Characteristics

General - All casks and railcars in service 275 days/year.
- Spent fuel and HLW are transported by rail (90%) and truck (10%). TRU waste transported by rail only.

Spent Fuel and HLW Casks (rented)

Spent Fuel Cask Capacities/Shipment	4.5 MT - rail 0.5 MT - truck
HLW Cask Capacities/Shipment	9 cannisters (56¼ ft^3) - rail 1 cannister (6¼ ft^3) - truck
Cask Shipments/Year	14 (20 day roundtrip) - rail 39 (7 day roundtrip) - truck
Costs/Shipment 1/	$66,500 - rail 4,000 - truck

ATMX Railcars For TRU Waste (purchased)

Capacity/Railcar	1000 ft^3
Shipments/Year	14
Acquisition Cost	$150,000
Operating Cost	$3000/shipment

1/ Includes use charges, operating costs, decontamination, and maintenance.

APPENDIX H
Decontamination and Decommissioning

Commercial Facilities

Nuclear power reactors as well as other fuel cycle facilities will eventually reach the end of their useful life either due to obsolescence or adverse economics of continued operation. Ultimately, it will be necessary to provide for the disposition of these facilities in a way that assures protection of public health and safety and permits the facility and land to be released for other nuclear use or unrestricted use.

Establishing the future costs and obligations of decommissioning large reactors and estimating the quantities of waste materials to be managed are principal concerns of industry, utilities, government, and the public. Most estimates of cost and quantities of radioactive wastes to be handled have been based on decommissioning experience for small reactors and extrapolated to arrive at conclusion about large reactor decommissionings.

Table H-1 shows the decommissioning history of licensed experimental and demonstration reactors and indicates the type of decommissioning used.

The United States Nuclear Regulatory Commission (NRC) Guide 1.86 describes methods and procedures currently considered acceptable by the NRC staff for decommissioning alternatives (1). The Guide presents three primary decommissioning alternatives, namely, mothballing, in-place entombment, and removal of radioactive components and dismantling.

Mothballing - consists of removing all fuel and radioactive fluids and wastes and putting the facility in protective storage. Adequate radiation monitoring, environmental surveillance, and appropriate security procedures must be established to ensure public health and safety.

Entombment - consists of removing all fuel assemblies, radioactive fluids and wastes, and shipment of selected components off-site, followed by the sealing of all remaining highly radioactive or contaminated components (e.g., reactor pressure vessel and materials) within a structure integral with the biological shield. An appropriate and continuing surveillance program is required to assure public health and safety.

Removal/Dismantling - requires removal from the site of all fuel assemblies, radioactive fluids and wastes, and other materials having activities above acceptable surface contamination levels established in the U. S. NRC Guide 1.86. Materials which contain induced radioactivity are evaluated on a case-by-case basis. The facility owner may then have unrestricited use of the site.

The Atomic Industrial Forum recently sponsored a study (2) of decommissioning alternatives for a 1160 MW(e) Light Water Reactor (LWR) and of a similarly sized High Temperature Gas Cooled Reactor (HTGR). The quantities of radioactive wastes estimated to result from decommissioning commercial nuclear facilities are based on the information developed in the AIF study.

Basic data, such as reactor structure, radioactive inventory, component contact radiation dose rates, number of cuts required to remove vessel internals, number of feet of various pipes to be decontaminated, volume of contaminated or activated concrete to be removed and buried, were specifically calculated for each reactor type. This information led to the definition of the individual work activities including required equipment and personnel resources, determination of program schedule, calculation of activity duration, program costs, and other impacts such as occupational radiation exposures, effluent releases and non-occupational exposures.

Other reports on decommissioning experiences are identified in the References (3 through 14).

In the Atomic Industrial Forum study, the inventory by component in a typical 1160 MW(e) reactor was calculated with time, beginning at shutdown and continuing for 200 years. The fuel and control rods were excluded from the inventory. Based on an 80 percent plant factor and a 40-year life, the largest total inventory at shutdown will occur in a PWR, and will be about 15 million curies. At the end of 100 years after shutdown this decreases by a factor of 35 with over 90 percent of the remaining inventory being nickel-63.

Initially after shutdown the reactor vessel and its internal components together will contain greater than 99 percent of the total residual radioactivity. Over 90 percent of the activation product inventories will consist of the shorter-lived isotopes of cobalt-60 and iron-55.

Because of the high contact dose rate shortly after shutdown, any removal of vessel internals for an LWR would require sophisticated underwater cutting and handling equipment. A delay period of about 100 years would permit sufficient decay of the cobalt-60 to allow manual removal techniques with local personnel shielding.

While the contact dose rate due to nickel-59 at shutdown was calculated to be only 30 MREM/HR, because of its 80,000 year half-life, the reduction in dose rate will require a long time. In decommissionings of the small experimental and demonstration reactors, nickel-59 has not been a limiting nuclide because of the relatively short periods of reactor operations.

The quantities of a radioactive waste estimated to require disposal from a nominal 1160 MW(e) nuclear power station are shown in Table H-2.

Assuming a reactor mix of 1/3 BWR 2/3 PWR, a reference 1200 MW(e) LWR might generate the following quantities of low-level radioactive waste. It is also assumed that a 1000 MW(e) reactor would not reduce these quantities significantly.

Waste Volume for a Typical LWR (In thousands of cu. ft.)

Mothballing	2,000
Entombment	70,000
Removal/Dismantling	500,000

The actual quantities of low-level waste resulting from decommissioning licensed nuclear power facilities between now and the year 2000 are dependent on decisions yet to be made on the timing of reactor shutdown and mode of decommissioning.

Table H-3 lists the commercial reactors which are considered candidates for decommissioning action by the year 2000.

Assuming a 40-year reactor operating life, only those reactors listed would be shut down, and depending on the mode of decommissioning selected, it is conceivable that no low-level wastes from decommissioning will be generated by the year 2000.

However, in actual fact, there may be technical, economical, environmental, regulatory, and political issues which may result in all of the listed reactors, or others, being shut down and in various stages of decommissioning by the year 2000.

As a basis for the low-level radioactive waste volume estimates, it is assumed that for the high case reactors located on sites where no other nuclear facilities are located, the decommissioning mode will be total dismantlement and removal. Such sites include Yankee, Big Rock Point, Humbolt Bay, Genoa, and Haddam Neck.

For the smaller reactors, the volume of low-level wastes assumed to be generated are based on the experience of total dismantling/removal at the Elk River Reactor, i.e., 100,000 cu. ft. of radioactive waste.

For the large reactors, the volume of wastes estimated in the AIF study for a 1200 MW(e) station are assumed.

For the low case it is assumed these same five reactors are mothballed. The low level waste volumes are based on the AIF study for a 1200 MW(e) station. The estimated waste volumes are shown in Table H-4.

Retired Defense Facilities

A program to establish methods, costs, and priorities for the decontamination, decommissioning and disposition (D/D) of retired contaminated facilities was initiated in 1973 as part of the annual DOE site plans for waste management.

The majority of the currently contaminated surplus facilities are at Hanford. A "Resource Book - Disposition of Retired Contaminated Facilities at Hanford," BNWL-MA-88, was issued in 1975 and is updated by the Battelle Pacific Northwest Laboratories. In addition, development of a DOE National Disposition Planning System was initiated in July of 1977. The DOE National Disposition Plan will provide a tabulation of all DOE facilities that are radioactively contaminated and surplus to current program needs, a means for documenting the status and key data pertinent to disposition, and will also provide a basis for prioritizing disposition projects. At present, there are over 460 surplus DOE facilities, 80 percent of which are located at Hanford. Included are buildings, reactors, reprocessing plants, ponds, cribs, pits, and ditches, and an additional 100 facilities are expected to become excess over the next few years. The system to be established for generating the plan will provide periodic updates to assure that the list of surplus facilities is complete and that the information provided is accurate. Eventually, all radioactively contaminated DOE sites and facilities may be included in the plan as well as former AEC contractor sites and inactive uranium mill tailings sites.

The output from the planning system will be utilized in developing annual budget estimates and five-year plans for the surplus facilities program. It will be issued annually and will identify projects, priorities, alternative disposition modes, schedules, costs and budgets, manpower needs, and waste volumes. The priorities for various disposition projects and cost estimates will provide a basis for developing a rationale for future budget requirements.

For this study preliminary estimates of radioactive waste volumes resulting from decontamination and decommissioning of excess facilities at all DOE sites are based on estimates for D/D of retired Hanford facilities. Estimated total waste volumes from D/D actions are given on Table H-5. Table H-6 provides the base of estimated volumes resulting from Hanford D/D. It is assumed the volumes will be generated over a 20-year period of 1981-2000. The actual volumes will be contingent on the priorities and funding levels assigned to D/D actions at DOE sites, and the modes of decontamination selected. Table H-7 summarizes the total volumes of low level wastes which may result from various D/D actions.

Estimated Costs for Decontamination and Decommissioning of DOE Currently Surplus Facilities

Three cases were calculated based on information in the Preliminary Plan for Decontamination and Decommissioning at Hanford, and from personal communciations with J. W. Litchfield, PNL.

All costs are in constant 1977 dollars. All cases assume a 20-year campaign from 1980 to 2000.

The total costs are based on cost estimates for D/D of currently surplus facilities at Hanford plus 25 percent to cover the cost of D/D of currently surplus facilities at other DOE sites.

High Case:

Assumes total dismantling of all currently surplus facilities. LLW is buried while TRU wastes are stored or put in a geologic repository.
Estimated Total Cost: $1300 million

Medium Case:

Assumes dismantling of reactor building in the Hanford 100 and 300 areas, entombment of the 200 area fuel processing building and placing all other facilities such as cribs and trenches, in protective storage. Resultant waste materials disposed of as in high case.
Estimated Total Cost: $300 million

Low Case:

Assumes placing all facilities in protective storage. It is recognized that this case is not a final solution but defers further action for 50 to 100 years. Resultant waste materials disposed of as in medium and high case.
Estimated Total Cost: $130 million

Estimated Costs for Decontamination and Decommissioning Commercial Nuclear Power Stations

Two cases were assumed based on information contained in the AIF study on D/D alternatives for Nuclear Power Reactors (2).

All costs are in constant 1977 dollars.

The five reactors listed in Table H-4 were assumed to be candidate reactors for decommissioning section. It is recognized the reactor size ranges from 50 MWe to 575 MWe and the AIF study is based on a 1200 MWe station. Therefore, the cost estimates are only approximations.

High Case:

Assumes total dismantling and removal of five reactors. Wastes are removed to an off site LLW burial ground.
Estimated Total Cost: $125 million

Low Case:

Assumes mothballing of the same five reactors continued surveillance costs are not included. Wastes are removed to an off LLW burial ground.
Estimated Total Cost: $10 million

NOTE: The above estimates were developed from information contained in "An Engineering Evaluation of Nuclear Power Reactor Decommissioning Alternatives," AIF/NESP-009, November 1976, which gave the following cost estimates for decommissioning a 1200 MWe reactor:

	Millions of 1975 Dollars	
	PWR	BWR
Mothball	2.3	2.5
Entomb	7.4	7.6
Dismantle	26.9	31.2

Questions have been raised as to the adequacy of these estimates. Additional examination of the costs of decommissioning is required. Also, the NRC is presently conducting independent cost estimate studies for the BWR and the PWR, as well as fuel cycle facilities.

TABLE H-1 EXPERIMENTAL AND DEMONSTRATION REACTOR DECOMMISSIONING HISTORY[a]

Reactor Facility and Location	Reactor Type	Reactor Thermal Rating, MW	Type of Decommissioning	Status of License	Monitoring System	Protective Storage Measures
CVTR Parr, SC	Pressure tube heavy water	65	Mothballing	Byproduct per 10 CFR 30	Periodic surveillance	Welded closure, locked doors, security fence
Pathfinder Sioux Falls, SD	BWR nuclear superheat	190	Mothballing with steam plant conversion	Byproduct to state[b]	Continuous security force[c]	Welded closure, security fence
FERMI 1 Monroe Co., Mich.	Sodium cooled fast	200	Mothballing	Possession only[d]	Continuous security force[c]	Locked doors, security fence
Peach Bottom 1 York Co., Penn.	Gas cooled graphite moderated	115	Mothballing	Possession only	Continuous security force[c]	Not yet established
VBWR Alameda Co., CA	BWR	50	Mothballing with steam plant conversion	Possession only	Continuous security force[c]	Locked doors, security fence
NASA Plumbrook Sandusky, Ohio	Light water	0.1	Mothballing	Possession only	Continuous security force[c]	Locked doors, security fence
GE EVESR Alameda Co., CA	BWR with nuclear superheat	17	Mothballing	Possession only	Continuous security force[c]	Locked doors, security fence
Saxton, PA	PWR	23.5	Mothballing	Possession only	Intrusion alarms	Welded closure, locked doors, security fence
SEFOR Strickler, Arkansas	Sodium cooled, fast	20	Mothballing	Byproduct to state	Intrusion alarms	Welded closure, locked doors, security fence
Westinghouse Test Reactor Waltz Mill, PA	Tank	60	Mothballed	Possession only	Continuous security force[c]	Locked doors, security fence
B & W Lynchburg, VA	Pool	6	Partial dismantling	Byproduct per 10 CFR 30	Not required	Not required
Hallam Hallam, Neb.	Sodium cooled graphite moderated	256	Entombing	Operating authorization terminated	Not required	Welded closure, concrete cover, weatherproofed
Piqua Piqua, Ohio	Organic cooled and moderated	45.5	Entombing	Operating authorization terminated	Not required	Welded closure, concrete cover, waterproofed
BONUS Ricon, Puerto Rico	BWR with nuclear superheat	50	Entombing	Operating authorization terminated	Not required	Welded closure, concrete cover, locked doors, security fence
Elk River Elk River, Minn.	BWR	58.2	Dismantling & partial conversion	Operating authorization terminated	Not required	Not required

[a] *Reference: "Decommissioning and Decontamination of Licensed Reactor Facilities and Demonstration Nuclear Power Plants"*, by P.B. Erickson and G. Lear, U.S. NRC, presented at conference on Decontamination and Decommissioning in Idaho Falls, Idaho, August 19-21, 1975.

[b] A byproduct license may be issued by agreement state per 10 CFR 150.

[c] The use of a continuous security force was not required by the NRC because continuous manned security was provided for other on-site activities that were unrelated to the decommissioned reactor. If such a security force was not present, the NRC may have stipulated manned security or other additional access control measures.

[d] A possession-only license permits possession of a reactor facility but not its operation.

