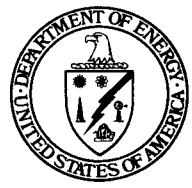
DOE/EIS-0046F
Volume 3 of 3
UC-70

FINAL

ENVIRONMENTAL IMPACT STATEMENT

Management of Commercially Generated Radioactive Waste

Volume 3
Public Comments
Hearing Board Report



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B Steele
Authorizing Official
Date: 10/24/06

October 1980

U.S. Department of Energy
Assistant Secretary for Nuclear Energy
Office of Nuclear Waste Management
Washington, D.C. 20545

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VOLUME 3

CONTENTS

INTRODUCTION 1

WRITTEN PUBLIC COMMENTS - POLICY ISSUES AND RESPONSES 5

WASTE PROGRAM 6

LICENSING AND THE DECISION-MAKING PROCESS 11

SITING ISSUES 15

FOREIGN WASTES 19

FUEL CYCLE ISSUES 20

LONG-TERM STORAGE 21

ATTRIBUTION OF COSTS/RISKS 22

ALTERNATIVE DISPOSAL ISSUES 23

GENERAL COMMENTS 24

WRITTEN PUBLIC COMMENTS - TECHNICAL ISSUES AND RESPONSES 25

ORGANIZATION AND PRESENTATION 26

SCOPE 34

RADIOLOGICAL ISSUES 39

CONSEQUENCE ANALYSIS 61

DOSE CALCULATIONS 113

RISK PERSPECTIVES 128

WASTE MANAGEMENT OPERATIONS 139

Reactor Operations 139

Waste Characterization 140

Waste Treatment and Packaging 144

Waste Storage 155

Waste Transportation 162

Decommissioning 167

Repository Construction and Operation 169

FUEL CYCLES 188

COSTS 190

SAFEGUARDS 199

GROWTH SCENARIOS 204

GEOLOGIC CONSIDERATIONS 206

MULTIBARRIERS FOR DISPOSAL 271

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES 283

RESOURCE REQUIREMENTS 294

REFERENCE ENVIRONMENT 296

COMPARATIVE ASSESSMENT 300

ALTERNATIVE DISPOSAL CONCEPTS 313

General 313

Chemical Resynthesis 317

Very Deep Hole 320

Rock Melt 329

Island Disposal 338

Subseabed Disposal 351

Ice Sheet Disposal 377

Well Injection 383

Transmutation 394

Space Disposal 399

HEARING BOARD REPORT AND RESPONSES 408

REFERENCES 439

APPENDIX A: LIST OF RESPONDENTS TO DOE/EIS-0046D A.1

APPENDIX B: INDEX FOR COMMENT LETTERS B.1

APPENDIX C: FEDERAL AND STATE COMMENT LETTERS C.1

INTRODUCTION

This volume is prepared in compliance with present regulations which provide for the assessment and consideration of public comment on draft environmental impact statements (40 CFR 1503.4, 1506.6). The purpose of this volume is to summarize public response to the draft Statement (DOE/EIS-0046D). Recommendations for revision of the draft Statement, provided through individual written comment and through the Hearing Board, are presented with a description of the way in which these comments were used during preparation of the final Statement.

Notice of availability of the draft Statement appeared in the Federal Register of April 20, 1979. This Federal Register notice requested interested public groups and individuals to review and comment on the draft Statement. Comments on the draft Statement came in the form of written comments addressed to the Department of Energy and/or as oral testimony given before the Hearing Board. Discussion of written comments comprise the major portion of this volume and are presented first. Discussion of the Hearing Board recommendations (which were based on the oral testimony) are presented following the written comments.

Written Comments

Written comments on the draft Statement were received from numerous sources, including individuals, representatives of industry, public interest groups, and state and Federal government agencies. Two hundred and nineteen comment letters were received. Individual comments presented in the letters ranged from one to approximately 300 for a total of greater than 2000 separate comments identified in the letters received by DOE.

Each letter was given an identification number when it was received. Letters were then examined and substantive comments were identified. As shown in Figure 1, comments were categorized into three general areas: policy, technical, and editorial. Policy issues are, in general, those which recommend an approach, courses of action or legalistic concerns regarding issues of waste management. Technical issues are those which specifically address the content, presentation and/or the analysis presented in the draft Statement: Policy and technical categories were further subdivided into topic areas. In the case of comments regarding policy, nine specific topic areas were identified. In the case of technical comments, there were eighteen topic areas. After comments were assembled into topic areas, they were gathered together in similar groups and paraphrased as summary or key issues where possible. Key issues were then addressed and responses were prepared for each key issue. In many cases, comments were of such a specific nature that they could not be grouped as summary or key issues within a topic area. In such instances, responses were prepared for the individual comment. Editorial comments (i.e., spelling and grammatical errors, incorrect cross-referencing, and errors in tables and figures) were considered during preparation of the final Statement and the appropriate changes were made. Such comments have not been discussed in this volume.

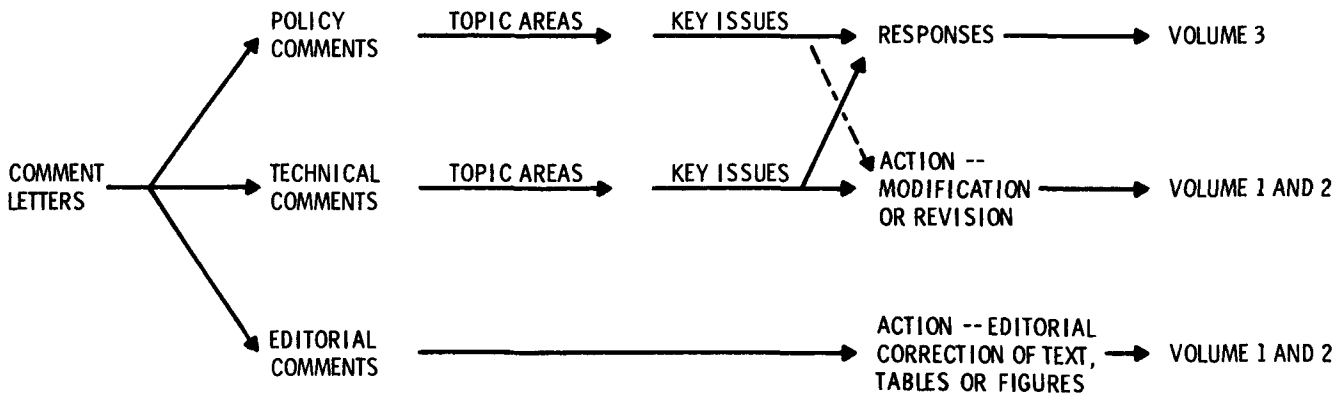


FIGURE 1. Process for Handling Public Comment Letters

This written comment section is structured such that policy comments (by topic area) are presented first followed by technical comments. Within a given topic area issues and responses are presented sequentially by page number of the draft Statement (where such page numbers were provided by the commenter). After each issue is stated the pertinent letter number(s) is cited in parentheses.

In addition, those issues raised by Federal Agencies (Department of Commerce - DOC, Department of Health, Education, and Welfare - HEW, Department of Interior - DOI, Environmental Protection Agency - EPA, Federal Energy Regulatory Commission - FERC, Nuclear Regulatory Commission - NRC) show the agency abbreviation next to the letter number.

The form of the response to each issue is as follows:

a) Responses to policy issues will be either as a direct response to the issue or as a statement identifying why the issue is not considered to be within the scope of this Statement. In some cases, policy issues did result in changes to the statement and these are noted.

b) In the case of technical issues, the response to the issue will identify how and to what degree the issue has been incorporated into the final Statement. Where possible the response will identify where in the final Statement the change was made. For technical comments addressing concerns outside the scope of the document, a statement is made to that effect.

Hearing Board Recommendations

This section of Volume 3 presents responses to the recommendations of the Hearing Board. To provide the reader with some background, this section contains a discussion on the Board and its members and contains a reproduction of the Hearing Board's report.

Three appendices appear at the end of the volume. Appendix A identifies those individuals and organizations that commented in writing on the draft Statement and identifies the number assigned to each letter. These numbers appear after each issue. Appendix B notes for each letter, the topic areas under policy and technical categories and the

particular page(s) of Volume 3 on which the letter has been cited. Appendix C contains reproductions of those letters submitted by Federal agencies and cover letter from states or state agencies.

As a result of the organizational changes made to the draft Statement, the tables below have been provided. These tables identify the correspondence between sections of the final Statement and the draft. These tables will be of assistance to the reader during the remainder of Volume 3 when reference is made to either the draft or final Statements.

Volume 1

Section of Final Statement	Corresponding Section of Draft
Foreword	Foreword
1.0	1.0
2.0	Foreword, 2.1
3.1	--
3.2	2.1
3.3	2.2, 2.3
3.4	Portions of 3.1.3 dealing with risk and risk perspectives
3.5	Portions of 3.1.2 and 3.1.3 dealing with non-technical issues
4.1	--
4.2	2.1
4.3	3.1.4, 3.2, portions of 3.9 and Appendix L
4.4	3.1.4 and portions of Appendix M
4.5	3.1.4 and portions of Appendix N
4.6	3.1.4 and portions of Appendix O
4.7	3.1.5.3
4.8	3.1.5.3
4.9	3.1.5.3
5.1	3.1.1 plus portions of 3.1.3 relating to the multiple barrier concept
5.2	3.1.2, 3.1.3, and 3.1.6
5.3	3.1.5.1
5.4	3.1.5.1
5.5	3.1.5.2
5.6	3.1.5.1
5.7	3.1.5.1
6.1	3.3-3.10
6.2	4.0
7.0	Portions of 3.1.5.4

Volume 2

Section of Final Statement	Corresponding Section of Draft
Appendix A	Appendix A
Appendix B	---
Appendix C	Appendix C
Appendix D	Appendix D
Appendix E	Appendix E
Appendix F	Appendix F
Appendix G	Appendix G
Appendix H	Appendix H
Appendix I	---
Appendix K	Appendix K, Appendix Q
Appendix L	---
Appendix M	---
Appendix N	---
Appendix P	Appendix P

WRITTEN PUBLIC COMMENTS

POLICY ISSUES AND RESPONSES

This section contains policy issues raised by the comment letters on the draft Statement as well as responses to these issues. For the purpose of this volume, policy issues are considered to be predominately of a subjective nature. In general, policy issues recommend an approach, courses of action or legalistic concerns regarding issues of waste management. In most cases, policy issues did not directly address the draft Statement. However, the Department does recognize the importance of such comments and has, therefore, provided responses to these comments.

WASTE PROGRAM

Issues

Several commenters pointed out that development of a geologic repository should place emphasis on:

- Demonstrating one repository medium while studying others because technology does exist to initiate an environmentally acceptable waste management program. (45, 154)
- Proceeding with investigations into a number of sites in a variety of media in different geographic regions either to ensure that the program is conducted in a technically conservative manner or to encourage timely implementation of a waste management program. (21, 28, 128, 166, 180)

Response

In his February 12, 1980 statement on radioactive waste management and disposal, the President called for the qualification of a number of alternative sites in a variety of media in different geographic regions.

Issues

Several commenters stated that the waste management program should be concerned about using resources (eg. chromium, copper and nickel) largely imported at this time because of potential economic or political pressures that could be brought to bear. (2, 30, 144) Other commenters noted that the isolation strategy chosen should assure protection of valuable/limited natural resources (eg. salt domes which may contain gas, oil, sulfer, potash in addition to salt). (22, 139, 218-DOI)

Response

In performing the environmental analysis of the total systems involved in waste disposal strategies, one element analyzed is the resources committed, such as land, water and materials. Part of the decision-making process required of agencies by the National Environmental Policy Act is a consideration of significant effects on natural resources, renewable and nonrenewable, including any mitigation measures which might be taken to lessen adverse impacts. This Statement provides such analysis of effects on resources in a generic sense; site or (program) specific statements would provide more detailed information.

One of the functions of a generic environmental impact statement is to indicate resource requirements for each alternative strategy under consideration. Should the selected program require that waste be placed in stainless steel canisters for disposal, consideration would be given in future environmental statements to this area of concern. Another of the functions of a generic environmental impact statement is to bring matters of key resource commitment to

the attention of the decisionmakers, as has been done in this Statement (see final Sections 4.7, 5.4, 7.5). Further refinements in the estimates of use of resources will be developed for site specific statements.

Issue

Several commenters stated that program approaches and geologic disposal choices should require retrievability of wastes after emplacement (i.e., to take advantage of improvements in technology or discovery of a more acceptable site, to provide availability of access in case of malfunction, and to take advantage of the potential future resource value of the waste). (3, 27, 45, 96, 151, 164, 187, 196, 205)

Response

DOE defines retrievability as the removal of waste following emplacement in a repository but prior to closure of the repository system (backfilling of rooms and shafts). The initial emplacement of wastes so that they can be retrieved for periods of five and up to twenty-five years following placement, is a basis for the analysis of geologic repositories in this Statement. Further discussion of retrievability is in Section 5.3 and a description of requirements for five and twenty-five year ready retrievability is provided in Appendix K. The exact period of retrievability that will be required for a waste repository has not yet been determined.

Initial emplacement of waste in at least the first repository will permit retrievability for some initial period of time to allow for removal of emplaced wastes if unexpected phenomena are observed which could lead to the failure of the repository system to provide the required isolation or containment of the radioactive wastes.

Since the radioactive wastes are continually undergoing radioactive decay, the heat emission and radiation levels will be constantly decreasing. Consequently, the period immediately following waste emplacement will provide the most severe conditions on the nearfield environment. At the same time, accelerated tests will be performed at the repository level with artificially heated or concentrated waste forms, probably in closer arrays, to seek out any unpredicted phenomena. After an initial period of operations, much greater confidence in the understanding of the interaction between the waste and the repository structure will have been gained and permission to abandon the ability for ready retrieval will be sought from the NRC.

Issues

Several commenters expressed concern about the multiple barrier concept:

- More research and development is needed in the area of rock mechanics. (21)

WASTE PROGRAM

- The multibarrier approach must/should be adhered to in any disposal option, and waste forms and containers should receive equal attention to medium and disposal site. (28, 152)
- The multibarrier approach appears to be a false concept, because not enough is known about the systems involved or the interactions. (42, 68, 98)

Response

The Department of Energy's Statement of Position in the recent NRC rulemaking proceedings on storage and disposal of nuclear waste (DOE 1980a) contained the following quotation:

> "In order to meet the primary objective for a waste disposal system, namely to isolate the wastes from the biosphere and to pose no significant threat to the public health and safety, waste must be prevented from reaching the human environment in quantities in excess of those permitted by radiation standards. . . The multibarrier concept requires that the success of the system be protected against deficient barrier performance or failure, by using a series of relatively independent and diverse barriers that would not be subject to common made failure. Barrier multiplicity is required both as a hedge against unexpected occurrences or failures and to provide appropriate means for protecting against a wide variety of potentially disruptive events. Acceptable system performance must not be contingent on the performance of any non-independent barrier combinations."

DOE plans to continue to pursue the multibarrier approach to repository design recognizing that development of detailed identification of system components will be dictated by site-specific parameters.

Issue

Two commenters stated that the policy of not requiring the canister to provide containtainment after emplacement was a negligent one in that it would be difficult to control the wastes after emplacement. (9, 36)

Response

DOE anticipates that the canister will provide containment for a hundred years or more following emplacement. The final Statement has been changed to reflect this (see Section 5.1.2). It is uncertain at this time whether NRC will require that the canister function as a barrier to radionuclide migration for a specified period of time. See also response above.

Issue

One commenter suggested that if the material presented in the Statement is valid (that is, from a technical standpoint, no reason exists why the development of mined geologic repositories cannot proceed) then a large information gap exists between DOE and the public because a large segment of the public and many public officials believe this is the worst problem facing the U.S. (7)

WASTE PROGRAM

Response

The Report to the President by the Interagency Review Group (IRG) on Nuclear Waste Management, called for, "sustained, effective efforts to inform the public and to provide opportunities for discussion between the public and the government." These words appeared in the draft Report of the IRG when it was first released in October 1978 (IRG 1978). They were retained and even further emphasized in the final version of the report March 1979 (IRG 1979). DOE's plans for implementing this policy were announced May 1979, in the National Waste Terminal Storage Public Information Plan (DOE 1979a).

DOE believes that state and local governments, interest groups, and citizens in general must be informed about what is being considered, and that they must be involved in the decision-making process. DOE is seeking to implement this important recommendation of the Interagency Review Group.

To assist in carrying out these functions, DOE has developed a spectrum of activities which range from those normally associated with efforts to inform the public to those activities which are deliberately intended to facilitate the exchange of information between participants in the program and members of the public.

The preparation of this Statement and the recent DOE Position Paper to the NRC rulemaking on nuclear waste storage and disposal (DOE 1980a) will hopefully bridge the "information gap" the commenter refers to.

Issue

Several commenters suggested that before DOE begins a long range program for a permanent disposal of radioactive waste, DOE should recognize (i.e., should consider as an issue in this statement) the potential value of the waste as a future resource and should make provisions to store this material in a retrievable mode, if necessary. (29, 35, 164, 187, 198, 205, 218-DOI)

Response

The primary goal in disposing of the radioactive material is to ensure its safe, permanent isolation from man's environment. To provide for the long-term retrievability of these wastes would potentially compromise the integrity of the repository system. If future decisions are made that the waste material is a valuable resource, the decision made may be to extract such material. This, however, is not a consideration in DOE's plans for the disposal of commercially-generated radioactive waste at this time.

Issue

Several commenters stated that the use of pilot scale facilities should be a part of the overall waste management program. (32, 152, 153, 203)

WASTE PROGRAM

Response

The objective of the program is to ensure the development of safe permenent isolation and disposal of radioactive wastes with a high degree of assurance in the safety and permanency of such isolation and disposal. The program is oriented to achieve this assurance as expeditiously as possible without a premature committment to unproven solutions. If the use of pilot scale facilities is viewed as a way to enhance achievement of these objectives then such facilities would be utilized.

Issues

Numerous letters provided suggestions or stated preferences as to how the Department of Energy should conduct its waste disposal program(s). For instance, DOE should:

- Proceed with the demonstration/establishment of a waste repository. (3, 12, 13, 17, 21, 27, 32, 33, 34, 35, 49, 53, 55, 64, 152, 154, 166, 168, 177, 180, 182, 183, 196, 205, 210)
- Emphasize geologic disposal but continue studying other concepts. (32, 34, 180, 196)
- Move more deliberately and cautiously. (2, 28, 41, 86, 122, 128, 133, 153, 158, 164, 167, 187, 191, 195, 217, 218-DOI)
- Continue testing alternatives. (28, 158, 199, 215, 218-DOI)

Response

The recommended strategy supported by the analysis in this Statement and put forth by the Presidential Statement of February 12, 1980, is that several alternate sites for geologic disposal will be qualified in different geologic environments and host rock types prior to the selection of a preferred site for construction of a repository.

It is estimated that four or five such alternate sites could be qualified on the basis of exploratory and geophysical techniques from the surface by 1985 which could lead to an operating repository by the mid-1990's. If in-situ exploration at depth is required at each of these alternate sites before a license application for construction can be submitted to the Nuclear Regulatory Commission this schedule will slip by at least three years.

The strategy of delaying selection of the first repository site until several qualified alternatives are available is perceived as providing greater assurance of program success.

LICENSING AND THE DECISION-MAKING PROCESS

Issue

One commenter stated that all nuclear waste repositories should be Federally licensed. (3)

Response

DOE agrees with this statement as it applies to commercial high-level (HLW) and transuranic wastes (TRU). According to Federal law, all repositories for disposal of commercial waste and DOE repositories for high-level waste are subject to licensing by the Nuclear Regulatory Commission. Legislation has been proposed to Congress to extend the requirement to disposal of all transuranic wastes.

Issue

A commenter stated that states which have nuclear waste repositories should have state laws to govern health and safety at the repository, with the Federal government paying for state enforcement of those laws. (3)

Response

At this time, the most appropriate relationship between state and Federal governments concerning state jurisdiction and financial responsibilities over nuclear waste repository siting and monitoring is still being evaluated. Any state in which a repository might be located will most likely have specific authority for health and safety regulation which will be recognized by the Department of Energy.

Issues

Several commenters suggested that maximum release rates for radionuclides placed in repositories be established and adequate safety standards be defined, presumably by the Environmental Protection Agency and the Nuclear Regulatory Commission. (17, 28, 44, 95) Another commenter requested that this Statement outline EPA's role in waste management. (202-HEW)

Response

The Environmental Protection Agency is currently formulating standards concerning the management and disposal of radioactive wastes. The standards are expected to include specifications concerning release rates to the accessible environment. The Nuclear Regulatory Commission regulations with which DOE must comply will reflect the Environmental Protection Agency standards. A discussion of applicable existing standards is presented in final Section 3.3.

LICENSING AND THE DECISION-MAKING PROCESS

Issue

Several commenters pointed out that the Statement does not identify the "decision makers" in the waste management process. (63, 208-NRC)

Response

In the President's February 12, 1980 speech on radioactive waste management, he stated that for disposal of high-level radioactive waste he was adopting an interim planning strategy focused on the use of geologic repositories which would be able to accept waste from reprocessing and unreprocessed commercial spent fuel. The interim strategy is required since full environmental review (according to NEPA) must precede final decisions on many steps which need to be taken. Following these environmental reviews, the President will reexamine the interim strategy and determine if any changes need to be made. Issuance of this environmental impact statement is intended to serve as a basis for that reexamination. See also response above on regulations.

Issue

Several commenters pointed out, that the Department of Energy should consult with the public and state and local governments in the selection of a proposed disposal method (and corresponding disposal site) as well as in solving of related waste management problems (i.e., transportation). (19, 22, 28, 37, 41, 43, 97, 98, 123, 129, 139, 156, 191, 204, 218-DOI)

Response

DOE agrees with this comment. During the process of preparing draft and final environmental impact statements on commercial waste management program alternatives, state and public comment and participation has been, and will continue to play a role in the decision-making process. Problems in related areas of concern (e.g., transportation) will be solved with input from both the public at large and state governments. In addition the President has recently created by executive order, a State Planning Council made up of Federal and state officials, chaired by a state governor (Governor Riley of South Carolina) whose function will be to advise the Executive Branch and to work with the Congress to address radioactive waste management issues, such as planning and siting, construction, and operation of facilities.

Issue

One commenter stated that the Statement does not identify how future national decisions will impact waste management. (22)

LICENSING AND THE DECISION-MAKING PROCESS

Response

The Statement analyzes several parameters which are intended to represent possible future situations resulting from national decisions. Five different growth scenarios are examined:

- Present inventory (equivalent to industry shutdown).
- Present capacity to retirement (equivalent to licensing no new reactors).
- Installed capacity of 250 GWe in year 2000 and declining to zero in year 2040.
- Installed capacity of 250 GWe in year 2000 and continuing at 250 GWe to year 2040.
- Installed capacity of 250 GWe in year 2000 and growing to 500 GWe in year 2040.

The Statement also examines two fuel cycle alternatives (see Section 3.2). The once-through fuel cycle is consistent with the present administration policy on reprocessing. The uranium-plutonium recycle option that is addressed could become viable if the moratorium on reprocessing were to be lifted.

Issue

Several commenters noted that the Statement does not discuss the process and schedule being used to resolve radioactive waste management questions. (43, 97, 147, 154, 198, 208-NRC)

Response

The Statement is intended to be the environmental input to the National Waste Management Plan which was called for by President Carter in his statement of February 12, 1980, and which will be issued for the public review in the near future. This plan will outline the programmatic structure for the management of radioactive wastes. The overall schedule and major milestones for implementation of the program will be identified in this plan. In his message of February 12, the President called for the Department of Energy to mount an aggressive research and development program over the next five years to support waste solidification and packaging, and repository design and construction including experimental test facilities. Selection of a site for the first full-scale repository should be accomplished by about 1985 and should be operational by the mid-1990's.

Issues

Several commenters questioned the use of an environmental impact statement at this stage of program development for waste disposal. (181, 217) A question was also raised as to the validity of using a generic approach in this particular EIS. (214)

Response

DOE has prepared this generic environmental impact statement in order to adequately examine the environmental impacts of alternative disposal strategies, including the

alternative of no action. This procedure is in accordance with accepted methods of complying with council on Environmental Quality (CEQ) regulations and the National Environmental Policy Act (NEPA). 40 CFR 1502.20 notes that agencies are encouraged to tier impact statements to eliminate repetitive material and focus on those issues that are pertinent at the given level of environmental review.

Issue

One commenter suggested that the Statement should note that radioactive waste disposal of any kind is prohibited or severly restricted in several states. (218-DOI)

Response

Since governmental jurisdiction of radioactive waste disposal is currently a matter of litigation DOE does not consider it appropriate to include in this Statement. The President in his February 12 statement on radioactive waste management stated "my administration is committed to providing an effective role for state and local governments in the development and implementation of our nuclear waste management program." By executive order, he subsequently established a state planning council to strengthen inter-governmental relationships to help fulfill joint responsibility to protect public health and safety in radioactive waste matters.

SITING ISSUES

Issue

Several commenters suggested the Statement note that during repository siting, an evaluation should be made of the effects on the states' historic, architectural, archeological, and cultural resources; on other potential energy sources (i.e., hydroelectric power); and on state and Federal laws. (4-FERC, 31, 39, 70, 184, 218-DOI)

Response

The NEPA process does provide the mechanism for ensuring that such concerns are addressed. Examination of potential sites will include a detailed examination of all the environmental impacts of the repository. This will include examination of the effects of the repository on historic, cultural, and natural resources and aesthetic values and on enforcement of applicable state and Federal laws. Section 2.3 also points out that such concerns will be addressed in detail as part of the site selection process.

Issues

Several commenters stated that if a repository is sited in a particular state, the Federal government should:

- Give states or communities impact funds. (28, 139)
- Consider mitigating the effects of increased monitoring, escorting, and emergency planning responsibilities of the states. (39, 184)

Response

As part of the process for siting a waste repository in a state, consideration will be given to the social and economic effects of that siting, including measures for mitigating undesirable direct and indirect effects. This consideration would be detailed in environmental analyses prepared for a specific site and is beyond the scope of a non-site-specific generic statement such as this. If specific funding to mitigate impacts in states or communities appears appropriate, DOE will need to request authority from the U.S. Congress to provide such aid. The President has directed the Secretary of Energy to provide financial and technical assistance to facilitate full participation of the state and local governments in review and licensing proceedings.

Issue

One commenter stated that sites selected for waste disposal must satisfy all the critical technological constraints, even if sites are located on Federally owned property. (43) Another commenter noted that it is unreasonable to limit site selection to those sites for which government has "an inferred availability of title." Eminent domain would seem appropriate. (113-EPA)

SITING ISSUES

Response

While the Statement acknowledges that siting may be affected by factors beyond those of a technical nature, Appendix B states that "satisfaction of appropriate technical criteria and siting considerations is essential at each stage" of the site-selection process. Licensing requirements being developed by the Nuclear Regulatory Commission and siting criteria under development by DOE will require any site under consideration for commercial nuclear waste repositories to be examined in detail and compared against relevant technical criteria for demonstration of technical adequacy.

DOE also recognizes that State acceptance of a site is an important component in the waste disposal program. DOE is now and will continue to be consistent with the "consultation and concurrence" approach recommended by the IRG (IRG 1979) and the President in his February 12, 1980 message on radioactive waste management. This approach allows for State and local interests to be represented in the repository site-selection process.

Issues

Several commenters stated concerns with specific siting problems, including:

- Repository siting should minimize transportation problems by locating near rail lines. (43, 157)
- Transportation should not occur in a particular area, near population centers or near food and water supplies. (87, 135, 209, 218-DOI)
- Repositories should not be sited in a particular state or area. (15, 52, 93, 94, 97, 99, 100, 112, 115, 139, 148, 162, 173, 174, 175, 179, 204, 206, 207, 209, 218-DOI)
- A particular site, type of site or regional siting was advocated. (2, 6, 28, 35, 71, 74, 115, 116, 136, 139, 180, 181)
- Regional siting should not be used. (35)

Response

The actual siting of waste disposal facilities will include consideration of minimizing waste transportation problems during the site-selection process. Site selection or exclusion criteria are being developed by DOE and its contractors and are currently under review by a broad spectrum of reviewers. As stated above, site selection will consider the pertinent environmental and legislative issues.

The Foreword notes that it is proposed that several alternative sites for geologic disposal should be qualified in different geologic environments and host rock types prior to the selection of a preferred site for repository construction. Four or five of these sites could be qualified on the basis of exploratory or geophysical techniques by 1985 leading to an operating repository by the mid-1990's.

SITING ISSUES

Issue

One commenter suggested that the final Statement include sufficient detailed information that would outline those requirements of the Federal Land Policy and Management ACT (FLPMA) that pertain to withdrawal of public lands for a waste disposal site. This commenter also suggested that an analysis of the trade-offs between storage of nuclear wastes and existing uses of public lands be given attention in the final Statement. (218-DOI)

Response

Legislation such as the FLPMA will be considered as part of the site selection process. Such concerns would be evaluated in specific environmental impact statements following selection of several candidate sites. Except for the spoils piles the surface could reasonably be restored to preconstruction use(s). The spoils piles, even if on the order of 2 km square would not significantly impact on most land use. It is unlikely that a repository would be sited in an area where removal of small parcels of land from present use would constitute a substantial impact.

Issue

One commenter was confused by the repository site characterization process outlined in the draft Statement and raised a question as to the land use arrangements that will be required prior to test coring at a site. (181) Another commenter felt that more information should be provided on the site evaluation process. (218-DOI)

Response

A revised and more detailed discussion of the site exploration and characterization process appears in Section 2.3 of the final Statement. The DOE Position Paper to the NRC rulemaking proceedings (DOE 1980a) contains a thorough presentation of the Department's program for identification, characterization, aquisition and selection of potential repository sites.

Issue

One commenter noted that from the analysis presented, it appears that nonradiological environmental impact considerations will not influence the selection among the six geological disposal options for a given fuel cycle operation. However, even if this is true, consideration of environmental impacts will be important in site selection for any of the geological options selected. It is not readily evident whether one geological option should be selected before a comparison of alternative sites is made or whether, indeed, at a later date the site selection will include consideration of different geological options. Considerations of this type should be part of the "programmatic strategy" selection to be supported by the GEIS. (208-NRC)

SITING ISSUES

Response

In keeping with the IRG's recommendation and the President's message, a balanced approach is proposed with respect to repository media and site selection. As presently viewed, it is believed unlikely that a satisfoctory repository in terms of media would not be acceptable on terms of site specific environmental impacts.

FOREIGN WASTES

Issues

Several commenters stated that foreign-generated commercial waste:

- Should not be transported to the U.S. (2, 98, 186)
- Should not be accepted if it cannot be properly disposed of. (62, 111)

Other commenters also asked who decides on shipment of foreign-generated commercial waste. (63, 186) Another commenter inquired as to whether such waste is presently being accepted into the U.S. (218-DOI)

Response

This Statement does not advocate a position on the receipt of foreign-generated waste. The decision to receive shipments of spent fuel from a foreign nation falls within the nation's international policy on nuclear fuels. Acceptance of foreign-spent fuels is anticipated to be based on one or both of the following criteria:

- The country is located in a region where protracted availability of spent fuel would be ill-advised in terms of nonproliferation objectives.
- Acceptance of the spent fuel would lead to significant nonproliferation gains (e.g., by encouraging alternatives to developing a national reprocessing capacity to meet spent fuel disposal needs, by stimulating implementation of desirable regional or international fuel cycle approaches consistent with overall U.S. policy, or by inducing adherence to the Treaty on the Nonproliferation of Nuclear Weapons) (IRG 1979).

Disposition of fuel which was supplied by the U.S. and used for power generation abroad is presently under the general direction of the Departments of State and Energy.

At this time, the U.S. is preparing to accept limited quantities of spent fuel from foreign nations.

Issue

Several commenters suggested discussing existing storage of foreign-generated wastes. (22, 167)

Response

The Statement does not address the subject of receipt and storage of foreign commercial wastes in detail. The estimation of the incremental foreign waste volumes is highly speculative; however, the characteristics of waste transported to the U.S. from abroad would not differ appreciably from domestic wastes. As a result, technical considerations presented in the Statement would apply to receipt and storage of foreign-generated wastes. The document DOE/EIS-0015 (DOE 1980b) discusses in more detail the impacts and issues associated with the receipt of foreign spent fuel.

FUEL CYCLE ISSUES

Issues

Several commenters stated that the Statement should include an analysis of:

- Head-end operations (mining and milling). (22, 39, 62, 155, 157, 184, 217)
- Low-level and defense or military waste. (22, 62, 97, 136, 198, 217)
- Breeder reactors. (39, 184)
- Reactor accidents. (62)
- Depleted uranium disposal. (196)

Response

The scope of the current Statement focuses on the impacts of the post-fission activities in the LWR fuel cycle. Defense wastes are addressed in the context of being additional wastes for disposal. Tables comparing key characteristics of defense wastes to commercial wastes is presented in Appendix I. Statements covering treatment and disposal of material (radiological and non-radiological) currently stored at three major DOE facilities have been (or are being) prepared for each site.

Other fuel cycle activities have been (or will be) addressed in separate DOE-prepared environmental impact statements (see final Chapter 2.0). Regulation of the management of commercially generated low-level waste (LLW) is not the responsibility of DOE. This function is performed by the NRC or by individual states having agreements to regulate LLW activities. (See Introduction for additional information.)

LONG-TERM STORAGE

Issues

Several commenters stated that spent fuel storage:

- Should be limited to the extent possible to reactor sites. (45, 56, 78, 86, 122, 133)
- Could be at an Independent Spent Fuel Storage Facility whether offsite or at the reactor facility. (17)
- Either at reactor sites or at Independent Spent Fuel Storage Facilities should not be considered adequate waste management solutions. (35, 55, 157)
- In an above-ground facility is the best thing to do for the next 30 to 40 years. (158)

Response

Two EISs have been issued which discuss the impacts of spent fuel storage alternatives:

- DOE/EIS-0015, U.S. Spent Fuel Policy, May 1980 (DOE 1980b).
- NUREG-0404, Handling and Storage of Spent Light Water Power Reactor Fuel, Office of Nuclear Materials and Safeguards, March 1979 (NRC 1979a).

Presently, spent fuel is stored by the utilities at the reactor facilities. Under the President's Spent Fuel Storage Program, the U.S. Government would accept title, store retrievably, and dispose of commercially-generated spent fuel for a one-time charge. The use of an Away-from-Reactor Independent Spent Fuel Storage Facility (ISFSF) or an Away From Reactor (AFR) storage facility will permit programmatic flexibility in the development and scheduling of operational HLW disposal facilities. Storage at reactor sites and at Independent Spent Fuel Storage Facilities will not, however, be allowed to delay progress toward a licensed waste disposal repository.

DOE is in agreement with the third item in that an "adequate solution" implies permanency. As discussed in the Statement a no action alternative (leaving spent fuel at reactor sites or at AFR facilities indefinitely) is not considered a reasonable alternative.

ATTRIBUTION OF COSTS/RISKS

Issue

Several commenters pointed out that the Statement should discuss the idea that the total impact of nuclear power (cost, risk) should be attributed to the project (beneficiaries) that created them and that the entity generating waste should be responsible for its disposal. (2, 3, 8, 9, 36, 55, 74, 77, 112, 116, 151, 155, 163, 193, 199, 205) Other comments suggested nuclear waste disposal should not be financed by the Federal government since this acts as a subsidy of nuclear power. (42, 68, 163, 193)

Response

The Statement develops the waste management costs (1978 dollars) for the entire reference nuclear power generating system. Costs associated with treatment, interim storage, transportation, decommissioning, and disposal in geologic repositories are presented (see Sections 4.9, 5.6, and 7.6). The Statement identifies the dollar value a consumer of nuclear power could be charged for the waste management aspect of nuclear energy production. An assumption made when developing cost estimates was that all waste management costs, whether the services are provided by private industry or by the government, will be borne by the consumers of the electric energy generated by the nuclear power facility and thus are reflected as an increase in cost of power. The Department of Energy has, in addition, published estimates of proposed charges for spent fuel storage and disposal services in DOE/EIS-0015 (DOE 1980b). The stated basis for these estimates is full recovery of all waste management costs including research and development expenditures.

ALTERNATIVE DISPOSAL ISSUES

Issues

Several commenters stated that certain of the alternative concepts should:

- Receive additional funding and study in order to further investigate feasibility of concept (or some aspect thereof). (9, 11, 23-DOC, 28, 35, 36, 63, 84, 96, 113-EPA, 120, 180, 194, 196, 212)
- Be eliminated as potential alternatives for such reasons as cost, safety, or technical feasibility. (9, 28, 30, 36, 43, 62, 86, 88, 96, 121, 122, 123, 140, 141, 144, 177, 194, 196, 213, 216)

Response

This Statement has been prepared to analyze the environmental impacts of implementing a national strategy for the disposal of commercially-generated radioactive waste including the possible effects of implementing a number of alternative concepts for waste disposal. To the extent possible, with information currently available, these alternative concepts have been considered in this Statement.

As a result of analysis in this Statement, and independent analysis by the Interagency Review Group on Nuclear Waste Management (IRG, 1979), the Department of Energy proposes to continue to place primary programmatic emphasis on geologic disposal with other disposal technologies (e.g., seabed and very deep hole disposal) receiving less program emphasis.

Issue

Several commenters felt that more exotic or additional disposal concepts should be included and analyzed. (6, 119, 149, 158, 164, 187, 192)

Response

The concepts analyzed in the Statement are viewed as a comprehensive set of disposal technologies. Any other disposal options that have so far been proposed are variations on one or more of the techniques addressed in the Statement.

GENERAL COMMENTS

In addition to the comments on policy aspects of commercial waste management, a number of comments were received which advocated points of interest or suggested items that were beyond the scope of this document. A number of these comments are discussed here, in general terms.

A number of letters were received that suggested slowing down or halting generation of electricity by nuclear power to stop the production of any more nuclear waste. (42, 57, 60, 65, 68, 90, 91, 96, 98, 102, 103, 105, 106, 109, 110, 111, 117, 128, 131, 134, 137, 138, 140, 142, 143, 145, 153, 155, 159, 160, 162, 165, 169, 171, 172, 174, 186, 194, 197, 199, 204, 206, 212, 216) Other commenters stated that generation of nuclear power should be halted until there is an accepted means of disposal of such waste. (59, 67, 69, 74, 78, 93, 118, 123, 125, 127, 135, 141, 146, 149, 177, 185, 195, 209, 213) As the Introduction to the Statement points out, the issue of waste production has been addressed only from the standpoint of the waste management impacts that would be associated with various future industry growth scenarios (including present inventory only).

Several letters contained statements about the future of fuel reprocessing. (27, 29, 35, 55, 82, 128, 147, 153, 158, 180, 181, 198, 205,) At present, reprocessing is indefinitely postponed under Presidential directive and this Statement has considered alternative approaches to treatment and disposal of commercial wastes including those that would require no reprocessing. Consideration of an alternative in no way endorses the alternative. DOE agrees that the Presidential deferral of reprocessing would have to be rescinded before any such reprocessing could take place. The waste disposal program should be applicable to all potential waste and waste forms. Since reprocessing is deferred but not banned, reprocessing wastes are potential waste forms and have been considered in this generic impact statement. An analysis of the pros and cons of reprocessing spent fuel and recycling uranium and plutonium can be found in NUREG-ES-0002 (NRC 1976a).

Commenters mentioned the undesirability of a breeder reactor program. (29, 96, 153) The breeder analysis is not covered in the Statement nor is this Statement the appropriate forum for a discussion of the appropriateness of instituting such a program. Such discussions have been covered in another impact statement (ERDA 1975).

Other methods for generating energy or encouraging energy development (e.g., solar installations, fusion reactors, and various tax incentives) as well as analysis of implementing these methods (e.g., comparison of expected exposures from nuclear sources to non-nuclear sources) were advocated. (7, 15, 20, 29, 63, 67, 72, 74, 76, 83, 91, 96, 102, 105, 108, 117, 138, 141, 142, 145, 171, 172, 173) This Statement evaluates only the alternatives for disposing of post-fission waste from commercial nuclear power production. Discussions of alternate forms of energy production or mechanisms to stimulate energy production and their impacts are outside the scope of this document.

WRITTEN PUBLIC COMMENTS

TECHNICAL ISSUES AND RESPONSES

The technical issues (regarding the draft Statement) identified in the comment letters and the responses to these issues are presented in this section. Technical issues are those which specifically address the content, presentation and/or the analysis in the draft Statement. Such issues, if within the scope of the document, resulted in either modification or revision of the text. The responses to these issues identify how and to what degree the issue has been incorporated into the final Statement. Within each of the eighteen technical topic areas, issues are presented sequentially according to the page number referred to in the draft Statement. Issues not addressing specific pages or sections appear at the conclusion of each topic area.

ORGANIZATION AND PRESENTATION

Draft p. iv

Issue

One commenter objected to a perceived implied accusation (paragraph 4, sentence 3) that interim away from reactor spent fuel storage is lacking a firm technological base. (181)

Response

This comment is the result of a misinterpretation of the topic being discussed in the referenced paragraph. The ISF referred to in this paragraph is not an away from reactor storage facility or an interim spent fuel storage facility but an intermediate-scale facility for a geologic repository development.

Draft p. 1.1

Issue

Several commenters did not feel that the two primary conclusions stated on p. 1.1 were completely substantiated by the information in the text. (43, 97, 208-NRC, 217)

An additional commenter noted that it has not been established that geologic repositories are the best option--only that they may be an acceptable option for the first phase of disposal. Therefore, conclusion (2) does not follow from conclusion (1). (218-DOI)

Response

As noted below, DOE has taken several steps to improve the organization and content of the Statement. While the Department is of the opinion that the two primary conclusions

- The disposal of radioactive waste in geologic formations can likely be developed with minimal environmental consequences, and
- Therefore, the program emphasis should be on the establishment of mined repositories as the operative disposal technology.

were a logical result of the analysis in the draft, the final Statement more fully supports these conclusions. DOE is not required to develop the "best" action from an environmental perspective before proceeding, an environmentally acceptable one is sufficient.

The proposed action outlined in this Statement calls for primary emphasis on geologic disposal with secondary emphasis on other disposal technologies.

ORGANIZATION AND PRESENTATION

Draft p. 1.3

Issue

In presenting the IRG's "key characteristics of a near-term interim strategic planning base for high-level waste disposal" parts omitted from the "key characteristics" seem significant and should be inculded. (208-NRC)

Response

In revising the Statement the "key characteristics" outlined by the IRG were deleted and replaced with the pertinent portion of the President's February 12, 1980 message to Congress announcing a comprehensive program for management of radioactive waste.

Draft pp. 1.3, 4.22, 4.38

Issue

Clarification of the meaning of short-term and long-term as pre-closure and postclosure of the repository should be made when the terms are first used. The difference between short-term and near-term is not clear either. On p. 1.3, third and fourth paragraphs, the meaning of the "near-term" and "long-term" consequences are mentioned. The explanation for near-term in this paragraph is the same as that given for short-term on page 4.22. (208-NRC)

Response

Near-term and short-term are considered synonymous. However, the terms used in the final Statement are near-term and long-term where near-term is pre-repository closure and long-term is post-repository closure.

Draft p. 1.12

Issue

Several commenters stated that detail concerning ^{14}C was out of keeping with the rest of the introductory scope. (34, 181)

Response

The detailed example using ^{14}C was removed from the final Statement.

ORGANIZATION AND PRESENTATION

Issue

Several commenters provided numerous suggestions for improving the organization and readability of the Statement.

- Clearly indicate purpose and proposed action. (38, 154, 182, 198, 217)
- Organize volumes so that it is easy to identify major conclusions. (58, 124, 154, 182)
- Revise summary to include more information to support proceeding with geologic disposal. (13, 34, 154, 181, 182)
- Improve summary by highlighting differences between alternatives. (201)
- Write a summary volume describing reference system which is easily understood by layman. (219)
- Draft p. 3.1 - Do not give impression that rationale for proceeding with geologic disposal is the amount of effort (funding) previously applied towards the technology. (35, 58)
- Minimize likelihood that statements taken out of context will contribute to uncertainties regarding waste disposal. (58, 124)
- Identify adequacy of current technology to support immediate repository program. (38, 124, 167)
- Present information in a form that can be readily understood. (13, 58, 124, 167, 219)
- Come up with a condensed version that most people will be able to understand. (2)
- Make better use of summary tables after each major topic. (7)
- Decrease size of document. (201)
- Do not constantly use technical jargon which weakens the analysis, and expand the Glossary. (208-NRC, 218-DOI)
- Improve cross referencing to material in body of report as well as supporting volumes and edit to remove redundancy. (58, 124, 154, 208-NRC)

Response

In preparation of the final Statement, the Department of Energy (DOE) has taken several steps to be responsive to the recommendations on the organization and presentation of the draft Statement. First, the structure of Volume 1 was modified to focus on the proposed Federal action and to make more evident the extent of the analysis in the Statement.

This was accomplished by:

1. Outlining the purpose and need of the Statement (Chapter 2.0). This chapter discusses the intent of the document, the proposed Federal action, and the "decision territory" covered.
2. Identifying programmatic alternatives (Chapter 3.0) including a statement of a no-action alternative which the draft Statement did not do.
3. Developing Chapter 4.0 which discusses predisposal options and systems.
4. Emphasizing the proposed action (a program leading to a mined geologic repository) by discussing in a separate Chapter (5.0) with the presentation of disposal alternatives in Chapter 6.0.
5. Including a new Chapter 7.0 which discussed tradeoffs between the proposed action and the two alternative actions on a complete system basis.
6. Expanding the Glossay (Chapter 8.0) to include additional geologic, environmental, and waste technology related terms.

The Summary chapter was extensively revised so that the material would be more easily understood by the general public. In revising this chapter DOE was sensitive to the comments that the significant conclusions be highlighted in the Summary and that they be substantiated by the material in the text. An effort was also made to increase the overall clarity and readability of the document by reducing the page length, being consistent in the use of terminology, using summary tables whenever possible, and relegating supporting data or information to the Appendices.

The Statement is now consistent with DOE policy as directed by President Carter in his February 12, 1980, Waste Management Policy Statement and conforms to the DOE Position Paper for the NRC confidence rulemaking hearing activities (DOE 1980a).

The Statement has been edited to reduce the ambiguities and redundancies found in the draft. The method for referencing supporting documents was not changed. The present method is believed to allow adequate access to the material referenced.

The tables that follow identify the correspondence between sections of the final Statement and the draft. These tables will be of assistance to the reader during the remainder of Volume 3 when reference is made to either the draft or final Statements.

Draft pp. 3.1.173-214

Issue

Discussion of environmental impacts of predisposal activities (storage, packaging and transport) is confusing. Some variations with various deferrals of decisions are included. All together 14 different options and sub-options are included. This sort of proliferation simply complicates the presentation. (154)

ORGANIZATION AND PRESENTATION

Volume 1

Section of Final Statement	Corresponding Section of Draft
Foreword	Foreword
1.0	1.0
2.0	Foreword, 2.1
3.1	--
3.2	2.1
3.3	2.2,2.3
3.4	Portions of 3.1.3 dealing with risk and risk perspectives
3.5	Portions of 3.1.2 and 3.1.3 dealing with non-technical issues
4.1	--
4.2	2.1
4.3	3.1.4, 3.2, portions of 3.9 and Appendix L
4.4	3.1.4 and portions of Appendix M
4.5	3.1.4 and portions of Appendix N
4.6	3.1.4 and portions of Appendix O
4.7	3.1.5.3
4.8	3.1.5.3
4.9	3.1.5.3
4.10	3.1.5.3
5.1	3.1.1 plus portions of 3.1.3 relating to the multiple barrier concept
5.2	3.1.2, 3.1.3 and 3.1.6
5.3	3.1.5.1
5.4	3.1.5.1
5.5	3.1.5.2
5.6	3.1.5.1
5.7	3.1.5.1
6.1	3.3-3.10
6.2	4.0
7.0	Portions of 3.1.5.4

Volume 2

Section of Final Statement	Corresponding Section of Draft
Appendix A	Appendix A
Appendix B	---
Appendix C	Appendix C
Appendix D	Appendix D
Appendix E	Appendix E
Appendix F	Appendix F
Appendix G	Appendix G
Appendix H	Appendix H
Appendix I	---
Appendix K	Appendix K and Appendix Q
Appendix L	---
Appendix M	---
Appendix N	---
Appendix P	Appendix P

ORGANIZATION AND PRESENTATION

Response

The presentation was simplified and shortened to include only the reference or example case for each activity.

Draft p. 3.1.214

Issue

Impacts are integrated for waste treatment, transport storage and final disposal. Tables 3.1.84-87 should be checked to eliminate errors in the supporting tables. (154)

Response

Draft Tables 3.1.84 through 3.1.87 were thoroughly checked. Some values that may appear to be in error were the result of rounding off the value.

Draft p. 3.1.233

Issue

The discussion referring to Tables 3.1.84-87 should emphasize that environmental impacts (radiological and non-radiological) associated with all of the fuel cycles and media considered are trivial. This perspective should be brought into the final EIS. (154)

Response

This perspective has been brought into the final Statement (see Chapter 7.0).

Draft Section 3.1

Issue

Summary tables that show the range of environmental impacts for geologic disposal would be helpful. (202-HEW)

Response

Chapter 7.0 and the Summary present such tables.

Issue

Several commenters noted that the analysis in the Statement should emphasize the systems aspect of waste management. (201, 219)

ORGANIZATION AND PRESENTATION

Response

The draft Statement did analyze the entire cycle of post-fission waste management activities. However, to ensure that the reader is able to recognize the scope of the analysis carried out, the final Statement is structured such that the predisposal activities (waste treatment and packaging, waste storage, waste transportation, and decommissioning) are first presented (see Chapter 4.0), the disposal activities are then outlined in subsequent chapters (Chapters 5.0 and 6.0) with the system impacts presented in Chapter 7.

Issue

Several commenters stated that the title should show that the document deals primarily with the disposal of high-level wastes. (113-EPA, 198, 201, 218-DOI) It was requested the term "generic" be in the title. (181)

Response

The title does include the word "generic" in it. The chapter presenting the document's purpose and need (Chapter 2.0, Introduction) discusses the "decision-territory" of the Statement and the bounds of the analysis. This chapter also contains a discussion which notes that the analysis is generic in nature.

Issue

Several commenters noted that the overwhelming emphasis of the document on geologic disposal does not enable a legitimate comparison to be made. (113-EPA, 214, 218-DOI) Other commenters took exception to what they stated as "bias" of DOE toward a single method of disposal. (167, 217)

Response

The regulations for implementing NEPA require that an environmental impact statement be a full disclosure document and present whatever relevant information is available on each of the alternatives. To this end, each of the disposal options in the Statement is discussed to the extent information is available. In preparing the final Statement an effort was made to increase the depth of analysis (quantitative and qualitative) in the sections discussing alternative disposal technologies. The disparity in the number of pages addressing geologic disposal versus the alternative disposal options results from the significant difference in the existing data base between mined geologic disposal and other techniques.

Issue

The suggestion was made that in the concluding chapter, a comparison of alternative disposal schemes and the alternative systems should be prescribed. (201)

ORGANIZATION AND PRESENTATION

Response

Section 6.2 and Chapter 7.0 of the final Statement present a system comparison of the disposal alternatives.

Issue

One commenter suggested that when deciding which course of action to follow, DOE should consider the CEQ regulations (40 CFR 1502.14) which require the identification of any preferred alternatives in the draft Statement. (208-NRC)

Response

The proposed action (a program leading to mined geologic disposal) and the preferred alternative are the same.

SCOPE

Draft pp. iv and 1.2

Issue

The Statement should provide a comparative analysis of regional versus national repository approaches as discussed in the IRG report. (43)

Response

A discussion of tradeoffs involved in siting regional repositories is presented in final Section 5.3.

Issue

Several letters commented on the relationship between the Statement and the IRG Report.

Draft p. 1.3 - The relationship of the conclusions of the IRG report to the final EIS should be made more clear. (154)

The GEIS should examine each of the national strategies discussed in the IRG Report in an explicit manner which permits an environmental comparison of the alternatives. (208-NRC)

Response

The relationship of conclusions in the final Statement to the IRG report has been expanded upon (see Section 3.1, Chapter 7.0, and Summary).

The proposed action (see below) encompasses Strategies I, II, and III as described in the IRG Report. The alternative action is consistent with IRG Strategy IV.

Draft pp. 1.10-11

Issue

Several letters commented on the need to address the excess quantities of plutonium available in the year 2040.

All of the waste which enters into consideration in the EIS should be addressed. (26)

It is not immediately obvious why there is 1300 MT excess. (34)

Some qualitative statement about the plutonium on hand in the year 2040 probably ought to be made. (154)

On p. 1.10 (and elsewhere) the statement is made that a separate and distinct nuclear fuel cycle might be in existence to receive 1300 metric tons of plutonium by the year 2040. This "Alternative" fuel cycle would also produce radioactive waste. Although this disposition may appear to be possible, the more prudent approach would be to consider this excess plutonium to be TRU waste requiring safe disposal in a repository. However, if credit is to

be taken for use of the plutonium in this "alternative" fuel cycle, the disposal of radioactive wastes from this fuel cycle should be discussed. (208-NRC)

Response

In developing a basis for this generic Statement, DOE recognized that it is not possible nor even reasonable to attempt to identify the impacts of commercial nuclear waste management over the entire indefinite future. No one can predict whether or not nuclear power will be utilized for another 10, 50 or 500 years. DOE attempted to place a reasonable boundary on the system to be analyzed that would be sufficient in scope to provide the information needed to reach well-balanced decisions necessary for the waste management requirements that can be foreseen today. DOE assumed that the future course of actions can and will be reexamined periodically in the future. For example, if the burden of nuclear waste management should become so onerous that nuclear power generation should be discontinued, which is not a conclusion of the present analyses, the decisions and necessary actions can be initiated when and if that becomes apparent.

The intent of the analysis in the draft Statement was to account for the waste management requirements for the maximum projected nuclear power capacity reached by the year 2000 and the implied waste management commitment of allowing these plants to complete a normal life cycle and be decommissioned after 40 years of operation. It was assumed that other plants were likely to be added after the year 2000 but the waste management requirements for these plants were considered to be outside the boundaries of the system analyzed. Thus, it was reasonable to assume that plutonium recovered in excess of requirements for the sytem analyzed could be utilized by these other plants. But the waste management requirements for these operations were clearly outside the scope of the analysis. DOE did not speculate as to what these additional plants might be--light water reactors, fast breeder reactors, or some other type of nuclear facility.

In the final Statement, DOE considers a similar situation but has reduced the maximum installed capacity in the year 2000 from 400 GWe to 250 GWe as that now appears to be the maximum reasonably achievable. In addition, in the final Statement, DOE has included consideration of much lower growth possibilities, a case that analyzes the steady-state operation of a 250 GWe system through the year 2040 and a case that considers continued growth to 500 GWe by the year 2040.

An expanded discussion of plutonium utilization can be found in final Section 7.3.7.

Draft p. 1.15 and Section 3.1

Issue

Severial commenters stated that sufficient reference was not made to the efforts of other nations in the area of waste management. (144, 147, 154)

Response

Such activities have been included where appropriate by reference (see Sections 5.1 and 5.2).

Issue

Several commenters noted that storage and transportation were not addressed sufficiently in the draft.

The few paragraphs which are devoted to transportation impacts may not be sufficient to analyze this issue. (7)

The hazards of storage and transportation of radioactive wastes should be addressed. (14, 145)

Determination of a direct impact relationship between the transportation factors discussed in Appendix N and the disposal techniques discussed in the body of the document is difficult. (43)

The standard environmental impacts associated with any transportation, such as air pollution, noise, and water quality impacts are important to evaluate. (43, 97)

No reference is made to the factors involved in transporting wastes, such as, adequacy and availability of present system risk, safety, etc. (43, 97)

The Statement does not consider that humans will handle this material on the way to storage. (126)

A relative lack of emphasis is placed on the handling and transportation of these radioactive materials prior to emplacement. (197)

The impact of the transportation of nuclear wastes should be included in any broad analysis of the risks and impact associated with nuclear waste disposal. (215)

An issue which is inadequately addressed is the transport of radioactive materials from production site to storage site. (216)

Response

The draft Statement did analyze impacts of waste storage and transportation (see Section 3.1.5.3 and Appendices M and N) including:

- radiological releases
- non-radiological releases
- resource commitments
- costs.

DOE recognizes that the text may not have given the reader a full appreciation as to the depth of the analysis; therefore, DOE has taken steps in preparing the final document

to alleviate this. The restructured outline devotes a chapter to predisposal systems (Chapter 4) and in Sections 4.4 and 4.5 describes the waste storage and transportation systems. Sections 4.7, 4.8, 4.9, and 4.10 present the environmental impacts, accident analysis, cost analysis, and safeguard requirements for storage and transportation operations (as well as the other predisposal activities). Section 4.2 identifies the relationship between the various predisposal activites (including storage and transportation) and the disposal concepts that are analyzed in Chapters 5.0 and 6.0.

In addition, DOE has prepared a separate EIS which addresses the impacts of storage and transportation of spent fuel (DOE 1980b).

Issue

Several commenters stated that the Statement should address the implications of delaying a decision on the dispostion of nuclear wastes (i.e. giving the matter further study or deferring the decision to select a disposal alternative). (147, 154, 217)

Response

The final document examines three basic waste management program alternatives. The proposed action is for DOE to maintain its primary research and development emphasis on mined geologic disposal with some secondary efforts directed towards other concepts. The alternative action would be then for DOE to adjust (or reorder) their R&D priorities. Presumably mined disposal would receive less emphasis and one or more of the other diposal concepts would be investigated more vigorously than under the proposed action. The third program alternative considered was no action, defined as a continuation of present action (water basin or AFR storage) with no steps taken by the Federal government to provide for final disposal of commercial wastes.

Implicit in the structure of the proposed action and the alternative action is that the point at which a geologic disposal facility would become operational would occur earlier under the proposed action. Chapter 7 examines the tradeoffs between the various program alternatives and, as a result, addresses the issue of a delay in the decision on the disposition of nuclear wastes.

Issue

Several letters noted that the subject of decommissioning should be addressed in the Statement.

Decommissioning should be discussed thoroughly in this document. (62)

No mention is made of cladding of nuclear power plants. No mention is made of shielding equipment necessary for handling processing, transportation and storage. (144)

Disposal of dismantled nuclear plants hasn't been resolved. (155)

SCOPE

The problems or costs associated with eventual decommissioning are not discussed. (167)

Consideration should be given to ultimate disposal of activated reactor parts in the repository. (196)

Response

The draft Statement did examine the impacts of decommissioning retired facilities, including nuclear plants (see Appendix O). To ensure that the reader is aware of the systems nature of the analysis the final Statement presents the predisposal systems in a separate chapter (4) and the decommissioning activites in particular in Section 4.5.

Decommissioning activites related to disposal are discussed in the chapter on geologic disposal (Chapter 5) and in the section on alternative disposal concepts (Section 6.1) to the degree that information was available. The cost figures cited in Chapter 5 (see Section 5.6) and in Section 6.1 do include the estimate of the costs associated with eventual decommissioning.

Issue

Several commenters stated that an analysis of a no action alternative should be included in the Statement. (34, 38, 113-EPA, 154, 167)

Response

A no action alternative is discussed in the final Statement (see Section 3.1). This alternative is defined as continued storage of spent fuel elements in water basins (either using AFR storage or at reactor water basins).

Issue

One commenter recommended the environmental aspects of delayed commitment of wastes to the repository be discussed in the final Statement. (208-NRC)

Response

The proposed action (see p. 37) examines the impacts of repository availability for the years 1990-2010. The alternative action (see p. 37) examines the impacts of repository availability for the years 2010-2030.

RADIOLOGICAL ISSUES

Draft p. 1.19

Issue

One commenter mentioned that the Summary quotes a range of 50-500 somatic effects per million man-rem. The conservatism of the larger of these two numbers should be pointed out in view of the current BEIR Committee activities. (166)

Response

The values cited were arrived at after much deliberations over available data. The values reflect an estimate of the upper end of the range of possible health effects from small doses delivered over long periods of time at low dose rate. The values are believed to be conservative as suggested; the other end of the actual range may include zero effects.

Draft p. 1.19

Issue

One commenter felt that the Statement assumes a rather small range of 50-300 incidents of "multi-factorial" genetic disease over all generations per million man-rem of exposure. (40)

Response

The values given represent what is believed to be acceptable to most of the scientific community as conservative numbers of incidents of genetic disease resulting from exposure to very low levels of ionizing radiation.

Draft pp. 2.1 and 2.2

Issue

The NRC final EIS on spent fuel storage, NUREG-0575, (NRC 1979a) should be cited. (208-NRC)

Response

This EIS is cited in Section 4.4.1.1 of the final Statement.

Draft p. 2.1.7

Issue

Regarding the transfer of plutonium oxide powder from the reprocessing plant to a mixed oxide fuel fabrication facility, this comment states, "DOE transportation regulations

presently require at (sic.) whenever plutonium is shipped, it must be shipped in a nitrate solution. Transport of oxide powders is expressely forbidden." (147)

Response

On the contrary, except for less than 20 Ci amounts, the only form allowed for plutonium shipment is as a solid (oxide or metal) (10 CFR 71.42).

Issue

Several letters requested that additional information be provided on background radiation levels.

Draft p. 2.2.1--Some baseline exposure needs to be presented so the reader will know what increase and what risks are entailed by additional exposures. (62)

Draft Appendix F-- Examples of existing radioactivity levels in the biosphere (surface, water, drinking water, air, etc.) would illustrate conditions prior to the operation of a waste disposal facility. (43)

Response

The discussion of natural background has been modified in order to give the reader a better feel for the existing environment in terms of the existing radioactivity levels (see final Section 3.3).

Draft p. 2.2.1

Issue

The document neglects to mention overall guidance provided by the FRC: Radiation Protection Guidance for Federal Agencies, 25 F.R. 4402 et seq. (5/18/60), for which 10 CFR 20 is one of several implementing regulations. (113-EPA)

Response

The cited reference was added in the final Statement (see Section 3.3).

Draft p. 2.2.2

Issue

One commenter noted that 10 CFR 20 only gives limiting concentrations. That means that a utility may put out as much radioactivity as it wants as long as it dilutes it sufficiently. This merely spreads the cancers throughout an entire population. It does not place a limit on how many cancers nuclear power may produce. (30)

Response

The concentrations in 10CFR20 are limiting concentrations, however, the principle of As Low As Reasonably Achievable (ALARA) as given for reactors in 10CFR50, Appendix I, and in 40CFR190 for fuel cycle facilities, also apply and guard against such population exposures.

Draft p. 2.2.2

Issue

The formula given for allowable whole-body radiation dose should be checked for possible error. It is given as 5(N-18), N being age. The meaning is unclear. (218-DOI)

Response

This formula is correct as given. It represents allowable life time dose limit.

Draft p. 2.2.3

Issue

No mention is made of EPA's regulations developed under the regulatory authority of the Marine Protection, Research and Sanctuaries Act of 1972 (Public Law 92-532). This authority should be referenced in this section. (113-EPA)

Response

The cited reference was added in the final Statement (see Section 3.3).

Draft p. 2.2.3

Issue

Under EPA Uranium Fuel Cycle Standards, the last sentence in this section is in error. The effective date for application of 40CFR190 can be found in 40CFR190.12. This error should be corrected. (113-EPA)

Response

The sentence was revised.

RADIOLOGICAL ISSUES

Draft p. 2.2.3

Issue

The way in which the EPA drinking water regulations would be applied, if at all, is not made clear. These regulations are not directly appropriate to the disposal of radioactive waste since they do not control the contamination of the environment. They are directed toward a water supplier and applied to monitoring and corrective treatment regardless of the source of the contamination. The draft Environmental Impact Statement relates to activities of persons whose contamination of the environment is being limited. (113-EPA)

Response

Reference to EPA drinking water regulations was removed.

Draft p. 2.2.4, line 6

Issue

This should be corrected to read: (b) Gross alpha particles activity (including ^{226}Ra but excluding radon and uranium)--15 pCi/l. (113-EPA)

Response

The commenter is correct. See response above.

Draft p. 2.2.5

Issue

Under "Clean Air Act Amendments of 1977" the text states: "The administrative and legal problems arising from the potential conflict with NRC regulatory authority and procedures originating in the Atomic Energy Act of 1954 have not been resolved. However, it is unlikely that existing EPA radiation standards will be changed, although administrative requirements may." This statement is presumptuous and does not reflect the major effort underway at EPA to develop regulations under the Clean Air Act, as amended. The text should be revised in the final EIS. (113-EPA)

Response

The cited sentences were removed from the final Statement.

RADIOLOGICAL ISSUES

Draft Section 2.2

Issue

Several commenters noted that in preparing the final EIS, reference is needed to the present development by EPA and NRC of Federal guides for radioactive waste management and standards for high-level radioactive waste. (113-EPA, 154, 198, 202-HEW)

Response

Mention of their development appears in Section 3.3 of the final Statement.

Draft pp. 2.3.2 and 2.3.3, Tables 2.3.1 and 2.3.2

Issue

Both of these tables are taken from an obsolescent reference (ORP/CDS 72-1). More appropriate reference would be EPA report ORP/SID 72-1 (Reference 21, draft Section 2.3) with the cosmic ray doses augmented by the new information in NCRP Report #45 (Reference 10, draft Section 2.3). (113-EPA)

Response

Data from NCRP-45 (NCRP 1975) were used in the final Statement. (ORP/CDS 72-1 was used by EPA in EPA 520/1-77-009 released in September 1977).

Draft pp. 2.3.2 and 2.3.3

Issue

One commenter noted that the tables on these two pages list the estimated cosmic-ray and natural terrestrial radioactivity doses to people in each state. The doses are dependent on latitude, altitude, and the presence of certain elements in the earth's crust. Measurements were obtained at many locations, and the results averaged within each state, then reported as an average value for the state. Since there are often large differences within a state, the results should have been reported in a way to display this, as by a contour map. A portion of a northern state that contains rock-bearing radioactive material, and is at a high elevation may not be acceptable as a disposal site. In California, there could be large differences between the dose received by a person at Lake Tahoe and one in the Imperial Valley. (214)

Response

Natural background radiation dose was presented only as a perspective against which other doses could be compared.

RADIOLOGICAL ISSUES

Draft p. 2.3.3

Issue

According to the note at the bottom of Table 2.3.2 some 39% of the political units are assumed to have the national average annual dose. This assumption is unwarranted. (147)

Response

The material in the distribution of dose from natural background appearing on p. 2.3.3 has been extensively revised. The refinement as dose distribution by political unit was no longer considered relevant and was removed.

Draft p. 2.3.4

Issue

The dose estimates for radon are obsolete. Currently, dissolved radon in the body would give a dose of about 2 to 3 mrem/yr and the range of estimated dose from inhaled radon and daughters at 0.7 pCi/liter would be 130 mrem/yr to 1800 mrem/yr. See United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Report (1977) for a more complete treatment of the question, also NCRP-45 (NCRP 1975). (113-EPA)

Response

The Statement notes that the whole body dose from dissolved ^{222}Rn is 3 mrem/yr. EPA states that dose is 2 to 3 mrem/yr. NCRP-45 on page 110 says dose to total lung is 90 mrem/yr and to segmental bronchioles is 450 mrem/yr. But Table 45 on page 109 gives 90 for ^{218}Po-^{214}Po only plus 2 from ^{222}Rn and 3 for ^{210}Pb-^{210}Po for a total of 95. (The range of 100 to 900 mrem/yr to lung would correspond to the average ^{222}Rn concentrations in some places in the U.S.) The value of 0.7 pCi/ (700 pCi/m^3) was not found in either UNSCEAR report or NCRP-45. The values given in UNSCEAR, 1977, Table 30, page 80, are 160 (20-2000) for bronchial epithelial and 30 (3-300) for lung in rad/yr. If Q = 10, then these are 1600 mrem/yr for bronchial epithelial and 300 mrem/yr for lung.

Draft p. 2.3.5, Table 2.3.3

Issue

The data in this table are obsolete, see UNSCEAR 1977 or NCRP-45 for current data. (113-EPA)

Response

Data from NCRP-45 (NCRP 1975) were used in the final Statement.

RADIOLOGICAL ISSUES

Draft p. 2.3.5, Table 2.3.4

Issue

This table is obsolete. Use natural background as summarized in NCRP-45. (113-EPA)

Response

Data from NCRP-45 (NCRP 1975) were used in the final Statement.

Draft p. 2.3.5, Table 2.3.4

Issue

One commenter noted that the 130 man rem/yr is at variance with the 102 man rem/yr in BEIR I. (8)

Response

In final Section 3.3 natural background is given as 65 to 125 man rem/yr depending on location in the country. These values were obtained from NCRP-45 (NCRP 1975). The value in Table 2.3.4 was taken from an EPA document. However, EPA in commenting on the draft suggested use of NCRP-45 as more appropriate.

The discrepancy with BEIR I was not investigated.

Draft p. 2.3.5

Issue

One commenter noted that in discussing radioactivity DOE states "Presently the linear theory is unproven at low levels. For this reason, health effects numbers at low levels must be stated as a possibility, with another possibility being zero."

DOE does not mention the treatise of Dr. Karl Z. Morgan, noted health physicist, entitled "The Linear Dose is Non-Conservative" which suggests that low doses rather than having linear health effects result in a higher number of health effects than had previously been considered and higher than linear anticipates according to the BEIR report. The studies of Dr. Morgan should be included in DOE's section on radioactivity, especially when the theories at the opposite end of the spectrum are given recognition. (See p. 2.38 re N. A. Frigerior and R. S. Stone).

Also Dr. Ernest P. Radford, chairman of the BEIR Committee, testified before Congress (Feb. 1978) that his Committee had erred in 1972 in setting radiation standards and that in certain cases, the permissible limits were set at least 10 times too high. He said: "The human data obtained from populations exposed to highly ionizing radiation such as alpha

particles (high LET radiation) indicates that cancer induction at low doses is probably greater per unit of physical dose than at high doses..." (55)

Response

This controversy is still going on. The reader is referred to Appendix E for a more detailed discussion.

Draft p. 2.3.6

Issue

The use of the Congressional Research Service (Reference 23, draft Section 2.3) estimate of 200,000 defective children per year does not agree with current estimates of 9.5% to 10.5% incidence of genetic disorders in newborn (see UNSCEAR 1977, p. 519). The UNSCEAR estimates suggest that this estimate of 200,000 is at least a low by a factor of two.

Estimates of malignancies occurring each year are better obtained from the American Cancer Society annual publication "Cancer Facts and Figures--19xx." For example estimates have been: 395,000 deaths, 765,000 cases of cancer--1979; 390,000 deaths, 700,000 cases--1978; 385,000 deaths, 690,000 cases--1977; etc. (113-EPA)

Response

The basis for the estimate of persons born "with some type of physical or mental defect", as quoted from the Congressional Research Service, was somewhat different from the basis employed by UNSCEAR in arriving at an incidence of "genetic disorders", and the estimates are consequently not the same. A factor of two does not seem important, however, for the purposes of this very general discussion of the implications of natural radioactivity. Similarly, more current data on malignancies could be given but the general implications would not differ. The number 340,000 in the Statement should have been identified as deaths due caused by malignancies.

Draft p. 2.3.6

Issue

The use of Frigerio and Stowe as a reference should be put in context. Aside from using the same obsolete reference of natural background used in the DEIS which inflates the probable difference in background between areas of the country, the others neglect to consider the potential effect of other carcinogens in the work place and the environment. Some of these problems are highlighted in multiauthor sections on "Demographic Leads to High-Risk Groups" and "Environmental Factors" in the volume Persons at High-Risk of Cancer

(J. F. Franmeni, Jr., editor, Academic Press, New York, 1975). Little support is given for the assertions in the referenced paper.

In a more complete report by the same author (N. A. Frigerio, K. F. Eckerman, and R. S. Stowe, "Carcinogenic Hazard from Low-Level, Low-Rate Radiation," ANL/ES-26, 1973) where all methods and assumptions are given, there are several flaws. A major flaw is the assumption that "all forms of cancer show very similar doubling doses and closely similar increases in mortality rate per rad". This assumption is made contrary to the evidence in ICRP, UNSCEAR, BEIR, and other reports that variations in the susceptibility of tissue to induction of different forms of cancer by irradiation are quite large and not necessarily related to the marked variations in natural incidence of the diverse types of cancer.

There are also problems in the statistical analysis in ANL/ES-26: misuse or misinterpretation of the t-statistic, failure to use Scheffes' test or calculations of variance ratio to check the significance of the series of t-tests, and use of gross averages in the analysis.

In reality, the paper can be shown to be erroneous by inspection of Frigerio et al.'s source of cancer mortality data, NCI Monograph 33, Patterns in Cancer Mortality in the United States: 1950-1967. In Monograph 33, Burbank presented an analysis of Dynamic Geographic Distribution for each cancer. The complex pattern of increasing and decreasing cancer mortality by state and cancer show that factors other than background are the major driving force in cancer mortality rates and that natural background radiation is not.

Indeed, in a later publication (A. P. Jacobson, P. A. Plato and N. A. Frigerio, "The Role of Natural Radiations in Human Leukemogenesis," Am. J. Public Health, 66, p. 31-37, 1976), a more reasonable major conclusion was reached: "It appears that conditions relative to populations and their environment could mask a radiation effect, if in fact one is present." (113-EPA)

Response

References 25 and 26 were deleted.

Draft Section 2.3.3

Issue

Several commenters suggested that a discussion of the observed health effects caused by differences in natural radioactivity between different regions or states should be included in the Statement. (10, 198)

Response

The general public is probably too mobile to permit development of the epidemiological data in quantity and certainty in order to identify effects at these low levels. However,

it has been suggested in the recent DOE Position Paper to the NRC rulemaking hearings on nuclear waste storage and disposal (DOE 1980a) that normal variations experienced in natural background could reasonably serve as an upper bound for allowable standards for the impact of waste management.

Draft p. 3.1.35, First Paragraph

Issue

This paragraph suggests that the fission product problem terminates with the decay of ^{90}Sr and ^{137}Cs. While this may be substantially true for the production of heat and for acute radiation hazard, it is not true for the significance of the waste as a health hazard. Doses from ^{99}Tc, ^{129}I, and ^{135}Cs are not negligible over a long time frame. This problem is repeated in the last sentence of the next paragraph. (113-EPA)

Response

The wording "majority of the dose": was not intended to imply what the commenter says it does. Doses from longer lived nuclides, ^{99}Tc, ^{129}I, and ^{135}Cs, are small because their abundance is low. Even at very long times the contribution to dose would be expected to be relatively small in comparison with that from ^{236}Ra.

Draft p. 3.1.38

Issue

In the early phases, actinide elements, particularly ^{238}Pu and ^{241}Pu, are significant. Tritium (^{3}H) may also be significant. In the long time frame ^{135}Cs and ^{14}C might also be significant. (113-EPA)

Response

The paragraphs referred to are describing the division of radionuclides into two main groups; 1) short-lived fission products and 2) long-lived fission products and actinides. No attempt has been made to determine which actinides are significant with respect to time. The lists of nuclides presented in each paragraph is prefaced by the words "Some of the key isotopes". The significance of ^{3}H and ^{14}C is dependent on the fuel cycle and off-gas treatment system at reprocessing facilities.

Draft p. 3.1.38

Issue

^{239}Pu should be considered a long-lived isotope. (17)

RADIOLOGICAL ISSUES

Response

A typographical error. ^{238}Pu should have been ^{239}Pu.

Draft p. 3.1.54, Item 2

Issue

The chemically separated high-level waste to be considered must include the ^{129}I (and the other volatiles) recovered from the fuel reprocessing plant as required by EPA's Uranium Fuel Cycle regulations (40 CFR 190, 10(b)). (113-EPA)

Response

The wording in question has been changed to avoid this misunderstanding. Control of ^{129}I and other volatiles is indeed required. While ^{129}I is not included in the high-level waste, it is recovered in the reference waste management concept and sent to the repository with the TRU wastes. See Section 4.3 of the final Statement.

Draft p. 3.1.60

Issue

The quote of 10 CFR 50, Appendix F, is in error. The regulatory policy stated therein is that liquid wastes at a reprocessing plant must be converted to a dry solid which is "....chemically, thermally, and radiolytically stable to the extent that the equilibrium pressure in the sealed container (required before shipping) will not exceed the safe operating pressure for that container during the period from canning through a minimum of 90 days after receipt (transfer of physical custody) at the Federal repository." (208-NRC)

Response

The quote of 10 CFR Part 50, Appendix F was corrected in the final Statement.

Draft p. 3.1.122

Issue

One commenter suggested that the discussion of the interaction of run-off from storage piles as well as water pumped from the mine with freshwater systems should include a presentation of appropriate state and Federal discharge parameters. (43)

Response

State and Federal discharge limits could have been discussed in this generic Statement. However, the usefulness of including such limits is questioned.

RADIOLOGICAL ISSUES

Draft p. 3.1.144

Issue

Define "health effects" and assumptions for "translating" 1.8×10^8 man-rem into 1.8×10^4 to 1.4×10^5 health effects. (208-NRC)

Response

Health effects are defined in Appendix E, Volume 2 of the Statement; 100 to 800 health effects per million man-rem equates to 1.8×10^4 to 1.4×10^5 health effects for 1.8×10^8 man-rem.

Draft Appendix C

Issue

This appendix is grossly unsatisfactory. It concentrates heavily on doses to individuals and does not appear to recognize that more recent standards, although they may be expressed in terms of dose to the maximum individual, have population dose as part of their basis. Among such regulations are:

1. Limitations on releases of effluents from power reactors (Appendix I to 10 CFR 50);
2. The uranium fuel cycle standards (40 CFR 190); and
3. The drinking water standard (40 CFR 141).

The limitations on releases of ^{85}Kr, ^{129}I, and transuranic elements, in 40 CFR 90, are explicitly based on population dose.

The general thrust of this appendix is that population dose is not a concept suitable for radiation standards. This is incorrect because the concept of ALARA usually involves balancing the cost against the reduction in population dose. It is perhaps significant that this appendix does not include any of the BEIR reports but limits itself to the 1969 report of the National Academy of Sciences. For currency, the appendix should consider additional references (e.g., References 1, 2, 10, and 16 from Appendix E) to bring the appendix up to 1977 at least. (113-EPA)

Response

DOE does not agree. The development presented in final Section 3.3.2 and Appendix C is based on individual dose which is a matter of historical record. No attempt was made to suggest that at very low doses and dose rates that population doses are not of major interest in exposure control.

RADIOLOGICAL ISSUES

Draft p. C.2

Issue

The paragraphs ending the section on "Background" and initiating "As Low As Reasonably Achievable Application" reflect some bias and a lack of candor in describing the use of risk coefficients in radiation protection. Almost all government agencies, particularly the EPA but including the NRC and the OSHA, have used or are using risk coefficients to estimate impact of radiation exposure. The ICRP (Reference 11, draft Appendix C) has gone entirely to a risk-based radiation protection system, using estimates of risk in optimizing radiation protection. ICRP has stated, "These risk factors are intended to be realistic estimates of the effects of irradiation at low annual dose-equivalents (up to the Commission's recommended dose-equivalent limits)" (ICRP Publication No. 28, 1978). The NCRP (Reference 15, draft Appendix C) seems to stand alone in its position discounting the use of linear, non-threshold risk coefficients in radiation protection. (113-EPA)

Response

Risk factors were used in extimating health hazards, but only to the extent that the incidence of cancer and genetic effects could be related to doses to population groups.

Draft p. C.3, Table C.1

Issue

While the table is titled "Comparison Chart of Radiation Standards," it then lists "Standards or Criteria" and references ICRP and NCRP values or reports. ICRP and NCRP reports are recommendations or suggestions which may or may not be adopted or modified and adopted by national regulatory agencies. The references to ICRP and NCRP should be deleted from the table.

It should be noted, however, that there are ICRP reports pertinent to health effects. ICRP Publication 26 (Reference 11, draft Appendix C) and ICRP Publication 27 ("Problems Involved in Developing an Index of Harm," 1977), both provide recommendations on "acceptable" numerical risk estimates for radiation workers. (113-EPA)

Response

Because the work of NCRP and ICRP should be identified, the column heading has been changed to include recommendation; ICRP 26, 27 and 28 has been added under health effects.

RADIOLOGICAL ISSUES

Draft Appendix C

Issue

The discussion of the "as low as reasonably achievable" principle in this appendix is misleading in that it treats ALARA dose levels as fractions of maximum permissible dose levels for individuals. Instead, ALARA is primarily an analysis of risks to an entire affected population and of the cost-effectiveness of reducing that population risk. While ALARA individual dose limits can be derived for specific activities (e.g., operating nuclear power plants), the most basic ALARA judgement concerns the cost-effectiveness of reductions in overall population risk (e.g., $1,000 per man-rem, Appendix I). (208-NRC)

Response

The use of fractional dose levels is meant to be a practical approach to the ALARA philosophy. As inferred in the final paragraph, Appendix C.1 (and in agreement with the commenter's suggestion), use of the ALARA philosophy should be cognizent of dose reduction factors, cost effectiveness considerations, and should typically be evaluated on a case by case basis. The intent of the existing wording and use of ALARA does not appear to be in conflict with generally accepted definitions of ALARA.

Draft p. C.4

Issue

One commenter noted that the Regulatory Guide "Calculational Models for Estimating Radiation Doses to Man From Airborne Radioactive Materials Resulting from Uranium Milling Operations" contains many errors and that these errors might be carried through into Appendix C. (30)

Response

Subject guide was not used in Appendix C.

Draft p. E.1

Issue

The bias in selection of reference is obvious. While the last sentence quotes the NCRP and its dislike of linear nonthreshold risk and its use in radiation protection, to maintain balance the ICRP's use of risk factors as realistic estimates (see comment on Appendix C, p. C.2) for radiation protection and their use in ICRP Publications 26 and 37 should also be documented. EPA's policy statement, 41 F.R. 28409 (1976), should also be noted. (113-EPA)

Response

EPA contends that the quotation from NCRP in the final paragraph on draft p. E.1 reflects a bias, in that quotations more favorable to the linear nonthreshold approach to risk estimation could and should have been included. The NCRP quotation was, indeed, chosen because it represented the negative point of view, and it was the purpose of this particular paragraph to reflect that point of view. Most of the rest of the appendix consists of a positive application of the linear nonthreshold approach, with extensive documentation. It seemed only proper that the limitations of the approach be also cited.

Draft p. E.3

Issue

In the discussion of BEIR risk estimates, emphasis is put properly on the range of uncertainty. However, mention is made of the BEIR Committee report that (Reference 1, draft Appendix E), "With this limitation in mind, the Committee considers the most likely value to be approximately 3,000 to 4,000 cancer deaths (or a 1% increase in the spontaneous rate)" (emphasis added). (113-EPA)

Response

EPA contends that, in the first full paragraph on draft p. E.3, reference should be made to the fact that the BEIR Committee, while acknowledging uncertainties, did state a "most likely value" of approximately 3000 to 4000 cancer deaths." The BEIR committee did not define what they meant by a "most likely value". For the proper appreciation of these risk factors, the unavoidable uncertainties should be stressed, not a false sense of certainty.

Draft p. E.3

Issue

The paragraph considered only EPA's Uranium Fuel Cycle documents and states that the risk estimates there continue to be used by EPA. In reality EPA risk estimates have continued to change as new data becomes available. In addition to papers published by staff (e.g., Ellet, Nelson, and Mills, "Allowed Health Risk for Plutonium and Americium Standards as Compared with Standards for Penetrating Radiation," pp. 587-601 in Transuranium Nuclides in the Environment, IAEA, Vienna, 1976), various EPA reports (e.g., A Computer Code for Cohort Analysis of Increased Risks of Death, EPA 520/4-78-012, 1978, or Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment, EPA 520/4-77-016, etc.) show updated risk estimates and how they were derived. (113-EPA)

Response

EPA contends that the risk factors attributed to the EPA in the second paragraph on draft p. E.3 have been superseded by more recently derived numbers, and a more extensive consideration of the various risk factors that have been suggested by the EPA, and by others, could have been included. In any case, the more recent EPA numbers would not have led to different conclusions with regard to the range of values employed in the Statement, as summarized in draft Table E.2 (draft p. E.6).

Draft pp. E.3 and E.5

Issue

EPA's dissatisfaction with the health effects estimates in the Reactor Safety Study (RSS) is documented in Reference 53, draft Appendix E. Recent literature has done nothing to dispel our belief that the use of a dose rate reduction factor is ill-advised as is the minimal plateau duration (30 years) used in the RSS.

The UNSCEAR 1977 Report suggests (except for leukemia) a 50-yr expression period unless the period has been shown to be shorter or longer for a specific cancer (Reference 2, draft Appendix E, par. 12, page 363).

In particular, the two major human cancers associated with radiation, lung and breast, are considered to elevate risk for the duration of lifespan following exposure (C. E. Land, and J. D. Norman, "The Latent Periods of Radiogenic Cancers Occurring Among Japanese A-Bomb Survivors," Late Biological Effects of Ionizing Radiation, 1, IAEA, Vienna, pp. 29-47, 1978; V. E. Archer, E. P. Radford and O. Axelson, "Radon Daughter Cancer in Man: Factors in Exposure-Response Relationships," Health Physics Society Annual Meeting, June 1978).

The dose reduction factor in the RSS report appears to be derived from an analysis by Mays, et al. considering ten sets of animal data from nine studies. If an additional two studies (that happen to show a reverse effect) are included in the analysis, the dose reduction factor becomes 1.7 $\pm$ 0.20 reported by Mays, et al. As UNSCEAR 1977 points out, most of the existing animal carcinogenesis data comes from observations at doses above 50 rads and that each tumor-model system has peculiarities which prevent generalization across multiple organ systems and cancers. See Reference 53 of this appendix for comments on the dose reduction factor in the RSS.

As has been pointed out by Crump, et al. (K. S. Crump, D. G. Hoel, C. H. Langle, and R. Peto, "Fundamental Carcinogenic Processes and Their Implications for Low Dose Risk Assessment," Cancer Res., 36, pp. 2983-2979, 1976): "It is likely that the error in the acceptable dose associated with a simple linear extrapolation will be made less than those associated with species extrapolation to man from the laboratory animal data. The BEIR Report (Reference 16) recommended linear extrapolation on pragmatic grounds. The theoretical conclusions of the present paper are that linear extrapolation to low-dose levels is

generally valid as a realistic yet slightly conservative procedure" (emphasis added). That carcinogenesis by an external agent acts additively with any ongoing process is accepted by Crump, et al. and by Hilberg (Hilberg, A. W., "Low-Level Ionizing Radiation: A Perspective with Suggested Control Agency Options,") in 10th Annual National Conference on Radiation Control, HEW Publication (FDA) 79-8054, pp. 386-391, 1979) in his allusion: "And, conversely because man is living in an environment of chemical additives and pollutants, these may set the stage for action of a very small amount of radiation exposure."

Most of the arguments on the RSS report centered on low dose rate, low LET radiation. Alpha radiation dose response curves are usually characterized as both linear and dose rate independent (BEIR 1972; UNSCEAR 1977) or as possibly providing underestimated effects at low doses (J. Martin Brown, "Linearity versus Non-Linearity of Dose Response for Radiation Carcinogenesis," Health Physics, 31, pp. 231-245, 1976; V. E. Archer, E. P. Radford, and O. Axelson; "Radon Daughter Cancer in Man: Factors in Exposure-Response Relationships," Health Physics Society Annual meeting, June 1978). No reports except the RSS report considers a threshold curve a viable concept. (113-EPA)

Response

In this comment the EPA discusses its objections to a number of aspects of the Reactor Safety Study (WASH-1400), as reflected on pp. E.3 and E.5 of draft Appendix E. Since the Reactor Safety Study represents the conclusions of a respected body of scientists, many of whom were also members of the BEIR Committee, their conclusions deserve to be considered along with those of other experts. Appendix E does not adopt the values of WASH-1400 but merely considers them as part of the input from which the adopted values of Table E.2 are derived.

Draft p. E.4, Table E.1

Issue

A column in Table E.1, headed "Environmental Protection Agency," purports to be the risk estimates used by EPA. They are actually averages for various risk models used by EPA in reports and therefore are not directly comparable to the other risk estimates in the table.

The estimates of 54 leukemia deaths/10^6 person-rem listed in the table were extracted from EPA 520/9-73-003-B (Reference 4, draft Appendix E). As stated in that report (p. A.14), the risk conversion factors are average values for absolute and relative risks in the BEIR Report, 1972. Moreover, they apply only to the dosimetric models used in EPA report 520/9-73-003-B.

RADIOLOGICAL ISSUES

The EPA risk for thyroid listed in Table E.1, 25 thyroid cancer death/10^6 personrem, is referenced to EPA 520/4-76-017 (Reference 6, draft Appendix G). That risk estimate cannot be found in the cited reference. However, on p. 96, ibid., it states"..., a population age weighted value of 60 thyroid cancers per million rems to the thyroid was used." A similar risk estimate is shown in Tables 45 and 46 of EPA report 520/9-73-003-C, Environmental Analysis of the Uranium Fuel Cycle. Part II--Nuclear Power Reactors, 1973. Note that these thyroid risk estimates refer to cases, not fatalities, and so do not fit into Table E.1 (113-EPA)

Response

In this comment the EPA notes certain qualifications on its risk factors as quoted in draft Table E.1 (p. E.4). The only substantive comment related to the value for the thyroid risk factor, which, as the EPA correctly observes, does not appear in the reference given. The number included in draft Table E.1 represented an attempt to translate the EPA "case estimate" as given in the quoted reference, to a "fatality estimate". In retrospect this seems ill-advised and the thyroid risk factor has been deleted, since EPA has not given such a factor in terms of fatal cancers.

Draft p. E.7 and p. E.8, Table E.3

Issue

Newcombe's estimate of ten genetic effects based on a normal incidence rate of 0.1% for autosomal/dominant disorders has not been supported by other studies. Current incidence estimates are about 1% autosomal dominant and X-linked disorders, the estimate in UNSCEAR 1977. (113-EPA)

Response

The genetic effects estimates attributed to the BEIR report and EPA in draft Table E.3 are not comparable to those given in the 1977 UNSCEAR report since they assume a 30-yr reproductive generation time. To compare the BEIR and EPA estimates with those of UNSCEAR, the BEIR and EPA estimates should be multiplied by a factor of about 0.6 to adjust for a 30-yr population generation versus the current, approximately, 50-yr population generation. More recent EPA estimates have been adjusted for the current population generation (Feldmenn 1976), to yield 200 genetic effects, close to the UNSCEAR 1977 estimate.

EPA notes that some of the bases for Newcombe's estimate of a genetic risk factor, as included in draft Table E.3 (p. E.8), are not supported by other studies and have not been accepted by UNSCEAR. The fact that Newcombe's value "has not been generally accepted" is noted, as quoted, in the sentence on overlapping draft pp. E.7 and E.8. Newcombe's arguments still carry weight, however, and deserve to be noted as a responsible view, albeit one which is not employed in the Statement. The EPA also notes in this comment that the BEIR

and EPA genetic risk factors are not derived on the same basis as the UNSCEAR factors and that corrections can be made to eliminate this discrepancy. The same comment could be made for nearly every risk factor quoted in this appendix, but it seemed more appropriate to list the factors as originally reported. The corrections, in any case, would not alter the selection of values in draft Table E.2 and employed in the Statement.

Draft p. E.9, Table E.4

Issue

The column titled "Mays (19)" may contain an error. Mays, et al. (Reference 19, draft Appendix E) estimated 200 bone cancer deaths/10^6 person-rads. Using a Q of 10, this would be equivalent to 20 bone cancer deaths/10^6 person-rem. In a contemporary paper (C. W. Mays, Estimated Risk from ^{239}Pu to Human Bone. Liver and Lung, pp. 373-384 in Biological and Environmental Effects of Low-Level Radiation, Vol. II, IAEA, Vienna, 1976), Mays estimated (again assuming a Q of 10) 20 lung cancer deaths, 20 bone cancer deaths and 10 liver cancer deaths per 10^6 person-rem.

EPA in its guidance on transuranium elements (EPA 520/4-77-016) provided an analysis of the health impact of exposure to transuranium elements in the environment which includes both risk and dose-rate estimates for a cohort of 100,000 exposed since birth. This guidance is supplemented by technical reports, Technical Report EPA 520/4-78-010 and Technical Note CSD-78-1, which provide background information for the basic guidance document. Since the health impact calculated in these reports is based on lifetime exposure and risk coefficients for specific organs, the results are not indirectly comparable with Table E.4 but they are a more realistic estimate of health impact from transuranium elements in the environment. (113-EPA)

Response

The EPA suggests that the bone cancer risk factor of four bone cancer deaths/10^6 organ rem, attributed to Mays, in draft Table E.4 (p. E.9), may be in error. They note that the Mays reference gives a value of 200 bone cancer deaths/10^6 person-rads; and dividing by a quality factor of 10, the EPA suggests that the equivalent factor is 20 bone cancer deaths/10^6 person-rem. They neglect however, to apply the additional "distribution factor", n, which has a value of 5, and reduces the risk factor to four bone cancer deaths/10^6 person-rem, as listed in draft Table E.4. For surface-seeking alpha emitters in bone, 1 rad is equivalent to 50 rem, all doses being considered on an average-dose-to-bone basis. The later Mays paper referenced by the EPA gives the same estimate of 200 bone cancer deaths/10^6 person-rad.

The EPA also calls attention in this comment to its own risk factor for transuranics in bone, as developed for their Proposed Guidance on Dose Limits for Persons Exposed to

RADIOLOGICAL ISSUES

Transuranium Elements in the General Environment. Since this Guidance has appeared only for comment and has not been officially promulgated, it seemed inappropriate to cite it as an official EPA position. In any case, the risk factors proposed by EPA in that document differed only marginally from the Mays factors (e.g., 250 bone cancer deaths/10^6 personrad versus 200 bone cancer deaths/10^6 person-rad).

Draft p. E.10

Issue

Although BEIR, 1972 did not provide a risk estimate for skin cancer, the 1978 Stockholm meeting of ICRP suggested if a skin cancer risk is required, an estimate of one fatal cancer per 10^6 person rem could be used. Averaging the risk estimates in UNSCEAR 1977, the skin cancer incidence is around 0.5 cases per year per 10^6 person-rem; with a 6% mortality this would be about two fatal skin cancers per 10^6 person-rem. The 1977 UNSCEAR Report suggests alpha risk might be higher. (113-EPA)

Response

The EPA correctly notes that, although the BEIR Committee considered numerical estimates of skin cancer risk unwarrented, as quoted on page E.10, data have been published from which such estimates could be derived. While UNSCEAR-77 discussed these data, it did not put forward a single risk factor. The ICRP at its 1978 Stockholm meeting did, as noted by the EPA, suggest a risk factor of one fatal skin cancer/10^6 person-rem, primarily because their weighted system of dose evaluation was logically incomplete without such a number. Although it would be possible to estimate fatal skin cancer incidence employing the ICRP risk factor, the EPA has not suggested that this be done. It seems more instructive to call attention to the general lack of significance of radiation-induced skin cancer than to produce numerical estimates of infinitesimal risk.

Draft Appendix E

Issue

There is no mention of recent findings by the British National Radiological Protection Board or American National Academy of Sciences which were reported in the May 19, 1979 issue of the "London Economist." (104)

Response

Appendix E contains reference to the bulk of recent literature regarding the relationship between radiation exposure and possible latent health effects. It is believed that the material presented is in essential accord with the findings of the American National Academy

of Sciences. It may be noted that Appendix E provides ranges of health effects per unit quantity of radiation received by a population to reflect the range of views of authoratative bodies.

Use of findings from studies of the British National Radiological Protection Board becomes a part of the protection in America both through scientific exchange among individuals and via the International Committee on Radiological Protection.

Draft pp. F.15-17

Issue

Further significance of the pathway parameters used could be demonstrated if referenced to a model radioactivity surveillance program. (43)

Response

Even though null measurements will always be expected, a postclosure monitoring system will probably be established and observed for as long as future generations care to operate it.

The DOE Position Paper to the NRC rulemaking hearings on nuclear waste storage and disposal (DOE 1980a) identifies as a component of one of its performance objectives for waste disposal that active maintenance or surveillance for unreasonable times into the future not be a requirement.

Draft p. N.4

Issue

A reference to NRC/DOT/State surveillance program results would be useful for adding realistic perspective and credibility to the estimates of maximum driver and handler exposure in transportation. See "Summary Report of the State Surveillance Program on the Transportation of Radioactive Materials," NUREG-0393. (208-NRC)

Response

The reference suggested was not included in the final Statement. All the truck driver doses in DOE/ET-0029 and the Statement are based on the conservative WASH-1238 (AEC 1972) estimate.

Issue

The calculations of health effects in the draft understate the credible potential range by about a factor of two on the average because they use the BEIR I (1972) rather than the

RADIOLOGICAL ISSUES

BEIR III (1979) figures for cancer induction from low-dose, low-LET ionizing radiation which have been sex and age factored. (115)

Response

The 1979 draft of BEIR III was withdrawn. NAS released an updated BEIR III report in July of 1980 which indicates that risk estimates of cancer death from low levels of radiation are only half what they were thought to be in 1972 (and as reported in the BEIR I report). The range of conversion factors used in this Statement encompass the values suggested by both BEIR I (1972) and BEIR III (1980).

CONSEQUENCE ANALYSIS

Draft p. 1.6

Issue

The statement, "... it is very probable that integrated nuclear waste systems can be designed to assure that current and future generations of man will not be subjected to undue levels of risk form radioactive wastes, has not yet been established in the report. (218-DOI)

Response

DOE is of the opinion that this particular statement is supported by the body of the document. In preparing the final Statement, efforts were made to strengthen the ties between the material in the text and the conclusions outlined in the Summary.

Draft p. 1.16

Issue

In the definition of risk, "magnitude of the loss" is better expressed as "consequences of the event." This will also make the definition of risk consistent with that used in footnote e to draft Table 1.4 and the footnote on draft page 1.21. (208-NRC)

Response

The DOE believes that there is not a sufficient difference between the two expressions to warrant a change.

Issue

Several letters commented on whether an assessment of the risk of radioactive waste disposal had been performed.

Draft pp. 1.16 and 1.20--We note that a risk assessment requires the identification of a broad spectrum of event probabilities and consequences. It is not limited to worst case consequence assessments as is indicated in draft Tables 1.3 and 1.4. (208-NRC)

The GEIS fails to perform a risk assessment; instead it performs a consequence analysis ("what if" calculation) resulting from four disruptive events. (217)

To multiply consequence times probability to yield a risk and then to say that the risks obtained represent the worst possible risks is not always proper. This is valid only where it has been demonstratively shown that a disruptive event with a lesser consequence but a higher probability does not have a higher risk (that being a product of two numbers) than the risks resulting from the high consequence but low probability disruptive events. The approach of the GEIS in obtaining risks is simply unsound. (217)

CONSEQUENCE ANALYSIS

Risk defined as the product of probability times consequences should be qualified to reflect the possibility of increased public concern where serious consequences are involved. (219)

Response

While risk assessments are not limited to worst cases, only cases believed to be "worst" were analyzed in the Statement. In its presentation, the Statement first outlines the radiological impacts of unintended events from a consequence viewpoint. The frequency of occurrence of the particular event is then identified so that if one desires to determine the expected impact from such an event one may do so. However, the consequences of a given event (in the absence of the frequency of occurence) are certainly an upper bound estimate of the impacts.

Draft p. 1.17

Issue

The difference between "major disasters" and "primary events" is unclear. (34, 208-NRC, 218-DOI)

Response

The breach of a repository by a major disaster has two sources of environmental damage. The first is due to the physical disruption of the landscape by the primary event; for example, crater formation in a meteorite impact or a nuclear weapons strike. A second source of damage is the radiological consequences of a release of radionuclides to the environment. For all disasters considered in this Statement except solution mining, the consequences of radionuclide releases are less than those of the initiating natural disaster.

Draft p. 1.17

Issue

One commenter noted that the uncertainty of geologic prediction does limit the application of risk assessment. If the probability of a certain geologic event occurring is not known, how can a reliable risk assessment be calculated to include the potential impact of such an event. (218-DOI)

Response

DOE agrees. However, if the consequences remain insignificant over many orders of magnitude, then the uncertainty may not be important.

CONSEQUENCE ANALYSIS

Draft p. 1.18

Issue

One commenter requested that the basis for the frequency of stream invasion of a repository should be presented. (218-DOI)

Response

The total probability of release of waste materials from a repository via stream invasion is 4×10^{-15} (for one year). This figure is the product of the following:

- A fault intersection in the repository-4×10^{-11}/yr
- A failure of a waste container-10^{-2}/yr
- Chance of aquifer intersection which leads to biosphere-10^{-2}/yr

The value of $4 \times {}^{-11}$/yr is taken from H.D. Clairborne and F. Gera, 1974, Potential Containment Failure Mechanisms and Their Consequences at a Radioactive Waste Repository in Bedded Salt in New Mexico: Oak Ridge National Laboratory, ORNL-TM-4639.

A more conservative value of 2×10^{-13}/yr for the probability of release of waste via stream invasion (versus 4×10^{-15}/yr) was chosen for illustrative purposes in the draft. Because it is believed that such a value may not be defensible over millenia, a value of 4×10^{-11}/yr was used in this final Statement to assure conservatism.

Draft p. 1.19

Issue

The chemical nature of waste and of the geosphere appears to be largely ignored. Much of the reduction of radiation dose appears to occur as a result of the delay of radionuclides by sorption from the groundwater. The sorption of radionuclides depends on several factors, including the oxidation-reduction state of the nuclide, the presence or absence of complexing or chelating agents, and the nature of the specific geological materials present. In some cases, particularly if large and rather exotic containment canisters are postulated, the ion exchange requirements of the canister materials may be quite significant and might overload the exchange capacity of the media in which the waste was emplaced. (113-EPA)

Response

In some accident scenarios ingestion and use of ground water would contribute to the maximum individual dose. In those cases these pathways were analyzed.

The chemical nature of the waste geosphere is not ignored. Retardation of radionuclides is dependent upon several factors. However, with respect to transport modeling of radionuclides, this Statement utilizes generally accepted modeling techniques. Of course

Sr and Cs have been studied extensively, and as a result their chemical behavior can be modeled quite well in groundwater systems. The same is not true of the other nuclides.

Data is also a problem. Quite simply, available data is usually insufficient to perform this type of modeling with accuracy. What one is left with is the conservative approach. This was the approach taken for the Statement.

Draft p. 1.19

Issue

It would be useful to provide any available risk (consequence x probability) estimates for the transportation accident being discussed. This will allow a comparison to be made with the risks for the other accident scenarios. (208-NRC)

Response

Accident frequencies are given in the accident description tables of Section 6, DOE/ET0028, Vol. 4, and in Section 4, DOE/ET-0029, Vol. 1. The basis for accident analysis is described in Section 3.2 of the final Statement.

Draft p. 1.19

Issue

Several commenters did not agree with the Statement that "...the expected frequency (from a transportation accident) brings the risk to a negligible value." (62, 128)

Response

Risks from transportation of nuclear material, as discussed in this report, are low compared to other societal activities. See Sections 3.4 and 4.8 of the final Statement.

Draft p. 1.19

Issue

The Statement says transportation risks are the same for all options. However, estimates of risk in the tables in the supporting documents do not seem to support this conclusion. (208-NRC)

Response

The text states that the differences in transportation risks are small for all options. A review of these risks indicates that the risks themselves are small. Therefore any difference would also be small or insignificant. See DOE/ET-0029, Section 4 for analysis of risks from transportation.

CONSEQUENCE ANALYSIS

Draft p. 1.19

Issue

A credible event missing from the discussion is the possibility of a water well drilled into adjoining hydrostratigraphic units that could disrupt regional flowlines and equipotentials such that radionuclide migration may be increased. Leakage through overlying aquitards into more permeable units could significantly speed the movement of radionuclides to the biosphere. The pumping well in this scenario would not be pulling radionuclides directly into its cone of depression since most water wells are not at that depth nor would the repository be located in a productive aquifer of potable grade water.

Further, the discussion on solution mining and the missing scenario on deep drilling activities such as natural gas and oil exploration ignore the potential for groundwater hydraulic and pollution effects. (208-NRC)

Response

A case of well contamination has been added in Section 5.5.

Draft p. 1.19

Issue

One commenter pointed out that health effects based on routine operations are not trivial to nonexistant. (62)

Response

Routine operations are defined as accident free situations. In this Statement 100 to 800 health effects are postulated to result for each million man-rem of whole body dose received. The collective dose from routine operations resulted in between 0 and 750 health effects (on a world wide basis for the 250 Gwe growth and decline system).

Draft p. 1.20 Table 1.4, Item 1

Issue

Although the person closest to the repository will be killed, there will still exist a maximum individual who receives the largest dose as a result of the release. (208-NRC)

Response

DOE agrees. However, the maximum individual chosen is a worst case. Since this

individual is killed by the meteorite strike, his dose was not included in the draft Statement. The dose to this person has been added in the final Statement.

Draft p. 1.20, Table 1.4

Issue

(a) The potential for a dose due to airborne dispersion caused by a meteorite impact does not appear to have been considered, (b) the units of "Health Effects," e.g., acute fatalitites, morbidities should be defined, (c) the units of "Risk," e.g., total health effects, health effects per year should be defined, and (d) a description of how "accident probabilities" were arrived at and an associated uncertainty should be presented, e.g., both the probability for meteorite impact and the probability for fault fracture and flooding were given as 3×10^{-13}. Including uncertainty in the estimates of probability is also important since point estimates of probabilities as low as 10^{-13}, are difficult to justify when little data is available. (208-NRC)

Response

For the meteorite-impact scenario, the airborne dispersion was considered (see DOE/ET-0029). Appendix E of the Statement provides a definition of health effects. Derivations of accident probabilities are contained in those sections of DOE/ET-0029 where the accidents are analyzed.

Draft p. 1.20

Issue

One commenter noted that Table 1.4 summarizes the results of long-term radiological impact analyses presented later in Section 3.1.5.2 of the Statement. While ranges in the estimates for health effects are given, there appears little discussion of the uncertainties associated with the stated accident probabilities, particularly for meteorite impact and fault fracture and flooding. The corresponding uncertainties should be fully addressed in this presentation. (168)

Response

There is indeed little discussion on uncertainties associated with probabilities used. The information was not available. It is pointed out that errors in the probability estimate of several orders of magnitude would not suggest a significant mathematical expectation of societal risk (see final Section 5.5).

CONSEQUENCE ANALYSIS

Draft p. 1.20 and 3.1.169

Issue

Several commenters questioned the accident probability used for the solution mining scenario. (30, 40, 58, 142)

Response

The cited probability was arbitrary and has been removed.

Draft p. 1.20

Issue

Several letters commented on the probability assigned to the drilling event.

Draft p. 1.20--The use of 0.005 as the probability of drilling is not understood. (40)

Draft p. 3.1.165--The overall probability of a contaminated drilling event occurring can exceed 0.005, since multiple drilling events over a period of time are possible. (113-EPA, 114)

Draft p. 3.1.165-168--If drilling occurs, probability is 0.005 that interception of a canister occurs. Accident consequences are based on 1/4 canister brought to surface and distributed through top 5 cm (15 cm?) of 0.5 ha. Probability of drilling actually occurring in the area is not given. (154)

Response

The first sentence of paragraph 3, draft p. 3.1.165, states, "Because it is not possible to determine a probability for exploratory drilling it was not possible to assign an overall probability to this event." The probability of any one drill hole striking a waste canister is 0.005 based on areas involved. The text was changed to reflect this fact.

The probability of drilling in the repository is considered unlikely but has not been quantified.

Draft p. 1.20

Issue

One commenter noted there is continued reference to "what if" and "design basis" accidents. The distinctions between these terms are never clearly drawn. (40)

CONSEQUENCE ANALYSIS

Response

The definition of design basis and non-design basis appears in final Section 3.2. The so-called "what-if" accidents are considered to be in the non-design basis category.

Issue

Several commenters questioned the time frames used in the accident analysis, recommending investigations of both earlier times as well as later times.

Draft p. 1.20--It is amusing to see the "summary of estimated long-term radiological impacts of worst case what-if accident scenarios for breach of repository 1000 years after closure" when no one knows how to calculate the likelihood of a nuclear war within, say, the next 20 years. (108)

Draft p. 1.20--It does not seem adequate to restrict the EIS to only 1000 years, when it is dealing with radioactive waste which will not decay for up to several hundred thousand years. (142)

Draft pp. 3.1.165, 168--Basing the drilling and solution mining scenarios on a 1000 year time interval is not defensible and causes significant alteration of the predicted dose consequences. These time intervals should be reduced, preferably to approximately 250 years. (198)

Draft pp. 3.1.165-172--These discussions do not represent "worst-case" scenarios because the intrusions take place 1000 years in the future rather than 500 or 100 years in the future. (114)

Response

The analysis of the impacts of long-term (non-design basis) accident scenarios at a geologic repository was generally performed at four points in time: at year 2,050, +1000 years, +100,000 years, and +1,000,000 years (solution mining was only examined at +1000 years). The occurrence of such events at the time of repository closure is highly unlikely. The use of +1,000 years was to contrast the impacts for shorter surveillance times. The maintenance of institutional control for 1000 versus 100 years was not contended. The later time frames provide additional points of reference with which to view the accident consequences. Examination of additional time periods would yield similar results.

Draft p. 1.20, Table 1.4 and p. 3.1.173, Table 3.1.54

Issue

There were a number of errors and inconsistencies in these two tables. (154)

CONSEQUENCE ANALYSIS

Response

Tables 1.4 and 3.1.54 were removed.

Draft p. 1.36

Issue

The conclusion that long-term radiological impacts are low for the general population was not supported by the text of the Statement. (213)

Response

DOE's position is that the information presented in the Statement relative to radiological impacts does support the conclusion that over the long term such impacts are anticipated to be low.

Draft p. 1.36

Issue

One commenter questioned the statement, "and very few maximum individuals receive significant dose; thus long term risk is not a decisive factor." Does this statement imply that some persons are deemed to be "maximum" and therefore more important than others, or is it misplaced modifier? (213)

Response

The statement was poorly constructed. The use of "maximum" was a case of a misplaced modifier.

Draft pp. 3.1.28, 36, 41, 120

Issue

The subject of occupational radiation exposure is not adequately addressed in the GEIS. It should be considered in connection with short-term environmental impacts and the probability of various accidents occurring during the handling and emplacement of canisters. (208-NRC)

Response

It is believed that additional information on occupational exposure from accidents could strengthen the Statement. Some view EISs as describing consequences to individuals located in the environs of a plant and not to plant workers. Some additional material has

been provided in the final Statement. For example, the exposure that might result to the workforce from a canister drop down a mine shaft followed by a rupture of the canister was developed and presented in Section 5.4.

By and large, protection of the workforce is stressed in other documentation such as Safety Analysis Reports for specific plants.

Draft p. 3.1.41, last bullet

Issue

The use of adsorption coefficients from one set of Hanford subsoils, measured under laboratory conditions, is not an adequate basis for scoping the effect of adsorption. There are some substantial differences between the adsorption coefficients of the Hanford subsoil and of those given on page K-20 of the Waste Isolation Pilot Plant EIS (DOE/EIS-0026-D), for example. (113-EPA)

Response

At the time the work was done the Hanford, or typical western desert subsoil sorption data was the only set of data available for reference.

Draft p. 3.1.64

Issue

One commenter questioned the definition of risk as "the sum product of the magnitude of losses and the probability that the losses will occur." A tendency exists for aversion of high consequence accidents, which would imply a valuation other than a strict probability-consequence product. (113-EPA)

Response

The final Statement refers to the product of probability and consequences (or societal losses) or mathematical expectation of societal risk. This does not include "risk aversion" which is likely to vary from individual to individual. Where first introduced in the text the aspect "non-linearity of risk aversion" is addressed.

Draft p. 3.1.64

Issue

Consequence analysis for any release is the estimation of the effect of that release. It is not restricted to postulated worst cases. (113-EPA)

CONSEQUENCE ANALYSIS

Response

Consequence analysis is indeed not restricted to postulated worst cases. The text was changed accordingly (see Section 3.4).

Draft p. 3.1.67

Issue

Since the long-term behavior of the parameters is uncertain, risk assessment should be based on upper estimate predictions as well as on "reasonable" predictions. (113-EPA)

Response

It should be based on "reasonable" predictions plus an estimation of the uncertainties involved.

Draft p. 3.1.67

Issue

Are the probabilities in the first paragraph best estimate probabilities, upper bound probabilities, or what? (113-EPA)

Response

The probabilities referred to are best estimate probabilities.

Issue

Several letters commented on the probability cited for the faulting and flooding accident.

Draft p. 3.1.67--Uncertainties and the method for determining them should be consistently included with probability and consequence estimates. Although uncertainties are discussed in isolated cases, they are usually not included with point values, e.g., the probability of faulting through the repository is estimated at 4×10^{-11} per year (pp. 3.1.67) with no indication of associated uncertainties. (208-NRC)

Draft p. 3.1.155--The value of 4×10^{-11}/yr for the probability of faulting or fracturing (H.D. Claiborne and F. Gera, 1974, Potential Containment Failure Mechanisms and Their Consequences at a Radioactive Waste Repository in Bedded Salt in New Mexico: Oak Ridge National Laboratory, ORNL-TM-4639) used in risk considerations is outdated and its uncritical acceptance is a major shortcoming of the draft. This is not to say that the values for faulting or fracturing probabilities ultimately used for a site-specific risk assessment will not be some low number such as this, but these probabilities will have to be determined

on a sound basis. Research to do this should be identified in the section on research and development needs. (218-DOI)

Draft p. 3.1.155, last paragraph--This is an improper combination of probabilities. If the probabilities are multiplied together, as has been done here, the result is the probability of all three conditions occurring in the same year. If the probabilities are taken over 10,000 years, for example, the probability of a fault intersecting the repository is 4×10^{-7}. The probabilities of failure of waste containment, or of aquifer intersection, over this period are likely to be one, each. The total probability is therefore about 4×10^{-7}, not 4×10^{-15}. (113-EPA)

Response

The total probability of release, 4×10^{-15} is for one year. The probability discussed on draft p. 3.1.155 is referred to as "total probability" because it is the product of

- a fault intersection in the repository 4×10^{-11}/yr
- a failure of a waste container 10^{-2}/yr
- chance of aquifer intersection which leads to biosphere 10^{-2}/yr

The text was changed to make clear that the total annual probability is being referred to. In order to assure conservation, this final statement uses a value of 4×10^{-11} for the total probability of release for one year and a probability of 4×10^{-7} for the 10,000 year period, as suggested by EPA.

Draft p. 3.1.67

Issue

One commenter noted that the statement pointing out that ^{90}Sr and ^{226}Ra dominate the health effects of a release of radioactivity from a repository needs discussion. (40)

Response

This statement is actually discussing consequence analysis. ^{90}Sr and ^{226}Ra were used as examples. The importance of these nuclides at different times can be found in final Sections 5.4 and 5.5 or in Chapters 4.0 and 9.0 of DOE/ET-0029.

Draft p. 3.1.67

Issue

Several commenters questioned the probabilities in Table 3.1.3.

These probabilities are for purely random events. They are completely in error for non-random events. (30)

The draft states that the Poisson process is used to model the occurrence of geologic events, based on past observation. However, whether this table presents the probability that one event occurs for the "interval" of concern or, more properly, that one or more event occurs during this period is not clear. From $P(\ ) = 3\ (gQ)/x!$, the probability of one or more events occurring is (1 - the probability of zero occurrences) = $(1 - P(0)) = 1 - e^{-gQ}$. This formulation, however, produces somewhat higher probabilities than those listed in draft Table 3.1.3, e.g., for the "number of occurrence years" equal to 10^6 years, and an "interval" equal to 10^4 years, the probability that one or more geologic event occurs is 9.95×10^{-3} as compared to 6.9×10^{-3}. Thus, more explanation of the probabilities in draft Table 3.1.3 is needed. (208-NRC)

Response

The probabilities listed in Table 3.1.3 are for random events. The discussion surrounding the use of this table relates to the possibility of geologic events that would disrupt the integrity of the waste repository. It is agreed that these probabilities would be in error for non-random events. However, it is felt that careful site selection to identify all potential containment failure mechanisms would preclude other than random geologic events with potential to cause a waste repository failure.

Draft p. 3.1.68

Issue

One commenter suggested referencing the model calibration done by J. B. Robertson (1974, Digital Modeling of Radioactive and Chemical Waste Transport in the Snake River Plain Aquifer at the National Reactor Testing Station, Idaho: U.S. Geological Survey Open-File Report (AEC-22054)). (218-DOI)

Response

More recent references were added in the final Statement, Section 3.4.3.2 (Cole 1979 and Robertson 1977)

Draft p. 3.1.69

Issue

The man-caused events listed should be discussed in depth. (114)

CONSEQUENCE ANALYSIS

Response

DOE/ET-0029 presents a more detailed discussion of the release scenarios analyzed in the Statement.

Draft p. 3.1.70

Issue

The last sentence in paragraph 3 contradicts the first two. (218-DOI)

Response

The subject paragraph was deleted from the final Statement.

Draft p. 3.1.71

Issue

It should be noted that all numerical models will require more satisfactory verification on a variety of real field problems before they can confidently be applied to very long-term and large scale prediction. (218-DOI)

Response

DOE agrees with the commenter and would point out that field verification of mathematical models is an on-going effort and is an essential element in repository safety assessment.

Draft p. 3.1.71

Issue

One commenter alluded to the Stone and Webster computer errors in determining piping loads during earthquakes and stated that the computer codes used in the Statement will eventually be shown to be in error. (30)

Response

Modeling of complex systems is approximate at best. Codes are continually being checked and it is hoped that the comment will not prove true to a significant extent in this Statement.

CONSEQUENCE ANALYSIS

Draft p. 3.1.72

Issue

Discuss the relevance of the EPA assessment method cited here. (43)

Response

Discussion of the EPA Assessment method has been deleted from the final Statement.

Draft p. 3.1.73

Issue

The statement--"the uncertainty of risk results from the statistical uncertainty in its models"--should be modified. (40)

Response

The statement has been deleted.

Draft p. 3.1.98 and Appendix I

Issue

One commenter noted that the draft states that "...methods and detailed results for groundwater transport of radionuclides are presented in Appendix I." However, Appendix I contains no detailed discussion of groundwater transport models. That appendix is primarily a discussion of radiological consequences of leaching of waste in a repository. The hydrologic assumptions stated and presumably used in the modeling (which is not discussed) are simple (e.g., constant velocity). (208-NRC) Several commenters stated that there is no discussion of the effects of different hydrologic characteristics, i.e., no sensitivity analysis is given. (208-NRC, 218-DOI)

Response

Draft Appendix I gave references to where detailed discussions of groundwater transport were presented. The limitations of the presentation in the Statement were noted. It is believed that parameters chosen (except perhaps for Kd values) were such that the consequences presented are conservative estimates.

CONSEQUENCE ANALYSIS

Draft p. 3.1.100

Issue

One commenter noted that the probability of a meteor striking an urban area would be at least 1,000-fold greater than striking a (single) repository, based on urban population density of 3,540/km^2 (draft p. 3.1.145) and assuming 70% of the U.S. population in urban areas. If such comparisons are to be made, they should be reasonably accurate. (58)

Response

DOE agrees that the probability of a meteor striking an urban area is many times greater than that of a single repository based on their respective surface areas.

Draft p. 3.1.100

Issue

The destruction caused by a meteorite striking one of our large metropolitan areas is irrelevent to this consideration. We have no control over where a meteorite will fall; therefore, one place is as good as another, and the possibility of a meteorite strike does not become a consideration in the location of cities. The probability that a meteorite will disperse materials from a deep geologic repository is controllable in that the probability of a meteorite large enough to cause disruption as a function of depth and can be reduced as much as desired by going deep enough. (113-EPA)

Response

The first point regarding a meteorite strike in a metropolitan area was given simply to provide the reader with perspective. The second point regarding depth of repository is well taken and the text revised accordingly (see Section 5.5).

Issue

Several letters questioned the analysis of meteorite scenario.

Draft pp. 3.1.100 and 3.1.138--The meteorite scenario does not appear to be a credible event because there are not enough craters of sufficient size to support supposition. (35)

Draft pp. 3.1.138-147--It is not clear why a meteorite should be considered in view of the vastly greater damage the meteorite itself would do (than any dispersed radioactivity). (154)

CONSEQUENCE ANALYSIS

Response

There are "astroblemes" (any scar on the surface of the earth caused by the impact of cosmic body) that have been recorded in Canada and elsewhere that suggest breach by such a mechanism is possible, although very unlikely. The meteorite scenario does serve as an upper bound for the kind of improbable events required to compromise repository containment and disperse radioactive material over large areas. Damage caused by a meteorite strike to the surrounding environment (e.g., nonradiological) are mentioned in the text as being severe, but no elaborations were made.

Draft pp. 3.1.120-123

Issue

The discussion in GEIS under "routine releases of radioactive materials" does not address the problem of radionuclide contamination of ground water and run-off water. This could happen as a result of accidents, clean-up operations in storage rooms, decontamination operations during the retrieval cycle, etc.

In the section titled "Ecological Effects" seepage and water inflow from overlying strata for repositories in granite and in shale are discussed. The estimated inflow of water in a granite repository ranges from 550 to 1550 m^3/day. The estimated maximum inflow during the last stages of operation in shale will range from about 3,800 to 19,000 m^3/day (50,000 gpd) (sic). There appear to be two implications by omission from the discussion:

- No continued water inflow is expected in the repositories in granite and in shale after the last stage of operation.
- No water inflow is expected in the repositories in salt and in basalt.

The generic stratigraphy for salt includes possible aquifers overlying the salt bed. An area of uncertainty in state-of-the-art technology is whether the effects of mining a repository in salt and of the thermal loading are such as to create fractures that would connect the aquifer bed to the repository. TM-36/21 (p. C-1) discounts this in assuming that the permeability for salt remains at zero. No justification is provided. (208-NRC)

Response

With respect to groundwater migration of radionuclides, the impact of operational accidents and normal procedures is negligible compared to the overall repository inventory. The assumptions are that no flow will occur in any repository after final stage. The purpose of the Statement is to address the impact if flow does occur after the final stage.

CONSEQUENCE ANALYSIS

Draft p. 3.1.123

Issue

A common fatal/nonfatal accident rate was used for surface construction activities which seems reasonable. However, a common rate was also used for the underground construction. This rate was derived from underground mining other than coal. To be closer to the truth in this area, the accident rates for more representative industries should be used. For the salt repository, the accident statistics from salt mining and potash mining should be used. For granite and basalt, underground metal and nonmetal hardrock mining is more appropriate, and for shale, use the coal mine accident statistics. (218-DOI)

Response

DOE agrees that the inclusion of this information would be desirable. However, DOE does not believe that such a level of precision is necessary nor that the conclusions of the Statement would be changed if more precise data had been available.

Draft p. 3.1.123

Issue

Provide justification for all the assertions in the discussion of a tornado strike. Specifically, the dimensions of the salt pile, the size of the pieces, the probability of the tornado, its maximum wind speed, the amount of material removed and the resultant concentration in air.

In addition, no reason is given for discussing this accident. Is it the worst nonradiological accident possible, is it the only one considered, or is there another reason for its choice? What about other accidents? No conclusions are presented. Should measures be taken to protect salt piles from tornados? Has a cost-benefit analysis been made? (208-NRC)

Response

Section 3.2 describes the basis for non-radiological accident analyses in the final Statement. Several non-radiological accidents were selected for analysis with potential for off-site consequences. The tornado, striking a salt tailings pile, is considered to be representative of non-radiological accidents at a mining site with potential for offsite consequences. The salt tailings pile at the waste repository is discussed in Section 7.4 of DOE/ET-0028. It is 1 km wide at the bottom, 910 m at the top, 30 m tall and 940 m long. All of the pile would be covered with soil except for parts that are being used. Several days mining volume could be uncovered in a pile 100 m long by 70 m wide and at 18 m high. The size distribution of salt pieces is assumed to be typical of salt in an "as mined" condition. Small sizes would be required to allow mechanical handling of the mine muck.

CONSEQUENCE ANALYSIS

No specific cost-benefit has been done at this time, but if a repository were to be constructed in salt, such an analysis could be expected.

Draft p. 3.1.125

Issue

One commenter noted that the first paragraph should acknowledge redundancy of safety devices for such an obvious hazard as a "drop" accident in a vertical shaft. (58)

Response

Page 3.1.125 of the draft Statement was intended to communicate environmental impacts due to releases of radionuclides in accidents. See DOE/ET-0028 for a complete discussion of accident scenarios.

Draft p. 3.1.125

Issue

Uncertainties in doses predicted by models are misleading. The discussion should indicate the uncertainty to be expected when a critical parameter has a range of values such as the magnitude of earthquake, floods, etc. (208-NRC)

Response

The Statement calculates the dose caused by a natural phenomenon capable of producing the given effect. The range of possible phenomenon intensity is not included.

Draft pp. 3.1.136-172

Issue

In this section several scenarios resulting in the release to the biosphere of large amounts of radioactivity are postulated. Because of the generic nature of the repositories and the lack of specific data needed in the calculation, many of the parameters controlling the physical transport of the radionuclides are not even known to order of magnitude certainty. The resulting dilutions that are used in the dose models have even larger bands. Therefore, breaking down the resulting doses by reprocessing procedure and rock type makes little sense, when the differences between them are much less than the error band due to transport-dose modeling. (208-NRC)

Response

The DOE agrees with the issue statement. One useful purpose of the analysis as presented is to show differences between alternatives for "all else being equal". It also

demonstrated the point suggested, e.g., that the differences between alternatives in terms of radiological impact are insignificant compared to other considerations and uncertainties.

Draft pp. 3.1.136-172

Issue

Section 3.1.5.2 is entitled, "Potential Impacts Associated with Repository Wastes in the Long-Term." Although this section gives population doses caused by different accident scenarios, it does not discuss the problem of land contamination caused by these accidents. (208-NRC)

Response

Land contamination is included in the sense that part of the population doses is derived from crops grown in the contaminated land.

Draft pp. 3.1.136-172

Issue

The section on long-term impacts is devoted entirely to accidents that may breach the repository, most of which are presented as being so improbable that they are unlikely to even occur. No discussion is presented of expected long-term impact. If the facility is sited, filled and sealed according to plan, what will the long-term consequences of this action be in the absence of unlikely accidents? This question is discussed partially in Appendix I, but the discussions are not presented in the text of the GEIS as projected impacts of the action. (208-NRC)

Response

If the repository acts as planned no long-term consequences will occur (aside from small amounts of uplift and subsidence).

Draft pp. 3.1.136-172

Issue

Several letters commented on the selection and classification of accident scenarios analyzed in the draft Statement.

A different classification system than the one used for the long-term accident scenarios in the Statement should be considered. (198)

Releases are estimated for four hypothetical accident sequences. The numbers associated with the releases are presented by the GEIS as "what if" calculations, without

discussion of why these sequences are important except to say that they are "believed most representative" of release events. How these events were chosen and why they are believed to be representative and to bound the impact of long-term consequences should be discussed. (208-NRC)

Response

As described in DOE/ET-0028 and DOE/ET-0029, an umbrella source term concept was used to limit the number of accidents requiring detailed impact analysis. Viewed independently of accident initiation sequences and frequencies, the accident source terms can be grouped by release severity for environmental consequence analyses. Release groups were defined based on similar release pathways, chemical form, accident severity, and isotope types released. The umbrella source term was that accident having the largest release in a particular group of accidents.

The information below lists those postulated accidents (for geologic repositories) examined in this Statement and notes the umbrella source term.

Minor	Umbrella Source Term
LLW drum rupture due to handling error	
Minor canister failure	X
Receipt of externally-contaminated canister	
Dropped shipping cask	
Moderate	
Waste container drop during handling	
Waste package dropped down mine shaft	X
Tornado strikes mined materials storage area	X
LLW drum rupture due to mechanical damage and fire	
LLW drum rupture due to internal explosion	
Non-Design Basis	
Nuclear warfare	
Repository breach by meteorite	X
Repository breach by drilling	X
Repository breach by solution mining	X
Volcanism	
Repository breach by faulting with groundwater transport	X
Erosion	
Criticality	

CONSEQUENCE ANALYSIS

The following definitions of minor, moderate, and non-design basis were used.

- Minor - infrequent events with potential for small material release, major equipment damage, or the creation of radiation fields in occupied zones which could result in occupational exposures exceeding 10 CFR 20 limits (5 rem/yr).
- Moderate - relatively frequent occurrences involving process interruptions with potential for significant release of radioactive or other hazardous materials.
- Non-design basis - events which exceed site criteria.

Site criteria include 1) definition of the maximum credible earthquake, surface faulting, floods, and wind velocities based on historical evidence, local and regional geology, and expert judgement; 2) local and regional demography; and 3) proximity and definition of hazards caused by man.

Draft p. 3.1.137

Issue

The groundwater releases did not appear to include the "two aquifer case," which is most significant for groundwater releases. This case involves a hydrologic connection between two aquifers through a repository, with subsequent groundwater transport. The analysis also appears to consider only release of the total radionuclide content, which does not appear to be a credible or useful form of analysis. (113-EPA)

Response

Such a scenario was added to the final Statement (see Section 5.5).

Draft p. 3.1.137

Issue

Line 7 is the first mention of phosphates. What is the tie-in with salt repositories? (218-DOI)

Response

Phosphates are often found in association with salt deposits as both are the result of evaporate deposition. See also p. 3.1.8 of draft.

CONSEQUENCE ANALYSIS

Draft p. 3.1.138

Issue

References relevant to this discussion and not cited include:

1. K. A. Solomon, R. C. Erdmann and D. Okrent, "Estimate of Hazards of a Nuclear Reactor from the Random Impact of Meteorites," Nucl. Technical, 25. 68 (1975)
2. K. A. Solomon, R. C. Erdmann, T. E. Hicks and D. Okrent, "Estimates of the Hazards to a Nuclear Reactor from Random Impact of Meteorites," USCL-NEG-7426, University of California at Los Angeles (March 1979). (208-NRC)

Response

These were reviewed, but not included in the reference list.

Draft p. 3.1.138

Issue

The presence of salt would probably not preclude the use of the water as a source of food or recreation. The salt would be diluted to acceptable levels by any reasonable amount of water far more quickly than the radioactivity. (113-EPA)

Response

In the faulting and flooding accident large quantities of water flow rapidly through the repository and then to the surface. Once at the surface these waters flow to a larger river in the area. If the assumption is made that salt would not interfere with use of the stream for food and recreation, then the non-salt repository data are applicable. However, the DOE feels that the scenario is reasonable in that salt content would preclude the use of the stream.

Draft pp. 3.1.138-147

Issue

This appears to be based on the Gera, Claiborne paper which contains an error of 10,000. Whether the draft EIS picked up this error is not clear. We have been unable to reproduce the draft EIS results. Our results are lower than the draft EIS values at 2,050, 100,000, and 1 million years but higher at 1,000 years. (154)

CONSEQUENCE ANALYSIS

Response

The Gera, Claiborne paper was not used in a manner that would make any errors in its data applicable to the radiation doses incurred by the public as a result of this hypothetical accident.

Draft p. 3.1.139

Issue

What are the bases for assuming that 10 percent of the particulates suspended are of respirable size? (113-EPA)

Response

Based on the explosive nature of the meteorite impact, a conservative estimate of 10% of airborne material in the respirable size range (<10 μ AMAD) was assumed. This assumption is based on the expected size distribution of all material that becomes airborne as a result of the meteorite strike. Most of this material will be larger pieces of debris.

Draft p. 3.1.147

Issue

A meteorite of the described size would undoubtedly produce a local disaster area. The impact of the meteorite, however, would also disperse radioactive materials into the atmosphere from which they would impact over an extended area. The additional impact of this radioactive material is what is significant. The impact would not likely be local nor be controlled by local monitoring. (113-EPA)

Response

The dose to the population of the eastern U.S. was calculated and presented (see Section 5.5).

Draft p. 3.1.147

Issue

Even for an incredible scenario in which water enters the repository the year it is closed (2050), goes unnoticed, works its way 10 km to a stream where it is used in all possible ways and for which conservative assumptions were used for every parameter, it is shown that society's risk from lightning is 10 million times the risk from this event! At 1,000 years the probability that such a release would go unnoticed is somewhat higher. If this event were to occur at 1,000 years, maximum individual doses are 5 to 10 mrem/year and population doses are about 1% of natural background.

CONSEQUENCE ANALYSIS

This highly important section, if read very carefully, supports the Utilitiy Waste Management Group position - namely, a most conservative bounding calculation of the results of repository breach shows that there are no catastrophic doses. This fact is obscured, however, by

- Simply poor presentation.
- Using 50-yr and 70-yr accumulated doses, the reader sees a relatively larger (70X larger) number than he may be used to thinking of (100 mrem/year background; 3 rem/year occupational dose).
- Going overboard on the bounding. For example, in addition to the somewhat plausible cases of 0.1%/yr and 0.01%/year leaching, cases for the entire (100%) leaching in a single year. Now that is truly incredible and there is no known mechanism by which this could happen. All these calculations are put together in the same tables. The only things people generally are likely to credit are the largest values.

We suggest that the final EIS presentation could be vastly improved by

- Sticking to first-year maximum individual doses with an indication on each table of the comparison to natural background and occupational dose rates.
- Separating the more plausible calculations (unnoticed breach after a few hundred to a thousand years and leach rates in the range of 0.1 to 0.01%/year) from the implausible "bounding calculation" (immediate breach and 100% leached in one year). (154)

Response

The presentation of the date was clarified and simplified in the final Statement. The 50 year doses referred to were adjusted to reflect 70 year-estimates. The bounding condition of 100% leaching in one year was removed for the final Statement.

Draft p. 3.1.148

Issue

The scenario does not appear to be a particularly bad case because of the limitation of the contact for one year. Such a limitation, together with slow leaching, results in a minimal release of radionuclides. What is the effect of continued erosion? (113-EPA)

Response

Final Table 5.5.9 gives 70-yr accumulated dose from continued leaching.

CONSEQUENCE ANALYSIS

Draft pp. 3.1.148-155

Issue

Discuss the reasons for the choice of 2.8 m^3/sec (100 cfs) for water flow through the breached repository. Identify the flow rate of hypothetical River "R" used in transport and dilution calculations. (208-NRC)

Response

The choice of 2.8 m^3/sec (100 cfs) was arbitrary. The flow of River "R" is 120 m^3/sec.

Draft p. 3.1.149 and 3.1.155

Issue

The leach rates presented on p. 3.1.149 require further examination. The long-term leach resistance of the spent fuel is 1 x 10^{-5} g/cm^2/day and times a fracture factor of 5 equals 5 x 10^{-5} g/cm^2/day which is lower than the 10 x 10^{-5} g/cm^2/day for vitrified high-level waste. There is no physical evidence to support a lower leach rate for spent fuel. (198)

Response

The leach rate figure of 10 x 10^{-5} g/cm^2/day presented for vitrified high-level waste was a typographical error. The information in the table should have been presented as follows:

Leach rate	Time
1 x 10^{-4} g/cm^2/day	first 10 days of leaching
1 x 10^{-5} g/cm^2/day	remainder of time

See also response below.

Draft p. 3.1.149

Issue

A leach rate of 10^{-4} g/cm^2/day, applied to a one centimeter cube of density 2, would result in a leaching rate of 3 x 10^{-4} per day, or approximately 0.1 per year. Is this the value that was used in the analysis? (113-EPA)

CONSEQUENCE ANALYSIS

Response

Actual leach rates for HLW in glass used were

$1 \times 10^{-4} g/cm^2/day$ - for first 10 days of leaching
$1 \times 10^{-5} g/cm^2/day$ - for remainder of time

This is equivalent to approximately 1% loss of material contacted per year by leaching assuming a density of waste in glass as 3 g/cm^3.

Draft p. 3.1.149

Issue

What is the source of the listed leach rate ($1 \times 10^{-4} gm/cm^2/day$) for intermediate level and low-level waste? What waste forms are involved? (218-DOI)

Response

The values listed for intermediate-level and low-level wastes are unpublished concensus judgments of senior individuals at Battelle-Northwest Laboratory. Another individual believed that $1 \times 10^{-3} gm/cm^2/day$ was more appropriate for wastes solidified with cement. In terms of radiological impact intermediate-level and low-level wastes are not significant in comparison with high-level wastes.

Draft pp. 3.1.150-155

Issue

The annual doses to a maximum individual associated with the breach of a salt repository are three to ten times the permissible annual dose for occupational exposures...Thus the calculated number of health effects attributed to this accident would range from 1×10^4 to 3×10^5.

GEIS goes on to multiply these figures by 1/100 as the probability of failure of waste containment and by $4 \times 10^{-11}/yr$ as the probability of a new fault intersecting the repository to arrive at insignificant risk levels. The probability of an existing fault becoming permeable should also be considered. (208-NRC)

Response

The case presented was felt to be sufficient; site-selection criteria are expected to preclude the presence of existing faults. (However, see also EPA's comments regarding probability of interaction with water).

CONSEQUENCE ANALYSIS

Draft p. 3.1.155

Issue

Values for southeast New Mexico should not be used in a generic Statement. Certainly faulting rates of 10^2/yr typical of the San Andreas system could be avoided. A reasonable, "conservative" upper bound for this analysis might be 10^{-4}/yr. The discussion on p. 3.1.156 would then conclude that the risk from repository breach by faulting and flooding would be no greater than the risk from lightning, assuming the rest of the analysis is correct -- not definitely seven orders of magintude. (218-DOI)

Response

DOE assumes the commenter was referring to a faulting rate of 10^{-2}/yr (as noted in the draft) as opposed to 10^2/yr. In addition, DOE would agree that the rate used is an ultra conservative one. However, the consequence analysis is generally based on such conservatism. The fault rate identified was documented in the draft Statement as referring to work done in the Delaware Basin.

Draft p. 3.1.157, Table 3.1.42

Issue

Dose commitments of 10^8 person-rem are estimated to result in 2 x 10^4 fatal cancers. The risk associated (including the probability) is much less. (113-EPA)

Response

The DOE agrees that the risk associated with the accident (including probability) is much less; this is addressed in Section 5.5.

Draft p. 3.1.158

Issue

Provide a reference for ten dilution factors given and discuss the cause of the 50-fold differences shown. (208-NRC)

Response

The data were derived from Hanford Annual Environmental reports, which represent several years data. The differences in dilution factors are due to the adsorptive qualities of certain elements when in contact with suspended river sediment. Those elements with dilution factors of 100 are deposited in river sediment and do not reach the estuary. Others such as ^3H, reflect only the increased river flow rate between the release point and the estuary.

CONSEQUENCE ANALYSIS

Draft pp. 3.1.160-161

Issue

One commenter noted that the special parameter choices for migration length and ground water velocity would effect the calculations. When all waste is leached in one year (in the faulting scenario) the assertion that the 50-year cumulative total body dose is at most 1 to 3 times occupational limits does not make sense. (40)

Response

The consequence analysis of groundwater transport employed a very restricted set of parameters. This was not by choice but what was available to use within the time allowed.

The scenario of all waste leached in one year was removed.

Draft p. 3.1.161

Issue

The release rates used in the groundwater transport analysis in the main body of the report jump strangely from 100%/yr to 0.1%/yr. The base case should clearly be for the low rates, but results for intermediate release rates should be presented. The consequence analysis should consider solubility limits of the various radionuclides in the groundwater system under consideration; the present analysis assumes varying source terms for nuclide transport, some of which may not be physically possible. (218-DOI)

Response

The bounding condition of 100% leaching in one year was removed in the final Statement (see final Section 5.5).

Draft p. 3.1.162

Issue

Distribution of the waste would lower the maximum and regional individual doses, but would increase the probability of the event by a factor equal to the number of repositories. (113-EPA)

Response

DOE is in agreement with the comment; the mathematical expectation of societal risk would remain unchanged.

CONSEQUENCE ANALYSIS

Draft pp. 3.1.165-168

Issue

Several letters noted that the repository breach by drilling accident assumes that drillers working in an environment where salt could be expected, and who are looking for salt, will assay samples which are not salt. If drillers are looking for salt, they do not need an assay to determine its presence and will not burden themselves with the additional cost of assays. This entire section then is based on an assumption which is not realistic. (114, 214)

Response

While it may be unnecessary for drillers to determine that they have reached salt, analysis would probably be required before purification would begin.

Draft pp. 3.1.168-172

Issue

One commenter noted that the solution mining accident is limited in scope and duration and assumes people 1,000 years from today possess today's radiation technology. (114)

Response

The final Statement notes (in Section 5.5.5) that other solution mining calculations have obtained results of somewhat larger doses that those presented in this Statement. Although possible, it is not believed realistic that people living 1000 years from today will possess technology equivalent to or in advance of today's.

Draft pp 3.1.168-172

Issue

One commenter noted that the consequences of solution mining of contaminated salt are stated in terms of man-rems. More detailed information should be given as to whether this is a whole-body dose, thyroid dose, etc. (166)

Response

In each of the accidental breaches of a repository, the whole-body dose was calculated and the health effects postulated to result were given.

CONSEQUENCE ANALYSIS

Draft pp. 3.1.168-172

Issue

Even on the basis of incredibly pessimistic assumptions the accident caused by solution mining in a salt repository is shown to have negligible consequences. In this case we find somewhat higher values than the draft EIS. Is it possible that the decontamination factor referred to on p. 3.1.171 was applied? (154)

Response

The decontamination factor was not used.

Draft pp. 3.1.179-192

Issue

The potential hazards of storage and transportation of radioactive waste did not include justification of the accident frequencies (the number of occurrences over a given time period) that were used. (40)

Response

Basis for the analysis of predisposal activities, including accident frequencies, are detailed in the support document DOE/ET-0028. DOE/ET-0054 (DOE 1978a) also contains an analysis of storage and transportation of spent fuel.

Draft p. 3.1.200

Issue

Several commenters noted that more complete analysis should be performed on the potential for accidents during storage and transportation of PuO_2.

Statement is made that "no accidental release of radioactive material is postulated for shipments of plutonium oxide." DOE has achieved perfection. No accidents with plutonium oxide in transportation will occur. (30)

There is a very brief discussion of a criticality accident in a storage facility for plutonium oxide. If anything, this treatment is even less convincing than the others. The suggestion is made that 200 grams of stored plutonium oxide would reach the atmosphere in the worst criticality accident. As you know, this is a very large amount, biologically speaking. But the progress of such an accident is never discussed. Rather it is claimed that the maximum 70-yr total body dose commitment to any individual would be 75 millirems. Similarly, these paragraphs imply that no accident analysis has been done for a surface storage facility for plutonium oxide. (40)

CONSEQUENCE ANALYSIS

Note the assumption that "no accidental release of radioactive material is postulated for shipments of plutonium oxide." (154)

Response

If a future national policy decision leads to the reprocessing of spent fuel and the recovery of PuO_2, PuO_2 will not be considered a nuclear waste but a resource.

The impacts of handling PuO_2 have been considered by the Department and its predecessor agencies in other environmental statements (ERDA 1976a) and by the Nuclear Regulatory Commission in its proceedings on GESMO (NRC 1976a). Further consideration of the impacts of PuO_2 storage and transportation would be covered in any reopening of the GESMO proceedings. Recognizing the in-place mechanisms to ensure radiological safety and safeguards, no credible accidental release of PuO_2 was envisioned.

Draft p. 3.1.212

Issue

On p. 3.1.212 is the apotheosis of this EIS approach to risk. It is asserted that in case of theft or sabotage, the risk to society will be small if any of the contributing probabilities or consequence are small. This is a revealing claim. Just such logic has always been used in evaluation nuclear risks over the last 20 years. What is implicitly being asserted is that no matter how large the consequences of a particular event may be, if the probability is sufficiently small the risk to society is negligble. It may be that society should take that view, but those who believe in it should be prepared to offer justification (including definitions of "small" and of what constitutes an appropriate estimation procedure). (40)

Response

The definition of risk used in this Statement is the probability of an event times the consequences of that event. Using this definition, events with relatively large consequences and small probabilities have low risk. Mathematically low risk level is not meant to imply risk acceptability. This is an issue to be decided in the regulatory and public hearing process. The revised Statement format includes a section on the discussion of risk perspective. See Section 3.4 for comments on risk.

Draft Appendix I

Issue

Appendix I discusses the possibility of release of radionuclides to the biosphere through groundwater mass transport. The impression given is that container life will be

about 1,000 years and that no significant release is expected for one million years. This is in apparent contradiction to results given in TM-36/21 (pp. xiv, 8.5 and 8.6). What is the expected rate of corrosion of the canister and the sleeve in salt brine or in fresh water? What are the values (or ranges) of effective hydraulic conductivity, porosity, retardation factors and hydraulic gradients of the rock mass surround the repository that were used to obtain Tables I.1 to I.12? (208-NRC)

Response

This was intended to be a parametric analysis and actual container life was not given. The commenter may have misunderstood the term "release". In some cases, no significant releases to the biosphere may occur for a million years.

Draft Appendix I

Issue

This appendix is deficient. It is based on leaching of the entire repository by ground water, passage of nuclides through a rather freely flowing aquifer, and discharge into a large surface stream (10,000 cubic feet per second or 8.9×10^{12} liters per year). If we apply the generic density of population in terms of river flow from our forthcoming dose assessment report, which is 3.3×10^{-7} person years per liter, the river is capable of being a water supply for about three million people, a great many of whom would receive close to the maximum individual dose. (113-EPA)

Response

The R river in the reference environment supplies about two million people which is close to the three million as estimated above using a generic population density. The drinking pathway is the only pathway of exposure. In the dose distribution a large fraction of the down stream population might receive nearly that dose received by the maximum individual. In another groundwater scenario a ratio of 1/5 was determined between the maximum individual and the per capita dose.

Draft Appendix I

Issue

An apparent conflict exists between the basic assumptions in the main text and Appendix I. The main text stated that "....disposal in salt has been emphasized..." (p. 3.1). However, the assumptions made in Appendix I (p. I.9) for an earlier analysis (which was the basis of the current version of the Impact Statement) assumed that the repository is in a non-salt media. Furthermore, some of the details of the model should be briefly summarized in the appendix. The statement "Detailed descriptions of these models

are found in references 1-7" (p. I.4), is not sufficient. GETOUT (p. I.10) should be briefly discussed as well. (113-EPA)

Response

There is some confusion as to the basis for the analysis in the Statement. The material of Appendix I was extracted from an earlier report but the methods of Appendix I were used for the slow groundwater transport analysis. No emphasis on geologic media was intended. Contamination of an aquifer by salt may preclude use of the aquifer for domestic purposes.

Draft Appendix I

Issue

The criterion for public acceptability of 120 millirems per year to the maximum individual is not defensible, and population dose needs primary consideration. If the approximately three million people who could be supported by the river were each to receive 120 millirems per year, the population dose would be 350,000 person-rems per year or approximately 70 health effects per year using the BEIR-whole body estimate. Although all the postulated three million people would not receive the maximum individual dose and although these nuclides would not produce whole body doses, there is no reason to believe that the concentration of nuclides in the river would decrease substantially as the nuclides moved down river. (113-EPA)

Response

Although the suggested scenario results in 70 health effects/yr which relates to 7×10^5 health effects over 10,000 years the probability (using EPA's value of 4×10^{-7}) reduces the mathematical expectation of societal risk of less than one health effect over 10,000 years. Regardless, the criterion stated was developed for a referenced report. DOE agrees that population dose from the events considered here should be controlling.

Draft Appendix I

Issue

The analysis uses unquoted sorption equilibrium constants. These are probably the Battelle desert soil values which may be unreasonably high. The text on p. I.6 refers to "three miles of western U.S. subsoil," which is reminiscent of the Battelle "desert soil." These sorption constants are not necessarily typical of all soils and rocks and, in any case, should be listed in tabular form. (113-EPA)

CONSEQUENCE ANALYSIS

Response

References at the end of final Section 5.5 contain the information the commenter requests.

Draft Appendix I

Issue

Just as it is improper to neglect population dose in the river, it is improper to neglect individual dose to users of groundwater. This is completely omitted in this section. Since the ground water velocity is stated to be equal to one foot per day, or a little over 100 meters per year, the aquifer would be expected to be a good water provider and comparable to the aquifer of draft Appendix F which is stated as supporting "numerous shallow wells supplying residences and farms" and also a "public water supply well" for a city. Population dose from use of the aquifer may very well be significant in addition to individual doses. (113-EPA)

Response

An additional case involving a well intersecting a contaminated aquifer has been added (see Section 5.5).

Draft Appendix I

Issue

We believe the comprehensive model used in the safety analysis is not applicable on a generic basis. The modeling efforts of H. C. Burkholder and his colleagues at Battelle are pioneering and commendable. However, in Appendix I the assumptions used in the model analysis are clearly spelled out on page I.9. Among these assumptions are a) that "the repository is located in a non-salt formation surrounded by a geology with nuclide retention properties similar to those for a particular Hanford Reservation subsoil"; and b) "the groundwater flows into a surface stream with a flow rate of 10,000 ft^3/sec (1/10 the flow rate of the Columbia River near the Hanford Reservation) where the nuclides are further diluted." This flow is equivalent to the average flow of the Delaware River at Trenton. With these and other simplifying assumptions, the model predicts a benign outcome. However, the problems are multiple.