Table H-2

Estimated Volumes of Low-Level Radioactive Waste
From various modes of Decommissioning a 1160 MW(e)
Reactor

Reactor Type	Volume of Low Level Radioactive Waste (in cubic feet)		
	Mothballing	Entombment	Removal/Dismantle
BWR	2,000	80,000	800,000
PWR	2,000	60,000	350,000

Table H-3

Commercial Reactors which may be Candidates for Decommissioning by the Year 2000

	Reactor	Type	Size (MWe)	Year of Start Up
1.	Shipping Port Nuclear Power Station	PWR	90	1957
2.	Dresden Nuclear Power Station, Unit I	BWR	200	1959
3.	Yankee Nuclear Power Station	PWR	175	1960
4.	Big Rock Point Nuclear Plant	BWR	72	1962
5.	Indian Point Station, Unit I	PWR	265	1962
6.	Humbolt Bay Power Plant, Unit 3	BWR	63	1963
7.	Genoa Nuclear Generating Station	BWR	50	1967
8.	San Onofre Nuclear Station, Unit I	PWR	430	1967
9.	Haddam Neck Plant	PWR	575	1967
10.	Ginna Nuclear Power Plant, Unit I	PWR	490	1969
11.	Nine Mile Pt. Nuclear Station, Unit I	BWR	610	1969
12.	Oyster Creek Nuclear Power Plant, Unit I	BWR	650	1969

Table H-4

Volume of Low-Level Waste from D/D of Commercial Reactors through Year 2000

<u>High Case</u> - Dismantling/Removal			<u>cubic feet</u>
Yankee Rowe	175 MW(e)	PWR	350,000
Big Rock Pt.	72 MW(e)	BWR	100,000
Genoa	50 MW(e)	BWR	100,000
Haddam Neck	575 MW(e)	PWR	350,000
Humbolt Bay	63 MW(e)	BWR	100,000
			1,000,000 $ft.^3$

<u>Medium Case</u> - Entombment	<u>cubic feet</u>
Yankee Rowe	50,000
Big Rock Pt.	15,000
Genoa	15,000
Haddam Neck	50,000
Humbolt Bay	15,000
	145,000 $ft.^3$

<u>Low Case</u> - Mothball	<u>cubic feet</u>
Yankee Rowe	2,000
Big Rock Pt.	2,000
Genoa	2,000
Haddam Neck	2,000
Humbolt Bay	2,000
	10,000 $ft.^3$

Table H-5

Estimates of Waste Volumes from D/D Activities Currently Surplus Facilities (460 total, 360 Hanford)*

	Vol (10^6 cu. ft.) TRU	Non-TRU
High Case		
Assumes a dedicated area will be identified at each site; for Hanford all contamination is removed from 100/300 areas and stored in 200 area (200 area protection storage)		
Hanford	91	144
Other Sites (4×10^6 cu. ft. total for ORNL, of which 4×10^3 cu. ft. is TRU)	1.5	15
	92.5	159
For purposes of this report	95.0	160
Low Case		
Soils are excluded from the estimates - assumes a method is found to decontaminate them. Only rubble and equipment is included.		
Hanford	3.8	3.0
Others	0.5	7.2
	4.3	10.2
For purposes of this report	4.5	10.0

*Based on draft "Preliminary Plans for Decontamination and Decommissioning at Hanford," Battelle Pacific Northwest Laboratory, by J. C. King and J. W. Litchfield, dated August 1977

Table H-6

Estimated Volumes of Contaminated Waste From D/D
Of Hanford Retired Facilities

	Vol. (10^6 cu.ft.) Highest Estimate
Liquid Waste Disposal Sites (Soils)	
200 Area	
1. Highly contaminated soil (0.06 Ci/cu. ft.)	54
2. Moderately contaminated soil (0.01 μCu/cu. ft.)	243
3. TRU and U contaminated soil	14
100 Area (assume 1/10 of 200 Area)	
1. Highly contaminated soil	5
2. Moderately contaminated soil	25
3. TRU & U contaminated soil	1
Solid Waste Disposal Sites	
200 Area	
1. Volume waste (TRU)	6
2. Volume waste and soil (TRU)	405
100 & 300 Area	
1. Volume waste: TRU	0.6
Non-TRU	0.7
2. Volume waste and soil: TRU	81
Non-TRU	108
Fuel Reprocessing Bldgs (3)	
1. Volume rubble (TRU)	3
2. Volume rubble and soil (TRU)	6
Fuel Storage Basin	
200 Area (3)	
1. Volume rubble (TRU)	0.2
2. Volume rubble and soil (TRU)	1.0
100 Area (8)	
1. Volume rubble (TRU)	0.6
2. Volume rubble and soil (TRU)	3.0

Table H-6 (Cont'd)

	Vol. (10^6 cu.ft.)
Gas and Exhaust Air Systems (Reactors)	
100 Area (8)	
1. Volume rubble (Non-TRU)	0.4
2. Volume rubble and soil (Non-TRU)	0.8
Reactors	
100 Area	
1. Volume rubble (Non-TRU)	1.1
2. Volume rubble and soil (Non-TRU)	2.2
Retention Basins (5)	
100 Area	
1. Volume rubble (some soil) (Non-TRU)	1.5
2. Volume rubble and soil (Non-TRU)	4.0

Table H-7

Summary of Estimated Volume of Low Level Wastes from D/D by the Year 2000

Commercial Reactor	Volume of Low-Level Waste (cubic ft)
Low (40-year operation--5 reactors mothballed)	10,000
Medium (5 reactors entombed)	145,000
High (5 reactors dismantled)	1,000,000
DOE Defense Sites	**Volume of Low-Level Waste**
Low	10 million cubic feet
Medium	100 million cubic feet
High	550 million cubic feet
	Volume of TRU Waste
Low	5 million cubic feet
Medium	95 million cubic feet
High	640 million cubic feet

No estimate made on contaminated waste from former MED/AEC sites which are being resurveyed for remedial action.

REFERENCES

(1) U. S. Nuclear Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors" (June 1974).

(2) MANION, W. J., and LAGUARDIA, T. S., "An Engineering Evaluation of Nuclear Power Reactor Decommissioning Alternatives", AIF/NESP-009, Nov. 1976.

(3) "Decommissioning of Nuclear Facilities - A Review of Status", Atomic Energy Review, 12, No. 1, IAEA, Vienna (1974).

(4) "Decommissioning of Nuclear Facilities", IAEA-179, Vienna (1975).

(5) "Boiling Nuclear Superheater Power Station Decommissioning", Docket 1154-2, Puerto Rico Water Resources Authority and United Nuclear Corp. (September 1970).

(6) "Report on Retirement of Hallum Nuclear Power Facility", AI-AEC-12709, Atomics International, Canoga Park, California (May 1970).

(7) "Final Elk River Reactor Program Report", COO-651-93 (September 1974).

(8) USERDA, "Proceedings of the Conference on Decontamination and Decommissioning (D/D) of ERDA Facilities", Idaho Falls, Idaho (August 19-21, 1975), CONF-750827.

(9) SANDE, W. E., et al., "Decontamination and Decommissioning of Nuclear Facilities - A Literature Search", Battelle Pacific Northwest Laboratories, BNWL-1917 (May 1975).

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APPENDIX I

URANIUM MILL TAILINGS

Uranium mill tailings contain residual radium which generates radon gas and other daughter products that raise the radiological background in the vicinity of tailings pile to potentially hazardous levels. A study of radiological conditions and practicable remedial alternatives and costs at 22 locations where uranium mills have been closed down is now complete. The total volume of tailings is estimated at about 500 million cubic feet (assuming a density of 100 lb./ft. for compacted soil). The general findings are as follows:

1. At none of the sites can the tailings be considered adequately stabilized for long-term storage. Contamination usually extends beyond the property boundaries due to wind or water erosion.

2. Based on the correlation observed between exposure to radon and other radium daughter products and incidence of lung cancer in uranium miners, the risk of incurring lung cancer is about double the normal to population living in close proximity to the tailings.

3. Most of the mill sites are in potentially favorable locations for alternative uses, and are in demand.

The question arises as to what obligation the Federal Government has to undertake remedial action. The tailings resulted from the operations of private companies that processed uranium ores for the Manhattan Engineering District (MED) and AEC under procurement contracts from the mid 1940's to the late 1960's. Most of the contracts provided fixed prices per pound of uranium delivered, based on production costs. The costs for eventual tailings stabilization were not included.

MED and AEC exerted no operational control or regulatory jurisdiction over the tailings and neither the Federal Government (DOE, NRC, EPA) nor the states appear to have legal responsibility for cleanup of the mill tailings sites. The owners are either unwilling or financially unable to clean up the sites. The Federal Government does not appear to have the authority to require them to do so. Thus, legislation would be required to authorize Federal assistance in a conprehensive remedial action program at the 22 sites.

A situation similar to the instant one existed at Grand Junction, Colorado, where tailings had been removed from an inactive mill site and used in the construction of buildings in and around that city. Similar to the 22 locations now at issue, the tailings at Grand Junction resulted from the operations of a private company that delivered uranium concentrate to the AEC under a fixed price procurement contract with the AEC exerting neither operational nor regulatory control over the tailings. Nevertheless, in 1972, Congress, using the approach which it originated in 1955 to ameliorate the health and safety problems arising from the "Texas City Disaster," enacted Title II of P.L. 92-314 which recognized and assumed "the compassionate responsibility of the United States" to assist in providing remedial action where no other remedy by law was apparent. That legislation authorized Federal assistance up to 75 percent of the direct cost of a state remedial action program for Grand Junction.

It is estimated that the cost of remedial actions at these 22 inactive mill sites will range form $80 million to $125 million. The variation is due to the uncertainty in the remedial option (stabilization or removal) to be adopted for each site.

A NEPA environmental assessment is in preparation to determine the environmental significance of the remedial options under consideration at each site.

NRC is utilizing NEPA to control and stabilize uranium mill tailings at active sites.

APPENDIX J

International Programs in Radioactive Waste Management

Although the problem of waste management is universal to the nuclear community, the technical approaches and programs of execution are in the main national in approach and execution. Waste management research and development is being supported by the respective governments through government affiliated companies such as BNFL (UK), CEA (France), and PNC (Japan). International cooperation exists most actively in the European combines such as United Reprocessors or the collaboratively funded program of the Organization for Economic Cooperation and Development (OECD).

The OECD (through its Nuclear Energy Agency) has established a comprehensive program of radioactive waste management technology development to be conducted in various laboratories throughout the European Community. It parallels the U.S. program and supports the Eurochemic high level waste solidification program, including geologic surveys of the suitability of disposal in various types of formations in UK, France, Belgium, Italy, Germany and Holland.

The International Atomic Energy Agency (IAEA) provides a multinational focus for investigation and development in the waste management area. The activities are carried out through technical meetings and research contracts dealing with a broad range of radioactive waste problems as well as through the development of health and safety standards to serve as examples for national regulations.

The IAEA organizes annual meetings of countries actually working in or working toward large-scale waste management programs. One of these is a group called the "International Working Group for High-Level Waste and Transuranium (Alpha) Waste." The meeting agendas usually include a mixture of policy and technical discussions. A panel is developing mutually agreed upon criteria for the selection and operation of long-term high-level waste disposal sites and practices for storing and disposing of high-level wastes. Another is developing recommendations concerning disposal of high-level radioactive wastes unsuitable for dumping at sea.

Following are summaries of waste management programs of countries with significant efforts in this area.

United Kingdom

The UK has been reprocessing Magnox fuel at Windscale from its domestic gas cooled reactors on a regular basis for about ten years at a rate of approximately 1000 metric tons per year. Fuel from the two gas cooled reactors exported to Italy and Japan is also being reprocessed at Windscale.

In addition to the reprocessing of domestic fuel the UK is conducting negotiations for the reprocessing of LWR fuel from other countries. The UK Department of Environment held a planning inquiry on a proposed 1000 metric ton per year plant, planned for completion in the mid to late 1980's and designed to handle this foreign LWR fuel. The inquiry has been completed but the decision to proceed with construction has not been made.

The high level wastes from the reprocessing operation are presently being stored in liquid form in doubled walled steel tanks.

The development of waste processing technology within the UK covers high-level waste, transuranic or alpha contaminated waste, and airborne waste. The UK plan is to store high-level liquid waste for the interim and then to convert it to borosilicate glass.

The UK is a member of United Reprocessors GMBH which is a combine of UK, France and West Germany entities to service primarily European commercial fuel reprocessing requirements.

The UK has initiated a program to evaluate the concept of terminal isolation of radioactive waste in geological formations. In the UK it seems likely that there are two options, clay formations and crystalline rocks.

France

France has been reprocessing domestic power reactor fuel from its graphite moderated gas cooled reactors since 1959. This reprocessing was originally accomplished at Marcoule and more recently at La Hague. A new front end facility to accommodate LWR fuel at La Hague started operation in early 1977. The second LWR fuel campaign is scheduled for completion in January 1978.

The French are also equal partners with the British and West Germans in United Reprocessors GMBH (URG). The French shareholder, originally the French Atomic Energy Commission (CEA) and now a CEA subsidiary, COGEMA, operates the reprocessing plants at Marcoule and La Hague. They plan to operate these plants at a low rate in 1978 and plan gradual increases in capacity, reaching 800 metric tons uranium per year by the mid 1980's. In addition, COGEMA plans a third reprocessing plant, to be built at La Hague, with two similar reprocessing lines each of 800 metric tons uranium capacity per year. These two lines are planned to come on stream during the mid to late 1980's.

COGEMA, under United Reprocessors auspices, is offering long-term contracts for storage and reprocessing services for 6,000 metric tons of irradiated fuels.

Reprocessing wastes have been stored in liquid form in engineered storage facilities. However, the French have recently started operation of their AVM plant (150 cubic meter capacity) at Marcoule for the continuous vitrification of high level wastes. Another such plant (AVH) for La Hague with a capacity of 800 cubic meters per year is now being designed and scheduled for completion in the early 1980's.

The French national waste management program, under the guidance of CEA, is at an advanced stage of development of technology for converting high-level liquid waste to a borosilicate glass. Their program involves non-radioactive engineering scale testing, radioactive testing and the AVM demonstration facility now completed at Marcoule.

The French geologic program is primarily an assessment of available geologic information. They have salt formations and even domes in the southern part of the country and are gathering data on them.

Canada

The CANDU nuclear power system, based on a high neutron economy natural uranium fuel cycle, currently closes with secure retrievable storage of spent fuel until such time as processing to recover the plutonium is economical. Future development of the CANDU system is focused on conversion to plutonium and thorium recycle fuel cycles.

The majority of the Canadian current waste management interest is on interim spent fuel storage concepts and packaging designs. Since reprocessing of fuel may eventually become a requirement, the Canadians are becoming interested in developing a reprocessing capability for the CANDU thorium U-233 fuel cycle, including waste processing.

Canada recognizes that geologic terminal storage of high level waste from reprocessed fuel will be necessary and is therefore engaged in efforts to find suitable geologic formations for both secure retrievable storage and terminal storage. The Canadians have followed the U.S. geologic program closely using the logic that they have the same formations as the U.S. and if a need for disposal capability should arise, they could use technology developed and demonstrated here. However, since the Canadian Geologic Survey has become more actively involved a more independent approach is evolving. While they are continuing to stay abreast of the salt technology, they are exploring the use of crystalline rocks.

In 1977 Canada's Department of Energy, Mines and Resources commissioned a group of independent experts to study the long term storage of radioactive wastes. This study was completed in August 1977 and the results published in a report entitled "Management of Canada's Nuclear Wastes".

The study group recommended that the Canadian Government develop a draft plan that should be submitted for Federal provincial discussions that would lead to its adoption as a national plan.

The group concluded that the prospects were good for the safe, permanent disposal of reactor wastes and irradiated fuel since they foresaw no environmental or health impacts once these radioactive materials have been placed in carefully selected repositories.

They considered underground disposal in igneous rock as the most promising option for the disposal of spent fuels and radioactive wastes. Also, that initially one repository will suffice, and that the repository chosen should be regarded as a central national facility, Federally owned and operated and available to all provincial utilities. The cost of building and operation should be recovered via charges from the organizations from whom the waste is received.

The group also concluded that spent fuel reprocessing is not necessary for safe disposal - both spent fuel and reprocessing waste can be disposed of in the same repository, and that no commercial fuel reprocessing plant should be approved in Canada until satisfactory methods for dealing with the associated radioactive wastes have been developed.

Finally, the group concluded that the ongoing Canadian research and development program in this area was well conceived but that it should be given greater priority and increased financial support, especially in the areas of geological, geophysical, geochemical and engineering research required for the geological formation disposal sites.

Japan

In Japan more than ten nuclear power plants of industrial scale are now in operation and some other ten plants are under construction or in the planning stage.

Japan has a 210 metric ton per year reprocessing plant at Tokai Mura that began limited operation in the Fall of 1977 and reportedly has intentions to build a 1500 ton per year plant for operation in the 1990's. To alleviate the spent fuel situation, in the meantime, consideration is being given to construction of a centralized away from reactor, spent fuel storage pool. They also have a contract with United Reprocessors (COGEMA) and a pending contract with BNFL.

The waste management program in Japan is coordinated through the Japan Atomic Energy Commission (JAEC). The high-level liquid waste from the pilot reprocessing plant they have purchased from France will be stored initially as acid liquid in stainless steel tanks pending a decision on solidification or more sophisticated processing treatment, such as partioning and transmutation which the Japanese have studied in some detail.

Japan does not permit the land burial of radioactive wastes at the present time. However, they are evaluating a number of sites for possible use. These are either at nuclear laboratories or nuclear power plants sites. Since Japan has no terminal storage capability, low-level waste is currently being mixed with cement in drums and stored in warehouses and underground concrete trenches. The tentative conclusion is that Japan may have no suitable geologic formation on the home island. Therefore, they are intensely interested in activities in other countries to conduct geologic disposal and while not open advocates of the program, are known to have intensive interest in seabed disposal. They are also intrigued by the island disposal concept.