First, although dilution of the radionuclide-bearing groundwater by a 10,000 ft^3/sec river is one plausible scenario for radwaste dissolved in Hanford ground waters, a 10,000-fold concentration might occur in other environments, for example, in areas where groundwater flow is toward marshes or wet playas. Second, what is the dose to man if the groundwater were tapped by a future town well-field upgradient from discharge into the river? Third, the Kd values for Hanford subsoil are unlikely to be applicable to fractured media.

CONSEQUENCE ANALYSIS

Briefly, the model is acceptable for one HLW scenario in Hanford alluvium. It is unacceptable for other scenarios at Hanford, and certainly unacceptable for any other rocks and waste types. Therefore, the seemingly comprehensive tables comparing health effects from radwaste disposal in salt, granite, shale, and basalt are difficult to justify. The draft EIS itself in several places follows the IRG in emphasizing the importance of site specific studies. We suggest the presentation of considerable numerical data in Section 3.1.5.2 is not warranted; this should be resolved in the final Statement. (218-DOI)

Response

Modeling of groundwater migration is indeed limited because of the choice of parameters. As suggested, less emphasis has been put on the analysis. An attempt to circumvent this problem was the introduction of a flooding and large stream flow scenario. This too is of limited use. In addition, a contaminated well scenario has been added.

Draft p. I.1

Issue

One commenter raised questions on the following statement: "...the geologic repository system provides two potential means of protection from radioactive waste. The first means is containment of the waste for a sufficient length of time for the hazardous nuclides to decay to innocuous levels such that unrestricted release to the environment presents no radiological hazard. The second means is to limit the rate of release of nuclides to the biosphere such that their concentration in the constantly renewed local surface water and air never exceeds acceptable limits. The actual repository system will provide protection using some effective balance of these two means."

What do the terms "innocuous levels," "acceptable limits," and "effective balance" really mean? These should be quantitatively defined. This statement indicates that a geologic repository system may be designed to include planned releases to surface water and air. Evidently the authors still support the archaic idea that the solution to pollution is dilution. (97)

Response

Such expressions as "innocuous levels," "acceptable limits" and "effective balance" have been, by and large, removed from the final Statement in favor of more meaningful language.

CONSEQUENCE ANALYSIS

Draft p. I.2

Issue

The discussion of compensating for a poor site by an extremely durable waste container in the last paragraph of page I.2 is irrelevant, since human intrusion cannot be ruled out. (113-EPA)

Response

The paragraph cited relates only to compensation in outcome from one release scenario as a function of variation in parameters.

Draft p. I.3

Issue

The concentration on individual dose rather than population dose is again shown in the fourth paragraph on p. I.3 which speaks of reducing the ^{129}I dose by a factor of 10 by reducing the release rate by a factor of 10. Population dose would not be changed. (113-EPA)

Response

The analysis dealt with in Appendix I and publications in which it was based concerned the maximum individual. It is agreed that population doses should be considered and in the reference statement the collective population dose would not be changed.

Draft p. I.3

Issue

The leach rate figures used throughout and specifically in Figure I.3 are unrealistically low. The "hypothetical waste management system characterization" is about a factor of 10 better than the values we have been given by our consultant, Arthur D. Little, Inc., and contrast strongly with the estimate of the EPA geologist panel: "There is no evidence that incorporation into a glass will ensure resistance to significant leaching over time scales over a decade." (EPA 520/4-78-004 page 7). (113-EPA)

Response

The referenced EPA report, EPA 520/4-78-004, by the Arthur D. Little, Inc., seems to disagree with other investigators in the field. Furthermore, the values in draft Figure I.3 are based on leach data obtained in the lab and in the field which appear to span the

rates to be expected in a repository. One of the possible shortcomings of the values in draft Figure I.3 is that they are determined for unfractured monolithic cylinders of the various glasses.

Draft p. I.7

Issue

Draft Figure I.4 appears to require a leach time of 100,000 years for "satisfactory" (less than 120 millirems per year) operation. This may not be possible for all contained nuclides, since some nuclides are geochemically mobile. (113-EPA)

Response

A confusion of terms appears in this comment. If the commenter refers to time when a nuclide is discharged to the biosphere, then a 100,000-yr water travel time is not unrealistic. By dating methods groundwater has been shown to be millions of years old.

Draft p. I.10

Issue

The notion that the dose from ^{226}Ra can be reduced by limiting the leaching of ^{238}U is incorrect. That ^{238}U migration could be controlled over its half-life (4.5 billion years) is doubtful.

We believe that the impact analysis is in a premature stage in this section. The analyses stated in Appendix I are divided into two categories: past work and present work. Since the present work is only partially complete, the results presented in the Statement may be revised when the present work is completed. This may change results in the stated conclusions in the Statement. We believe the present work should include an error analysis and sensitivity analysis.

All the references to this appendix are from Battelle Pacific Northwest Laboratories work. Has any of this work been performed elsewhere? (113-EPA)

Response

There was no suggestion in Appendix I that ^{238}U could be contained for 4.5 billion years or more. Radon-226 is a relatively short lived daughter of ^{238}U. In many systems Ra is less mobile than U. Furthermore, in most cases analyzed up to date, Ra is released to the biosphere only because it is a daughter of a long-lived parent. Therefore, the Ra dose can be very sensitive to ^{238}U leach characteristics.

As noted in final Appendix L much of the work done with respect to nuclear waste management has been conducted by Battelle Pacific Northwest Laboratories (PNL). With respect

to nuclide mobility in geologic media, again much of the work has been either conducted by or subcontracted by PNL.

Draft pp. I.11-15

Issue

The assumptions used in formulating the computer models and the variables utilized to generate the data should be fully explained and qualified. (97)

Response

DOE does not feel that such information is appropriate for inclusion in this Statement because of bulk considerations.

Draft Appendix L

Issue

One commenter questioned whether accidental releases by means other than sabotage had been considered. (113-EPA)

Response

Releases from high level liquid waste solidification and fuel residue packaging facilities are not limited to those of sabotage. Operational accidents can release small amounts of radioactive material to the environment. Accidents for predisposal waste treatment operations are discussed in Section 4.8 of this final Statement.

Draft Appendix M

Issue

The accidents leading to releases of radionuclides (Tables M.3 and M.8) are not characterized, so it is impossible to understand what is involved. The basis for release of 0.1% of total ^{85}Kr (p. M.52) is not given. The total releases of 22 Megacuries of ^{85}Kr should be compared with the permissible 40 CFR 190 values. There is no consideration of possible radionuclide releases from accidents in a spent fuel storage facility in Table M.52. There is some discussion in Table M.61 but there is no basis for judgement as to the releases or selection of accidents. For example, there is no discussion of the effect of loss of coolant in water basin storage through failure of the tank or through sabotage.

Note also that the risk estimates, pp. M.6, M.33, M.53, M.81, M.87, etc. will require revision if numerical risk coefficients are changed since all are derived from the risk coefficients developed in Appendix E. (113-EPA)

CONSEQUENCE ANALYSIS

Response

The format for this environmental impact statement does not include a detailed description of potential accidents for each waste treatment and storage technology. Individual accidents are described in DOE/ET-0028. Section 5.1 of that report discusses the storage of high-level liquid wastes. Section 5.2 discusses the storage of fuel residues.

The release of ^{85}Kr discussed on page M.52 of the draft Statement is due to anticipated leakage from the pressurized storage cylinders. Large cylinder failures also contribute to this number. The total ^{85}Kr release of 2.2×10^7 curies over 30 years is less than that allowed in 40 CFR 190. Up to 50,000 curies per Gigawatt year of electrical generation is allowed in that regulation.

Accidents related to spent fuel storage are discussed in Section 4.8 of this final Statement. Further discussion is given in Section 5.7 of DOE/ET-0028. The basis for accident analyses in this Statement is discussed in final Section 3.2. Sabatoge was not considered in the development of accident scenarios. Credible loss of coolant accidents in the water basin storage of spent fuel, including tank failures, would result in no significant releases to the spent fuel facility.

Draft Appendix N

Issue

The largest accident consequences presented in the GEIS occur during the transportation of radioactive wastes. Much of the detailed analysis is contained in DOE/ET-0029 as stated. An examination of these two documents reveals that accident release fractions, curie amount of isotopes that may be released, and doses to affected individuals are provided. However, some important details concerning accident assumptions are not given. These detailed assumptions involve the fraction of released material that is aerosolized in respirable form. Also missing are resuspension factors. In Appendix B, DOE/ET-0029, reference is given to other reports and computer codes that may contain these factors. These assumptions need to be outlined directly in DOE/ET-0029 so that factors in the degree of realism of the accident analysis can be more easily evaluated and the conclusion compared to other study results. (208-NRC)

Response

It was assumed that 100% of the released material was airborne and respirable. Resuspension factors were not used. The release was assumed to last the length of time given for each accident. Released material was calculated directly as the product of release fraction times inventory. Additional information can be found in DOE/ET-0028.

CONSEQUENCE ANALYSIS

Draft Appendix N

Issue

Our comparison of the impacts presented in the GEIS with those in DOE/ET-0029 examined spent fuel shipment only. In converting results from one document to another, several errors have apparently been made. The remaining transportation sections in Appendix N should be similarly reviewed for errors. (208-NRC)

Response

Errors in impacts presented in Appendix N were found. These errors were corrected for the final Statement.

Draft Appendix N

Issue

Throughout Appendix N, the total body radiation dose from the routine transport of radioactive materials is given in various tables. These tables show the dose to the population residing along the transport route and to members of the transport work force. The tables omit the dose to occupants of vehicles using the same route in the case of truck transport. It is not clear whether the dose that results from a delay in transit of the radioactive shipment has been included. These delays could occur from a traffic jam or a stop at a truck stop in the case of truck transport. For rail transport, a delay can be caused by adverse track conditions of a mechanical breakdown. (208-NRC)

Response

Vehicle occupant doses are given in each appropriate section of DOE/ET-0029. Transit delays are accounted for in the assumed average velocity of each shipment. Doses in man-rem are unchanged if the vehicle moves in spurts or continuously as long as the total travel time is unchanged.

Draft p. N.4

Issue

The transportation accident consequences presented on p. N.4 of the GEIS are based on accident number 6.2.8 described in Table 6.2.6 of DOE/ET-0028. Releases of cesium are based on vaporization mechanisms as reported in Supplement II to WASH-1238. A study conducted by Battelle's Pacific Northwest Laboratory, "An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck," PNL-2588 indicates that other mechanisms can cause additional releases of cesium and other isotopes. These mechanisms involve either oxidation or leaching of the fuel. Releases of radioactive material resulting from these mechanisms can occur

in addition to the releases used in accident number 6.2.8. The probability of accidents occurring where several release mechanisms operate is less than the probability associated with accidents where only a few release mechanisms operate. Thus the risk may be greater for the latter accident than the one involving many release mechanisms. Recommend the GEIS address these accidents that involve several release mechanisms and show that either the risks involved are less than those of accident number 6.2.8 or if the risks are greater, this more severe accident should be used as the umbrella source term for severe accidents. (208-NRC)

Response

An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck (PNL-2588, Elder et al. 1978 in reference list) was not available at the time of the writing of DOE/ET-0028. Available literature at the time, primarily WASH-1238 (AEC 1972), stated that a vaporization release of cesium was the most likely mechanism for the release of radionuclides from a spent fuel accident of the type considered in this EIS. Other mechanisms for radionuclide release may exist, but they are either small compared to those used in the present Statement or require cask failures in excess of the design basis accident spectrum. PNL-2588 (Elder et al. 1978) and DOE/ET-0028 agree that cesium is the largest contributor to consequences from accidents involving overheated fuel with a small breech of the cask wall or penetration.

Draft p. N.4

Issue

Although the radiation dose to the maximum individual from postulated accidents are given, the total population dose to persons in the vicinity of the accident is not given. Since this is an important environmental impact, it should be included in the GEIS in context with accident frequencies.

The actual value for this population dose can be found on p. 4.1.10 of DOE/ET-0029. The 70-year dose commitment is given as 140 man-rem. Although the analysis uses a population density of 90 persons per square km for routine radiological impacts, the population density used for the accident analysis is 130 person per square km. Note that population densities in suburban or urban areas can be at least an order of magnitude higher than this population density. A severe accident occurring in a suburban or urban area would, therefore, have a substantially greater environmental impact than the accident consequences presented in the GEIS. In order that all relevant impacts be included in the GEIS, recommend including the consequences of severe accidents in high population density areas.

The largest accident dose reported in the GEIS results from a severe accident involving a rail shipment of spent fuel. The resulting whole-body dose to the maximum individual is given as 120 rem for a one year period following the accident. The dose is based on the

amount of radionuclides released to the atmosphere as given in Table 4.1.1-12 of DOE/ET-0029. The amounts given in this table are based on release fractions given in Table 6.2.6 for accident number 6.2.8 in DOE/ET-0028. An examination of the release fractions and cask inventories given in DOE/ET-0028 indicates that the amount of radionuclides given in DOE/ET-0029, and hence the dose reported in Appendix N, are in error. There are three sources of error. Mixed fission products and actinides have been excluded from the release, the amount of ^{85}Kr released is underestimated, and the amount of ^{137}Cs released has been overestimated.

Finally, the following discussion shows that the amount of ^{134}Cs and ^{137}Cs released for accident number 6.2.8 has been overestimated. The discussion on page 6.2.14 of DOE/ET-0028 indicates that 6×10^{-4} of the cesium inventory may be available for release as a result of fuel rod perforation in a high temperature environment. This result is taken from Supplement II to WASH-1238. According to Table 6.2.6 of DOE/ET-0028, the availability fraction is divided in half between ^{134}Cs and ^{137}Cs. Table 3.3.8 of DOE/ET-0028 shows a cask inventory of 1.7×10^5 curies and 9.4×10^4 curies per MTHM for ^{134}Cs and ^{137}Cs, respectively. Since a cask contains 4 MTHM, this results in 6.8×10^5 curies of ^{134}Cs and 3.8×10^5 of ^{137}Cs in a cask. Applying the availability fraction of 3×10^{-4} for each isotope yields 204 curies of ^{134}Cs and 114 curies of ^{137}Cs available for release. Since in accident number 6.2.8, 50% of fuel rods are perforated, this results in 102 curies of ^{134}Cs and 57 curies of ^{137}Cs being released in this accident. Table 4.1.1-12 of DOE/ET-0029 shows 200 curies of ^{134}Cs and 110 curies of ^{137}Cs being released. Perhaps the fact that only 50% of the rods are perforated was not taken into account.

We recommend that the radiation dose to the maximum individual resulting from this accident be reevaluated in light of the above comments. (208-NRC)

Response

This comment raises three main issues. First is that population doses have been omitted from the discussion of severe accidents in the draft Statement. Second, population densities used to evaluate radiological consequences of spent fuel accidents are inappropriate for accidents in urban areas. Last, release fractions used for a severe spent fuel accident are in error. Each of these issues is discussed below.

The format used in the final Statement to discuss consequences of predisposal accidents presents both maximum individual and population doses from umbrella source terms. A definition for umbrella source terms is given in Section 3.2.7 of this report. Transportation accident impacts are described in Section 4.8.1.

The population density used for accident consequence analysis is 130 persons/km^2 and is based on an average of populous U.S. regions. Population doses vary approximately linearly with population density. It higher population densities are assumed, high doses would result. Current interim NRC rules prohibit the transport of spent fuel through highly populated areas.

CONSEQUENCE ANALYSIS

Three sources of error are identified in the discussion of the release fractions. The first is that releases of mixed fission products and actinides have been omitted. WASH-1238 (AEC 1972) states that actinides available for release in the pellet-clad gap would be negligible compared to other nuclides. Mixed fission products were conservatively assumed available for release due to leaching of fuel pellet surfaces. The leaching mechanism could only occur if clad failure occurs before the loss of cask coolant. This is not the case in Accident 6.2.8 (DOE/ET-0028). Actinide and fission product releases from the fuel may be possible following an impact that disrupts the fuel pellets and cladding. Accident 6.2.7 in DOE/ET-0028 discusses this possibility.

Second, this comment states that the amount of ^{85}Kr released is understated by Table 4.1.1-12 of DOE/ET-0029. The stated value in the table is low by 400 Ci of ^{85}Kr. The effect of this error is less than 1% of the doses reported in DOE/ET-0029.

The last part of this comment relates to the release fraction for Cs. The release fraction, 6×10^{-4} of all cesium was obtained from NUREG-0069 (NRC 1976b). Half of the fuel elements are assumed to rupture in the accident. This results in a release fraction for all cesium isotopes of 3×10^{-4}. Multiplying this value by the various isotope inventories yields the releases reported in Table 4.1.1-12 of DOE/ET-0029.

Draft p. N.4

Issue

The consequences presented in p. N.4 for severe accidents are based on the dose received by persons from radionuclides released to the atmosphere. Since severe accidents may cause a reduction in shielding efficiency, doses resulting from radiation emanating directly from the cask should also be evaluated. The description of severe accidents in Table 6.2.6 of DOE/ET-0028 indicates a small opening will exist in the cask.

Accident number 6.2.8 is based on number 6.2.7. Number 6.2.8 assumes that no emergency action is taken to cool the cask involved in the 6.2.7 accident. This results in 50% of the fuel rods being perforated in number 6.2.8 instead of only 1% being perforated in number 6.2.7, in addition to 100% of the coolant being released in both accidents. Thus, release fractions in number 6.2.8 should be 50 times higher than in number 6.2.7. Indeed, for ^{85}Kr, ^{129}I, and ^{3}H the release fractions given are 50 times higher for number 6.2.8 than for 6.2.7. However, although mixed fission products and actinides are reportedly released in number 6.2.7, only ^{134}Cs and ^{137}Cs are reported as being released in number 6.2.8. This can also be seen in Tables 4.1.1-10 and 4.1.1-12 of DOE/ET-0029 which gives the actual number of curies released. Note that Table 4.1.1-10 gives the curies released for accident number 6.2.6, a moderate accident in which only 5% of the cavity coolant is released and only 0.25% of the fuel rods exhibit cladding failure. The table shows fission products such as ^{90}Sr and ^{95}Nb and the actinides such as ^{239}Pu and ^{242}Cm being released. Table 4.1.1-12, which lists the radionuclides released for accident number 6.2.8, the severe accident does not contain any of the

additional fission products or actinides listed for the less severe accident. Is this simply an oversight or is the contribution to the dose from these nuclides negligible compared to the dose resulting from the nuclides that are listed?

A study conducted by Battelle's Pacific Northwest Laboratory, "An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck," PNL-2588, uses release fractions for actinides and fission products other than gases that are significantly higher than those derived from the accidents described in DOE/ET-0028. As previously shown, the release fractions for actinides and mixed fission products in accident number 6.2.8 should be 50-times higher than those used in accident number 6.2.7. Table 6.2.6. of DOE/ET-0028 shows a release fraction of 1×10^{-8} for actinides and mixed fission products for accident number 6.2.7. The release fraction for accident scenarios that involve creep rupture of fuel rod cladding. Since in accident number 6.2.8 it is assumed that 50% of the rods fail, the release fraction for actinides and other fission products should be 1×10^{-5} if the results of PNL-2588 are used. Recommend the basis for the release fraction for actinides and other fission products should be 1×10^{-5} if the results of PNL-2588 are used. The basis for the release fractions used in the PNL study should be resolved.

The following discussion shows that the amount of ^{85}Kr released for accident number 6.2.8, the most severe accident, has been underestimated. Table 6.2.7 of DOE/ET-0028 indicates that 30% of the ^{85}Kr will exist in fuel rod void spaces. Accident number 6.2.8 assumes that 50% of the fuel rods are perforated so that the release fraction reported in Table 6.2.6 of DOE/ET-0028 is 0.15. This table also indicates that the cask inventory given in Table 3.3.8 of DOE/ET-0028 should be used for determing the actual number of curies released. Table 3.3.8 indicates 9.5×10^{3} curies per MTHM. Since Table 6.2.6 indicates that a cask will contain a 4 MTHM, this means a total inventory of 38×10^{3} curies of ^{85}Kr. With a release fraction of 0.15, this results in 5.7×10^{3} curies of ^{85}Kr being released. Table 4.1.1-12 of DOE/ET-0029 shows only 5.3×10^{3} curies of ^{85}Kr being released. (208-NRC)

Response

This comment discusses potential reductions in shielding efficiency for a cask involved in a severe accident, compares releases from Accident 6.2.7 to those from 6.2.8, compares release fractions used in DOE/ET-0028 to those in currently available literature and points out an error in the calculation of ^{85}Kr releases for Accident 6.2.8. The first three areas are discussed below. Please see the response immediately above for a discussion of ^{85}Kr releases.

Accident 6.2.8 in DOE/ET-0028 is a cask loss of cooling accident postulated to occur following a moderate impact or derailment that disables the mechanical cooling system. An impact of this type would not be severe enough to significantly reduce the cask shielding and therefore was not considered in Appendix N of the draft Statement. Some reduction in shielding may be possible in a severe impact like that postulated in Accident 6.2.7 but

would depend on specific cask construction and behavior. Surface dose rates for casks are designed to not exceed 1000 mr/hr following Type B packaging qualification tests described in 49 CFR 173.398.

The assumption made by the commenter when comparing releases from Accidents 6.2.8 and 6.2.7 is that they are related. However, Accident 6.2.8 is based on Accident 6.2.6. The mixed fission product and actinide releases discussed in 6.2.7 are due to impact damage to the fuel. A severe impact was not postulated for either Accident 6.2.6 or 6.2.8.

Table 4.1.1-10 in DOE/ET-0029 does consider releases of mixed fission products with the cask coolant for Accident 6.2.6. The inclusion of actinides in this table is in error. Excluding plutonium and curium would reduce the dose expected for this accident. Revised Tables 4.1.2-7 and 4.1.1-11 from DOE/ET-0029 are included here. The mixed fission product contribution to the dose from Accident 6.2.8 was negligible.

Estimates of particulate releases from a spent fuel cask involved in a severe accident are different for DOE/ET-0028 and PNL-2588 (Elder et. al. 1978). DOE/ET-0028 assumed that particulates were only generated in an impact environment and that a small fraction would escape the cask cavity. PNL-2588 assumes that impacts and rapid outgassing of fuel elements during creep rupture can release particulates to the cask cavity. A higher fraction of particulates released to the cask cavity were conservatively assumed to reach the atmosphere in PNL-2588 (Elder et. al. 1978). Differences in actinide and particulate releases in the two documents are due to both the assumption of releases during creep rupture and the fraction of nuclides that escape the cask cavity. Particulates were not the largest dose contributor in PNL-2588 (Elder et. al. 1978).

TABLE 4.1.2-7. One-Year Dose and 70-Year Dose Commitment to the Maximum Individual Resulting from a Moderate Accident During Truck Transport of Spent Fuel

Organ	Dose, rem	
	1-Year	70-Year
Total Body	1.4×10^{-5}	7.6×10^{-5}
Thyroid	2.5×10^{-6}	2.5×10^{-6}
Lung	6.8×10^{-4}	9.4×10^{-4}
Bone	1.1×10^{-4}	3.9×10^{-4}*
Skin	4.5×10^{-6}	4.5×10^{-6}

*Original value was in error in Table 4.1.2-7

TABLE 4.1.1-11 One-Year Dose and 70-Year Dose Commitment to the Maximum Individual Resulting from a Moderate Accident During Rail Transport of Spent Fuel

Organ	Dose, rem	
	1-Year	70-Year
Total Body	6.8×10^{-3}	4.0×10^{-2}
Thyroid	1.2×10^{-3}	1.3×10^{-3}
Lung	3.4×10^{-1}	4.9×10^{-1}
Bone	5.4×10^{-2}	1.9×10^{-1}
Skin	2.4×10^{-3}	2.4×10^{-3}

DOE/ET-0028, pp. 7.4.24-25

Issue

What are the risks of escape of radionuclides via the fresh airway as a consequence of a transportation underground? (208-NRC)

Response

The operational risks associated with underground transportation of the waste containers have not yet been analyzed in detail because a site-specific repository design and operations schedule are not yet available. However, for this exposure pathway to be important, significant quantities of waste would have to be either vaporized or crushed into very fine particles. The repository does not contain either a source of intense heat or mechanical energy, and thus this pathway is not likely to be important.

DOE/ET-0028, p. 7.4.30, Table 7.4.11

Issue

No estimate of occupational risk is included in the accident analyses nor is there any discussion of possible impacts on continued repository operation, repository closure or retrieval of waste already emplaced. For example, what will such impacts be for accident 7.5 or 7.6?

For accident 7.6, the safety system is a failsafe wedge-type braking system on the cage. What is the maximum allowable braking distance of the cage for the expected release? (208-NRC)

Response

Estimates of occupational risks from the canister dropped down the mine shaft accidents are included in the final Statement. The doses calculated include exposure to airborne aerosal to a limited number of workers in the area during the accidents and doses incurred during decontamination.

CONSEQUENCE ANALYSIS

Issue

A question was raised as to whether or not the scenario of a nuclear attack on a geologic repository had been considered. (40)

Another commenter suggested that such a scenario not be analyzed because the effects of the bomb itself would greatly exceed the effects of any release from the repository. (17)

Response

As a previous comment points out, the effects of nuclear war (i.e. release of repository contents) would be bounded by the meteorite strike scenario. Therefore, the effects of weapons strike were not specifically calculated.

Issue

One commenter noted that a more likely initiating event for water intrusion into a repository is exploratory drilling or shaft seal failure. (7)

Another commenter felt that the effect of water intrusion where spent fuel elements are placed in steel canisters be given more extensive consideration. (219)

Response

The faulting and flood accident is a worst case scenario which would bound those suggested by the first commenter. The breach of a spent fuel repository followed by water intrusion is discussed in detail in Section 5.5. For purposes of identifying an upper limit with respect to consequences of such an event, no credit was taken for the presence of steel canisters. Multiple barriers (including steel canisters) have been suggested as being able to assume the lack of release of radionuclides to the repository proper for perhaps 1,000 years. On that basis, the consequences suggested for a breach 1,000 years after closure would apply.

Issue

One of the assumptions that makes mined geologic disposal feasible is that radioactive sources placed in a hydrologic environment with slow-moving groundwater will take long periods of time to be transported to the biosphere. Furthermore, retardation effects will slow down (relative to groundwater velocity) the movement of certain species. This basic characteristic is common to all forms of geologic disposal.

The GEIS and its supporting documents fail to analyze flowpaths other than porous flow through intact media. The possible creation of high velocity flow paths by mining operations or fractures created by the thermomechanical response of the rock mass are not considered. Fracture flow driven by thermal convection deserves more attention than meteorite impact or nuclear war as mechanisms for establishing communication between the repository and the biosphere. (208-NRC)

CONSEQUENCE ANALYSIS

Response

Fracture flow surely has an acceptability level lower than porous media flow. Fracture flow velocities will have to be slower in ratio to retardation coefficients of the most dose-significant nuclide. If that nuclide was a nuclide with no retardation, then the fracture flow velocity would have to be slow enough to allow significant decay. Clearly a repository siting and design parameter would be the amount of migration retardation available. The Statement assumes that the repository is placed in a hydrologically unacceptable location. Thermo-mechanical effects are relatively near field.

Issue

Measures of performance used in the GEIS and its supporting documents made it difficult to judge statements that claim "no deleterious effects." For example:

1. Dose received by maximum individual. This seems to be someone using a water supply separated by 10 miles of porous flow from the repository. Note that fracture flow with its lower retardation factor is not considered.
2. Concentration at three miles from boundary. This was used in TM-36, Volume 21. In this case, ^{99}Tc occurs near the surface at 400-600 years and exceeds maximum permissible concentrations by one thousand (TM-36/21 pgs. xiv, 8.5-8.6). (208-NRC)

Response

The repository will be sited to reduce the possibility of fracture flow impacts.

Issue

The Statement does not address potential accidents at the spent fuel facility such as zirconium catching fire upon heating up or an airplane crash. (55)

Response

Analysis of events (accidents) at a spent fuel storage facility may be found in DOE/EIS-0015 (DOE 1980b). Accidents are described as either "operating" or "severe." The two scenarios above do not appear under either the operating or severe category.

Issue

The ground-water transport analysis in the main body of the statement uses a path length of only 10 km. The analysis should use a longer flow path for the base cases and discuss consequences of shortening of the path due to tectonic and/or climatic change. (218-DOI)

CONSEQUENCE ANALYSIS

Response

As noted the ground water transport analysis used only a 10 km path length. It had been decided that because of timing only one case would be modeled and it was further decided that the shorter length would receive less criticism than an overly long path length. As suggested something of a sensitivity analysis on consequences versus path length would have been useful.

Issue

The worst-case accident scenarios are unrealistic and should be reformulated.

Analyses of worst-case accident scenarios should be carried out on the assumption that application of state of the art techniques will limit dissolution rate of waste forms, including proposed packaging of spent fuel. The availability of a flow of 2.8 m^3/second of ground water through any site chosen for a repository is unrealistic. The pressure head to drive such a flow would not be available. Even when underground rock formations become saturated with water, the volume will be inconsequential, and flow rates will be generally close to zero. (219)

Response

It is hoped that a flow rate of 2.8 m^3/s (100 cfs) would indeed be unrealistic as a ground water flow rate through any site chosen for a repository. This scenario was developed as an extreme case and while highly improbable is not believed impossible when viewed as an occurrence over millenia, due to tectonic and/or climatic changes.

Issue

Accidents occurring soon after the repository is closed should be given more prominence.

A less dramatic but more likely failure occurring at an earlier time-such as the slower but more extensive flushing of a saturated repository-should be examined with respect to consequences and risk. An early chapter should describe the step-by-step process by which the dose estimates are developed. The model should be illustrated diagrammatically and, wherever possible, relevant source terms and rates should be indicated. (219)

Response

In most instances the consequences for accidents were calculated for a time just after repository closure. A case was examined where a relatively large flow of water penetrated the repository and the consequences presented. It is not believed credible that even a saturated repository would contain significant amounts at an early time.

The size and organization of the EIS precludes putting all material in early chapters; a relatively detailed presentation of dose models was presented in Appendix D.

CONSEQUENCE ANALYSIS

Issue

One commenter noted that consequences of hypothetical events and resulting absolute doses are presented, but no quantified predictions of the probability of these events happening are given. The U.S. Geological Survey recommendation to provide a candid assessment of the uncertainties associated with the spectrum of alternative out-comes of geologic containment is an objective safety criterion. These probabilities and their limits should be given at 10, 100, 1,000, 10,000, 100,000, and 1,000,000 years for each of the barriers of waste form and container, medium, and site geohydrology, that is, through to the time of radioactive decay of the waste to natural levels of radiation density in the ground. (28)

Response

To the contrary, where available, predictions of probabilities were given in the draft and appear again in the final Statement (see Section 5.5). Some events do not lend themselves to estimates of probability and the associated societal risks remains a more subjective assessment. In a number of instances large errors in probability would not result in a conclusion that a serious societal risk would exist.

Aside from multiplying the number of years times the probability per year little can be done at this stage to provide probabilities over time periods suggested.

Reference to reduction of radiation levels to natural levels in the ground was also made by the commenter. This aspect is treated briefly in Section 3.4. However, the reader is cautioned that while such hazard indices provide perspective, a direct comparison of waste nuclides and naturally occurring nuclides needs qualification.

Issue

The release of ^{222}Rn from soil and/or rock should be evaluated for a leaking repository. The entrance of radon into homes through foundation walls or base slabs may be the most important source of future human exposure. (196)

Response

^{222}Rn is not a significant contributor to human exposure.

Issue

Several commenters stated that the Statement should clearly outline the sensitivity of the parameters used in the calculations and to the extent possible how conservatism offsets uncertainties in the analysis. (38, 43, 58, 97, 113-EPA, 124, 202-HEW)

CONSEQUENCE ANALYSIS

Response

The DOE believes that what was done was correct within the limititations of the data. An error of a million or more would not change the conclusion that the accidents analyzed would have an insignificant mathematical expectation of societal risk.

Y/OWI/TM-36/21

Issue

The results of simplified calculations given in Y/OWI/TM-36/21 show ^{99}Tc exceeding acceptable concentrations 3 miles from the center of the repository 400-600 years after recharge. Top quote from page 8-5: "^{99}Tc, due to its long half life and unity retardation coefficient exists in all layers of the generic stratigraphic columns studies (shale, granite and basalt) at concentrations near or equal to the source activities. The maximum source activity for ^{99}Tc used in this study is approximately 0.2-0.3 Ci/ml (Section 7.0) which is at least 10^3 times greater than an acceptable level. The first arrival of ^{99}Tc occurs in the near surface layers between 400-600 years after repository decommissioning and resaturation and at concentrations near or equal to that of the repository source activity." This would appear to indicate unacceptable repository performance. An explanation should be given of how this will be remedied or why this analysis is not believed to indicate a problem. (208-NRC)

Response

Unacceptable repository performance would result only under a very improbable set of events. The scenario is indicative of a faulting and groundwater intrusion accident rather than expected parameters.

DOSE CALCULATIONS

Draft p. 1.11

Issue

The annual dose from naturally occurring sources is given as 100 millirem/yr. It should be pointed out that this is a lower limit estimate and not an estimate of typical exposure. (166)

Response

Natural background radiation was used to provide a perspective. According to NCRP-45 (NCRP 1975) 100 millirem/yr would over estimate rather than under estimate the typical exposure.

Draft p. 1.11

Issue

It is stated that 0.1 rem per year will be used as the background dose rate. Over 70 years this will result in an exposure of 7.0 rem. One percent of this exposure is 0.07 rem. The 0.1 rem the maximum individual receives as a result of transportation is greater than 1% of background exposure, not less than 1% as stated in the Statement. (208-NRC)

Response

The comment is correct. $\frac{0.1 \text{ rem}}{0.1 \text{ rem} \times 70} = \frac{0.1}{7.0} = 1.4\%$

Statements comparing 0.1 rem to 70 years background now indicate that the dose is approximately 1% of background.

Draft p. 1.11

Issue

In comparing natural and manmade doses, person-rem is the sum of doses to individuals in the population and so is a function of both individual doses and population size. The extra 260,000 person-rem in Colorado compared to Louisiana is meaningless in that population size selection was arbitrary. Why not use New York and Hawaii? (113-EPA)

Response

Comparisons of population doses caused by naturally occurring sources in various regions of the United States were deleted.

DOSE CALCULATIONS

Issue

Several commenters questioned comparisons of manmade and natural doses.

Draft p. 1.11--The comparison of natural radioactivity received in any particular sector with that artificially induced is totally fallacious and has no place in the serious consideration of radiation doses. (144)

Draft p. 1.11--All values in this section should be based on the same units. The term man-rem/yr/individual may be confused with population dose. (196)

The frequent comparisons with background radiation are irrelevant. (8)

When comparing resulting doses to the natural background, the concentrations should be compared to the maximum permissible concentrations given by the International Commission on Radiological Protection (ICRP). (28)

Response

The comparison of dose from natural sources to that received from waste management operation is provided to give the reader perspective. Such comparisons are not intended to imply that background radiation levels are harmless and were made when doses were large enough to warrant comparison.

The use of man-rem/yr/individual was unfortunate and was avoided in the final Statement.

Comparison of MPC's must be done nuclide by nuclide to be meaningful. Comparison of doses obviates such long lists which would not add clarity to the presentation.

Draft p. 1.11

Issue

Having set an (arbitrary?) annual dose radioactivity at 0.1 man-rem/yr/individual, a new unit of man-rem/yr is referred to in sentence 4, followed by another unit, man-rem/yr population. Will people in Colorado receive natural radiation at the dose rate of 258,000 man-rem/yr, with an additional burden of 2,000 man-rem/yr from reprocessing? Will Louisianans receive natural radiation at the rate of 0.1 man-rem/yr/individual with an additional 2,000 man-rem/yr population (what population?) from reprocessing? The sentence begs for more information: How many individuals in Colorado and Louisiana? How many individuals in 'population?' It seems all apples and oranges and will either totally confuse the general reader or provoke rash quoting of the raw numbers on a comparative basis when there is no basis for comparison. (181)

Response

The material comparing population dose from natural background between states has been removed from the final Statement. The thrust of the regional material was to indicate that

people (as a group) could reduce their collective dose by moving from Colorado where the collective dose rate was given as 650,000 man-rem/yr to Louisiana where the collective dose rate was given as 380,000 man-rem/yr but apparently do not choose to do so. This was removed because it is believed that most of the population does not have the knowledge upon which to base such a judgement and therefore the illustration was misleading.

Where a reprocessing plant contributed 2,000 man-rem/yr to a regional population the total for Colorado if the dose rate from background was 258,000 man-rem/yr would be 260,000 man-rem/yr.

Draft p. 1.19

Issue

Some of the main conclusions given in the summary concerning radiological impacts are not readily traced back to the supporting text, e.g., p. 1.19, lines 14 to 17. The text in the summary section (Section 1.3) states that, "Calculated radiation dose to the total population from routine operations including transportation, assuming that all facilities are located in the same region (a highly conservative and unlikely scenario) amount to no more than about 0.3% of the dose factor of less than 15 among fuel cycle options." Although the summary gives no reference to where the supporting test for this conclusion is, it appears that the supporting data base is in Tables 3.1.87 (summarizing environmental effects from routine operations). However, several entries (e.g., see U and Pu recycle column on p. 3.1.215) give regional population doses (6×10^{-4} man-rem) that are greater than 0.3% of background as quoted above. (208-NRC)

Response

The values listed in draft Tables 3.1.84 through 3.1.87 are rounded to one significant figure. This rounding process caused changes in the listed numbers which affected the changes noted. Therefore, comparison of the ratio of regional dose to natural background from these numbers could easily be high by the amount found in the stated example.

Draft p. 1.19

Issue

The commenter noted that a statement is made regarding the occupational population dose and resultant health effects without identifying the population base. (34)

Response

The work force among which the population dose and health effects were calculated amounted to about 18,000.

DOSE CALCULATIONS

Draft p. 1.20

Issue

Some of the numerical values on page 1.20 (e.g., maximum individual dose) cannot be traced to Section 3.1.5. (208-NRC)

Response

The numerical values on page 1.20 of the draft Statement are repeated in draft Table 3.1.54. These tables give only worst-case results. For the maximum individual the dose presented is the dose during the first year of exposure. Values for faulting and flooding and drilling were taken from draft Tables 3.1.41 and 3.1.51, respectively. The first-year dose from solution mining is not given elsewhere.

Draft p. 1.20

Issue

In Item 3 of Table 1.4, the regional natural radiation dose is calculated for three generations. In Item 2, doses are calculated for only one generation (70-yr total body) resulting in inequitable bases for comparison. (208-NRC)

Response

In draft Table 1.4, page 1.20, regional natural radiation dose under the columns labeled meteorite impact, fault fracture and flooding, and drilling accident should be 1.4×10^3 to 1.1×10^4.

Issue

Several commenters questioned the regional population assumption.

Draft p. 1.20--The regional population assumption appears to be far too conservatively high. (147)

Draft p. 3.1.100--The use of a reference population of 2,000,000 people within 80 km of a respository to calculate doses is questionable when nuclear plants in the Northeast U.S. have a surrounding population (within 50 km) of 50,000,000 people. (30)

Response

The reference environment of 2,000,000 was taken from actual data (adjusted slightly for location) at a mid-west reactor site.

DOSE CALCULATIONS

Draft p 3.1.100

Issue

The regional population for the types of releases considered most likely in the long term in waste disposal is the population in a river basin rather than the population within an 80 kilometer radius of the plant. (113-EPA)

Response

The DOE agrees with the comment. However, in the reference environment the majority of the population lives along River R, downstream of the release point.

Draft p. 3.1.101

Issue

Why is bone an organ of principle interest? According to the BEIR work, more health effects would be expected from a dose to red marrow than from the same dose to bone. The liver should also probably be considered a significant organ. (113-EPA)

Response

The bone dose is used because it supplies an adequate estimate of doses to various portions of bone. Liver dose is not significant except for a few actinides.

Draft p. 3.1.120

Issue

The draft states that the regional population dose for a geological repository during construction and operation is 100 man-rem. However, no reference is given to the basis for this estimate. For example, how much radon is estimated to be released during construction and operation at the repository? (208-NRC)

Response

The data requested is contained in DOE/ET-0029, Sections 4.4 and 9.0.

Draft pp. 3.1.136-172

Issue

The radiological impacts should be based on the worldwide population and over all time following release. (8)

DOSE CALCULATIONS

Response

In preparing the final Statement, the feasibility of expanding population and time parameters in dose calculations was examined and found to have no appreciable effect on the conclusions.

Draft pp. 3.1.142-144

Issue

There seems to be inconsistency in the values given in Tables 3.1.30 to 3.1.32. Comparing Tables 3.1.30 and 3.1.31 for 100, 100,000, and one million years the 70-yr doses are just about 70 times the first year doses. At 2050, however, they are 250 to 750 times the first-year doses. Comparing Tables 3.1.31 and 3.1.32, in order to obtain the regional population doses in Table 3.1.32 from the maximum-individual doses given in Table 3.1.31 at the year 1050 it requires from 10 to 27 persons, which simply is not reasonable. The 1,000 year values require from 40,000 to 60,000 persons--much more reasonable. At 100,000 years the values range from 600 to 5,000--much too much variation and too low; at one million years the range is 500 to 17,000 persons, again too large a range and too low. (154)

Response

Draft Tables 3.1.30 to 3.1.32 were checked for errors and consistency. The significant pathway to man changes with time and as a consequence ratios between maximum-individual dose and per-capita dose are not constant.

Draft p. 3.1.150

Issue

Doses to a maximum individual are not the best measure of the impact of this accident. Total population dose and integrated population dose are most significant. The emergency dose limits of 100 rem and 25 rem apply implicitly to the case where only one or a few people are exposed. (113-EPA)

Response

Dose to the maximum individual is one measure of impact, the population dose another; both were presented. Reference to emergency dose limits was provided for perspective only to the maximum individual.

DOSE CALCULATIONS

Draft p. 3.1.162

Issue

One commenter questioned the total body dose (in Table 3.1.47) at one million years exceeding the dose received at one hundred thousand years. (43)

Response

After extremely long periods of disposal, the decay to ^{226}Ra of ^{238}U plus selective transport of nuclides could result in a higher dose after one million years than after one hundred thousand years.

Draft p. 3.1.163

Issue

The area used for regional dose estimates is too small. (8)

Response

The 50-mile radius has been standard for some time. The Statement did, in some instances, examine the dose to the eastern U.S. population and the world wide population from gaseous releases.

Draft p. 3.1.163

Issue

It is not proper, to assume doses to the regional population from a ratio basis with total body dose. (113-EPA)

Response

DOE would suggest that the method used is imprecise and may have broad uncertainty bands. However, DOE believes the results are illustrative and perhaps conservative.

Draft p. 3.1.164

Issue

Diverting the entering stream until it is diluted by another stream does not change the population dose. It merely means smaller doses to more people. (113-EPA)

DOSE CALCULATIONS

Response

Dilution will likely reduce concentration of radionuclides in the water by adsorption or other mechanisms while the total water usage will remain the same. Therefore, total radionuclide intake is expected to be less as in population and individual dose. If it were simply a matter of dilution in water, the comment would indeed be correct.

Draft pp. 3.1.165-168

Issue

Doses to individuals are said to be due in the first year predominantly to direct radiation. Food pathway doses to bone "increase substantially" during the 70-yr dose accumulation pathway. It is not clear why. We have been able to roughly check these values. (154)

Response

The increase in 70-yr dose commitment to bone is because of the buildup of actinides in the bone. No clearance of actinides from bone is assumed by the models used.

Draft p. 3.1.179

Issue

Since the releases in Table 3.1.58 are suspect, so are the population dose values in Table 3.1.59. (154)

Response

No problem was found with draft Table 3.1.58 and the dose values in draft Table 3.1.59 are believed to be correct.

Draft p. 3.1.192

Issue

The overstated value for ^{14}C in Table 3.1.68 would imply that Table 3.1.69 should be in error, particularly for world-wide dose which is totally dominated by ^{14}C, but the quoted figures cross check with Section 5.4.2.4 of DOE/ET-0029. Before issuing the final EIS it should be determined which figures are correct. (154)

Response

The value for ^{14}C was given incorrectly and has been adjusted. However, the world-wide dose in draft Table 3.1.69 is correct as shown in the draft.

DOSE CALCULATIONS

Draft p. 3.1.192

Issue

The most severe accident postulated for predisposal operations is a transport accident involving HLW. Maximum-individual 70-yr dose is 7 rem. This is significantly lower than normally seen for this accident. Nor does it seem reasonable in relation to the spent fuel transport accident discussed on pp. 3.1.178-179. (154)

Response

The dose to the maximum individual from a severe transportation accident involving HLW is 37 rem. This typographical error was corrected for the final Statement.

Draft Appendix D

Issue

While the calculation models employed may be adequate, in light of the uncertainties inherent in the input data, they are not state-of-the-art, as claimed. For example, the calculation of the 5-cm gamma dose as the total body dose for air immersion could be improved by the use of an existing code employing the TGLD model. It does not explicitly treat the daughter products formed after inhalation as do more complete codes. (113-EPA)

Response

Use of programs giving specific organ doses from external radiation do not give significantly different results than the 5-cm estimate to warrant their use (see NCRP-45 pp. 108 and 109, NCRP 1975 in reference list). The DACRIN code dose considers daughter product radiations formed in organs of interest. Daughters produced in transit to the organs are not considered, but for the majority of cases this omission is not significant.

To avoid unnecessary argument, the expression "state-of-the-art" in reference to the codes used has been dropped.

Draft Appendices D and F

Issue

Although the sections on radiological models indicate that all pathways were considered, the contribution of various pathways to the total dose is not given in the document. Additional information on the radiological analysis for scenarios (e.g., source terms, concentrations of nuclides for different locations, solubility classifications of particulates, etc.) would help document the major conclusions concerning radiological impacts. (208-NRC)

DOSE CALCULATIONS

Response

The contribution of various pathways to total dose is dependent on the radionuclides released and varies markedly among the many release situations considered. Inclusion of this information for all dose tables would lead to excessive bulk and is not practical.

Draft p. D.4

Issue

On page D.4, the draft Statement states that the methodology used to calculate the direct radiation dose to persons along the shipping route follows that developed in WASH-1238. Subsequent to the issuance of WASH-1238, an environmental statement on transportation of radioactive material has been published by the NRC. This statement is NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes." The latter document uses a more realistic demographic model in determining population density along the transport route and an improved method for evaluating integrals used in the model. We recommend this refined methodology be used in the GEIS in assessing the radiological impact to the population residing near the transport route. (208-NRC)

Response

The DOE disagrees. While the demographic model used in NUREG-0170 may be more realistic and the method of evaluating integrals improved, the results are similar.

Draft p. D.4

Issue

One commenter raised a question as to the accuracy required for input parameters (to dose models) derived from environmental measurements of radioactivity. (43)

Response

The most accurate data that is available is required and even that results in uncertainties of perhaps overestimation by a factor of 100 or underestimation by a factor of 10.

Draft p. D.5

Issue

Population density assumptions used in determining the radiological consequence of transporting radioactive wastes are given on page D.5. A value of 330 persons per square mile is used for the Eastern U.S. and California and 110 persons per square mile is used for the Western U.S. The environmental aspects presented in DOE/ET-0029, page 4.1.7, use a

population density of 90 person per square km (230 persons per square mile). If this is a weighted average, the weighting factors should be given so that their validity can be evaluated. (208-NRC)

Response

The population density, 90 persons/km^2, is a weighted average. Fifty percent of the AFRs were assumed to be in the West (40/km^2) and 50% were assumed to be in the East (130/km^2) for an average of about 90/km^2. These are equivalent to the 330/mi^2 and 110/mi^2 given on draft p. D.5.

Draft p. D.8

Issue

The model used to estimate the population dose commitment from ^{14}C is too conservative (i.e., overestimates the impact). If dilution by the Suess effect is not considered and the total number of health effects is integrated over all time, the release of 1.4 MCi (from Table 3.1.68) would result in about 5×10^6 deaths, assuming a stable world population of 6.4×10^9 people. A more realistic comparison might be to the natural production of ^{14}C and associated health risk. (113-EPA)

Response

Suess effect is dilution of ^{14}C with increased CO_2 from fossil fuels. This could dilute ^{14}C by a factor of 0.5 - 1.0. Certainly this small change is far less conservative than integrating population dose out to time infinity like EPA suggests. Even 5×10^6 deaths are small by their method. For example, a constant population implies death rate = birth rate = 1.9% per year, or $(1.9 \times 10^{-2}/yr) \times (6.4 \times 10^9) = 120$ million deaths each year. This is 24 times the 5×10^6 value of EPA in the first year alone. The model use was designed for reasonable times not infinite times, and the DOE feels that it works well for the times for which it was used. If health effects were integrated to infinite time, a model which took into account the sinks for ^{14}C (such as the deep ocean), which remove it from the human biosphere, would have been used.

Draft Appendix I

Issue

This appendix as well as Appendix G to DOE/ET-0029 present impacts at time periods of 10^2 years, 10^5 years, and 10^6 years. Sometimes 10^4 years is discussed. Since preliminary versions of the EPA standard for high-level waste specifically reference the 10^4-yr period, presentation of cumulative dose calculations for this time period for all cases studied would be prudent. (208-NRC)

DOSE CALCULATIONS

Response

The time required to calculate doses for 10^4 years after production of the draft was not available. It is suggested that interpolations between results at 1000 and 100,000 may be sufficient for present purposes.

Draft p. N.4

Issue

Repeated reference to discussion of trucker's dose on p. N.4 is misleading. The reference on p. 13 indicates the discussion on p. N.4 explains the overestimate of the dose and the reference on p. N.16 indicates the discussion on p. N.4 is based on experience. The actual discussion on p. N.4 satisfies neither of these descriptions. (208-NRC)

Response

All of the truck drivers' doses in DOE/ET-0029 and the Statement are based on the conservative WASH-1238 (AEC 1972) overestimate. The discussion on draft p. N.4 is an attempt to point out that the model results in an over estimate and actual values are smaller.

The following quote from WASH-1238 (AEC 1972) is the basis for this statement.

"Experience in truck transport of radioactive materials has shown actual doses to drivers to be 0.1 of the regulatory limit. Use of the regulatory limit of 2 rem/hour in any normally occupied space is therefore considered conservative."

Draft p. N.4

Issue

Did this result take into account the growth of population along the transport route during the 70-yr period? (208-NRC)

Response

No, it did not.

Draft p. N.4

Issue

An inconsistency exists between these two paragraphs. In the third paragraph, the draft states that population doses are calculated based on the permissible limit of radiation. Individual doses given in the fourth paragraph are taken from WASH-1238 which used dose rate values derived from experience rather than permissible limits. In addition, these WASH-1238 numbers were obtained from considering average exposures resulting from the transport of fuel and waste from power reactor. Since the discussion on page N.4 of the GEIS

concerns transportation of spent fuel, it would be better to examine the WASH-1238 analysis of exposures caused by transport of spent fuel which can be found on pages 40-42. (208-NRC)

Response

The intent is to illustrate that the approach used was conservative and to illustrate the magnitude of doses incurred.

Draft p. N.9

Issue

Last paragraph: The accident postulated here results in 37 rem to the total body. Table 3.1.224, shows the results of the worst-design basis accident, which for SHLW--severe impact and fire is 7 rem. (208-NRC)

Response

This is a typographical error in draft Table 3.1.88. The dose should be 37. See Table 7.1.1-5 in DOE/ET-0029.

Draft pp. N.13, 16, 21

Issue

On pages N.13, N.16 and N.21, reference is made to page N.4 and a discussion on dose to truckers. The reference on page N.13 indicated the discussion on page N.4 explains the overestimate of the dose and the reference on page N.16 indicates the dose discussed on page N.4 are based on experience. These references are misleading since the discussion on page N.4 satisfies neither of these descriptions. Is the reference intended to apply to WASH-1238 which is the basis for the truckers dose given on page N.4? (208-NRC)

Response

Yes. See the response to comment above referring to p. N.4.

Draft p. N.13

Issue

"Doses to the maximum individual...and population dose are comparable." This statement does not make sense, since there is a 10,000 times difference between the maximum individual dose and population dose in Table N.12. This should be clarified in the final EIS. (113-EPA)

DOSE CALCULATIONS

Response

The statement should read, "The dose to the maximum individual for rail and truck shipments is comparable as are the population doses attributed to each transport mode."

Issue

The several appendices which support the long-term impact assessment need to be coordinated so that their results are directly comparable. Some cumulative doses are for 50 years, some for 70 years. Different times are referenced. The total picture is confusing and leaves many questions about the internal consistency of the supporting calculations. (208-NRC)

Response

The problem is due to computer models availability. Differences in doses caused by the parameters used in the computer models are discussed in the final Statement.

Issue

One commenter stated that background radiation and doses from waste disposal analyses are in different units throughout the report. (13)

Response

It is believed that the analysis is best served by using different doses for different purposes. Accident doses are often given in rem/yr to the maximum individual with emphasis on the first-year dose where it is believed that such a dose could have acute effects. Population doses are expressed in man-rem, being the sum of the number of people receiving a given dose over the population of interest. The use of natural background is to provide perspective to the doses tabulated.

Issue

There are substantial problems in the calculation of radiation doses and health effects to the public. The time-integrated population dose is frequently neglected. Furthermore, population doses are not always expressed as fatal, non-fatal, and genetic health effects; we think that they should be.

The Draft EIS appears to indicate that the major hazards occur in the first few hundred years while ^{90}Sr and ^{137}Cs are present. As a result, long-lived nuclides, such as ^{99}Tc and ^{129}I, are neglected despite the fact that they can be geochemically mobile under some circumstances. (113-EPA)

DOSE CALCULATIONS

Response

There are no substantial problems in the calculation of radiation dose and health effects to the public as EPA has stated. Most of the general comments presented are answered in response to specific EPA comments. In general, DOE does not feel that emphasis on time-integrated population doses is required. In some cases doeses to first, second, and third generations are given (70 yrs/generation)and in a few cases doses were integrated over 10,000 years.

Doses caused by ^{99}Tc and ^{129}I were not neglected. These were included in the source terms, but if they did not contribute at least 1% to doses calculated they were not listed in the source terms presented in the Statement.

Issue

A commenter suggested that a presentation of radiation dose summaries in a separate section of the document could provide the public with a better understanding of the health impact from various operations. (202-HEW)

Response

For the disposal technologies analyzed, the Statement presents the radiological impacts under the sections titled "Environmental Impact of Construction and Operation," (5.4, 6.1.1.4, 6.1.2.4 - 6.1.8.4) and "Environmental Impacts Over Long Term" (5.5, 6.1.1.5, 6.1.2.5 - 6.1.8.5). The radiological impacts of predisposal activities are addressed in Sections 4.7 and 4.8. Section 7.4 outlines the radiological impact for entire waste management systems.

RISK PERSPECTIVES

Issue

Several commenters noted that the period of time cited as critical for containment of radioactive wastes within a repository was not presented in a consistent fashion.

Draft p. 1.5--Five hundred years rather than 1000 years in the period that is most critical On p. 1.9 it is stated that high level wastes must be retained safely for up to one million years. This is patently ridiculous. (147)

Draft p. 1.5--The 1000 years noted as the time period necessary for decay of ^{90}Sr and ^{137}Cs is too long a period. (154)

Draft p. 1.9--The time required for isolation is inconsistent with the discussion presented in Section 3.1.3. (124)

Draft p. 1.9--Uranium, plutonium, and the balance of the TRU's do not need to be isolated for up to one million years. (154)

Draft p. 3.1.16--The statement that "High level wastes must be kept isolated from the biosphere for a long time period, perhaps hundreds of thousands of years" is at variance with statements made elsewhere in the draft document (eg., p. 1.9-- up to one million years and p. 1.28--500 years). (198, 218-DOI)

Draft p. 3.1.64--It is stated that "..after several hundred years of decay, the wastes do not exceed the natural radioactivity of the ones from which they came." Elsewhere in the report, however, references is made to isolation times of one million years or isolation until the waste has decayed to harmless levels. (38, 218-DOI)

Draft p. 3.1.65--The statement was made that "containment times of 500 years are the most important." However, on page 3.1.59 it is stated that a significant release "could occur at 1000 years" and on page 3.1.64, it stated that after "700 years, the radioactivity in the repository poses a greatly reduced threat." Some consistency should exist in the document for the period of concern and basis for arriving at this time should be clearly delineated. (208-NRC)

Statements which point out the essentially "back to nature" radioactive decay time of 500 years may not be clear to the general public. (166)

Response

The material has been thoroughly revised and attention paid to such consistency. The "500 year" and "700 year" numbers are from the referenced work of other authors. The value used in this Statement is 1,000 years.

The 1,000 years allocated for the decay of mixed fission products typified by ^{90}Sr and ^{137}Cs is based in part on conservative calculations of the percentage impact of these nuclides on the total base and on proposed canister design criteria. The language used on draft p. 1.5 has been modified to omit reference to general acceptance. For the inventories involved, 500 years would be adequate (or more than) for just ^{90}Sr and ^{137}Cs.

RISK PERSPECTIVES

Repositories are designed with the expectation that radionuclides will not reenter the bioshpere. Reference to " ... isolate ... for several millenia ...one millenia" is superfluous and has been removed.

Draft p. 1.16

Issue

The hazard indices discussed in Section 3.1.3.4 and mentioned here are at best crude estimates. The hazard of a material is based on three factors: 1) the quantity of the materials available, 2) the toxicity of the materials, and 3) the pathways between the materials and human beings. Hazard indices which do not consider all of these (and it is difficult to think of a generic hazard index which would be useful for specific pathways) are not particularly useful. (113-EPA)

Response

While the hazard indices used are not refined estimates, they do provide some insights to the hazards of the wastes.

Draft p. 1.16

Issue

The following statement is made--"The conclusion is that the available lethal doses in radioactive waste are far less than the available lethal doses in toxic nonradioactive chemicals now being handled routinely by society as shown in draft Table 1.3. Further, radioactive wastes decay with time whereas toxic chemicals have no half-lives and hence their quantities remain unchanged with time."

- Is the value in Table 1.3 for radioactive waste based on deaths caused by the radiotoxicity or the chemical toxicity?
- How does this value behave with time?
- Provide references for Table 1.3.
- Available lethal dose is defined as (the number of) potential deaths if dose is uniformly administered.
  - What does this mean?
  - What "dose" is uniformly administered?
  - Administered to what populations?
- How many available lethal doses result from the eventual stable daughter products of the radioactive waste? (208-NRC)

RISK PERSPECTIVES

Response

- The deaths postulated are due to radiotoxicity.
- The value decreases with time.
- References can be found on p. 3.1.79 of the draft Statement.
- The available lethal dose is based on the total inventory of a toxic substance available divided by the amount of that substance known to cause death in man. This gives the number of available lethal doses.
- One could determine amount of stable daughter products from radioactive nuclides in a repository and compute the available number of lethal doses. These would be insignificant when compared to magnitudes of other numbers in the table.

Draft p. 1.16, Table 1.3

Issue

One commenter did not understand how the annual available lethal doses from a "hypothetical all-nuclear electric economy" could be as low as the 10^7 figure cited. (211)

Response

This table was in error. The 10^7 figure should be 10^{10} lethal doses.

Draft p. 1.16

Issue

Is the statement--"available lethal doses in radioactive waste are far less than the available lethal doses in nonradioactive chemicals now being handled"--referring to chemical or radiological toxicity? (197)

Response

As noted above radiotoxicity is being addressed.

Issue

Many letters commented on the comparisons presented between radiological wastes and hazards from toxic wastes, as well as lives lost in automibile accidents.

Draft p. 1.16, Table 1.3--The authors have performed a service in putting the hazards of radioactive waste in perspective with the much greater hazards from other forms of toxic waste. It was also entirely appropriate for the GEIS to point out that, "radioactive wastes decay with time whereas toxic chemicals have no half-lives and hence their quantities remain unchanged with time." (198)

RISK PERSPECTIVES

Draft p. 3.1.41, 64-74--We note with considerable interest the following: Each year 55,000 persons lose their lives on highways. Although tragic to families, this does "not represent a significant societal loss to a population of 200,000,000." On conservative bases and even at relatively imprecise levels of knowledge, the annual loss of life from a waste repository will be "a small fraction of one." (emphasis added). We agree completely with this analysis. But one must then ask why waste disposal has not been put in proper perspective. The risk associated with the disposal of nuclear waste has been exaggerated out of all proportion-by many orders of magnitude. DOE should come right out and state this obvious fact. (154)

Draft p. 3.1.65--The relative toxicity of plutonium and lead should be more widely promulgated. Although it does not mean that concern for plutonium be reduced, it does put the problem in better perspective. (32)

The statements which point out the advantage radioactive wastes have over toxic chemicals should be emphasized. (166)

Draft p. 1.16, Table 1.3--This comparison is superfluous and misleading. (30)

Draft p. 1.16, Table 1.3--Comparison of lethal doses from a postulated all nuclear economy is absurd. This number should be reduced. (147)

Draft pp. 1.16--There appears inappropriate comparisons of the lethal doses from a variety of toxic materials and lives lost in auto accidents with deaths caused by nuclear waste disposal. The real question is whether a considerable area of water shed will be contaminated. (40)

Draft p. 1.16--The fact that we run a greater risk of lethal contamination from the environmental presence of arsenic or cyanide than from high-level radioactive wastes will not assuage the public's concern over the safe disposal of these wastes. (41, 170)

Draft p. 1.16--Your figures are misleading because some of the chemicals cited are not lethal if diluted; others are not lethal when in certain chemical compounds. (128)

Draft p. 1.16--The statement is made that--"The conclusion is that the available lethal doses in radioactive wastes are far less than the available lethal doses in toxic nonradioactive chemicals now being handled routinely by society as shown in Table 1.3." Chlorine, phosgene, and ammonia are unstable in contact with the atmosphere and consequently do not persist in their uncombined state. Inclusion of these substances in that table negates its credibility. Radioactivity, of all types and in all forms, leaves a persistent trace in cell structures and its ambient strength is eternal relative to the human span of life. The listed chemicals combine with other elements and become harmless. (144)

Draft p. 1.16--The statement--"Radioactive wastes decay with time whereas toxic chemicals have no half-lives and hence their quantities remain unchanged with time."--seems also to be a distortion of the nuclear question in that it equates chemical toxicity with radioactivity. As I understand it, they are two separate phenomena. (145)

RISK PERSPECTIVES

Draft p. 1.16--The results shown in Table 1.3 are interesting but can be misleading. Several of the substances listed are innocuous when their concentrations in the environment are sufficiently low, as for that matter is nuclear waste. We do agree with the premise that many other products and wastes are as significant an environmental problem as that associated with high level waste. However, Table 1.3 does not support this conclusion in a meaningful way and reliance on this simplistic comparison may be counter-productive. (154)

Draft p. 1.16--The statement--"Radioactive wastes decay with time whereas toxic chemicals have no half-lives and hence their quantities remain unchanged with time."--does not recognize the fact that many chemicals (toxic or not) undergo transformations into other chemicals. (211)

Draft p. 1.16, Table 1.3--This table could be misleading, in the sense of comparing apples to oranges. Chlorine gas, for instance, will rapidly deteriorate in most environments because of its high reactivity. Phosgene and ammonia are also non-persistent. Most of these substances can easily be treated to render them relatively harmless. (218-DOI)

Draft p. 3.1.41--Comparison of consequences from radiation in comparison with those from automobile accidents is invalid. There are two primary aspects to the establishment of bases (for determining acceptable consequences for operational and post-operational radiological accidents):

1. How much will society accept on an absolute basis?
2. How much better than this can the technology provide? (113-EPA)

Draft p. 3.1.41--It is recommended that "bullet" three be removed, since these are major NEPA considerations, not just information to be discussed under the subject of mined geologic disposal. (124)

The toxicity comparison on p. 3.1.65 is interesting, but rather irrelevent. (8)

The reasoning that the high rate of auto accidents and the toxicity of arsenic, mercury and other toxic substances are "acceptable risks" to our society is justification for acceptance of a whole new source of possible contamination of the environment by radioactive substances is a specious argument. (195)

It is proper to compare, for example, the possible risks from coal ash disposal with possible risks from high-level and low-level nuclear waste disposal. However, it is improper to compare either of these risks with the risk of being hit by lightning or being injured in a highway accident because the risks are associated with wholly unrelated activities. (217)

Response

The discussion of risk and risk perspectives in the draft has been substantially modified and is presented in a separate section in the final Statement (3.4). The comparisons

made in this section are for the purpose of giving a perspective as to the relative impacts of radiological wastes versus the hazards of other materials in the environment. Such comparisons are not intended to justify the potential impacts from radioactive waste management but are intended to assist the reader in understanding the concept of risk as it relates to radioactive waste management.

The points regarding chemical toxicity are well taken. The toxicity of many substances depends on chemical form whereas radioactivity is relatively independent of chemical form. However, some dependence still exists because the chemical state of the radionuclide determines its movement in the body.

The number of automobile deaths was included merely for perspective. A nation that apparently condones the loss of 55,000 lives annually on the highways may not, as one is sometimes led to believe, be interested in perserving human life.

Contamination of land is important as suggested. In the Statement the degree of importance is reflected in the number of health effects that such contamination would produce.

Draft p. 3.1.28

Issue

The measurement of the equivalence of the hazards of waste repositories and natural ore is a complex subject. Many of the hazard indices are concerned only with the amount of radioactive material and its toxicity, without consideration of routes by which the activity can reach man. (113-EPA)

Response

The comment is well taken. However, the routes to man for the ore and waste will be quite similar in this case.

Draft pp. 2.1.16, 2.1.18, 3.1.64

Issue

Several commenters noted that there does not appear to be treatment of the hazard index of the waste versus the toxicity of the natural ore (over time) in the context of the real risk presented by the spent fuel or high level waste in a repository. (38, 166, 196, 218-DOI)

Response

The high-level waste toxicity equals the toxicity of the ore that produced it at 1500 years. See Figure 3.4.1 of the final Statement.

RISK PERSPECTIVES

Draft p. 3.1.64

Issue

Paragraph 7 is very questionable. Hazard indices are not based on estimates of societal risks compared to other societal risks, in general. There is also the question of whether the hazard of the waste after several hundred years of decay, considering nuclides and pathways, is less than the hazard of the ores. (113-EPA)

Response

DOE disagrees. If one is to determine the significance of a hazard it must be compared to other hazards.

The text does not state that the hazard of the waste after several hundred years of decay is less than the hazard of the ores. The statement made was that the radioactivity of the wastes would not exceed that of the natural ore. However, because of the nature of a repository, i.e., 600 meters of overburden, compared to the overburden of most commercial mines, the hazard to the population from repository wastes stored several hundred years would not exceed the hazard from natural ores.

Draft p. 3.1.65, Hazard Indices

Issue

One commenter noted that this section contains several specious arguments culled from various sources and that more detail should be presented or the entire discussion be eliminated. (218-DOI).

Response

In preparing the final Statement an effort was made to provide more detailed information for the reader in the discussion of hazard indices (see Section 3.4).

Draft p. 3.1.65

Issue

The following statement is made: "Eventually ^{239}Pu will disappear due to its 24,000 year half life; the lead will persist indefinitely." Although ^{239}Pu will decay, its daughter is ^{235}U which is the parent of a decay series terminating, after more than a dozen radioactive decays, in ^{207}Pb (lead-207). Thus the legacy of ^{239}Pu also persists indefinitely. (217)

RISK PERSPECTIVES

Response

Agreed, this statement has been changed in the final document.

Draft p. 3.1.65

Issue

The total quantity of radioactivity in curies is irrelevant. The nature of the radionuclides and their pathways to man are significant. (113-EPA)

Response

The paragraph noted was poorly worded and has been deleted. The expression of quantity of radioactivity in curies without qualification is indeed irrelevant.

Draft p. 3.1.66

Issue

Describe how the estimate of 1×10^{-6} for the "annual fatalities estimated due to isolated waste" is determined. Specifically, explain and justify the use of the "annual transfer probability for an atom of radium to enter the body from the geosphere." (208-NRC)

Response

Based on the quantity of ^{226}Ra in cadavers and the quantity of ^{226}Ra in the biosphere, the ratio of ^{226}Ra in man versus the biosphere was derived. This ratio, 4×10^{-13}, coupled with the quantity of radioactive material in the repository was used to calculate the dose to man. Based on the dose to the population, the health effects were calculated to be 1×10^{-6}/yr.

Draft p. 3.1.161

Issue

The conclusion drawn from the comparison with the ore body would be improved if some analysis were provided. (113-EPA)

Response

An expanded treatment of deep geologic waste disposal and hazard from ore bodies appears in Section 3.4.1.

RISK PERSPECTIVES

Draft Appendix H

Issue

This appendix could well be omitted. Many of the hazard indices quoted are of no value as indices, and no information is available to enable one to select which, if any, of the indices are useful.

Although purporting to be a basis for determining the "hazard index," the material as presented in the appendix does not even approximate the potential hazard. The MPC is derived on the basis of dose to a "critical organ" rather than on the risk related to a given intake of isotope. The cumulative risk from intake of isotopes should be used as the basis for deriving a comparative "hazard index" since organ sensitivities are the controlling factor as noted in ICRP-26. (113-EPA)

Response

The intent was to indicate the variety of hazard indices that were available. Since there is no critical review of these indices then use is marginal. The revised appendix notes that--"Although each hazard index has merit for a particular set of conditions, the provision of simple measures of hazard can confuse rather than clarify. For this reason hazard indices are infrequently used in this Statement and dose and associated health effects are presented instead."

Issue

One commenter requested that the concentrations of plutonium in waste should be related to the natural radioactivity of the rock excavated for disposal. (6)

Response

For perspective on concentrations of plutonium the reader is referred to Figure 3.4.1. In the strictest use of concentrations (i.e. grams/cc of total rock) comparison of the plutonium content to say 0.2% uranium ore is not an improvement in clarity. This fails to recognize the need for pathways to man for the material to be significantly toxic.

Issue

A commenter stated that a mistake of the Statement was to rely solely on the technique of risk assessment as a criteria for safety decisions. (167)

Response

As noted in a previous response, impacts are presented from a consequence standpoint first. The document also identifies other criteria in Section 6.2 (in addition to radiological impacts) that the "decision-maker" would consider in evaluating the various disposal options.

RISK PERSPECTIVES

Issue

Several commenters noted that the reader's perspective of relative risk would be further enhanced if health effects due to natural background were stated as a range rather than as a discrete value. (58, 124)

Response

By and large, reference to natural background as a comparison has been made on a basis of dose. Health effects for the regional population from natural background over a 70-yr period would (on the basis used in this Statement) range from 1,000 to 9,000.

Issue

Several commenters stated that a summary presentation should be provided for each option of all the elements of risk. (58, 124)

Response

From the standpoint of classical risk assessment, this issue calls for a detailed examination, and DOE does not feel that the data is available to make such a presentation with any confidence.

However, Chapter 7.0 of the final Statement does outline from a systems viewpoint the impacts of waste management (i.e., radiological and nonradiological impacts, land use, materials and energy requirements).

Issue

The Statement should specify incremental risk in initiating repository program in near-term versus deferring initiation until additional (or "complete" data) is obtained. (38, 134, 217)

Response

The Statement analyzed the environmental impacts of repository startup for the years 1990 through 2010 as part of the proposed action. The Statement also looked at repository startup in the year 2010 to 2030 and the associated impacts as part of the alternative action. The Statement did not perform a "risk calculation" per se comparing near-term repository startup versus a deferred startup.

Issue

Several commenters noted that the Statement should provide rationale for what is considered acceptable risk and/or define adequate safety. (6, 58, 97, 98, 124, 154)

RISK PERSPECTIVES

Response

EPA is currently formulating standards relative to radioactive waste management and disposal. Such standards are expected to include specifications concerning release rates to the accessible environment and will be used to determine the acceptability of a waste repository.

Issue

One commenter noted that a comparison of the potential for electrocution as a result of nuclear-generated energy and the hazards of commercial waste products be presented. (178)

Response

There are about 55 lineman electrocuted in the U.S. each year bringing electricity to consumers regardless of the mode of electrical generation.

WASTE MANAGEMENT OPERATIONS

Reactor Operations

Draft pp. 1.7 and 2.1.2

Issue

Several commenters noted that the assumed reactor performance characteristics assumed (40 year life and installed generating capacity) are difficult to justify in view of experience to date. (2, 40, 62, 181)

Response

With regard to reactor performance, DOE agrees that the operating experience with nuclear plants is not yet sufficient to predict their life-time performance characteristics with great accuracy. However, for purposes of the analysis of waste management, present assumptions are representative and considered adequate to predict potential effects.

Draft p. 2.1.2

Issue

The impacts of an incorrect assumption regarding nuclear power plant performance degradation should be assessed in terms of how much less waste would be generated. (147)

Response

An analysis of five different nuclear power growth scenarios is provided in Chapter 7.0 of the final Statement. This chapter provides information on total energy generated for each growth scenario in terms of GWe-years and also the total quantities of waste generated. If plant performance is or is not degraded, the amount of waste generated will be proportional to the reduced or increased energy generation in each case.

Draft p. 2.1.10

Issue

A burnup of 29,000 MWD/MTHM is low given that utilities are being given permission to use burnup to 58,000 MWD/MTHM. (55)

Response

If an average burnup higher than 29,000 MWD/MTHM is achieved, it will reduce the quantity of spent fuel. However, the total fission product activity would change very little while the actinide activity would increase as in the fuel recycle cases considered in this Statement. Thus, the waste disposal requirements arising from using fuel to higher burnup levels are within the envelope of the analyses presented in this Statement.

WASTE MANAGEMENT OPERATIONS

Draft p. 3.1.55

Issue

Because the effect of burnup on leach-rate has not been studied, the effect on leach rates of utilizing higher burnup fuel would be questionable. (55)

Response

DOE has established research programs to examine the impacts of higher burnup fuel.

Issue

The schedule for transferring spent fuel assemblies from power plants to dispositon facilities should be presented. (129)

Response

A range of possible spent fuel transfer schedules is considered in the systems analysis in Chapter 7 of the final Statement.

Waste Characterization

Draft p. 1.1

Issue

One commenter requested clarification of the definition of "radioactive wastes" used in the draft Statement and noted that traditionally, high level waste (HLW) does not include transuranic (TRU) intermediate and low-level wastes. (208-NRC)

Response

DOE agrees that, traditionally, HLW does not include other TRU wastes. DOE cannot find (on cited page, at least) a statement that the TRU wastes are included in HLW. Section 4.2 of the final Statement describes the radioactive wastes with which this Statement is concerned.

Draft p. 1.5

Issue

One commenter objected to the confusion that can result when spent fuel is sometimes called spent fuel and other times called a radioactive waste. (181)

Response

DOE agrees that this can be a problem and has endeavored to be more precise in the final Statement. When discussing the once-through cycle, spent fuel is considered to be a waste, but in most cases we still refer to spent fuel as spent fuel or as spent-fuel waste. In the reprocessing cycle, spent fuel is not necessarily a waste because it contains the useful by-product uranium and plutonium but it also contains the waste products from the reactor operation.