Germany

The Federal Republic of Germany has an extensive nuclear power program, however, unlike its partners in United Reprocessing the French and the British, it does not have an existing spent fuel reprocessing capability except for the small WAK 40 MT/yr experimental reprocessing facility located at Karlsruhe. The FRG has a commitment from their French United Reprocessing partner, COGEMA, to reprocess all uncommitted German fuel discharged through 1981.

The FRG is heavily committed to spent fuel reprocessing and eventual geologic disposition. In fact, approval of reactor construction licenses have been contingent on the Radiation Protection and Reactor Safety Commission's approval of a reprocessing and waste disposal complex. Recently these two Commissions concluded that the feasibility of such a concept is proven from a safety and technological point of view.

The German nuclear industry and political and governmental circles feel that in order to gain public acceptance of nuclear power they must prove that nuclear wastes can be handled and disposed of safely. The classic FRG position to date has been that reprocessing is an essential precondition to effective disposal of radioactive wastes. It is also important to them that nuclear power, including the backend of the fuel cycle, must be successfully demonstrated domestically in order to demonstrate to the world nuclear export market that German industry has the technical and management resources required for both converter and breeder reactor systems.

The FRG does not expect to have its first commercial reprocessing plant in operation until the late 1980's. This is expected to be a 1400 metric ton per year plant to be located at Gorleben in Lower Saxony. The Germans plan to concentrate reprocessing, recycling and disposal of fissionable material, waste handling treatment and storage at Gorleben. It is also their plan to solidify their high level waste and to place it in intermediate storage in retrievable form to allow sufficient time to develop and demonstrate a final disposal system in geologic formations.

As a result of reactor storage pool size restrictions and the distant dates for the operation of the reprocessing plant, the government plans to construct large scale, away from reactor, storage pools (3500 MTU capacity by 1989) to be located at the eventual reprocessing site.

Waste processing technology in the FRG is being developed for treating high-level, alpha contaminated, intermediate-level, and airborne waste. The German plan for high-level liquid waste disposal involves spray calcination and vitrification.

The Germans are recognized as one of the world's leaders in the disposal of radioactive waste. They have a salt mine located at Asse which is receiving waste on a routine basis much like a scaled-down version of the pilot plant for DOE defense waste in New Mexico. Their Asse salt mine is limited to waste having a low transuranic content and is not intended to serve as the major fuel reprocessing waste disposal facility.

<u>Belgium</u>

Belgium presently has three operating power reactors and another four planned for operation by 1982. Currently none of the fuel from these reactors is committed for reprocessing. Reportedly, Belgium is planning to expand the storage pools at some of the reactor sites.

Until July 1974, the Eurochemic reprocessing plant was operated at Mol, Belgium as a multinational pilot venture. At that time it was shut down as uneconomic. The Belgium government is now considering refurbishing, upgrading, and reopening that plant by mid 1981. Its capacity would be devoted to Belgium needs. Reportedly the plant would be brought up to full 30C MTU/year capacity over a 3 to 4 year period.

The Belgium government's proposed Waste Management Research and Development 5 Year Plan for 1978-1982 includes work to be done mostly under the framework of the Commission of European Communities, in the following areas: Radioactive waste burial in geologic formations; studies of compaction and encapsulation of cladding waste; investigation of high temperature incineration of plutonium containing waste; and purification of gas released from reprocessing operations.

A waste management technical exchange agreement with the U.S. is now under negotiation. The proposed areas of cooperation are: terminal storage in geological formations; technology of retrievable storage; high level waste solidification and environmental effects of radioactive waste disposal.

Sweden

Sweden currently has five LWR plants in operation, two more expected to begin operation shortly and a total of twelve reactors are expected to be in operation by 1983.

The Swedish government requires that, prior to initial operation, reactor operators must demonstrate that they have a valid reprocessing contract and demonstrate that waste generated can be safely deposited or demonstrate that spent fuel can be stored with absolute safety.

In 1976 a waste management policy committee chartered by the government recommended that Sweden develop a reprocessing and waste management capability. With the recent change in government emphasis is being placed on external reprocessing with a major research and development effort directed toward the disposal of nuclear wastes in Sweden. However, the Swedish government has indicated that they will not have their fuel reprocessed until the completion of International Nuclear Fuel Cycle Evaluation Program.

The present waste management strategy is to store solidified waste or unreprocessed spent fuel in bed rock, probably granite foundations. Therefore, waste management research and development is directed toward this end. The present program includes:

- Ion exchange processes for fractionation of high level liquid wastes and collection of radionuclides in solid form.
- Powder-pressing and sintering techniques for making waste glass forms and for making ceramic containers for spent fuels
- Design of underground spent fuel storage pools
- Preparation for commissioning a pilot plant for terminal storage of spent fuel or solidified high level wastes

Recently a Swedish group has been concentrating on a scheme that would involve the placement of high level wastes or unreprocessed spent fuel in crystalline rock waste repositories located in existing mine shafts at depths on the order of 500 meters. The waste or spent fuel would not be put into a final repository until after a sufficiently long cooling period such that the rock in the vicinity of the cannisters would not exceed $60^{o}C$.

This group is especially interested in the retardation of hydrologic flow and repository designs with long sorptive flow paths to the biosphere. For this reason they are looking at the placement of secondary barriers, immediately around the waste containers, made of material with high absorptive properties such as bentonite (a clay mineral) and the backfilling of the mine workings with this material after the wastes are in place.

USSR

It is estimated that the USSR will have on the order of 20,000 MWe of nuclear power generating capacity on line by the early 1980s. The USSR has a significant LMFBR program and is committed to the plutonium breeder cycle.

According to available information, the Soviet Union does not have a commercial-scale spent fuel reprocessing plant on line but is reportedly building one with a 5 metric ton per day capacity, to be operational in the early 1980s. A vitrification plant to be located near the reprocessing plant is also projected.

The USSR has an experimental high level waste solidification program. They have a pilot vitrification unit using a single stage phosphate glass process that has been operating for several years. They have also been working with a two stage fluidized bed calcination process.

In the area of high level waste disposal, studies of geologic isolation have been conducted, however, they presently seem to emphasize surface storage for solidified high level wastes.

APPENDIX K

CASE STUDIES AND COST ESTIMATES

TABLE OF CONTENTS PAGE

I. INTRODUCTION 1

II. CASE DESCRIPTIONS 1

III. LOW LEVEL WASTE (LLW) STORAGE REQUIREMENTS 8

IV. TRANSURANIC WASTES (TRU) 15

V. HIGH LEVEL WASTES (HLW) 22

VI. REPOSITORY REQUIREMENTS FOR TRU AND HLW 26

VII. REPOSITORY REQUIREMENTS FOR COMMERCIAL SPENT FUEL 26

VIII. TRANSPORTATION REQUIREMENTS FOR SPENT FUEL, HLW, AND TRU ... 41

IX. COST "GUESSTIMATES" 45

Note: The numerical detail shown in this Appendix is to allow others to independently reproduce the calculations. Most of the input data are estimates.

I. INTRODUCTION

The term "waste management" encompasses a complex system comprised of numerous types, sources and dispositions of radioactive waste and the processing and transportation required to move them from source to ultimate disposal. To facilitate the understanding of waste management as a system, two basic cases are defined and analyzed. The objectives of this analysis are multifold:

a) to explicitly express the physical nature of the waste management system;
b) to identify and analyze the consequences of key assumptions;
c) to provide a framework for identifying the major decisions and actions required to make the system viable; and
d) to define the boundaries of possible conditions and situations that may develop in the future.

What follows are, admittedly, two extreme cases. This is not to imply that all the assumptions for each case are extreme and, by implication, unrealistic. Rather, the composite effects of individual assumptions for each yield results which delineate broad boundaries for the whole waste management system. Both cases are generally consistent with the proposed policy.

II. CASE DESCRIPTIONS

The first case reflects a geographically centralized waste management system.

Case 1 is designed to minimize the need for LLW (low level waste) burial ground acreage and the need and number of geologic repositories for TRU (transuranic) waste, HLW (high level wastes), and spent fuel. This is accomplished through assumptions which reflect low nuclear capacity levels, volume reduction techniques for LLW and TRU, small-scale decontamination and decommissioning (D&D) programs for commercial and DOE facilities, and minimization of material sent to a single DOE repository (WIPP).

The second case describes a larger, more decentralized waste management system. Case 2 is structured to maximize burial ground needs and the need and number of repositories (DOE and commercial) by assuming significant nuclear growth consistent with the National Energy Plan (NEP), no volume reduction for LLW and TRU, a moderate scale D&D program for DOE and a large commercial D&D program, maximization of DOE material sent to two DOE repositories, and more technically conservative repository design assumptions.

The following discussion focuses on the forms and quantities of radioactive wastes to be handled and the requirements for transporting and disposing of them. Table K-1 summarizes the assumptions used in each case. Assumptions about nuclear power and repository design which apply throughout the appendix are discussed below. Other assumptions are presented in the appropriate section.

Table K-2 gives the nuclear capacity projections used in the cases. The first projection includes only those reactors which are presently operating or have construction permits or limited work authorizations. The second projects nuclear growth consistent with the National Energy Plan. Table K-3 presents annual spent fuel and waste generation rates for a typical 1000 MWe reactor (1/3 BWR, 2/3 PWR) and associated fuel cycle activities, assuming a "once through" fuel cycle (no reprocessing), an average capacity factor of 67 percent, a thermal efficiency of .32, and an average burnup of 25,000 MWD/MTHM. Table K-4 summarizes key repository design assumptions for the commercial spent fuel repositories and required DOE repositories. (These design bases are covered in more detail in Appendix E and later sections.)

TABLE K-1

CASE DESCRIPTIONS

DESCRIPTION	CASE 1	CASE 2
Nuclear Capacity, Year 2000	148 GWe	380 GWe
Commercial Waste Generation		
o Low Level Waste		
- Reactors		
Through 1980	a) Past Experience Continues	Past Experience Continues
1981-1985	b) Volume reduced to 1/3 of a)	(all years)
Post-1985	c) Volume reduced to 1/9 of a)	↓
- Fuel Cycle	(Same annual quantities per reactor for both cases)	
- Non-Fuel Cycle	(Same projection for both cases)	
- D&D to the year 2000	Mothball 5 reactors	Dismantle 5 reactors
o Transuranic Wastes	(Same for both cases)	
DOE Waste Generation		
o Low Level Wastes		
- Operations		
Through 1985	No volume reduction	No volume reduction
Post-1985	Volume reduced to 1/5	(all years)
- D&D to the year 2000	10 million cubic feet	160 million cubic feet
- Other	Decontaminated salt	none
o Transuranic Wastes		
- Operations	Volume reduced to 1/5 after 1985	No volume reduction
- D&D to the year 2000	5 million cubic feet	95 million cubic feet
- Exhumation of buried TRU	No	Yes

Table K-1 (continued)

	CASE 1	CASE 2
o High Level Wastes		
- Savannah River (Decontaminate salt cake and vitrify the balance)	1. Salt cake to LLW burial 2. Balance to WIPP	All waste sent to WIPP
- Idaho (calcine or vitrified calcine)	Entomb on-site	Ship to WIPP
- Richland (same as Savannah River)	1. Salt cake to LLW burial 2. Balance to WIPP	All waste placed in a basalt repository below site.
- West Valley (NFS)	Vitrify and colocate with DOE HLW	Same as Case 1
o ORNL Intermediate Level Wastes	Inject grout made with waste into hydrofractured shale below site	Same as Case 1

TABLE K-2 - NUCLEAR CAPACITY PROJECTIONS

Year	Gigawatts (GWe) Case 1[1/]	Case 2[2/]
77	47.9	47.9
80	61.1	61.1
85	126.9	126.9
90	148.4	194.6
95	148.4	282.8
2000	148.4[3/]	380.0[3/]

[1/] The 148.4 level represents reactors which are now operating or have construction permits or limited work authorizations.

[2/] Consistent with the National Energy Plan.

[3/] Excludes decommissioning.

TABLE K-3

ANNUAL WASTE GENERATION RATES
(Normalized to a Typical 1000 MWe LWR)

Spent Fuel Discharged (Ave.)	25.4 MTHM/yr ($332\ ft^3/yr$)
Low Level Waste, Onsite[1/]	
a) Present Experience	$45,000\ ft^3/yr$
b) Design Basis	$15,000\ ft^3/yr$
c) Advanced Volume Reduction[2/]	$5,000\ ft^3/yr$
Low Level Waste, Offsite	
a) Uranium Mill, Tailings Solutions[3/]	254,000 MT/yr
Tailings Solids[3/]	96,000 MT/yr
b) UF_6 Conversion	$1,200\ ft^3/yr$
c) Enrichment[3/,4/]	$50\ ft^3/yr$
d) Fuel Fabrication	$750\ ft^3/yr$
Transuranic Waste, Onsite and Offsite	0

[1/] Roughly 40% of current volumes generated is contaminated trash.

[2/] This estimate reflects the use of methods which are presently not economical. Current, allowable activity levels per package may preclude actual achievement of this level in the future.

[3/] These wastes are currently disposed of at the processing facility site.

[4/] This value is based on gaseous diffusion technology. The new centrifuge process could potentially generate more (up to $2900\ ft^3/yr$).

TABLE K-4

REPOSITORY DESIGN ASSUMPTIONS

(Commercial and DOE)

	CASE 1	CASE 2
A. Medium	Salt	Salt(except for basalt at RL)
B. HLW heat load	150 KW/acre 1/	100 KW/acre 2/ (127 for basalt)
C. Spent fuel, min. age heat load	5 years 99 KW/acre 1/	5 years 66 KW/acre 2/
D. TRU and other non-heat limited waste	36,500 ft^3/acre	Same as Case 1

1/ These parameters reflect the amount of heat generated per acre when the material is emplaced in the repository, as described in Appendix E, assuming 5 year retrievability. The spent fuel parameter has been adjusted for the shorter period of cooling (5 vs. 10 years). Since spent fuel emplacement is determined by long-term heat effects (thousands of years), which do not vary dramatically with the age of the fuel, the initial heat loads are higher than for 10 year old fuel.

2/ Arbitrarily established at 2/3 of the Case 1 values to reflect a greater degree of technical conservatism.

III. LOW LEVEL WASTE (LLW) STORAGE REQUIREMENTS

There are three basic sources of commercial low-level waste: nuclear reactors and associated fuel cycle facilities; non-fuel cycle sources such as industry, academia, and hospitals; and D&D activities.

Table K-5 projects the quantities of LLW expected from these sources for Case 1.

The model reactor data in Table K-3 were used for projecting LLW from reactor and fuel cycle activities. It is assumed for reactor waste that volumes consistent with past experience will continue through 1980, followed by achievement of levels expected when the reactor was designed for 1981-85 and institution of advanced volume reduction techniques thereafter. Low level waste (LLW) from reactor operations (i.e., onsite) consists of contaminated trash, used HEPA filters, ion exchange resins, etc., and is packaged and shipped to commercial burial grounds for disposal. The packaging step increases the volume by a factor of 2. Present operating practices result in volumes which are 3 times what was anticipated during design and about 9 times more than if advanced, though not presently economical, volume reduction techniques were instituted.

LLW is also generated by fuel cycle activities related to the reactor, as previously shown in Table K-3 normalized to one year of reactor operation. Only UF_6 conversion and fuel fabrication LLW are packaged and shipped to commercial burial grounds. Volume reduction is not assumed for fuel cycle wastes shipped offsite. LLW generated by industrial, academic, medical and other sources are also not expected to undergo volume reduction because the particular quantities generated by these many small contributors probably preclude economic justification of individual investment in volume reduction facilities. Finally, LLW from D&D activities are assumed not to undergo volume reduction, since much of the material is contaminated equipment.

The quantities of projected LLW under Case 2 assumptions are presented in Table K-6. Individual reactor waste quantities reflect a continuation of previous experience without any volume reduction and are applied to the 380 GWe projected for the year 2000. Fuel cycle wastes on a normalized basis are unchanged. The total waste from non-fuel cycle sources are the same as in Case 1. The D&D component, however, reflects complete dismantling of the five small reactors, as described in Appendix H.

TABLE K-5 - TOTAL COMMERCIAL LLW GENERATED - CASE 1
(millions of cubic feet)

Year	Reactors and Fuel Cycle[1/]	Non-Fuel Cycle	D&D[2/]	Total		Burial Ground Acres Required[3/]
				Ann.	Cum.	
77	2.25	1.0	0	3.25	3.25	11.82
78	2.45			3.45	6.70	24.36
79	2.69			3.69	10.39	37.78
80	2.87			3.87	14.26	51.85
81	1.21	1.5		2.71	16.97	61.71
82	1.40			2.90	19.87	72.25
83	1.59			3.09	22.96	83.49
84	1.86			3.36	26.32	95.71
85	2.15			3.65	29.97	108.98
86	0.98	2.0		2.98		
87	1.01			3.01		
88	1.02			3.02		
89	1.02			3.02		
90	1.03			3.03	45.03	163.75
91		2.5		3.53		
92						
93						
94						
95					62.68	227.93
96		3.0		4.03		
97						
98						
99						
2000			~0.01	4.04	82.84	301.24

1/ Reflects present experience (77-80), design basis (81-5), and advanced volume reduction (86-2000) for reactor wastes.

2/ Mothball 5 reactors, each yielding 2000 ft^3.

3/ At 275,000 ft^3/acre.

TABLE K-6 - TOTAL COMMERCIAL LLW GENERATED - CASE 2
(millions of cubic feet)

Year	Reactors and Fuel Cycle 1/	Non-Fuel Cycle	D&D 2/	Total Ann.	Total Cum.	Burial Ground Acres Required 3/
77	2.25	1.0	0	3.25	3.25	11.82
78	2.45			3.45	6.70	24.36
79	2.69			3.69	10.39	37.78
80	2.87			3.87	14.26	51.85
81	3.34	1.5		4.84	19.10	69.45
82	3.78			5.28	24.38	88.65
83	4.40			5.90	30.28	110.11
84	5.14			6.64	36.92	134.25
85	5.98			7.48	44.40	161.45
86	6.62	2.0		8.62		
87	7.21			9.21		
88	7.80			9.80		
89	8.43			10.43		
90	9.14			11.14	93.60	340.36
91	9.88	2.5	0.10	12.48		
92	10.67			13.27		
93	11.46			14.06		
94	12.35			14.95		
95	13.28			15.88	164.24	597.24
96	14.21	3.0		17.31		
97	15.14			18.24		
98	16.07			19.17		
99	17.00			20.10		
2000	17.84			20.94	260.00	945.45

1/ Based on current experience, no volume reduction.
2/ Dismantle 5 reactors.
3/ At 275,000 ft^3/acre.

Both tables also provide the acres of burial ground required to accommodate these wastes assuming an average utilization factor based on commercial practice of 275,000 ft^3/acre. As shown, the cumulative acres required differ by a factor of about 1.5 in 1985, 2 in 1990, and 3 in the year 2000. The 1985 difference is due solely to lower unit quantities generated by reactors, since nuclear capacity in 1985 for both cases is the same, whereas the difference in the year 2000 is due about equally to differing nuclear capacity levels and unit quantities deriving from volume reduction techniques.

Projections of LLW resulting from DOE programs are given for Case 1 and 2 assumptions in Table K-7 and K-8 respectively. Case 1 results depict a constant generation rate of 1.25 million ft^3/year from normal operations through 1985, when volume reduction techniques which cut the rate to 1/5 the original level are assumed. This assumption is generally consistent with current DOE R&D programs for developing volume reduction technology. Case 2 projects the constant rate of 1.25 million ft^3/year through 2000.

The D&D program impacts reflect "small" and "moderate" programs for Cases 1 and 2, respectively, and are described in more detail in Appendix H. The "other" category pertains only to Case 1 and includes about 10 million cubic feet of decontaminated salt recovered from the removal of radionuclides from HLW present at RL and SR. (The decontaminated salt cake is a "fluffy" product which has a larger volume than the material processed.) For calculational purposes, the projected HLW inventory for the beginning of 1985 (as discussed later) is assumed to be processed over the preceding five years with the follow-on rate representing the decontaminated salt cake derived from newly generated HLW after 1984. (This may not reflect actual, future practice.)

Also shown is the burial ground acreage required, assuming the commercial practice rate of 275,000 ft^3/acre. Though DOE experience to date is actually about 1/2 this value, it is assumed that the assumption of responsibilities for commercial burial grounds, as proposed under the new policy, will lead to licensing of all sites. This, coupled with the premium placed on dedicating land for this purpose in the future, may result in a future DOE utilization factor more comparable to commercial experience.

The acreage of burial grounds required to handle LLW from DOE and commercial sources are summarized in Table K-9 for both cases. The commercial results show that additional acreage beyond the presently unused and licensed 360 acres would be required after 2000 for Case 1 and around 1990 for Case 2. This , in fact, is not particularly significant under the proposed policy since the distinction between commercial and DOE sites would be lost. However, the fact that volume reduction techniques can have such a profound effect on land requirements leads to the following recommendations:

TABLE K-7 - TOTAL DOE LLW GENERATED - CASE 1
(millions of cubic feet)

Year	Base	D&D	Other	Total Ann.	Total Cum.	Burial Ground Acres Required[2/]
77	1.25	0	0	1.25	1.25	4.55
78	↓	↓	↓	1.25	2.50	9.09
79	↓	↓	↓	1.25	3.75	13.64
80	↓	↓	2.03[1/]	3.28	7.03	25.56
81	↓	0.5	↓	3.78	10.81	39.31
82	↓	↓	↓	↓	14.59	53.05
83	↓	↓	↓	↓	18.37	66.80
84	↓	↓	↓	↓	22.15	80.55
85	↓	↓	0.16	1.91	24.06	87.49
86	0.25	↓	↓	0.91		
87	↓	↓	↓	↓		
88	↓	↓	↓	↓		
89	↓	↓	↓	↓		
90	↓	↓	↓	↓	28.61	104.04
91	↓	↓	↓	↓		
92	↓	↓	↓	↓		
93	↓	↓	↓	↓		
94	↓	↓	↓	↓		
95	↓	↓	↓	↓	33.16	120.58
96	↓	↓	↓	↓		
97	↓	↓	↓	↓		
98	↓	↓	↓	↓		
99	↓	↓	↓	↓		
2000	↓	↓	↓	↓	37.71	137.13

1/ Decontaminated salt from SR & RL HLW processing. Backlog is assumed to be worked off by beginning of 1985, though this may not be the actual practice.

2/ At 275,000 ft^3/acre. Actual experience has been roughly half this value in the past.

TABLE K-8 - TOTAL DOE LLW GENERATED - CASE 2
(millions of cubic feet)

Year	Base	D&D	Other	Total Ann.	Total Cum.	Burial Ground Acres Required[1/]
77	1.25	0	0	1.25	1.25	4.55
78					2.50	9.09
79					3.75	13.64
80					5.00	18.18
81		8.0		9.25	14.25	51.82
82					23.50	85.45
83					32.75	119.09
84					42.00	152.73
85					51.25	186.36
86						
87						
88						
89						
90					97.50	354.55
91						
92						
93						
94						
95					143.75	522.73
96						
97						
98						
99						
2000					190.00	690.91

[1/] At 275,000 ft^3/acre. Actual experience has been roughly half this value in the past.

TABLE K-9 - LLW BURIAL GROUND REQUIRED
(acres[1/])

By Year	Case 1 DOE	Case 1 Commercial	Case 1 Total	Case 2 DOE	Case 2 Commercial	Case 2 Total
1980	26	52	78	18	52	70
1985	87	109	196	186	161	347
1990	104	164	268	355	340	695
1995	121	228	349	523	597	1120
2000	137	301	438	691	945	1636

[1/] Assuming average utilization of 275,000 ft^3/acre. Excludes acreage used through January 1, 1977.

a) Substantial opportunities exist to reduce the volume of waste for burial in the future through minimization of volume creation at the source and through volume reduction prior to disposition. DOE should pursue these approaches aggressively;

b) Consideration should be given to both R&D and institutional approaches (e.g., pricing, support of centralized volume reduction facilities) to reduce the volumes of waste buried; and

c) Alternatives to shallow land burial (hydrofracturing; deep geologic disposal for some materials) should also be pursued.

Present LLW Situation

There are six licensed, commercial low level burial grounds currently existing in the United States, but two are presently closed. (A new site near Cimarron, New Mexico, is under consideration by the state). Waste buried to date at these sites is summarized in Table K-10 and totals 15.8 million cubic feet.

The current volume of DOE low level waste buried at seven major sites and numerous smaller ones is shown in Table K-11 and equals almost 51 million cubic feet, consisting of 7,000,000 cubic feet of dried sludge and 44,000,000 cubic feet of solids. These quantities include DOE transuranic waste buried prior to 1975. (The recent generation rate of DOE low-level waste is roughly comparable in volume terms to solid waste generated annually by a community of 55,000).

IV. TRANSURANIC WASTES (TRU)

For case purposes, all TRU wastes are assumed to be emplaced in DOE geologic repositories, including commercial TRU. Transuranic waste is "unofficially" defined as low level waste with concentrations of transuranic elements in excess of 10 nanocuries/gram. (This cutoff level is under review by NRC but has been adopted by the burial site operators, save Hanford).

Table K-10

EXISTING COMMERCIAL LOW LEVEL WASTE (LLW)
(as of 1/1/77)

Site 1/	Status	Millions of Cubic Feet Buried 2/
Barnwell, S.C.	Open	3.52
Beatty, Nev.	Open	1.97
Hanford, Wash.	Open	0.51
Maxey Flats, Ky.	Closed	4.95
Sheffield, Ill.	Open	2.40
West Valley, N.Y.	Closed	2.46
	Total	15.81

1/ Another site near Cimarron, New Mexico, is under consideration by the state.

2/ Includes commercial TRU waste buried.

Table K-11

EXISTING DOE LOW LEVEL WASTE (LLW)
(as of 1/1/77)

Site	Millions of Cubic Feet Buried 1/
Hanford, Wash.	6.40
Idaho Falls, Idaho	5.27
Los Alamos, N.M.	8.55
Oak Ridge National Lab., Tenn.	6.42
Savannah River, S.C.	9.27
Nevada Test Site	0.27
Sandia Lab., N.M.	0.04
Other 2/	14.59
Total	50.81

1/ Includes previously buried TRU waste.

2/ These are wastes contaminated with uranium only which are buried onsite at Pantex (Texas), FMPC (Ohio), National Lead (N.Y.), ORGDP and Y-12 (Tenn.), Paducah (Ky.), Portsmouth (Ohio), and Weldon Springs (Mo.), Projected quantities of TRU waste generated by DOE programs and commercial sources are given in Tables K-12 and K-13 for Cases 1 and 2, respectively. For DOE programs, a constant generation rate of 250,000 ft^3/yr is assumed for Case 2 whereas Case 1 reflects a volume reduction to 1/5 the original level, as assumed earlier for LLW. However, since stored and newly generated TRU will be readily available prior to emplacement in a repository, volume reduction is assumed to apply to both. TRU wastes resulting from the small and moderate DOE D&D programs used in the earlier LLW section also apply (see Appendix H for details). Commercial generation rates in both cases are assumed to continue at their 1977 levels (10,000 ft^3/yr). Case 2 also assumes exhumation of all previously buried DOE TRU waste over the 1981-90 timeframe. Volume reduction of wastes from commercial sources, exhumation, and D&D is not assumed. (A large fraction of D&D material is contaminated equipment and soil.)

The acres of repository required to receive these quantities are also shown. An effective utilization factor of 36,000 ft^3/total acre is used since TRU wastes are not heat limited. This figure reflects a packing efficiency of 0.6 (due to the geometry of the containers), storage room (440' x 36' x 12') capacity of 190,000 ft^3 x 0.6 or 114,000 ft^3, 8 rooms per 21 acres of useable space, and a total useable space of 1680 acres per each 2000 acre repository. As shown, the acreage requirements by the year 2000 differ by a factor of over 15. The predominant reason for this difference is the much larger scope of the D&D program assumed for DOE under Case 2.

All TRU wastes are assumed to be shipped to the WIPP facility for disposal.

Present TRU Situation

Existing inventories of commercial transuranic waste are buried at five of the six commercial low level burial sites (i.e., the Barnwell, South Carolina, site has always prohibited burial of transuranic wastes). The TRU content of low level waste buried totals 123 kilograms, and ranges from 69 kilograms at Maxey Flats, Kentucky, to 4 kilograms at West Valley, New York, as shown in Table K-14. The only commercial waste burial site currently receiving TRU waste is Hanford.

TABLE K-12- TOTAL TRU WASTE GENERATED - CASE 1
(millions of cubic feet)

Year	DOE Base	DOE D&D	Commercial[1]	Total Ann.	Total Cum.	Repository Acres Required[2]
77 + Stored	0.05 + 0.34	0	0.01	0.40		
78	0.05			0.06		
79						
80		↓		↓	0.58	15.9
81		0.25		0.31		
82						
83						
84					1.82	49.9
85					2.13	58.4
86					2.44	66.8
87					2.75	75.3
88					3.06	83.8
89					3.37	92.3
90					3.68	100.8
91					3.99	109.3
92					4.30	117.8
93					4.61	126.3
94					4.92	134.8
95					5.23	143.3
96					5.54	151.8
97					5.85	160.3
98					6.16	168.8
99					6.47	177.3
2000	↓	↓	↓	↓	6.78	185.8

[1] Assumes cessation of burial of commercial TRU.

[2] At 36,000 ft^3/acre.

TABLE K-13 - TOTAL TRU WASTE GENERATED - CASE 2
(millions of cubic feet)

Year	DOE Base	DOE D&D	DOE Exhumation	Commercial	Total Ann.	Total Cum.	Repository Acres Required 1/
77 + Stored	0.25 + 1.72	0	0	0.01	1.98		
78	0.25				0.26		
79					0.26		
80					0.26	2.76	75.6
81		4.75	1.3		6.31		
82							
83							
84						28.00	767.1
85						34.31	940.0
86						40.62	1112.9
87						46.93	1285.8
88						53.24	1458.6
89						59.55	1631.5
90						65.86	1804.4
91			0		5.01	70.87	1941.6
92						75.88	2078.9
93						80.89	2216.2
94						85.90	2353.4
95						90.91	2490.7
96						95.92	2627.9
97						100.93	2765.2
98						105.94	2902.5
99						110.95	3039.7
2000						115.96	3177.0

1/ At 36,000 $ft.^3$/acre.

Table K-14

EXISTING COMMERCIAL TRANSURANIC (TRU) WASTE
(as of 1/1/77)

SITE	BURIED TRU CONTENT (KG)[1/]
Barnwell, SC	0
Beatty, NV	14.3
Hanford, WA	22.7
Maxey Flats, KY	69.1
Sheffield, IL	13.4
West Valley, NY	3.6
	123.1

1/ The associated volumes of TRU waste are not known. The only site presently receiving commercial TRU waste for burial is Hanford.

Approximately 15,000,000 cubic feet of TRU waste exist at six DOE sites, as shown in Table K-15. Of that total volume, nearly 2,000,000 cubic feet is retrievably stored while the balance is buried. Burial of DOE TRU waste ceased at most sites in 1970 and at all sites by 1974.

Intermediate Level Waste - Oak Ridge

Some radioactive wastes generated at the Oak Ridge National Laboratory are disposed of onsite by mixing the wastes with cement and injecting the resultant grout into the shale medium (after hydrofracturing) which exists below the site. This technique has resulted in the disposal of 1,600,000 gallons as of January 1, 1977. Of that total, approximately 25 percent consisted of sludge and the remainder, waste solution. Annual additions of approximately 90,000 gallons are expected to continue for the foreseeable future. This disposal technique has no effect on burial grounds or repository requirements.