Draft p. 1.7

Issue

Sentence 3, paragraph 4 implies that there are high-level wastes from mixed oxide fuel fabrication. Is "spiked" fuel being referred to? This has not been indicated. (181)

Response

The high-level wastes referred to are generated in the fuel reprocessing plant and not the mixed-oxide fuel fabrication facility.

Draft p. 1.8

Issue

One commenter requested a definition of transuranic (TRU) waste and wanted to know the concentrations of plutonium expected in TRU waste. (6) One commenter did not feel the use of 10 nanocuries per gram as definition of TRU waste is justified. (154)

Response

A definition of TRU waste is contained in the introductory paragraph to final Section 4.2. Variable concentrations of plutonium are expected in TRU wastes ranging from about 10^{-8} to 10^{-3} curies of transuranic alpha activity per gram of waste.

Draft p. 1.9

Issue

The heat generation in HLW from one metric ton of spent LWR fuel is below 600 watts 30 years from the time of reprocessing, when heat generation was over 8 kw. The critical duration cited (500 years) is about an order of magnitude high when considering the impact of heat generation. (181)

Response

DOE agrees that the heat generation in high-level waste 30 years from the time of reprocessing is at or below about 600 watts per metric ton. However this does not mean that the heat generated following that time can be ignored or that the critical period is as short as 30 or 50 years. For a discussion of thermal criteria in a geologic repository and the temprature profiles in the geologic media as a function of time see Appendix K of the final Statement.

Draft p. 1.15

Issue

Do sentences 1 and 2, paragraph 1, refer to intact spent-fuel assemblies, or to the HLW from the reprocessing of same? (181)

Response

Both. It is a summary statement concerning waste focus that may potentially be disposed of in geologic repositories.

Draft p. 1.17

Issue

The term "fuel residues" is dangerously ambiguous. The commenter assumes that it was used to mean cladding hulls and other hardware. (181)

Response

The assumption is correct. DOE defined what it included as "fuel residues" in Section 3.1.4.2 of the draft Statement, but the comment arose from reading an earlier section. First use in the final Statement is in Section 4.2 where it is defined.

Draft p. A.3, 4, 20

Issue

Several commenters questioned DOE's credibility for using "truncated lists".of radionuclides. The commenters claim that more than 90% of the known 400 radionuclides in the spent fuel are not accounted for. (42, 68)

Response

Appendix Tables A.2 and A.3 in the draft were intended to show only the most significant (in terms of radioactivity) nuclides in the wast components described. Table A.17 in

combination with Table A.16 and similar tables account for all of the radionuclides in the waste that have half-lives longer than a few weeks. While there are many more radionuclides that are initially present in spent fuel, many of those that are initially present have very short half-lives (measured in seconds and minutes) and are not important in terms of long-term waste disposal. The calculations carried out in support of this Statement considered 175 separate radionuclides. Not all of these were found to be significant in regard to disposal requirements. The tables in Appendix A identify quantities of 55 fission and activation products and 65 actinides and daughter actinides which for practical purposes are believed to account for all of the radioactivity in the disposal repositories. The detailed radioactivity Tables for the final Statement can be found in Appendix Tables A.2.1a-A.3.9b.

Draft p. A.17

Issue

Although not implicitly stated, it appears that the inventory values in Table A.14 were based on a charge of 3.8×10^5 MTHM. However, the mass associated with the ^{232}Th (+2 daughters) given in the 1,000,000 year column is 5.8×10^6 MT. There is an obvious error in the program used to generate this table. This single, obvious error brings into question all output generated by the computer program which was used to generate Table A.14. (208-NRC)

Response

The value for ^{232}Th is 1.91×10^1 Ci for $t = 10^6$ years. This error was not due to computer error but was a typographical error.

Issue

It would be helpful to summarize the important general characteristics of nuclear wastes. (6)

Response

The characteristics of nuclear wastes of concern to this Statement are now summarized in Table 4.2.1.

Issue

Popular misconceptions combine the short-term heat and high-level radiation properties of short half-life fission products with the long half-life of TRU wastes. Correct the misunderstanding by providing in the Summary a graphic representation of the decay of these properties with time. (13)

WASTE MANAGEMENT OPERATIONS

Response

This appears to be a good suggestion and plots are provided in the final Summary showing total radioactivity and total heat generation rate as a function of time for an example metric ton of spent fuel and a metric ton equivalent of high-level waste.

Issue

Detailed information on the nuclear growth scenario assumed should be provided, including; numbers and types of reactors that come on line each year; and the annual waste streams from the plants, including spent fuel and low-level waste (volume and activity). (208-NRC)

Response

Information pertaining to waste volumes and waste logistics is presented in Chapter 7.0 and Appendix A of the final Statement.

Issue

A concise summary of the chemical and biological properties of the important radionuclides in high-level waste should be provided, including solubilities and ion exchange characteristics with soil minerals. (6)

Response

While it is possible to concisely summarize radioactive half-lives and the types and energy of the radiation involved, a similar summary of solubility or ion exhange behavior is not practicable. These properties vary with temperature, water composition, and other factors, and are not amenable to being summarized concisely. Where these properties are important for specific analysis made in the Statement, the values used are stated concisely along with pertinent references.

Waste Treatment and Packaging

Draft p. 1.9

Issue

One commenter questioned the statement "in either event, the HLW contains fission products, uranium, plutonium, and the balance of the TRUs." In both the recycle options most of the uranium is removed, and in the U-Pu recycle most of the plutonium is removed as well. Furthermore, if one assumes U & Pu recycling, sooner or later one reaches the point where fuel elements no longer have sufficient fuel value to be worth recycling. This case should be considered.

The volatile materials and TRU elements separated in fuel reprocessing and captured in accordance with the uranium fuel cycle standards (40 CFR 190) are omitted in this discussion. They should be included. (113-EPA)

Response

The sentence in question does indeed appear to be redundant and need not have been included in the draft Statement. It does not appear in the final Statement.

DOE agrees that there is likely to be a point where the uranium and plutonium no longer have sufficient value to justify recycle. How much segregation of uranium and plutonium recycle batches may be practiced is an economic and technical decision that will be determined by the industry when and if recycle becomes a reality. Recycled uranium and plutonium are not necessarily contained in the same fuel elements. Segregation of recycled uranium will be difficult if it is sent back to the diffusion cascade for reenrichment. DOE has assumed in the system simulation (Chapter 7.0 of the final Statement) that uranium or plutonium enriched fuel elements that represent third recycle discharges will be reprocessed but neither the uranium nor the plutonium is further recycled. The uranium is assumed to be sent to storage with diffusion cascade tails for other potential uses. The plutonium is assumed to be dispersed in and immobilized with the high-level waste.

The handling of the volatile materials and TRU elements separated in fuel processing was included in the draft Statement in Section 3.1.4 and, in more detail, in Appendix L. In the final Statement, the treatment and storage of these materials are covered in Sections 4.3 and 4.4.

Draft p. 1.9

Issue

One commenter noted that regarding Table 1.1 of the draft Statement:

- Some of the numbers cannot be derived from other tables presented.
- Column heading or footnote should indicate that hulls and hardware are included in the TRU intermediate-level waste, if that is the case.
- Column heading should indicate that the low-level waste is TRU contaminated. (208-NRC)

Response

Table 1.1 in the Summary of the draft Statement represented an attempt to present complex data-sets in a summary fashion, however, the table did contain errors and may have been overly condensed. It is not used in the final Statement.

WASTE MANAGEMENT OPERATIONS

To avoid confusion regarding the use of the terms intermediate-level TRU waste and low-level TRU wastes, DOE has adopted the convention in the final Statement of referring to these wastes as remotely-handled TRU waste and contact-handled TRU wastes.

Draft p. 1.9

Issue

One commenter requested an explanation of the method used to obtain the values in Table 1.1 (208-NRC)

Response

This table does not appear in the final Statement. The basis for Table 1.1 can be found in Table 2.1.8 and Appendix A, Tables A.19, A.26, and A.35 of the draft Statement. Assumptions relative to waste treatment and treated waste volumes are discussed in Section 4.3 of the final Statement.

Draft p. 1.11

Issue

Some sort of conversion factor should be provided so that realistic comparisons can be made between storage requirements for spent fuel and waste containers for reprocessed wastes. (147)

Response

Information on waste container requirements for treated wastes is provided in the final Statement in Section 4.3.6.

Draft p. 1.17

Issue

The process of incinerating combustible waste has not been shown to be a safe method. (62)

Response

The final Statement includes references to the operation of combustible radioactive waste incinerators (see Section 4.3).

WASTE MANAGEMENT OPERATIONS

Draft p. 1.18

Issue

The fact that the wastes from MOX-FFPs are TRU wastes is more vital than their being "non-high-level." (181)

Response

DOE agrees with the statement, and has endeavored in the final Statement to use the term "TRU wastes" in preference to "non-high-level wastes."

Draft pp. 2.1.6, 8, 22

Issue

Several commenters noted that the startup dates for reprocessing facilities are not realistic. (6, 35)

Response

The range of dates used in the analysis has been adjusted to the years 1990 to 2010. This range of dates was selected to bound the waste management impacts that one would expect from such facilities.

Draft p. 2.1.11

Issue

One commenter asked if fuel reprocessing is to be done in DOE spent fuel reprocessing plants. (62)

Response

For this Statement, reprocessing of commercial fuel is assumed to be carried out at facilities under custody of the Federal government. These plants would have to be licensed for operation by the Nuclear Regulatory Agency.

Draft p. 2.1.11 and 2.1.13

Issue

Cooling towers are listed as major environmental release points. However, sufficient engineering safeguards will exist to prevent releases through a closed cooling water system. (147)

Response

Cooling towers were mentioned as major environmental release points because DOE considers the environmental impact of nonradiological as well as radiological releases, and nonradiological releases do occur at cooling towers. DOE agrees that adequate technology exists to prevent radionuclide releases via cooling towers.

Draft p. 2.1.22

Issue

One commenter noted that DOE should justify the assumption that spent fuel will be packaged prior to storage. This procedure should be based on a cost-effectiveness analysis. (208-NRC)

Response

The example case in the final Statement (see Section 3.2, 4.3 and 4.4) is now based on packaging spent fuel after storage and shows packaging prior to storage as an option including a generic cost for shipping packaged spent fuel. Selection of a procedure based on cost optimization is not yet feasible.

Draft p. 2.1.24

Issue

No reason is given for packaging spent fuel assemblies while the option of reprocessing is still kept open. If reprocessing is the chosen option, sealed-steel canisters would be an economic and procedural burden at the head-end of the fuel reprocessing procedure, besides creating yet another waste stream. (181)

Response

DOE agrees and has revised the method assumed for storing spent fuel assemblies while the option of reprocessing remains open. Water basin storage of spent fuel is assumed for this interim storage. Storage of packaged spent fuel is considered a possibility only if a very long time of interim storage can be foreseen when it might be considered desirable to provide an extra measure of safety by storing the spent fuel in a packaged form.

Draft p. 2.1.26

Issue

If the first reprocessing plant starts in the year 2010 some of the spent fuel may be as old as 50 years. What is the known experience of reprocessing 50-year old spent fuel?

Shouldn't that be considered in your GEIS? You tell us that the oldest fuel is reprocessed first. I assume you are proposing that the oldest fuel go first since you share some of my apprehensions. (55)

Response

If reprocessing is delayed for many years, it is conceivable that some of the spent fuel may be as old as 50 years before reprocessing. No problems are foreseen in reprocessing this age fuel. In fact, it should be considerably easier to reprocess 50-year old fuel than much younger fuel because the radioactivity will be substantially reduced. All of the short half-life nuclides will have decayed to insignificant levels. Most of the tritium and krypton will be gone and the amount of ^{90}Sr and ^{137}Cs will be reduced by nearly 70%. See Section 4.3 of the final Statement.

Draft p. 3.1.54, Item 3

Issue

Unless actinides from chemically separated high-level waste are recycled, they must be disposed of as waste and would still require consideration in this Environmental Impact Statement. Even if one assumes recycling of uranium and plutonium, one eventually reaches the point where recycling is not economically feasible and the transuranics must then be disposed of as waste. (113-EPA)

Response

This comment concerns a statement that was apparently interpreted to mean that not all of the actinides in the spent fuel are sent to the repository. This appears to be a case of misinterpreting the intent of the text in the draft Statement. In the reprocessing fuel cycle, all of the actinides except for plutonium are sent to the geologic repository with the high-level waste. DOE agrees that one may eventually reach a point where recycling is not economically desirable. In the system simulation in Chapter 7.0 of the final Statement, DOE assumes that plutonium discharged from the third recycle is no longer attractive as a recycle fuel and it is discarded to the high-level waste.

Draft p. 3.1.84, Table 3.1.4

Issue

Wastes from spent fuel cleaning operations should be included in intermediate or low-level wastes listed in this table. (58)

WASTE MANAGEMENT OPERATIONS

Response

While wastes from spent fuel cleaning operations would indeed be expected to be radioactive, they are not expected to contain sufficient transuranic radioactivity to require consideration as transuranic waste. Since the Statement is not concerned with treatment of nontransuranic wastes, these wastes were not included in the table.

Draft pp. 3.1.84 and 3.1.186

Issue

Table 3.1.4 compares volumes of wastes from four possible fuel cycles. Text should note that volumes differ by no more than a factor of three. The footnote to the table and the assumption on p. 3.1.186 which indicates that 38 MTHM of reference spent fuel and 7.6 MTHM MOX fuel produced per GWe-yr is 50% too high. (154)

Response

DOE agrees that the volume ratio of 3:1 is a valid observation. See Section 3.4.6.

38 MTHM per GWe-yr is correct. The average fuel exposure for the reference fuel is approximately 29,000 MWD/MT. Thus:

$$\frac{365\ \text{D/yr} \times 1{,}000\ \text{MW/GW}}{29{,}000\ \text{MWD/MT} \times 0.33\ \text{MWe/MW}_{\text{Th}}} = 38\ \text{MTHM/GWe-yr}$$

The author of the comment probably had in mind the amount of fuel discharged from a 1,000 MWe plant which, because it operates at say 70% of capacity over the period of a year, produces 0.7 GWe-yr of electricity and discharges about 0.7 x 38 = 27 MTHM. Each metric ton of spent fuel can provide plutonium for approximately 0.2 metric tons of MOX fuel thus 7.6 MTHM MOX fuel per GWe-yr.

Draft p. 3.1.87

Issue

One commenter questioned why plutonium would be partially purified before blending with the high-level liquid waste (in one of the uranium-only recycle cases considered in the draft Statement). (181) Another commenter suggested that it may be done for reasons of criticality. (154)

Response

There is no criticality reason requiring the partial purification of plutonium prior to putting it back into the high level waste; DOE did not intend the wording would be taken to suggest the opposite. What was meant is that liquid high-level waste containing all of

the plutonium could not be stored in large tanks because of criticality reasons, so the plutonium was recovered separately, and then blended back just prior to solidification. Partial purification occurred during the recovery, but it was not required for criticality reasons.

Draft p. 3.1.87

Issue

One commenter expressed concern over the concept of storing aqueous plutonium nitrate for "several years" prior to blending it into high-level liquid waste for solidification in one of the uranium-only recycle options. (181)

Response

In the discussion of the uranium-only recycle option in the draft Statement, the approach selected as a reference involved essentially immediate solidification of the high-level waste and plutonium nitrate mixture so that very little storage of plutonium nitrate solution would be required.

Draft p. 3.1.87

Issue

The technique of using concrete to consolidate hulls in 55-gallon drums should be mentioned. (181)

Response

This technique is included in the final Statement (see Section 4.3.3.1).

Draft p. 3.1.87

Issue

Calcination (conversion of metals in soluble salt solutions to dry, metallic oxides) can hardly be called an alternative solidification process. It's the first step or co-step in all consolidation processes. (181)

Response

Section 4.3.2.3 of the final Statement points out that various consolidation techniques can be utilized following calcination.

WASTE MANAGEMENT OPERATIONS

Draft p. 3.1.90

Issue

To say that "all" the fission product tritium is released in reprocessing is not true. A large proportion of the tritium is bound to the Zircaloy cladding as the hydride. Only if the fuel is first roasted, as in voloxidation, will the hydride decompose, oxidize to water, and thus be removed from the cladding. (181)

Response

It was noted in the draft Statement, "the reference FRP operation results in the release to the atmosphere of essentially all the tritium present in the spent fuel." DOE meant the fuel itself (UO_2), but can see now that the wording could be construed as including the cladding. The wording in the final Statement (Section 4.3.4.2), "...the tritium present in the UO_2 portion of the spent fuel is released...," should be clearer.

Based on discussions with personnel at Oak Ridge National Laboratory, the tritium bound to the cladding will be released during voloxidation only if a temperature higher than that currently planned for use with LWR fuels is employed.

Draft p. 3.1.90

Issue

Several commenters noted that the storage and separation of ^{85}Kr may create a greater hazard than allowing it to disperse and the rationale for ^{85}Kr storage should be given. (6, 35, 154) One commenter recommended decay interval storage of ^{85}Kr. (28)

Response

Direct release of ^{85}Kr versus its separation and storage did receive additional discussion in the final Statement (see Section 4.4.4 and 4.7).

The rationale for the storage of ^{85}Kr for 50 years before it is released is that the radioactive decay reduces the amount present after 50 years to only about 4% of that present initially; a factor of 25 reduction in the amount released is thus achieved. The 50-year storage period is not necessarily optimum. However, it is well within our technical capability, and reduces total krypton released to within EPA standards which limit ^{85}Kr releases to 50,000 Ci/GWe-yr (10 CFR 190.10).

Draft p. 3.1.191

Issue

The quantity of ^{85}Kr released to the air should be related to gigawatts of electricity produced for comparison with uranium fuel cycle standards. (113-EPA)

Response

This has been done. See preceding response.

Draft p. 3.1.191

Issue

Table 3.1.68 appears to be in error with regard to ^{14}C. ^{14}C is supposed to be removed in reference FRP. The ^{14}C value shown is the full amount in the fuel. (154)

Response

^{14}C in Table 3.1.68 was given incorrectly. The value should have been given as and was corrected to 2×10^{1} Ci-^{14}C.

Draft p. A.58

Issue

Table A.52 shows 5,760 metric tons of plutonium in spent fuel in the U + Pu recycle mode. Our calculations indicate that this quantity of plutonium indicates an extremely high mix of spent fuel from plutonium recycle as compared with UO_2-enriched uranium only fuel As averaged over the entire time span to the year 2040, the MOX to UO_2 fuel ratio we calculate is 60/40. Please provide your basis for this estimate. (208-NRC)

Response

The data in Table A.52 in the draft Statement were developed using the computer code ENFORM (see Section 7.2 of the final Statement). This program calculates fuel cycle logistics and recycles recovered plutonium as MOX fuel as it becomes available. Table A.52 shows 5,760 metric tons of plutonium in spent fuel but it also shows 4,400 metric tons of plutonium actually recycled. The ENFORM program results for this case show 97,000 MT of MOX fuel and 379,000 MT of total fuel. This is a 26/74 ratio of MOX to UO_2 enriched fuel. The recycled plutonium is approximately 60% fissile plutonium. Thus, the 60/40 ratio calculated by the author of this comment contains a substantial error.

Draft Appendix N

Issue

One commenter felt that some discussion should be included concerning the useful life of spent fuel casks and noted that the analysis appears to assume the casks used in the early time frame will be available for use 30-40 years later. (208-NRC)

WASTE MANAGEMENT OPERATIONS

Response

The useful life of spent fuel casks was estimated in DOE/ET-0028 (Section 6.2) to be 20-30 years. A 10 year capital recovery period was used in the cost calculations but an indefinite life was used when estimating the resource requirements. In the final Statement a 20-year life is used to estimate resource requirements.

Draft p. N.2

Issue

One commenter noted that the cask availability data in the draft Statement is out of date. The commenter also requested that some discussion be provided relative to the industry's ability to meet demand for spent fuel casks at the rate they will be required. (208-NRC)

Response

The cask availability data have been updated for the final Statement in Section 4.5, Table 4.5.1. The second issue is addressed in DOE's EIS on Spent Fuel Policy (DOE 1980b) in Volume 2, Section III.

Draft p. N.7

Issue

One commenter questioned why the cask maximum thermal design load is set at 50 kW (208-NRC).

Response

The conceptual high-level waste shipping cask described in this report is based on work done by Battelle-Northwest (Rhoads 1978). The 50 kilowatt heat rejection limit is imposed by the design considered in this report. Nine canisters of 5-year-old solidified high level waste, 30 cm in diameter and 3 meters long, could be carried by this design.

DOE/ET-0028, p. 4.1.30

Issue

In DOE/ET-0028, supporting documentation for the Statement, fluidized bed calcination is identified as the most well developed calcination process, yet the reference vitrification process is spray calcination/in-can melting. Why is one calcination process referenced to make glass waste form and another to make calcine waste form? (208-NRC)

WASTE MANAGEMENT OPERATIONS

Response

The selection was based on degree of development and amount of operating experience for the given service. Fluidized bed calcination has been used to calcine radioactive waste at the Idaho National Engineering Laboratory since 1963. This operating experience made it the obvious choice for the reference process to make a calcine waste form. However, there has been only very limited experience in coupling a fluidized bed calciner to a glass melter. Instead, spray calcination has been quite well developed for use with waste glass melters in the U.S. and in Germany, therefore it was selected for the reference vitrification process.

Waste Storage

Draft p. 1.1

Issue

One commenter requested that the Statement should include interim storage facilities in the general description of the fuel cycle since it is apparent from the discussions in the Statement that these facilities will be built. (208-NRC)

Response

DOE agrees with the concept stated here. Interim storage facilities are described in Section 4.4 of this final Statement. The number and type of interim storage facilities that "will be built" depends on the fuel cycle that is implemented, processing mode chosen for the fuel cycle, and also on the timing of repository availability relative to treatment of the wastes. For a discussion of storage requirements with a range of fuel cycle assumptions see Section 7.3 of the final Statement.

Draft p. 2.1.3

Issue

The statement, "Storage can occur either at the reactor site or at an offsite independent spent fuel storage facility (ISFSF) sometimes referred to as away from reactor (AFR) storage," is misleading. The fact that an ISFSF can be an at-reactor or an AFR spent fuel storage site was not made clear to the public in the draft Statement. (55)

Response

DOE agrees that the quoted sentence does not make clear to the public that spent fuel can be stored in an ISFSF, either at the reactor site or away from the reactor. DOE felt that the important point was that spent fuel can be stored either at the reactor or at an

AFR. DOE has clarified in the final Statement, Section 4.4.1.1, that storage at a reactor site may be in either the reactor storage basins or in an ISFSF located on the same site as the reactor.

Issue

Several commenters questioned the water basin storage period for spent fuel.

Draft p. 2.1.4--There are some apparent inconsistencies in sections on spent fuel cooling times and age at the time of disposal. There is not reasonable chance for disposal at 6.5 years of age and a more likely age is 20 to 25 years. For these reasons the sizes of repositories have been significantly overstated. A minimum cooling time prior to disposal of 20 years is proposed for the final Statement and it is suggested that a reasonable option is further cooling for another 20 to 40 years. (154)

Draft p. 3.1.83--What is the reason for the assumed 6.5-yr storage period, and without some kind of explanation, 6.5 years seems arbitrary. (181)

Draft p. 3.1.173--Cooling only 6 to 7 years before disposal will not occur in the foreseeable future. (154)

Response

DOE agrees that the age of the spent fuel or high-level waste sent initially to the first repository will be much greater than 6-1/2 years, because of the large backlog of spent fuel that will accumulate by the time the first repository becomes available. The age of the waste at the time of disposal is discussed in Section 7.3.4 in the final Statement. The mimimum spent fuel age for the earliest repository date is approximately 15 years and ages up to 55 years are shown to be conceivable. However, it is assumed that the storage backlog will eventually be worked off and the minimum design age of 5 years for spent fuel and 6.5 years for solidified high-level waste will eventually be reached. DOE also agrees that it is possible that a decision may be reached to continue to provide interim storage so that the minimum age for delviery to a repository might be maintained at 20 years or greater. However, for the final Statement, it was considered prudent to assume the possibility of younger waste going to the repository so that the impacts would not be understated.

Draft pp. 2.1.22, 2.1.25, 3.1.184, 3.1.181, 3.1.184, 3.1.186

Issue

One commenter noted that it appears that all terms listed below refer to the same facility. Terms should be used consistently throughout to avoid confusion and to facilitate comparisons. (208-NRC)

Packaged spent fuel storage facility
Storage
Offsite storage facilities
Extended storage facilities
Storage facility
(ESFSF) Extended Spent Fuel Storage Facilities
Dry caisson storage facility
SURF

Response

DOE agrees it is desirable to use terms consistently throughout to avoid confusion and to facilitate comparisons. DOE also agrees that some valid confusion over terminology could have resulted in the draft Statement; efforts have been made to correct this in the final Statement. The acronym AFR has been used in the final Statement to denote a storage facility separate from the reactor site.

Draft p. 2.2

Issue

Four impact statements on TRU waste are mentioned as being in preparation by DOE (SRP, INEL, RL, AND LASL). Data from DOE received by NRC in conjunction with the DOE licensing study showed TRU waste to exist at ORNL. Will there be an environmental statement for ORNL? (208-NRC)

Response

Yes, Oak Ridge National Laboratory is also preparing an EIS for transuranic wastes.

Draft p. 3.1.83

Issue

Spent fuel storage at the reactor pool certainly will be done, not "can be done," for a minimum of six months. (181)

Response

The referenced statement in the draft Statement was, "...interim storage of the unpackaged fuel can be done at either the power plant basin or at an independent spent fuel storage facility...." DOE did not intend to imply that the duration of storage at the reactor would be less than six months, which appears to be what concerned the commenter. DOE agrees that spent fuel will most likely be stored for at least six months in the reactor pools.

WASTE MANAGEMENT OPERATIONS

Draft p. 3.1.85

Issue

The draft Statement is inconsistent in saying one place that spent fuel assemblies can be stored dry in the unpackaged condition, but saying in a second place that dry storage of unpackaged fuel is not feasible. (181)

Response

The draft Statement is not inconsistent in this instance; rather, it contains a distinction that apparently was missed by the reviewer. In the one place, DOE said that spent fuel assemblies can be stored in the unpackaged condition in forced-draft air-cooled vaults. In the second place we said that natural-draft air-cooled vault storage was not feasible for unpackaged fuel. The distinction is drawn because of the belief of DOE that the effluent air from an unpackaged fuel storage facility should be filtered before it is released to the atmosphere. The pressure drop attending the use of appropriate filters does not allow natural-draft cooling to be employed. In the interest of brevity, this distinction was not detailed in the draft Statement.

Draft p. 3.1.85

Issue

Interim storage of packaged spent fuel will increase the danger of leaking. Note the "leak after leak at Hanford, West Valley, Savannah." (30)

Response

DOE feels confident that packaged spent fuel storage facilities can be operated with negligible release of radionuclides to the environment. It should be noted that these sites have experienced some leaks from liquid waste storage tanks, not from packaged spent fuel storage facilities (which have not been employed at these sites).

Draft p. 3.1.92

Issue

Use of "refrigerated air" to cool Kr-storage cylinders implies installation of a refrigeration system which is, based on the low heat load from the cylinders, both unnecessary and impractical. (181)

Response

The Kr-storage cylinders each have an initial heat generation rate of 150 W. In the storage concept considered here, 104 cylinders are contained in a storage cell and

recirculating, refrigerated air is provided for each cell to remove the heat and to provide improved leak detection and containment in case of leaks. Other storage concepts could doubtless be developed in which the use of refrigerated air would be unnecessary.

Draft p. 3.1.92

Issue

If only 10% of the krypton is released in the dissolver, where does the rest go? Would it not be released during shearing and dissolution? (181)

Response

DOE agrees that all of the krypton would be released to a gas phase during shearing and dissolution. The statement that, "Ten percent of the inventory of ^{85}Kr is released in the dissolver off-gases." was meant to convey the information that we assumed that 10% of the ^{85}Kr was not removed by the dissolver off-gas treatment process and was released to the atmosphere.

Draft p. 3.1.178

Issue

Where do the releases in draft Table 3.1.58 come from? Why is there a factor of 50 difference in routine releases to air between ^{137}Cs and ^{90}Sr? (154)

Response

The releases in draft Table 3.1.58 are based on releases during transportation, receipt, storage and packaging of spent fuel based on data contained in the support documents DOE/ET-0028 and -0029. The difference in release factions for ^{137}Cs and ^{90}Sr are due to the release fractions contained in DOE/ET-0028. These release fractions are based on the higher leachability of cesium compared to strontium. This causes the larger release fraction for cesium which results in larger source terms and larger doses.

Draft p. 3.1.184

Issue

One commenter suggested that the document provide support for the statement that no releases of radioactivity would occur during planned operation of the extended spent fuel storage facility (dry caisson options). (208-NRC)

WASTE MANAGEMENT OPERATIONS

Response

This matter is now covered by the statement that double containment of the radionuclides is depended on to maintain releases at negligible levels (see Section 4.4.1.4 of the final Statement).

Draft p. 3.1.186

Issue

One commenter disagreed with some of the reprocessing case assumptions stating that they seriously overstate source terms and thus environmental effects. The following basis was suggested.

1. 30 tonnes fuel per GWe-yr
2. Shipment to AFR at 6.5 years
3. Reprocessing with 15 years cooling
4. Disposal to repository with 20 year cooling. (154)

Response

1. In the final Statement, DOE assumes 7 years capacity at the reactor basins after which spent fuel is shipped to AFR's.
2. For the earliest repository availability (1990) the age of fuel at reprocessing is approximately 13 years but as the storage backlog is worked off, this declines to 1.5 years.
3. An additional 5 years cooling for the high-level waste after reprocessing is assumed. Thus, the age of the initial waste for the earliest repository is approximatley 18 years. This declines to 6.5 years after the storage backlog is worked off.

Draft p. A.49

Issues

Explain the erratic discharge schedule for spent fuel in the years between 1983 and 1988 that is indicated by the inventory accumulation. (208-NRC)

Response

Table A.43 is a typewritten table and the problem is the result of a typographical error. The table shows 13,600 MTHM of spent fuel in reactor storage basins in both 1985 and 1986. The 1985 value should be 12,900. Use of this value will eliminate the erratic discharge schedule observed by the commenter.

WASTE MANAGEMENT OPERATIONS

Draft p. N.1

Issue

One commenter pointed out a perceived inconsistency to the effect that in one location (Table N.1) the draft Statement does not show movement of spent fuel from reactor directly to reprocessing plant (which would occur for recycle options) but in another location (p. 2.1.5) the draft Statement says that storage requirements can be met by power plant storage basins for the recycle options (thus allowing direct shipment to reprocessing). (208-NRC)

Response

This perceived inconsistency apparently arose because a qualifying statement in the first location was overlooked. This statement was "...wastes that are assumed to require Federal custody for storage or isolation..." If spent fuel is going to a reprocessing plant, DOE did not assume it to require Federal custody. This material has been completely revised in the final Statement. Final Section 3.2.1.2 discusses the movements of spent fuel in the reprocessing cycle and these movements are illustrated in Figure 3.2.2. Additional details on spent fuel shipments such as that contained in Appendix N of the draft Statement are presented in Section 4.5.1 in the final Statement.

Issue

One commenter requested that the basis be given for assuming that two Independent Retrievable Waste Storage Facilities would be needed to serve the needs of the reprocessing industry if repositories are not available until the year 2000. Particular interest was expressed in the economics of facility costs versus transportation costs. (208-NRC)

Response

The requirement was based solely on the quantity of waste requiring storage and the assumed capacity of a retrievable waste storage facility for reprocessing and MOX plant wastes. The capacity of a single facility was arbitrarily set to meet the storage requirements at the year 1995. This was equivalent to the wastes resulting from processing 45,000 metric tons of spent fuel. In the scenario employed in the draft Statement the requirement increased to 77,000 metric tons equivalent by the year 2000. Thus two retrievable waste storage facilities were required. In the final Statement, five different nuclear growth scenarios are considered. Storage requirements for these cases with two different reprocessing dates and three different repository dates are described in Chapter 7.0 of the final Statement.

WASTE MANAGEMENT OPERATIONS

Waste Transportation

Draft pp. 1.11

Issue

The transportation operation should receive further attention because at all points along the routes the general population and the operating personnel would be exposed to above ambient levels. (144)

Response

As Section 4.5 points out, the transportation system must be designed to be consistent with the regulations outlined in Title 49 and Title 10 of the Code of Federal Regulations. The prescribed exposure limits for both the general population and operating personnel cited in the above documents are lower than ambient levels.

Draft p. 3.1.85

Issue

There is confusion over the meaning of three sentences regarding the shipping of spent fuel (packaged or unpackaged) between wet and dry storage facilities and to the repository. (181)

Response

DOE feels that much of the confusion on the point of the reviewer comes from our efforts to be brief and yet also at least mention the various options that can be implemented. DOE has tried to minimize such confusion in the final Statement, where spent fuel packaging, storage, and transportation are addressed in Sections 4.3.1, 4.4.1, and 4.5.1, respectively.

Draft p. 3.1.93

Issue

Nonrequirement of neutron shielding for shipping cask hulls implies that hulls do not generate neutrons, which is not the case. (181)

Response

This implication was not intended.

WASTE MANAGEMENT OPERATIONS

Draft p. 3.1.175

Issue

Note the assumption that 90% of fuel from reactors to ISFSF and 100% from ISFSF to Repository goes by rail. This is not likely. This assumption leads to 89,000 truck shipments totalling 280 million km (1.7E+08 miles). This is equivalent to 2.5 highway fatalities, which would become 25 highway fatalities if all trucks were used as is more likely. (154)

Response

Because of the great advantage to receiving and loadout efficiencies when handling large rail casks compared to handling 5 to 10 times as many trucks casks and because of reduced radiation exposure to the public during the transport, DOE assumed that all shipments between major waste management facilities such as independent spent fuel storage basins and geologic repositories would be 100% by rail. Because many reactors do not have rail facilities, we assumed that 10% of the fuel shipments from reactors would be by truck and one-half of the remaining 90% that is shipped by rail would be shipped in intermodal casks allowing shipment by truck to the nearest rail head.

Draft p. N.2

Issue

The document states that about 50% of the operating reactors do not have rail spurs at the site. The reference system given on p. N.3, line 5, shows 90% by rail and 10% by truck. Is this 50% by rail, 40% by intermodal rail and truck, and 10% by truck? Note: on p. N.5, a 45%/45%/10% breakdown is given. (208-NRC)

Response

The fact that 50% of operating reactors do not have rail spurs is factored into the analysis. The 45%/45%/10% breakdown given on draft page N.5 refers to the type of casks used; 45% NLT 19/24 (rail cask), 45% IF300 (intermodal truck/rail cask) and 10% SNF4 (truck cask). This allows as much as 55% of the shipments to start out by truck but 45 of 55 are transferred to rail cars at the nearest rail siding. Thus the 90k% rail 10% truck division.

Draft p. N.3

Issue

The impacts presented in Table N.3 and N.4 of the GEIS are based on a shipping scenario where 100% of all shipments are transported either by rail or by truck. Whether these impacts are presented only for comparison purposes or whether the scenarios upon

which these impacts are based are alternatives to be considered in addition to the reference case is not clear. If the latter is true, then the impact of building rail spurs to the 50% of reactors that do not have these spurs should be given in the GEIS. For the reference case, the impact of transporting the spent fuel by truck from these reactors to the nearest rail siding does not appear to have been included in the analysis. (208-NRC)

Response

The impact of 100% shipment by rail or truck are presented for comparison purposes only and are not alternatives to the reference case. For the reference case, the impact of transporting the spent fuel by truck to the nearest rail siding has not been included in the analysis.

Draft pp. N.3 and N.4

Issue

Impacts presented on p. N.3 (Tables N.3 and N.4) and on p. N.4 are based on the assumption that all spent fuel is shipped by either rail or truck. Values given in DOE/ET-0029 are based on the reference case of 90% of the spent fuel being shipped by rail from reactors to ISFSFs and 10% by truck with 100% of the shipments from ISFSFs to the final repository being transported by rail. We recommend converting the results presented in Table N.3 and N.4 and on page N.4 to the reference case so that actual resource commitments can be known and comparison of the GEIS with the backup documentation can be facilitated. (208-NRC)

Response

Since this reference case is already presented in DOE/ET-0029, the corresponding portion of Appendix N is not required and was therefore deleted. See DOE/ET-0029.

Draft pp. N.3 and N.4

Issue

It is not clear that the impacts shown in the GEIS have been correctly obtained from DOE/ET-0029. The following discussion develops ratios which can be applied to the results in DOE/ET-0029 to convert them into results that would be obtained if 100% of all shipments are transported by either rail or truck. Following this ratio development discussion is a table outlining some cases where impacts presented in the GEIS appear to have been improperly obtained from DOE/ET-0029.

Table 26.2.3 of DOE/ET-0028 shows 7,370 packaged PWR assemblies and 11,340 packaged BWR assemblies needed shipment from ISFSF to a final repository in the year 2000. In the reference case these assemblies would be shipped by rail in a modified NLI 10/24 cask which can

accommodate only 7 packaged PWR assemblies or 17 packaged BWR assemblies. (Normally, this cask can handle 10 PWR or 24 BWR assemblies.) For truck cask normally only 1 PWR and 2 BWR assemblies can be accommodated. Assuming a modified truck cask can be developed that can accommodate 1 packaged PWR assembly or 1 packaged BWR assembly, the number of truck shipments, for the year 2000, from an ISFSF to a final repository would be 7,370 + 11,340 = 18,710 truck shipments. Table 4.1.1-3 of DOE/ET-0029 indicates a ratio of 120,000 to 1,700 for the total number of shipments through the year 2050 compared to the number for the year 2000. Applying this ratio to the 18,710 truck shipments results in a total of about 1.3×10^6 truck shipments through the year 2050 for movement of packaged spent fuel from and ISFSF to a final repository. To determine that total number of truck shipments, the number of truck from reactors to ISFSFs must be added to this value of 1.3×10^6 truck shipments.

Table 4.1.2-1 shows 8.9×10^4 truck shipments through the year 2050 for the reference system. Since this reference system is based on only 10% of the reactor shipments being transported by truck, a total of 8.9×10^5 truck shipments would occur if 100% of the shipments were transported by truck. Thus, the total number of truck shipments of all types through the year 2050 would be $1.3 \times 10^6 + 8.9\ 10^5 = 2.2 \times 10^6$ truck shipments. Impacts presented in the GEIS for 100% of all shipments by truck should be $(2.2 \times 10^6) - (8.9 \times 10^4)$ or 25 times greater than the impacts given in DOE/ET-0029.

A ratio can also be developed for rail shipments. The reference system has 100% of shipments from ISFSFs to the final repository being transported by rail and no conversion to a 100% rail system is needed here. For shipments from reactors to ISFSFs, the reference system has 90% of all shipments transported by rail. Table 4.1.1-3 of DOE/ET-0029 shows 89,000 reactor shipments, through the year 2050, transported by rail. Since this is 90% of all shipments transported by rail, an all rail shipment scenario would have about 12,000 rail shipments. To this total must be added the 12,000 rail shipments from ISFSFs to final repositories, also shown in this table, for a total of 219,000 shipments for an all-rail scenario. For the reference system, the total number of rail shipments is 89,000 + 120,000 = 209,000 shipments. Thus, the ratio of the number of rail shipments for an all-rail shipping scenario to the number of rail shipments in the reference scenario is 219,000 to 209,000 = 1.05. Impacts presented in the GEIS for rail shipments should therefore be 1.05 times greater than impacts given in DOE/ET-0029.

A comparison of some of the GEIS results with those presented in DOE/ET-0029 indicates that the ratios developed in the above discussion are apparently the values used in converting impacts from one document to another. For example, on page 4.1.15 of DOE/ET-0029, Table 4.1.2-3 gives a value of 3.1×10^2 man-rem for the dose to the population living along the transport route, through the year 2050, for spent fuel truck shipments. Using the ratio derived in the above discussion, the impact presented in the GEIS, for an all-truck shipping scenario, should be 25 times greater giving a value of 7.8×10^3 man-rem

and indeed the result given in the GEIS is 8×10^3 man-rem. There are some values, however, that do not agree after this ratio is applied. Cases where there is a lack of agreement between the two documents are outlined in a table which follows the discussion of rail shipments.

For rail shipments, it is more difficult to determine if results for the reference system given in DOE/ET-0029 have been properly converted to an all-rail system which is used as the basis for impacts in the GEIS. The difficulty arises because the two systems are so similar and only differ by the 10% of shipments from reactor to ISFSFs that are transported by rail. It is difficult to determine if the ratio of 1.05 derived above has been used or whether a ratio of 1.11 has been used. The 1.11 ratio is obtained from the fact that the reference system has 90% of shipments from reactors to ISFSFs transported by rail, and this may have been improperly applied to the total system to include shipments from ISFSFs to final repositories which for both systems are 100% by rail. In addition, both ratios are close to 1.0 and some results presented in the GEIS have been rounded off, making it difficult to determine which ratio, if any, has been used. For example, the amount of diesel fuel needed through the year 2050 is given in Table 4.1-5 of DOE/ET-0029 as 1.7×10^6 m^3. On page N.3 of the GEIS, it is stated that 2×10^6 and m^3 of diesel fuel is needed for an all-rail shipping scenario. It is therefore difficult to determine what, if any, ratio was applied to obtain this result. The following table outlines cases where the impacts presented in the GEIS are substantially different than properly converted values obtained from DOE/ET-0029. Values given in parentheses are the results that would be obtained if DOE/ET-0029 values are multiplied by the appropriate conversion factor developed in the above discussion, i.e., 25 for truck shipments, 1.11 for rail shipments. It should be noted that there is one impact where apparently the incorrect ratio of 1.11 was used instead of 1.05. This is the result for nonradioactive effluents released through the year 2050 for spent fuel rail shipments. Table 4.1.1-6 of DOE/ET-0029 shows, for example, that 4.8×10^3 MT of particulates will be released under these circumstances. Applying the incorrect ratio of 1.11 gives a result of 5.3×10^3 MT and this agrees with the result presented in Table N.4 of the GEIS. If the proper ratio of 1.05 had been used, the GEIS result would be 5.0×10^3 MT. Since the results are not substantially different and are within the uncertainty of these types of calculations, improper conversions of this type are not included in the following table. It is recommended, however, that for accuracy and consistency, the values given in the GEIS be properly converted. (208-NRC)

Response

All numbers were verified and errors in the Statement have been corrected.

WASTE MANAGEMENT OPERATIONS

Draft p. N.5

Issue

One commenter requested that some discussion be included describing the compositon of a special train and the advantages and disadvantages resulting from its use. Is it a safer mode of transport? Does it have better safeguard features? (208-NRC)

Response

Special trains were assumed not to be used in the spent fuel transportation for this report. Increased safety by using special trains has not been demonstrated (Rhoads 1977). Disadvantages of special trains are their high cost. Details of cost aspects may be found in Section 6.2.1.6 of DOE/ET-0028. Some discussion is given in final Section 3.2 on the effects of interim NRC safeguard rules for the shipment of spent fuel.

Draft p. N.7

Issue

One commenter felt that the discussion in the draft Statement which pointed out that heat dissipation is a prime consideration in the shipment of spent fuel may be misconstrued. The prime safety considerations are containment, shielding, and subcriticality. Heat dissipation is important to the performance of the other safety features. (208-NRC)

Response

Use of the word "prime" may indeed have been in error and "important" would have been a better choice.

Decommissioning

Draft pp. 3.1.86 and 3.1.87

Issue

The discussion on decommissioning should draw clearer distinctions between decommissioning requirements for reactor plants and the other fuel cycle facilities (since neutron activation of equipment does not occur in the other facilities). What isotopes are of interest at storage facilities? (181)

Response

The decommissioning section of the final Statement (Section 4.6) does not address reactor plants (since they are not a part of high-level or TRU management activities). Data

are now presented on the isotopes present in the decommisioning wastes from FRPs and MOX-FFPs and on the quantities released to the environment as a result of the decommissoning activities.

Draft Appendix D

Issue

The 1,000 year storage and surveillance assumptions used in the calculations are in conflict with proposed Criteria for Radioactive Wastes (43 F.R. 53262 et seq., November 15, 1978) developed by EPA. The appendix should be revised using the proposed period of storage and surveillance of no more than 100 years. (113-EPA)

Response

Two decommissioning alternatives were analyzed for each of the three basic fuel cycle facilities considered in the Statement. The alternatives were selected to show the possible range of environmental effects from decommissiong activities. The alternatives considered are permitted under current regulations, although it is recognized that future regulatory activities by NRC, EPA, and state agencies could significantly impact the choice for decommissioning alternatives at a particular facility.

The Statement recognizes that hardened safe storage of facilities, such as an FRP or MOX-FFP, that contain significant quantities of long-lived radionuclide would have to be followed at some time by final decommissioning activities that would remove residual radioactivity from the site and permit final termination of the facility license. A variety of factors would determine the length of time that a specific facility would remain in hardened safe storage. The period of 1,000 years was selected as a conservative upper bound. It should also be noted that because of uncertainties surrounding the surveillance and maintenance of decommissioned facilities for long periods of time, immediate dismantlement was selected as the reference decommissioning alternative for the MOX-FFP. Dismantlement after 30 years of safe storage was selected as the reference mode for the FRP (see final Section 4.6).

DOE/ET-0028, Section 8

Issue

The preliminary information offered by the DOE in Section 8.0 of the back-up document DOE/ET-0028 is obsolete and does not accurately reflect the Pacific Norhtwest Laboratory studies of decommisssioning for the NRC as stated on page 8.1. The NRC information should be properly referenced and the DOE should provide current estimates of the TRU wastes to be expected from all decommissioning activities. (208-NRC)

WASTE MANAGEMENT OPERATIONS

Response

The decommissioning information presented in Section 8.0 of the back-up document (DOE/ET-0028) and summarized in Appendix O of the draft Statement, was based on detailed studies of decommissioning methods, costs and safety performed at PNL for NRC. The information presented is in substantial agreement with studies that have been published by NRC (NRC 1978b and NRC 1978c) since the draft Statement was issued. Information from these studies was modified as required to account for differences between the reference facility descriptions used in the NRC studies and those used in the present Statement and to account for other differences in study assumptions. It should also be noted that information such as estimated decommissioning waste volumes are presented in different ways in the NRC studies than they are in this Statement. For example, waste volumes presented in the Statement back-up document DOE/ET-00028, Vol 4., Section 8, are volumes prior to treatment and packaging. Both before and after treatment volumes are presented on pages 10.A.71 and 10.A.72 of Vol. 5. Waste volumes presented in the NRC studies are volumes of packaged waste requiring disposal. These differences make direct comparisons between the NRC studies and this Statement somewhat confusing but they are not inconsistent.

Repository Construction and Operation

Draft pp. 1.1, 1.5, 2.1.26

Issue

One commenter pointed out that the draft Statement indicates that the quantity of waste can be directly scaled to the total energy generated during the operating reactor life cycles. Thus, the 250 GWe case generated 0.64 times as much waste as the 400 GWe case. From this a reader can conclude that the number of repositories required for the alternative growth scenarios would be 1/3 less than those required for the 400 GWe scenario. However, the draft Statement does not provide information on the specific number of repositories required for the alternative scenario and this is cited as a serious ommission since environmental effects vary according to the number of repositories. (43)

Response

The intent of the information presented in the draft Statement was to show that the number of waste management facilities inculding repositories for the alternative scenario would be 0.64 times as many as those for the 400 GWe scenario. In the final Statement, the number of repositories required for 5 different energy scenarios is presented in Table 7.3.10.

WASTE MANAGEMENT OPERATIONS

Draft p. 1.4

Issue

One commenter suggested using TRU waste containers as heat buffers between high-level containers in the repository. (181)

Response

It may be possible to design the repository operation so that the TRU waste containers are dispersed in the high-level waste disposal area. This might indeed provide a more efficient use of repository space but the implications of this concept have not been fully analyzed and the more conservative concept of providing separate areas for TRU waste and high-level waste was used for the conceptual repositories in this Statement.

Issue

Several letters commented on the topic of retrievability of waste from a repository.

Draft pp. 1.3 and 3.1.53--There are a few technical reasons why retrievability should be attempted and a number why it should not. Further, over any time period in which maintenance of retrievability is technically practical there is relatively little in the far-field which can be learned. The movement of radioactivity would be so slow as to produce little meaningful data. (154)

Draft pp. 3.1.105--The period of retreivability should be discussed at an earlier point in the final statement. (154)

The subject of retrievability is not treated in either a systematic or cohesive manner. More consideration should be given to the period of retrievability and the risks associated with retrievability. (58, 124)

Response

DOE agrees that little far-field data can be collected during a retrievability period of five years. However, the objective is to confirm predictions about behavior in the near-field in response to placement of the waste. It was never intended that there would be any possibility of observing movement or radioactivity which is not expected to even be possible for several hundred years after placement.

The draft Statement examined retrievability for periods of five and up to 25 years following emplacement. The final document contains a discussion of retrievability for periods up to 50 years (see Section 5.3.1.5 and Appendix K). The section on Technology Comparisons (Section 6.2) uses "Potential for Corrective Action" as one of the factors by which disposal options are examined.

WASTE MANAGEMENT OPERATIONS

Draft p. 1.9

Issue

The total amount of radiation in curies for each disposal site and for all sites and for each waste type should be stated. Also what percent of the radiation will still be left after 500 years? (62)

Response

The total curies of radioactivity disposed of in each of the five growth scenarios in the final Statement is identified in Tables 7.3.13 and 14. The number of repositories and thus the portion of the total radioactivity that may be disposed of in any single repository will depend on the specific site and the geologic media selected. The range of nominal 2000 acre repository requirements for each of the nuclear growth cases is shown on Table 7.3.10. Figure 1.1 in the summary shows that the amount of radioactivity remaining after 500 years will be reduced by a factor of 100 to 500 or more relative to the amount originally placed in the repository.

Draft p. 1.10

Issue

One commenter requested that more detail be provided on area thermal loading limits. (40)

Response

Such information can be found in final Section 5.3, Appendix K of Volume 2, and Section 7.3 of DOE/ET-0028.

Draft p. 1.10

Issue

Table 1.2 should present the repository acreage requirements for a 6,300 GWe-yr economy. (208-NRC)

Response

The relationship described on page 2.1.27 of the draft Statement shows that acreage requirements for the 6,300 GWe-yr growth scenario would be 63% of the requirements shown in Table 1.2.

WASTE MANAGEMENT OPERATIONS

Draft p. 1.10

Issue

One commenter requested an explanation of the method used to obtain the values in Table 1.2. (208-NRC)

Response

The basis for repository area requirements shown in Table 1.2 of the draft Statement can be found for the once-through cycle in Table 7.4.2 of DOE/ET-0028 and for the reprocessing cases in Table 7.5.3 of DOE/ET-0028. The total number of containers classified by waste type for each of the nuclear growth cases and the range of 2,000 acre repository requirements, considering the four geologic media, can be found in the final Statement in Section 7.3.

Draft p. 1.11 and Chapter 4.0

Issue

Several letters questioned the range of repository availability dates (1985-2000) used in the draft Statement. (154, 181, 208-NRC, 219)

Response

The final Statement examines (under the proposed action) repository availability from 1990-2010 (see Chapter 7.0).

Issue

Several letters expressed concern with the retrievability process.

Draft p. 1.14--The retrieval capability of 5-50 years mentioned may be inadequate especially if a very serious incident occurs. (62)

Draft p. 3.1.105--The whole question of retrievability is bothersome. The statement says that "This would involve returning to the emplacement rooms, removing the spent fuel canister from its sleeved hole with the same transporter originally used for emplacement, transporting the canisters to the receiving stations where they are hoisted to the surface and providing some sort of interim storage for the canisters until another repository is ready to receive the spent fuel." This assumes that the failed fuel canister is not so damaged that it can still be handled with the same equipment used for handling one which is undamaged; that "some sort of interim storage" is available for failed fuel canisters; and, that another repository will eventually be ready. There is doubt that another repository would ever be ready should the first one not work out satisfactorily. (35)

Response

Failure of a spent fuel canister does not necessarily imply failure of the host repository. It is anticipated that providing retrievability for some initial period of time will allow for removal of waste if unexpected phenomena are observed which could lead to the failure of the repository system to provide the required isolation or containment. If retrieval is required, waste removed could be transferred to temporary surface storage. Ultimately, the waste will be disposed of in a separate repository or repackaged for re-emplacement.

Draft p. 1.18

Issue

Several commenters questioned the following statement--"After return of the biota which had been displaced during construction operations, the unoccupied buffer land could provide an undisturbed wild life sanctuary." (144, 213)

Response

Except for the rock spoils pile, the land could and would most likely return to useful habitat for biota. This has been observed in many large plants. That the rock spoils pile must be dealt with is acknowledged but these form a very small portion of the site.

Draft p. 1.19

Issue

Several letters noted that the statement--"Based on repository design criteria, the health effects would be zero as long as the repository performs to the design basis and no accidents occur after closure."--is overstated. (142, 154)

Response

Based on this Statement's definition of isolation, the quantities of waste which might reach the accessible environment would not be large enough to cause any health effects.

Draft pp. 2.1.3-4

Issue

One commenter requested that the Statement address the repository startup and shutdown schedules (i.e., how many will be needed and on what schedule). (208-NRC)

Response

The number of 2000 acre repositories required is identified as a range of values for both the once-through and reprocessing cycle in Table 7.3.10 of the final Statement. The startup schedule will be dependent upon whether the proposed program or the alternative program is adopted and on the geologic medium selected for the initial repository, and on the extent that regional repositories are sited (i.e. how many repositories will be operating concurrently). Because of these variables, it is not feasible to identify the repository startup schedules in this Statement except to identify a range of dates for startup of the initial repository.

Draft p. 2.1.4

Issue

One commenter stated that the draft did not address the question of the final disposition of very long-lived fission or activation products, such as ^{129}I, ^{59}Ni, and ^{99}Tc, which are separated from TRU or high-level wastes. Cost/benefit estimates including them with the HLW and TRU wastes should be addressed. (208-NRC)

Response

The only long-lived fission product or activiation products that are assumed to be separated from TRU or high-level wastes in the assumed processing are ^{129}I and ^{14}C. The separated ^{129}I and ^{14}C is captured, immobilized, and packaged for disposal in a repository along with the packages of TRU waste. The ^{59}Ni is retained in the fuel residue (hulls and hardware) while the ^{99}Tc is retained with the rest of the fission products in the high-level waste. Thus, the effect of including these long lived nuclides with the TRU wastes has been addressed. See final Appendix A, Tables A.2.1a-A.3.9b.

Draft pp. 2.1.17, 18, 19

Issue

The data on radioactivity content of the low-level TRU wastes in Section 2 of the draft Statement indicates it might not be necessary to send the low-level TRU waste to deep geologic disposal. In view of the large impact the low-level TRU waste has on repository volume, careful consideration should be given to the need for such disposal and the rationale clearly explained. (208-NRC)

Response

Although the volume of low-level TRU waste (referred to in the final Statement as contact-handled TRU waste) is quite large, it has a very small impact on repository area requirements. Table 7.5.3 in DOE/ET-0028 shows that these low-level TRU wastes utilize only 1 to 2% of the repository area. This is because they can be placed much more compactly in

the repository than other wastes that have significant heat generation or surface radiation rates. DOE agrees, however, that ultimately not all of these wastes will necessarily require disposal in the deep geologic repositories. For the purpose of this generic Statement it was considered prudent to assume that all suspect TRU wastes require geologic disposal.

Draft p. 2.1.22

Issue

One commenter stated that the discussion of dynamics in Section 2.1.4.4 is incomplete. (40)

Response

An expanded discussion of system dynamics is presented in Chapter 7 of the final Statement. Additional information on dynamics can be found in Appendix A of Volume 2 and in Sections 3.1, 3.10 and 10.1-10.6 of DOE/ET-0028.

Draft p. 2.1.22

Issue

The maximum spent fuel receiving rate considered for a repository in the draft Statement is 12,000 MTHM per year which amounts to a handling requirement of 10 canisters per hour. These rates appear unrealistically high and the design of the handling system to accomplish this should be presented. (208-NRC)

Response

The canistered waste handling facilities designed for this receiving rate are described in DOE/ET-0028 for receiving facilities on p. 7.4.10, for shafts on pp. 7.4.15 and 16 and for sub-surface facilities on pp. 7.4.17-20. Because lower growth rates are assumed in the final Statement, the maximum handling requirement is substantially reduced. In addition, the waste disposal requirements may be divided between two or more regional repositories.

Draft p. 3.1.35

Issue

The GEIS should address retrievability in a fashion that the potential for such retrievability (over the full term of operation) can be properly addressed. Consideration of the creep behavior of salt under thermomechanical loading is important for the design of a repository in salt because it will affect the short (operational) and long (retrievability) term stability of storage rooms and access ways. (208-NRC)

Response

Conditions at specific repository sites may warrant longer (up to 50 years) periods of readily retrievable emplacement before sufficient confidence exists to permit backfilling. For a repository in salt, the amount of salt creep is also highly site dependent and may be more severe at some locations. For this generic Statement, a site was assumed where 5 years was a sufficient period of ready retrievability and salt creep was not excessive. Section 5.3.1.5 of the final Statement discusses alternative measures to allow longer ready retrievability periods.

Draft p. 3.1.36

Issue

One commenter noted that seismic occurrences during repository construction and operation are the primary risk to repository integrity. (35)

Response

Due to the relatively short period of time that the repository is in the operational phase compared to the isolation phase, earthquakes during this period are unlikely. If an earthquake does occur during the construction and operation of the repository, consequences of the event are mitigated by a facility designed to resist ground motion and trained personnel and equipment available to respond to any localized destruction.

Draft p. 3.1.37

Issue

The statement--"...maintaining retrievability longer than needed to reasonably assure repository operation increases the occupational and general populace risk."--is unsubstantiated. (208-NRC)

Response

The substantiation is as follows: If workers enter the repository for inspections, occupational dose will increase and simply being in a deep-geologic mine has a certain amount of risk involved. Also, the general populace risk increases because the geologic barrier is not sealed, thus decreasing the number of barriers that assure containment of the nuclides.

WASTE MANAGEMENT OPERATIONS

Draft p. 3.1.40

Issue

The discussion of physical protection makes sense if it refers to physical protection during the operational phase of a repository. The first paragraph on p. 3.1.41 is self-contradictory. Because operational controls will cease to exist long before any appreciable decay of ^{239}Pu, the protection must be inherant in the inaccessibility of the waste in the repository and the massive effort that would be required to remove it. (113-EPA)

Response

This discussion applies to the operational period only. Once decommissioned, the wastes are isolated from human access.

Draft p. 3.1.41

Issue

The listed impacts are essentially written off without any perceived bases. For example, storage and disposal of mined mineral on the surface is a visual, as well as potential biological impact. These impacts should be fully considered and analyzed by a generic manner, and not be left for a later determination. (208-NRC)

Response

The first sentence under Operational and Post-Operational Impacts states that the issues listed need to be resolved to further clarify operational and post-operational environmental impacts associated with waste repositories in deep geologic formations; and the first of these issues is the proposed deposition of mined repository material, especially for salt repositories. On draft pp. 3.1.120-123 (final Section 5.4) there is some discussion of the toxicity of mined salt to certain plants, values given for the amount of salt deposited at the repository fenceline, and comparisons of salt to other candidate geologic formations. The values for fenceline salt deposition are given as 9.3 and 93 g/m^2 for the arid and reference environment, respectively, in the Statement (draft p. 3.1.121, final Section 5.4) and as 8.4 and 83 g/m^2 in DOE/ET-0029, p. 10.1.10. A similar discussion of salt impacts is given in Section 10 of DOE/ET-0029. For geologic disposal, salt was the option judged to have the potential for significant ecological impacts beyond what would result from change in land use. The acid effluents from mined pyrites from the shale formation could also be potentially damaging to aquatic ecosystems.

Issue

Several letters noted that the issue of storage and disposal of mined material was not sufficiently addressed.

WASTE MANAGEMENT OPERATIONS

Draft p. 3.1.41--Approximately 50 million tons of rock will be left on the surface during operation of the repository. This is 70 million yards of material or a mound of material 60 feet high occupying one square mile. Has the leaching consequences of this pile been addressed? Can suitable acreages be identified in the model site area to accommodate this material? How will the residual waste rock at the surface be reclaimed? (43)

Draft p. 3.1.109--There is doubt that surface storage of salt is possible for 25 years. Techniques that enable this to occur should be described in the Final EIS. (35)

Draft p. 3.1.115--The surface storage of mined material is not sufficiently evaluated as an environmental impact. A more detailed impact analysis of surface storage should be provided and cross referenced whenever it is discussed. (208-NRC)

Draft p. 3.1.120--A more detailed discussion of the ultimate disposal of excavated material is needed. In some ways this problem is analogous to the disposal of dredged material. The volumes (tens of millions of cubic yards) are similar to those involved in large dredging operations. It cannot be dismissed out of hand without more detailed discussion. (208-NRC)

Draft p. 3.1.121--What are the mitigating procedures mentioned in the third paragraph concerning salt depositions? (35)

Draft p. 3.1.121--Information should be provided regarding the size of the area over which the effects of salt dispersal would be felt. (58)

What are the plans for the tens of millions of tons of salt at the repository? (2)

What plans have been made to dispose of mined materials? (213)

Response

Sufficient site-specific information does not exist to make a detailed generic impact analysis of much value. The potential impacts beyond those associated with change in land use are those resulting from environmental release of mined salt and the creation of acid liquid leachates from the pyrites in the mined shale. Environmentally-safe management of both these mined materials is considered to be possible.

The disposal of material excavated from the repository is included in the comparison of environmental impacts (see final Section 5.4). The basis for this discussion is contained in DOE/ET-0029 (Section 4.4.1). These questions will be analyzed on a site specific basis in the EIS required for an actual repository.

Draft p. 3.1.105

Issue

The Authur D. Little work for EPA found that spent fuel heat loadings should be about the same for granite and salt. This seems reasonable considering that the salt has a

higher conductivity than the hard rocks and is surrounded by shale which is not a good conductor. We would like to correct this discrepancy between DOE and A. D. Little heat loading models. (113-EPA)

Response

Our reading of the A. D. Little report prepared for EPA (EPA 1977) indicates that the primary consideration relative to the repository heat loading in that study was the far-field effect of surface uplift. DOE's analysis did not find far-field effects to be the limiting factor for 5 to 10 year old waste except in the case of spent fuel disposal in salt. For all other cases, the thermal loading limit was set by near-field criteria, i.e., rock stresses in the implacement region. To allow for uncertainties in the criteria and calculations, actual loadings used for the conceptual repositories were limited to two-thirds of the calculated allowable loading. All temperature profiles were recalculated and rechecked for the final Statement using an improved version of the computer code used in the draft Statement. The thermal criteria and temperature profiles can be found in Appendix K.

Draft p. 3.1.106

Issue

No discussion is given of the air content of the repository following backfilling. The mobility of several significant radioelements, plutonium, neptunium, uranium, and technetium, are affected significantly by their oxidation state. (In some schemes for the in situ solution mining of uranium, air is used as the source of O_2 and is the oxiding agent of the uranium.) The air content should be briefly discussed. (113-EPA)

Response

A room backfilled to within 0.6 m of the top will be slightly over 90% filled as rooms in the different host rocks range in height from 6.7 to 7.6 m. Since the backfill cannot be compacted to theoretical density, it is apparent that only some 70 to 80% of the room volume will be occuppied by solid matter. Thus, the remaining 20 to 30% will be air. However, significant oxidation of the various radionuclides from this source of oxygen is not anticipated for several reasons.

1. Air, alone, is not expected to corrode, erode, etc., or otherwise damage the waste package.
2. Some of the air will dissolve in circulating water (ground water or brine) making ground waters somewhat more aggressive. The waste package will be designed to last 50 or more years at which time waste package temperatures will have passed their peaks and be declining. Consequently, the waste form will not be exposed simultaneously to its maximum temperature and an aggressive environment.

3. Design of the repository will insure that the maximum temperature achieved by the waste form will not be high enough for significant oxidation of heavy metal elements even if an oxidizing environment were present.

Draft p. 3.1.106

Issue

One commenter was interested in what the rooms, shafts and tunnels will be backfilled with. (218-DOI)

Response

Backfill material can be previously excavated rock (see Section 5.3.1.6) or it may be special absorbant material (see Section 5.1.2).

Draft p. 3.1.107

Issue

One commenter requested to know the volume of material for permanent onsite storage and whether adequate mining capability is included in the repository design. (43)

Response

Volume of permanent on site storage is included in Tables 5.3.4 and 5.3.8 of the final Statement. Adequate facilities and equipment have been included in the repository design.

Issue

Several letters commented on the placement of various types of wastes next to each other in a repository.

Draft p. 3.1.111--There should be some consideration of the possible interaction of the various wastes with each other. If the transuranic waste contains organic material, these may contain chelating materials, which could have an effect of mobilizing other waste. (113-EPA)

Draft p. 3.1.114--There can be potential problems from placing low-level wastes next to high level waste if low-level waste has significant organic constituents or other chemical incompatabilities. (218-DOI)

Response

The transuranic wastes and high-level wastes are sufficiently removed from each other in separate areas to preclude this problem.

WASTE MANAGEMENT OPERATIONS

Draft p. 3.1.113, Table 3.1.9

Issue

There is a considerable difference (in the case of salt) in the amount of storage between fuel cycles. (154)

Response

As explained in Appendix K and Sections 5.3.1.1 and 5.3.2.1 of the final Statement, the difference is due to the plutonium content of the wastes. Wastes containing increased amounts of plutonium (spent fuel and uranium-only recycle waste) have increased long-term heat generation that can adversely affect the salt formation. For this reason, the amounts of this type of waste that may be stored in a salt formation is restricted.

Draft pp. 3.1.116, 117, 120

Issue

There appears to be a contradiction between Tables 3.1.14 and 3.1.11. In Table 3.1.14 the average dust concentrations at a salt repository are higher for reprocessing waste than for spent fuel, whilst in granite, shale, and basalt, the reverse is indicated. However, from Table 3.1.11 less salt is mined per MTHM for reprocessing waste, whereas for the other three rock media, more rock is mined for reprocessing waste. In any event the concentrations of salt at the reference site are less than that in seaside air. (154)

Response

This apparent contradiction has been corrected in the final Statement (see Section 5.4).

Draft pp. 3.1.115-136

Issue

No discussion of the hydrologic design criteria of the surface facilities is given. If the site is to be designed to withstand the probable maximum flood, so state and discuss. If not, discuss the consequences of the flood more severe than the design criteria. (208-NRC)

Response

As per 10 CFR 1022, facilities are not to be built on flood plains. The base flood plain is the 100-year flood and the critical flood plain is the 500-year flood.

WASTE MANAGEMENT OPERATIONS

Draft p. 3.1.116

Issue

It appears that the resource requirements are biased in favor of salt due to poor design of repositories in other media. (208-NRC)

Response

In the absence of detailed site specific geologic data, optimization of the repository design to account for the special qualities of each medium is not possible. Instead a standardized repository design using a conventional underground layout is specified.

Draft p. 3.1.118

Issue

Table 3.1.12 presents total quantities of effluents released to the atmosphere during construction and operation of a geologic repository. The potential effects of these effluents on ecosystems should be evaluated. (208-NRC)

Response

The first sentence at the top of draft p. 3.1.119 states that "The estimated releases of the pollutants (those presented in Table 3.1.12) from construction and operation of a geologic repository would not in any case result in Federal air quality standards being exceeded at the repository boundary." It was assumed that if pollutant releases were below the limits specified in Federal standards, that no significant ecological impacts would result. Therefore, no evaluation of the potential effect of these effluents on ecosystems was made.

Draft p. 3.1.120

Issue

Little or no discussion is given of the potential hydrologic implications of repository construction and operation. For example, what would be the effects on surface drainage and downstream water quality of excavated material stored on the surface? Would the material be laid out on level surfaces, would low spots be filled in, would streams be diverted or dammed? What would happen during heavy rain and/or floods? Where would water needed for construction/operation be obtained? A description of a typical site, its construction and the hydrologic and water use impacts is needed. (208-NRC)

WASTE MANAGEMENT OPERATIONS

Response

Section 4.4.1 (DOE/ET-0029) contains a discussion on surface drainage from excavated material.

Draft p. 3.1.123

Issue

It does not seem credible for water inflow through shale to be ten times that of granite. (218-DOI)

Response

The figures cited represent conservative estimates of inflow volumes during repository operation only.

Draft p. 3.1.136

Issue

Justification is needed for the stated maximum surface temperature rise and uplifts. (208-NRC)

Response

Justification has been included in Appendix K of the final Statement.

Draft p. 3.1.244

Issue

"Other factors influencing the time required include licensing procedures . . ." This is a really gross understatement. Taking nuclear power plants on historical precedent, the greatest delays in undertaking a project have not been in siting, designing, or other technical problems prior to construction, but in the licensing process and its procedures. This fact of life is not a condemnation of the NRC, but an indication of the difficulties in deciding technical issues relating to safety and environmental impact within an adjudicatory administrative framework. In the case of a geologic repository, these difficulties will be compounded by the present lack of established criteria and standards. (154)

Response

The sentence referred to has been deleted from the final Statement. However, it should be noted that the EPA and NRC are currently developing criteria and formulating

standards for the repository licensing procedures well in advance of the construcion of the first repository.

Draft pp. A.17, 32, 46, 58

Issue

One commenter was unable to reconcile the statements of inventory of plutonium-239 in Table A.14, 29, and 42 with those in Table A.53. (6)

Response

Using a half life for ^{239}Pu of 2.44×10^4 years, one gets 16.29 grams/curie of ^{239}Pu. Multiplying this value times the curies of ^{239}Pu shown in Table A.14, A.29, and A.38, in the year 2050 (presuming the commenter intended Table A.38 rather than A.42) one gets 1790, 1840, and 27 metric tons of ^{239}Pu respectively. The first two numbers agree with the values in Table A.53 while the third value indicates a typographical error. It was reproduced in Table A.53 as 17 rather than 27.

Draft p. K.5

Issue

It is stated that 25-year retrievability required lower thermal densities. For salt and shale the decrease is a factor of two while for granite and basalt it is 2.5. Why? (208-NRC)

Response

The discrepancy was due to rounding error. The change is approximately a factor of 2 in all cases. The reason for the reduced loading (i.e. reduced stresses) was described on the same page.

Draft p. K.5

Issue

Optimization of the design for a given waste type in a particular medium would likely result in a different capacity estimates. (208-NRC)

Response

DOE agrees that this would be the case. See response to issue in this section referring to p. 3.1.116.

WASTE MANAGEMENT OPERATIONS

Draft p. K.8

Issue

Figure K.6 shows a smaller temperature increase after emplacement of waste for a repository in shale (Figure K.6, p. K.8) than for a repository in salt. (208-NRC)

Response

Figure K.6 in the draft Statement was incorrect. The final Statement contains a revised figure.

DOE/ET-0028, pp. 7.1.2 and 7.2.18

Issue

The GEIS should discuss whether retrievability in salt can be guaranteed under the expected thermal loadings. It should also discuss whether the integrity of seals in the salt repository can be maintained following closure. (208-NRC)

Response

As discussed in Appendix K of the final Statement, analyses indicate that wastes will remain readily retrievable for at least the initial 5 year period.

Details of shaft sealing techniques are highly site dependent and are not discussed in the final Statement. Discussion of shaft sealing techniques is provided in NUREG/CR-0495 (NRC 1979b).

DOE/ET-0028, p. 7.3.5

Issue

Emplacement of waste containers without the sleeves does not appear to be considered in the thermal analysis. (208-NRC)

Response

The thermal analysis considers the use of sleeves with an associated air gap surrounding the canister. This maximizes the temperature of the waste canister and was conservatively used to represent the thermal conditions of canisters without sleeves also.

WASTE MANAGEMENT OPERATIONS

DOE/ET-0028, pp. 7.4.43 and 7.5.46

Issue

The times allowed to complete licensing and construction of a repository are much shorter than those estimated by NRC. Figures 7.5.13 and 7.4.14 in DOE/ET-0028 show seven years from preliminary design to operation with one year between submission of a PSAR and construction approval. NRC estimates 10 to 12 years from preliminary design to a decision on operating approval. These longer times should be used in establishing repository availability dates as these delayed availability times may affect conclusions on the impacts of waiting until alternate methods are developed. (208-NRC)

Response

The time delays have been adjusted to reflect current estimates of the times required.

Issue

One commenter suggested that early in the impact statement discussion should appear which points out that the geologic disposal facility is to be filled with excavated material and the facility sealed in the decommissioning process. (27)

Response

Section 5.3 of the final Statement presents a description of the geologic disposal concept and those activities that will occur during the operation of a waste repository.

Issue

The GEIS should discuss the occupational hazards associated with retrieval options and acknowledge that in order to have ready retrievability all main entries, storage rooms and exhaust airways must be kept open. (208-NRC)

Response

For the 5-year period of ready retrievability assumed in the final Statement occupational hazards, both mining and radiological, are not severe. It is acknowledged that for longer periods of ready retrievability or for removal of emplaced wastes after backfill, special precautions will be necessary and difficult. See Section 5.3.1.5 and Appendix K of the final Statement for additional discussion.

Issue

Several letters noted that the Statement should address the issue of the effect of emplacing waste in a geologic repository after extended storage periods. (208-NRC, 218-DOI)

WASTE MANAGEMENT OPERATIONS

Response

Appendix K of the final Statement discusses the impact of waste age on repository capacity. DOE agrees that there appears to be an advantage in terms of repository spacing requirements for aging high-level wastes.

Issue

The rationale for the thermal and thermomechanical limits on which repository design is based is missing from the GEIS and should be provided. (208-NRC)

Response

The rationale has been added to Appendix K of the final Statement.

Issue

Different repository designs and waste storage designs should be considered for different media. (208-NRC)

Response

In the absence of detailed site specific geologic data, a standardized repository design using a conventional undergound layout is specified.

FUEL CYCLES

Draft pp. v and 3.1.6

Issue

Several commenters suggested that discussions of fuel cycles did not emphasize that in the once-through cycle, potentially valuable nuclear fuel is treated as waste. (198, 218-DOI)

Response

The Statement compares the waste management environmental impacts of the once-through cycle with the recycle fuel cycle. Except for the waste management aspect, no attempt is made to address the overall advantages and disadvantages of reprocessing versus no reprocessing.

Draft pp. 1.11 and 2.13

Issue

The established fuel cycle, deferring a decision on the ultimate disposition of spent fuel, should be addressed in the Statement. (181)

Response

The Statement does examine the implications of deferring a decision to dispose of or to reprocess spent fuel (see Section 2.1 of draft and Chapter 7.0 of final).