V. HIGH LEVEL WASTES (HLW)

High level waste resulting from DOE defense and R&D related programs exists in a variety of forms at a number of sites. Total volume of high level waste stored at the Savannah River, Idaho and Hanford sites currently equals 9.4 million cubic feet and is projected to decline to 9.1 million cubic feet in 1985 as a result of evaporation and processing (cesium/strontium recovery and encapsulation; calcining of HLW). Liquids constitute about 40 percent of the current volume, with salt cake and sludge representing nearly all of the remainder.

High level wastes have also accumulated through the operation of the only commercial reprocessing plant in the United States, the NFS facility at West Valley, New York (which is shutdown). These wastes currently total 82,000 cubic feet and are stored in the form of liquids in underground tanks.

It is assumed below that all existing HLW (Table K-16) and material projected through 1984 (Table K-17) are converted into whatever final form is chosen for each case by the end of 1984. This may not reflect actual practice in the future. HLW generated after 1984 is assumed to be processed immediately.

Table K-15

EXISTING DOE TRU WASTE
(millions of cubic feet as of 1/1/77)

	Buried[1]	Retrievably[2] Stored	Total
Hanford, WA	5.40	0.27	5.67
Idaho Falls, ID	2.30	1.28	3.58
Los Alamos, NM	4.10	0.06	4.16
ORNL, TN	0.20	0.05	0.25
Savannah River, SC	1.00	0.06	1.06
Nevada Test Site	< 0.01	< 0.01	< 0.01
Total	13.00	1.72	14.72
TRU Content (KG)	(>700)	(374)	(>1100)

1/ These are approximate volumes of TRU waste included in the buried LLW. Burial of DOE TRU waste ceased in 1974 (most sites in 1970).

2/ Do not reflect any potential volume reduction.

Table K-16

EXISTING HIGH LEVEL WASTE (HLW)[1/]
(Thousands of cubic feet as of 10/1/77)

DOE	Total	Liquid	Salt Cake	Sludge	Calcine	Cs;Sr Capsules
Savannah River	2900	1700	900	300	0	0
Idaho	404	350	0	0	54	0
Hanford	6102.5	1600	2800	1700	0	2.5
Sub	9406.5	3650	3700	2000	54	2.5
West Valley (NFS)[2/]						
Neutralized (600,000 gal.)	80.2	80.2	0	0	0	0
Acidic (12,000 gal.)	1.6	1.6	0	0	0	0
Sub	81.8	81.8	0	0	0	0
Total	9488.3	3731.8	3700	2000	54	2.5

1/ This reflects the present form of the existing waste, not necessarily the form that would be placed in permanent disposal.

2/ The neutralized waste is stored in a 750,000 gal. carbon steel tank while the acidic waste is in a 15,000 gal. stainless steel tank. There is a spare tank for each in case of leaks.

TABLE K-17

PROJECTED HLW (as of 1/1/85)
(Thousands of cubic feet)

DOE	Total	Liquid	Salt Cake	Sludge	Calcine	Cs;Sr Capsules
Savannah River	2630	560	1660	410	0	0
Idaho	310	150	0	0	160	0
Hanford[1/]	6122.9	1340	3060	1720	0	2.9
Sub	9062.9	2050	4720	2130	160	2.9
West Valley (NFS)						
Neutralized	80.2	80.2	0	0	0	0
Acidic	1.6	1.6	0	0	0	0
Sub	81.8	81.8	0	0	0	0
Total	9144.7	2131.8	4720	2130	160	2.9

1/ This assumes that the entire backlog of fuel from N reactor has been processed by 1/1/85 (i.e., Purex startup), which may not necessarily be the case.

The detailed derivation of repository acreage and burial ground impacts are shown for both cases in Tables K-18 (Savannah River), K-19 (Idaho), K-20 (Richland), K-21 (West Valley), and are generally self-explanatory. The options selected for Savannah River, Idaho, and Richland are among many contained in the corresponding Defense Waste Documents (DWD's) for those sites (NUREG-0043 for West Valley).

VI. REPOSITORY REQUIREMENTS FOR TRU AND HLW

The acres of repository required for TRU and HLW in Cases 1 and 2 are summarized in Table K-22. The requirements are principally driven by the TRU waste quantities but in neither case exceed the total potential WIPP capacity of 4000 acres (2 levels at 2000 acres per level *if* the waste is predominantly TRU). Case 2 results in two repositories, WIPP and a smaller repository, because it assumes some disposal in basalt beneath the DOE reservation near Richland, Washington. The repository loading schedules in either case appear to be feasible; however, the existence of storage facilities at the sites makes the schedule less critical. As mentioned earlier, the HLW processing rates assumed may not reflect actual future practice.

While there is no compelling land-use reason to pursue volume reduction of TRU, such techniques might be necessary for repository safety reasons such as prevention of placement of combustible material (fire hazard) or of waste that might generate significant quantities of gas through decomposition, thereby potentially leading to a breach in the geologic formation.

In conclusion, the potential of large volumes of TRU waste from D&D and exhumation supports the view that WIPP should remain dedicated to the emplacement of TRU waste and possibly solidified high level waste.

VII. REPOSITORY REQUIREMENTS FOR COMMERCIAL SPENT FUEL

For a once-through fuel cycle, spent fuel is assumed to be disposed of in geologic repositories. Since spent fuel has a high (and long-lived) heat content, repository design assumptions for allowable heat loads, as well as the age of the spent fuel disposed of, become very important. General repository design criteria and maximum loading rates are presented in Table K-23 for the two cases. The lower assumed heat load* for the spent fuel in Case 2 results in a 2000 acre repository capacity of two-thirds the capacity under Case 1 assumptions. Since the ability to handle canisters containing spent fuel is the limiting factor, maximum loading rates are the same in both cases. Repository and away-from-reactor (AFR) storage requirements for both cases were calculated, assuming

* Case 2 heat loads in KW/acre were arbitrarily set at two-thirds of the value used in Case 1 to reflect a higher degree of technical conservatism in repository design.

TABLE K-18- SAVANNAH RIVER (SR) HLW

Case 1
(150 KW/acre) Decontaminate salt cake; vitrify radionuclides and remaining sludge and liquid

Ship decontaminated salt to LLW burial

Ship glass to WIPP

A) Beginning of 1985 inventory (assuming processing of entire backlog)

i) Decontaminated salt = 2.60 million ft^3 (9.5 acres at burial ground)

ii) Glass = 156,000 ft^3 @ 12.6 watts/ft^3 = 1966 KW (heat limited) for heat load = 150 KW/acre, repository acres = 13.1

B) Generation rate (1985 on)

i) Decontaminated salt @ 140,000 ft^3/yr needs 0.5 acres/yr (burial)

ii) Glass @ 7000 ft^3/yr (88.2 KW/yr) needs 0.59 acres of repository/yr

Case 2
(100 KW/acre) Decontaminated salt and glass from vitrification shipped to WIPP

A) Beginning of 1985 inventory

i) Decont. salt (not heat limited) 2.60 million ft^3/36,000 ft^3/acre =		72.2 acres
ii) Glass @ 1966/100 =		20.0 acres
	TOTAL repository	92.2 acres

B) Generation rate

i) Decont. salt 140,000/36,000 =		3.89 acres/yr
ii) Glass @ 88.2/100 =		0.88
	TOTAL repository	4.77 acres/yr

TABLE K-19 - IDAHO (ID) HLW

Case 1 — Leave calcine (or vitrified product) in bins and entomb

------ No impact on WIPP or burial grounds ------

Case 2 (100 KW/acre) — Ship calcine (or vitrified product) to WIPP

A) Beginning of 1985 inventory
   $180,000\ ft^3$ of calcine @ $17.5\ watts/ft^3$ = 3150 KW
   Repository acres = 3150/100 = 31.5 acres

B) Generation rate
   $11,000\ ft^3/yr$ @ $17.5\ watts/ft^3$ = 192.5 KW/yr = 1.93 acres/yr

(Acreage would be the same for vitrified product since it is heat limited, even though volumes of glass would be higher ($294,000\ ft^3$ in 1985; $18,000\ ft^3/yr$ generated).)

TABLE K-20 - RICHLAND (RL) HLW

Case 1
(150 KW/acre) Decontaminate salt, recover Cs/Sr, vitrify balance (including Cs/Sr recovered)
Ship decontaminated salt to LLW burial

Ship glass to WIPP

A) Beginning of 1985 inventory (assuming processing of entire backlog)

i) Decont. salt 7,540,000 ft^3/275,000 = 27.4 acres of burial ground

ii) Glass from radionuclides, sludge and liquid = 485,000 ft^3/36,000 = (not heat limited @ 1 watt/ft^3)* — 13.5 acres

Glass from Cs, Sr capsules = 2900 ft^3 @ 345 watts/ft^3 = 1000.5 KW/150 = — 6.7 acres

TOTAL repository — 20.2 acres

B) Generation rate

i) Decont. salt @ 24,000 ft^3/yr — .09 acres of burial/yr

ii) Glass (R, S & L) 1300 ft^3/yr/36,000 = — 0.04 acres/yr

Glass (Cs, Sr) 53 ft^3/yr @ 345 watt/ft^3 = 18.3 KW/yr = — 0.12 acres/yr

TOTAL repository — 0.16 acres/yr

Case 2
(100 KW/acre equiv. or 127 for basalt) Send decont. salt and glass to on-site basalt repository

A) Beginning of 1985 inventory

i) Decont. salt 7,540,000/36,000 = — 209.5 acres

ii) Glass (R, S, & L) — 13.5 acres

Glass (Cs, Sr) 1000.5 KW/100 = — 10.0 acres

TOTAL repository — 233.0 acres

B) Generation rate

i) Decont. salt 24,000/36,000 = — 0.67 acres/yr

ii) Glass (R, S, & L) — 0.04

Glass (Cs, Sr) 18.3/127 = — 0.14

TOTAL repository — 0.85 acres/yr

* This is true because Cs & Sr are the major sources of heat in HLW.

TABLE K-21 - WEST VALLEY (NFS) HLW

All Cases: Vitrify and colocate with DOE HLW in WIPP

Case 1
(150 KW/acre) 600,000 gal + 12,000 gal yields
504 meter^3 or 17,800 ft^3 of vitrified product (NUREG-0043)

Heat = (0.7 BTU/hr - gal) (570,000 gal) +
(140 " ") (30,000 gal) +
(3 " ") (12,000 gal) = 4,635,000 BTU/hr
= 1,359 KW

Acres = 1359/150 KW/acre = 9.1 acres of repository

Case 2
(100 KW/acre) 1359/100 = 13.6 acres of repository

(For purposes of case, this material is assumed to be available by the beginning of 1985.)

TABLE K-22 - CUM. REPOSITORY ACRES REQUIRED (DOE AND WEST VALLEY) 1/

	Case 1			Case 2			
	TRU	HLW	WIPP Total	TRU	HLW (Excl. RL)	WIPP Total	Basalt Repository @ Hanford
through 1984	49.9	42.4	92.3	767.1	137.3	904.4	233.0
85	58.4	43.2	101.6	940.0	144.0	1084.0	233.9
86	66.8	43.9	110.7	1112.9	150.7	1263.6	234.7
87	75.3	44.7	120.0	1285.8	157.4	1443.2	235.6
88	83.8	45.4	129.2	1458.6	164.1	1622.7	236.4
89	92.3	46.2	138.5	1631.5	170.8	1802.3	237.3
90	100.8	46.9	147.7	1804.4	177.5	1981.9	238.1
91	109.3	47.7	157.0	1941.6	184.2	2125.8	239.0
92	117.8	48.4	166.2	2078.9	190.9	2269.8	239.8
93	126.3	49.2	175.5	2216.2	197.6	2413.8	240.7
94	134.8	49.9	184.7	2353.4	204.3	2557.7	241.5
95	143.3	50.7	194.0	2490.7	211.0	2701.7	242.4
96	151.8	51.4	203.2	2627.9	217.7	2845.6	243.2
97	160.3	52.2	212.5	2765.2	224.4	2989.6	244.1
98	168.8	52.9	221.7	2902.5	231.1	3133.6	244.9
99	177.3	53.7	231.0	3039.7	237.8	3277.5	245.8
2000	185.8	54.4	240.2	3177.0	244.5	3421.5	246.6

1/ These schedules are not to imply that the material must be emplaced in the time frame shown. Rather, the results define the acreage requirements as a function of time if the material and repository(s) were both available.

TABLE K-23 - COMMERCIAL REPOSITORY DESIGN DATA

Assumptions: 1) 2000 acre facility in salt

2) Spent fuel cooled 5 (or more) years.
3) Loading rates (maximum)

Year	MT
Partial year	100
First full year	1500
2	5000
3	5000
4	5000
5 on, until full	10,000

4) Ultimate repository capacity

Case 1 -

99 KW/acre heat load when emplaced
99,000 MT capacity
(49.5 MT/acre)

Case 2 -

66 KW/acre heat load when emplaced 1/
66,000 MT capacity
(33.0 MT/acre)

5) Earliest time of full loading

Case 1 - 13 years
Case 2 - 9 years

1/ Arbitrarily set at 2/3 of Case 1 value to reflect a greater degree of technical conservatism.

the first repository is available in 1988 (first full year 1989). For this analysis, an AFR is assumed to hold 5,000 MT of spent fuel.

The spent fuel available for geologic disposal is determined by:

a) the nuclear growth rate assumed, with the inclusion of 10% of foreign spent fuel discharges through the year 2000 (or 22,000 MT); and

b) the cooling period required by the Government before accepting spent fuel for disposal (and storage, if necessary). The recently announced Spent Fuel Policy requires a minimum of five years cooling.

AFR requirements are expected to reach a maximum level during operation of the first repository and then decline as the backlog is worked off. In order to obtain conservative estimates of repository needs, the AFR backlogs are assumed to be depleted as rapidly as possible. Once the AFR's have been emptied, the schedule for subsequent repositories is determined by not allowing another buildup in AFR spent fuel inventory. In effect, the AFR's can be considered as standby capacity in the event repositories are delayed or, in the extreme, a repository must be emptied early in its operational life due to some unforeseen occurrence.

AFR requirements are calculated by subtracting the cumulative quantity of spent fuel placed in the repository from the cumulative spent fuel available (i.e., cooled for 5 or more years) for disposal. The recently announced Spent Fuel Policy envisions "Government" AFR's (either owned by the Government or private facilities under Government contract) being available starting in 1983. As a result, spent fuel available through 1982 is subtracted from the cumulative values for subsequent years to reflect the assumption that a like amount of material will remain in private storage facilities.

For Case 1, Table K-24 shows that only one repository is needed through 2005 and probably wouldn't be full for another 2-1/2 years. The maximum Government AFR requirement of 11,800 MT of storage occurs in 1989 and is worked off in five years.

TABLE K-24 REPOSITORY AND AFR REQUIREMENTS - CASE 1 1/
(in MT of Heavy Metal)

YEAR	CUMULATIVE SPENT FUEL AVAILABLE	CUMULATIVE LOADING REPOSITORY #1	GOVERNMENT AFR STORAGE REQUIRED
82	0		0
3	1300		1300
4	3000	0	3000
5	4600	0	4600
6	6400	0	6400
7	8400	0	8400
8	10,700	100 (Startup)	10,600
9	13,400	1600	11,800 (Max.)
90	16,600	6600	10,000
1	20,100	11,600	8500
2	24,200	16,600	7600
3	28,500	26,600	1900
4	33,000	↑	0
5	37,700	Same as Spent Fuel Available (Loading Limited By Demand)	↓
⋮	⋮	↓	↓
2003	78,000	↓	↓
2004	83,300	↓	↓
2005	88,600	↓	↓

1/ Spent fuel is cooled a minimum of 5 years prior to "availability". The cumulative quantity of spent fuel available has been reduced by the amount available through 1982 (4200 MT) to reflect a like amount of material being kept in onsite storage pools and any required private AFR capacity. The Spent Fuel Policy envisions Government AFRs being available starting in 1983.

If the first repository were delayed, the amount of Government AFR storage required and the time necessary to work off the backlog would increase (Table K-25). The AFR requirement roughly doubles for a 3-year delay and triples for a delay of 5 years in the first repository. Due to assumed AFR loading and unloading limitations of 1500 MT/yr, more AFR's would be required for delays of 1 or 2 years than implied by storage requirements (See Figure K-1).

In Case 2, higher nuclear growth assumptions and the lower capacity of a repository will lead to a greater number of repositories required. As shown in Table K-26, two repositories are needed through 2005. The second repository will need to start up in 1997, with a third and fourth required shortly after 2005. The third and fourth repositories are necessary since the first two will be full by then and the rate of increase in spent fuel availability (about 10,000 MT/yr) is roughly double the permitted loading rates during the second through fourth years of operation (5000 MT/yr). Once full design loading is possible, the latter two repositories should be sufficient for a number of years until the spent fuel availability rate increases markedly or the repositories are filled.

The loading rate for repository #1 from 1997 to 2001 is reduced to allow repository #2 to gear up as rapidly as possible, thereby gaining experience in a new formation and providing a buffer, if needed.

The impact of delays in the first repository on Case 2 results is shown in Table K-27. In the case of delays of 3-5 years, the second repository is needed in 1996 (1 year earlier).

A variation of Case 2 was calculated using the heat load (99 KW/acre) assumption of Case 1. The AFR requirements, delay impacts, and times required to eliminate the spent fuel inventory for the base case and various delays analyzed were the same as in Case 1 for delays up to 3 years, since spent fuel availability from reactors in excess of 148 GWe does not occur until 1999. The need for a second repository, however, was advanced to 2001 (from 2007-8 in Case 1).

Spent Fuel Discharges

Annual and cumulative quantities of U.S. spent fuel discharged are shown in Table K-28 for projected nuclear capacities of 148 and 380 GWe by the year 2000. Spent fuel is presently stored in water storage pools on the reactor site and storage facilities in Morris, Illinois and West Valley, New York. Also shown is 10% of the foreign, free-world discharges projected through the year 2000.

TABLE K-25 - GOVERNMENT AFR NEEDS FOR DELAYS IN FIRST REPOSITORY - CASE 1

Years of Delay	Maximum Government AFR Storage (MT)	Year of Max. AFR	Minimum Time Required To Eliminate Backlog (Years)	Number of AFR's 1/
0	11,800	1989-90	5	3
1	15,000	1990-1	5	4
2	18,500	1991-4	7*	4
3	22,600	1992-5	8*	5
4	26,900	1993-6	9*	6
5	31,400	1994-7	10*	7

* The backlog remains relatively constant for four years and then declines.

1/ An AFR facility could have a storage capacity of 3-10,000 MT, with a typical value of 5,000 MT used above.

Figure K-1

Effect of Repository Delays on AFR Requirements

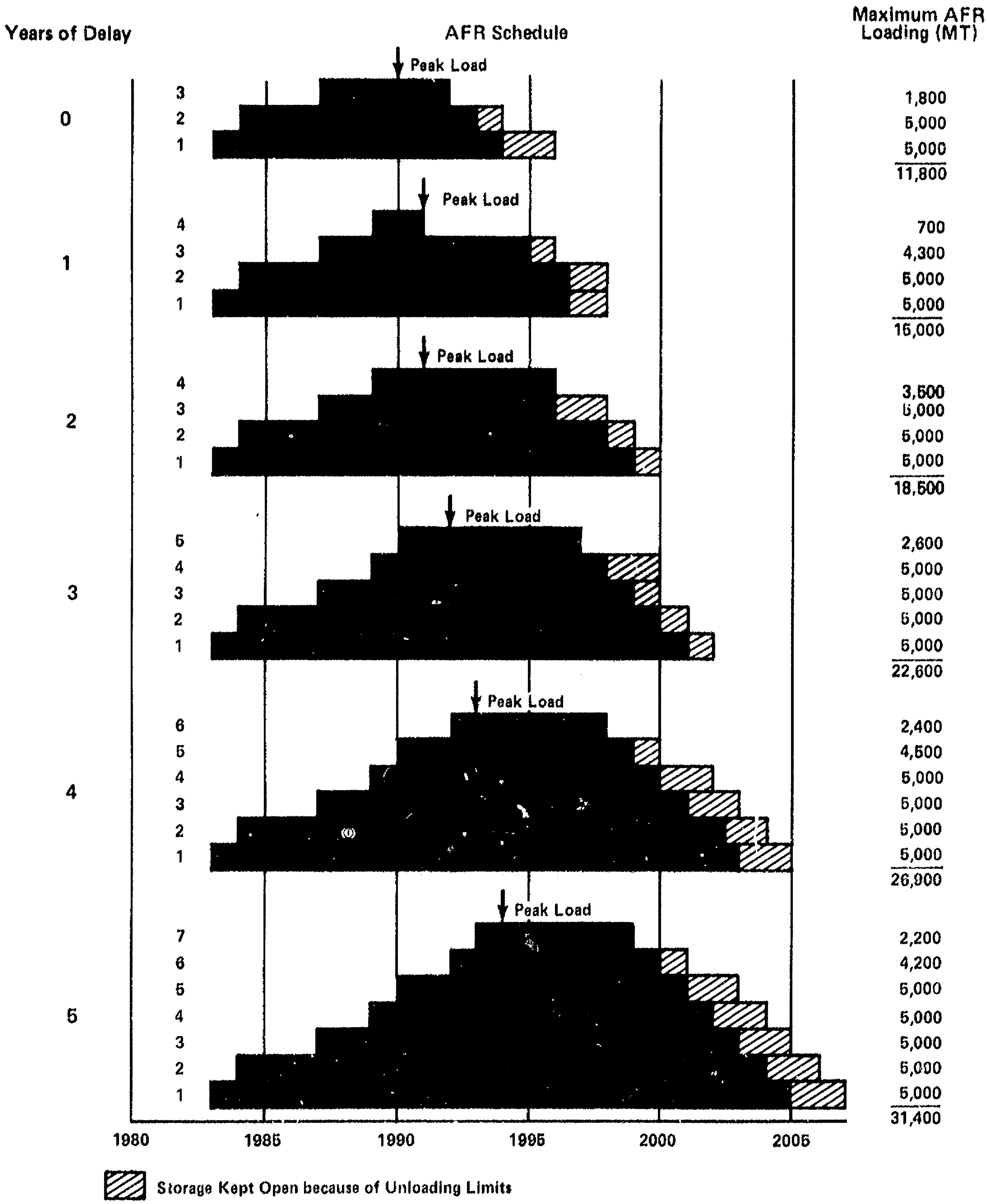

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TABLE K-26 REPOSITORY AND AFR REQUIREMENTS - CASE 2[1]
(in MT of Heavy Metal)

YEAR	CUMULATIVE SPENT FUEL AVAILABLE	CUMULATIVE LOADING REP #1 (1988 startup)	CUMULATIVE LOADING REP #2	GOVERNMENT AFR STORAGE REQUIRED
	(Same results as Case 1 through 1993)			
1993	28,500	26,600	0	1900
4	33,200	33,200*	↓	0
5	38,000	38,000*		↓
6	43,900	43,900*		
7	49,900	49,800[2]	100 (startup)	
8	56,300	54,700[2]	1600	
9	63,200	56,600[2]	6600	
2000	70,600	59,000[2]	11,600	
01	78,500	61,900[2]	16,600	
02	87,000	64,000*	23,000*	
03	95,900	66,000	29,900*	
04	105,400	↓	39,400*	
05	115,300		49,300*	

*Determined by demand, not loading rate.

1/ Same assumptions on spent fuel availability as Case 1.

2/ Loading is reduced in Repository #1 in order to gain experience in bringing Repository #2 up to early design loading rates.

Table K-28

SPENT FUEL GENERATED 1/
(MT of Heavy Metal)

YEAR	DOMESTIC 148 GWe ANNUAL	DOMESTIC 148 GWe CUMULATIVE	DOMESTIC 380 Gwe ANNUAL	DOMESTIC 380 Gwe CUMULATIVE	10% of Foreign ANNUAL	10% of Foreign CUMULATIVE
Existing	-	2,300	-	2,300	-	600 2/
1977	1,000	3,300	1,000	3,300	300	900
1978	1,100	4,400	1,100	4,400	200	1,100
1979	1,300	5,700	1,300	5,700	400	1,500
1980	1,300	7,000	1,300	7,000	300	1,800
1981	1,400	8,400	1,400	8,400	400	2,200
1982	1,600	10,000	1,600	10,000	400	2,600
1983	1,900	11,900	1,900	11,900	400	3,000
1984	2,200	14,100	2,200	14,100	500	3,500
1985	2,700	16,800	2,700	16,800	500	4,000
1986	2,900	19,700	2,900	19,700	600	4,600
1987	3,400	23,100	3,400	23,100	700	5,300
1988	3,600	26,700	3,600	26,700	700	6,000
1989	3,700	30,400	3,900	30,600	800	6,800
1990	3,700	34,100	4,200	34,800	1,000	7,800
1991	3,800	37,900	4,600	39,400	900	8,700
1992	3,800	41,700	4,900	44,300	1,100	9,800
1993	3,800	45,500	5,200	49,500	1,200	11,000
1994	3,800	49,300	5,700	55,200	1,200	12,200
1995	3,700	53,000	6,000	61,200	1,400	13,600
1996	3,700	56,700	6,500	67,700	1,400	15,000
1997	3,700	60,400	6,900	74,600	1,600	16,600
1998	3,600	64,000	7,300	81,900	1,600	18,200
1999	3,600	67,600	7,800	89,700	1,700	19,900
2000	3,500	71,100	8,100	97,800	1,800	21,700

1/ Volume is about 13.1 ft^3 /MT HM for spent fuel.
2/ Excludes discharges prior to 1975.

VIII. TRANSPORTATION REQUIREMENTS FOR SPENT FUEL, HLW, AND TRU

Shipments of spent fuel from industry to the Government and the corresponding requirements for shipping casks are given in Table K-29 for both cases. There are 9 truck casks and 4 rail casks available for use today.

Truck and rail casks also will be required to unload spent fuel from Government AFR's and ship it to repositories. Assuming Government AFR's are unloaded as rapidly as possible and accounting for possible delays in repository opening, the transportation requirements would be as shown in Table K-30. This requirement could be reduced (or even eliminated) by locating AFR's at repository sites.

Finally, the movement of HLW from DOE sites and West Valley, N.Y. will place demands on the same transportation resources. For Case 1, HLW will require 1,590 shipments/year (21 truck casks, and 57 rail casks) on the average, for each year from 1985 to 2000. Over the same period, Case 2 will require 2,530 shipments/year (33 truck casks, and 91 rail casks). Both of these results are comparable to the industry spent fuel shipments required under each case.

Taken together, these requirements sum to roughly 200-270 casks needed in the 1990's (5000-6500 shipments per year). These requirements more than triple the transportation requirements for the 1990's when compared to industry needs alone.

The magnitude of the total transportation requirement raises serious doubts as to the feasibility of meeting these needs and, thus, questions the wisdom of emptying AFR's as rapidly as possible. The problem is overstated since AFR's will probably remain full for longer periods and HLW disposal will probably occur over a period greater than the 15 years assumed.

Nonetheless, given the potential for a shortage of transportation casks for commercial spent fuel and HLW, the following recommendations are offered:

a) Every effort should be made to construct AFR's at the repository sites to minimize transportation needs, even at the risk of constructing an early AFR at a potential repository site which may subsequently be foresaken. Serious thought should be given to the appropriate balance between (1) emptying AFR's to provide for contingency capacity in the event of delays or unforeseen events, thereby maximizing transportation needs, and (2) building additional AFR's for contingency purposes, working inventories off at a much slower pace, and reducing transportation requirements.

TABLE K-29 - DOMESTIC SPENT FUEL TRANSPORTATION[1/]
(from Industry to Government)

Assumptions:
1) Shipments 90% rail, 10% truck
2) Casks in service 275 days/year
3) Cask capacities: 4.5 MT rail; 0.5 MT truck
4) Average round trip: 20 days rail; 7 days truck
5) Cask capability per year:
rail @ 14 shipments/yr = 63.0 MT/yr per cask
truck @ 39 shipments/yr = 19.5 MT/yr per cask

	Case 1					Case 2				
Year	Annual Spent Fuel (MT)	Shipments Truck	Shipments Rail	Casks Truck	Casks Rail	Annual Spent Fuel (MT)	Shipments Truck	Shipments Rail	Casks Truck	Casks Rail
1985	1300	260	260	7	19	1300	260	260	7	19
1990	2700	540	540	14	39	2700	540	540	14	39
1995	3700	740	740	19	53	4200	840	840	22	60
2000	3700	740	740	19	53	6000	1200	1200	31	86
2005	3700	700	700	18	50	8100	1620	1620	42	116

[1/] This does not include (1) any shipments from a Government AFR to a repository, (2) foreign shipments, or (3) HLW shipments.

TABLE K-30 - TRANSPORTATION REQUIREMENTS TO UNLOAD AFR'S

	Delay (Yrs.) in First Repository					
	0	1	2	3	4	5
Case 1						
Total # of Shipments	4720	6000	7400	9040	10760	12,560
Time of Peak Withdrawal[1/]	1993	1995	1995-6	1998	1998	1998
Shipments in Peak Year	2280	2560	2120	2040	2040	2040
Additional Casks Required in Peak Year	60	66	56	54	54	54
Case 2						
Total # of Shipments	4720	6000	7400	9040	10,920	13,320
Time of Peak Withdrawal[1/]	1993	1994	1995	1996	1997	1998
Shipments in Peak Year	2280	2120	2080	1640	1600	1440
Additional Casks Required in Peak Year	60	56	54	44	42	38

[1/] This assumes that Government AFR's are emptied as rapidly as possible. The same split for rail and truck traffic is assumed as in Table K-29.

b) Special attention should be given to transportation as a potential weak link in the waste management system. Near-term action should be taken to ensure that casks will be available when needed. Development of dual purpose casks (spent fuel and HLW) should be seriously considered.

Transportation Requirements for TRU

In the U.S., DOE TRU is currently being shipped in AMTX rail cars. There are now 10 AMTX units in service, each capable of averaging 14 shipments/year while carrying 1000 ft^3 of TRU/shipment.

Assuming that the TRU generated in Case 1 (6.78 million ft^3) is moved over 15 years, this would require 33 AMTX rail cars averaging about 452 shipments/year starting in 1986. Using similar assumptions for Case 2, its 116.0 million ft^3 of TRU would require about 553 AMTX railcars making about 7731 shipments/year.

IX. COST "GUESSTIMATES"

An attempt to quantify the DOE cost implications through the year 2000 (capital, operating, program, and R&D costs) of the two basic cases is summarized in Table K-31.

These represent "ballpark" estimates and are, in some cases, only educated guesses. An additional contingency of about 20% has been added to each case. The cost categories cited include the following:

a) Commercial and DOE respositories - spent fuel repositories, WIPP, basalt repository at RL (Case II only) and facilities for putting spent fuel into canisters prior to emplacement.

b) AFR's - capital and operating costs for Government AFR's.

c) LLW/TRU Operations - burial ground operations, TRU retrievable storage and D&D; plus cost of TRU exhumation for Case 2 and volume reduction costs for Case 1.

d) HLW treatment programs - facilities and operating costs for preparing HLW for geologic disposal, including packaging.

e) DOE Transportation - cost of spent fuel shipments from AFR's to repositories and HLW and TRU shipments, including cask lease charges (spent fuel, HLW) or acquisition costs (AMTX rail cars for TRU).

f) DOE R&D programs - all R&D programs for HLW treatment, WIPP, commercial repositories, LLW and TRU volume reduction, and other waste management related activities.

As shown, the cost of Case II is roughly 50% higher than Case I. The two major cost factors are repositories and HLW treatment. Transportation costs account for about 10% of the total in each case.