Draft p. 3.1.75

Issue

One commenter questioned whether the statement--"The majority of nuclear wastes are residuals from defense programs."--represented a measure of volume or a measure of curies. (32)

Response

On strictly a volume basis, there is a large quantity of defense wastes on hand. However, high-level wastes from the defense program are radioactively more dilute than commercial HLW. The TRU wastes from both sources are similar. See Appendix I for additional discussion of key defense and commercial waste characteristics.

FUEL CYCLES

Draft p. 3.1.83

Issue

It is stated that--"Required activities are described for four possible fuel cycles."--while previously it was stated that--"Three fuel cycle alternatives are considered." (218-DOI)

Response

The "four" refers to once-through, U-Pu recycle, U-only recycle (plutonium stored), and U-only recycle (plutonium disposed of with high-level waste). Only the once-through and the U-Pu recycle cycles are considered in the final Statement.

Draft p. 3.1.93, 214

Issue

Several commenters noted that the U-only recycle is not a logical fuel cycle. (6, 35, 154)

Response

Presentation of this fuel cycle has been deleted from the final Statement. Related information can be found in the support documents DOE/ET-0028 and DOE/ET-0029.

Draft pp. 3.1.98-111

Issue

Thirteen pages of description of a geologic repository for spent fuel seems out of place. (154)

Response

Consideration of the once-through fuel cycle is mandated by Federal policy.

Issue

The primary thrust of the Statement should be on the disposal of high-level wastes (U/Pu recycle fuel cycle). (154)

Response

As the present administration policy dictates a moratorium on spent fuel reprocessing, the once-through fuel cycle was one of the fuel cycle options examined in the Statement.

COSTS

Draft pp 1.10, 1.23, 3.1.133

Issue

The discussion of costs and capacities for repositories in different media for the two fuel cycles is confusing and some of the data appears contradictory. For example:

1. The unit power costs do not appear to reflect the construction costs.
2. Why does a basalt repository cost $500 million more than one in granite if the difficulties of mining in granite are comparable?
3 Why do the construction costs between fuel cycles for the same media vary in a seemingly unrelated pattern? (208-NRC)

Response

DOE agrees that some of the cost relationships are confusing since the data necessary to obtain an understanding of the costs appear in different locations. The repository cost tables in the final Statement have been revised into a single table in Section 5.6 which consolidates all of the necessary information. This table is reproduced below for reference in answering the specific questions above. Unit power costs are shown in the last column of the table for additional reference. All repositories have the same total area (800 ha or 2000 acres).

1. The ratios of unit power costs between media differ from ratios of construction cost for the reasons below:
   - Unit power costs include the effect of repository waste capacity.
   - Unit power costs include predisposal costs.
   - Unit power costs include the effect of the cost of money on costs through discounting.

   The effect of the latter two reasons on cost can be discerned by comparison of the unit heavy metal costs in column 7 with the unit power costs in column 8. The largest effect by far, however, is the difference in waste capacities (noted in column 4 in the table) in the repositories due to the different thermal loading limits in various media. Thus, while the construction cost for a basalt repository is three times that of a salt repository, the unit heavy metal cost is only 67 percent greater since 2.4 times more waste can be stored in basalt than in salt.
2. The unit costs of mining basalt were estimated to be about five percent greater than those for mining granite. Most of the cost difference, however, is due to differences in mining requirements as noted in column 3 in the table.

Waste Type	Geologic Media	Mined Quantity 10 MT	Equivalent MTHM of Waste Stored		Construction Cost millions of $	Total Operating Cost millions of $	Unit Cost $/kg Hm	Unit Power Cost mills/kwh
Spent Fuel	Salt	30	51,000		1,000	590	52	.45
	Granite	77	121,600		2,600	2,350	78	.51
	Shale	35	64,500		1,300	810	57	.46
	Basalt	90	121,600		3,100	2,390	87	.53
			HLW	Other				
Fuel Reprocessing Waste	Salt	35	62,000	100,000	1,200	1,210	48	.50
	Granite	53	69,000	108,000	2,000	1,940	77	.58
	Shale	30	30,500	56,000	1,300	830	73	.59
	Basalt	59	56,000	92,000	2,300	1,740	93	.63

3. The construction cost differences between fuel cycles for the same repository media are mainly due to the different mining requirements noted in column 3. The rest of the differences are due to slightly higher costs for facilities and shafts in the reprocessing waste repositories.

Draft p. 1.28

Issue

A question was raised whether DOE had used a reliable contractor in developing an estimate of the cost of deep excavation into a hard rock formation. (213)

Response

The cost figures cited for the mining aspect of the disposal operation were developed by a firm recognized as an expert in development of cost information for mining engineering activites.

Draft p. 3.1.119

Issue

One commenter noted that there is an inconsistency in the unit cost of spent fuel storage stated in Table 3.1.82 and the text. (113-EPA)

Response

The inconsistency noted in the question apparently refers to the assumption that six year storage of 3/4 of the spent fuel at $6/kg/yr and 1/4 at $14/kg/yr should cost 36 and 84 $/kg respectively instead of the $30/kg and $67/kg stated in the footnotes to Table 3.1.82.

The above calculation does not take into account the effect of the cost of money on the timing of the storage charge receipts. This effect can be taken into account by discounting the unit costs by the present worth uniform annual series factor which is 4.8 for 6 years at a 7 percent cost of money. Thus, the accurate cost calculation is (3/4 x 6 + 1/4 x 14) x 4.8 = $39/kg.

While draft Table 3.1.82 has been deleted from the final Statement for other reasons, similar calculations are embodied in the tables replacing it (see Section 4.9).

COSTS

Draft p. 3.1.132, Table 3.1.28

Issue

One commenter pointed out that for added perspective the Statement should note that the values given in Table 3.1.28 represent a range of 0.2 to 0.4 mills/kwh. (154)

Response

As noted in the tables and the text of the final Statement, the predisposal costs in Section 4.9 and the disposal costs in Section 5.6 do not include key cost elements such as cost-of-money effects and research and development costs. For this reason, DOE has elected not to state these cost segments in terms of power costs. The range of power costs for waste management are outlined in Chapter 7.0 and in the Summary and their significance relative to total power cost noted.

Issue

Several letters commented on the costs associated with accidents.

Draft p. 3.1.125 - Individual and population doses, as well as health effects, are calculated and presented in the GEIS for certain postulated accidents. The potential decontamination cost and property damage associated with the same postulated accidents should also be evaluated. (208-NRC)

Cost data do not reflect damages during storage and transportation. (14)

Response

Damages caused by accidents are generally described in terms of health effects attributable to a particular scenario. For transportation accidents, however, the requested data are available (see DOE/ET-0029).

Draft p. 3.1.133

Issue

One commenter noted that the statement - "granite unit costs are less than those for shale." is inconsistant with the data presented in Table 3.1.28 on draft p. 3.1.134. (208-NRC)

Response

DOE agrees and the quotation has been deleted in the final Statement.

COSTS

Draft pp 3.1.210-212

Issue

One commenter noted that costs based on costs of capital of ten percent for privately-owned facilities and seven percent for federally-owned facilities are low. (154)

Response

The final Statement in Section 3.2.8.2, notes that the costs of capital employed are constant-dollar weighted-average cost-of-money rates which exclude the inflation premium. Viewed in this perspective, DOE feels that these rates are conservative (i.e. high) estimates of the actual constant-dollar cost of money.

Draft p. 3.1.211, Table 3.1.82

Issue

One commenter noted that Table 3.1.82 also contains a very interesting number - the \$16.40/kg for the ^{85}Kr storage facility. This cost was completely ignored by EPA when it "showed" the separation of ^{85}Kr was "cost-beneficial"--although just barely by EPA's estimates. This cost, by itself, amounts to \$40,000 per man-rem (to the US population). In other words simply the storage cost is non-cost-beneficial by a factor of 40. EPA ought to be asked to comment on this cost. (154)

Response

The high cost of krypton separation and storage is noted in the final text in Section 4.9.2. DOE agrees that this should be taken into account in considering the cost-benefit trade-offs of krypton recovery.

Draft p. 3.1.229

Issue

One commenter suggested that it should be mentioned that the relative ranking of the deferred fuel cycle alternative by total cost is significantly different depending on whether cost Table 3.1.89 or 3.1.90 is used. (113-EPA)

Response

The comments in the third and fourth paragraphs on p. 3.1.229 were intended to draw attention to the difference in costs of deferred recycle under the 0 and 7% discount cases. DOE agrees that this difference could have been more clearly emphasized. See Chapter 7.0 of the final Statement.

COSTS

Draft pp. 3.1.233 and 3.1.235

Issue

A commenter questioned whether 1) the Statement can estimate reporting cost to within a factor of two (±50%) and 2) if money is presently being collected from users to cover the costs of waste management. (217)

Response

Chapter 3.8 of the support document DOE/ET-0028 presents in detail the cost bases used in the Statement and discusses the effect of uncertainty on the cost assumptions. (see also final Section 3.2) In terms of commercial waste management, the only activity (involving utilities) that is presently occurring is water basin storage of spent fuel. The costs associated with this activity are assumed to be passed on to users of generated electricity.

Draft p. 2.1.244

Issue

If the zero in Table 3.1.94 corresponds to the year 1986, this project was started in 1973. (43)

Response

The table is structured in such a fashion that no particular repository (or project) start-up date is implied.

Draft pp. M.55-85

Issue

One commenter requested that DOE reconcile differences in various cost estimates for independent spent fuel storage facilities. (1)

Response

Estimates of construction costs for an independent spent fuel storage facility have been published in several DOE reports. Most of these recent studies use cost estimates found in the reports listed below.

Title	Basin Size	Cost Estimate
Economics of Water Basin Storage of Spent LWR Fuel, DPST-ISFS-78-1, Savannah River Laboratory, Aiken, SC, February 6, 1978 (SRP 1978).	5000 MTHM	$201 Million (1978)

COSTS

Title	Basin Size	Cost Estimate
Conceptual Design Report for the Away From Reactor Spent Fuel Storage Facility, DOE-3547, U.S. Department of Energy, December 1978 (DOE 1978b).	5000 MTHM	$270 Million (1978-84)
Technology for Commercial Radioactive Waste Management, DOE/ET-0028, U.S. Department of Energy, Vol. 3, May 1979.	3000 MTHM	$200 Million (1976)

The December 1978 Conceptual Design Report is an updated estimate of the venture guidance appraisal on which the Savannah River report was based, and includes additional costs for independent service facilities. The estimates in the present Statement are based on the DOE/ET-0028 report.

The table below presents a summary comparison of costs in DOE-3547 and DOE/ET-0028.

Adjustment to Common Basis	$ Millions DOE/ET-0028	DOE-3547
Initial Cost Estimate	200	270
Add 2000 MTHM Storage Capacity	48	--
Add Service Allowance	3	--
Adjustment to Receive Older Fuel	(12)(a)	--
Include Storage Baskets	--	24
Delete 85% of Owners Cost	(46)(a)	--
Adjust to 1978 Dollar Basis	33	(43)(a)
Estimated Cost in 1978 $ Excluding Interest During Construction	226	251

(a) Figures in parenthesis are subtracted.

Thus, the two estimates agree within 10%.

Draft Appendix N

Issue

One commenter stated that bases for cost estimates for transportation of spent fuel and waste should be referenced in the final document. (113-EPA)

Response

DOE agrees. Section 3.2.8.4 of the final Statement summarizes the cost methodology for transportation and notes that additional detail can be found in DOE/ET-0028, Volume 4. The predisposal cost section in the final Statement (Section 4.9) also notes that additional detail on predisposal facility costs can be found in DOE/ET-0028, Volumes 2, 3 and 4.

COSTS

DOE/ET-0028, Appendix 7A

Issue

One commenter noted that the tables in Appendix 7A (DOE/ET-0028) present only the mining and construction costs for a repository. The GEIS should consider all costs that will be incurred through repository closure including operating and decommissioning costs. (208-NRC)

Response

The tables in Appendix 7A are only intended to present detailed back-up data. All pertinent costs including operating and decommissioning costs are included in the repository cost estimates as explained in sections 7.4.10 and 7.5.10 of DOE/ET-0028 and Sections 4.9 and 5.6 of the final Statement.

Issue

From the aspect of a utility regulatory commission, the Statement inadequately describes the cost of radioactive waste management. (43)

Response

The Statement presents estimates of the systems cost of various waste management options based on descriptions of conceptual facilities. The uncertainties in these cost estimates are also identified. In addition, the total cost of waste management may be found discussed in DOE/EIS-0015 (DOE 1980b) which includes a "best" estimate of the total waste management cost. The spent fuel charge data in DOE/EIS-0015 is the information that should be used by a utility regulatory commission.

Issue

One commenter requested that the Statement show range of cost estimates and how little disposal costs impact electric rates. (13)

Response

The range of cost estimates is shown in the draft Statement in Tables 3.1.89, 3.1.90 and 3.1.91 on pp. 3.1.230 and 3.1.232. The impact of disposal costs on electric rates is shown in Table 1.5 on p. 1.23 and compared to total nuclear power generation costs in the last paragraph of the text on p. 1.22.

Total waste management system costs and a comparison to total nuclear power costs are presented in Section 7.6 of this final Statement.

COSTS

Issue

An issue which needs to be addressed is the expense involved for safety precautions. The technology for "near-perfect" safety can probably be found, however it will be very expensive. If it comes at the taxpayers expense this will, in effect, subsidize nuclear energy. This could make nuclear energy appear more commercially favorable than another source of energy that does not receive such preferential treatment. Or if the safety costs are born by the producer, can we be guaranteed that a private corporation can afford such a large expense on a competitive energy market. (216)

Response

The Statement develops the waste management costs (1978 dollars) for the entire reference nuclear power generating system. Costs associated with treatment, interim storage, transportation, decommissioning, and disposal in geologic repositories are presented (see Sections 4.9, 5.6 and 7.6). The Statement identifies the dollar value a consumer of nuclear power could be charged for the waste management aspect of nuclear energy production. An assumption made when developing cost estimates was that all waste management costs, whether the services are provided by private industry or by the government, will be borne by the customers of the electric energy generated by the nuclear power facility and thus are reflected as an increase in cost of power.

SAFEGUARDS

Draft p. 1.23

Issue

One commenter suggested that the paragraph on Safeguards is misplaced and should be highlighted as a conclusion. (124)

Response

DOE agrees that the paragraph is out of place. The structure of the final Statement has been organized to reflect this.

Draft p. 1.23

Issue

One commenter suggested that the statement that regulations which are in place to protect against theft and sabotage will also be in place for waste disposal is not a reassuring one. There is no mention of the fact that in some respects it is dangerous to attempt to divert or sabatoge nuclear wastes. (40, 128)

Response

The final Statement does address the hazard to would be thieves or sabatours from radiation (see Sections 4.10.1.2 and 5.7).

Draft p. 1.23

Issue

One commenter noted that the statement regarding in place regulations which are to protect against theft and sabotage has not been proven to be true. Witness the theft of 245 lbs of uranium from a "Navy nuclear plant." (142)

Response

Safeguards and physical protection measures now in effect are specifically intended to protect the public from theft of nuclear material. The material in question at a navy nuclear plant cannot be accounted for. Theft is one of the possibilities and must remain so but it was also concluded that this much material did not leave the plant clandestinely. Another explanation of the missing fissile material was that it is a result of imprecise material acconting practices. It is a significant challenge to account for material where large quantities are processed in scrap recovery or waste handling procedures. The scrap and waste may be degraded process material in many different forms such as degraded solids or liquids or material impacted onto filters, or inside of pipes or inside equipment.

SAFEGUARDS

For the waste in the waste management programs the accountability problems are trivial by comparison. Only gross measurements will be required to account for bulk material and simple item count inventories will suffice to account for the balance i.e., a visual count, identification and minimum record system of each cannister, drum or container.

Draft p. 1.23

Issue

One commenter expressed concern about a statement in paragraph 2 apparently calling fission products an attractive material (for theft and sabotage) while non-proliferation strategies call for introducing fission products because of their hazardous properties. (181)

Response

This subject of attractiveness of materials for theft or sabotage is addressed in the final Statement in Section 3.2.9. A material that is an unattractive target for theft may be an attractive target for sabotage.

Draft p. 1.23

Issue

Several commenters noted that the first sentence, second paragraph, and the last sentence, third paragraph are assertions that are not backed up by analyses in this section or in later sections. They should be substantiated. Further, the second sentence, second paragraph. From a sabotage standpoint, high-level waste without plutonium might also be an attractive material and should be included in the list of material in this sentence. (208-NRC, 218-DOI)

Response

See Sections 4.10, 5.7 and 3.2.9 of the final Statement.

Draft p. 1.23

Issue

One commenter expressed a concern that the material used for the waste cannisters might also be valuable enough in the future to attract invasion of the repository (copper, stainless steel, titanium, and even gold have been mentioned...). (218-DOI)

SAFEGUARDS

Response

Materials of some value used for the cannister, are not expected to be an attractive target. The quantity of this material being used in the repository is so small compared to the amounts used and readily available elsewhere in our society that invasion of a repository for its recovery is not a credible concern. Copper and titanium and even gold have been suggested as cladding materials to provide corrosion resistance for the waste cannisters. The relatively small quantity and difficulty of recovering these materials by a mining operations makes them a very unlikely target.

Draft pp. 1.23 and 3.1.40

Issue

One commenter expressed concern regarding an inference that the safeguard provisions for spent fuel and high level waste containing plutonium must be similar to those required for facilities processing strategic quantities of plutonium. (154)

Response

The reference that spent fuel or high level waste might require the same level of safeguards as facilities handling strategic quantities of plutonium has been deleted from the final Statement.

Draft p. 3.1.40

Issue

One commenter stated that the paragraph on p. 3.1.40 under Physical Operations should be modified to correct the misconception that these materials--spent fuel or HLW from the uranium only recycle option--are desirable to steal since they contain weapons material. (124)

Response

The redrafting of the safeguards discussion in Sections 4.10 and 5.7 eliminated this concern.

Draft p. 3.1.41

Issue

Several commenters were concerned that use of armed guards, physical and procedural access controls, intrustion detection devices, secure communication systems, and contingency

planning for assistance in emergencies sounds like the beginning of the police state. (55,73) One of the commenter suggests "The New Tyranny" by Robert Jungk should be read to discover how Western Europe has already learned the "hard way." (55)

Response

Security measures including those enumerated in this analysis are not believed to indicate the beginnings of a police state in our society. The presence of armed guards and inspections the public accepts at every airport terminal, armed guards at many banks in our communities, armed guards on every armored truck on our cities' streets, similar protection around federal property and at army, navy, air force, marine, and other service stations are accepted without allegations of police state. Physical protection measures at a very few (certainly less than six in this country) waste isolation facilities that are located in remote areas would not contribute to a police state syndrome.

Draft p. N.6

Issue

One commenter asked if an aerial radiation survey could detect a spent fuel cask that had not been breached and is located inside a building. (208-NRC)

Response

See Section 4.10.1.3 of the final Statement.

Draft p. N.6

Issue

One commenter noted that the NRC has promulgated an interim rule on physical protection of spent fuel shipments (Federal Register 44, 34466, June 15, 1979). Accordingly the foot note is no longer valid. (208-NRC)

Response

See Section 4.10.1 of the final Statement where the recent NRC rule is cited.

Issue

One commenter noted that the uranium-only fuel cycle is not addressed from a safeguards standpoint although the health, safety and environmental aspects of the U-only fuel cycle are discussed. In addition, although the basic purpose of a safeguards system is identified, there is no discussion of the concepts or elements of safeguards systems potentially applicable to each waste form and storage mode. Also, the draft GEIS does not identify how much

effort would be needed to mine the waste nor does it address the issue of how the repository management would assure the public that all waste material is in its authorized location if faced with a blackmail threat after closure of a repository. Finally, the draft GEIS should make clear the kind of adversary that is considered when a safeguards system is designed. (208-NRC)

Response

The uranium-only cycle has been deleted from consideration in the final Statement. An expanded discussion of safeguards considerations for other waste forms is included in the final Statement (see Section 4.10, 5.7, and 3.2.9).

Issue

The possibility of deliberate reopening of a radioactive waste disposal site should be presented in the final Statement. (218-DOI)

Response

Section 5.7 of the final Statement presents a discussion of safeguards and physical protection measures for geologic disposal. Following repository closure waste would be available only through re-excavation or mining. The position taken on this Statement is that theft or sabotage after closure and decommissioning is not credible, but that inadvertent intrusion must be guarded against.

GROWTH SCENARIOS

Draft pp. 1.10 and 2.1.2

Issue

Considering the 400 GWe and the 250 GWe growth scenarios described in Chapter 2 of the draft Statement, would the low growth scenario change DOE's approach to repository siting and development?

What effect would the lower growth scenario have on the selection of alternatives? (208-NRC)

Response

In the final Statement, DOE has assumed that the maximum nuclear growth will be no more than 250 GWe in the year 2000 and it does not affect our approach to repository siting and development. The only effect of very low growth asssumptions (eg., the present inventory case in Chapter 7.0) might be to eliminate the feasibility of regional repository consideration.

DOE does not see any direct relationship between nuclear growth and selection of disposal alternatives.

Issue

Several letters commented on the growth scenarios used in the Statement.

Draft p. 2.1.2--The assumption of 400 GWe installed capacity by the year 2000 is undoubtedly optimistic by at least 33%. (154)

The growth scenarios are excessively optimistic and/or do not exhibit neutrality regarding nuclear growth. (22, 35, 42, 55, 62, 63, 68)

An analysis of no growth should be included. (30)

An analysis of a high growth scenario of 550 GWe in the year 2000 and a low growth scenario of 150 GWe in the year 2000 should be included. (43)

There should be treatment of situations in which nuclear growth rises through the twenty-first century and in which nuclear generating capacity remains constant. (40)

It may be more conservative and realistic to adopt the lower estimate of 200 GWe, augmented by the estimated wastes generated by the postulated early reprocessing of U. S. and foreign spent fuel elements, defense wastes, and wastes from head end operations. (22)

Response

The final Statement quantitatively analyzes the waste management impacts of the following growth scenarios:

GROWTH SCENARIOS

1. Present inventory (equivalent to industry shutdown).
2. Present capacity to retirement (equivalent to licensing no new reactors).
3. Installed capacity of 250 GWe in year 2000 and declining to zero in year 2040.
4. Installed capacity of 250 GWe in year 2000 and continuing at 250 GWe to year 2040.
5. Installed capacity of 250 GWe in year 2000 and growing to 500 GWe in year 2040.

These scenarios do bound the range of nuclear futures which are presently thought to be reasonable. However, the data are presented in a manner which allows the reader to adjust for other nuclear industry growth patterns.

Issue

Several commenters noted that the Statement should address the issue of not generating additional waste until nuclear waste can be placed into ultimate disposal in an environmentally acceptable manner. (42, 68, 167)

Response

As noted above, the Statement analyzes a no growth situation in the nuclear industry. This analysis is conducted from the standpoint of waste management impacts and does not examine the issue of macroeconomic impacts caused by the shutdown of the nuclear industry or the environmental concerns related to the accelerated use of alternate energy sources.

Issue

Several commenters noted that the growth scenarios examined in the Statement should be tied to a discussion of the dynamics of nuclear growth vis-a-vis waste disposal. (40, 62, 113-EPA)

Response

In developing facility requirements for the Statement, DOE is cognizant of the constraints placed on the waste management system by the differing growth scenarios. The constraints have been factored into the system design (e.g., growth vis-a-vis waste disposal is presented in the support document DOE/ET-0028).

GEOLOGIC CONSIDERATIONS

Draft, p. 1.3

Issue

The need for in-situ testing to obtain site-specific information should be stressed. (208-NRC)

Response

The need for site-specific information, once a site has been selected, is mentioned repeatedly (draft pp. 3.1.16, 3.1.17, 3.1.19, 3.1.23, 3.1.26 and others). Rock types, properties, and site characteristics can only be described in a general way until an actual site is selected and local investigation and testing are conducted.

Draft p. 1.6

Issues

Several commenters noted that the Oklo phenomenon cannot be used as justification for geologic disposal of radioactive waste. (2, 55, 96, 97, 129, 144, 211, 213, 218-DOI) Others felt the reference to Oklo should be retained and/or Oklo should be further emphasized. (11, 13, 147, 166, 181, 198)

Response

DOE is not trying to use the description of Oklo to justify conventional geologic disposal. Oklo is, however, an example of a situation where geologic material has retarded the movement of radionuclides and contained them within the earth. The Oklo phenomena are not cited to be justification for geologic material to contain radionuclides. From investigation and measurements at Oklo, estimation of distances and rates of movement can be determined. The information obtained at Oklo is of value in expanding our understanding of transport phenomena and in helping to develop models of radionuclide transport. Oklo is meant to be supporting evidence for estimating the long-term behavior of radionuclides placed in a geologic environment.

Draft p. 1.12

Issues

Why the four rock types were considered representative of all geologic media? (208-NRC, 218-DOI)

Response

The words "of all" were deleted in the final Statement.

GEOLOGIC CONSIDERATIONS

Draft p. 1.12

Issue

Geologic disposal should not be restricted to salt, basalt, granite and shale. (6)

Response

DOE agrees that numerous possible geologic media exist which could be considered for disposal. However, in this Statement, only salt, basalt, granite and shale were examined in any detail. These four media are considered representative geologic media for this study.

Draft p. 1.12

Issue

Two more general geologic considerations should be added to the "Six general considerations for geologic disposal":

7) Density and reliability of investigation required by this media.
8) Ease of demonstrating adequate knowledge of the host rock and its surrounding environment.

Also a sentence should be added to the last paragraph: "They (rock discontinuities) also complicate investigations of the host rock, increasing time and cost of exploration and analysis, and detracting from confidence in knowledge of rock conditions." (154)

Response

Density and reliability of investigation required by the media--a rough, general estimate could be made to characterize these factors, and some numerical or quantitative rating system developed to rank them for the four media.

Ease of demonstrating adequate knowledge of the host rock and its surrounding environment--again some rating system could be devised. For both 7) and 8), the terms "required" and "adequate" imply some sort of criteria by which the ratings would be judged.

The two suggested considerations are specific to the various media and particularly to the geologic setting in which any medium was being investigated, i.e., the setting may impose conditions on a medium that are not typical of that medium in general.

The last paragraph was amended to read "...may complicate design, and increase exploration and construction costs."

GEOLOGIC CONSIDERATIONS

Draft pp. 1.12 and 3.1.32

Issue

One commenter indicated that the media properties consider only properties which make it possible to construct a repository. (113-EPA) Several commenters noted that groundwater is discussed only during the construction phase and there appears no discussion of the likelihood of water inflow following repository closure. (113-EPA, 208-NRC)

Response

Emphasis is on the construction phase because it is believed that groundwater is more likely to enter a partially mined repository as opposed to a finished repository in a medium selected partly because of its essential lack of flowing groundwater. Groundwater transport and possible ways by which groundwater might reach a repository are considered in Section 5.5.

Draft pp. 1.12, 1.25, 3.1.28

Issue

One commenter pointed out that rock falls rather than rock bursts account for the majority of injuries and fatalities in mines. (218-DOI)

Response

The text has been changed.

Draft p. 1.13

Issue

Not only hydraulic gradients should be measured in situ but other hydraulic and geochemical parameters such as permeability, porosity, and sorptive properties should be measured on site as well. (218-DOI)

Response

The text has been changed.

Draft p. 1.13

Issue

One commenter suggested that any disposal method that requires maintenance (e.g., the need for dewatering in high permeability rock) should be avoided. (128)

GEOLOGIC CONSIDERATIONS

Response

The site selection process takes into account parameters such as the hydraulic conductivity of the rock mass. A repository would not likely be sited in highly permeable rock requiring dewatering.

Draft p. 1.13

Issue

In addition to salt's excellent thermal properties, the favorability of salt's lower variation and fewer discontinuities should be mentioned. (154)

Response

It is questionable that salt deposits as a rock group show lower variation than say masses of granite intrusions. The reader should refer to Table B.2.1 of the final Statement.

Draft p. 1.13

Issue

One commenter found no section in the draft Statement that deals specifically with site selection. The commenter felt that the Statement should note that considerable work has already been done at stages one and two and also some at stage three. (154)

Response

See draft pp. 3.1.17 and 3.1.28 under The Site Selection Process. This draft section discusses the process of site selection from the standpoint of four rock types, their properties and their occurrence. The intent is not to select a site but to describe a method for approaching the problem and to point out how the method would apply as the process leads to smaller areas and more detailed investigation.

Also, Section 2.3.1.2 of this final Statement discusses DOE's proposed site selection process.

Draft p. 1.13

Issue

In order to assess fracturing and permeability in granitic rocks, field measurements are required. Further, the commenter suggested the difficulty of properly interpreting geophysical data gathered on granitic rocks in place. (190)

GEOLOGIC CONSIDERATIONS

Response

Fracturing and permeability in granite may be difficult to detect, measure and model, particularly for a large rock mass with widely spaced or even random fracturing. See Section 5.2, which also states that field tests will be necessary after a site is selected. Geophysical methods have developed to where they are a valuable and widely used method of obtaining subsurface information. Locating and describing relatively small zones with anamolous properties (such as fractures) in a large rock mass are still difficult.

The National Waste Terminal Storage program (NWTS) recognizes that permeability tests are required in the field. During exploration for any potential repository site, permeability tests will certainly be performed.

In the Climax facility at 1400 ft. depth in Nevada Test Site granite, in-situ rock permeability measurements are part of the experimental program.

Draft p. 1.13

Issue

The opening statement (under Adequacy of Data Base) has the appearance of a bid proposal and does not adequately reflect the extent of research covered elsewhere in the document. (34)

Response

This statement has been deleted.

Draft p. 1.14

Issue

One commenter stated his work demonstrates the futility of laboratory measurements on rock properties for shallow granitic rock bodies (less than 1 km depth), at least in California. The commenter suggested that there remains a lot to be learned about interpretation of geophysical data gathered on granitic rocks in place. (190)

Response

The NWTS program recognizes that rock properties and behavior must be obtained in granitic rock bodies at depth. The program has participated in the Stripa tests in a mine at about 1200 ft. depth in Sweden. Analyses of data from those tests is ongoing.

At present, the NWTS program includes work in the Climax facility at about 1400 ft. depth in the Nevada Test Site. The Climax tests are just beginning and will provide field data at depth for several years to come.

GEOLOGIC CONSIDERATIONS

Draft p. 1.14

Issue

One commenter stated that predictions, which need be known with a high degree of certainty for only a few hundreds of years, are much easier to be comfortable with than those for 100,000 years. The commenter suggested the following addition in the second paragraph: "Some media (i.e., salt and deep sea sediments) offer opportunities for confidence in uniformity of characteristics and predictability of future conditions." (154)

Response

For the purposes of this Statement the critical period cannot be said to be only the first few hundred years--this may depend on the final waste form, type of container, type of engineered barriers, etc., as well as the disposal alternative selected. The Statement in its overall treatment at this stage considers the state of the repository and waste after several hundreds of years just as significant as before, even though the processes that can affect the repository may be different in importance than say during the high thermal activity phase for the waste.

The "uniformity of salt characteristics" comment may be misleading to readers who are not aware that most massive bedded salt contains layers/beds of anhydrite, gypsum, limestone, dolomite, shale, sandstone, siltstone, polyhalite, sylvite. (See reference 8, draft Section 3.1.1).

Draft p. 1.14, Fourth Paragraph

Issue

This indicates an attempt to dismiss a real problem. Presumably water will enter any mined repository, except perhaps one above a deep water table in an arid western basin. Leachability is still an unresolved issue. (218-DOI)

Response

It is agreed that water might eventually enter a mined repository but not in significant quantities. The site investigation and testing program will characterize the repository well enough to show that sizeable amounts of water would not be present--any indication that a significant amount of water might enter the repository would likely delay or prevent use of the site.

Leachability is an area of hydrologic and waste rock interaction which is currently being studied. See final Section 5.2 and Appendix L for additional information.

GEOLOGIC CONSIDERATIONS

Draft pp. 1.14 and 3.1.11

Issue

The recent studies/work in Sweden, Canada, and the United Kingdom should be cited. The data base for granite exceeds that for basalt and shale and is rapidly approaching that of salt. Mention should be made of the sorption characteristics of granite. (218-DOI)

Response

A description of research and experience by countries other than the U.S. has been added in Section 5.2 of the final Statement.

Draft p. 1.17

Issue

In the first paragraph dealing with consequence analysis, fault offset as a primary event should be included (e.g. "faulting and rock fracturing followed by flooding..."). (154)

Response

The text has been changed.

Draft Section 3.1.1.1

Issue

The general introductory section on geology is verbose and confusing. Many of the terms are unusual or used in unusual ways. (6)

Response

This section has been extensively revised and rewritten with this comment in mind. (See Section 5.1)

Draft Section 3.1.1

Issue

There are deficiencies in the choice of references used to support the material presented. Contractor reports have not received proper peer review by the scientific community; original references used in contractor reports would have been easy to use; textbook references were old. (208-NRC)

GEOLOGIC CONSIDERATIONS

Response

Contractor reports are available at the Department of Energy's (DOE) public document reading rooms and at DOE offices, and have been since the draft Statement was released for comment in April, 1979. Reports were prepared by various subcontractors as the "Technical Support for GEIS (TM Series): Radioactive Waste Isolation in Geologic Formations" (OWI 1977, 1978) under subcontracts administered by the former Office of Waste Isolation, Nuclear Division of Union Carbide Corporation. Each report contains numerous reference lists. DOE believes it to be sufficient for the present Statement to cite these technical support documents rather than the individual references. The consultants who contributed to the draft Section 3.1 had the TM Series documents supplied to them as part of their data base, but not all the references cited in the TM Series were cited in the Statement. Several references have been added and some revisions made. For example, draft Table 3.1.2 (Chemical Composition by Oxides...) has been revised using a USGS Open-File Report (see reference number 8 in final Appendix B reference list.

Draft p. 3.1.1

Issue

Salt is emphasized because this alternative has received the most study. Other media and methods should receive adequate scrutiny. (113-EPA)

Response

The Statement points out (draft Section 3.1) that the amount of available data on the various disposal techniques is unbalanced, with more data available for a bedded salt disposal method, and that more study is needed for the other media and methods. Wording has been modified from a sense of "emphasis" to one of "treated in more detail." Later revision for the final statement eliminated this comparison.

Draft p. 3.1.2

Issue

One commenter felt that the four climatic factors listed to be considered in assessing the long-term isolation are not sufficient; precipitation patterns and man-induced changes must also be considered. (208-NRC)

Response

The items listed are typical climatic factors that relate to natural surficial processes as they could affect the depth requirement for a repository. Precipitation patterns, both temporal and spatial, are characteristic of a given area. Because no area is specified

in these general factors, precipitation is included as part of the climatic conditions that would characterize an area when selected. Man-induced changes in the climate are not considered under the natural processes.

Draft p. 3.1.2

Issue

Faulting and deformation should be mentioned in addition to erosion as hazards associated with glaciation. (208-NRC)

Response

The text has been changed (see Section B.1 of the final Statement).

Draft p. 3.1.2

Issue

Several commenters indicated that predicting the lower depth of glacial erosion with any degree of certainty would be difficult. Other than uniform crustal depression, a repository located at the 500 to 600 m depth should be relatively unaffected by direct glacial processes. Future glacial front advance beyond former areas is an overly conservative assumption. (43, 208-NRC, 218-DOI)

Response

A depth of 600 to 1000 m is generally considered adequate to avoid most glacial effects. Much of the Statement is deliberately conservative in approach, particularly the accident scenarios.

Issue

One commenter made the following points regarding the role of containment and isolation:

Draft pp. 3.1.1-3--Erosion processes affect isolation rather than containment. Data sampling points may not be representative of the entire rock; younger rocks must be present in order to have confidence that the geologic history is completely known up to the present time. (154)

Draft p. 3.1.5--The statement--"Waste isolation requires that the properties of the host rock minimize transport of the waste and that the host rock be isolated from more permeable media." is true for containment and false for isolation. (154)

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.14--The ratings contained in the Table on p. 3.1.14 of the draft Statement, are suspect. If they were redone, taking containment/isolation into account, the relative merits of salt and granite should increase. (154)

Draft p. 3.1.16-17--"Uncertainties" cited in the USGS Circular 779 relate only to containment and not to isolation and thus are important for only a few hundred years. "Uncertainties" should be placed in the proper perspective. (154)

Draft p. 3.1.24--Geochemical aspects of repository isolation (containment) have not yet been adequately studied. "Engineered barriers ... will probably have negligible permanence compared to lifetime of the repository," but not for the limited time period for which containment is required. (154)

Draft p. 3.1.52--If the role of containment versus isolation is properly reflected, there is no need for precise predictions of geologic events over hundreds of thousands of years. (154)

Response

The presence of younger rock is not an absolute requirement. Much geologic history has been deduced from the gaps or absences in the stratigraphic column. The Canadian Shield has pre-Cambrian rocks at the surface and is considered one of the most stable parts of North America.

The draft table on p. 3.1.14 summarizes the properties of the four media by assigning a numerical value to the property in terms of its potential for isolation (Statement usage) for each medium. All have potential for isolation of waste -- this draft table compares them by their properties. Three items have been added to the table: Plasticity, Ion Exchange Capacity and Absence of Linear Discontinuities.

Density of sampling to adequately represent the rock mass is a problem that will depend on the specific conditions at a site and can be considered after exploration and testing have begun. Also, see item 3, draft p. 3.1.51.

There is some ambiguity and perhaps confusion between the terms "isolation" and "containment." In the Statement, containment is used in a retention sense for both containers and host rock. This usage is commensurate with the definitions for "isolation" and "containment" given by the recent DOE Position Paper to the NRC rulemaking hearings on nuclear waste storage disposal (DOE 1980a).

The following definitions for isolation and containment are taken directly from this DOE Position Paper. "Isolation means segregating wastes from the accessible environment (biosphere) to the extent required to meet applicable radiological performance objectives. Containment means confining the radioactive wastes within prescribed boundaries, e.g., within a waste package."

GEOLOGIC CONSIDERATIONS

The revision of the draft includes current R&D programs that apply to uncertainties... i.e., what is being done about data gaps (see Section 5.2).

Draft p. 3.1.3

Issue

One commenter suggested that, "... and sometimes earthquakes" should be added to "Environmental components important to mass-wasting processes..." (154)

Response

The text has been changed (see Section B.1 of the final Statement).

Draft p. 3.1.3

Issue

For the sentence beginning "A surface environment conducive to long-term deposition ..." the comment was made that the process of long-term deposition is so slow that adding to containment is no longer of importance. Adding material at the surface would not change in any significant way, migration at depth. (154)

Response

The text has been changed (see Section B.1 of the final Statement).

Draft p. 3.1.3

Issue

In addition to adding material on top of a repository, deposition would also lead to a change in the in-situ stresses. What effect, if any, would increased compressive stress have on the repository design? (43)

Response

The National Waste Terminal Storage program (NWTS) includes laboratory experiments, field observations, and analytical and numerical solutions to obtain information on rock properties and the behavior of rock at repository depth to the modified stress fields resulting from construction and operation of the repository. The design of the repository will include the best available information regarding the anticipated stresses and rock behavior, and a technically conservative design so that safety can be assured.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.3

Issue

Several commenters felt the equilibrium fringe concept is not significant for long-term isolation because of the potential for disruption of containment. (113-EPA, 124)

Response

The equilibrium fringe concept has been expanded and is only defined qualitatively---it is not a fully developed concept at this point.

Draft p. 3.1.4

Issue

One commenter felt the problems listed in the draft p. 3.1.4 are considered only from a cost standpoint. Reduction of effectiveness of the repository by fracturing rock is not discussed. (113-EPA)

Response

This paragraph is part of the Canister Spacing discussion under Generic Basis for Repository Design/Waste Management Costs and is thus cost oriented. The same paragraph states that the extent of induced rock fracturing around canisters needs further investigation. Natural or existing fractures in the host rock are discussed in the same draft section with respect to rock support structures, strength, design, ground water movement, and excavation problems, as well as heat flow.

Draft p. 3.1.4

Issue

One commenter recommended that the final Statement address the fact that most intense tectonic activity and virtually all volcanic activity for North America occur along global plate boundaries. (113-EPA)

Response

The text has been changed. During the site-selection process, crustal plate boundaries, areas of known active faults and zones of recent earthquakes and volcanic activity would be avoided.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.4

Issue

"An optimum repository will be located in a relatively stable tectonic region." One commenter requested a rationale be provided for the above quotation in the final Statement. This commenter also asked, "What is relatively stable? How is the site region defined?" (154)

Response

These points are addressed on draft pp. 3.1.20, 3.1.21, 3.1.22 for Tectonics, Seismic Considerations and Magmatism, and draft pp. 3.1.17 to 3.1.20, for The Site Selection Process.

Draft p. 3.1.5

Issue

One commenter questioned the concept of "geologic stability" in the context of a nuclear waste repository which will be required to function for an extended period of time. (141)

Other commenters felt that it is not necessarily true that future tectonism may not be reflected in past tectonic history. This factor will probably have to be a probability-based estimate. (213, 218-DOI)

Response

Complete and utter stability is probably not found anywhere in terms of surface erosion, deposition, and areal subsidence or uplift, particularly over hundreds of thousands of years. However, these normal dynamic processes are unlikely to affect a deep repository. The site-selection process will reject areas known to be tectonically active in favor of areas that can be shown to have been stable with regard to major tectonic activity for millions to hundreds of million years. While there is no guarantee that tectonic activity will not occur in the distant future, it can be said, based on past geologic history, that this is good evidence for continued stability.

Draft p. 3.1.5

Issue

One commenter felt that faulting can do more than alter the hydrologic regime. There is no section describing disruption by faulting. (154)

GEOLOGIC CONSIDERATIONS

Response

The assumption is made in the Statement that for a deeply buried (600--plus m) geologic repository groundwater is the most likely agent to transport waste from the repository to man's environment. Over the long-term, faulting is considered as a means of forming possible conduits for ground-water flow (See "Faulting and Flooding" accident scenario, draft p. 3.1.147). For a sealed geologic repository, faulting is not considered disruptive if it does not lead to ground-water movement into or through the repository.

Draft p. 3.1.5

Issue

Several commenters indicated that the definition of convection is incorrect. Convection signifies the transport of a contaminent by a moving fluid. Thermal differences may produce fluid motions and thermally-driven convection must be considered in the analysis of a radioactive waste repository. The usual driving force for ground-water flow is the head gradient. (208-NRC, 218-DOI)

Response

Convection concerns the transfer of heat by a moving fluid and can operate whether a contaminant is present or not. Convection effects as described in this section are those occurring within a repository and impermeable host rock. The repository and host rock under expected operating conditions will not behave as if they were in a saturated porous medium with flowing water. The convection effects could transport nuclides if the repository were to eventually fill with water and the heat from the waste could cause some thermally driven convection, even in the absence of any flow through the repository.

Draft p. 3.1.5

Issue

Advection of nuclides with the local ground-water flow should be added to the list of major mechanisms related to nuclide transport through the disposal media. (208-NRC)

Response

Transport by migrating ground-water is not included in the general list of mechanisms related to movement of nuclides because under normal operating conditions in the essentially impermeable disposal media flowing groundwater should not occur. That is, barring any breaching of the repository that would establish flow paths, any water movement through the repository should be so slow that other processes would be more important.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.5

Issue

One commenter felt the section on Hydrology of the Host Rock is highly simplified; for more detailed explanations standard reference works should be cited. (208-NRC)

Response

This section is intended as an overall description of a general geologic consideration as it applies to waste isolation and site selection. Two references were added: Davis and DeWiest, and Walton (see reference list Appendix B).

Draft. pp. 3.1.5, 6, 19

Issue

One area of serious concern which appears to be neglected is the effect of repository construction and operation and hydrologic barriers to long-term transport of radioactive materials from the repository. The following examples are cited:

Construction is likely to increase hydraulic conductivity of the rock mass. There is no evidence presented in GEIS to show that such factors have been considered. This is a serious defficency.

Rock fractures, joints and fissures are potential paths for increased ground-water flow. Mine construction and testing may induce local fracture conditions that may or may not be identified in sample permeability testing. However, the in-situ extent of fractures, joints, and fissures could produce increased ground-water flow in other than direct down-gradient directions. Have such factors been considered and what conclusions have been drawn? (208-NRC)

Response

These concerns are part of Effects of Changes Induced by Emplacement of Waste Excavation (draft p. 3.1.34). In general, these effects are discussed qualitatively as concerns and sources of possible effects. Most of the effects will depend on specific site conditions which will not be known until a site is selected and some testing/excavation has been conducted.

For hard rocks, such as granite, permeability is difficult to measure in boreholes because the fractures intersecting the hole are most likely not representative of those in the larger rock mass. To obtain rock mass permeabilies a new test has been developed by Lawrence Berkeley Laboratory and is being applied in granite in the Stripa mine in Sweden. Briefly, the test involves isolating a section of mine drift, pumping in air of known humidity, and measuring the humidity of the discharged air. Also, pressures are measured in

drill holes beyond the drift surface. In the experiment at Stripa, it is believed that the volume of rock on which the permeability is being measured is about 1×10^6 cubic meters.

Measurement of this type includes the increased permeability caused by mining. As yet, the experiment is not complete but we believe it to be a step forward in measurement of rock mass permeability. In addition, a few of the heater tests in granite have included borehole measurement of permeability that were taken as the rock was heated.

Draft p. 3.1.6

Issue

One commenter felt that to group geologic materials as aquifers or aquitards is misleading; a whole continuum of both permeability and porosity exists; local site conditions generally determine how one would classify a unit, since the terms are often relative. A discussion is needed of piezometric levels, and leakage between confined and unconfined units. A discussion of steady state versus transient flow conditions and the variabilities of parameters governed by the matrix plus secondary features such as faults, joints, etc., is needed. (208-NRC)

Response

Information and discussion of hydrology and ground water have been collected from draft Sections 3.1.2 and 3.1.3 (e.g. pp. 3.1.23, 3.1.32, 3.1.48) and assembled under final Section 5.1.

The discussion is intended to be an overall treatment as a consideration for site selection and to consider some potential problem areas. Potential site areas are discussed only in general terms, as are the "desirable" or favorable physical conditions. When more specific sites are designated, a more specific description with site data can be made.

Draft p. 3.1.6

Issue

Resource potential of the host rock will attract future human intrusion and increase the probability that a repository will be breached by man's activities. (113-EPA)

Response

The site selection process is designed to avoid areas of known resource potential, or what are considered resources today. If this can be done, the problem becomes one of locating a site where there are no materials, ores, etc., that could conceivably be considered resources in the future. The latter problem becomes more difficult and does involve some speculation.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.6

Issue

It should be pointed out that fractures and joints may also be important permeability features of shale. (218-DOI)

Response

Fractures and jointing of shale are briefly identified on p. 3.1.12 of the draft Statement.

Draft p. 3.1.7

Issue

First paragrapah: "...conform to geologic selection requirements..." What are these? The previously described "General Geologic Considerations" or the "Siting Criteria"? The Final EIS could be improved if the terminology were made more consistent. (154)

Response

"Requirement" refers to the "General Geologic Considerations."

Draft p. 3.1.8

Issue

The confining pressure whose release causes joints should be characterized; for example, glacial retreat and thermal contraction should be named as causes of jointing in rock. (208-NRC)

Response

Thermal effects on fracturing and joints are discussed on draft p. 3.1.24 and glacial effects on draft p. 3.1.3.

Draft p. 3.1.8

Issue

The way in which discontinuities can impact "the transport of waste material" should be elaborated. (154)

GEOLOGIC CONSIDERATIONS

Response

The purpose in this section is to describe the physical properties of the four specified media -- especially as they relate to isolation (or lack of it) of the waste. Ground water is assumed to be the most likely agent for waste transport, should it occur. Joints and fractures are probably the most likely candidates for flow channels, given a supply of water, the necessary gradients, etc., thus, the primary concern is with them. Thermal effects on existing joints and fractures are treated under Effects of Changes Induced by Emplacement of Waste (draft p. 3.1.34) and other places (e.g., draft p. 3.1.4). In-situ tests are specifically recommended for representative rock mass properties as opposed to laboratory test (draft p. 3.1.26).

Draft p. 3.1.8

Issue

Because of the complexity and nature of deep geologic and hydrologic investigations, simple analysis using permeability, porosity and hydraulic gradients are not sufficient. Appropriate fluid and matrix parameters need to be determined; difficulties in determining them and the uncertainties should be discussed. (208-NRC)

Response

To thoroughly characterize a geologic and hydrologic setting and to model it would require a detailed knowledge of the site. This type of information would be collected during site investigation and testing. Simulation modeling would probably be used to predict performance once a site had been selected and the information could be obtained. For a generic approach to repository siting, an overall geologic and hydrologic assessment must be made with less detail. As the site selection process is described, each stage or phase will add to the detail and depth of investigation.

Draft p. 3.1.8

Issue

Salt domes may deform overlying strata without penetrating them. (208-NRC)

Response

The text has been changed (see Section B.6.1 of the final Statement).

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.8

Issue

Lower water content of salt domes compared to bedded salt should be mentioned. (113-EPA)

Response

The text has been changed (see Section B.6.1 of the final Statement).

Issue

Several comments were made regarding water migration through salt beds.

Draft p. 3.1.9--The Statement "... water incorporated in them (salt beds) was trapped when the beds were formed and does not migrate," is erroneous; fluid inclusions migrate along thermal gradients. (17, 208-NRC)

Draft pp. 3.1.9 and 3.1.35,--The assertion is made that water incorporated in salt beds when the beds were formed does not migrate. This should be qualified by reference to effects of elevated temperatures on migration of brine. Also, it should be mentioned that one of the problems with salt is that brine contained within the deposit tends to move toward heat sources, such as radioactive waste. These hot brines can be highly corrosive to some canister materials and waste forms. (17, 218-DOI)

Response

The text has been changed (see Section B.6.1 of the final Statement).

Draft p. 3.1.9, Table 3.1.1

Issue

Basalt or granite do not always, or even usually, have a permeability of "nil." Shale minimum permeability is much lower than 10^{-4}, perhaps 10^{-11} or 10^{-12} ft/yr. Moreover, the key hydrogeologic parameter for evaluating these rocks as repository hosts is transmissivity, not permeability. Yet, this parameter is omitted. (30, 218-DOI)

Response

The text has been changed (see final Appendix B).

GEOLOGIC CONSIDERATIONS

Draft 3.1.9

Issue

One commenter indicated that the statement "Joint can be ..." is too vague. Are joints usually, often, or seldom anhydrite-filled, near vertical, unopen, moderately spaced, and generally extensive? (208-NRC)

Response

Salt, as a generic rock and mineral type can contain joints with properties as identified in the statement. To characterize the joints more specifically would require specific data at a specific location.

Draft pp. 3.1.9, 3.1.13, 3.1.14

Issue

Permeabilities of granite and basalt, while low, are not nil. If they were, the repositories in granite and basalt could be located a few meters beneath the weathered layer. There seems to be no appreciation that values of permeability determined in the laboratory differ quite frequently from effective (rock mass) permeability by several orders of magnitude. (208-NRC)

Response

"Joints, fracutres and faults are generally not faborable from a geologic site selection..." See draft p. 3.1.48. These types of settings will be avoided, as possible. "Methods of evaluating free water and its movement...(for example, laboratory determinations of porosity and permeability...) but zones of fracture or joint flow are difficulat to evaluate and describe in laboratory tests." See draft p. 3.1.49. "Joints and fractures (and possibly faults) that act or could act as preferrential flow paths for water can be difficult to locate and describe in terms of distribution and flow properties..." See draft, pp. 3.1.49, 50. These comments are in contrast to those made for flow in a porous medium. See fourth paragraph, draft p. 3.1.26.

Draft p. 3.1.10

Issue

One commenter pointed out that in the last paragraph it is indicated that igneous rocks closely related to granite might not be suitable because of trace element and mineralogic

composition. However, the "Sierra Nevada granites" are shown in the draft Figure 3.1.2. These are predominantly quartz monzonites. Would this eliminate them from consideration? (218-DOI)

Response

Trace element and minerological compositional differences between granite and closely related igneous rocks would not be the sole determining factor which would eliminate any media from consideration. In the case of the Sierra Nevada granites, long term site stability, resource potential, hydrologic regime, etc., would require detailed evaluation if a candidate site were selected in that or any other media.

Draft pp. 3.1.10-14

Issue

One commenter was not able to figure out what the maps on these paper are supposed to show. (30)

Response

The maps are intended to show location of potential repository salts, granites, basalts and shales. These maps appear in Appendix B of the final Statement.

Draft p. 3.1.10

Issue

The reference cited (#8) for Figure 3.1.1 is incorrect for this figure. The information is not found in that report. However, there is an identical map in Y/OWI/TM 36/3. This was derived from USGS Bulletin 1148. The original reference should be used especially since it is readily available to the public whereas the contractor report is not. (208-NRC)

Response

The reference has been corrected to Y/OWI/TM-36/3. See Appendix B of the final Statement. Contractor reports are available to the general public.

Draft p. 3.1.11, First Paragraph

Issue

The statement is, "Granites are basically unaltered by heat because of the high temperature of formation." Granites are subject to decrepitation at temperatures above 300°C. Cracks may also form above this temperature, leading to surface heave, followed by subsidence and cracks propagating to a water-bearing zone. (214)

GEOLOGIC CONSIDERATIONS

Response

The text has been changed.

Studies have been and are being made of the properties of granite at elevated temperatures. These studies include the Stripa tests in Sweden and the Climax test facility now being operated at the Nevada Test site.

These field studies, along with laboratory studies on small samples and development of analytical and numerical models, are being continued in the NWTS program. This program is intended to obtain sufficient information to permit design of a repository so that it will function safely for its full design life and not be impaired by such phenomena as cracks, heave, or subsidence.

Draft p. 3.1.11

Issue

One commenter requested an explanation of why the areas shown in Figure 3.1.2 are favorable granitic sites; there are other areas where granitic rocks are either at or close to the surface. (208-NRC)

Response

The areas shown in draft Figure 3.1.2 are shown as potential repository granites because they are near or at the surface and, as stated, because they are large granite masses. At this stage, they are potential repository sites--there certainly are others.

Draft p. 3.1.11

Issue

One commenter asked if "hard" refers to hardness (as in scratch test) or strength? (208-NRC)

Response

The statement--"Most mineral components are hard..."--refers to the resistance of a smooth surface to abrasion.

Draft p. 3.1.11

Issue

One commenter indicated that in addition to thermal expansion, expansion of secondary minerals can also be caused by weathering, decomposition and alteration. (154)

GEOLOGIC CONSIDERATIONS

Response

This is true. However, weathering and decomposition are generally near surface phenomena, compared to "fresh" rock at 600-1000 meters in depth. Alteration could occur anywhere given the right conditions and causes. The effects of waste heat and stress release by excavation (draft p. 3.1.26) are believed to be of more concern.

Draft p. 3.1.11

Issue

The reference sited for Fig. 3.1.2 is incorrect and it could not have been developed from the information found in Reference 9. However, it appears in Y/OWI/TM-36 and is based on a diagram in OWI-76-27. Original sources should be used. (208-NRC)

Response

The reference has been corrected to Y/OWI/TM-36/3. See Appendix B of final Statement.

Draft p. 3.1.11

Issue

The final Statement should mention horizontal jointing; and other features such as veins, dikes, vugs, etc. (154)

Response

The sentence--"Joints ... to be blocky or sheet-like on a large-scale, and their orientation may be vertical and intersect at right angles and/or horizontal and subparallel to the topographic surface."--was added. "The statement--Granite masses may contain dikes, veins and occasionally fragments of other rock material."--was also added to the text.

Draft p. 3.1.12

Issue

One commenter pointed out that chemical reactions also affect shales and the significance of discontinuities in shale should be discussed. (154)

Response

The text has been changed (see Section 5.1). The effects of discontinuities are discussed on draft p. 3.1.29.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.12 and DOE/ET-0028, p. 7.2.9

Issue

It would be better to use either a more recent reference than Pirsson's 1947 book or to be more selective in the data excerpted from Pirsson. For example, the silica content of the granite is rather high. It turns out that this represents a single sample from Pikes Peak (Pirsson, pg. 169). It would have been better to use Tschirwinsky's average of 90 analyses (Pirsson, pg. 169) which results in a significantly different chemical composition for an "average" granite. An alternate source of information is Clark, S.P., 1966, "Handbook of Physical Constants," Geol. Soc. of Amer. (208-NRC)

Response

The granite composition given in Table 3.1.2 has been changed to that given in USGS Open-File Report 74-158 and the reference has been changed. See Appendix B of final Statement and references 8, 11 and 23 in the Appendix B reference lists.

Draft p. 3.1.13

Issue

Figure 3.1.3 does not appear in reference 10 (draft Section 3.1.1). (208-NRC)

Response

Reference is incorrect and has been changed to reference 6 (see final Appendix B).

Draft p. 3.1.13

Issue

One commenter suggested it should be mentioned that a major problem of basalts is sedimentary interbeds. (154)

Response

This is discussed under Rock Permeability and Groundwater Flow (draft p. 3.1.32).

Draft p. 3.1.13, DOE/ET-0028, p. 7.2.12

Issue

Several commenters strongly disagree with the assertion that there is limited porosity, permeability in basalt rocks. (43, 208-NRC, 214, 218-DOI)

GEOLOGIC CONSIDERATIONS

Response

The text has been changed (see Section B.6.4 of the final Statement).

Draft p. 3.1.13

Issue

The fact that basalts are layered with discontinuities, volcanic ash, "soil," sandstones, etc., between the layers was left out of the discussion of basalts and jointing. The zone between layers ranges in permeability from opened to sealed. (218-DOI)

Response

The text has been changed (see Section B.6.4 of the final Statement).

Draft p 3.1.14

Issue

The selection of numerical ratings should be discussed. (208-NRC)

Response

The ratings are for comparative purposes and represent an attempt to assign a relative scale to the media properties for comparison among the media types. The intent is more to summarize rather than rank the isolation potential of the rock types. Later revision deleted this portion of the text.

Draft p. 3.1.14

Issue

There should be two categories of salt, bedded salt and salt domes, so that the difference in moisture content can be emphasized. Salt domes have lower moisture content which is a major consideration.

Plasticity, ion exchange capacity, and linear discontinuities should be added to the properties for the rock types. Plasticity values would have the following relative scale values: bedded salt (3), salt domes (3), granite (1), shale (2), and basalt (1). Ion exchange capacity would have values of 1, 1, 2, 3, and 2, respectively. Linear discontinuities would have values of 3, 3, 2, 3, and 1, respectively. (113-EPA)

GEOLOGIC CONSIDERATIONS

Response

The table in question has been deleted. The reader is referred to Table B.2.1 of final Appendix B. The data cited for salt do bound the range of values one would expect for both bedded and domed salt.

The other properties requested by the commenter can be derived from those presented.

Draft p. 3.1.14

Issue

The table showing the isolation of various rock types has basalt listed as having the highest rating for the quality of permeability. This may be true on a laboratory specimen, but it is not true on a large scale. According to Meinzer (1942), of the 65 first magnitude springs in the United States, 38 come from basalt rocks. (214)

Response

When considering a sequence of basalt it is true that permeability may indeed be high as a result of sedimentary interbeds. What is intended however, is for the repository to be located in a single, thick, coherent layer of basalt rather than situated such that it intersects or crosses these interbeds. Bulk rock properties are therefore the best approximation of the characteristecs of this thick rock layer. The comparison of media properties on draft p. 3.1.14 are based on laboratory testing of small rock samples which represent these bulk rock properties

Draft p. 3.1.14 and DOE/ET-0028, p. 7.2.13

Issue

Figures 3.1.4 and 7.2.4 are incorrectly referenced, are incorrect and misleading:

1. They fail to show some of the other basalt areas which should be assessed as candidates for deep geological burial of HLW, e.g., Colorado Plateau, Rio Grande Valley, San Juan Mts. of Colorado, Snake River Plains, Triassic Basins of the Carolinas, Virginia and Pennsylvania.
2. The Keweenawan Series is misplotted as is the Triassic of N.J. and Connecticut. This is not suprising as the map of the Keweenawan which was supposedly used in compiling this map (Y/OWI/TM 36/7, Figure 3-1) is illegible.
3. Reference Y/OWI/TM 36/7 is cited as a source of information for the location of the Triassic "Lavas." There is no information on the Triassic in this publication.
4. The expression Keweenawan and Triassic "Lavas" is misleading, as many of these basalts are not extrusive igneous rocks, e.g., Palisades Sill.

GEOLOGIC CONSIDERATIONS

5. Figure 7.2.4 could not have been developed from information found in Y/OWI/TM-44. (208-NRC)

Response

The Keweenawan and Triassic locations have been corrected and are now referred to as lavas/basalts. See Appendix B of the final Statement and references 5 and 15 of the Appendix B reference list.

Draft p. 3.1.16

Issue

One commenter felt that, "General Statement" is too vague to be useful in the site selection process--it is necessary to specify how long the waste must be kept isolated and how complete the isolation must be. (113-EPA,)

Response

The text has been changed. The question of how long and how complete the isolation must be is not addressed specifically. No exact performance data are specified in this generic approach. However, in the recent DOE Position Paper to the NRC rulemaking hearings on nuclear waste storage disposal (DOE 1980a) the following National Waste Terminal Storage Program Performance Objectives are provided.

> "Waste containment within the immediate vicinity of initial placement should be virtually complete during the period when radiation and thermal output are dominated by fission product decay. Any loss of containment should be a gradual process which results in a very small fractional waste inventory release rates extending over very long release times, i.e., catastrophic losses of containment should not occur."
>
> "Disposal systems should provide reasonable assurances that wastes will be isolated from the accessible environment for a period of at least 10,000 years with no prediction of significant decreases in isolation beyond that time."

Draft p. 3.1.17

Issue

Global plate boundaries should be excluded as locations for potential repository sites. (113-EPA)

Response

This statement was made in draft Section 3.1.31, on p. 3.1.47. The paragraph containing this statement has been moved (to Section 5.1 dealing with site selection) for emphasis in the final document.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.17

Issue

The impression given was that a site may be arbitrarily picked and then justified by subsequent investigation. (154)

Response

This paragraph is a continuation of topics in the preceding paragraph and should be considered with it. The wording has been changed to give the meaning intended--that non-technical factors may enter into the "selection of initial regions for investigation." Technical factors will still govern the exploration, testing and qualification of a site.

Draft pp. 3.1.17, 18

Issue

Who should set the criteria relative to stages I and II of the site selection process? (218-DOI)

Response

The National Waste Terminal Storage Program operated by DOE has developed criteria for geologic disposal of nuclear wastes relevant to the site selective process. These requirements are being used by DOE to guide research and development activities until formal licensing criteria have been established by the NRC. These criteria are summarized in the recent DOE Position Paper to The NRC Rulemaking Proceedings (DOE 1980a).

Draft p. 3.1.19

Issue

One commenter felt that the selection process described in the draft Statement implies too simplistically that each stage is largely more detailed than the previous one. This misses the fundamental logic of a thoughtful siting process. (154)

Response

No scope definition is given for Stage I of the proposed site selection process because a large part of it can be done with available data and has been done with Figures B.6.1 through B.6.4 of this Statement. The site selection process as described is intended to proceed (given a rock type and its distribution or occurrence) from regions to areas to a site(s). The process will become more detailed in each stage, e.g., as areas are selected from within regions, and as each area of interest is examined in detail to find the next smallest areas within it.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.20

Issue

How important is climatic change in determining the evaluation of the hydrologic environment? (113-EPA)

Response

Climatic change is cited as ranking with tectonism and magmatism as important factors in determining the evolution of the hydrologic environment. An example is the difference in present day aquifer systems in arid climates and humid climates. This statement points out that climatic changes have helped determine present hydrologic regimes and should be considered as a factor for possible affecting future ones.

Draft p. 3.1.20

Issue

It was indicated that the constraints mentioned in the last sentence are real, but possibly exaggerated and a little misleading. The Western U.S. may be more active, but at least the action/inaction can be demonstrably documented there and is more difficult to document in the east. (154)

Response

The text has been changed (see Section B.3 of the final Statement).

Draft p. 3.1.21

Issue

A reference should be provided for the statement that shaking caused by earthquakes is not expected to have serious effects on the repository at depth. (208-NRC)

Response

A reference has been added (see reference list Appendix B).

Draft p. 3.1.22

Issue

The commenter agrees that the statements on plate tectonic concepts being useful. The really significant theory (very old) is that the earth tends to continue those tectonic

activities and patterns that have prevailed for many years; "... is correct because projection of changing stresses on a regional, not local, scale is required." This is where the plate theory provides insight. (154)

Response

The theory of plate tectonics provides a mechanism and cause for such geologic items as the distribution and occurrence of earthquakes on a world-wide basis, volcanism and regional stress patterns.

Draft pp. 3.1.22 and 3.1.47

Issue

Isotopic date boundaries and provinces may rank second to crustal plate boundaries in importance to site selection and this should be mentioned. (113-EPA)

Response

Isotopic ratio dating and province boundaries have added considerably to our knowledge of former mobile zones in the earth's crust, particularly those older than say 400 million years. However, the question of future activity along these zones is not thoroughly resolved.

Initial strontium ratios ($^{86}Sr/^{87}Sr$), for example, have been used to partly define the western limit of the North American continent (Armstrong, R. L. et al. 1977 and Peto, P. and R. L. Armstrong 1976).

At present, because of uncertain knowledge of the distribution, significance and potential for affecting a repository, it is believed premature to rank isotopic date boundaries second only to crustal plate boundaries in importance to site selection. Isotopic ratio dating has been added to the draft as an item for consideration.

Draft p. 3.1.23

Issue

If regions are to be eliminated because aquifers are present at depth, then the threshold proximity of aquifers should be defined. (154)

Response

The text has been changed (see Section B.4 of the final Statement).

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.23

Issue

Ground water as a major potable water supply for many western states should be addressed. (208-NRC)

Response

See draft p. 3.1.48.

Draft p. 3.1.23

Issue

One commenter felt it should be noted that both climate and hydrologic gradients may change with time. (113-EPA)

Response

For site selection, existing climate and hydrologic conditions describe the area at the time it is being investigated for use as a potential repository site. If these are favorable, the site selection will continue and questions of trends or changes, if evident, would be addressed.

Draft p. 3.1.23

Issue

Research on thermal effects on rock permeability is all right, but should not be overstated. It may be more practical to select sites where this effect is not important. (154)

Response

Permeability is emphasized because ground-water is believed to be the most likely agent to transport waste from a repository and that anything affecting the factors related to ground-water flow should also be emphasized. Until the effects of waste heat on the host rock are more fully known, it is difficult to say where or for what rock type these effects are unimportant.

Draft p. 3.1.23

Issue

The consequences of drastic changes in the surface water regime should be more carefully investigated before asserting that interior drainage is favorable. (208-NRC)

GEOLOGIC CONSIDERATIONS

Response

The potential can be evaluated when a specific interior drainage area is selected for investigation. For a first consideration the fact that all surface runoff is contained within a basin is more favorable than a basin with a perennial stream or river flowing from it.

Draft p. 3.1.24

Issue

The repository host rock will not neccessarilly be the primary geological barrier to waste migration. Man's intrusion or natural processes may put the primary dependence on other geologic formations. (113-EPA)

Response

Site selection and qualification will consider the rates of natural processes at a prospective site and will be considered in accepting or rejecting a site. Intrusion by man's activities is an accidental or "unplanned" condition that cannot be predicted. If the estimated rates of natural processes are acceptable and if there is no intrusion by man, the host rock will provide the primary barrier to waste migration over long time periods.

Draft p. 3.1.24

Issue

Thermal uplift around the repository may increase the effective hydraulic conductivites of the host rock and may even result in flow paths between overlying aquifers and the repository. (208-NRC)

Response

Heat radiated by the waste and its induced thermal stresses in the host rock and repository are described as posing the "most difficult engineering uncertainities and could have the most significant impact on the design and cost..." (draft p. 3.1.34). In general, the heat effects are expected to affect a small volume of rock compared to the volume of the host rock. Also, some consideration is given to adjusting the heat load per unit area by canister spacing or possibly reducing the waste density per canister (draft p. 3.1.35), if research and field tests show this to be necessary.

GEOLOGIC CONSIDERATIONS

Draft pp. 3.1.24, 33 and 235

Issue

Several commenters expressed concern that it may not be realistic to depend on the "self-healing behavior" (of salt) to produce an impermeable seal around the repository. The design should consider worse case behavior (i.e., the opening of thermally or mechanically induced fractures around the repository to water flow from an overlying aquifer). (208-NRC, 218-DOI)

Response

There is an impermeable boundary or sheath around the exterior of a salt dome that has existed for 20 or more million years. The need to produce an impermeable seal should only exist if construction or testing breaks this. Because of the known plastic behavior and "self-healing" properties of the salt domes at depth and the small size of a repository compared to a salt dome, it seems unlikely that fractures would propagate (from repository construction or operation) through several hundred meters of salt and remain open conduits for water transport.

Draft p. 3.1.26

Issue

How will the list of problems in the draft, with only speculative solutions be handled? (113-EPA)

Response

The problems cited are those in predicting future human activity and no specific method of handling this problem is proposed. For the accident release scenarios based on human activity, it has been assumed that the intrusion occurred. The scenario is then analyzed under the assumed conditions without assigning a probability to the human activity. For certain types of human activity, such as resource exploration, the site selection process would reduce the chances of human intrusion by selecting areas where the resource potential is as low as possible.

Draft pp. 3.1.26-28

Issue

The section on Deficiencies in Data Base is much to general and non-specific. For example, it fails to mention lack of data on long-term shaft and borehole sealing; large-scale sorption measurements; long-term verification of models; large scale dispersivity measurements; and other deficiencies. (218-DOI)

GEOLOGIC CONSIDERATIONS

Response

An effort has been made to more clearly identify the research and development needs for mined geologic disposal. See Section 5.2 and Appendix L of the final statement.

Draft p. 3.1.26

Issue

The great deficiency in the hydrologic data base is actual field studies and methods for obtaining rock dispersivities and in-situ sorption studies for a variety of geologic, hydrologic and geochemical environments. (208-NRC)

Response

The Department agrees that this is an area where information is incomplete. These types of data gaps or insufficiencies are pointed out where they are known to exist and an effort is made to identify what is being done to remedy them. Both dispersivities and sorption are currently being studied. See Section 5.2 of the final version.

Draft p. 3.1.27

Issue

If aqueous radioactive waste is that which has been leached from the solid form by groundwater, this should be said. Otherwise people might think there is a plan afoot to bury liquid wastes. (181)

Response

The statement has been deleted.

Draft p. 3.1.28

Issue

The discussion of the design of the repository considers most of the factors which would influence the isolation of the waste. However, there is no consideration of the possibility of underground collapse. The literature is filled with accounts of underground mines which have collapsed, and caused progressive fracturing to extend upwards toward the surface. Some of these failed mines are several hundred feet deep. None of them are more than a few hundred years old. (214)

GEOLOGIC CONSIDERATIONS

Response

Collapse of tunnels, cavern walls and roofs and the engineered methods of counteracting and preventing this is discussed in Section 3.1.2. Considerable experience from the mining and construction industries indicates that during the operational and retrievable storage phases this should not be a problem. Once a repository is backfilled and sealed, collapse or partial collapse into the remaining open space in the future is a possibility. This is not considered to be a threat to the repository integrity and could eventually be beneficial by adding additional rock material or increasing the density of the backfill in the repository.

Draft p. 3.1.29

Issue

Salt and abyssal-sea clay are more favorable than other media with respect to "unforseen rock conditions," "number and spacing of fractures" and assurance that significant discontinuities are not over looked. (154)

Response

This is true. However, these properties are only part of the total conditions and properties for a site/disposal medium.

Draft pp. 3.1.30 and 3.1.116

Issue

One commenter pointed out that ground support in a shale repository at a depth of 600 m is likely to be a major and costly problem; support costs on draft, p. 3.1.116 are clearly understated. (208-NRC)

Response

See draft, p. 3.1.31, first paragraph. It is pointed out that shales are the most difficult to support in underground openings; that tunneling and support could add significantly to the costs; that a study at the Nevada Test Site has concluded that costs in shale could increase at least 25%, and could be much greater.

Draft pp. 3.1.30-31

Issue

The draft Statement missed stressing its main point because of attempts to discuss minor problems. For example, the positive statement "...strength has major impacts on

design and cost; but in all rock types, engineered support can be designed using current techniques" almost gets losts in the discussion of problems. (154)

Response

In rewriting this section (Section B.2 of the final Statement) attempts were made to place equal emphasis on the problems as well as the engineering techniques which might be used to remedy these problems.

Draft p. 3.1.31

Issue

Since closure rates are expected to be high, the GEIS should describe the support systems and expected closure rates and the effectiveness of the support systems. (208-NRC)

Response

The support required for main corridors, crusher rooms, site conditions will have to be based upon 1.) how long the repository is operated retrievably and 2.) closure rates of the repository medium. The design will probably not be for a permanently open facility like a metropolitan transport tunnel, but designed for a certain operating period, possibly until the repository is filled and sealed. The design will be based on the physical properties of the particular medium at a particular site, and won't be final until these specific properties are known.

Draft p. 3.1.32

Issue

The draft Statement did not reflect fissure and joint permeability differences, and induced characteristics due to construction. The draft Statement makes an assertion that is not supported; i.e., no bases have been provided to support the conclusion that groundwater inflow can always "...be controlled by state-of-the-art engineering technology." (208-NRC)

Response

This topic, under the "Generic Basis for Repository Design/Waste Management Costs" Section, does not distinguish between "joint and fissure permeability" and that induced by construction. Repository design will be influenced by data gained through the site selection process and the testing of a site before construction begins. Site testing will give some idea of the extent of fractures and joints, and state-of-the-art technology can make some estimates of the effects of these features as related to construction. Presumably, site

selection and testing would disqualify any site which had joint-fracture characteristics that could lead to severe problems or uncontrollable water flows.

Draft p. 3.1.32

Issue

The questions of shaft and borehole plugging apply to all media, not just salt. (218-DOI)

Response

This section of draft was revised. Questions associated with borehole sealing and research currently under way on these questions is discussed in the Final Statement in final Section 5.2.3.3 and in final Appendix L.

Draft p. 3.1.32

Issue

This section about Rock Permeability and Ground-water Flow accurately describes the problems of ground-water flow, particularly through fractures. The statement that "Ground-water flow into repository shafts and rooms can be controlled by state of the art engineering technology", is only true of a mine which operates wet. The statement is not true if radioactive waste is to be isolated. (214)

Response

For repositories located in formations other than salt, the assumption is made that the repository will fill with water after closure. The capacity of the repository to isolate waste is then a function of the ground water flow rate, the transport rate of radionuclides through the formation, the leaching rate of the waste form, and the decay rate of the radionuclides. Because many uncertainties are involved in calculating the migration of radionuclides (arising in part from uncertainty in the validity of the models and parameters used in them) an additional level of protection will be added. This level of protection will be provided by the engineered barriers that make up the waste package. These barriers include the canister, the overpack sorption materials and backfill. The package itself will be designed to contain the waste under repository conditions for hundreds of years which allows for decay of a majority of short lived radionuclides with a corresponding reduction of waste temperature. The reduction in temperature after the life of the package is reached reduces the leach rate of the waste form and thus the concentration of radionuclides available for migration in ground water.

GEOLOGIC CONSIDERATIONS

Draft pp. 3.1.33 and 3.1.138

Issue

One commenter questioned why 600 m is selected as the disposal depth. (40)

Response

The use of 600 m is an arbitrary depth selected from work done at the Carlsbad, New Mexico site. It is based on the depth (700 m) and the thickness (600 m) of the Salado formation. See Section B.1 of the final Statement.

Draft p. 3.1.33

Issue

Ground-water flowing into operating mines (in Canadian Shield Granite) is probably evaporated by ventilation airflow. In the long run, seepage rates low enough to appear negligible by visual inspection are expected to be significant. (208-NRC)

Response

See draft p. 3.1.,49, where it is mentioned that flow rates and velocities that are insignificant over a 50-year period could be important over hundreds to thousands of years, and that it is reasonable to assume as one possibility that free water, over a period of thousands of years, may enter the repository (with the possible exception of a salt repository). It may be unrealistic to believe that any repository (excepting salt) would remain totally free of water for times up to a million years or longer. However, with careful site selection investigation, construction and a detailed knowledge of the site it may be possible to show that the time of water ingress and/or the rate are such that the repository serves its purpose.

Draft p. 3.1.33

Issue

This section states "Thus, cost considerations dictate that the depth of emplacement should be minimized, whereas isolation requires that the depth be maximized." The first part of that statement is sufficiently clear. However, it is not clear that the second part of the statement is correct or if correct, significant. The support for this part of the statement is qualitative and intuitive rather than quantitative and rigorous.

Geological Survey Circular 779 states: "The suggestion of Winograd (1974) that waste be placed at relatively shallow depths (30 to several hundred meters) in the thick (as thick as 600 m) unsaturated zones of the arid Western United States deserves consideration." We concur.

GEOLOGIC CONSIDERATIONS

The Teknekron, Inc. report prepared for PNL, "A Cost Optimization Study for Geologic Isolation of Radioactive Wastes," May 1979, does not indicate any significant advantages to great depths of burial except the reduced probability of repository disruption. If the large meteorite strike is truly improbable and if erosion and glaciation can be avoided (at least during the first 10's of thousands of years) then there may not be any advantages to great burial depths, only disadvantages.

The following questions should be addressed:

1. Are there regions of the U.S. otherwise suitable for a repository which can provide a safe environment for the waste at relatively shallow depths without a meaningful threat of interruption by natural events?
2. If so, what is the reduction of risk between such a repository and a deep repository (and what is the increase in cost)? What is the potential for an increase in confidence which could result in a more complete site characterization and simpler modeling of a shallow versus deep repository?
3. If not, what is the quantitative reduction in risk as a function of depth for a deep repository? (208-NRC)

Response

For the reconnaissance and generic treatment of the geologic considerations, containment of the waste and isolation from man's environment were the prime considerations. Depth to the repository has been an unresolved issue (draft p. 3.1.25) and the early estimates of depth were made for bedded salt (draft p. 3.1.48). In general the reduced probability of disruption provided by deeper burial was assumed to be desirable. Because neither a rock type or geographic area is specified in this Statement and because cost was not considered to be an environmental factor, cost-depth considerations were only treated qualitatively.

The Winograd concept would store waste in mesas and buttes in the arid west. The waste would be placed in unsaturated (above the water table) material and could require shallow depth because of the high elevation of the unsaturated material above the surrounding land surface and/or the relatively great depth to saturated material. However, mesas and buttes are erosional remnants that are exposed to surficial processes and they are being reduced in area even under today's arid climate. These features were considered more temporary than a buried rock unit that is not exposed to surface processes. The concept is worth consideration as a special case and could well be useful if a time of containment is firmly fixed and if the present arid conditions remain unchanged.

Sections 5.1 and 5.2 of the final Statement discusses disposal of waste, in geologic units within the earth, from a generic standpoint; depth of repository is one of the relevant geologic factors mentioned and discussed, but in general terms rather than specific. These factors all are concerned with the location and/or performance of a repository. The

questions above are beyond the scope of the generic treatment in this Statement, particularly because cost was not considered an environmental factor and because there are no specific criteria for depth, length of time necessary for containment/isolation, or even what repository behavior can be considered isolation.

Draft p. 3.1.34

Issue

The comment was made that the effect of mining on rock depends on rock type and mining technique, fracturing can be controlled by existing techniques. The greatest changes occur within a relatively short time following excavation, and that stress relief in most rock types decreases dramatically following emplacement of supports. (154)

Response

The text has been changed to read "It should be noted that the greatest change in the rock occurs within a relatively short time following excavation." See also draft pp. 3.1.30-3.1.31 under Rock Strength and Excavation Stability.

Draft pp. 3.1.34-36

Issue

One comment was that the discussion of the effects of heat in the waste on repository design and construction section is not crisp. This section should recognize that if a realistic position is taken as to cooling time prior to disposal, the heat effects will be significantly reduced and that they can be further reduced if desired. (154)

Response

The draft Statement discusses a variety of waste forms and predisposal options, and assumes certain conditions for the purposes of analysis. This is intended to cover a variety of options and the cooling time is one of the factors about which a final decision has not been made. The Statement does mention decreasing the heat output per unit area by spacing between the canisters and by decreasing the waste density per canister.

Draft p. 3.1.35

Issue

In the last paragraph, the resins used with resin grouted bolts are polyester, not epoxy. (218-DOI)

GEOLOGIC CONSIDERATIONS

Response

The text was changed.

Draft p. 3.1.36

Issue

The basis for the conclusion that costs for additional support necessitated by the reduction in rock strength caused by radiation are not expected to be significant should be given. (208-NRC)

Response

Some data are presented in paragraph three for salt. This paragraph points out that adequate knowledge of radiation on rock properties is lacking. Based on the information available, it was concluded that the known effects on costs would be small compared to the total costs. An additional reference was added to the list at the end of Section 5.2 (reference 26).

Draft p. 3.1.36

Issue

Regarding seismic loads, a brief description of how underground structures respond characteristically to earthquakes would be appropriate. (154)

Response

A reference has been added for seismic effects on underground structures under Tectonic Considerations Seismicity and Magmatism.

Draft p. 3.1.41

Issue

Operational difficulties which may prevent sealing are not discussed; it may be difficult to backfill or retrieve if a repository becomes flooded. (208-NRC)

Response

The site investigation and testing program should characterize the repository well enough to show that there would not be problems like flooding--any indication of these kinds of problems would likely delay or prevent use of the repository.

GEOLOGIC CONSIDERATIONS

Draft pp. 3.1.47-53

Issue

The discussion in this section repeats that of Section 3.1.2. (154)

Response

Sections 3.1.1, 3.1.2 and 3.1.3 have been reorganized to eliminate repetition.

Draft pp. 3.1.47-76

Issue

Discussion of brine migration is missing; no mention is made that sorption by salt is different than for other media. (208-NRC)

Response

Mention of brine inclusions in salt migrating toward a heat source was added (with reference) to draft, p. 3.1.9, and the table of physical properties comparisons (draft, p. 3.1.14) has "Ion Exchange Capacity" added, with salt given the lowest rating. Sorption is discussed briefly on draft p. 3.1.5, and listed under "Deficiencies in the Data Base" (draft p. 3.1.26) as a significant item.

Draft p. 3.1.47

Issue

An additional premise should be added to the effect that certain geologic conditions will be avoided and others can be coped with through mitigating measures. (154)

Response

The two premises listed are basic to the concept of geologic disposal and are the reasons for considering geologic disposal. They apply equally to all the media discussed. To distinguish between conditions that would lead to avoidance or to acceptance with mitigating measures is more specific to each medium (i.e., not as general) and was not included here.

Draft p. 3.1.47

Issue

Hydrology should also be a prime consideration in geologic site selection. (218-DOI)

GEOLOGIC CONSIDERATIONS

Response

Hydrology is discussed as an important factor in selecting the site, qualification of the site and assessing the potential for retrievability of the waste. The subject is divided into surface hydrology (draft p. 3.1.47) and groundwater, as a separate topic, (draft p. 3.1.48-49). The final Statement includes Hydrologic Considerations under Factors Relevant to Geologic Disposal (See final Appendix B), and then under final Section 5.1.1.2, as one of the most important factors in repository site selection.

Draft p. 3.1.47

Issue

One commenter pointed out that for tectonics and seismicity, the critical point to demonstrate is that the activity pattern is such that future action is not likely to occur during the repository's life. This should be expressed in terms of probability and acceptably low probabilities need to be defined. (154)

Response

This is true and hopefully will be done. The difficulty is in assigning acceptable probabilities to events in the distant future, as well as defining what is acceptable in terms of these probabilities. One solution is suggested in the second paragraph draft p. 3.1.53. This problem is receiving study.

Draft p. 3.1.48

Issue

The emplacement medium should be of an older age, and be overlain and surrounded by rocks of younger age, so that the absence of significantly adverse activity for an adequately long time period can be demonstrated. (154)

Response

The requirement that the medium be overlain and surrounded by younger rocks may be unnecessarily restrictive. For a disposal medium and site location, the stability and character are more important than whether or not there are younger rocks overlying the disposal material. See the comment for pp. 3.1.1-3.1.3 about the Canadian Shield, for example.

Draft p. 3.1.48

Issue

Regarding jointing, faulting and fracturing, one commenter recommended the addition of the following sentence: "They increase the time and cost of investigations, complicate the

representative quantitative modeling necessary for design and decrease confidence that all conditions are known." (154)

Response

The text has been changed (see Section B.2 of the final Statement).

Draft p. 3.1.48

Issue

One commenter indicated that the first statement under ground-water implies that a repository can be sited in conjunction with a useful ground-water source and not affect its quality. (113-EPA)

Response

The text has been changed. The intent of the statement is not clear from the wording. The central idea in discussing ground water as resource is that it must be preserved.

Draft pp. 3.1.48, 49, 64

Issue

Table 3.1.49 of the draft states that there could be an unacceptable 50 year body dose as a result of ground-water transport of radionuclides by the year 2050; pp. 3.1.48 and 3.1.49 state that insignificant flow rates over the short term may be a problem over the long term. (208-NRC)

Response

Table 3.1.49 of the draft presents the results of a "faulting and flooding" accident scenario that "assumes an improbable combination of events...." (p. draft 3.1.148); this is only true if all the given assumptions are made--a fault breaches the repository, 100 cubic ft/sec of water flows into the repository, past the waste, and enters man's environment. The other statements refer to an intact repository and not to the special "accident" scenario.

Draft p. 3.1.49

Issue

Several letters noted that the statement--"Flow rates and velocities of groundwater that are insignificant over a 50 year period will have to be considered over hundreds of thousands of years." does not make sense over the long-term. (113-EPA, 154)

GEOLOGIC CONSIDERATIONS

Response

This Statement is intended to point out that, over long time periods, slow or low-rate processes could have effects that are not obvious over a short time period, and should be considered.

Draft p. 3.1.49

Issue

The chemical nature of any aquifers around a repository should be briefly discussed, including oxidation-reduction considerations. (113-EPA)

Response

Aquifers are discussed from a generic standpoint and without any specific location specified. The chemistry of the ground-water is not specified either, because the chemical nature of the water will vary depending on the location of the site. The solubility and sorption effects on the various ions and elements will also depend on the aquifer material characteristics as well as the waste form. Because of the-site specific nature of the ground-water chemistry and the effects that even small differences in water chemistry could have, this question can be better addressed when water analyses for a particular setting are available.

Draft p. 3.1.51

Issue

The statements that some issues may not be resolved with the necessary degree of certainty seems to conflict with the very next sentence, which states that uncertainties can be reduced to acceptable levels. (208-NRC)

Response

The intent is that more research may be required to reduce the degree of uncertainty to acceptable levels.

Draft p. 3.1.51

Issue

One commenter was concerned about the following statement: "...acceptability criteria may need to be adapted or modified, or even developed if unexpected conditions are met." It is important that the implication not be left that justification for a particular site can be an ex post facto exercise not based on scientific and technical grounds. The rationale and bases for criteria development and application need to be elaborated. (154)

GEOLOGIC CONSIDERATIONS

Response

There are presently no quantitative criteria for repository or site qualification. Until there are and until some site specific data are available, it is not possible to say what the acceptability criteria are. These may be proposed and then need to be adapted or modified as the site testing is conducted. At this time, the primary objective is to establish criteria that protect the environment and the public safety, both for the short and long-term.

Draft p. 3.1.52

Issue

One commenter felt the belief that all problems can be solved by major efforts is unjustified. Investigations into a basic research area do not necessarily have satisfactory outcomes. (113-EPA)

Response

The text has been changed (see Section 5.2). The Statement does not say that the problem would be solved, but that a serious research effort would yield results. The capability may never be developed to predict exactly what geologic phenomena will have occurred at a given location by the end of another million years. Research into the processes that affect and change the earth would certainly yield information on the processes themselves, their interactions, the driving forces, rates of activity, timing of events, etc.. All of these items represent areas in which full understanding is lacking. As more understanding is gained, some of the basic uncertainty in predicting geologic events could be reduced or removed.

Draft p. 3.1.53

Issue

Concerning long-term geologic stability of a geologic repository, the statement, "It (long-term geologic stability) only becomes a concern if and when the test facility or conservatively-loaded facility becomes a full-scale repository, and only then when the period of retrievability has ended and the repository is sealed." This statement is true, but the long term stability certainly must be considered in depth before the repository is sealed. (214)

Response

Long-term stability of a repository is a major consideration of the NWTS program. Laboratory and field observations of the behavior with time of geologic materials are being

made. The results of these ongoing studies will be considered in the final design of the repository system.

Draft p. 3.1.54

Issue

The statement that for longer-lived nuclides a delay in release to groundwater will probably be provided by the host geology, is not true of salt since it does not absorb great amounts of the nuclides that leach out. (62)

Response

The text has been changed.

Draft p. 3.1.67

Issue

The current geologic estimate of the age of the earth is 5 billion years, not 10 billion as given. (208-NRC)

Response

The text has been changed.

Draft p. 3.1.68

Issue

Lithosphere/Biosphere Transport: While the reader is correctly advised that "Some ground-water and transport models have been calibrated," he is not told that modeling of flow through fractured aquifers is in its infancy. (218-DOI)

Response

DOE agrees with the commenter and notes that these points are well taken. Final Section 3.4.3.2 discusses the limitations of mathematical models. Appendix L of the final Statement indentifies research currently underway which is designed to better the understanding of the nature of fracture flow, thereby, aiding in the development of more accurate fracture flow models.

GEOLOGIC CONSIDERATIONS

Draft P. 3.1.71

Issue

Sorption of radionuclides is controlled by the site-specific geology. It seems unlikely that radionuclide behavior data from one site can be applied to another site. (113-EPA)

Response

Radionuclide behavior data from one site cannot be applied to another site with precision; however, they appear adequate for use in a generic statement.

Draft p. 3.1.104

Issue

A major deficiency in the design of the repositories in granite, shale, and basalt is that they have been designed as if the host rock were salt. The repositories in the four geologic media should not be of similar design. For instance, the inherent structural characteristics of granite have not been taken into consideration. The design of a mine in hard rock is substantially different from that in salt. Where, by the nature of the material, a repository in salt is confined to a single level, a repository in massive granite need not be. The long term stability of large rooms in granite is well known. (208-NRC)

Response

Room and pillar mining provides for efficient use of the rock formation for the emplacement of nuclear wastes. The concept of room and pillar mining was tailored to the rock structural characteristics of the four rock types shale, salt, basalt and granite as plainly indicated in Table 7.4.2. The multiple level concept for room and pillar mining in repositories is constrained only by the physical dimensions of the geology. No technical basis is known to disavow multiple levels. In the case of bedded salt, multiple levels may be physically impossible since it is a horizontally layered geology. Room height may be of the same order dimensionally as the geologic layer thickness, thus restricting a repository to one-level thickness does not entirely rule out multiple levels though. With a thinly layered geology multiple levels may be possible if multiple thin layers exist as in the case of the WIPP site.

Domal salt has a potential for providing for multilevel emplacement since its geologic vertical dimension is a couple magnitudes of order greater compared to the room height dimension. Therefore salt repository design is not confined to a single level.

Rooms in granite may be extremely stable. Thermal/mechanical analysis for the preconceptual design stages has been performed. Thermal/mechanical models are presently being developed to address the impact of the heat generated by nuclear wastes upon room stability in granite repositories.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.124

Issue

What the GEIS is really discussing is the creation of flowpaths by creating fractures or opening fractures that already exist. The question, then, is how does the predictive model treat the flow of liquids and transport of dissolved radionuclides through fractures? Both flow and transport could be significantly different in fractures than in porous media. We know that retardation is less and, also, that retardation is the most important attenuation mechanism that has been modeled. The term "thermally-induced permeability" does not convey the difference between porous flow and fracture flow. (208-NRC)

Response

The predictive models used do not treat flow or transport through fractures. A prevailing assumption for siting any nuclear waste repository is that ground-water flow rates will be very slow. If the flow velocity is high, then the repository will be located elsewhere.

Retardation is not the "most" important attenuation mechanism modeled. Several dispersion mechanisms exist that have a greater effect on maximum peak values. Examples include leach rate and spacial distribution of the waste in a repository. In certain instances, decay rate may have a larger attenuation than retardation.

Draft pp. 3.1.136 and 3.3.3

Issue

Areas of uncertainty common to different alternatives should be treated equally. Technology for long-term sealing, which has not been demonstrated, also does not receive uniform evaluation. (208-NRC)

Response

This type of treatment is being attempted in the revised Statement. Some of the problems are not the kind that past experience has dealt with and others that may appear similar among the alternatives really are not. For example, to date, no structures have required a design life of even say one-thousand years, let alone to 10 thousand years. It is impractical to try to demonstrate a thousand-year proof period in real time. An example of apparent similarity is the sealing of a very deep hole and a mined repository in a deep hole, the "repository" is part of the drilled hole but in a mined repository the hole or shaft is only the access; the repository is constructed away from the hole and can be sealed separately. However, sealing the drilled surface to repository level will present similar problems.

GEOLOGIC CONSIDERATIONS

Draft p. 3.1.148

Issue

First paragraph, last sentence reads, "It is doubtful that any fault would form a continuously permeable conduit to the repository, even if a fault should occur through the repository to the land surface." Faults often form conduits which transport water, and are often located by the presence of springs along their length. The study by Meinzer (Meinzer 1942) states that 3 of 65 first magnitude springs in the United States are located in sandstone, and that they are believed to owe their existence to faults or other special features. (214)

Response

The influence of postclosure faulting on the capacity of a repository to isolate waste will be considered in the analysis of repository performance. Currently the modeling capability exists to conduct detailed calculations of the effects of post-closure faulting on radionuclide migration. Preliminary calculations have been done for a hypothetical repository in salt and are published in a document entitled Test Case Release Consequence Analysis for a Spent Fuel Repository in Bedded Salt (Raymond et. al. 1980). These calculations assumed a vertical fault through the repository and overlying aquifers and extended to the ground surface. Because of the nature of the test case, many of the parameters had to be assumed; therefore, a sensitivity analysis was conducted to determine how changes in parameter values affected the resulting dose-to-man calculations. These results are published in Paradox Basin Sensitivity Analysis (Bond and Kaszeta 1979). These types of calculations will be done for all repository sites to determine the effect of post-closure faulting even though the likelihood of faulting is small.

Draft pp. 3.1.228, 3.3.22, 3.3.27, 3.3.30

Issue

Maintenance of the integrity of shaft seals, room seals and canister seals (particularly in salt) would be expected to pose greater problems than in Very Deep Hole disposal. (208-NRC)

Response

The entire question of sealing is still under study (See Section 5.2 of final Statement). For the underground mined repository, it has been proposed to backfill the rooms with material removed from the repository during mining, thus completely surrounding the waste with host rock material. The shaft(s) to the repository are a more complicated problem because of the various rock materials between the repository and the land surface. The very deep hole is similar to the mined shaft in this respect plus having drilling mud

effects and casing (pipe), if used, and being more directly "connected" to the waste location. Salt, depending on the depth, is expected to deform plastically and may eventually seal the backfilled rooms to original density material. The shafts into the salt unit are expected to be the main sealing problem.

Draft, p. 3.1.237

Issue

The questions posed in the first paragraph are correct, but this does not mean that boundary conditions/characteristics cannot be defined now as minimum criteria to be applied at least during siting.

It is true that standard techniques for nondestruction analysis of geologic formations are not complete nor generally available. However, this varies with the media and its environment, and with the type of information desired. For example, qualitative high-resolution data on the nature and distribution of abyssal sea clays and their contained discontinuities can be easily obtained by seismic reflection profiling. Quantitative data, however, are not yet so readily available using such techniques as they are for sedimentary environments on land. For granites and many basalt environments, seismic reflection profiling is minimally useful. The point that should be made here is that on optimum set of destructive and non-destructive exploration techniques will be applied on a site by site basis with recognition of the resulting trade-offs between accurate knowledge and troublesome penetrations. The possible notion that progress should await the development of new techniques should be dispelled. (See p. 3.1.240, 5th paragraph, next to last sentence.) (154)

Response

During preparation of the final Statement this section was revised. Section 5.2 of the final Statement discusses the R & D needs to enhance existing site characterization analysis techniques. Both standard geophysical and non-destructive techniques are discussed in this section. Additional information regarding R & D needs and programs to meet these needs can be found in the final Appendix L.2.

Draft p.3.1.237

Issue

There is no discussion of research needs in the hydrologic transport aspects of geologic disposal. Of prime importance are the chemical and thermal interactions involving dissolved wastes and the natural rock. (113-EPA)

GEOLOGIC CONSIDERATIONS

Response

Such discussions appear in Sections 5.1.2 and 5.2, Appendix B.4, and Appendix L of the final Statement.

Draft p. 3.1.238

Issue

There is a fundamental problem in preparing the repository which is not brought out in the statement. The inability to test non-destructively means that the boreholes drilled to characterize the repository area make it less suitable for a repository. (35)

Response

Tests at a candidate repository site should not proceed to such a degree that they would compromise the integrity of the site. Geophysical and borehole techniques are generally available to analyze geologic formations. Non-destructive sonic and a variety of other testing methods can also be utilized as reasonably effictive tools to locate voids, fractures or even previously undetected drill holes. The need for additional research and development to improve and provide new methods for determining geologic and hydrologic properties is recognized in Section 5.2 of the final statement.

Draft p. 3.1.238

Issue

One commenter felt it should be pointed out here that satisfactory shaft and tunnel sealing techniques have not been developed. (218-DOI)

Response

Shaft and tunnel sealing is an important part of the total Repository Sealing Program. Most of the field work on the RSP has been done on boreholes but much of that work will have application in sealing shafts and tunnels. Work specific to shafts and tunnels will commence in FY-81.

Draft p. 3.1.238-239

Issue

There has already been considerable study of thermal effects which leads one to believe that subsidence can be calculated. (35)

GEOLOGIC CONSIDERATIONS

Response

A general discussion of the thermal and radiation induced effects on the host rock are provided in Section 5.2 of the final Statement. Calculations of subsidence or doming are dependent upon parameters such as repository design, host rock, waste type, waste form and package, etc.. Such parameters are of a site specific nature and would be more appropriately considered in a site specific evaluation.

Draft p. 3.1.242

Issue

The study of rock-waste interactions should include the geochemistry. Mobility of a number of radionuclides is strongly affected by the geochemistry (particularly the oxidation-reduction potential of the repository and ground water) and by the potential presence of complexing agents. These should be included in the proposed reasearch program. (113-EPA)

Response

This concern is presently under study for the Department by the Office of Nuclear Waste Isolation (ONWI) through the Waste Rock Interaction Technology (WRIT) Program (See Appendix L of final Statement).

Draft p. 3.1.243

Issue

It should be pointed out here that sorption phenomena (or "Kds") are not yet well understood and characterized. Considerable fundamental and field research is needed in these areas for both near- and far-field analyses and modeling. (218-DOI)

Response

During preparation of the final Statement this section was revised. Section 5.2 of the final Statement presents a discussion of the current R&D needs; among which the need to improve data gathering techniques for specfic rock properties and improved modeling methods are mentioned. R&D projects which are currently underway and are designed to meet these needs are identified in final Appendix L.2.

GEOLOGIC CONSIDERATIONS

DOE/ET-0028, p. 7.2.2

Issue

The statement that: "The repository should not be sited in or near an area in which igneous or volcanic acctivity has occured during the post Pleistocene" should be assessed and actively discussed by DOE. An assessment should be made of the potential for volcanic activiey and its impact on repository performance. The assessment should estimate the actual effects, detrimental or beneficial, or repository performance by different types of erruptions. (208-NRC)

Response

Acres of volcanic activity are highly unsuitable and our current abilities to predict the effects of such events are poor. Although distant volcanic activity and related seismic events are not expected to directly disturb a repository, these processes may significantly effect the regional hydrology which could provide a transport mechanism and pathway for rationuclide migration to the biosphere. Preliminary assessments evaluating the effects of volcanic activity on a repository have been performed. Although the results show beneficial effects in some cases, other cases show negative effects as mentioned above.

DOE/ET-0028, p. 7.2.3

Issue

The credibility of Section 7.2 is weakened by either a lack of documentation for the Statements (e.g., see p. 7.2.6 Southwest Florida) or the use of very old references (e.g., see p. 7.2.6 paragraph 3 on the Supai Formation of the Holbrook basin of Arizona) when more recent material should be available. (208-NRC)

Response

The section in question utilizes as one of its references a USGS open file report that the commenter previously had requested to be cited because of it being an original reference.

DOE/ET-0028, p. 7.2.3

Issue

The geologic term "formation" is misused throughout the GEIS. Although this appears to be a minor editorial comment, it may have legal ramifications. The term is defined in The American Code of Stratigraphic Nomenclature which is to be found in the Bulletin of the American Association of Petroleam Geoloists (1961, pp. 645-660). Basically, a formation is a specific rock unit which has a distinctive lithologic characteristic which allows it to

be mapped. Sandstone, limestone, shale, granite and basalt are not formations, whereas rock bodies such as the Dakota Sandstone, Salem Limestone, and Pierre Shale, and Louann Salt are. (208-NRC)

Response

The improper use of the term "formation" will be corrected upon publication of an addendum or an errata to the DOE/ET-0029 and DOE/ET-0029 documents.

DOE/ET-0028, p. 7.2.9

Issue

The statement that igneous rock "...range is chemical and mineralogical composition from granite to closely related rocks such as granodiorite" is technically true but misleading. The range goes far beyond granodiorite through gabbro to pyroxenite and dunite. (208-NRC)

Response

The statement identified by the commenter identifies the range of granitic rocks receiving detailed analysis as potential host rocks. The statement is thought to be appropriate and is not expected to be changed.

DOE/ET-0028, p. 7.2.9

Issue

The statement that "granite is mostly composed of silica and mica" is misleading. Mica makes up a small percent of most granites and quartz rarely exceeds 30%. Mention should be made of other minerals common in granite such as the feldspar and ferromangesian minerals. (208-NRC)

Response

The DOE agrees that the statement as it stands is misleading. Quartz and mica minerals are among the major minerals making up granite but they do not necessarily constitute the majority granite composition. The appropriate corrections will be made upon publication of a errata or addendum to the DOE/ET-0028 and DOE/ET-0029 documents.

DOE/ET-0028, p. 7.2.10

Issue

The basic references of Pirsson 1947 and Gilluy, Woodford and Aateus, 1968 should be replaced by reference to one of the following: Robert L. Folks Petrology of Sedimentary

GEOLOGIC CONSIDERATIONS

Rocks (Hemphill's, Austin, Texas), Blatt, Middleton, and Murray's Origin of Sedimentary Rocks Prentice-Hall or Pettijohn's Sedimentary Rocks, Harper Borthers, N.Y.. (208-NRC)

Response

In revising the draft Statement more current geologic references were used and appropriately cited. Where deemed appropriate, additonal references would be added through publication of an errata or addendum to the DOE/ET-0028 and DOE/ET-0029 docuements.

DOE/ET-0028, p. 7.2.10

Issue

Contrary to line 5, Table 7.2.1 gives no direct information on the mineral content of shales. (208-NRC)

Response

The appropriate changes will be made upon publication of an errata or addendum to DOE/ETO028 and DOE/ET-0029 documents.

DOE/ET-0028, p. 7.2.12

Issue

The statement that basalt is an "extrusive volcanic mafic (high in magnesium rock silicates) rock" is doubly misleading: (1) Not all basalts are extrusive e.g., Palisades Sill, and (2) mafic minerals are not limited to magnesium silicates. (208-NRC)

Response

Basalt is commonly described as an "extrusive volcanic mafic rock". However, in the interest of being technically correct, the description of basalt used will be revised upon publication of an errata or addendum to the DOE/ET-0028 and DOE/ET-0029 doucments.

Issue

Because geologic historians suggest a rather constant transition and breakage of the earth's crust, the probability of a major disruption in the storage of at least some of the radioactive material is quite high. (73)

Response

Crustal breakage generally occurs in belts of activity along crustal plate boundaries or in tectonically active areas. The site selection process will avoid all areas of known

tectonic activity and look for areas of stability, such as some of the salt basins which contain salt that has been in existence and essentially undisturbed for several million to hundreds of millions years.

Issue

The effectiveness of the host rock to act as a barrier is dependent upon site-specific parameters and cannot be attested to at this time. (43, 97)

Response

A potential host rock has certain physical properties that make it favorable for a repository host rock. These properties are inherent in the rock and are typical of the rock. The geologic setting may contain elements related to structure, seismicity, physiography, etc. that modify the effectiveness of the site at a given location. The site selection process will seek out sites that are not modified by these elements and where the host rock properties will be intact.

Issue

If the repository were located in a salt bed, the ground-water would first have to dissolve tremendous quantities of salt prior to picking up and transporting the small amount of radioactive material remaining after 600 years. Would not the salt do far more damage to the environment and the local hydrology in particular than the small quantity of transuranics within the facility? Is not worrying about reprocessed nuclear waste beyond 600 years in a salt bed akin to worrying about arsenic being spiked with traces of a poison? Please discuss this concept in your draft. (178)

Response

Should ground-water contact a salt bed containing a nuclear waste repository, long times and large quantities of water would be required to uncover the waste. The ground water leaving the repository would be saturated with salt and would have to be diluted about 300 to 1 in order to be potable. The damage to the environment from both the salt and the radionuclides is expected to be small. Which is smaller depends on the conditions of the scenario and the definition of "damage".

Issue

One commenter mentioned that the Sierra Club Bulletin asserts: "The temperature within the (salt) repository may reach 300°C. Water, in the form of liquid and vapor, is drawn towards the heat source in a salt repository...This hot brine solution is acidic and very corrosive. According to EPA, the canisters would be breached in a decade or less" (Sierra July/August 1979, p. 51). The data relied on in the draft Statement are taken at room temperature. (153)

GEOLOGIC CONSIDERATIONS

Response

Brine migration of liquid already present in the salt (0.1 to 1% by weight) and its migration up the thermal gradient toward the waste package is under extensive study. If the environment produced by elevated temperatures and the presence of brine have an adverse effect on the performance of the waste package, then materials must be selected which can withstand this environment. Data from package material design and performance testing would be used for package design and material selection to insure optimum waste package performance.

Issue

There are many problems specific to salt as a repository medium that should be addressed. (42, 68)

Response

Problems specific to salt as a repository material (e.g., thermal effects, lack of sorption, closure rates, corrosive brines) are addressed in generally qualitative terms in Section 5.2. There are additional data in other reports (ERDA 1976b and Brandshaw et. al. 1971). These have been incorporated into Section 5.2. The DOE Position Paper to the NRC rulemaking proceedings on nuclear waste storage and disposal (DOE 1980a) also contains an extensive discussion of the environmental conditions in a salt repository.

Issue

One commenter noted that linear thermomechanical analysis is applied to a repository in salt. Such an analysis can result in significant error in predicting thermomechanical effects. Even with this analysis a surface uplift up to 1.5 m is predicted. The important question not addressed in the GEIS is what effect will this have on shaft and borehole seals, thermally driven convection and breccia pipe formation? (208-NRC)

Response

The NWTS program has developed analytical and numerical solutions, and material properties to apply non-linear thermomechanical analysis to the behavior of a repository in salt. These solutions and properties have been used to model the behavior of field experiments such as Project Salt Vault and Avery Island. These studies are continuing and the accuracy of modeling or predicting the behavior is expected to be improved. These improved models will be used to analyze the total behavior of a potential repository in salt.

Issue

"(Creep) is difficult to stabilize in tunnel openings."

"From experiments...equations can be developed to describe the creep behavior of salt."

GEOLOGIC CONSIDERATIONS

Since equations have been developed which describe the behavior of salt a posteriori, the GEIS should discuss whether they can predict the behavior of salt under thermomechanical loading conditions. (208-NRC)

Response

Some amounts of creep can be tolerated with no adverse effects in a repository. Excessive creep is not desirable and does present special engineering challenges. Stabilization of openings against creep is generally possible.

The NWTS program includes study of existing data and ongoing laboratory and field tests to obtain the creep and other thermomechanical properties of salt. With this data and the analytical studies also underway, it is anticipated that relationships will be developed to adequately describe the creep behavior of salt. It has already been demonstrated, for example, that the result of the Project Salt Vault field tests can be predicted to a reasonable accuracy with the materials properties and analytical solutions now available. Predictions of the behavior of salt under anticipated thermomechanical conditions will be included in repository design studies.

Issue

It was noted that in view of recent news articles from Mississippi reporting accidental releases of radioactive material from weapons testing sites, how does DOE view the integrity of salt as waste repository media? (43)

Other commenters pointed out that disposal in salt repository will not work because 1) salt is often found near mineral deposits, 2) of drilling concerns, 3) presence of brines will cause dissolution of waste form, 4) salt has low sorptive capacity, and 5) elevated temperatures and pressures and the presence of water will compromise waste form. (62, 197)

Response

Some contamination by tritium has been observed at the Tatum Dome in Mississippi where two test explosions of nuclear weapons took place in the mid-1960's. This contamination has however been shown to be related to disposal of tritiated water into surrounding aquifers as part of the clean-up operations. Geologic repositories, as described in this Statement, would only receive radioactive wastes in solid form. Contamination levels reported at the Tatum Dome were caused by specific operations and practices completely different than those to be undertaken in geologic repositories.

Salt is considered as a disposal medium because it has potentially useful properties (plasticity, isolation from flowing water, etc.) and because of its stability. In the Statement it is treated as one of the four geologic materials that are being considered as candidate repository media. Salt has had relatively more investigation than the other three media types at this time, but as with the others, it requires continued study and consideration.

GEOLOGIC CONSIDERATIONS

The preliminary site selection process (Section 5.1) considers such factors as resource potential, proximity to natural resources, tectonic stability, water system, etc. The Statement considers that repositories are potentially feasible in all media. However, the Statement acknowledges that there are some unresolved issues regarding these media and suggests continued research and development to fill existing data gaps.

Issue

The statement that granite has "...little ability to deform under stress" is not true. Under varying combinations of the following: 1) high confining pressure, 2) elevated temperatures, or 3) when the stresses are applied for long time spans, granite will deform. (208-NRC)

Response

Granite will undergo deformation under the influence of pressure, time, and temperature. For the levels of these phenomena predicted in a repository, however, such deformations are expected to be small and certainly manageable.

The deformation characteristics of granites are being studied analytically, in the laboratory, and in field experiments approximating repository conditions. Information obtained from these studies will be used to evaluate deformations in, and prepare designs for, a repository in granite.

Issue

The statement that the "mineral components of granite are almost inactive chemically under ambient temperature and pressure conditions" is misleading. Granite does decompose at surface temperatures and pressure as evidenced by well developed regoliths found on top of many granites. (208-NRC)

Response

Given the anticipated time frame (on the order of several tens of years) for exposure of granitic rocks to ambient temperature and pressure in a repository excavation, it is reasonable to assume that the mineral components of granite would be relatively inactive chemically. Decomposition of granite into well developed regoliths under conditions of surface temperature and pressure is a phenomena requiring periods of time orders of magnitude greater than those expected for similar physical conditions in a repository. In addition, regolith formation is assisted by constant exposure to the hydrologic cycle. Repository design will be such that moisture in the excavation will be kept to a minimum.

GEOLOGIC CONSIDERATIONS

Issue

Several commenters stated that the final Statement should address the interrelationship between deep and shallow ground-water aquifers and surface water systems and the potential for transport of nuclides between these systems. (43, 97)

Response

The relationship between subsurface aquifers and surface waters will become an issue when a proposed site is under investigation for site qualifications. The ground-water/surface water conditions and the associated physical parameters are likely to be different for each site and specific to each site. The potential for transport between the surface and ground water systems does exist, but the investigations and site qualification would look specifically at questions of this type. The particular set of physical conditions that will determine how effectively the water systems are isolated from each other will need to be investigated for each site and an assessment of transport potential made at that time. See Section 5.1 for a related discussion.

Issue

The Statement should address the unique geophysical characteristics of nuclear-overstressed caverns. (115)

Response

The Statement is directed specifically toward geologic disposal in openings formed by conventional mining and/or drilling methods. Nuclear-overstressed deep caverns are not considered for this reason.

Issue

"The heat from nuclear wastes will induce stress in the hot rock" and the significance of these stresses is uncertain as is the temperature effect on the rock properties. (98)

Response

The study of the thermomechanical behavior of rock is included in the NWTS program. This program includes laboratory experiments, field observations, and analytical and numerical solutions.

Laboratory experiments are proceeding at such institutions as University of Minnesota, Texas A&M, and University of California. Field testing of the thermomechanical behavior of rock is being conducted in Sweden (Stripa granite); at the Nevada Test Site (Climax quartz monzonite); in Kansas (Project Salt Vault); at Avery Island in Louisiana; and in Washington (basalt). It is expected that this integrated program will provide the necessary understanding of heat-induced stresses in rock, and of the thermomechanical response of the rock.

GEOLOGIC CONSIDERATIONS

Issue

Radiolysis will cause hydrogen and oxygen to form in a bedrock cavern, thus creating a potentially explosive atmosphere. Should an explosion occur inside the cavern, the consequences are really unknown. It will place stress on the cavern and the aquifer and increase the chances of water movement, thus increasing the potential for additional contamination of the aquifer. The authors fail to address such possibilities. (97)

Response

The consequences of an explosion were not addressed because the probability of one occurring after emplacement of waste is considered to be infinitesimally small. The explosive range for hydrogen in air is 4.1 to 74.2 volume percent. Mixtures in this range will ignite and burn if the temperature is above the ignition point, 1085°F (585°C) (Perry 1950). Temperatures will never be this high. Below this temperature, a spark could cause an explosion in mixtures in the explosive range. This will never be achieved in an open storage room (e.g., in salt; 5.5 m x 6.7 m x 1070 = 39,400 m^3), because a production of 1615 m^3 (0.041 x 39,400) of H_2 would be required. Production of this much hydrogen would require the complete radiolysis of 1300 liters of water with no recombination or the total corrosion of 3,000 kg of iron by an aqueous corroding medium.

Preliminary estimates of the quantities expected by radiolysis of brine (or water) in the backfill surrounding waste packages were performed by Jenks (Jenks 1980). His work indicates that such accumulations will not approached by even an order of magnitude. Jenks (Jenks 1979) also made estimates of corrosion accelerated by radiolysis which also indicates that adding hydrogen produced by aqueous corrosion will still not cause the quantity to approach that needed for the explosive range.

The explosive range could possibly occur in voidage in the backfill surrounding the waste package. Sparks are not likely in this location. In any case, the reaction could not be propagated through the backfill because the baffling effect of the backfill particles.

Issue

Additional geologic background information should be provided in the Statement, and the discussion of tectonic effects should be expanded. (10)

Response

This Statement is generic in nature, and the geologic history of formations (salt, basalt, granite, shale) and plate tectonics are discussed in general terms. Detailed discussions would be more appropriate and will be included in future site-specific EISs.

GEOLOGIC CONSIDERATIONS

Issue

It will take at least fifty years to really assess the effects on a geologic medium, further expansion of a site already in operation would be just asking for trouble. (164, 187)

Response

Design of a repository will include the best available information from laboratory studies, field observations, and analytical and numerical solutions. After construction of a repository begins, it will be monitored to obtain information on its behavior with time.

Issue

The plugging and sealing of shafts, tunnels, and boreholes should be discussed more extensively. (219)

Response

The subjects of plugging and sealing shafts, tunnels, and boreholes are discussed in detail in an Office of Nuclear Waste Isolation (ONWI) document (ONWI 1979).

Issue

It was pointed out that programs on the radiation effects of other minerals (than rock salt) should be initiated and/or expanded. (25)

Response

The effects of irradiation on inorganic materials, including many minerals, have been known for many years and are generally small, particulary with respect to mechanical properties. Although the effects on candidate host rocks are expected to be of only secondary concern, a program to investigate such effects has been underway for several years. Initial emphasis was on rock salt but other materials are included, e.g., granite and basalt. As considerable data has been accumulated on rock salt, the program emphasis is now shifting to the latter materials. Also, work involving candidate waste forms, canister materials, etc., and a variety of ground waters in the presence of radiation has been underway for some time. The effects of radiation are considered in screening candidate materials. Since interactions among materials in the presence of radiation is strongly dependent on waste package design, choice of materials, and the nature of the host rock, these tests will increase as site specific package designs become better defined.

Documents addressing radioactive waste-induced effects include:

- ERDA 76-43, Alternatives for Managing Wastes from Reactors and Post Fission Operations in the LWR Fuel Cycle, 1976.

GEOLOGIC CONSIDERATIONS

- Brandshaw, R. L., and McClain, W. C., Editors, Project Salt Vault: A Demonstration of the Disposal of High Activity Solidified Wastes in Underground Salt Mines, ORNL-4555, Oak Ridge National Laboratory, Oak Ridge, TN, April 1971.
- DOE/NE-0007, DOE Position Paper to the NRC Rulemaking on Nuclear Waste Storage and Disposal, April 1980.

Issue

It was suggested that the effect of radiation on the four repository media (salt, basalt, granite, shale) should be discussed. (25)

Response

Data on the subject of radiation effects on media is very limited. There is some information for salt, but almost nothing for granite, basalt, and shale. The effects of radiation on potential geologic host media have generally been considered to be of secondary importance (DOE 1980a). Information from comment letter #25 (Levy, Brookhaven National Laboratory) has been integrated into Section 5.2.

Issue

One commenter noted that the Statement should contain more discussion of (or information on) the geology and exploration effort required to support conventionally mined geologic disposal. (12)

Response

From a generic standpoint for the Statement, candidate regions for the four rock type disposal media were selected based on rock properties, known occurrence, and suitability for conventional mining techniques. This was done primarily from available literature and no further breakdown to smaller areas was made. The description of a site selection and qualification process is given for the time if and/or when a medium is selected and further investigations are begun. From this time on geologic exploration and data gathering become increasingly important at each progressive level until a site is accepted or rejected.

The DOE Position Paper to the NRC rulemaking proceedings on nuclear waste storage and disposal (DOE 1980a) presents the status of the on going geologic exploration programs and discusses in depth the site exploration, characterization, and selection process.

Issue

The underground firing of nuclear explosives results in the formation of vitrified debris, because of the solidification of molten and vaporized rock. Thousands of tons of such vitrified debris have been in place for periods of up to 25 years, mostly in tuff at

the Nevada Test Site, but also in granite, shale (Gas Buggy), and salt. This experience bears directly upon the proposed long-term storage of vitrified high level waste, and should be discussed. (208-NRC)

Response

A discussion regarding the investigation of underground nuclear tests relative to the migration of radionuclides can be found in a separate report (Ramspott 1978).

Y/OWI/TM 36/21

Issue

This document addresses only three host rock media - granite, basalt and shale. No basis for the apparent conclusion that groundwater movement in salt is negligible has been presented in either GEIS or in TM-36. Note also that the permeabilities of granite and basalt presented in the GEIS (Table 3.1.1, p. 3.1.9) are nil and therefore the repositories in granite and basalt could presumably be located at depths significantly less than salt and shale. (208-NRC)

Response

Appendix B of the final Statement (and draft Section 3.1.1) point out that existence of salt formations that are estimated to be hundreds of millions of years old testifies to their stability and their isolation from water. The statement regarding permeabilities of granite and basalt being nil has been modified (see final Appendix B).

MULTIBARRIERS FOR DISPOSAL

Draft p. 1.5

Issue

One commenter suggested that the discussion of multiple barriers should include the barrier-like effect of liquid transport that result in dilution and dispersal, even though these processes are technically not barriers. (208-NRC)

Response

Dilution and dispersal imply fluid flow into or through the repository. The multiple barriers are meant to reduce or prevent fluid flow and/or transport of waste. It would seem paradoxical to assume benefits from the processes the barriers are intended to prevent.

Draft p. 1.15

Issue

Since some bentonites lose water above 100°C, perhaps illite which does not lose water above 100°C should be added as a potential overpack material for canisters. (113-EPA)

Response

The statement, "Absorptive overpack materials such as zeolites and bentonites..." is illustrative of types of materials considered and available for canister overpacks. The examples given are not recommended as the final or only ones.

The statement was modified to read "... bentonites/illite..."

Draft p. 3.1.1

Issue

Multiple barriers are listed as one of six characteristic for geologic disposal when, in fact, three of the other five characteristics are themselves important barriers to nuclide transport. (218-DOI)

Response

The six items listed are characteristics of a mined geologic disposal system. Item 6 was identified in order to emphasize the desirability of the combined (redundant) effects of the individual barriers.

MULTIBARRIERS FOR DISPOSAL

Draft p. 3.1.6

Issue

One commenter stated that multiple barriers should not "act together" but independently, so that if some fail the others compensate. (218-DOI)

Response

Multiple barriers are intended to act independently to prevent waste migration and enhance isolation. The wording in the final Statement was changed to reflect this (see Section B.6 of the final Statement.).

Draft p. 3.1.15

Issue

Concerning the proposed Swedish Containers, no appraisal is made as to whether this is felt to be a good design and an advancement on the state of the art. If it is, it should be so stated. If not, it is not clear why it is mentioned. (34)

Response

Section 5.1.2.3 of the final Statement presents a discussion of the Sweidish approach to waste package design. This section notes that the Swedish work did a great deal to promote acceptance of the multibarrier waste package and that although the Swedish design may be somewhat more complex than others presently being studied, the Swedish designs have increased understanding of long term package performance.

Draft p. 1.15

Issue

The proposed Swedish canister is not "highly" sophisticated; it is a simple copper can with lead fill. The engineered sorption barriers are not part of the canister but part of the backfill buffer around the canisters. In the last reference it is not clear what "redox materials" are. (218-DOI)

Response

As noted above, final Section 5.1.2.3 presents a revised discussion of the Swedish approach to waste package design. The final Statement uses the terms waste package or waste package system when discussing the waste canister and the overpack material (See Section 5.1.2). Redox materials are materials that could influence the oxidation-reduction potential of the repository system.

MULTIBARRIERS FOR DISPOSAL

Draft p. 3.1.17

Issue

Several uncertainties exist in the projected behavior of the system, such as the philosophy for radionuclide containment, waste form, the host rock, etc. Suggest a discussion as to how these uncertainties can be overcome. (113-EPA)

Response

The multiple barrier or multi-barrier discussion has been expanded (see Appendix 5.1.2) from what is in the draft and will add justification for the "defense-in-depth" philosophy quoted on p. 3.1.17 of the draft. The sections "Status of Technical Development and R&D Needs" discuss the uncertainties for each disposal concept and current efforts being made to resolve them.

Draft p. 3.1.39

Issue

One commenter stated that item 3 under Performance Criteria appears to be a listing of conditions requiring consideration rather than criteria. (58)

Response

The intent was to list conditions requiring criteria to be developed; they in themselves are not criteria.

Draft p. 3.1.40

Issue

Does the waste package design refer to the container alone, the container plus waste or the entire system? (113-EPA)

Response

For mined geologic disposal (including drilling) the waste package is described as the waste (form and material), any material between the waste and canister wall, the canister, and any overpack material around the canister or between the canister and the host rock.

MULTIBARRIERS FOR DISPOSAL

Draft p. 3.1.40

Issue

It is recommended that the bulleted items "Licensing" and "Cost/Benefit Issue" be removed, since those issues do not pertain to the technical feasibility of waste packaging. (124)

Response

DOE agrees. This has been done.

Draft p. 3.1.48

Issue

Anisotrophies in the rock body are identified (bedding, etc.). This is contradictory with the avowed goal of a homogeneous host rock. Anisotropies, whether in horizontal or inclined units are anisotropies. Even in horizontal units, lateral anisotropies are common. Horizontal bodies may have greater roof problems that an equivalent weakness along the footwall of the repository. (43)

Response

It is true that isotropy in some property(ies) is common in rock units, particularly in bedded or laminated units, but this is not contradictory to homogeneity of the same unit. Many sedimentary rocks are homogeneous and isotropic with respect to some propert a unit is homogeneous if the property(ies), isotropic or anisotropic conditions are constant over the unit. (See Davis and DeWiest 1967.)

Draft p. 3.1.54

Issue

Waste packaging can be important for the first 1000 years. Paradoxically, after that it would be better to allow the waste to move through the nearby host rock, thus reducing the concentration and increasing the isolation. (154)

Response

Some migration analyses have been made on which it was assumed all of the waste dissolved at 1000 years. Isolation is not increased. Depending on the assumptions made concerning flow rate of water, path length to the biosphere and the types of geological formations that the water passes through different amounts of radioactivity ultimately reach the biosphere.

MULTIBARRIERS FOR DISPOSAL

Draft p. 3.1.54-62

Issue

One commenter stated that since glass is already an adequate waste form, there does not seem to be any need to emphasize the need for "additional experimentation." The commenter also stated that it is unfortunate that calcine, which has more real operating experience behind it than any other waste form, is given scant praise. (154)

Response

It has not yet been established that glass is a fully acceptable waste form. For example, proposed NRC performance criteria, 10 CFR 60, E, (published 5/13/80) would require reasonable assurance that radionuclides be contained for at least 1000 years. Research is required to provide this assurance. Other experimentation is that normally associated with taking a process from a pilot plant status and scaling it up to a full-scale operating plant.

Concerning calcine, the operating experience has been with wastes that are generally over a factor of 100 less radioactive than commercial HLW and that have a quite different chemical composition. Granular calcine may be a satisfactory defense waste form for the long-term but it would probably have to be consolidated by incorporation in a matrix or by pressing and sintering before it would be a suitable HLW form. These latter processes have been studied to a limited extent and are discussed in Section 4.3 of the final Statement.

Draft p. 3.1.55

Issue

The leach rates of spent fuel in typical groundwaters at temperatures to be expected in spent fuel repositories are more important than leach rates of spent fuel in room temperature deionized water. (113-EPA)

Response

The comment is correct and such leach rates are being obtained in the ONWI-sponsored Waste Rock Interactions Technology program at Battelle-Northwest Laboratories. However, leach rates obtained in room temperature deionized water are not irrelevant. They furnish a good initial reference point for comparison, and experience has shown that they do not differ from groundwater by more than a factor of ten at the same temperature.

MULTIBARRIERS FOR DISPOSAL

Draft p. 3.1.55

Issue

The correlation between leaching of Zircaloy-clad fuel elements and referenced leach rates of unclad UO_2 pellets is very misleading. Explain why no credit is given to containers. (181)

Response

When full safety analyses are made, credit is usually given to the container by assuming that a certain time period elapses before the onset of leaching. The time period varies depending upon the scenario being studied. But, to be conservative, when leaching begins it is assumed that the cladding has "disappeared", i.e., no credit is taken for the protection provided by residual intact portions of cladding.

Draft p. 3.1.56

Issue

There is a discussion of the behavior of glass in hydrothermal environments which appears to ignore the potential for simply eliminating the problem by reduced waste loadings rather than extensive research studies. (198)

Response

Repository and waste package designs will be technically conservative to the extent that hydrothermal conditions will not occur under normal, anticipated repository conditions. Studies are underway to define abnormal scenarios that could lead to hydrothermal conditions if indeed they are possible. If so, the potential risk must be assessed and evaluated relative to trade-offs such as reduced waste loadings, improved waste form development, further aging of the waste prior to disposal, etc. The resultant decision must consider the impact on the total waste management system.

Draft, p. 3.1.56

Issue

Has the Eh-pH dependency of the waste form been investigated? The waste itself, having muliple oxidation states, will have different solubilities with differing Eh-pH. Can we adequately characterize the Eh-pH of groundwater after they have reacted to some extent with well rocks? We are not talking of a hypothetical distilled water interaction. Appendix I does not seem to consider water quality. (43)

MULTIBARRIERS FOR DISPOSAL

Response

The properties of the waste form, both physical and chemical, are being carefully considered so that the waste form selected will be best suited for the respective disposal environment. The Eh-pH of groundwater can be measured with sufficient accuracy to permit modeling the interaction between groundwater and waste form following disposal in a geologic repository.

Due to the site-specific nature of groundwater chemistry, it was not felt appropriate to have a detailed discussion of groundwater chemistry in this Statement. Such discussion and analysis will be provided in any future site-specific analysis.

Draft p. 3.1.59

Issue

It seems impossible to maintain canister integrity for a significant time period because disruption during gas, oil or mineral exploration may destroy the canister. (113-EPA)

Response

This comment discounts probability. There is a low probability that exploration will even occur since the repositories will be located in areas selected as having negligible commerical mineral value. (Salt repositories are an exception but salt is so widespread and abundant there remains a low probability a given site will be selected for commercial exploitation.) Even if drilling intrudes a repository, there is a low probability that a canister will be affected because only a small amount (<0.001) of the cross-sectional area is occupied by canisters.

Draft p. 3.1.59-62

Issue

Several commenters suggested various packing materials (zeolite, bentonite) be considered. (17, 154) Others questioned the effectiveness (sorptive qualities) of overpack at elevated temperatures (43,97).

Response

The final Statement contains a discussion of many different kinds of engineered barriers that are being considered (see Section 5.1.2).

It is agreed that additional R&D must be performed on absorptive barrier materials. Retardation of radionuclides should be a goal but the materials selected should be optimum for all possible events and scenarios which initiate radionuclide migration.

MULTIBARRIERS FOR DISPOSAL

Draft p. 3.1.61

Issue

One commenter stated that the stainless steel/lead/titanium composite canister is undoubtedly very expensive. Titanium is not exactly plentiful either. Mass production of these canisters may become prohibitive. (35)

Response

Using the canister description on p. 3.1.61 of the draft Statement, the cost of a steel/lead/titanium canister was estimated as follows:

lead requirement per canister	1,800 kg @ $1.10/kg	$ 2,000
fabricated titanium shell	108 kg @ $28/kg	$ 3,000
fabricated 30 cm dia. stainless steel canister		$ 5,000
total material cost		$10,000
additional fabrication and other costs		$ 5,000
TOTAL		$15,000 or $ 5/kg HM

The total cost of $5/kg HM for such packaging agrees well with EPA estimates of 4-6 $/kg HM. (EPA 1977).

The incremental cost over that stated in the document is about $3/kg HM in a total waste management cost of approximately $160/kg HM or about two percent. Thus, use of such canisters does not appear to be prohibitive from an economic standpoint.

In a 250 GWe system, approximately 80,000 canisters of high level waste would be generated. This would require a total of 8,600 MT of titanium metal or less than half of one years average annual production for the period 1968-72 (DOI 1972). Availability, therefore, also does not appear to be a limiting factor.

Draft p. 3.1.62

Issue

The statement is made that, "There apparently has been no information published on the corrosion resistance of the glass ceramic material under repository -- simulating test conditions." However, it is also stated (Table, p. 3.1.60) that glass ceramic canisters have an estimated life beyond 5,000 years. (9, 36)

Response

The statement is in reference to the Swedish program. The table was removed.

MULTIBARRIERS FOR DISPOSAL

Draft p. 3.1.62

Issue

Discussion of the Swedish waste disposal study does not acknowledge the negative comments made by the California State Energy Commission, the U.S Geological Survey and the Jet Propulsion Laboratory in their review of the KBS Safety Analysis. (55).

Response

Comments were sought from experts in many countries before the Swedish government accepted the feasibility of the KBS waste management concept. It was recognized that there will always be uncertainties in predicting long-range future behavior of materials and geological formations, but it was the concensus of the experts that the KBS concept reduced the uncertainties to such a low level that the viability of the proposed waste disposal system was assured with satisfactory confidence.

Draft p. 3.1.62

Issue

The likelihood that oxygen will be introduced into the repository when it is constructed and therefore be available to the groundwater should be considered in evaluating canisters and the mobility of some nuclides. (113-EPA)

Response

The technical data used in evaluating canister corrosion and nuclide mobility has almost all been obtained with oxygen (air) present, thus the introduction of oxygen in the repository is being considered. Experimentally, the bigger problem is to eliminate oxygen in order to study the conditions expected after a repository has been sealed for hundreds of years.

Draft p. J.6

Issue

Figure J.1 should be explained. Its applicability is unclear. (113-EPA)

Response

This figure does not appear in the final Statement.

MULTIBARRIERS FOR DISPOSAL

Draft Appendix L

Issue

In Appendix L (the draft statement) the statement that devitrified glass is stronger than ordinary glass and will resist further fracturing is not as important as the potential greater leaching from devitrified glass. (113-EPA)

Response

DOE believes the relative importance of these two factors depends on the circumstances being considered. For instance, the importance of fracturing behavior probably predominates in a transportation accident while leaching behavior will be more important after emplacement in the repository. The essential information that appeared in Appendix L of the draft Statement has been incorporated into Chapter 4 of the final Statement. Additional details can be found in DOE/ET-0028.

Draft Appendix P

Issue

Ringwood and co-workers have identified a suite of minerals for use in waste disposal. Their work should be referenced and seriously considered. (113-EPA)

Response

Ringwood's work is referred to in final Section 4.3.2.

Draft Appendix O

Issue

This is a rather interesting appendix although the development of the field does not appear to be sufficiently advanced for any convincing environmental impact analysis. There seems to be a contradiction between Tables 0.4 and 0.5. In Table 0.4 a 1 meter barrier is reported to retain strontium-90 and cesium-137 for about 30 years, or about one-half life for these nuclides. In Table 0.5 a 1 meter barrier is said to retain them for 30 half lives.

The possible competition for ion exchange sites on added minerals (or natural minerals for that matter) should be noted. Canister materials are elements of the transition series, notably iron, nickel, chromium, or titanium. In Sweden, lead and copper have been suggested for canisters. The ion exchange capacity of any added materials must be enough to handle the nonradioelements as well as the radioelements. (113-EPA)

MULTIBARRIERS FOR DISPOSAL

Response

This appendix has been deleted from the final Statement.

Issue

Several commenters stated that a more thorough treatment of the possible contribution of natural and engineered barriers should be provided in the final Statement together with a summary description of the related R&D program(s). (43, 58, 97, 114, 124, 154, 219)

Response

DOE agrees that the concept of multiple barriers and their use in future repository systems was incompletely described in the draft. Further discussion of multiple barriers and the associated R&D efforts may be found in Sections 5.1 and 5.2 of Volume 1, respectively.

Issue

Several commenters noted that the Statement should make clear whether or not glass is an acceptable high-level waste form for the initial repository. (58, 124)

Response

The acceptability of a particular waste form will depend upon the specifics of the final system design and repository medium. A discussion of the properties of glass as well as other possible waste forms is contained in final Section 4.3.

Issue

Several commenters questioned the effectiveness of engineered barriers and/or whether these barriers would be of significance over the long term. (6, 43, 113-EPA, 141, 142, 214)

Response

A systems (or multibarrier) approach to the design of waste repository assumes that the fate of radionuclides will be determined by geologic environment, the properties of the host medium, the waste form chosen, and any other engineered barriers utilized. In selecting these design components, the objective will be to prevent release of radionuclides to the biosphere by providing redundant as well as independent barriers. DOE recognizes that the engineered components of the multibarrier system would be of greatest importance in the short term and that the repository medium and the surrounding geology would be the critical elements over long periods of time. It is envisioned that the waste container will be designed to remain intact for about 1,000 years. The recent DOE Position Paper to the NRC Rulemaking proceedings on nuclear waste storage and disposal (DOE 1980a) notes that" Waste

containment within the immediate vicinity of initial placement should be virtually complete during the period when radiation and thermal output are dominated by fission product decay."

Issue

One commenter noted that a single, standard canister design capable of being used in all media may be advantageous in regards to health, safety and cost. (97)

Response

DOE (and in turn the general public) might enjoy some cost advantages if a single standard canister design were to be used in all repository media. However, DOE believes that the development of the system components (i.e., canister, overpack) will be dictated by site-specific parameters and, therefore, these components will probably differ across repository media and from site to site.

Issue

Data are available on existing and proposed low release solid forms. These data should be presented and their significance analyzed. (219)

Response

Section 4.3.2 of the final Statement discusses a variety of potential waste form alternatives.

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

Draft pp. iv and 1.13

Issues

It is all right to spell out the technical requirements to be met in siting of repositories, but should it not be mentioned that the major impasse in site selection will be the gaining of acceptance of the population surrounding the proposed site(s)?

Sociopolitical factors should be approached in Stage I in the selection of regions. It seems more logical to gain regional acceptance before tying into the local acceptance issue. (181)

Response

Appendix B of the final Statement notes that the nontechnical concerns will be evaluated throughout the entire site-selection process. Also see final Section 2.3.

Draft pp. 1.6 and 1.15

Issue

One letter suggested that institutional controls would increase isolation of waste but not containment. (154)

Response

It is believed that the effect of such control is apparent, however, as noted below, minimal reliance will be placed on long-term institutions.

Draft pp. 1.6, 1.15, 3.1.62-64

Issue

One commenter stated that institutions of man would provide adequate repository markers to prevent inadvertant human intrusion. (17) Other commenters felt that waste management programs could not and/or should not rely on long-term transfer of information, and such mechanisms would not prevent human actions over the long term. (41, 43, 62, 113-EPA, 171, 186, 213, 216, 218-DOI)

Response

While this Statement concluded that there are apparently no reasons in principle why human surveillance could not survive for hundreds of years, it is also concluded that waste management systems adopted in the present should place minimal reliance on any human institutional management after repository closure (see final Section 3.5).

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

Draft p. 1.6

Issue

One commenter suggested that the discussion of the relative permanence of human institutions was not illuminating and could best be removed. (40)

Response

DOE disagrees and would note that the purpose of the discussion of human institutions (as well as other non-technical issues relating to waste management) admittedly was to air such issues. Such issues will, however, have to be resolved in any on-going program.

Draft pp. 1.6, 21, 22

Issue

Several commenters questioned whether repository markers would last for millenia in view of the possiblity of vandalism, acts of war, natural processes. (55, 154, 208-NRC, 218-DOI)

Response

Such considerations would have to be included when designing markers. For non-salt repositories, rock remaining at the surface could be a starting point for a monument.

Draft p. 1.13

Issue

Several commenters requested that the criteria be identified which would be used for site screening based on socioeconomic and sociopolitical factors. (43, 208-NRC)

Response

DOE has adopted a set of siting criteria (ONWI 1980) concerned with human population density as well as socioeconomic and political factors.

Draft p. 1.15

Issue

One commenter stated that it is unacceptable to refer to historical examples which suggest that society can maintain certain systems over centuries and not to give examples. (40)

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

Response

Appropriate references have been included in the final Statement (see Section 3.5)

Draft pp. 1.15, 3.1.62-64

Issue

The section entitled Human Institutions calls attention to the merit of setting up such institutions in the long-term control of nuclear wastes. It would be helpful to address whose responsibility it would be to establish and maintain such institutions. (208-NRC)

Response

Institutional arrangement for regulation and control of the nuclear waste are the responsibility of the Federal legislature. At present the EPA and NRC have standards setting and regulating jurisdiction while the DOE has ownership control.

Draft p. 3.1.25

Issue

One commenter felt that the discussion of land use and transportation considerations does not adequately assess transportation demands. (43)

Response

The discussion on p. 3.1.25 of the draft Statement was intended to be only a general discussion of site selection criteria for a geologic repository. For a more complete discussion of transportation demands, see Section 4.5 of this final Statement.

Draft p. 3.1.25

Issue

Land use and transportation considerations are of concern only in the short term. (113-EPA)

Response

Compared to the lifetime of the repository, this material does apply to the near-term time period. However, these factors (land use and transportation) do need to be considered in the site selection process. They would enter into the acceptance or rejection of a site and are included for this reason.

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

Draft p. 3.1.25

Issue

The discussion in the section entitled Land Use and Transportation Considerations focused on some possible land use conflicts and refers the reader to a body of literature, some of which is described as speculative. It would be useful for the GEIS to summarize this information and to present it for review. (208-NRC)

Response

The question as asked is not understood. This particular section did not refer to a body of literature.

Draft p. 3.1.43

Issue

In the case of enforcement against private organizations, criminal penalties could be imposed. (208-NRC)

Response

Regulatory agencies usually do not have power to impose criminal penalties. Violations of the criminal code, however, can be handled through usual criminal justice procedures.

Draft p. 3.1.43

Issue

The following is a suggested additional paragraph under "Regulatory Tasks":

Monitoring. In view of the questions raised in technical and performance areas of geologic repositories, appropriate instrumental monitoring should be undertaken for a reviewing agency. The data should be directly received by the agency, copies should be distributed for analysis to technical groups within the agency or to contractors, and the agency should store the data for retrieval as required. Continuous, as well as periodic, analysis programs should be established by the agency. (154)

Response

Such a detailed monitoring plan is considered to be covered by the general functions of standard-setting and licensing (setting monitoring requirements) as well as inspection (receiving reports). Any specific approach such as this is beyond the scope of this document.

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

Draft p. 3.1.44

Issue

One commenter noted that in the second paragraph, the lack of direct benefits (from waste material) to future generations is discussed but the possibility of indirect benefits is relegated to a footnote. A balanced consideration of long-term risks and benefits must consider both. (58)

Response

This correction has been made in preparing the final Statement (see Section 3.5)

Draft p. 3.1.64

Issue

The first century after closure of the repository would be critical for "hands on" corrective action only if the monitoring program established some deficiency in the repository. Although the radioactivity of the repository has been reduced substantially after 700 years, the threat is by no means negligible. (113-EPA)

Response

The wording of this paragraph has been revised to better convey the intended meaning.

Draft p. 3.1.74

Issue

One commenter felt that the paragraph on "Candor" was an outrage. The large number of technical articles on waste disposal is not relevant. (40)

Response

The last sentence in the paragraph in question--"Some take this as evidence while others see the flood of articles as an attempt to confuse the layman and increase reliance on the technical expert." is a non-biased statement. It admits that the amount of published information on nuclear power may not be (in every instance) sufficient evidence of "Candor."

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

Draft p. 3.1.75

Issue

One commenter felt that the discussion of uncertainty should address the point that the magnitude of uncertainties alone can not determine whether one can proceed with any technological program. (40)

Response

This particular paragraph is under a discussion of "Non-technical Issues" and simply states some of the anomolies of the perception of many people towards uncertainty. There is no inference and certainly no statement in that paragraph which argues that because uncertainties are low one can proceed.

Draft p. 3.1.126-132, 3.1.179-181, 3.1.184-186, 3.1.193-195, 3.1.200

Issue

GEIS is characterized as generic and not site specific (page 3.1.98). The document further states that the ability to identify socioeconomic impacts increases as one proceeds from a generic to a site-specific situation. However, a model was employed which provided and compared very specific social service demands anticipated for each of the reference sites. It is unclear why the analysis, which used actual site specific population, employment, education and housing information to estimate service demands, did not relate the demands to existing capacities to indicate net impacts.

The reference sites are compared and the comparison reveals a range of different conditions and anticipated social service demands. Are these reference sites being presented as being representative of sites to be found in the Southeast, Southwest and Midwest areas of the country? How much variability can one expect to find among sites within the geographical boundaries of each of the above areas (Southeast, Southwest and Midwest)? If large differences are expected within each of the geographical areas, to what use is the reviewer to put comparative information presented in GEIS?

While a considerable amount of useful information is presented in terms of manpower needs and expected social service demands for the three reference sites, the demands are not related to the infrastructure capacities of the expected impacted communities to ascertain net impacts. The subjects of compensation, payments in lieu of taxes, and mitigation in general, need considerably more development. (208-NRC)

Response

Population distributions chosen for analysis are reasonably representative of the range of distributions likely for siting repositories and are not representative of

specific areas per se. Large, qualitative variation of mechanisms to handle social service demands within each type of distribution would make such analysis unrepresentative and possibly misleading. Analyses suggested by this comment are meaningful when actual (not hypothetical) sites are considered in a specific EIS.

Draft p. 3.1.129

Issue

Social service demands (Table 3.1.21) were derived by applying factors "to the project in-migration values" (Table 3.1.19). Therefore, the level of forecasted social service demands by individual site should be proportional to the estimated level of project in-migrants for each site. From Table 3.1.19, under the maximum impact condition the respective estimates for the number of project in-migrants for 1985 indicate the lowest value for the Midwest site (5800), followed by the Southeast Site (8600) and the Southwest site (15,000). However, in draft Table 3.1.21, also under the maximum impact condition, some of the social services--physicans and dentists, and hospital and nursing care beds--indicate values for 1985 which reverse the relative position of the Midwest and Southeast sites. This apparent error occurs in similar tables throughout the DEIS. (113-EPA)

Response

Some social service demand factors are not constant across sites, since they are based upon observed levels of social service provision, usually for the state containing the site. For example, the expected demand for physicians per 1,000 people is 0.86 at the Southeast site and 1.33 at the Midwest site. This is based upon the number of active non-Federal physicians providing patient care in those areas in 1973. Each of the factors listed under the Health category are larger for the Midwest site than either of the other two sites because of the metropolitan character of the state containing this site. All other factors are the same for each site, except for the crime index which is also based on state-level data. In addition, demand for nursing care beds is based on that component of the in-migrant population aged 65 and over and is therefore subject to variation in population age composition as well as population size. Thus, whenever the in-migrant population of the Southeast Site exceeds the in-migrant population of the Midwest site by a small amount, health services likely to be required by the Midwest in-migrants may exceed those required by the Southeast in-migrants for the same time period.

Draft p. 3.1.129

Issue

The following statement appears to be incorrect in light of the information presented in the accompanying tables:

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

"Although the numbers of in-migrants are smaller, the potential for impacts in the Southeast maximum impact condition is quite similar to the potential in the Southwest site under maximum conditions. This is the case because the base population in the Southeast is roughly twice that in the Southwest site; therefore, the Southeast is capable of adsorbing greater population influx, other things being equal."

It appears that the words "Southeast" and "Southwest" should be reversed, since if the number of in-migrants for site A is half the number of site B, and the number of in-migrants stated as a percent of each site's base population is the same for each site, then the base population of site B must be twice the base population of site A.

The identical statement is repeated in other portions of the GEIS (pp. 3.1.120 and 3.1.194) in referring to other estimates of the numbers of in-migrants associated with different types of waste management facilities. (113-EPA)

Response

The words "Southeast" and "Southwest" have been inadvertently reversed. The referenced statement on pages 3.1.129, 3.1.180, and 3.1.194 of the draft (Section 5.4 of final) should be read as follows:

"Although the numbers of in-migrants are smaller, the potential for impacts in the Southeast maximum impact condition is quite similar to the potential in the Southwest site under maximum conditions. This is the case because the base population in the Southwest site is roughly twice that in the Southeast site; therefore, the Southwest is capable of absorbing greater population influx, other things being equal."

Because the Southwest regional population base is considerably smaller than at the other two sites, in-migration tends to be high under both expected and maximum impact conditions. The reason that in-migration is proportionately greater for the Southeast and Midwest sites between expected and maximum conditions is due largely to a greater increase in secondary employment multipliers for these two sites, and the assumption that fewer jobs will be filled by regional unemployement, thereby reducing the effect of large differences in regional population size. The corrected wording of the above paragraph should not diminish the conclusion that the Southwest site is most likely to experience the largest socioeconomic impacts as defined in this analysis.

Issue

Several commenters noted that the Statement should expand on the discussion of non-technical (or sociopolitical) issues in the site selection process.

Non-technical issues will dominate the site selection process by being the initial barrier which much be overcome before furter investigation is possible. Therefore, more detailed discussion of these various issues may be warranted to delineate all the possible options which are available to overcome these potential barriers. (7)

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

Expand the analysis of the "sociopolitical" factors which will determine access to any technically feasible site. (18)

Specify a firm mechanism for state and local participation pior to detailed site investigations in Stage III of the proposed site selection process. (43)

Response

The non-technical issues that are relevant to the site selection process have been presented in final Section 2.3 and Appendix B. Further discussion of non-technical issues along the lines suggested is not considered appropriate for a generic impact statement because such considerations will be highly site-specific and cannot be detailed at this time.

Issue

Several commenters pointed out that the draft statement did not sufficiently address institutional issues relating to waste management. (35, 38, 154, 198)

Response

As a result of the revised structure (outline) for Volume 1, information relevant to nontechnical issues that did appear in several places of Section 3.1 of the draft was drawn together and presented in a single section (final Section 3.5). The function of this discussion is to air non-technical issues relating to nuclear waste management. In addition, the section on Technology Comparisons (final Section 6.2) uses Domestic Political Considerations and conformance with Federal Law International Agreements as two of the factors on which the disposal options are examined and evaluated.

Issue

One commenter stated that the draft Statement did not adequately address the uncertainties and risks with regard to future institutions and how this relates to the likelihood of securing a repository from man-caused events. (114)

Response

This Statement does address the issue of human institutions in long-term waste management. It notes that there is debate over the roles human institutions may have on long-term management of nuclear wastes including the following:

1. The functions that can or should be performed.
2. The subjective need for these institutions.
3. The likelihood the functions will be performed at any point in time.

A supporting document (Hebert et al. 1978) outlines in more detail non-technical issues in nuclear waste management and serves as the basis for the discussion in Section 3.5.

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

In addition, final Section 5.5 analyzes two man-induced repository breach scenarios (repository breach by drilling and, in the case of salt, solution mining). The consequences of these events are presented; however, no attempt is made to integrate the probability of occurrence into the presentation.

Issue

A question was raised as to how the issue of future institutions is to be considered in the overall decision-making process. (114)

Response

Upon implementing a specific disposal strategy, the area of institutional control of repositories will be further investigated.

Issue

One commenter stated that the future economic and employment impacts of commercial nuclear waste management should be considered. (15)

Response

These factors were considered in the analysis for entire waste management systems (see Sections 4.7 and 5.4 and Chapter 7.0).