Table K-31 COST "GUESSTIMATES" THROUGH 2000
(billions of undiscounted, constant 1977 dollars)

	Case 1	Case 2
I. Facilities and Programs (excl. R&D)		
Commercial and DOE Repositories	3.0 - 3.8	5.6 - 7.3
Away-From-Reactor-Storage - AFR's	0.7 - 0.9	0.7 - 0.9
LLW/TRU Operations 1/	0.6 - 0.9	1.8 - 2.4
HLW Treatment Programs	4.2 - 5.2	3.5 - 4.4
DOE Transportation	1.0 -1.2	1.9 - 2.1
Sub total	9.5 - 12.0	13.5 - 17.1
II. DOE R&D Programs	1.5 - 1.7	1.5 - 1.7
III. Contingency	2.0 - 3.0	3.0 - 4.0
IV. Total costs through 2000	13 - 17	18 - 23

Note: These values are preliminary estimates. In some cases, the values are based only on preconceptual design or educated guesses. Potential acquisition costs or offsetting revenues are not included.

1/ Includes operating costs of all LLW burial grounds, DOE D&D costs, and retrievable storage of DOE TRU. Cost estimates for TRU exhumation for Case 2 and volume reduction (LLW & TRU) for Case 1 are also included.

APPENDIX L

ENVIRONMENTAL PROCESS

All activities in the waste management area should be conducted in compliance with the National Environmental Policy Act (NEPA) and other relevant environmental protection statutes and regulations. In order to assure that environmental requirements are meaningfully considered in program planning, decisionmaking and implementation and that resulting strategies are environmentally acceptable, environmental issues must be integrated into the program design process.

NEED FOR STRENGTHENED PROGRAM ENVIRONMENTAL ANALYSIS CAPABILITY

In order to accomplish this task the environmental analysis capability of the waste management program needs to be strengthened to include the following broad functions:

- Identification of environmental issues and significant potential impacts associated with the program.

- Development of research and development strategy, including the gathering of base-line data to resolve or mitigate such issues and potential impacts.

- Preparation of environmental documentation, including records of environmental review, environmental assessments, negative determinations, environmental impact statements and supplements necessitated by program or project design changes.

- Monitoring of activities to assure that mitigation objectives are achieved during program implementation and system operation.

- Identification and implementation of all environmental- and land use-related permits, licenses and certificates necessary for the conduct of program activities.

It is essential that the Environmental Analysis Office maintain close working relations with both the technical programs within the Waste Management Division and the environmentally-oriented elements within and outside DOE.

NEPA STRATEGY

An attempt has been made to systematize the potential future actions in the waste management area, following the recommendations of this task force, by constructing a decision tree for DOE's recommended NEPA strategy in this area. The underlying basis for this strategy is to provide to future decisionmakers timely and reliable environmental information for all reasonably available decision options.

This NEPA strategy is presented in Figure 1. It projects through various stages of subprogram completion a maximum of forty-five (45) separate environmental reviews with the likelihood that those reviews would result in DOE's preparation of seven (7) environmental impact statements (EISs) and fourteen (14) environmental reports (ERs) to support Nuclear Regulatory Commission EISs and resulting licensing decisions. The projected minimum case would be eighteen (18) separate environmental reviews with the likelihood that those reviews would result in five (5) EISs and three (3) ERs.

COMMENTS ON BATTELLE-SUBMITTED PRELIMINARY VERSION OF GEIS

A major EIS currently under preparation is the so-called generic waste management EIS (GEIS). Review of the preliminary version of the GEIS submitted by Battelle suggests a number of areas that require further work in order to bring the GEIS to a level where it can be meaningful input for the two (2) key waste management decisions it seeks to support -- acceptable means (1) for permanent commercial waste isolation and (2) for retrievable storage of spent fuel elements -- as well as additional waste management research and development necessary to resolve areas of uncertainty. The following comments are designed to assist in identifying those areas where further effort can profitably be expended:

General Comments

1. Battelle may not yet have been furnished significant technical data necessary for an adequate environmental analysis of geologic media under current program consideration, i.e., salt, basalt and granite.

2. Major issues involved in reaching the two (2) major scope decisions should be more clearly articulated and analyzed (e.g., basis of repository design criteria). Indeed, the document appears to focus more on a description of technological status of the commercial waste management program than on an environmental analysis of waste management control.

Specific Comments

1. A description is not included concerning generic site selection factors and/or design criteria which would bracket the impacts associated with commercial waste disposal at designed production throughput and capacity.

2. Inasmuch as this is a generic statement, it should indicate the limitations and/or confidence level of the data and methodology, due to the fact that it uses typical, hypothetical disposal sites. This situation particularly applies to accidental release probabilities and resultant inputs.

3. Sufficient treatment does not appear to have been given to:

   (a) Analysis of accidents (physical events or design failures), the consequences, and quantitative probabilities;

   (b) The treatment of radiologic dose to both individuals and general population and other environmental consequences, subject to appropriate time commitments;

   (c) The fate of fission product gases and other safety/environmental questions about gases;

   (d) Environmental consequences of scenarios involving unloading and reemplacement at repository(ies) subjected to retrievability requirements; and

   (e) Monitoring and remedial action requirements at both interim storage and final disposal sites.

4. There is work in Sweden and elsewhere involving specific repository design concepts, and associated environmental protection philosophies. These concepts should be described and their possible relevance to selection of media, repository design, and environmental consequences for disposal of U.S. waste should be discussed.

5. The coverage of transportation scenarios for high-level and TRU commercial waste does not appear complete. The GEIS seems to cover only rail and motor shipments. With the advent of floating-nuclear plants and the possible increase in the use of barge shipments from fixed facilities near waterways, the barge shipping option should be included; work has been done in the area (e.g., ch. 8 of NUREG-75/113) and should be included.

6. The mining potential of the geological strata being investigated (e.g., potash indigenous to salt) should be briefly described.

7. The statement does not appear to cover the following miscellaneous topics:

   (a) Availability of institutional barriers during interim storage to limit releases;

   (b) Criteria for monitoring and remedial action for reducing long-term risks; and

   (c) Description of engineering barriers at appropriate time periods.

8. Some discussion should be provided of the probable time, costs, risks and environmental consequences of developing and using alternative technologies or media for ultimate disposal (e.g., transmutation, seabed) and deferring the use of deep geologic repositories in the interim.

9. Section 10 needs to be fleshed out to obtain a better feel for the significance of the issues raised by those outside DOE and if there is a difference of opinion with respect to a significant issue, this should be reflected.

<u>Broadening GEIS Scope</u>

The foregoing comments are all directed at improving the data base and analysis within the existing scope of the GEIS. While that effort is proceeding, reconsideration might be given to broadening the scope of the GEIS to include commercially-generated low-level waste.

FOOTNOTES

1 An environmental assessment (EA) will be prepared to determine the environmental significance of any action to acquire land at the potential WIPP site for burial of TRU waste.

2 The Idaho interim storage EIS has adequately analyzed the treatment processes which could potentially be utilized for the processing/packaging of stored TRU material that might be shipped to WIPP; therefore, only a brief environmental analysis should be necessary to support acceptance of the TRU waste at WIPP.

3 The environmental report (ER) will be prepared for the purpose of providing environmental input to NRC's licensing procedures and related documentation, particularly follow-on EIS's, for WIPP and final disposal sites (i.e., covering all categories of waste from both defense and commercial sources). In particular for WIPP, the original environmental report would describe the ultimate disposal of stored TRU at Idaho, the potential acceptance of commercial TRU, the capability to demonstrate the retrievable disposal of spent fuel and the capability to experiment with the storage of high-level defense waste.

4 It is assumed that a decision on the disposition of buried TRU waste at Idaho will be rendered together with decisions on the disposition of both stored and buried TRU waste at Richland, Savannah River, Oak Ridge and Los Alamos; therefore, one environmental review (probably an EIS) would appear sufficient.

5 No existing EIS's provide sufficient environmental analysis for these treatment processes, resulting in the likely need to perform future environmental assessments of these processes to determine their environmental significance.

6 The timing of these potential land acquisition decisions for ultimate disposal is critical for planning purposes, for it is likely one or more of these land acquisition actions will not be required, if the site is on DOE land (none required) and/or several categories of waste from both the commercial and defense sector are sent to a select number of ultimate disposal sites; in fact, the eight (8) potential land acquisition actions for ultimate repositories could be potentially boiled down to one (WIPP) or two (WIPP and "The Repository"). This, of course, assumes that WIPP and The Repository will not be located on DOE land.

7 An EA will be prepared to determine the environmental significance of each potential land acquisition action.

[8]The WIPP license, and its underlying environmental report could be supplemented to support decisions to dispose in WIPP buried TRU waste from Idaho and stored and buried TRU waste from Richland, Savannah River, Oak Ridge and Los Alamos.

[9]DOE's decisions on what category of wastes, if any, should be disposed of at a non-WIPP facility dictate the need to seek a new NRC license for such facility, the scope of that license, and the environmental review DOE (ER) and NRC (EIS) must undertake to support that licensing action. For example, if a decision is made to dispose of non-Idaho stored TRU at that facility and there is the potentiality for future disposal there of commercial spent fuel and high-level defense waste, the license would be so shaped as to provide for these contingencies and the environmental input for the license would be similarly scoped. Then, if a decision is later made to dispose of commercial spent fuel and high-level defense waste at this facility, no further environmental review would be required unless significant new environmental data was developed in the interim.

[10]It is assumed that the commercial GEIS will include in its scope the managing of both stored and buried, commercially-generated TRU waste, and that the schedule to publish the GEIS will be compatible with future NRC licensing proceedings.

[11]The decision tree(s) for the multi-repository case would duplicate exactly the flow appearing for the commercial spent fuel on a production basis, once the GEIS is published.

[12]It appears feasible to use the GEIS as the base-line environmental analysis for the disposal of all wastes in all geological media for which technical data can practically be obtained (i.e., other follow-on environmental documentation for defense waste decisions will utilize the data in The GEIS). The EIS's for long term management of defense high level waste for the Savannah River, Richland and Idaho sites could be combined into one overall EIS.

[13]If DOE has not determined a charge rate for the acceptance of spent fuel at the time other policy decisions are required for interim storage of spent fuel, a subsequent environmental review may be conducted as input for that determination.

[14]If the Federal Government takes over the West Valley site, cognizance should be given to the fact that no existing EISs provide sufficient environmental analysis to describe the treatment processes for West Valley commercial waste, resulting in the need to do an environmental review as input for any takeover decision.

[15]It appears that other EISs will adequately cover transportation impacts for West Valley commercial waste (i.e., Savannah River high-level waste EIS), if no decision is needed on transporting this waste until after one of these other EISs is available.

[16]The original environmental report for WIPP would indicate a potential future longer term capability to handle high-level defense waste on a production basis.

APPENDIX M

CURRENT RESOURCES

NUCLEAR WASTE MANAGEMENT SUMMARY

($ in Thousands)

	Estimate 1978		Estimate 1979	
	B/A	B/O	B/A	B/O
Operating Expense				
Commercial Waste Management	$158,500	$117,175	$152,100	$145,815
Domestic Spent Fuel Storage	-	-	3,000	3,000
International Spent Fuel Storage	5,000	5,000	3,000	3,000
Defense Waste Management	123,247	116,211	165,000	148,900
Decontamination & Decommissioning ...	18,000	16,150	25,000	23,500
Total	304,747	254,536	348,100	324,215
Capital Equipment				
Commercial Waste Management	11,500	6,850	9,700	5,460
Defense Waste Management	6,982	5,364	8,000	4,000
Decontamination & Decommissioning ...	200	200	200	200
Total	18,682	12,414	17,900	9,660
Construction				
Commercial Waste Management	10,482	2,097	25,000	12,025
Defense Waste Management	157,480	136,258	177,000	128,700
Total	167,962	138,355	202,000	140,725
Total				
Commercial Waste Management	180,482	126,122	186,800	163,300
Domestic Spent Fuel Storage	-	-	3,000	3,000
International Spent Fuel Storage	5,000	5,000	3,000	3,000
Defense Waste Management	287,709	257,833	350,000	281,600
Decontamination & Decommissioning ...	18,200	16,350	25,200	23,700
Total	491,391	405,305	568,000	474,600

Current Resources - continued

I. Commercial Waste Management - FY 1979

A. Terminal Storage

This program provides the research and development for the determination of sites for repositories and for the development of technology for designing, licensing, and operating a repository scheduled for operation in 1985. The repository will be designed to accept spent fuel, solidified high-level waste and other transuranic waste. In accord with the national nuclear nonproliferation objectives, the primary emphasis is directed toward the retrievable and terminal storage of unreprocessed spent fuel in geologic facilities, and the development of facilities for packaging spent fuel elements. More geologic work has been done over the years in salt formations than in other media and as a result, the work is more advanced in this area. Work is being accelerated in Crystalline and Argillaceous rocks at the Hanford and NTS sites. The packaging facility efforts will include evaluation of alternative concepts and preparation of conceptual designs and cost estimates for the packaging and storage facilities needed in association with the terminal sites. Packaging technology R&D studies will establish methods and packages which are suitable whether the fuel is placed in near-surface or retrievably stored in a geologic repository. Construction funds provide for site acquisition, A-E design, and long-lead procurement of specialized equipment. Material to be accepted for storage will include all commercially generated high-level wastes, TRU-contaminated intermediate and low-level wastes, and unreprocessed spent reactor fuel. The packaging facility to serve the geologic repositories is planned for 1985 operation concurrent with the repository.

B. Waste Immobilization R&D

This program provides costs related to the development of technology for immobilizing waste from the nuclear fuel cycle and converting it to forms which provide for better safety and economy of management, satisfy regulatory requirements, and are acceptable for receipt by repositories. The processes deal with three waste forms: liquid, solid, and gaseous. This technology is being developed in a fuel cycle insensitive manner so that waste can be prepared for appropriate disposal, including shipment to repositories when required. This also covers development of processes that will be required by the future operators of the West Valley NY plant (NFS) in converting the HLW from the Thorex and Purex processes to solid form. It will also satisfy the requirements of Title 10, Code of Federal Regulations, Part 50.

Current Resources - continued

II. Domestic Spent Fuel Storage - FY 1979

This program provides the government with the means with which to meet its commitment to assure that interim storage for spent fuel is available while retreivable geologic facilities are being developed. It is the objective of this program to: (1) prepare the studies and assessments of the timing and the need for AFR storage; (2) assess some of the unique problems AFR storage may present; and (3) develop arrangements between the federal government and private firms interested in building and financing AFR storage facilities for future government controlled or private spent fuel.

III. International Spent Fuel Storage - FY 1979

This program will be conducted by DOE and coordinated with the State Department and is in support of U.S. nonproliferation objectives in that it will seek to reduce the pressures to reprocess caused by critical spent fuel storage needs. Foreign fuel storage requirements and capabilities will be assessed and means for providing additional fuel storage will be developed. Ultimately the program may support the development of international spent fuel storage facilities.

This program will support U.S. nonproliferation objectives by enabling DOE to assess foreign fuel storage capabilities and requirements in conjunction with foreign requests for approval to transfer fuel. Means of providing increased storage at reactors will be developed as an alternative to possible fuel transfers to the U.S. This funding provides technical support to international studies being conducted on spent fuel storage. International criteria will be developed on siting, design, construction, and operation of fuel storage facilities. Preliminary design studies will be performed on an international spent fuel storage facility which is suitable for use by an international organization having responsibility for spent fuel storage. Contractual arrangements for international storage will also be investigated. Studies will be performed to estimate fuel clad lifetimes for safe storage of foreign-origin spent fuel, to extend basin storage capacities in foreign plants. Available data on potential sites for international facilities will be evaluated and studies and evaluations of logistics requirements and needed systems will be conducted. An Environmental Impact Statement (EIS) will be completed and the technical support for licensing, environmental, and economic aspects of spent fuel storage from foreign countries will be provided.

Current Resources - continued

IV. Defense Waste Management - FY 1979

This program provides for the management of DOE generated high-level nuclear waste including surveillance and maintenance of waste tanks, concentration and solidification of waste to a safer form, and fractionization and encapsulation of long-lived isotopes for retrievable storage. Start-up activities on operating costs are provided for the New Waste Calcining Facility (NWCF) as well as continued operation of the Idaho Chemical Processing Plant (ICPP) used for the reprocessing of spent naval reactor fuel. Management of TRU and low-level DOE generated wastes at six sites are also provided for in this program. Waste R&D efforts consist of investigations of: (1) alternatives for DOE defense related waste; (2) preparation of an EIS on high-level waste at Richland, Savannah River, and Idaho; and (3) development of information considered necessary for the start-up and operation of the Waste Isolation Pilot Plant (WIPP), including a Safety Analysis Report, waste acceptance criteria, pre-WIPP in-situ experiments and engineering studies, related geology studies and demonstration of Borehole plugging techniques. Conceptual design studies on a waste treatment and storage facility for secure long-term storage of high-level waste at Savannah River are planned in FY 1979. Construction funds provide for: (1) the continuation of work on facilities for the safe interim storage of defense high-level waste; and (2) A-E and long-lead procurement of special equipment, land and mineral rights, and Title I and II design on the WIPP project.