Issue

Analysis of both the microeconomic and macroeconomic impacts should be performed. Within the micro framework, the direct impacts on the customer's electric rates and fuel bills should be investigated. Macroeconomic considerations should include the degree of secondary impacts stemming from a rate increase to commercial and industrial electric users which can influence the cost of producing other goods and services in the economy. The economic impacts of the cost of waste management also need to be discussed on a regional basis since they depend on each area's relative reliance on nuclear-generated electricity. (113-EPA)

Response

The economic impact for the consumer has been addresed at least to the extent of determining the mils/kW-hr that would no doubt be added to the rate payer's charge because of waste management activities. Going beyond that point in this generic Statement was not believed to be warranted.

SOCIOECONOMIC/SOCIOPOLITICAL ISSUES

Issue

One commenter suggested that the Statement should emphasize the importance to the economy of proceeding with geologic disposal. (20)

Response

As noted above, economical employment impacts directly attributable to waste management activities were investigated. Other macroeconomic concerns (as perhaps suggested by the commenter) were not examined.

Issue

DOE's treatment of "socioeconomic impacts" seems designed to give more weight to plans for placing radioactive waste repositories in already populated areas where there would be a large employee population force in place. This is a specious consideration when it is made without consideration of the very considerable environmental and safety impacts being imposed on large segments of the population. (55)

Response

The Statement examines three reference environments with differing demographic characteristics for the purposes of analyzing socioeconomic impacts of repository construction and operation. For details of this analysis see final Sections 3.2, 4.7 and 5.4 and Appendix G.

Issue

One commenter felt the the analysis of socio-economic impacts should be modified. The analysis suffers from:

- failure to treat the socio-economic and institutional impacts of a stable nuclear economy;
- sensitivity of estimates of effected to choice of reference site;
- inappropriate application of the analysis across various disposal options;
- overly simplistic indicators for assessing complex social and economic impacts;
- incomplete analysis of impacts associated with repository decommissioning; and
- superficial discussion of equity issues and possibilities of their resolution. (219)

Response

DOE would suggest that there is a need to strike a balance between what is useful to the reader in a generic analysis versus the more complete analysis that might be required in

a site specific situation. As noted throughout this Section, DOE has attempted to improve the presentation of socioeconomic impacts and institutional issues relating to waste management.

Draft p. 1.17

Issue

One commenter requested that more detailed information should be provided as to how the energy needs vary across fuel cycles and geologic media. (34)

Response

This information is presented in Chapter 7.0 and in the support document DOE/ET-0029 (Chapter 2.0).

Draft p. 3.1.116

Issue

Table 3.1.11 purports to give estimates of resources needed for construction of operation of waste repositories in various geologic formation for different fuel cycle options. It also compares effluents for the various options. However, no basis for any of the numbers listed is given. The basis for such estimates should be included. (208-NRC)

Response

The sources of the information in draft Table 3.1.11 are DOE/ET-0028 and DOE/ET-0029.

Draft p. 3.1.116

Issue

One commenter requested that the values in Table 3.1.11 be denormalized. What is the daily electrical use, and what percentage of the model site is this? (43)

Response

Denormalized values can be found in DOE/ET-0029. The tabulations referred to have been put in terms of a model facility in the final Statement (see Sections 4.7, 5.4, and 5.8)

RESOURCE REQUIREMENTS

Draft pp. 3.1.179, 183, 188, 203

Issue

No basis for any of the values of resources committed shown in Tables 3.1.55, 62, 65, and 78 are given. In addition, no units are given for operational water use, concrete, propane and electricity in draft Table 3.1.55. (208-NRC)

Response

See DOE/ET-0029 for basis of values in draft Tables 3.1.55, 62, 65 and 78. Units for operational use of water (m^3), concrete (MT), propane (m^3) and electricity (kW) were missing from draft Table 3.1.55. These omissions have been corrected.

Draft p. 3.1.189

Issue

A question was raised as to how much energy would be required for the surveillance of nuclear wastes following disposal. (30)

Response

DOE anticipates some type of post-closure monitoring system will be implemented for as long as future generations care to operate it. While the amount of energy expended would be dependent on the length and extent of the monitoring effort, it is anticipated that the energy requirements would be less than that needed for the operation of the various waste management facilities (equivalent of 0.08% of energy produced in power plants through the year 2050--250 GWe growth and decline scenario).

Draft p. 3.1.223

Issue

The third paragraph suggests that water use will not be a problem. The basis for the statement was the assumption that the facilities could all be located near the "R" River, which had adequate flow. However, the statement should recognize that water use could be a significant environmental impact for a repository which cannot be located near a convenient water source.

The resource commitments listed include annual water use for the once-through fuel cycle option. The total annual use is about 1% of the annual mean flow of the "R" River, a small amount when water is plentiful. However, in the semi-arid west where river flows can be less than 100 cfs (one-fiftieth that of the R River) and where water is fully allocated, this is a significant amount of surface water use. (208-NRC)

REFERENCE ENVIRONMENTS

Response

DOE agrees. Care must be taken when siting a repository. The selection of such sites will be based on several site-specific parameters.

Issue

Several letters commented on the reference environment approach.

Draft Appendix F--The material presented on the reference environment was abbreviated and generally inadequate. (12)

Draft Appendix F--Why are additional reference environments not considered? If the reference environment described is located in Wisconsin, then serious consideration would have to be given to transportation problems. (43)

Draft Appendix F--Failure to identify the location of the reference environment has resulted in fear that DOE will not seek input from local officials when siting a repository. (129)

Location of the generic site in the middle west typifies the industry's disregard for human life. (96)

Inasmuch as the GEIS is a programmatic statement, a site-specific description of an environment is not necessary; however, development of data that will be required in a specific evaluation is appropriate, and the GEIS incorporates a reference environment to evaluate source terms on a generic basis. However, once having determined the significance of an impact on the reference environment, the GEIS fails to remind the reader that conclusions reached relate only to those particular conditions. Indeed, statements in the GEIS indicate that even its writers do not fully appreciate these limitations. Effects on the reference environment are presented as the impacts of an alternative without recognition of the fact that the impacts could be much different for a different reference environment. For an example of how to prepare a GEIS with detailed discussions of siting options and impacts, see the FES on Floating Nuclear Plants (NUREG-0056). (208-NRC)

Response

The reference environment concept was originally used to deal with the potential ecological and other impacts of geologic disposal, and the environment was representative of the North Central United States in a moderately wet environment. Subsequently some comparisons were made to an arid Southwestern U.S. location (draft Appendix G also compares socioeconomic aspects of these sites). To try to deal with ecological impacts on a generic basis is not very meaningful; the adoption of the reference environment was used to provide a degree of site specificity in order to overcome this problem.

REFERENCE ENVIRONMENTS

The complaint that the Statement fails to remind the reader that conclusions reached relate only to the particular conditions set forth in the reference environment are perhaps valid. To respond to this comment the following addition was made to Section 5.4 of the final Statement. "The reader should keep in mind that impact assessments and comparisons in this report that are based on reference environments are to a degree site specific and therefore limited to one set of environmental conditions. The conclusions reached relate only to these particular conditions and are not applicable in a generic sense."

The reference environment used as a basis for assessing environmental impacts of construction and operation of waste treatment, interim storage, and/or final disposal facilities (draft Appendix F) was developed, with changes, from information presented in the final Environmental Impact Statement on operation of the Monticello (Minnesota) Nuclear Generating Plant (Docket Number 50-263, November 1972). The reference demographic environments (draft Appendix G) used for determining socioeconomic environments impacts were centered around Monticello, Minnesota (Midwestern U.S.); Barnwell, South Carolina (Southwestern U.S.); and Eddy County, New Mexico (Southwestern U.S.).

The data base for the four geologic media analyzed (salt, basalt, granite, shale) was developed from a literature search after which real stratigraphic sections were compared and combined into a composite section generally representative of each study area. By subjectively comparing and combining the composite stratigraphic sections, the generic stratigraphic section was developed for each media type. In developing the generic stratigraphic section for salt, the properties of bedded salt deposits from three different areas (Salina basin, Permian basin, Paradox basin) were considered. Gulf coast salt domes were also investigated. The generic basalt stratigraphy was developed after reviewing rock property data for the Dresser, Amchitka, Nevada Test Site and Columbia River Group basalts. The "typical" shales selected for review were the Pierre, Chagrin, and the Waynesville and Arnheim formations. The granite formations selected for study were the Barr, Colville, Pikes Peak, and Charcoal granites.

Use of these reference environments and geologic media characterizations is not to be construed as a selection of these areas, types of environments, or media characterization for any nuclear fuel cycle facility. More specific environments will be addressed in later environmental impact statements.

Draft p. F.2

Issue

The description of the geology at the bottom of page F.2 would be improved if there were some indication of the depth of the basement rocks and of the general nature of the overlying rocks. (113-EPA)

REFERENCE ENVIRONMENTS

Response

The reference environment was developed principally for above ground environmental analyses such as population dose which requires a description of demography and was not intended to be considered of as a candidate site.

Draft Appendix F

Issue

If the maximum flood on record was 3 meters above the normal river stage, and the one in a thousand year flood would be expected to be 5 meters above normal river stage, under what conditions would the "maximum probable flood" which is 10 meters above normal river stage be expected. Is this a once in a million year flood? (113-EPA)

Response

The probable maximum flood is the worst case flood. No time is specified.

Draft Appendix F

Issue

There is a short paragraph on ground water, but nothing as to the nature of the aquifer--permeability, hydraulic gradients, or retardation factors. This should be included. (113-EPA)

Response

This type of information was not available in sufficient detail to be useful. Moreover near surface features were considered adequate for the use to which the information was put.

Draft p. F.3

Issue

The hydrology of the hypothetical site is presented with no explanation or discussion of its appropriateness for general sites. No discussion of other hydrologies is given. Considering the great length of discussion that is given throughout the document to effects of comparatively small changes in the characteristics of the waste, an apparent lack of appreciation of the effects of the sites hydrologic characteristics is manifested by this treatment. (208-NRC)

REFERENCE ENVIRONMENTS

Response

The problem is that no generic site can be justified. The earth's aquifers have a broad range of measurable characteristics. DOE cannot define a generic groundwater system, because there will always be disputes over the definition. The best that can be done is to use a conservative approach.

COMPARATIVE ASSESSMENT

Draft pp. 1.1, 31, 35, 36

Issue

The GEIS is self-contradictory on whether it is recommending a particular decision or decisions. In some sections it appears a certain course of action is being recommended. In particular on draft p. 1.36, after eliminating most other factors as unimportant, it is stated, "Thus, state of technology stands out as a major decision factor, and the geologic disposal option has an edge over other options as regards the technology status." On draft p. 1.1 it is stated: "DOE proposes that 1) disposal of radioactive wastes in geological formations can likely be developed and applied with minimum environmental consequences, and 2) therefore the program emphasis should be on the establishment of mined repositories as the operative disposal technology."

However, as indicated on draft p. 1.31, the comparative analysis is intentionally not completed to "avoid value assumptions--more appropriately the responsibility of the decision maker." On draft p. 1.35 is found: "It is emphasized that the scores in draft Table 1.8 cannot be combined without careful consideration of the relative importance of the attributes and of the criteria." The relative importance was not determined. Further, draft p. 4.1 states that "No attempt is made to identify specific CWM options for further research and development." Draft p. 4.24 reiterates that weighting factors have not been assigned and decisions not recommended.

The GEIS should not terminate the comparative analysis midway before assigning weighting factors, disclaim the making of a recommendation, and then proceed to make such recommendations as are found on pp. 1.36 and 1.1. (208-NRC)

Response

The statements quoted from the draft document in the first paragraph are correct. The contradictions (and inconsistancies) referred to in paragraph two were corrected and the comparative analysis has been revised to specifically identify and rank those technologies warranting continued development.

Issue

Several commenters felt that the comparative assessment should more clearly emphasize differences between disposal alternatives and identify to what extent DOE's program will pursue disposal options other than geologic disposal.

COMPARATIVE ASSESSMENT

Draft p. 1.3--The final Statement should eliminate from further consideration most if not all of the alternatives other than geologic disposal. (154)

Draft p. 1.23-1.30--The Statement should enable the reader to discern what alternatives (aside from geologic disposal) should receive further program emphasis. (154)

Draft p. 1.31-36--The summary comparative analysis should concentrate on the recommendations for the entire program and note which alternatives (in addition to geologic disposal) should receive further study by DOE. (208-NRC)

Draft p. 1.35--The conclusion that state of technology is a major decision factor and that geologic disposal has an edge over other options in this regard should be more explicitly supported in Chapter 4.0. (198)

Draft p. 4.1--The final Statement ought to provide to the decision maker a reasonable summary of the bases upon which the identification of specific options for further R&D can be made. (154)

The information provided on the ten alternative concepts shows clear and significant advantages for three of the concepts: geologic disposal, island disposal, and shale grout injection. Chapter 4 fails to bring out this distinction. (11)

The final Statement should improve the comparative assessment as much as possible as should specify to what extent the program will pursue alternatives other than geologic disposal. (113-EPA)

The Statement should address the feasibility of, the level of R&D funding and the basis upon which the alternative disposal concepts should be reconsidered as the basis for a future proposed Federal action. (154)

Some method of emphasizing differences between the disposal alternatives should be sought. (201)

The need for continued puruit of other technologies should be more heavily stressed in the final Statement. (218-DOI)

Criteria could be used to more effectively present the advantages, disadvantages, and unresolved technical, sociological, political, and esthetic issues involved with various disposal options. (218-DOI)

Response

The section on Comparison of Disposal Technologies (final Section 6.2) was revised with the following objectives:

1. To use criteria that are both relevant to an environmental impact statement and would assist the decision-maker in distinguishing between the disposal technologies.

2. To structure the section in order to specifically identify and rank disposal options warranting continued development.

This revision is also reflected in the Summary Chapter (1.0).

Draft p. 1.31

Issue

In comparing the options the claim is made that "value judgements are not within the scope of this document." An EIS should provide at least the basis for value judgments in our opinion. (154)

Response

When examing the alternative disposal options, the basis for comparisons made are provided. See final Section 6.2.

Draft p. 1.31

Issue

Several commenters noted that the names and qualifications of the people who comprised the "panel of Experts" involved with the comparative assessment of alternatives should be discussed. (208-NRC, 217)

Response

Quantitative assessments (utilizing the consensus of a panel) were replaced by more qualitative interpretations of information by the entire DOE research team involved in preparation of the final Statement. A presentation of the Department's authority and experience in the waste management area can be found in DOE's Position Paper to the NRC rulemaking proceedings (DOE 1980a).

Issue

Several letters commented on the numerical rating scheme used in the draft Statement.

Draft p. 1.31--The significance of the comparative analysis is clouded by the use of scales that are nonlinear with no relative scaling distributions given and nonindicative of acceptability (e.g., page 4.10 contains a statement that "...'five' the maximum rating does not necessarily represent a 'good' situation..."). (208-NRC)

Draft pp. 1.34 and 4.2--Most of the rankings in Table 1.8 are value judgments in spite of the fact that it stated that the matrix approach was used to minimize value judgments. It is inconsistant to make estimates for some criteria and not for others. (218-DOI)

COMPARATIVE ASSESSMENT

Draft p. 4.10--The statement "Strict scale linearity should not be assumed" contradicts earlier statements concerning the absolute nature of the intervals. (147)

Draft pp. 4.10-11--We seriously quarrel with the analysis. It is inconceivable that several of the alternatives rate a score as close to geologic disposal as they do. We hope the final EIS present a summary which is not only more realistic but of more use to the decision maker. (154)

Draft p. 4.11--Qualitative numbers are assigned in Table 4.5.1 on the basis of subjective judgment in areas where technology is admittedly thin. Such an analysis should be deleted. (11)

Response

The numerical scale used in the draft was replaced by a qualitative method of examining the disposal concepts. The final Statement (see Section 6.2) also includes a discussion of the performance objectives outlined in the recent DOE Position Paper to the NRC confidence rulemaking proceedings on nuclear waste storage and disposal (DOE 1980a) and addresses the degree to which the disposal technologies meet these performance objectives.

Issue

Many letters noted that the comparison of alternatives did not give sufficient consideration to environmental factors.

Draft p. 1.34, Table 1.8--It is strongly disagreed that insufficient data exists to determine ecosystem impacts. (147)

Draft p. 1.35--We were disappointed that the body of the Statement seemed to have considerable information on ecosystem impact yet the Summary concludes that "Insufficient data were available to evaluate Ecosystem Impact criterion." (34)

Draft p. 1.35--It is difficult to make a decision without complete data on ecosystem impacts. The comparative assessment fails to present reliable data on ecosystem impacts. (128)

Draft p. 4.11--Table 4.5.1 indicates that insufficent data is available to compare ecosystem, aesthetic, and critical resource consumption impacts. These are among the most basic and fundamental, true environmental impacts. The majority of the remaining criteria are better described as policy considerations than as environmental factors, e.g., status of technology, cost of construction, policy and equity considerations. Thus, it appears that the final comparative analysis in this environmental impact statement drops out environmental factors and is based on the policy considerations. Environmental impacts, other than dose assessments, such as hydrologic impacts including water use and availability impacts of construction and operation of the repository need more detailed discussion. The GEIS does not present sufficient information on ecosystem impacts or critical resource consumption impacts. (208-NRC)

COMPARATIVE ASSESSMENT

Draft p. 4.22--The final Statement should identify what the potential ecosystem impacts are with the management of commercially generated radioactive waste and consider the radiological effects on plants and animals in addition to humans. (218-DOI)

The comparative assessment fails to provide reliable data on ecosystem impacts. (167)

The GEIS does not present sufficient information on ecosystem impacts or critical resource consumption impacts. (217)

Response

The most complete environmental assessment was made for the geologic repositories, and for salt in particular. To provide what is asked for (the provision of more detailed information and a more detailed discussion/comparison of the environmental impacts of alternatives) would require a considerable effort in acquiring site specific data. For ecological impacts, the site specific kinds of baseline information needed for comparing alternative disposal methods may be lacking; and the generic treatment of comparative impacts may not have much meaning unless one were to develop a set of conditions (i.e., a reference environment) for each alternative. The final Statement includes updates of information available concerning alternatives. However, much of the information remains site specific and is not included.

Draft p. 1.34, Table 1.8

Issue

One commenter stated a criteria reflecting internal policy conflicts be included. (218-DOI)

Response

Section 6.2 of the final Statement includes a criteria called Domestic Political Considerations.

Draft p. 1.34 Table 1.8

Issue

The section entitled Socio-economic Impact mentions that the impacts were not converted to a 1 to 5 scale; refers the reader to Table 4.5.2 and states that the impacts are small for all options. It would be helpful to discuss why the 1 to 5 scale was not used and what rationale was used in both tables to conclude that the impacts would be small. These conclusions appear to be at variance with the statement made on page 1.22 (line 19) which states: " . . . socioeconomic impacts . . . could be either small or significant."

Also refer to the statement on page 3.1.47 (lines 10 and 11) which points out that socioeconomic and political factors may eventually play a determining part in repository site selection. (208-NRC)

Response

This comment is well taken and has been incorporated in the revision of the draft (Section 6.2.4.2).

Draft p. 1.36, 4.11

Issue

"Years until operational" is picked as the major decision factor in selecting technology. But, a basis for considering this to be an important factor, that is a near-term need is not articulated. On page 5.1, it is indicated that alternatives have been ranked with respect to the ease and likelihood of implementation by "the design target date" to evaluate development status of technology. What this target date is is not revealed. This approach is backwards in any event as the GEIS should present information to support the determination of a need date or of need as a function of time and not evaluate options by assuming a need date. (208-NRC)

Response

The DOE Position Paper to the NRC rulemaking proceedings (DOE 1980a) notes as one of its objectives for safe and environmentally acceptable disposal of high-level waste that "waste disposal systems selected for implementation should be based on a level of technology that can be implemented within a reasonable period of time, not depend upon scientific breakthroughs, should be able to be assessed with current capabilities . . ..". The DOE Position Paper also stated a range of target dates for the availability of the first mined repository (1997-2006).

Draft p. 3.1.246

Issue

In the last paragraph on draft page 3.1.246, it is stated that "Table 3.1.95 presents for conventional geologic disposal the data used as a basis for scalar quantities in the comparative analysis discussion." Table 3.1.95 implies that there is "no data" in a number of key areas for making a comparative analysis. Based on this, it would appear that 1) no substantive basis exists for making a rational comparison among disposal options and 2) there may not even be a sufficient basis for assessing the expected environmental impacts from conventional geological disposal. (208-NRC)

COMPARATIVE ASSESSMENT

Response

The reference material was not well worded and modifications were made. Moreover it is believed that the data base exists to generically assess the adequacy of geologic disposal.

Draft pp. 4.1-45

Issue

Chapter 4.0 gives little guidance in judging the relative environmental and social impacts of the possible courses of action. (208-NRC)

Response

The revised comparative assessment attempts to address the potentially significant environmental and social impacts of the waste disposal alternatives to a depth appropriate for this assessment and current level of knowledge.

The President, in his February 12, 1980, message, noted that past governmental efforts to manage radioactive wastes have neither been technically adequate, nor have they sufficiently involved states, local governments and the public in policy and program decisions. This message established a program with mechanisms for full participation of these groups and continuous public review. The Department of Energy is fully committed to this program.

Draft p. 4.2

Issue

There seems to be a contradiction between the statement on page 4.2, second paragraph, which says: "Value judgments were required in at least two areas: 1) judgments relative to selection of the decision criteria and 2) judgments relative to selection of appropriate methods of measuring effects on criteria," and the statement in the footnote on p. 4.2 which says: "Because these questions relate to the values of society and individuals they are avoided here where possible." (208-NRC)

Response

It is stated that "...they be avoided here where possible." In this instance, value judgments were necessary and their avoidance was not possible.

COMPARATIVE ASSESSMENT

Draft p. 4.4

Issue

Table 4.2.1 indicates that "non-high-level" TRU wastes cannot be disposed of by, among others, the very-deep hole, island disposal, and subseabed disposal methods. It is not apparent why this is so. The GEIS should either present a rationale for requiring separate disposal methods or include "non-high-level" wastes in the wastes to be disposed of by those disposal methods. This is important because the current GEIS assumptions require that if disposal of HLW by the above methods is used, disposal in mined cavities in bedded salt also be an acceptable method. (208-NRC)

Response

Non-high-level TRU wastes can be disposed of by methods other than geologic disposal; however, other constraints, principally volume, make geologic disposal of these wastes the preferred alternative. This distinction was brought out in Section 6.2.

Draft p. 4.7

Issue

Beginning on page 4.7 eleven decision criteria are presented and discussed. One is called Ecoystem Impact and consists of two attributes. No rationale is given for selecting these particular measures as criteria. On p. 4.11, Table 4.5.1 states that available information on the physical and operating characteristics of the commerical waste management options is not sufficient to permit comparative assessment of these attributes. Appendix F does not give any primary production information. While Table 3.1.95 presents data used as a basis for scalar quantities in comparative analysis. They give a value of 5×10^{10} g dry organic matter for reversible ecological effects. There is no explanation of where this number comes from or why it is used except that on page 5.19 a formula is given for determining primary production. (208-NRC)

Response

The attributes cited under the Ecoystem Impact criterion in the draft Statement were removed during preparation of the final document. The data relating to reversible ecological effects was also deleted from the Statement.

COMPARATIVE ASSESSMENT

Draft p. 4.9

Issue

Determining net primary production has no value in deciding which option should be selected nor in making decisions at other levels in the program. (208-NRC)

Response

The "Net Primary Production" measure was removed from the final Statement.

Draft p. 4.16

Issue

One commenter noted that discussion of the criterion Safeguards and Security is incomplete for several reasons. The GEIS has been prepared for decision makers and the public. The uranium-only recycle has not been addressed in this draft GEIS from a safeguards standpoint. This and other cycles could have significant safeguards implications. In addition, this section attempts to identify the purpose of proposed safeguards systems but does not provide the decision maker or public with a discussion of the concept or elements of proposed systems for specific forms of waste. It will be difficult to form a judgment on the adequacy of any safeguards system without this information. (208-NRC)

Response

The uranium-only cycle has been deleted from consideration in the final Statement. An expanded discussion of safeguards considerations for other waste forms is included in the final Statement (see Sections 4.10, 5.7, and 3.2.9).

Draft p. 4.16

Issue

One commenter noted that the footnote at the bottom of p. 4.16 is not accurate. The Nuclear Regulatory Commission is studying this problem but has not yet published safeguards requirements specifically applicable to waste repositories. (208-NRC)

Response

This has been deleted from the final Statement.

COMPARATIVE ASSESSMENT

Draft p. 4.44

Issue

There are references to: "some argue that public confidence would be lost..." and on the first paragraph, page 4.45: "some people argue that..." Are these people DOE staff, results of public survey, comment letters? Who "some people" are should be specified. (208-NRC)

Response

The material in question has been deleted from the final Statement.

Draft p. S.1

Issue

Specialties of experts that assessed a number of effects are given but it is not stated what the specialties of experts that assessed ecosystem impacts were. (208-NRC)

Response

Specialties of the experts assessing ecosystem impacts were included in the draft where applicable.

Draft p. S.3

Issue

One commenter noted that the uranium-only cycle should be included in the discussion and factors of attractiveness should be identified for this cycle. Because of the presence of plutonium in this cycle the sabotage and the theft susceptibilities should be analyzed separately.

Consequences and environmental impacts of successful acts of dispersal, sabotage or theft have not been considered in establishing the susceptibility index. These factors could have a bearing on the level of safeguards required in factor number 3 in the short-term susceptibility to encroachment case.

The level of safeguards appropriate for a type of waste appear to be based upon an evaluation concerning the types of wastes which would be attractive for theft or sabotage. This attractiveness criterion is inherently conjectural and should not be used as a basis for determining safeguards requirements. The appropriate considerations in this area are the potential consequences to public health and safety and common defense and security that result from successful theft or sabotage of each specific type of waste. (208-NRC)

COMPARATIVE ASSESSMENT

Response

See response to issue in this section referring to p. 4.16. Also, the relationships between environmental consequences and risk is covered in Section 3.2.9 of the final Statement.

Draft p. S.11

Issue

One commenter noted that Table S.3 "Proposed Safeguards Requirements" does not include any material control and accounting requirements. Safeguards requirements for a high-level waste repository might include some form of accountability requirements during the period prior to final closure, particularly in the case of the uranium-only fuel cycle where significant quantities of plutonium would be present. (208-NRC)

Response

Material control and accounting requirements are discussed in Sections 3.2.9 and 5.7.2 of the final Statement.

Draft p. S.19

Issue

Under Ecosystem Impact, it is stated that the significant ecological effects may occur from construction of buildings, etc. No basis is given for this conclusion. (208-NRC)

Response

The conclusion that ecological effects may accrue from construction of facilities and the establishment of exclusion areas is based principally on expected changes in land use and the associated modification of plant and animal habitat. As mentioned in the paragraph in question, these changes include paving and construction of retention ponds and spoil piles. The effect of change will depend on site-specific parameters. The value of the natural and managed resources at risk, the uniqueness of the affected habitat and the presence of rare species are all factors to be considered. Construction impacts may be relatively short-term and reversible, lasting only during the construction period or through the life of the facility.

Issue

Criteria for which sufficient data not available should not be included in the comparative assessment. (217)

COMPARATIVE ASSESSMENT

Response

One of the benefits of a structured decision analysis is the identification of important issues for which additional information should be obtained. Consequently an attempt was made to include all major issues of importance in the comparative analysis.

Issue

One commenter suggested that the Statement discuss the concept of mitigation in terms of taking corrective action if unanticipated events occur. (219)

Response

The concept of mitigation was considered as a criterion in the final Statement (see Section 6.2).

Issue

One commenter felt that the comparative assessment was not valid and that the excercise should be performed over. (217)

Response

DOE agrees with the commenter and has performed the exercise over (see Section 6.2).

Issue

Several commenters suggested that the Statement present an integrated assessment of the disposal alternatives. (38, 58)

Response

The draft Statement did evaluate each of the disposal options from a systems perspective (e.g. examination of the seabed concept requires consideration of treatment, storage, transportation, and disposal operations for the entire waste stream). In preparing the final Statement the latest data available was utilized in developing this comparative assessment.

Issue

One commenter noted that all of the alternatives to conventional geological disposal recommend separate disposal of non-high-level wastes in mined salt repositories. The lack of an alternative to salt repositories for this waste is noteworthy, unacceptable, and should not be allowed to bias overall choices for the waste management program. (28)

COMPARATIVE ASSESSMENT

Response

The choice of salt (in the draft Statement) was for the purpose of simplifying comparisons. It does not imply that non-high level wastes could not or would not be placed in repositories of other rock types. The selection of other rock types would not alter the conclusions of the comparative assessment. References to salt as a medium for disposal of non-high level waste for those alternatives requiring ancilliary non-high level waste disposal were deleted from the final Statement.

ALTERNATIVE DISPOSAL CONCEPTS

General

Draft p. 1.23, 24, 25, 27

Issue

One commenter noted that the nature and relative importance of research (necessary for the alternative concepts) should be expressed more clearly in the final EIS. (154)

Response

In preparing the final Statement, effort was made to present the research and development requirements in a clear and concise discussion for each of the concepts (see Sections 6.1.1.3, 6.1.2.3, . . . 6.1.8.3).

Draft pp. 3.1.136, 3.3.3

Issue

Where there exist areas of uncertainty common to different alternatives they should be equally treated. For example on page 3.3.3 it states, "Information to satisfactorily assess the feasibility of the very deep hole concept is inadequate. This is not to say that the concept is not feasible, but there is not sufficient knowledge at present to confirm that radioactive waste can be isolated deep enough. . .to avoid transport of radioactive material to the biosphere. The main uncertainty is the lack of information about porosity, permeability and water conditions at great depths." On page 3.3.1 of the GEIS it states that very deep hole disposal is considered flawed because more information is needed on groundwater systems, rock strength and sealing of holes over long periods of time. On the other hand it is argued on page 3.1.136 that no long term significant impacts are expected to result from waste repositories described previously in this statement whether located in salt, granite, shale or basalt formation. It would appear the information needs stated for deep hole disposal would also exist for conventional geological disposal. (208-NRC)

The only alternative that is covered in any degree of detail is deep geologic disposal. While it is realized that less information is available for other alternatives, it appears they could be considered in more detail than these have been. (208-NRC)

Response

The first comment correctly addresses the issue of uncertainty regarding knowledge pertaining to the hydrology of deep geologic systems. Current limitations of such knowledge are important reasons for not considering the very deep hole concept as the primary technical alternative. Also, there are other areas of uncertainty regarding the very deep hole concept that are important though not addressed by the commenter. These are addressed in the final Statement and include deep bore hole sealing, deep emplacement technology,

geochemistry at depth, deep rock mechanical characteristics, and temperature effects that would result from waste emplacement. On the other hand, extensive experience gained--for example, through natural resource exploration and development, including mining, and a variety of geologic exploration programs for other purposes--has provided a plethora of information relevant to hydrologic and geologic characteristics of mined repositories at depths between 500 m and 1500 m. Although this information is available and there have been many studies for mined repositories, information for depths beyond 1500 m becomes significantly less available as depth increases.

The second comment suggests that more detail should be considered in the discussion of of impacts that may be attributable to alternatives. Such detail is included to the extent practicable in Section 6.1 of the final Statement.

Although the comments address two different subject areas, an important relationship is noteworthy; namely, both comments illustrate the significantly different levels of information that exist for mined repositories as compared to all of the other alternatives being considered. The mined repository concept has been the subject of a large number of studies over many years. The studies include transportation logistics, detailed repository design, waste and host rock interaction, to name a few general categories. The most advanced of the alternative concepts, subseabed, has only recently advanced to the stage where host media and waste material interactions are being studied.

Discussions presented in Section 6.2 and Chapter 7.0 of the final Statement address the issue of relative stage of development and its importance to the evaluation of alternatives and to the selection of a programmatic option for disposal of radioactive waste.

Draft p. 3.2

Issue

This entire section appears to be largely speculative. The comment as to the speculative nature of the discussion applies to Sections 3.2, 3.3, 3.4, and, in fact, all of the rest of Chapter 3.0. (113-EPA)

Response

Alternative concepts for the disposal of radioactive waste are at various levels of development with the mined repository being the most developed. For most of the concepts there are large uncertainties regarding their characteristics and attributes. These uncertainties are discussed in Section 6.1 of the final Statement. Section 6.2 presents a comparative assessment of alternatives in which the current status of development, and therefore uncertainty, is discussed. These sections also offer the reviewer a synopsis of a number of the various alternatives that have been proposed for the disposal of radioactive waste and a summary of the rationale for selection of the mined repository as the

the preferred alternative. In general, alternatives that are considered to have large performance uncertainties are ranked lower in preference than those having more well defined and acceptable performance characteristics.

Draft Section 3

Issue

It would be useful to provide concise summaries of advantages and disadvantages for the three subsections now lacking them: chemical resynthesis (Section 3.2), very deep hole concept (Section 3.3), and space disposal (Section 3.10). (218-DOI)

Response

Section 6.1 presents a discussion of the attributes, uncertainties, disadvantages, and other characteristics of the alternative concepts. Section 6.2 of the final Statement provides a comparative assessment of alternative concepts. This assessment identifies the relative merits of the concepts under review consideration.

Issue

One commenter noted that the alternative disposal options should be given emphasis appropriate to their plausibility. (219)

Response

The final Section 6.1 on the alternative disposal technologies was revised to reflect the depth of information available. An assessment of the alternatives that provides a comparison of attributes, including current development status, is presented in Section 6.2 of the final Statement.

Issue

Sections of the EIS discussing the alternative disposal concepts do not discuss either the problems or costs associated with the eventual decommissioning of waste disposal sites. Is this to be our legacy to future generations? Can we not consider such implications now before passing on such an irrevocable "gift"? (167)

Response

Decommissioning costs, where information is available from the literature, are discussed in the final Statement. Section 6.1.1.6 is one specific example where the cost of decommissioning and decontamination are addressed, and Section 6.1.8.6 is another.

In the preparation of the final Statement the DOE has made efforts to assemble and use all of the relevant information on alternatives that is in existence. It is important,

however, to recognize that many of the alternative concepts have not been advanced to the stage where detailed design studies, operations analyses, and subsequent decommissioning costs have been prepared. Conversely, decommissioning of the mined repository concept (Chapter 5.0) has been studied and cost estimates for such decommissioning exist.

Issue

Several letters requested additional analysis of transportation operations.

The feasibility of accomplishing the required transportation as well as the impacts associated with them should be studied and presented as part of the development of the alternative concepts. (43, 97)

Transportation impacts vary widely among alternatives yet generally are dismissed, without much discussion, as being insignificant. (208-NRC)

Response

Greater attention is given to this subject in the final Statement. Section 4.5 discusses in detail waste transportation systems for mined repository disposal as well as alternative concepts. Sections 4.7, 4.8, 4.9 and 4.10 present the environmental impacts, accident analyses, cost analyses, and safeguard requirements for transportation operations (as well as other predisposal activities). The relationship between transportation activities and the alternative disposal techniques discussed in Section 6.1 is presented in Section 4.2 of the final Statement.

Issue

What are the difficulties associated with following disposal site means:

- very deep hole?--cost?
- rock melting concept?--contamination?
- island disposal?--security?
- subseabed?--contamination?
- icesheet disposal?--melting?
- reverse well disposal?--leakage?
- space disposal?--space probe collision?--contamination of the solar furnace? (82)

Response

With the exception of the space disposal issues cited, each of the commenter's questions is addressed in Section 6.1 of the final Statement. A complete listing of research reports pertinent to the alternative concepts is presented in Appendix M.

Space probe collisions have not been specifically addressed because such occurrences are thought to be extremely unlikely. However, should the space disposal concept be pursued, careful analysis of system operations, system failures, accidents, and interaction

with the space environment would be necessary. The purpose of such analysis would be to evaluate the potential near-term and long-term impacts to human health and the natural environment. Evaluation of impacts to the sun has not as yet been considered, although disposal of waste by injection into the sun has been eliminated from consideration due to energy requirements.

Chemical Resynthesis[a]

Draft pp. 1.1, 1.23-24, 3.2.1-23

Issue

Several letters noted that chemical resynthesis is not a disposal alternative but a treatment option. (154, 181, 208-NRC)

Response

In the final Statement discussion of the chemical resynthesis concept is presented in the chapter dealing with predisposal systems (4.0), specifically in the section on waste treatment alternatives (4.3).

Draft p. 1.23

Issue

Several commenters questioned why 600 m is selected as the disposal depth. (62, 218-DOI)

Response

The use of 600 m is an arbitrary depth selected from work done at the Carlsbad, New Mexico site. It is based on the depth (700 m) and the thickness (600 m) of the Salado formation. See Section B.1 of the final Statement.

Draft p. 1.23-24, 3.2.1-23

Issue

One commenter noted that the potential processing problems associated with Chemical Resynthesis should be pointed out. (154)

(a) This concept was placed in the section discussing waste treatment and packaging alternatives in the final Statement (see Section 4.3.2).

Response

The fact that chemical resynthesis is a proposed waste form preparation technology that has undergone very little development, and that it would add processing complexity and produce secondary waste streams are discussed in the final Statement, Section 4.3.

Draft p. 3.2.2

Issue

It is suggested that monazite may be a poor example to use to defend the mineralogic options, since monazite in nature is normally discordant, typically through the loss of uranium. (43)

Response

The extreme age of the monazites described (10^9 yrs) demonstrates that the fractional loss of uranium that may take place occurs at an extremely slow rate. This demonstrated stability is what makes monazite behavior relevant in the context of waste immobilization.

Draft p. 3.2.2

Issue

The word pegmatite should be replaced by migmatite. The reference (Leondardos, 1974) specifically states that pegmatite contribution to monazite deposits are trivial (p. 1126). On p. 1127, Leonardos states "migmatites have supplied the material for the bands within the quartzite". Thus, migmatite is the term required to support the reference." (113-EPA)

Response

The correct terminology is incorporated into the Glossary of the final Statement (Chapter 8.0).

Draft p. 3.2.3

Issue

This paragraph (second) does not consider the effect of radiation damage in the glass. This should be mentioned. (113-EPA)

Response

Information on the effects of radiation on glass can be found in the references given in Section 4.3.2 of the final Statement. The effects of radiation on glass in the presence of heat and water have been studied extensively and have generally been found to be minor.

Glass is a very radiation resistant material. However, a final decision regarding the use of glass as an acceptable waste form for use in a mined repository has not been made. Before the decision can be made, consideration must be given to many factors including the synergistic effects of radiation, heat, host rock chemistry, the presence of water, and the chemistry of the glass waste form. Current ongoing studies are addressing these and other important factors relative to the use of glass as the waste form component of the multi-barrier waste package.

Draft p. 3.2.13

Issue

We are not interested in the integrity of the mineral (referring to detrital metamict grains), but rather whether or not the radioactive elements are retained within the structure. Of the minerals tabulated on Table 3.2.11, most, if not all, when analyzed by geochronologic methods are commonly discordant. (43)

Response

It is acknowledged that the mineral forms are discordant. However, the forms are attractive for incorporation of waste because their mineral integrity is considered to be an important attribute. The draft Statement pointed out in Section 3.2.3.2 that there is virtually no data base on the stability and insolubility of synthetic materials emplaced in the appropriate repository as far as the man-made elements are concerned. It would be necessary to assemble such information to provide confidence that the synthetic material waste form would comply with acceptable release rates such as those proposed by the NRC in its draft 10 CFR 60.

Draft p. 3.2.16

Issue

The first two paragraphs are highly biased in favor of the synthetic mineral (as are the sources cited) and should be rewritten in a more objective manner. (58)

Response

The information on synthetic minerals has been revised for the final Statement (see Section 4.3.2).

ALTERNATIVE DISPOSAL CONCEPTS

Draft Appendix P

Issue

Appendix P represents, on the whole, original and innovative work on the promising concept of geologic emplacement following chemical resynthesis. However, the USGS has found numerous misspellings, incorrect formulas, etc. and suggest setting up a consultant group from universities and the USGS to review the concept and go over the CWMS sections on this approach thoroughly for accuracy and completeness. (218-DOI)

Response

The DOE recognizes the potential of chemical resynthesis and similar concepts that utilize analogs of naturally occurring minerals. It is supporting research on the concepts at DOE laboratories, several universities and the USGS. Their research will provide the accuracy and completeness the commenter seeks. The description in the draft Statement is only an overview of a concept that is still in the very early stages of development.

Very Deep Hole

Draft pp. 1.24, 3.1.33, 3.1.34, 3.3.1

Issue

Several commenters noted that in the summary section of the deep hole concept and in the discussion of the deep hole and mined repository concepts, the question of an appropriate disposal depth is continually alluded to but never directly addressed. (9, 36, 40, 121)

One commenter also expressed concern that too many holes would be required for the deep hole concept. (88, 121)

Response

Discussion of "How deep is deep enough?" is provided in Section 6.1.1.1 of the final Statement. Section 6.1.1.2 of the final Statement discusses the number of holes which would be required. The environmental impact of constructing the very deep hole is presented in final Section 6.1.1.6 and a comparison of this very deep hole concept with the other alternatives is presented in Section 6.2.

Draft pp. 1.24, and 3.3.1

Issue

The question "How deep is deep enough?" (referring to the very deep hole and rock melt concepts) presents many unanswered questions. No geologist, geophysist or hydrologist can

say for certain how deep fractures and joint patterns extend that do contain some water, not only in sedimentary rock but also crystalline rocks. Even very small amounts of water could be vaporized by radioactive decay. The steam would travel upward, lose temperature until it became a liquid and then could contaminate the surrounding groundwater. This water in turn could contaminate a major aquifer within a large area. (9, 36)

Response

Revised and updated information regarding the question of "How deep is deep enough?" is presented in the final Statement. The question of migration of nuclides to the biosphere, via steam particles or other means, would be the subject of possible future technical studies for the very deep hole concept. It is important, however, to recognize that the pressure at depth is likely to prevent the formation of a phase fluid.

Draft p. 1.24

Issue

The last paragraph implies that rock structures can be determined to be unfractured. Is this implication accurate, or should the statement be qualified or rewarded? (124)

Response

The draft Statement acknowledges that rock characteristics, including fracturing, are not well known at these depths. The sentence in question was intended to suggest that a good site selection for a deep hole would contain predominant unfractured rock. Whether such a deep rock section can be located remains to be determined. See Section 5.1.1 and Appendix B of the final Statement for a more complete discussion of the uncertainties of geology and hydrology of depth.

Draft p. 1.25

Issue

Experience of rock bursts in deep mines (approaching 4 km depth) is cited on p. 1.12 in the geologic disposal section for mines 600 m deep but not here for deep holes 4 to 10 km deep. (181)

Response

The deep hole concept is somewhat different than the conventional geologic disposal concept in that the waste canisters will be placed directly into the drilled shafts. As a result, it is not anticipated that anyone will be physically inside these shafts at the depths considered for deep hole disposal. In addition these holes will have a drilling fluid in them to help keep the side wall material in place.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 1.25

Issue

There are major problems with this option, if the hole is lost (collapses or is otherwise rendered unuseable) during the waste emplacement or backfilling-sealed stages, we would end up with the waste in the wrong place or irretrievably placed in an unsealed hole, both of which are probably unacceptable. These potential problems should be pointed out. (218-DOI)

Response

The problems mentioned in this comment are real and might be handled by casing the hole, as discussed in Section 6.1.1.2 of this revised Statement. Other potential problem areas are also discussed in the Section.

Draft p. 3.3.1

Issue

It is stated in the draft: "In summary, the deep hole concept cannot be evaluated as a nuclear waste alternative without more information on the deep groundwater system, rock strength under increased temperatures and pressure due to decay of wastes, and the sealing of the holes over long periods of time."

These are three areas that have also been identified under the research and development needs (Section 3.1.6) for Conventional Geologic Disposal.

Why does the evaluation of deep hole disposal as an alternative depend on obtaining this information, while it is taken for granted that conventional Geologic Disposal is a viable alternative? If this information is obtained for conventional geologic disposal, would it apply to deep hole disposal? (208-NRC)

Response

The discussion from p. 3.3.1 referenced in this comment has been substantially revised and updated in the final Statement. In the final version (Section 6.1.1.1) the geologic characteristics of the site are presented in terms of the very deep hole concept, with the objective of locating the wastes below circulating groundwaters. In addition, the status of information available on very deep geology is discussed in Section 6.1.1.3.

In response to this question, it is worth noting the main difference between deep hole and mined repository disposal: deep hole disposal conceptually applies to depths which may not be practical for mined disposal and, hence, for geologic and hydrologic regions that might be quite different.

ALTERNATIVE DISPOSAL CONCEPTS

See a prior response in this section (General comment-Letter 208) for discussion of current status of knowledge of alternative concepts and the mined repository concept.

Draft p. 3.3.7

Issue

Although fractures may be only a few meters long, they are often interconnected with others making a continouous flow network; therefore, the statement in paragraph 2, lines 7 and 8 in the report is misleading. (218-DOI)

Response

It is agreed that fractures are often interconnected; measuring/assessing this interconnection is an important problem of hydrology in fractured media and is the subject of several ongoing studies. The size and degree of interconnection of fractures is quite variable and may account for as much as 12 orders of magnitude variation in measured hydraulic conductivities.

Draft p. 3.3.7

Issue

Fracture porosity should not be discounted. Fracture traces are systematically used in the exploration of oil and gas to at least 3 km. In areas of the crystalline shield, water well drilling commonly uses the concept of fracture traces to develop high capacity water wells. (43)

Response

DOE is in agreement with the comment that fracture porosity is very important, although to some extent the reviewer might be misinterpreting fracture porosity to mean fracture permeability. The latter was discussed in the subsequent paragraph on page 3.3.7 of the draft Statement. Deep resistivity measurements reflect only on interconnected porosity, which is quite low compared to the bulk porosity of crystalline rocks as measured in the laboratory. The difference in the two porosities is quite important to waste disposal; if water in the rocks is flowing so slowly that diffusion is important, then the entire interconnected porosity will provide large surface area for sorption/reaction. If the water is flowing rapidly, then only the small volumes of the fractures are of first-order importance.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.3.7

Issue

In terms of fluid and solute migrate, fracture porosity might be the most important in many host rocks including basalt, granite and shale. Although there may be very few fractures, their permeability can be several orders of magnitude greater than that of the pores. (218-DOI)

Response

The statement in the draft Statement that fractures are seldom continuous for more than a few meters is misleading, except in the context of the paragraph, where the previous sentence states that ". . . permeability of typical geologic materials may vary over 12 orders of magnitude."

A detailed discussion of geology and hydrology has not been included in the final Statement. However, the final Statement does make reference to various sources of pertinent information in Appendix M.

Draft p. 3.3.7, Last Paragraph, lines 6-7

Issue

This sentence appears misleading or erroneous; oil companies have tested many wells below depths of 500 m for permeability. If the reference is only to crystalline rocks, that should be made clear. (218-DOI)

Response

The comment is correct; the discussion is about crystalline rocks only, as noted on the caption to draft Figure 3.3.3 referenced earlier in that paragraph. This point is stated clearly in the final Statement. (Section 6.1.1.1.)

Draft p. 3.3.8

Issue

Permeability measurements for one well in a sparsely fractured medium have little transfer value to the surrounding bulk medium. Measurements on many wells drilled at different angles are needed (which might compromise the site) or some new nonpenetrating method is needed (not yet developed). (218-DOI)

Response

The measurement of fracture permeability is recognized as a difficult problem and additional research will be needed to resolve remaining problems in its expermental determination for situations where it is an important factor. It is recognized from experience and has been experimentally shown that increasing compressive force or stress in a rock mass will decrease its permeability, including that contributed by fractures. At depths of 10,000 m the forces on the rock are substantial and the total permeability is expected to be extremely low. In view of lack of experience, experimental evaluation of this fact will be required before a final conclusion can be drawn.

Draft 3.3.11-13

Issue

It appears that in the context of the duration of periods under consideration in repository planning, the discussion of rock strength needs to include at least in a general way changes in rock strength and characteristics that may occur with increasing time and their effects on permeability. (218-DOI)

Response

Section 6.1.1.4 (Issues and R&D Requirements) of the final Statement contains a discussion of thermomechanical and thermochemical factors relavant to the deep hole disposal concept. It notes that one of the area where additional study is needed is in permeability changes caused by a rock mass being heated.

Draft p. 3.3.13

Issue

The possibility that oxygen introduced with the waste will change the reducing conditions should be considered. (113-EPA)

Response

A discussion of the effects of waste heat and chemistry on the host rock is presented in the final Statement, Section 6.1.1.3, Status of Technical Development and R&D Needs, under the sub-heading Heat Transfer (Thermomechanical and Thermochemical Factors).

Draft p. 3.3.30

Issue

The fifth paragraph discusses the emplacement of a long column fuel canisters but fails to mention how crushing of the lower containers is prevented. The potential for crushing and the results thereof during the period of emplacement should be treated. (58)

Response

The final Statement includes, in Section 6.1.1.2, a discussion of measures required to prevent crushing of the waste package.

Draft p. 3.3.31

Issue

In the third paragraph it is indicated that leakage considerations from the deep hole repository are similar to those for a conventional geologic repository. This comparison fails to consider that the transport shaft proceeds directly to point of emplacement, that it must remain open during the entire emplacement period and that the geometry of the repository would strongly affect thermohydraulic considerations. (58)

Response

There is no conceptual problem in a shaft proceeding directly to the point of emplacement if the seal, including the interface to the rock, has an integrity at least as good as that of the undisturbed host rock and if the seal were a multibarrier system of seals. A discussion of R&D requirements, including those necessary to develop borehole seals, for the very deep hole concept is presented in Section 6.1.1.3.

Draft p. 3.3.33

Issue

If the permeability is less than as microdarcy, is not this permeability satisfactorily low? (35)

Response

If no very short interval in the hole had a greater permeability, if there were reasonable porosity, and if there were a low hydraulic potential gradient throughout the region of interest, then the answer would most likely be yes. One fracture in an otherwise "tight" rock mass can make considerable difference, thus the permeability cannot be an average over much hole length. And since permeability is only one component to the flow the flow equation, the other factors in the equation (hydraulic potential and porosity) must be taken

into account at any given site. However, conceptual and mathematical modeling will be required to analyze the impact of permeability on the consequences of operation. This type of analysis is important in defining the values of parameters that are satisfactory.

Draft p. 3.3.33

Issue

Some discussion of retrievability from deep holes should be provided. (208-NRC)

Response

This issue is one that would require careful consideration before any waste could be emplaced using the very deep hole concept. A thorough analysis of failure modes and possible corrective actions, including retrieval or recovery of the waste, would be necessary. Methods employing overcovering or other means for retrieval would be analyzed. Although overcovering or other methods might be feasible for use, as currently envisioned, waste emplaced in a hole would not be retrievable.

Draft p. 3.3.33

Issue

It is stated that, "It will be necessary to locate sites in strong, unfractured rock of low water content." This will exclude such media as shale and salt because of strength, and most other media because of fracturing. Why hasn't this same site selection criterion been applied to conventional geologic disposal? (208-NRC)

Response

In defining the very deep hole concept for the Statement it was necessary to make assumptions regarding the criteria for siting of a concept repository. The requirement for strong unfractured rock of low permeability was one such assumption. On the basis of current information about the characteristics of deep geologic systems, other assumptions might be equally valid. For example, emplacement of waste in very deep holes that terminate in salt, shale, or other media may be feasible. Research would be required however, to resolve geologic requirements for this concept. For the mined repository, however, many of the site selection criteria have been established on the basis of the large body of information available.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.3.33

Issue

The section on thermomechanical behavior of rocks does not acknowledge that a significant body of information has been published on studies of hydrothermal alteration of natural rock bodies. The time, temperature, and the nature of ion migration in hydrothermally altered rocks has been studied for years by igneous/metamorphic petrographers, geochemists and mining companies. (208-NRC)

Response

The DOE acknowledges the existence of the significant body of information referenced by the commenter. However, this information pertains to much shallower depths than those envisioned for a very deep hole. The question of depth and its concomitant increasing pressure is the principal reason that significant information on the thermomechanical behavior of rocks is not available to support the concept. The information concerning hydrothermal alteration mentioned in the comment is available for rocks at depths where the total impact of the altering forces are less than that expected in very deep holes.

Draft p. 3.3.34

Issue

Note $500,000,000 just to drill the first hole; $760,000,000 for R&D. Simple back-of-envelope cost estimates surely would show the costs of this system, even if it were possible to work out all the problems, to be prohibitive. (154)

Response

The cost of implementing a disposal option is a significant point of concern. Cost estimates that are accurate are dependent on the availability of thorough conceptual designs and a detailed understanding of the technical developments that must be completed. Although deep hole is an interesting concept and has a number of attractive advantages, detailed design studies or a thorough evaluation of technology requirements has not been undertaken. The comment that the cost may be unacceptably high may be correct. It will not be possible, however, to support this conclusion until these studies are completed.

Draft p. 3.3.36

Issues

Is not borehole sealing covered under the shallow geological repository program? (35).

It should be reemphasized here that satisfactory backfilling-sealing techniques have not yet been developed and proven. (218-DOI)

ALTERNATIVE DISPOSAL CONCEPTS

Response

Section 6.1.1.3 of the final Statement discusses the R&D requirement associated with borehole sealing for the very deep hole concept. For very deep hole disposal, borehole sealing is potentially a greater R&D problem than for the mined repository because of the depth, pressures, temperature, and possible need for down-hole seal emplacement.

Draft p. 3.3.37

Issue

The citation for Reference 27 is inadequate. Provide information whereby Mr./Ms. Stevens can be contacted. (208-NRC)

Response

Victor Stevens is a mining consultant located in Salt Lake City. His address is 808 Kearns Building, Salt Lake City, Utah, 84101.

Issue

It would seem advisable, if not already considered, to gather information regarding the long-term stability of boreholes, wells, and other deep rock penetrations in regions considered favorable for repository location. These observations can provide additional clues on assessing the stability of the repository location. This would be useful in assessing the host media, as well as that of the overlying and underlying formations especially when considering the very deep hole concept of waste isolation. Perturbations of the earth's near-surface are readily detectable in both cased and uncased holes through sheared, ruptured, and squeezed boreholes and casings. (208-NRC)

Response

Gathering information on the long-term stability of existing holes has been considered. The final Section 6.1.1.3 contains discussion of geophysical logging and instrumentation techniques associated with data gathering of this nature.

Rock Melt

Draft p. 1.25

Issue

The introductory writeup on the rock melting concept does not present the disadvantages for this alternative, which were presented for the very deep hole concept, sub-sealed geologic disposal, etc. Equal treatment of all alternatives should be demonstrated in the final EIS. (208-NRC)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The final Statement has attempted to develop an equal assessment treatment under a standard format to all alternatives, consistent with the state of knowledge available. The information in Section 6.1 is a factual presentation and Section 6.2 presents a comparison of the alternatives. In all cases an explicit comparison of advantages and disadvantages is presented.

Draft pp. 3.4.1-22

Issue

Rock Melting Concept--Would not radioactive heat act as a "pressure cooker" and cause an eruption of radioactive material into the environment? (88, 121)

Response

Sufficient rock is removed during construction of cavity that expansion of heated/melted rock can be accommodated. The point is a valid issue that must be considered. The understanding of the role that water might play in the melting of the rock and its availability to create high pressure steam is not well understood. For rock melting to be seriously considered as a disposal method, substantial R&D would be required to understand this phenomena and its associate operational difficulties. Some engineering features could be built into the rock melt repository to reduce the potential impact of such an event. The cavity itself can be excavated to a size such that thermal expansion of the rock can be accommodated, filtered vents can alleviate pressure buildup, cooling waste can assist in controlling temperatures of the mix, and waste can be added at a slow rate.

Draft pp. 3.4.1-22

Issue

A shortcoming of the description of the rock melt alternative is that no mention is made of the need for or availability of the water that's necessary for this alternative. Provide an estimate and discussion of the water requirements. (208-NRC)

Response

If the rock melt repository is co-located with a fuel reprocessing plant, little or no additional water (over that required for reprocessing) should be needed. Actual water requirements have not been accurately estimated; clearly, water availability will have to be one of the factors considered in the site selection process.

Section 6.1.2.2 of the final Statement indicates that the cooling water will likely be recirculated in a closed system where the steam driven off from the waste would be condensed and recirculated to cool the charge in the cavity. The closed cooling system would prevent

the release of radioactivity to the environment and minimize the amount of water required compared to a once-through system.

Draft p. 3.4.1-22

Issue

The Rock Melt Concept discussed in Section 3.4 assumes that the cavity is loaded over a period of years. This prolonged loading time has at least two disadvantages. First, the physical integrity of access and venting shafts must be maintained for the duration of the loading. Second, the cooling water itself will be contaminated and must be carefully contained and eventually the contamination must be disposed of as yet another waste.

Another loading scheme should be considered. The waste could be stored at the surface until the full load for the cavity has been accumulated. The waste could then be rapidly loaded into the cavity and the cavity quickly sealed.

It appears that the quick loading of the cavity is a practical alternative to the prolonged loading suggested in the GEIS. Further variations should also be considered, such as the use of an array of cavities (a few to maybe 10's of cavities). This would reduce the loading rate (in the case of the quick load) and distribute the heat load over a large volume. (208-NRC)

Response

While rapid loading of the cavity in the rock melt alternative has the advantage of minimizing the time that the access shaft must be kept open, it has the disadvantage of storing waste above ground for a long period of time. The risk of possible population exposure to radiation is considered to be higher from waste stored above the ground than in the case for waste downhole. The storage tanks required for approximately 40,000 MTHM of liquid high-level waste (33 million liters) which is necessary to fill each cavity (see Section 6.1.2.2 of the final Statement) is a primary consideration in the decision. Since the rock melt process was developed to handle a liquid waste steam the problem of disposal of contamination liquid (either residual from the waste stream of from evolving water) is one of the important factors which would eventually be addressed in the detailed engineering design studies of the process. See Section 3.4.2.1 and 3.4.2.2 of the draft Statement. In addition, further discussion is contained in Section 6.1.2.2 of the final Statement.

In addition, the problem of maintaining physical integrity of the cavity, shafts, and vents was identified as a disadvantage in Section 3.4.1.4 of the draft Statement and is similarly addressed in Section 6.1.2. of the final Statement. The approach of rapidly loading the cavity is not considered to be technically conservative or to be consistent with a step-wise approach, two requirements which are inherent to the DOE philosophy.

ALTERNATIVE DISPOSAL CONCEPTS

As presented in the final Statement (Section 6.1.2), the reference case use of 3 cavities, each approximately 20 m in diameter (6000 m^3 volume) was selected on the basis of engineering judgment and would be subject to extensive review if the option were pursued. Factors which entered in the judgment were numerous; e.g. ease of excavation, desired spacing to prevent interaction between cavities, the likelihood of a geologic formation of appropriate size, etc. Many of the judgments were influenced by technical conservatism.

It should be noted that there is probably some as yet undetermined minimum size of cavity (corresponding to a maximum number of cavities) that will be required to accumulate a sufficient quantity of liquid waste. Smaller quantities, with very low attendent heat contents would not adequately melt the rock.

Further details of the basis for selection of the cavity size can be obtained from the various documents listed in Appendix M of Volume 2 of the final Statement.

Draft pp. 3.4.1-22

Issue

The treatment of "Rock Melt" in the GEIS misleads the reader as to the depth of investigation which has been completed. For example in the first paragraph on p. 3.4.4 of the GEIS, it is stated: "The concept has been assessed and reviewed (4,5) and preliminary laboratory scale investigations have been performed (6,7)." The workshop referred to as Reference 5, as productive as it may have been, fell far short of assessing "Rock Melt." The laboratory scale investigations were designed to study the descent of solid containers by rock melting, not the molten cavity concept. (208-NRC)

Response

Section 6.1.2.3 of the final Statement more properly describes the status of knowledge regarding the rock melt concept. It is agreed that the original referenced text was misleading.

Draft p. 3.4.1-22

Issue

While the potential for reduced cost certainly exists with this concept, it is hard to see how it could conceivably stand up to a "Circular 779" litany "uncertainties." In particular, we cannot conceive of NRC licensing this concept for spent fuel--criticality questions alone would doom the project. This entire section seems to be a rather blase treatment that not only reduces the concept's credibility but jeopardizes the credibility of the analyses of all the concepts. Some of the ideas and objectives are not bad, but achieving them with assurance seems very doubtful. This concept obviously lacks multiple barriers, control, retrievability, and opportunities for implementing contingency plans were things

to go wrong. We question the statement on p. 3.3.4 that "studies have identified no major technical issues which would cast doubt on the feasibility of the concept." This statement made elsewhere for other concepts may be plausible, but not for this one. Its expression here reduces its credibility elsewhere. (154)

Response

A fairly substantial re-evaluation was accomplished in the preparation of the final Statement. The comparison of concepts in Section 6.2 casts severe doubt on the credibility of rock melt based on current DOE waste management objectives and the status of knowledge regarding the concept. The concept would require resolution of significant questions in a number of areas (including criticality question) before it can be considered to be an acceptable candidate. See draft Section 3.4.1.4, Disadvantages and 3.4.2, Technological Issues Regarding Resoulation for Rock Melting. Isolation or Disposal has been rewritten to reflect current state of knowledge more realistically. The studies detailing the feasibility of the concept are referenced in the final Statement.

Draft pp. 3.4.4, and 3.4.12

Issue

Probable ground-water migration and circulation patterns associated with the rock-melting alternative need further consideration and discussion, preferable in conjunction with effects of thermal crack. (218-DOI)

Response

The need for additional data regarding the role of groundwater in the rock melt process is discussed in Sections 3.4.2.5 and 3.4.2.7 of the draft Statement in conjunction with other topics needing further study. More detailed discussion is presented in Section 6.1.2.3 of the final Statement. Many such questions need to be further resolved before this concept could be field tested with radioactive waste.

Draft p. 3.4.5

Issue

It is stated that retrieval of waste following emplacement would be difficult. This is understood, and not adequately addressed. (208-NRC)

Response

The commenter raises a valid point. It should be pointed out that the rock melt process was to make retrieval of waste as difficult as possible, since in one regard (safeguards) retrievability has been perceived as being equivalent to vulnerability. The current

ALTERNATIVE DISPOSAL CONCEPTS

DOE philosophy of providing for retrievability of waste in the event of some unanticipated event or repository shortcoming cannot be readily met for the rock melt concept. For this reason, among others, the rock melt concept is not considered worthy of further development at this time. The reader is referred to Section 6.2 for a more complete discussion of the situation.

Draft p. 3.4.6

Issue

It is stated that the consequences of seismic activity appear minimal with proper facility design. Discuss the effects of seismic activity on surface facilities supplying cooling water and cleaning up the steam, and on the reliable supply of cooling water to the waste. (208-NRC)

Response

A waste repository should be located against rigid siting criteria that are assumed to specify an aseismic area. Moreover, the surface facilities should be designed to survive significant (probably about 0.5 g) ground accelerations with complete containment of radioactivity. If water to the waste cavity is shut off, the facility should be designed so that the emplacement shaft will close automatically, and the rock melting process will start. Thus, the cavity would not be available for additional waste (early melting started); however, this is not serious economically and should have no significant effect on safety. Before rock melt could be seriously considered for a disposal operation the impact of seismic events would have to be considered. Empirical observations indicate, that unless an underground structure is transversed by a capable supporting surface equipment, such as cooling and steam clean up equipment, it would have to be designed to withstand a seismic event appropriate to the region in which the facility is located. This would be in consonance with the precept that waste disposal facilities would be required to meet appropriate standards which are applied to other nuclear fuel cycle facilities.

Draft p. 3.4.9

Issue

A major point missed with rock melting is the consequent melt cooling. Differentiation will result, and the last formed liquids will concentrate elements such as uranium. This will form late hydrothermal liquids of extreme radioactivity. Whether or not this might result in criticality should be investigated. (43)

ALTERNATIVE DISPOSAL CONCEPTS

Response

This point is addressed in Section 3.4.2.8 of the draft Statement, Study of Criticality Potential in Rock Melting (p. 3.4.8). As pointed out in Section 6.1.2.2 of the final Statement, only the use of liquid high level waste from reprocessing is assumed for the reference case, and this waste is relatively low in fissile isotopes. Thus, in the reference case, spent fuel is not considered due to "uncertainties associated with emplacement, such as additional criticality concerns..." While it is not yet accepted unequovically that the last formed liquids will concentrate uranium, this is a distinct possibility. Other possible mechanisms can be postulated also, so that the concern over criticality is quite pertinent.

Draft p. 3.4.10

Issue

Figure 3.4.4 does not present the temperature profiles that are necessary to completely characterize the extent and duration of the thermal load on the host media. The maximum increase in temperature at the earth's surface can occur hundreds of thousands of years later than shown. (Numerical models can be very costly to run for long times and distances require, however any analytic model is available. See Reference 3 of Appendix C of TID-28818 (Draft), "Subgroup Report on Alternative Technology Strategies for the Isolation of Nuclear Waste.") (208-NRC)

Response

Figure 3.4.4 was intended to be only illustrative of the relatively early temperature distribution around a rock melt repository. Future engineering studies would investigate this topic in the necessary detail. In addition, site-specific calculations should be made to determine the effects of different strata, aquifers, etc.

Draft p. 3.4.13

Issue

If operations as unattractive as grinding solidified HLW to a powder are proposed, the full impact of those operations should be included. (58)

Response

This commenter raises an important point regarding the rock melt information in the draft Statement. The potential approach questioned has been eliminated from the reference concept in the final Statement since there is no obvious reason to first convert liquid high-level waste to glass and then to convert that to a powder. The high-level liquid itself has the desired properties for direct emplacement in this concept.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.4.13

Issue

Handling equipment for these operations will be formidable. (35)

Response

The point made in this comment (regarding Section 3.4.4.2 of the draft Statement) accurately indicates potential problems with the proposed handling method. At this point, the method is only a proposal and has a high probability of being rejected on a more thorough engineering review and analysis. In fact, the final Statement does not incorporate these approaches into the reference system. If the rock melt disposal technique is to be used, there would be no obvious reason to convert to glass before emplacement, and the as-produced liquid high-level waste would be emplaced directly. Similarly, there appears to be no current interest in emplacing solidified canisters of HLW in the rock melt cavity.

Draft p. 3.4.15

Issue

Extended subsurface storage of waste would be very difficult to implement. What would it accomplish? (35)

Response

Extended subsurface storage of waste was discussed to identify the potential options available in the operation of the disposal method. There is no particular known advantage to this approach, and it is believed that other methods are much more satisfactory. In the final Statement (Section 6.1.2) it is pointed out that retrieval of the HLW after emplacement is considered very likely to be difficult or impossible. This is a primary reason for rating the potential of the rock melt cavity to be very low, as measured against DOE program objectives.

Draft p. 3.4.17

Issue

The post sealing period environmental effects are assumed to be "the same for (non-salt) conventional and Rock Melt repositories." The basis for this assumption should be given. If the thermal barrier effect protects the HLW from groundwater leaching for possibly a few thousand years, might not the post sealing performance be superior to that for conventional geologic disposal? (208-NRC)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The assumption that post-sealing environmental effects would be the same for the rock melt process as for the mined repository was re-assessed subsequent to the issue of the draft Statement and the conclusions are presented in final Sections 6.1.2.5 and 6.2. The current DOE position is that there are substantially more uncertainties relating to a performance assessment capability for rock melt and that the expected performance is less than for a mined repository, especially during the period when the waste-rock mixture is molten. Subsequent to solidification, the environmental effects are dependent on factors such as the immobility of the resultant waste forms and the hydrologic regimes in existance at the time. Because there is a lack of multiple barriers, the concept is not consistent with DOE policy. More refined assessments will be made as the rock melting concept is developed. Many potential environmental effects will be sensitive to individual site parameters.

Draft p. 3.4.18

Issue

The reasons for post-operational monitoring of melt growth, etc. for prolonged periods should be explained along with any response that might be made to the information gained. (58)

Response

Post-operational measurements will be carried out during R&D phase to validate calculational results obtained from modeling. Post operational monitoring following an actual full-scale application would be an activity that would maintain confidence and also increase knowledge of the disposal operation. The information would be useful in building similiar facilities and, in case of unplanned events, to provide guidance to the nature and magnitude of the problem. The technically conservative approach suggests that post emplacement monitoring should be desirable in any disposal option until such time as it is operating satisfactorily and the lack of any unanticipated events is verified.

Issue

Information on the possible failure of the cooling system, mitigative actions, and environmental impacts should be provided. (208-NRC)

Response

Information that is available has been presented in Section 6.1.2.2, 6.1.2.3, and 6.1.2.4 of the final Statement. Because the sections are relatively lengthy, no detailed answers are provided here, but the commenter is referred to those sections.

ALTERNATIVE DISPOSAL CONCEPTS

Issue

In the event that the cooling system for the waste fails while still needed, it will be very difficult to repair because of its proximity to the waste. (208-NRC)

Response

The commenter addresses a valid concern. DOE's approach would be the incorporation of independent cooling systems to the design. This is discussed in Section 6.1.2.2 of the final Statement. Another would be to design a "fail-safe" mode of operation where the emplacement shaft will automatically close upon stoppage of cooling water so that rock melting would commence at that point and the cavity would be sealed. Either approach is considered technically conservative.

Island Disposal

Draft p. 1.26

Issue

The statement on line 9, that island arcs are highly active seismically and volcanically is not necessarily correct as there are tectonically inactive island arcs. (208-NRC)

Response

The text in the final Statement (Section 6.1.3) has been revised to note that island arcs, at ocean continent margins, are frequently active seismically and volcanically.

Draft p. 1.26

Issue

Other unresolved problems or disadvantages that should be mentioned regarding island disposal are: greater probability of disruptive geologic events (faulting, earthquakes, volcanism, etc.); perhaps greater erosion rates; more subject to higher rainfall rates, tropical storms, and tsunamis. (218-DOI)

Response

In the preparation of the final Statement efforts were made to provide a balanced discussion of the advantages and disadvantages of the concept using the most current information available in the technical literature . Accordingly, for relatively undeveloped concepts, many of the issues that would be the subject of future R&D are not addressed. An example of such an issue is rainfall rates that would be expected to be site specific although very important to the evaluation of island hydrologies. No island sites have been considered by the DOE. Therefore, rainfall rate data are not available.

ALTERNATIVE DISPOSAL CONCEPTS

Draft Section 1.3.5

Issue

Section 1.3.5 states that, "Salt deposits are unlikely to be available at island sites; the most probable disposal formation (sic) is crystalline rock." From this statement one would conclude that crystalline rock was the most common rock type exposed on islands. This is not the case; e.g. the Antilles, the Japanese and Phillippine archipelagos, New Guinea, Bikini, Bermuda, etc. (208-NRC)

Response

The statement does not suggest that crystalline rock is the most common type exposed on islands; rather it is the most probable disposal formation.

Draft Sections 1.3.5 and 3.5

Issue

In view of the statements:

"The DOE Task Force Rough Draft Report states that the DOE has no program to actively investigate the concept." (p. 3.5.1)

"Institutional and political aspects of acceptance of either U.S. or foreign island sites have not been addressed and are neither suggested nor implied." (p. 3.5.2)

it is not clear why this "alternative" is included. (154)

It is nowhere stated as to why this alternative is being considered. (34)

Response

Island disposal is a potential disposal method which has been suggested as a candidate for consideration in the alternative waste program. This disposal concept is a variation of the mined repository disposal concept in that the waste would be entombed in a deep geologic formation and is therefore a valid concept for consideration. Section 6.1.3.1 in the final Statement briefly presents a discussion of the attributes and disadvantages of this disposal option. A comparative assessment of the eight alternatives and the mined repository is presented in Section 6.2 of the final Statement.

ALTERNATIVE DISPOSAL CONCEPTS

Draft Section 3.5

Issue

This concept in a way is not an alternative to geologic disposal but simply geologic disposal in a specific place. (154)

Response

It is recognized that island repositories would be mined repositories sited at island locations. However, the unique hydrologic and geologic settings of islands and the ocean transportation requirements are a sufficient departure from the continentally located mined repositories to warrent separate consideration of the concept. The differences between the two concepts are clarified in Section 6.1.3.3, System and Facilities Description, and in Section 6.1.3.3, Technical Issues, of the final Statement.

Draft Section 3.5

Issue

Island Disposal--Too costly, sea transportation, security system, how will the island be protected by our military men? What will be the cost to the taxpayers? (88, 121)

Response

These comments are addressed in the comparative analysis in Section 6.2 of the final Statement. This statement also points out that although detailed cost estimates for construction, operation, and decommissioning have not been made, it is presently estimated that these costs would be at least double those for a continental mined repository (see Section 6.1.3.6 of final Statement).

Draft Section 3.5

Issue

The discussion in Section 3.5 indicates that two options for Island disposal are being seriously considered. One option is disposal in oceanic islands for which relatively long sea voyages for transporting the radioactive wastes will be necessary. The other option is disposal in continental islands. For this option, the transport time at sea is small with the possibility of using a ferry-type transport system; facilities at the embarkation and receiving port could be simplified. The two options should continue to be treated separately and additional information concerning environmental impacts and accident risks be developed for both options. It is important to continue to explore both options with the ultimate choice being left to a risk benefit analysis after more complete imformation is developed. (208-NRC)

Response

The differences between oceanic and continental islands do not justify a totally separate treatment at the current stage of development for this concept.

Draft Section 3.5

Issue

The ability to dewater a site is an extremely important site characteristic. Dewatering with the attendant equipment may impose such an economic burden that an other-wise suitable site may be ultimately rejected. The dewatering problem may, in the end, result in the rejection of the island arc and oceanic island locations. In addition, the retrievability of waste placed in any island watery environment, particularly salt water, is questionable considering the effects of corrosion on dewatering equipment. (208-NRC)

Response

One of the criteria for selection of a site would be for a host rock of low permeability. Thus, major dewatering problems during construction would be unlikely to occur at a site suitable as a repository location.

Draft Section 3.5.1

Issue

While this option approaches in effectiveness some technological advantages of the conventional geologic option, it offers additionally an international approach that is attractive. However, detailed studies of this option have not been made, and it is now merely a concept lacking a strong consensus for adoption. (124)

Response

As noted in Section 6.1.3.1 of the final Statement the DOE does not currently have a program to actively investigate the concept. However, the DOE believes that information presented in the final Statement provides a sufficient basis for assessment of the attributes and disadvantages of alternatives and mined repository. Section 6.2 of the final Statement presents a comparative assessment of the disposal technologies.