V. Decontamination and Decommissioning - FY 1979

The Decontamination and Decommissioning (D/D) program is responsible for the safe management and disposition of surplus radioactively contaminated DOE sites and facilities, as well as programs to identify and eliminate unacceptable radiological conditions at former contractor sites and facilities, buildings at Grand Junction constructed using uranium mill tailings, and the inactive uranium mill tailings sites. Programmatic activities include: (1) Management of Surplus Radioactively Contaminated DOE Facilities; (2) Remedial Action for Inactive Uranium Mill Tailings Sites; (3) Grand Junction Remedial Action under (PL-92-314); and (4) Remedial Action for Former Manhattan Engineering District and Atomic Energy Commission (MED/AEC) Sites. The goal of this program is to provide planning, R&D programmatic support to projects that will progressively reduce the number of surplus DOE facilities and, within a term of five years, complete remedial actions at sites formerly utilized by MED/AEC, inactive tailings sites, and Grand Junction.

APPENDIX N

ALTERNATIVES TO CONVENTIONAL GEOLOGIC DISPOSAL

I. Introduction

The principal goal of DOE's Waste Management Program is the ultimate disposal of radioactive waste in stable, continental geologic formations at depths reachable by conventional mining methods. The subject radioactive waste may be spent fuel, transuranic and high-level wastes from the defense program, or the transuranic and high-level wastes derived from reprocessing of commercial spent fuel if the indefinite deferral of reprocessing is rescinded in the future. Alternatives to this approach are under study by DOE, other federal agencies, and foreign nations. The alternatives to conventional geologic disposal discussed below are of two basic types: a) variations on geologic disposal, which may entail (i) added processing steps prior to disposal to reduce the volume or change the character of the wastes and/or (ii) the use of alternate geologic approaches or locations; and b) alternatives to the use of geology as the barrier between man and the wastes.

II. Variations on Geologic Disposal

The approaches discussed in this section are:

A. Additional Processing Steps

1. Partitioning and Transmutation
2. Chemical Resynthesis to reduce the mobility of the waste

B. Alternate Geologic Approaches

1. Island Disposal
2. Ocean Bed Disposal
3. Tectonic Plate Disposal
4. Rock Melting Alternatives

The processing alternatives would require some form of chemical reprocessing of spent fuel prior to further treatment via these techniques. With the possible exception of rock melting, the alternate geologic approaches could accommodate disposal of spent fuel or reprocessing wastes.

A. Additional Processing Steps

Partitioning and Transmutation

While the reprocessing fuel cycle would include partitioning of the uranium and plutonium from high-level wastes for subsequent reuse in a reactor, this alternate approach would recover more of the

The Department of Energy has no program to actively investigate the concept. Suggestions for assessment of the concept have been made from time to time by groups considering international aspects of radioactive waste repositories. However, a consensus for the need of such an international repository has not developed.

Ocean Bed Disposal

The basic concept of ocean bed disposal is to place wastes beneath the deep ocean floor in a geologically stable, biologically inactive region. The concept is being investigated to determine its environmental and technical feasibility and to develop and maintain the capability of assessing similar programs developed by other countries.

A three-phased program is envisioned, i.e., determine environmental feasibility, assess engineering feasibility, and provide demonstrations of the concept. Within the Phase I period of 1978 to 1983, the major objectives are to acquire oceanographic, biological, and sedimentologic data to establish that the deep sediments in isolated regions of the ocean floor are an effective barrier to the dispersal of radionuclides from suitably emplaced waste. Provided that feasibility is established, appropriate data would be accumulated to allow further consideration of this option.

The investigations which began in 1974 are concentrating on the mid-gyre, mid-tectonic plate regions of the North Pacific and North Atlantic oceans in the abyssal-hill provinces. Detailed assessments are being made of: the deep ocean sediments as barriers to radionuclide migration; coherency of the sediments; heat and heat transfer effects; characteristics of the deep dwelling biological communities; and biological transfer and interactions of radionuclides. In-situ heat transfer and biological experiments are planned.

Technical program manag ment is provided by Sandia Laboratories, in conjunction with Woods Hole Oceanographic Institution, Scripps Institute of Oceanography, and the University of Rhode Island. Other participants include Lamont-Doherty Geological Observatory, University of Washington, University of New Mexico, and Harvard University.

long-lived radionuclides (actinides) from the high-level waste and transmute them into shorter-lived or stable isotopes. Transmutation could be accomplished by neutron bombardment using a nuclear reactor or an accelerator.

Partitioning could be of possible benefit in dividing the ultimate geologic disposal and isolation problems into two parts. The fission product fraction is characterized, to a first approximation, as involving nuclides with short (< 30 years) half-lives and high specific thermal power, while the actinide fraction (assuming Pu removal) is characterized by long half-life nuclides with low specific thermal power in general. If Pu remains in the material to be disposed of, the generalization regarding lower specific thermal power of the actinides must be modified. For example, in the case of typical LWR spent fuel elements, more than 15% of the thermal output (per metric ton heavy metal fuel) generated 10.5 years after removal from the reactor is produced by the actinides in the fuel as demonstrated in the accompanying table which summarizes the thermal properties of spent fuel, high-level waste, and partitioned high-level waste over time.

Though the objective of this approach need not be the economic recovery of unused nuclear fuel (uranium and plutonium), this method would be more costly than conventional reprocessing which assumes recycle of these fuels for economic reasons. The use of partitioned and/or transmuted elements in defense or commercial activities would be desirable as an economic offset. The feasibility and economics of this option are under study. An assessment is scheduled for completion in 1979 with publication of the report in 1980.

Chemical Resynthesis

The chemical resynthesis of elements recovered subsequent to reprocessing in order to reduce the mobility of these species is the main goal of this option.

However, separation of elements beyond the fission product-actinide partitioning stage through further chemical processing specifically for purposes of simplifying the ultimate geologic disposal and isolation problems has not to date received significant attention. The objective of such further chemical separation on an element-by-element, or elemental group, basis would be to provide starting materials for preparation of synthetic crystalline mineral phases that incorporate the environmentally undesirable nuclides.

Ideally, the synthetic crystalline mineral phases would be: thermodynamically stable over the range of intensive parameter variation to be expected in the geologic disposal scenario; in equilibrium with the assemblage of natural minerals in the geologic host; and exhibit low solubility in contact with natural ground waters. In addition, the concentration of radio-nuclides would be maintained at a level sufficiently low in the synthetic mineral phase so that radiation damage to the crystal structure would not violate the previously stated boundary conditions. It would seem highly probable that a variety of specific geologic media with different natural mineral assemblages would be required for the disposal of the hazardous, toxic, radiogenic and heat-producing nuclides. The fundamental premise underlying this alternative to conventional geologic disposal and isolation is that dispersing undesirable nuclides in a form analogous to stable natural crystalline minerals of low inherent solubility in natural waters, with a minimal perturbation of the natural environment, results in a system which has long-term environmental safety and stability independent of any natural breaching of the repository site.

Several potential problems of a scientific and technological nature are obvious in this proposed alternative. Chemical processing typically results in an increase in the amount of contaminated material. The approach requires synthesis of mineral phases in a "hot" environment. Retrievability of material once disposed of could be a significant problem. A major research program would be required to address these and other questions related to scientific and technical feasibility of this alternative.

B. Alternate Geologic Approaches

The options discussed below continue to rely on geology (i.e., rock, sediments) as the primary barrier between nuclear wastes and the biosphere, though additional barriers may be used (e.g., the ocean). Each of the options below, with the possible exception of rock melting alternatives, could accommodate the wastes from either the "once-through" or reprocessing fuel cycles, as well as the wastes arising from the additional processing options just described.

Island Disposal

Island-based disposal would involve the emplacement of wastes within deep stable geological formations at depths reachable by conventional mining methods. The island would be used for port facilities and access tunnels, while providing a remote location and possibly an international repository. The concept is similar to land based geologic disposal, with an over water transportation route.

Through the OECD/NEA Radioactive Waste Management Committee, a Seabed Working Group with members from Canada, France, Japan, United Kingdom, and the United States provide a forum for international cooperation, assessment of progress, and exchange of data.

Funding has been provided at the following level:

Fiscal Years	Thousands of Dollars
1977	1300
1978	3100
1979	3100

Tectonic Plate Disposal

This variation of ocean bed disposal involves emplacement of waste in deep-sea trenches found at the base of most leading edges of continental margins where the ocean tectonic plate is being driven (or pulled) beneath the continental plate. The waste would ideally be entrapped within the sediments overlying the oceanic plate and could, ultimately, descend to a depth of > 400 km beneath the earth's surface.

There appear to be several significant problems associated with this concept. The trench zones are the most seismically and volcanically active zones of the earth. The sediments are unstable with abundant evidence of sliding and slumping. Where well studied, the sediments on the oceanic plate appear to be in part subducted and in part crumpled or thrust onto the edge of the continental plate, thus there is no assurance that the radioactive waste would in fact be subducted. Adjacent to continents, the waters of the trench are often characterized by high biological productivity and are rich fishing zones. ERDA 76-43, volume 4, section 25.2.2 briefly discusses the dynamic nature of the continental margins and trenches in the context of radioactive waste disposal. It does not appear that any significant effort has been devoted to a further and more detailed study of this concept.

Rock Melting Alternatives

Emplacement of liquid or solid high level waste produced by reprocessing of LWR spent fuel in a particular geologic host can produce melting if the thermal power per unit volume is high enough and the emplacement geometry is appropriate. The melting and subsequent cooling (to a glass or crystallized liquid) could provide a barrier to migration of potentially hazardous nuclides from the repository site. This alternative might also be attractive from the standpoint of minimal land usage. The 1977 report on Radioactive Waste Disposal by the American Institute of Physics Committee suggested further study of this alternative. ERDA 76-43 volume 4, section 25.1.6 noted, "No disposal technique involving melting has yet been extensively investigated," in connection with high level waste produced by reprocessing of LWR spent fuel. The potential problems associated with generic rock melting waste disposal schemes and four specific options were discussed in ERDA 76-43, volume 4, section 25.

To evaluate the scientific feasibility of geologic disposal using this approach of spent fuel elements and isolation of their toxic hazardous constituents would entail a major research program of a site-specific nature.

III. Alternatives to Geologic Disposal

The principal alternatives to some form of geologic disposal are:

A. Disposal in the ice sheets of Antarctica; and

B. Extraterrestrial or space disposal.

Retrievable surface storage is not considered as an alternative since it is an interim measure encompassing storage for up to a few hundred years, followed by some type of permanent disposal.

Ice Sheet Disposal

This alternative would emplace wastes within the ice sheets of • Antarctica. Although various Federal agencies support scientific studies of the Antarctic regions, no programs are specifically funded to evaluate ice sheet disposal of nuclear waste. A thorough environmental analysis of this alternative would be required and, since Antarctica is an international region, implementation would probably be subject to international treaties. The recent American Physical Society report strongly recommended against pursuing this option.

Space Disposal

NASA is presently funding a study to explore the possible use of space to augment the DOE studies on terrestrial disposal of radioactive wastes. In the early 1970's a cooperative AEC/NASA study indicated the technical feasibility of space disposal. However, on the basis of the cost and apparent risk, terrestrial methods were favored for immediate development. The current NASA study is giving more specific attention to a space system based on the space shuttle capability and the experience established with isotopic power systems for space applications. The space transport system would use two shuttles to place the waste package and an orbiting transfer vehicle into an earth orbit. The waste would then be coupled to the transfer vehicle and maneuvered into the final emplacement mode. The current NASA study is emphasizing the use of a solar orbit between the Earth and Venus for the emplacement of the waste with the possible use of a moon crater as an alternative. Both the solar orbit and the moon crater provide long-term stability. The moon crater system would require more energy but could provide a retrieval capability.

The NASA study, funded in FY 1977 and FY 1978 at $400,000 per year, is being carried out by NASA's Marshall Space Flight Center with the support of JPL and Ames. By the end of FY 1978, NASA in cooperation with DOE intends to complete the present study and, based on this study, consider action for further work. DOE has provided information informally requested by NASA to support this study and has participated in NASA program reviews.

The capacity of the shuttle appears adequate to handle the waste from the U.S. nuclear power program through the year 2000. However, to achieve this and possibly for economic reasons, it would be necessary to process the spent fuel to remove the fuel hardware and uranium for terrestrial disposal. If recycle of plutonium in the future was not consistent with national nonproliferation goals, the plutonium along with the other actinides and fission products would be sent into space. This would reduce the toxicity of the commercial waste remaining for terrestrial disposal to a few percent of the toxicity of spent fuel. The space shuttle is now undergoing flight tests. The orbiting transfer vehicle will be developed for other operational missions by 1985. The energy requirements for space disposal, to be further evaluated in FY 1978, appear to be a few percent of the energy generated from the nuclear fuel.

THERMAL PROPERTIES OF SPENT FUEL AND HIGH-LEVEL WASTES

Spent Fuel[a]			High-Level Waste[b]			Partitioned High-Level Waste[c]		
Time[d] (years)	Thermal power (W/MTHM)	Integrated thermal energy output[e] (J/MTHM)	Time[d] (years)	Thermal power (W/MTHM)	Integrated thermal energy output[e] (J/MTHM)	Time[d] (years)	Thermal power (W/MTHM)	Integrated thermal energy output[e] (J/MTHM)
10	1.14×10^{3}	0	10.44	9.29×10^{2}	0	10.44	8.81×10^{2}	0
30	7.15×10^{2}	5.44×10^{11}	30.4	5.20×10^{2}	4.23×10^{11}	30.4	4.92×10^{2}	4.02×10^{11}
100	2.81×10^{2}	1.47×10^{12}	100	1.01×10^{2}	1.01×10^{12}	100	9.14×10^{1}	9.48×10^{11}
300	1.26×10^{2}	2.61×10^{12}	300	6.58	1.18×10^{12}	300	8.38×10^{-1}	1.04×10^{12}
1000	5.46×10^{1}	4.31×10^{12}	1000	2.32	1.26×10^{12}	1000	2.91×10^{-2}	1.04×10^{12}
3000	2.26×10^{1}	6.48×10^{12}	3000	0.81	1.35×10^{12}	3000	2.44×10^{-2}	1.04×10^{12}
10000	1.36×10^{1}	1.04×10^{13}	10000	0.48	1.47×10^{12}	10000	2.25×10^{-2}	1.05×10^{12}
30000	5.29	1.52×10^{13}	30000	0.20	1.69×10^{12}	30000	1.94×10^{-2}	1.06×10^{12}
100000	1.06	2.01×10^{13}	100000	0.07	1.94×10^{12}	100000	1.35×10^{-2}	1.09×10^{12}

[a] Zircaloy-clad, enriched-UO_2 fuel continuously irradiated at a specific power of 37.5 Mw/MTHM to a burnup of 33,000 Mwd/MTHM.

[b] High-level waste contains 0.5% of the uranium and plutonium, 100% of the neptunium, americium and curium, 0.1% of the iodine and bromine, and 0% of the tritium and noble gases in the spent fuel at the time of reprocessing (160 days after fuel is discharged from the reactor).

[c] Partitioned high-level waste contains 0.01% of the uranium and plutonium, 0.1% of the neptunium, americium, and curium, 0.1% of the iodine and bromine, and 0% of the tritium and noble gases in the spent fuel at the time of reprocessing (160 days after fuel is discharged from the reactor).

[d] Time is with respect to discharge of the fuel from the reactor.

[e] Integrated between ten years after fuel discharge and the indicated times.

*U.S. GOVERNMENT PRINTING OFFICE : 1978 0-257-140/6045