Draft p. 3.5.1

Issue

The "possible advantageous hydrogeological" features do not stand out in reading Section 3.5. (124)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The "possible advantageous hydrogeological features" are discussed in Section 3.5.1.1 under Groundwater Transport: Freshwater Lens Location and Groundwater Transport: Saline Lens Location of the draft Statement. However, due to the lack of site-specific data, the Statement cannot go into detail concerning hydrogeological features. From a generic description point of view, the Statement does clearly depict the present understanding of the isolation features inherent with the island hydrogeology. These features may represent favorable isolation barriers. Section 6.2 of the final Statement discusses advantages and disadvantages of the alternative concepts, including the island disposal concept, and the mined repository.

Draft p. 3.5.1 and 3.5.5

Issue

The assumption of a "practically static" salt water system below the fresh water lens should be approached with reservation. The stability depends upon many factors some of which are mentioned in the text (p. 3.5.19), some aren't . Examples of these factors are: amount of rainfall, frequency of rainfall, water usage (pumping regimes), tides, sea level fluctuations, and erosion. In what sense is the ocean considered to provide an additional barrier? (208-NRC)

Response

The ocean is not considered a barrier. However, radionuclide leachate bearing groundwaters that might discharge into deep oceanic waters would be expected to be diluted and dispersed to very low concentrations. Shallow water releases would be expected to cause greater impacts than deep water releases. Conversely, while dispersion of the radionuclides in the ocean might occur, concentration could also take place in the food chains, especially in littoral and coastal areas.

Draft p. 3.5.6

Issue

It is not clear how the need for 6 to 10 island repositories was developed. (124)

Response

The final Statement draws no conclusions regarding differences in the required numbers of island repositories as compared to continental mined repositories. However, the final Statement does note that physical limitations on useable island areas might cause a need for a greater number of island repositories than Continental mined repositories. For a comparison of the alternatives and the mined repository see Section 6.2 of the final Statement.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.5.12

Issue

The statement that 85 percent of the world's earthquake energy is released in the Pacific margins should be documented. (208-NRC)

Response

The sentence referred to in the comment was taken from Physics of the Earth's Interior, (Bott 1971). "About 75 percent of world-wide shallow earthquakes (focus 0 to 70 km depth) and 90 percent of a world-wide intermediate and deep earthquakes (focus greater than 70 km depth) occur beneath the circum-Pacific margin belt of island arcs, deep trenches and mountain ranges." The reference is included in the Reference List for Section 6.1 of the final Statement.

Draft p.3.5.12

Issue

Figure 3.5.6 does not show major basement rock types. There is a figure showing major basement rock types in Reference 5 (Bayley and Muehlberger 1968), which has Figure 3.5.6 as an inset, titled "Principle Basement Provinces." (208-NRC)

Response

Figure 3.5.6 of the draft Statement should have been titled "Principle Basement Provinces Along the Pacific and Atlantic Coast."

Draft p. 3.5.16

Issue

An unequivocal statement that island arcs are completely unsuitable for waste disposal because of seismic activity would be in order. (124)

Response

Some island arcs are seismically inactive. However, before any island were chosen for the disposal of waste thorough evaluation of the geology and hydrology would be required. Islands found to be in geologically active areas would be eliminated for the same reasons that tectonically active continental areas have been eliminated from consideration for siting of a mined repository. See Section 5.2.1.1 of the final Statement for a discussion of long term geologic stability.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.5.16

Issue

The reference to measurements in deep artesian wells in paragraph 3 seems inconsistent with the concept of a floating freshwater lens, because conditions in a confined or artesian aquifer might not necessarily reflect the freshwater/saltwater ratio. Influences other than differences in density can be effective in confined aquifers. (218-DOI)

Response

The term "artesian" should be deleted from the referenced sentence. The commenter correctly notes that a hydrologic system characterized by a freshwater lens floating or deep saline water would not support artesian aquifers.

Draft p. 3.5.17

Issue

Second paragraph: "Of lesser significance are local alluvial (and other sedimentary) deposits..."

This is true if "significance" refers to abundance. However, in terms of importance the sedimentary deposits are of great significance because, with the lava flows, they provide the dateable units for defining tectonic history and predicting future activity. (154)

Response

The intent in the draft Statement was to discuss significance in reference to aquifers. It is acknowledged that alluvial (and other sedimentary) deposits would be of importance in characterizing the geologic history of the island.

Draft p. 3.5.18

Issue

The discussion of sorptive phenomenon is not sufficiently covered. A comparison of the sorptive properties associated with island disposal with those associated with conventional geologic disposal should be presented, to determine if the multibarrier approach has been effectively utilized. (208-NRC)

Response

Data on the comparative sorption properties associated with the island disposal option compared to mined repository disposal are not presently available. However, some

information on the absorption properties of deep sea sediments is contained in Section 3.6.3.2 of the draft Statement of the subseabed geologic disposal alternative.

Draft p. 3.5.19

Issue

Figures 3.5.9 and 3.5.10: "Isolation" in the Figure titles should be "Containment" (our terminology). (154)

Response

Please refer to the Glossary, Chapter 8.0 of the final Statement.

Draft p. 3.5.19

Issue

It should be noted that the dispersion and diffusion may be very active in this type of system, especially in combination with a natural zone of dispersion along the saltwater/freshwater interface. (208-NRC)

Response

A study of the mechanisms of dispersion and diffusion for radioactive species within the geohydrologic setting of island repositories would be a necessary part of a development program for this concept. It is likely that emphasis would be placed on the freshwater/saltwater interface and the sorption and transport characteristics of the boundary region. The effects of a moving interface would also be considered.

Draft p. 3.5.20

Issue

Two disadvantages of the island concept at the bottom of the page the following should be added:

- Because of ocean cover and limited stratigraphy, the tectonic activity will be difficult to document with adequate assurance of safety relative to faults and earthquakes.

Fifth paragraph: "The accuracy of geological information at actual data points (drill holes, surface exposure, underground workings) will be good. However, accuracy of the spatial extrapolation will depend upon the density of available data in space and time, the complexity of the geology, and the knowledge and experience of the scientist performing the work. Similar comments apply to oceanographic data with an additional proviso that many

oceanographic phenomena are constantly varying in time, thus requiring more intensive data collection." These statements are of such fundamental importance, that they should not wait for expression in this section. Rather, they should be expressed right up front in the Summary or Background sections together with other similar truisms of geology. (154)

Response

The commenter addresses uncertainties that are currently applicable to the island disposal concept. Section 6.2 of the final Statement discusses the influence of uncertainty on the selection of preferred alternatives for continued development and presents a comparative assessment of this concept.

Draft p. 3.5.20

Issue

The disadvantages of island sites should include the sociological objection to the use of continental islands and concern for volcanism on oceanic islands. At least in the U.S. context, continental islands are cherished by the environmentalists and proposals to use them as a nuclear "dumping ground" could be expected to raise a monumental furror. Similarly, although theory would suggest that some islands of volcanic origin will remain inactive for geologic time spans, the critics of nuclear power and the media would have a field day decrying the 'faulted logic' of the nuclear advocates. Information should be presented to show how islands of volcanic origin will be proven to be inactive. (58)

Response

Section 6.1.3.4 of the final Statement addresses the impacts to natural system that might be expected if the island repository concept were to be used. Section 6.2 presents a comparative assessment of alternative concepts and the mined repository. This assessment includes consideration of the differences in impacts between alternatives. The volcanic inactivity for oceanic islands would be based on geologic data on the time of the most recent eruption. As shown in Figure 3.5.7 of the final draft Statement, the age of the oceanic islands and time since the last erutpion can be shown in many instances to increase with distance from a hot spot or mid-oceanic ridge.

Draft p. 3.5.21

Issue

Another disadvantage should be mentioned. Islands are often more associated with resources and more subject to faulting, seismicity, volcanism, erosion, effects of sea level changes, extreme storms, and tsunamis. (218-DOI)

Response

Such considerations are presented in Section 6.1.3.4 (Subpacts on Natural System Impacts and Resource Consumption) and Section 6.1.3.5 of the final Statement.

Draft p. 3.5.21

Issues

It is noted that the transporation link from the mainland to the island would involve an additional potential for accidents. It would seem appropriate to note that this increase is not necessarily linear with distance, in that the most common location for accidents would be near one or the other ports, and that ship accidents are strictly proportional to the number of port calls made. (124)

Response

The final Statement has been revised to reflect the point made in this comment. The potential for accidents will increase although not necessarily linearly as the distance to the island increases. Reference is made to Section 6.1.4 (subseabed concept) of the final Statement for additional discussion pertinent to sea transportation as it applies to concept in terms of requiring over water transportation of the waste. Section 4.5 of the final Statement presents a comprehensive discussion of transportation impacts.

Draft pp. 3.5.21, 23, 24

Issue

The hydraulic gradient and the stability of freshwater lens may also be affected by the sea level slope induced by coastal currents and topographic focussing of surface and internal gravity waves. (23-DOC)

Sea level slope is another factor in the stability of freshwater lens. (23-DOC)

Factors of importance to sediment patterns and movements include tides, land discharges, coastal circulation, littoral currents induced by surface gravity waves, and direct wave actions during storm and tsumani. (23-DOC)

Response

Stability of the freshwater lens may be affected by changes in sea level, glaciation, thermal convection effects, respository construction, changes in climate and precipitation, modifications of surface runoff, and by changes in the sea level slope induced by coastal currents and topographic focussing of surface and internal gravity waves and other effects.

ALTERNATIVE DISPOSAL CONCEPTS

Sediment patterns may be affected by changes in sea level, glaciation, changes in climate and precipitaion, modification of surface runoff, tides, littoral currents induced by surface gravity waves, and direct wave actions.

Draft p. 3.5.22

Issue

Report should state whether or not prior chemical or other disposal has ever been conducted on island sites and what the results were. (124)

Response

If selected as a viable option the island disposal concept would require in-depth R&D support of a thorough licensing process. Information regarding releases from such disposal sites, if they exist and if the geologic and hydrologic settings are sufficiently analogous, would be useful. However, there is little likelihood that information is in existance for waste deposited in selected hydrologic regimes deep within an island geology. No such information was used in the preparation of the final Statement.

Draft p. 3.5.23

Issue

Under Section 3.5.2.2, some estimate should be provided of the probability of accidents on the sea lanes, which might lead to loss of the radioactive cargo. Cost estimates should also be provided. (208-NRC)

Response

Estimates of sea transportation accident probabilities were not undertaken in this study. Data is undoubtedly available and could be assembled and interpreted. Work done in Europe, especially by the U.K. and in Japan in relation to spent fuel sea transporation, may be available. In the U.S. the American National Standards Institute working group, ANSI N552, is currently considering standards for the water transportation of radioactive (spent nuclear reactor fuel) materials. These standards were not complete at the time of the final Statement.

Detailed costs have not been estimated. For further discussion of cost analysis see Section 6.1.3.6 of the final Statement.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.5.25

Issue

Replace the sentence beginning with: "However," on line 13 with: However, their natures and time variant behaviors, particularly of subsurface current, are incompletely understood. (23-DOC)

Replace the sentence beginning with: "Similar" on line 15 with: For oceanographic data there is need for both intensive and extensive observations over a long period in order to resolve the time and space scales of the coastal, littoral, and other flows. (23-DOC)

Response

The above sentences are preferred substitutes for the applicable text of the draft Statement.

Draft p. 3.5.27

Issue

It should be noted that current models are not able to accurately predict flow through fractured media, which will be normally encountered in islands of volcanic origin. (208-NRC)

Response

Models for accurately predicting the migration of radioactive species through fractured media are not currently available and basalts that are extruded to solidify under the ocean are normally highly fractured. Also, as noted in Section 3.5.1.2 of the draft Statement, islands of volcanic origin have highly fractured basalts that may be bounded by sheets of dense impermiable rocks (dikes). Detailed characterization of the host geology would be a necessary part of the development of the island concept. Until characterization of the host geology for an island was completed, the modeling needs for groundwater flow would not be known.

Draft p. 3.5.29

Issue

Section 3.5.6.2 implies that there are no uncertainties associated with island disposal beyond those associated with conventional geologic disposal, an implication that appears simplistic. The areas of uncertainty should be summarized and some quantitative assessment of their potential consequences provided. (58)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The primary area of uncertainty and difference between island disposal and continental geologic disposal is the geohydrology of the island. In addition, the tectonics of oceanic islands or island arcs would be different from continental locations. The rock mechanics, waste container, waste form aspects, etc., however, would be expected to be very similar to those for conventional mined disposal in crystalline rocks.

Draft p. 3.5.29

Issue

Section 3.5.6.3 identifies research and development areas that need to be explored in order to resolve uncertainties in island disposal. One area is the level of risk associated with extended sea transportation paths. Since the complexity of port facilities varies with the island disposal option being considered, the level of risk, both in terms of routine occupational exposure and exposures due to accidents, should also be considered as an area needing development. (208-NRC)

Response

Section 6.1.3.4 in the final Statement includes consideration of port facilities. Also, reference is made to the subseabed alternative (Section 6.1.4 of the final Statement) for additional discussion of the current development status and R&D needs for transportation of waste. In the presentation of comparative analyses, Section 6.2 of the final Statement includes the transportation aspects of the various alternatives.

Draft p. 4.15

Issue

It is not accurate to state that the insular geologic surroundings are of inherently dynamic nature. This is not so especially for the east coast continental islands. East coast islands are probably less likely to contain, or be near, valuable resources than some of the west coast islands, thus lessening the possibility of repository intrusion. (208-NRC)

Response

The referenced text from the draft Statement was included in draft Section 4.5.3.2, Susceptability to Natural Phenomena. The dynamic nature of insular geologic surroundings refers to the natural processs of geologic and meterologic changes. These changes are pronounced at continental boundaries where the erosional effects of the ocean may combine with tectonic changes to make island geologies and hydrologies inherently unstable.

ALTERNATIVE DISPOSAL CONCEPTS

Draft 4.20

Issue

Table 4.5.2 presents preliminary estimates of the socioeconomic impact of the waste management options. An assumption stated under island disposal is that dockside shipping faciiities will be constructed in a well established port area. For the no recycle option, packaged spent fuel will be shipped to the island disposal area. The recent NRC interim rule for safeguarding spent fuel shipments may prevent the use of well established port areas so that the conclusion reached, that the incremental impact is small, may not be valid. (208-NRC)

Response

Rules and regulations regarding safeguards and security for the shipment of spent fuel and high-level waste are prescribed in the Code of Federal Regulations Title 10, Part 23. Paragraph 73.37 prescribes rules for routing of such shipments. These rules do not preclude properly secured shipments to existing port areas.

Subseabed Disposal

Draft p. 1.26-29

Issue

The section on sub-seabed disposal is the most complete and concise section in the summary. It describes a concept that appears highly favorable from a geologic viewpoint and concludes that "five years of research have revealed no technological reason why further development of the sub-seabed disposal option should be abandoned..." Considering that this concept is the second most favorable one, the conclusion should be stated positively rather than negatively. Also consideration should be given to simple disposal on the seabed, as reproposed by Dr. Bernard Cohen. (154)

Response

The change in emphasis requested by the commenter has been brought into the final Statement (see Sections 1.4 and 1.8). Seabed emplacement techniques have been under study for several years. The example or reference method utilized in this Statement is a free-fall penetrometer. All alternatives to this technique (cited in this Statement) involve penetration or emplacement beneath the ocean sediment. Section 6.1.4.3 of the final Statement points out that penetrometers are widely used in Marine, land, space, and arctic operations.

Draft p. 1.27

Issue

If there is sufficient heat to modify the red clay of the ocean floor, there may be sufficient heat to initiate convection currents in the overlying water. If sufficiently large in a real extent, this would cause an upwelling, bringing to the surface material from the lower depth of the ocean and possibly from the ocean floor. This material could be nutrients, inert material, or if a canister ruptured on impact, radioactive material. (218-DOI)

Response

The red clays should not be modified if the temperatures are kept below 250°C. The organic carbon content of these clays is less than 0.1%. Thus, the nutrients which will be released will be minimal. Calculations indicate that convective currents in the sediments will move a water molecule only 3 m in 1000 years. Convection cells in the water column will not occur.

Draft Section 3.6

Issue

More emphasis should be placed on understanding the nature of transport of materials in water column in areas under study for waste disposal. Ongoing programs in quantifying biological pathways should be expanded and comprehensive program of physical, chemical, and biological measurements should be undertaken, and models developed for deep ocean layers. It is essential to quantify what will happen in the case of accidental breakage or unexpected leakage in terms of the water column serving as an emergency barrier. (23-DOC)

Response

The Subseabed Disposal Program Plan (Sandia 1980a) details projected or ongoing studies regarding transport in the water column via physical oceanographic processes as well as biological processes. Also discussed there are the impact of radionuclides on biota as well as the potential impacts on man if radionuclides were to get into the water column or to the ocean surface.

ALTERNATIVE DISPOSAL CONCEPTS

Draft Section 3.6

Issue

Somewhere in this section several other matters should be briefly considered: How deep would the projectiles be sent? What distance beneath the sediment surface, and how far from the rock beneath? What about the concept of recovery, if unforeseen dangers are found to exist? (113-EPA)

Response

A methodology for canister emplacement is proposed to be determined during Phase 3 (Engineering Feasibility) of the Subseabed Program current system pursued by Sandia National Laboratory for the DOE. Questions regarding distances below the sediment surface and above the basement rocks are to be answered as part of Phase II (Technical and Environmental Feasibility) which is now in progress. Firm answers are not yet available. It appears at this point, however, that a minimum of 30 m of sediment may be needed to separate a canister from both the sediment surface and the basement rocks. Also see Emplacement and Retrievability/Recoverability in Section 6.1.4.2 of the final Statment.

Draft Section 3.6

Issue

This secton is very interesting and very well done. The concept is probably the safest one with regard to geologic factors. Some basic truths about necessary elements for demonstrating tectonic stability are expressed here that not only apply to other concepts as well, but which should be expressly set forth as guidelines in the Summary or Background section of the Final EIS. For example:

p 3.6.2 ". . .ability to make long-term predictions of stability and uniformity on the basis of . . . sediments that have been accumulating for 70 million years."

p 3.6.3 "The more predictable and uniform the geologic environment, the less detailed the specific site studies must be to determine the properties of the geologic formation."

". . . areas where processes are slow and continuously depositional, and where tectonic processes have been and are predicted to be minimal for millions of years, are the most uniform and pedictable on the globe."

p 3.6.11 ". . . areas with the greatest uniformity and predictability will be those where uplifting will not occur again for millions of years and where deposition is continuous and uniform." (154)

While it is not well enough advanced to be considered for an initial repository, this concept appears to have enough promise that it should receive some R&D funding. (154)

Response

Although DOE would like to restrict ourselves to only the most stable, uniform, and predictable areas, adequate areas can probably be found wherever natural uplifting and reprocessing processes have not occurred. One must be very careful to delineate overall global processes and to show where and why the highest reliability can be found.

The subeabed program is currently being funded by the DOE. Fiscal year 1980 funding was for $5.9 million.

Draft Section 3.6

Issue

The option has been under active development since 1973, and is considered one of the leading alternatives to the conventional geologic option. The development effort now includes four other countries, which recognize that an international approach may be necessary to an effective solution. (124)

Response

Six countries are now included in an NEA/OECD working group on subseabed disposal of radioactive waste: U.S., Netherlands, Japan, Great Britain, France, and Canada.

Draft Section 3.6.2.3

Issue

This section starts off with the identification of the barriers to the movement of radionuclides, then fails to discuss two of them: "any controlled modification of the medium," and "the benthic boundary layer." A discussion of these barriers should be provided. (208-NRC)

Response

The various barriers are described briefly in the Section 6.1.4.2 of the final Statement under Waste System Description.

ALTERNATIVE DISPOSAL CONCEPTS

Draft Section 3.6.3.6

Issue

Subseabed geologic disposal--Legal and political issues will be raised. Why should Japan and Russia allow us to dump our radioactive waste in that area? (88, 121)

Response

No country, under present internatonal law, has any right to control the activities of another country upon the high seas. Japan and many other maritime nations, since there are no stable geologic formations suitable for waste disposal on the islands proper, will probably be required to safely dispose of their waste either in the international ocean regime or rely upon some other nation to dispose of Japanese waste--and the latter is considered to be a very unlikely resolution.

Draft, Section 3.6.6.1

Issue

This section is labeled "Site Selection and Preparation" but nothing is mentioned of site preparation. What is involved in preparing a seabed site for use? (208-NRC)

Response

Site preparation would include the placement of locating devices on the bottom in such a way that the position of the ship and the canister in question will be continuously known. Preparation also includes a complete survey in three dimensions of the area of interest. This preparation is well within present state-of-the-art, deep ocean technology.

Draft p. 3.6.1

Issue

The fourth paragraph states that a ship will monitor the emplaced wastes for an "appropriate length of time." How long (or short) is this "appropriate length of time?" (113-EPA)

Response

This period will be determined on the basis of engineering feasibility studies and model calculations of the subseabed system. It is anticipated that an appropriate length of time would be that time necessary to provide assurance that the waste package is properly emplaced in the sediments, that effective entry hole closure has occurred, and that the package temperatures are in accordance with prescribed operating limits. Package

emplacement would not occur on a routine basis until a waste disposal site had been qualified through emplacement of and monitoring of a number of test packages. Monitoring of test packages would likely continue after routine operations had begun.

Draft p. 3.6.1

Issue

It is stated that the goal "to aid in solving national and international legal and political problems" will be started only after the technical and environmental feasibility is demonstrated. Has this been factored into the schedule that has been developed for this program? What lead time and resources have been planned? Has the DOE participated in any international discussions of this problem. A description of the programs of other countries interested in seabed disposal would be helpful. (208-NRC)

Response

A discussion of international legal and institutional considerations is included in the final Statement Section 6.1.4 . This section mentions factoring these considerations into scheduling as "it is not too early" to identify them. (See also Sandia 1980b)

Draft p. 3.6.1

Issue

The first paragraph of this section should state that at present it is illegal to put high-level wastes in, on, or under the seabed and that legislative action would be required before implementation. (113-EPA)

Response

There are various differing positions at this time as to the legality of subseabed disposal or legislative action required. During the next few years the subseabed program includes planning for research at universities and institutes within the U.S. to identify these issues and attempt to resolve them.

A discussion of the legal and political concerns has been revised in the final Statement and is presented in final Section 6.1.4.4.

Draft pp. 3.6.1, 3.6.4

Issue

A surface current gyre is a partially closed circulatory (not circular) system of surface and upper layer waters. (23-DOC)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The comment is valid and appropriate changes were made in the final Statement.

Draft p. 3.6.2

Issue

The difficulty of documenting a repository's location for future generations is presented as a major disadvantage of the seabed concept. Explain why this would be any more difficult to do for seabed than for conventional geologic disposal? (208-NRC)

Response

Documenting disposal locations in the subseabed concept is now seen to be no more difficult than for continental geologic disposal, and is well within the capabilities of current oceanographic technology.

Draft p. 3.6.2

Issue

The last bullet under "Advantages" suggests that an advantage to seabed disposal is the lack of need to resolve Federal-State relations problems. This is not so because problems would surely arise from port use and the loading and transportation of waste to the port. (113-EPA)

Response

There is a difference between the Federal and state problems related to a transient (30-year) dock facility where no waste will be disposed of, and Federal and state problems relating to a disposal facility where wastes will remain forever and the chance of contamination may be seen by the local public to be higher. The commenter is correct, however, in that there will be Federal and state problems relating to location of a dock facility and to train or barge transportation to that facility.

Draft p. 3.6.2

Issue

In mid gyre there is little benefit from deposition of sediments since this process is very slow there. The document states that less than 0.01 percent of the ocean floor would be used for disposal. What total area does this represent? (113-EPA)

ALTERNATIVE DISPOSAL CONCEPTS

Response

No benefit is claimed from additional deposition after canister emplacement. For the total area needed on the ocean floor, see Emplacement, Section 6.1.4.2.b of the final Statement.

Draft p. 3.6.2

Issue

Section 3.6.1 discussed advantages and disadvantages. Suggest adding consideration of benefits of the low temperature and large heat sink resources automatically a part of the subseabed environment. (124)

Response

The benefits of the low temperatures and the large heat-sink capabilities of the ocean are being considered. The relatively small distance from the canister to the heat sink is considered an advantage.

Draft p. 3.6.3

Issue

Two--MPG1 and MPG2--are named but do not seem to come up again in the discussion. A map showing the areas, or at least listing the coordinates, would be a help. (124)

Two study areas were identified as having been chosen in the central North Pacific. Where are these study areas located? (Locate on a map.) (208-NRC)

Response

MPG areas 1 and 2 are in essentially the same location, at about 30°N, 158°W.

Draft p. 3.6.3

Issue

The Statement--"This region (the continental margin) is therefore unsuitable for consideration as a possible waste disposal site."--is too final for such a large region and cannot be justified without detailed discussion. A much more reasonable and specific statement is that made for fracture zones in the mid-ocean ridge: "On the basis of present knowledge, therefore, the fracture zones are not probable candidates as study sites."

Similarly the statement, "The abyssal plains . . . are therefore unacceptable for further consideration." should be modified. (208-NRC)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The continental margins have been removed from consideration as possible sites for waste disposal. Reasons for this include present knowledge of the abundance of biological and mineral resources in these areas; the frequency and broad use of coastal waters; the relatively low and highly variable sorptivity of coastal margin sediments; and the difficulty in developing reliable methodologies for predicting the future characteristics of sediments in these regions. Similarly, proximal (i.e. landward) portions of abyssal plains, where relatively thick and permeable sand layers generally exist, have been removed from consideration. (See also Talbert 1979 and Talbert 1980.)

Draft p. 3.6.3

Issue

The footnote on p. 3.6.3 discusses abyssal "deserts". This may be an overstatement. As abyssal depths continue to be explored, we are finding that deep areas are not biologically sterile. We know the real desert is a complex and fragile ecosystem. The lay reader, however, may interpret desert to be equal to sterile. Table 3.6.1 is more accurate and corrects the overstatement in the footnote. Suggest deleting the note entirely. (124)

Response

The deep sea is likely to be equivalent to the desert in terms of being a subtly complex ecosystem. While the deep sea has a very low standing crop, "desert" is not an accurate simile. As suggested in this comment, the note has been deleted from the text of the final Statement.

Draft p. 3.6.4

Issue

The sediment thickness is reported to be 50 to 100 meters, while in Table 3.6.1 it is given as 100 to 300 meters. (208-NRC)

Response

Sediment thickness depends upon many processes: erosion and deposition, size of the ocean basin, inputs from the continental margins, etc. Generally, the older the crust, the thicker the sediments. The sediments have a thickness of approximately zero at the midocean ridge and get progressively thicker as one moves away from the ridge across the older plates. Sediments vary in thickness from ocean to ocean as well as within each ocean. The minimum thickness presently thought to be needed (from basement rock to sediment surface) is 60 m, but this is tentative, and depends on what is learned from the ion-transport studies that are just beginning to produce results.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.6.4

Issue

A statement is made regarding waste disposal in trenches: ". . . a plate being subducted would have moved only tens of kilometers during that time (250 to 500 thousand years) and would not be subducted fast enough for waste diposal purposes." This conclusion does not follow from the discussion proceeding it in the same paragraph.

a. How far would the waste have to move during that time to be subducted fast enough for waste disposal purposes? Reference?

b. What might the impact be of the waste not being subducted fast enough? (208-NRC)

Response

In general terms the first several hundred years are the most hazardous. During that period, the plate would have moved less than 200 m, which for practical purposes means it has not moved at all. The water column in a trench is dynamic and unpredictable, and contains many complex processes such as turbidity currents and landslides in addition to those we know of in the open ocean. In other words, the most unpredictable regimes in the oceans are the trenches, and for that reason have been removed from consideration for the purpose of the Statement. Responding to the specific comments:

a. The waste would have to be moved on the order of 100's of kilometers in order to be subducted.

b. Should the waste not be subducted fast enough, it could become part of the overriding plate and end up on the continental slope.

Draft p. 3.6.4

Issue

"The time needed to contain the waste (250 to 500 thousand years)," shows again a lack of understanding of the role of containment and isolation." (154)

Response

To establish a "target" time of containment and isolation, the longest half-life of the waste constituents is chosen--that of Pu (25,000 yrs)--and multiplied by 10, which yields 250,000 to 500,000 years. The waste will contain many kinds of nuclides with widely varying half-lives, and ultimately DOE intends to separately address each nuclide, its half-life, and its necessary containment time to meet the pertinent criteria.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.6.4

Issue

It is noted here that containment is required for 250,000 to 500,000 years. This appears inconsistent with current proposed criteria, which would require that the wastes maintain their integrity until they reach a radioactivity level comparable to ore bodies. This would entail about 500 to 600 years of storage, not 500,000. (124)

Response

In establishing early criteria, ultra conservatism was used. It is felt that any radioactive material entering the water column should have lower radioactivity than natural ore bodies, and therefore a time much longer than 500 years is needed. The figure of 500,000 years may, however, be too large.

Draft pp. 3.6.4, 3.6.7

Issue

Under "Water Column," there is a statement that bottom currents are slow and uniform. However, in Section 1.3.6 the DEIS says bottom currents are weak and variable. This inconsistency should be corrected. (113-EPA)

It is stated that: 'Bottom currents in the MPG areas of the North Pacific are generally weak and variable.' A reference should be provided. How weak and variable bottom currents affect emplacement, radionuclide migration, heat transfer, etc., should be discussed. (208-NRC)

The bottom flow is not uniform and plate-like. The mean flow is thought to be slow, but there is a transient component that is related principally to the tides. Within about 5 m of the bottom there is a boundary layer that is thought dynamically analogous to the lowest 2 km in the atmosphere. See Weinbush, M. and W. Muck (1970): The Benthic Layer in The Sea, Vol. 4, pt. 1, A. E. Maxwell, Editor. (23-DOC)

Response

The discussion on water columns has been revised and condensed for the final Statement; the inconsistancy noted above no longer appears. Bottom currents are weak and variable. (See also Bishop 1975, and Talbert 1976.)

Draft p. 3.6.5

Issue

It is noted that the waste should decay to innocuous levels. It would appear appropriate to define innocuous levels. (124)

Response

"Innocuous levels" are tentatively defined as the levels that would be reached when a waste package had been allowed to decay for 10 half-lives for any radionuclide of interest. NRC and EPA are mandated by Congress to define "innocuous levels", and the definition employed in the Statement must remain nebulous until they have defined the term.

Draft 3.6.5

Issue

There should be a mention that the philosophy behind this approach is isolation of the waste. This approach is required by EPA regulations. (113-EPA)

Response

DOE agrees. Isolation is accomplished by multiple barriers.

Draft p. 3.6.5

Issue

The biological productivity of seamounts should be included in the table. (113-EPA)

Response

Reasonable data on the biological productivity of seamounts was not found during preparation of this Statement. Seamounts have not been considered for reasons of geologic stability, uniformity, and predictability. Thus, additional biological data was deemed unnecessary.

Draft pp. 3.6.5-7

Issues

The multibarrier concept discussion in Section 3.6.2.3 makes several points that need clarification:

The Near-Field Effects (Section 3.6.2.3.b) presentation fails to make clear why heating is a problem--if the canister merely sinks or the clay sediments only rise, the radioactivity is still contained. The serious risk is rupture of a canister and accelerating release or radioactivity by the heat driven movements.

The Canister (Section 3.6.2.3.f) is described here as only a temporary barrier. This statement should be highlighted, being crucial to the whole assessment.

a. Thermal behavior, coupled with breached canisters, could lead to an upwelling of a (relatively) narrow radioactive plume in the ocean.

b. The likelihood of biotransport is enhanced by the combination of thermal and solution effect. (124)

Response

If the canister sinks, it will approach bedrock which is fissured and allows high water migration rates. If the sediment rises and carries the canister upward, the sediment column and, hence, long-term barrier is rendered less effective.

The canister currently envisioned is a temporary barrier in the sense that it is intended to contain the waste only through the heat generation period after which a breached canister will release wastes at essentially ambient temperatures only. It should be emphasized that the penetrometer represents an additional barrier to waste release, and that additional engineered barriers might be incorporated into the package.

Draft p. 3.6.6

Issue

Supposing the correctness of the assumptions, the breakthrough time, T, is not a million years, but is:

$T = D^2/A = (100\ m)^2/(3 \times 10^{-6} cm^2/yr) = 3 \times 10^{13}\ yrs$ (23-DOC)

Response

The A value should be:

$$3 \times 10^6\ cm^2/sec = 3.15 \times 10^7\ sec/yr \times 3 \times 10^{-6}\ cm^2/sec = 9.5 \times 10\ cm^2/yr$$

Thus:

$$D^2/A = 10^8\ cm^2/9.5 \times 10\ cm^2/yr = 1.05 \times 10^6 yr$$

or approximately 1 million years.

Draft p. 3.6.6, Table 3.6.2

Issue

The sorption coefficients listed are credible although they could easily be 1 or 2 orders of magnitude in error. Their source should be properly explained and cited. They should not be used for transport-time calculation. (218-DOI)

Response

The sorption coefficients have been measured and their values have been documented. (See Russo 1979, Talbert 1977, Tablert 1979, Talbert 1980, and McVey 1980)

The transport time calculation is based on an assumed molecular diffusion constan wherein no interaction between the dissolved nuclides and the sediment is assumed.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.6.6

Issue

"A pore water velocity of 10^{-1} m/yr (a factor of 10^{5} over natural pore-water velocity)," reflects the hypothetical hyperbole syndrome again. (154)

Response

The reason that the calculations were so conservative is that the mass transport code which was used was not capable of using pore water velocities smaller than 10^{-1} m/yr. Even with these higher velocities, however, a water molecule did not move far, and would have been contained within the near sedimentary geologic formation.

Draft 3.6.7

Issue

Under "Basement Rocks" the fracture nature of the basalts could provide lenses for the transport of radionuclides. This should be mentioned. (113-EPA)

Response

The basement rocks are indeed severely fractured, furnishing avenues through which nuclides could be transported more rapidly than through sediments. For this reason an equal thickness of sediments above and below the canister, a minimum of about 30 meters between the can and the surface, and an equal distance between the can and the basement rocks are being sought.

Draft p. 3.6.7

Issue

Delete estimates of barrier properties, or add "if any" to read: to allow estimates of barrier properties, if any, of the water column . . . (23-DOC)

Response

The water column is not considered a containment barrier. However, it is a limited dilutional barrier. It is a large barrier to man's intrusion. Only a nation or other civilization with high technology has the capability to reach the site.

Draft p. 3.6.7

Issue

Why would one expect low nuclide concentrations around a waste canister? If the canister failed, one would expect high levels. (113-EPA)

Response

Canisters will be designed so that containment rather than failure will be expected. In the multiple-barrier concept, there is a waste form inside the canister which, if the canister failed, would release nuclides very slowly if at all, and therefore one would not expect high contamination levels.

Draft p. 3.6.7

Issue

Previous reports on the U.S. seabed disposal program have not included the water column as a design barrier. Is it the program's intention to now identify the water column as a primary design barrier to radionuclide migraton, or rather to investigate its properties as a barrier only for unexpected releases? In other words, do the conceptual plans allow for radionuclides to enter the water column during the period when they may present a hazard to man or the ecosystem? What is meant by inadvertent release? Scenarios leading to inadvertent release should be described. (208-NRC)

Response

The water column, which extends from the benthic boundary layer to the surface of the water, would only provide dilutional mitigation to the release of radionuclides. It is not considered an isolation barrier between the water and the biosphere, but is considered a barrier in the sense that it impedes man's intrusion into the subseabed repository.

"Inadvertent" means "unintended by man". It is not appropriate at this early stage of the program to develop all possible scenarios of inadvertency.

Draft p. 3.6.7

Issue

The fourth sentence of paragraph 6 appears to overdramatize the potential effect of heating and should be more realistically reworded. Also, the "risks" associated with sinking of the waste in the sediment should be explained, particularly in light of the preference for penetrometer emplacement. (58)

ALTERNATIVE DISPOSAL CONCEPTS

Response

A list of major problems has been identified as needing resolution before technical and environmental feasibility can be demonstrated. Of those that remain to be addressed, one is the movement of the canister or the sediment due to heat after emplacement. It will be two more years before assessment of the risks associated with either the sinking of the waste can through the sediment or the rising of the sediment and canister can be made. In either case, however, the risks attendant upon such movement will be minimal unless the canister is breached, which should not happen until at least 500 years has passed.

Draft p. 3.6.8

Issue

Under current EPA regulations the canister must act as a barrier until the material decays to innocuous levels. The conservative calculational assumption, that the canister will release its entire inventory of wastes, does not reflect this regulatory requirement. (113-EPA)

Response

Although the canister will be engineered to contain the waste during its initial period of high activity, calculations based on instantaneous release of the entire canister inventory of radionuclides provide the upper limit for the rate of release.

Draft 3.6.8

Issue

"Since repackaged spent fuel rods contain less (emphasis added) fissionable material and fewer fission fragments than does a similar volume of processed HLW." This is true for fission fragments, it is not true for fissionable material.

"Sediments which are hot (over 200°C) and moist." Nowhere can we find any value for the thermal conductivity of these "moist" sediments. It would seem as though the value might be higher than for conventional geologic media being considered. If so, the surface temperature of the canisters should be lower than that otherwise expected in conventional disposal systems. (154)

Response

The discussion in the draft Statement addresses the thermal impact of the waste. The higher fissionable element but lesser high heat fission fragment content of spent fuel produces much less heat in the first several hundred years than the fission fragments of HLW. The thermal conductivty of saturated sediments at temperatures of 200°C and pressures of 500 bars in the subject of current study. (See also Sandia 1980a.)

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.6.8, 9

Issue

The Emplacement Section (3.6.2.4) is incomplete and inaccurate.

- The implication is that any drillship or trenching concept would require a second ship and that no technology is known for doing both hole drilling and emplacement from one ship. Drillships can certainly do both.
- The section also implies that the penetrometer is simple and accurate. Such is not the case. It could act like an unguided glider slipping its way down into the seabed. It may soft-land, ricochet off the bottom, or enter at an angle. As a result, its position may not be known, it may not be retrievable, and it can not be considered an accurate, simple way to emplace wastes.

The retrievability discussion (3.6.2.6) is misleading. It implies that the penetrometer is easiest, and hole-drilling, the hardest. As a matter of fact, GLOMAR CHALLENGER has demonstrated time and again in the Deep Sea Drilling Program of the National Science Foundation the ability to reenter a drill hole of about 18" in diameter at a depth of 10,000 feet. On the other hand, retrieval of penetrometer emplaced items has not been accomplished in situ.

Ocean Transportation (Section 3.6.4.5) needs more thought. The docking facility, not described, is supposed to be able to handle three ships, each operating on a schedule of four trips per year. Given the realities of dock utilization, it allows each ship only about ten days per trip at the dock. There will be a lot of times when a second ship will be waiting at anchorage for dock space. This seems a bad idea for ships handling this kind of material and performing such specialized tasks. (124)

Response

Drillships can certainly be used both for transport, drilling, and emplacement. But it would not be efficient to use a drillship for transport, in which most of its time is spent going to and from the dock facility.

The penetrometer is not a "glider", making soft landings or ricocheting off the bottom. With a nose and tail fitted, it is guided into the bottom at a predetermined location and to a predetermined depth. Its position would be known from its time of release until it came to rest because it would be tracked by a transponder array on the bottom. Furthermore, present technology allows accurate position determination.

There is no implication that the penetrometer is easiest and drilling the hardest: it is stated that the penetrometer is cheapest, and drilling the most expensive. Both are established facts, having been demonstrated with scale models in the deep ocean. The only remaining questions relate to the size of a penetrometer that can handle the waste, or the size of the drill that can make a hole big enough to hold a canister one foot in diameter.

ALTERNATIVE DISPOSAL CONCEPTS

The commenter misinterpreted DOE's information about ships at the dock facility. It is desirable to have ships waiting empty at the dock so that when filling starts it can be completed rapidly, and the ship can immediately move to the disposal area and be emptied as soon as possible. Under these circumstances, 10 days at the loading dock seems reasonable. The only suboptimum factor is that having a ship at the dock waiting is not as economical as if it could load immediately upon arrival.

Draft pp 3.6.10, 22, 23, 31

Issue

Seabed disposal refers to a disposition of wastes and as such falls within EPA regulatory authority for the disposal of radioactive waste in, on, or beneath the ocean floor. The seabed disposal option for HLW is not legal under current domestic law. However, we think DOE should continue to study this option to see if this is an environmentally acceptable option. (113-EPA)

Additionally, in Section 3.6.3.6, on p. 3.6.22, the DEIS states "implementation of a sub-seabed disposal program for non-HLW is now possible under EPA's ocean disposal permit program." DOE apparently believes dumping and sub-seabed emplacement are intrinsically different for high-level waste and identical for low-level waste. We believe there is no legal difference between ocean dumping and sub-seabed emplacement and any difference between the two is purely semantic. (113-EPA)

The fourth paragraph of this section perpetuates the notion that sub-seabed emplacement is not ocean dumping. We consider the difference between the two to be semantic. (113-EPA)

Again we find the semantic difference between ocean dumping and sub-seabed emplacement. Dumping and Dump should not be in quotation marks. It is defined in the Marine Protection, Research, and Sanctuaries Act of 1972 as a disposition of materials. This misleading section should be corrected in the Final EIS. (113-EPA)

Response

For the purpose of this discussion, the DOE provides distinction between ocean dumping and subseabed emplacement to draw attention to an important factor of the subseabed concept. The subseabed concept relies on the isolation characteristics of the sediments to act as an effective barrier between the waste and the accessible environment. As such, careful emplacement into the sediments in a relatively well defined location of known characteristics followed by emplacement hole closure is essential. Conversely, ocean dumping is often used to connote an action of discarding without consideration for prolonged separation from the water column and without a proper characterization of the site.

While final legal interpretation of the existing statutes will be required to resolve the point, it is also considered possible that international agreements could be generated to allow subseabed disposal, if technical merit and minimal environmental impact can be demonstrated.

Draft p. 3.6.14

Issue

This statement requires documenting evidence or a reference. (218-DOI)

Response

The referenced statement "The benthic regions below such areas are marine deserts more devoid of life than the Sahara" has been replaced by a less restrictive statement in Section 6.1.4.5 (see Potential Events) of the final Statement. However the quotation in the draft Statement originally was derived from Talbert 1977.

Draft p. 3.6.14

Issue

Bottom sediments in the mid-plate areas have extensive animal tracks. Furthermore, fish in these areas make extensive vertical and lateral migrations; this indicates that there is a possible pathway from the waste to people. (113-EPA)

Response

Over the next 15 years, the determination of the impacts of the water column and of biological movement on the transport of radionuclides from an accident back to man is planned to be made.

Draft pp 3.6.16-18

Issue

"d. Predictability" The first paragraph is particularly appropriate to all concepts and media. The entire section is generally applicable to all geologic disposal concepts, and the subject should be addressed for all host media, not just this one. (154)

Response

It is agreed that the paragraph (as opposed to the entire section) is generally applicable to all concepts and media. Performance assessment capability to a very high degree must be developed and expressed on all concepts.

Draft p. 3.6.18

Issue

Appropriate references on these sorption coefficients need to be cited here. (218-DOI)

Response

These conditions are specified for the experiments, and the environmental conditions deep within the sediments are also being characterized at this time. (See Talbert 1979 and Talbert 1980).

Draft p. 3.6.19

Issue

These sorption coefficients mean very little unless their exact measurement conditions (chemical and physical) are described. This would include as a minimum: ionic strength and compositon of the solution, initial exchange conditions of the clay, pH and Eh of the solution, surface area of the clay, sorption equilibrium time, and solid-to-liquid ratio. (218-DOI)

Response

This figure summarizes data presented in the 1975 Seabed Disposal Program Annual Report (Talbert 1976).

Draft p. 3.6.19

Issue

This statement appears in error. ^{54}Mn shows more than a factor of 10 spread. (218-DOI)

Response

^{54}Mn does show slightly more than a factor of 10 spread; however, ion transport calculations show such conservatism that a difference covering two orders of magnitude would still be a safe and acceptable level. As pointed out, sorption characteristics are probably less important than permeability.

ALTERNATIVE DISPOSAL CONCEPTS

Draft, p. 3.6.19

Issue

Although organic complexes might be insignificant, there is a chance that carbonate (or other inorganic) complexing might be significant. This should be pointed out. (218-DOI)

Response

Inorganic complexing could indeed be a problem, but the complexing probably will come from leaching of the waste form rather than from the sediments. Carbonate complexes would be less likely since the planned water depth is well below the calcium carbonate compensation depth; therefore, there is very litte carbonate available for complexing.

Draft p. 3.6.20, line 10 from bottom

Issue

Replace "a poor" with "no" in the sentence beginning on line 20 so that it reads: For the reasons given, the water column is likely to be no barrier against large quantities of nuclides.... (23-DOC)

Response

The water column is not considered a primary barrier. However, it will inhibit man from intruding, and it can contribute both isotopic, volumetric dilutional and dispersional benefits.

Draft p. 3.6.20

Issue

Under the discussion of the water column, it should be recognized that while the water column may not provide a barrier to migration, its enormous capability to dilute such releases below significant concentrations cannot be overlooked as a mitigative feature. (208-NRC)

Response

The point is being taken into account. However, DOE considers it of secondary importance to the primary barriers (canister, waste form, and geologic formation).

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.6.21

Issue

The research and development costs to support the penetrometer emplacement concept are quoted as $250 million on p. 3.6.21, and as $60 million on p. 3.6.31. The components of each figure should be given. What is the meaning of "state-of-the-art" (Figure 3.6.1) referring to penetrometer emplacement, given the quarter of a billion dollar research and development cost estimate? (208-NRC)

Response

The presentation of costs for this alternative has been improved in the final Statement. R&D costs estimated for the subseabed program are $250 million. A reliable estimate of R&D costs for the development of the waste package, including penetrator, is not available.

Draft p. 3.6.21

Issue

The basis for the following cost estimates should be provided (including the components and assumptions for each):

a. "The resulting order-of-magnitude figure is $200 million for the capital cost of handling 1800-3600 MTHM/hr" (p.3.6.21).

b. The $25 million/year operating cost (p. 3.6.21).

c. "It is estimated that the program can be completed in 25 years at an overall cost of about $560 million including construction of one ship and a port facility" (p. 2.6.27). Details on the 25 year schedules should be provided.

d. Each of the estimated costs of the multibarrier research and development porgram (Section 2.6.6.2). (208-NRC)

Response

Cost estimates have been improved and bases have been provided in the final Statement. For details on the 25-year schedule, see The Subseabed Disposal Program Plan, Volume I, Overview. (Sandia 1980a)

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.6.22-28

Issue

See comments for 3.6.10, Section 3.6.2.8. Subseabed emplacement must comply with EPA regulations promulgated under authority given exclusively to EPA under Public Law 92-532, the Marine Protection, Research and Sanctuaries Act of 1972. (113-EPA)

Response

Prior to application for a permit to dispose of waste in the subseabed sediments it would be necessary to successfully complete several procedural steps. These would likely include (in addition to current efforts to develop necessary information and verify environmental and engineering feasibility) a licensing and public review process as well as an EPA permit.

Draft p. 3.6.23

Issue

Should high-level waste be released, it most certainly will affect other nations, contrary to the suggestions in the fifth paragraph. (113-EPA)

Response

It appears that the third paragraph is actually being discussed. No similar opinion appears in the final Statement, as it is recognized that radionuclides which might be released from any disposal facility might have wide spread effects. The content of the original thought was to express the remote nature from populated land areas.

Draft p. 3.6.24

Issue

It should be made clear that tsunamis could pose no danger to a ship that was not in shallow, near shore waters, or near the source of tsunami. Even a large tsunami would probably not be noticed by a ship in mid-ocean because of the long wave length (typically hundreds of kilometers) and relatively small oceanic wave heights (usually less than a meter). A minor storm or just rough seas would pose greater danger in mid-ocean. (208-NRC)

Response

Tsunamis would pose no difficulty for ship directed emplacement operations or ship transportation to the disposal area. Tsunamis would only be of concern for water transport activities occurring in coastal regions.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.6.24

Issue

Port accidents occurred in the 60's during the loading of 55 gallon drums. This issue should be presented. (113-EPA)

Response

It is not believed pertinent to include such a discussion in the final Statement. The practice of discarding low-level waste in 55-gallon drums has been discontinued by the U.S. due to this and other inherent problems. The handling techniques were routine industrial practice, and not consistent with those which would be instituted in a conservative nuclear waste disposal system.

Draft p. 3.6.24

Issue

The Risks and Impacts section on Land and Sea Transport (Section 3.6.5.1) makes some incorrect assumptions, based on lack of review of actual ship accident data. Although intuition suggests operating in areas of low traffic volume will reduce accidents, data show that accidents are strictly proportional only to the number of port calls made. Thus, sailing on routes that avoid traffic does no good. Similarly, double hulls are not an accident-prevention measure, but a way of reducing the chance of an oil spill from tanker accidents. Since the radioactive waste will be in some kind of canisters, double hulls are of questionable value. (124)

Response

Sandia Laboratories has a program with the Department of Transportation that will address the location and frequency of ship accidents on the basis of study results; it will guide the program toward the most safe and reliable solution to the transportation problem. Little effort has been placed on ocean transport up till now because it is of greater importance to assess the technical, environmental, and engineernig feasibility of the concept before major monetary outlays are made for transportation studies.

DOE agrees that double hulls do not prevent accidents. However, they do decrease the chance of a ship sinking or the cargo (waste canisters) being damaged as the result of a collision.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.6.24

Issue

Is it proposed that several canisters go into one hole in the seabed, or will each penetrometer drop wherever it may, to be followed by monitoring of 9000 different holes per year? (113-EPA)

Response

If penetrometers are used, only one will be emplaced per location. If emplacement is by drilling, the number of canisters to be placed in each hole will be determined by the total thermal load allowed per unit horizontal area. In either case, monitoring will be of a region covering several canisters rather than of individual canisters.

Draft p. 3.6.25

Issue

Several ports have banned the shipment or recipt of spent fuel. Does the proposal include use of dedicated port facilities? (113-EPA)

Response

It is assumed that the program will utilize a military facility on one or both coasts. This facility would be dedicated for the time of disposal of the wastes.

Draft p. 3.6.26

Issue

Consideration of meteorite strike is truly incomprehensible. (154)

Response

It is agreed that the probability of meteorite strike is so small as to be almost incomprehensible. The discussion is included in the final statement, however, primarily because a similar scenario is evaluated for the mined repository, to which the subseabed concept must ultimately be compared.

Draft p. 3.6.26

Issue

What is the range of error in the results of the "unverified, theoretical model" in projecting impact? (113-EPA)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The range of errors will not be determined until the systems analyses are completed and the models are verified.

Draft p. 3.6.26

Issue

The assumption of 0.5 MT of HLW per canister is appreciably lower than 2.5 to 3.0 MT usually assumed for HLW canisters and should be explained. (58)

Response

The assumption of 0.5 MT of HLW per canister is based on preliminary results from studies of the near-field sediments and canister corrosion, which indicate that canister interface temperatures of approximatey 200-250°C should not be exceeded. Reasons are: (1) sediment mineralogic and flow characteristics are not appreciably altered at these temperatures, and (2) it is postulated from preliminary corrosion data that a canister capable of 500-year integrity can be obtained if the temperature remains below 250°C.

Draft p. 3.6.28

Issue

"...identifying centimeter-size imperfections in the sediment surface and decimetersize imperfections at depth."

On what basis were these quantitative criteria developed? Why are such criteria only here and not defined for imperfections in the host media of other concepts? (154)

Response

The final criteria for subseabed siting has not been developed and it is unlikely that identification of imperfections of this size will be required, even if the capability exists, unless a definite need is identified. As far as the need for similar criteria in other concepts, no obvious requirement exists.

Draft p. 3.6.29

Issue

Measurements of molecular diffusion coefficients will be needed for near and far-field transport analysis. (218-DOI)

ALTERNATIVE DISPOSAL CONCEPTS

Response

This is true. Current efforts focus on the use of formation factors to correct free seawater molecular diffusion coefficients to in situ values. Site-specific measurements will be made as potential disposal sites are identified.

Draft p. 3.6.30

Issue

Is the $15 million mentioned for R&D costs? If not, what costs does that figure represent? (113-EPA)

Response

The $15 million is for R&D costs only.

Draft p. 3.6.32

Issue

The sixth option should be clarified. Considering the dollar input, what is the intent and what will be the output? (113-EPA)

Response

The intent of the sixth study area is to promote international cooperation in providing for assurance of the environmentally acceptable use of the oceans and subocean geologies for isolation of radioactive waste. The cost for this activity is small when compared to the international cooperative benefits to the U.S. in providing for assurance of acceptable methods for disposal of radioactive waste.

Ice Sheet Disposal

Draft p. 1.27 and 1.37

Issue

It should be clarified that we are waiting for development of disposal techniques not development of ice sheets. (34)

Response

The wording of this statement has been corrected in the final Statement.

ALTERNATIVE DISPOSAL CONCEPTS

Draft Section 3.7

Issue

Ice Sheet Disposal unacceptable because of the possible interactions between waste, ice sheets and weather variations. (88, 121)

Response

The ice sheet disposal concept is not considered a preferred alternative for the disposal of radioactive waste. One reason is that there are significant environmental impact uncertainties associated with this concept. Section 6.1.5.3 of the final Statement addresses the areas of uncertainty. Section 6.2 presents a comparison of alternatives that further discusses the importance of these uncertainties.

Draft Section 3.7

Issue

Ice Sheet disposal - This entire section should be rewritten. Additional data from the Dry Valley Drilling Project, and the Ross Ice Shelf Project provide significant additional geologic scenario. (43)

Response

Alternate concept sections presented in the draft Statement have been significantly revised for the final Statement (see Chapter 6.0). The final Statement presents environmental and other information believed to be sufficient for comparison of the alternatives.

Draft Section 3.7

Issue

The general overall caution and concern voiced in this section about using the ice sheet method is concurred with. This section (3.7) is better presented than 3.6 or 3.5 because it treats the uncertainties in a clearer fashion. (124)

Response

In the preparation of Section 6.1 of the final Statement effort was made to present the concepts in an equivalent and more comparable manner. However, complete equivalence of presentation was not possible because of the underdeveloped status of many of the concepts.

ALTERNATIVE DISPOSAL CONCEPTS

Draft Section 3.7

Issue

This concept would provide a high degree of isolation (our terminology - make man's intrusion unlikely). However, the litany of unresolved technical and political problems make it clear this concept cannot possibly be considered for an early repository. Furthermore its cost would likely rule it out for even much later consideration. (154)

If the 1% heat load criterion is reasonable (draft p. 3.7.8) then it should be stated and the high area (7%) demand would rule out the Antarctic approach. This report requires better perspective to be useful. A clear statement should be made to rule out this alternative. (124)

The 10-30 years of extra lead time required for ice sheet disposal, as compared to other disposal options, will delay implementation of a publicly acceptable nuclear waste management system...(Section 3.7.5.4) should be highlighted, because it makes this option extremely unattractive to comparison to others whose technology is more developed. (124)

Response

Section 6.2 of the final Statement presents a comparison of the attributes of alternative concepts and the mined repository. This comparison employs the use of standards for judgment to evaluate the concepts for the purpose of identifying preferred concepts. In general, concepts that have significant technical and environmental performance uncertainties are lower in preference than the better defined concepts. The ice sheet concept is, therefore, one of the lesser preferred concepts.

Draft Section 3.7

Issue

The section treats rather severe transportation problems in a rather causal manner and without appraisal of non-radiological hazards. A more thorough and complete treatment of transportation, including accident and non-radiological hazards, should be provided. (58)

Under Section 3.7.1.5, the risks, hazards, and impacts of transporting HLW over ice in polar climates should be presented. (208-NRC)

The quality of the reasoning contained in the DEIS might be called into question by the apparently serious consideration of rather bizarre and untested methods of transport and emplacement of the waste in the Antarctic ice-sheet. The horrendous logistics problems of the Antarctic repository are discussed at length with no apparent consideration of the need for recognition and quantification of non-radiological hazards. (58)

ALTERNATIVE DISPOSAL CONCEPTS

Response

It is acknowledged that the safe transportation of wastes to and over the Antarctic ice would pose formidable engineering design and operations problems. It is believed, however, that the uncertainties of the ice emplacement medium itself and the Antarctic environment should receive greater attention for this Statement. There is no intent to minimize the other important issues such as those presented by the commenters. See Section 6.2 of the final Statement for comparative discussion of transportation characteristics for the alternatives and the mined repository.

In addition, Section 4.5 of the Predisposal Systems Chapter discusses transportation alternatives (including sea transport) in a more detailed and thorough manner than in the draft Statement. Quantitative and qualitative assessment of impacts were presented whenever possible using the most recent data available.

Draft p. 3.7.3

Issue

It is not clear why the example heat criterion is a factor of 20,000 less than that used for salt. (154)

Response

The criterion referred to was presented only for the purpose of providing a frame of reference regarding how heat load criteria might affect the land area required for disposal. The first sentence of the referenced paragraph of the draft Statement stated that additional study would be required to determine the heat load criteria for waste emplacement in the ice sheets.

Draft p. 3.7.3

Issue

It is proposed that aircraft be utilized to ferry waste canisters to emplacement sites. This is judged to be a poor choice in that risks of severe air transportation accidents are much higher than for ground transportation modes. (124)

Response

Section 6.1.5.2 of the final Statement notes that over-ice transport of casks via land vehicles is the preferred alternative (as opposed to aircraft).

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.7.4

Issue

A small body of data have been advanced in the past few years of more recent local glaciations (alpine type) and flooding of the dry valleys. Glacial permafrost drift locally exceeds 300 meters in Taylor Valley. (43)

Response

The referenced information would be reviewed for development of the ice sheet concept.

Draft p. 3.7.4

Issue

It is not clear why more is not made of the dry valleys since they seem to be more suitable than the ice itself. (124)

Response

The final Statement discusses the use of ice-free areas of polar regions called "dry valleys" as possible interim waste canister storage locals. A mined repository in dry valleys would be considered akin to the conventional geologic option and therefore subject to the same considerations.

Draft p. 3.7.7

Issue

Transportation - How many tons per year are we talking about? The realistic shipping season is two-three months (more like two months). Can the ground transport system handle the projected volume? In recent years, about one aircraft accident per year has occurred. The safety records, although enviable for harsh environmental areas, are still not good enough for carrying large quantities of waste. (43)

Response

While it is agreed that the severity of air transportation accidents is usually greater than that of surface transport accidents, the risk of air accidents involving radioactive materials has been demonstrated to be much lower than that of surface transport accidents. Careful consideration of the modes of transport would be a necessary part of any program to safely dispose of radioactive waste. See Section 4.5 of the final Statement for additional discussion of transportation issues.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.7.9

Issue

The cost figure (Table 3.7.1) seems to be low. Recent purchases of C-130's for polar work are expensive. Logistics support is extremely high. The present WSARP (NSF) program is about $40 million per year to support about 1,000 men and women in the summer and about 40 in the winter. About 90 percent of the costs are in logistics, and less than 10 percent is useful science. The environmental impact of large scale technology in polar regions may be too much to pay. (43)

Response

Cost figures have been updated in the final Statement (see Section 6.1.5.6).

Before such a disposal option would be implemented, a thorough study of environmental impacts would be made to determine acceptability in terms of environmental "costs". Section 6.1.5.4 addresses environmental concerns for the concept.

Draft p. 3.7.10

Issue

Disposal of wastes in an ice sheet would probably entail loss of control of spacing of waste containers. Flow velocities and perhaps even flow directions might change over long periods. Possible impacts should be evaluated. (218-DOI)

Response

Environmental impact uncertainties of ice sheet disposal are addressed in Section 6.1.5.5 of the final Statement. Impacts beyond those reported are not currently known due to incomplete development of the the ice sheet concept.

Draft p. 3.7.10

Issue

This statement should mention that there is one more handling and transportation step in ice disposal than in subseabed disposal-- from the unloading dock in the ice disposal site. (218-DOI)

Response

Section 6.2 of the final Statement includes a comparison of alternative concepts including ice sheet disposal and subseabed disposal transportation systems. The statement also includes the above-mentioned leg under "transport and handling", Section 6.1.5.1.

Draft p. 3.7.10

Issue

This statement (first item) is debatable; the fact that these remote areas are relatively unexplored for resources might attract considerable exploration in the future as some of the last frontiers for new discoveries. (218-DOI)

Response

The text of the final Statement has been revised to incorporate consideration of potential future exploration of remote Antarctic areas.

Draft p. 3.7.10

Issue

Elsewhere in the text sub-ice lakes are identified. Present hydrogeologic studies strongly suggest that the sub-ice lakes provide the groundwater for the discharges in the dry valleys. One drill hole by the Dry Valley Drilling Project (DVDP 13) identified upward moving groundwater at -16°C at a depth of 150 meters. The water appears to have moved through fractures in the crystalline bedrock. Preliminary heat flow studies by DVDP suggest high heat flow (equivalent to the basin and range province of the U.S.), and the possibility that uranium has been leached to a depth of 300 meters. (43)

Response

It is believed that the comment refers to the discussion of dry valleys presented in the draft Statement. If so, a repository located in bed rock caverns would be subject to the same site selection and site assessment criteria as those located in the continental U.S. Site hydrology would necessarily be completely characterized before a selection would be made. The referenced information and a great deal of additional hydrologic data would be included in the characterization.

Well Injection[a]

Draft p. 1.28

Issue

Although grout injection technology is rather well established, long-term durabilty of grout seals is unknown. It appears that considerable effort is needed to develop grout types and sealing techniques that can be relied upon with confidence for many millenia. (218-DOI)

(a) This concept was called "Reverse Well Injection" in the draft Statement.

ALTERNATIVE DISPOSAL CONCEPTS

Response

The need for seal systems development is discussed in the final Statement in Section 6.1.6.3, Status of Technical Development and R&D Needs. Estimates are not currently available for cost or time to develop technology that would be necessary for the implementation of the well injection concept. See Section 6.2 of the final Statement for a comparative assessment of alternative waste disposal technologies.

Draft p. 1.28

Issue

What advantages does the reverse well disposal alternative have? It is not clear why it is being considered. (34, 154)

Response

The well injection concept involves pumping grout slurry wastes to depths from 1000m to 5000m into porous or fractured rock strata which would be isolated from the biosphere by relatively impermeable overlying strata. The grout mixture would harden to a low leach mass. This is a relatively low cost alternative concept designed to retard nuclide movement by minerals within the rock strata. Because of the depth of disposal, the probability of a breach by either natural or human induced events are low. See Section 6.1 of the final Statement for additional discussion of the well injection concept. Also see Section 6.2 of the final Statement for a discussion of the attributes and disadvantages of a alternative concepts and the mined geologic repository.

Draft pp. 1.28 and 1.32

Issue

The discussion and assessment of the reverse well injection alternative should include a general consideration and evaluation of the vertical separation of individual plates or sheets of injected waste-bearing grout. Consideration of the impacts of the alternative should also include at least generalized assessment of effects of possible deviation of sheets from bedding planes and possible unplanned or unscheduled accumulation of wastes in any given zone. (218-DOI)

Response

Consideration and evaluation of the vertical separation of individual plates or sheets of injected waste-bearing grout would be important in the design of a well injection disposal system. For example, the number of grout sheets and their separation would be dependent on the gross thermal loading acceptable for the host rock.

Such information is not currently available for HLW waste injection. Other information that is presented in the final Statement should be adequate, however, to provide a comparison of the technical alternatives for the disposal of HLW, spent fuel, contact handled TRU, and remote handled TRU wastes.

An example of the assessment of deviation of grout sheets from a horizontal is given in the Environmental Statement for the ORNL operation.

Draft p. 1.29

Issue

The total capital cost for grout injection facilities at all five disposal sites is estimated to be $300 million with $10 million for annual operating costs. To which fuel cycle does this apply? Also what type of wastes do 12 states prohibit from being injected into deep wells? (147)

Response

Section 6.1.6.6 of the final Statement contains a more up to date and accurate discussion of cost. The type of waste that "12 states prohibit from being injected into deep wells" is high level waste.

Draft Section 3.8

Issue

The report treats Shale Grout Injection as a form of Reverse Well Injection. The latter should be treated separately, since the shale fracture aspect and the waste fixation in grout represent very different forms of isolation than that for reverse well injection of liquid waste in porous formations. (11)

Response

In preparing the final Statement, the section on well injection (Section 6.1.6) was revised in order to more clearly delineate between the shale grout injection and the reverse well injection techniques.

Draft Section 3.8

Issue

In today's climate, and considering the exquisite detail with which the possibility of leaching of highly insoluble waste forms might occur was discussed in Section 3.1, it is inconceivable that either "reverse well" concept could possibly be acceptable politically in any foreseeable future. (154)

ALTERNATIVE DISPOSAL CONCEPTS

Well developed technology for this option is seriously offset by uncertainties regarding the ability to demonstrate satisfactory long-term isolation which is strongly dependent on the host geohydrological system. (124)

Response

A major disadvantage of the well injection concept is that the waste form is not compatible with the multibarrier concept which is considered important for technical conservation. Attributes and disadvantages of the alternate concepts are compared in Section 6.2 of the final Statement.

Draft Section 3.8

Issue

The section adequately enumerates the advantages, disadvantages, and potential problems that must be addressed if well injection is to be used as a method of radioactive waste disposal. There are several considerations which, although briefly mentioned in the report, realistically cast serious doubt on the entire concept of utilizing well injection as as safe method of radioactive waste disposal.

Beginning with the shale-grout method, the critical aspects are the control of the orientation of fractures in which the waste is implaced, the leachability of the shale-grout mixture and its stability over time in a groundwater environment, the relatively shallow depth at which the waste is stored and the problems in maintaining an undisturbed or unpenetrated geologic environment over long periods of time.

In isotopic homogenous model studies, control of hydrofracture orientation is accomplished in a relatively straight-forward manner. In a real geologic environment, anisotropy and inhomogeneity are the rule. In addition, existing fracture systems controlled by post depositional stress on the rock units and later tectonic forces are present in rock units from grantite to poorly consolidated glacial-till. Those zones of weakness are difficult to detect in rock cores but will be the controlling factor in the orientation of artificially induced fracture systems, as important as the vertical and horizontal stress components discussed in Section 3.8.

The effects of existing fracture and joint systems should be addressed in a much more specific manner. It is probable that the presence of fracture systems will be found in any proposed repository zone and that their presence would be cause for the elimination of the shale-grout disposal method.

A further note here which is also applicable to the other following points of discussion is that in groundwater flow through shales of low permeability it is the fracture system which will control the amount of water flowing through the unit and not the low permeability of the shale itself.

This leads to the leachability and stability of the grout mixture. The binding agent is a combination of calcium carbonate and calcium silicate, both of which will be undersaturated in most flow systems encountered at the shallow depths required for this system. The stability of this binding agent should be addressed in more detail. It is not sufficient to rely on the presence of the shale to sorb any ions released by the dissolution of the cementing agent as most flow will be occurring in fractures created in the shale-grout mixture. (43)

Response

The effect of existing fractures and strength anisotropy when known can be included in an analysis of propagation directions. With multiple fracture sets, the combination of in situ stress and strength anisotropy will determine the fracture propagation direction. Depth limitations based on probable in situ stress conditons in the continental U.S. are discussed in the draft Statement in Section 3.8.1.4, and the final Statement in Section 6.1.6.2. Section 6.1.3, R&D Requirements, of the final Statement discusses the need for the collection of geologic data before the well injection concept could be implemented. The fracture permeability of shales is recognized as important (see Section 3.8.2.1 of the draft Statement)

Section 5.2.2.5 of the final Statement provides a discussion of requirements for depth of waste emplacement.

References 45 and 46 from the draft Section 3.8 contain data on the extensive testing undertaken by ORNL on grout leachability. Section 6.1.6.3 of the final Statement, R&D Requirements, briefly addresses waste material development needs.

Draft p. 3.8.1

Issue

A brief paragraph on retrievability appears. There is no assurance that the liquid waste, once pumped into a porous medium, is totally retrievable, a certain fraction of the waste will remain "captive" within the host rock. Total recovery, at any cost, is likely not attainable. A more detailed discussion focusing on the impact of partial recovery should appear. (208-NRC)

Response

The impacts of partial recovery are not yet fully known. Methods for effecting corrective action and the cost and benefits of their use would be a necessary development for the implementation of the well injection concept. See Section 6.2 in the final Statement for a comparative discussion of attributes including those pertaining to corrective action.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.8.2

Issue

One suggested storage media is depleted hydrocarbon reservoirs. There are obvious problems with this, as additional hydrocarbon reservoirs are often found beneath depleted fields. Recovery from the underlying reservoirs would necessitate penetrating the liquid waste reservoir. As improved hydrocarbon recovery techniques are continually being developed, utilization of depleted hydrocarbon reservoir area storage medium may preclude recovery of otherwise-available natural resources. (208-NRC)

Are there any other examples of porous fractured strata that could be used for deep well injection that would give a more balanced treatment to this concept? (208-NRC)

Response

The use of hydrocarbon reservoirs was introduced as an example of present-day reverse well disposal which is typically used, for example, for oil field brines. However, it may be that hydrocarbon reservoirs would not be considered suitable for toxic or radioactive waste due to the numerous wells, some of which may be inadequately plugged for radioactive waste isolation, and the possible sterilization and prevention of future resource recovery. Deep well injection at the Rocky Mountain Arsenal was into a porous fractured rock. Details are given in Reference 37 of the final Statement.

Draft Section 3.8

Issue

Shale-grout wastes would be irretrievable--what about well contamination and other underground water currents? Ten million a year is an unacceptable burden to taxpayers. (88, 121)

Response

Leaching of the grout is recognized as the probable primary pathway to the biosphere. It would, therefore, require extensive laboratory and field testing to ensure that release rates are such that concentrations in the biosphere would be within acceptable limits.

A comparative assessment of the costs for the well injection is presented in Section 6.2 of the final Statement.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.8.9

Issue

The discussion here of retrieval fails to address the potential reasons for retrieval or the net risk reduction that might be achieved. A more thorough treatment would probably indicate retrieval to be more harmful than beneficial. (58)

Response

Corrective actions for the well injection concept have not yet been developed. Identification of the risks and benefits of possible corrective actions would be a part of this development.

Draft p. 3.8.9

Issue

The discussion on retrievability ought to address what fraction of the waste might be retrievable. It is difficult to see how the retrievable fraction could be much more than 0.5. (154)

Response

For well injected waste, retrievability would be species-dependent and thus would be likely higher for ^{137}Cs than for transuranics. It would depend to a great extent to the reactions which take place in-situ between the injected waste and the host medium. Current information is insufficient to estimate the fraction of each species that would be retrievable or the method by which such retrieval would be effected.

Draft p. 3.8.9

Issue

The suggestion of acid flushing for retrievability is alarming. The unpredictabiity of solution mining is well known and acid flushing could never be justified in licensing procedures. (124)

Response

Reverse well disposal would generally be considered non-retrievable. The use of an acid as a flushing material for recovery would only be as a last resort. The use of acid flushing techniques might not be acceptable in licensing procedures, but it is mentioned in the final Statement for completeness.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.8.10

Issue

How can this dismissal of the problems of isolation for these concepts be rationalized with the 50 or more pages of detailed consideration given to these possibilities in Section 3.1? The Final EIS could apply this assessment to geologic disposal, but undoubtedly will not. In which event it should recognize that these concepts are as susceptible to intrusion as conventional geologic disposal -- or more so. (154)

Response

In the preparation of Section 6.1 of the final Statement effort was made to provide balance in the discussion of alternative concepts. However, in many cases because of the relatively undeveloped nature of the alternatives the information presented cannot reflect the breadth and depth of consideration given to the mined geologic repository. Section 6.2 of the final Statement takes this into consideration in the presentation of comparisons of the alternatives and the mined geologic repository.

Draft p. 3.8.10

Issue

The failure to distinguish between the concepts of containment and isolation (as we define them) is endemic to the entire Draft EIS but is more rampant than in these four pages. The two subsections labeled "Isolation" start with two and three bullets, respectively, which speak to the containment of waste. There then follows in each subsection the following statement:

> "isolation formation unlikely to be susceptible to breaching the natural events (tectonism, volcanism, meteorite impact) or man-made events (resource investigation or exploitation, surface or subsurface activities, acts of war or sabotage)." (154)

Response

Please refer to the Glossary in Chapter 8.0 of the final Statement.

Draft p. 3.8.11

Issue

Candidate Geologic Environments: Effects of local stresses and conditions -- such as varying topographic load and joint patterns -- on uplift resulting from reverse well injection should be further examined in the course of testing suitable monitoring methods that would not penetrate the individual waste sheets. (218-DOI)

Response

The use of uplift measurement in the area of grout injection is currently being used at ORNL to monitor performance.

Before the well injection concept could be implemented for HLW it would be essential that the total R&D program be supported by a data base that would cover all the components affecting performance of the disposal system. The effects of local stresses upon uplift resulting from well injection would likely be further examined.

Draft p. 3.8.13

Issue

It is indicated in the third sentence that the waste (emplaced by means of the reverse well option) is subject to rather simple unauthorized retrieval, however, Table 1.8 on p. 1.34 accords the reverse well option a 5 rating on susceptibility to short-term encroachment. The assessment of the withdrawal should be made more quantitative and the apparent discrepancy in characterization of the option should be clarified. (58)

Response

A discussion of retrievability is presented in the final Section 6.1.6.2. It provides a discussion of the retrievability of wastes and makes note of the fact (for liquid injection) that certain isotopes, for example ^{137}Cs, will likely remain in solution while others may be fixed by the host rock. Section 6.1.6.7 provides a discussion of safeguards issues important to the concept. Section 6.2 provides a comparative assessment of the alternatives in which corrective action, safeguards and future human intrusion, along with other factors are considered. Wastes that would be emplaced by well injection are considered irretrievable.

Draft p. 3.8.13

Issue

In the next sentence (at the top of page 3.8.13) the following is stated as a disadvantage of the concepts:

> "The waste may progressively disperse and diffuse throughout the permeable host rock and eventually encompass a large area (volume?) although at a lower concentration and after decay has occurred."

This would be a good place to pick up and expand upon this 'equilibrium fringe release' concept. In the longer term what is needed is isolation and that reducing concentration is the ultimate in isolation. Thus this is an advantage for these concepts, not a disadvantage. (154)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The final Statement states that the waste may progressively disperse and diffuse throughout the permeable host rock and eventually encompass a large volume, although at a lower concentration. The concentration may be variable and unpredictable. Thus there is no assurance that the waste would be diluted.

A discussion of currently accepted performance requirements for disposal of radioactive waste is presented in Section 6.2 of the final Statement.

Draft p. 3.8.19, 20

Issue

The following statement:

> "Geology. The predictive capability of the geological sciences for basic parameters such as rock type, lithology, and structure is well developed using drilling, mapping, and geophysical techniques. However, minor variations in these parameters are of significance in deep well injection. Investigation and predictive methods for structural features (joints, faults) and lithologic or geochemical variations will require improvement."

stands in stark contrast to multiplicity of pages of geological discussion in Section 3.1. Again the treatment throughout the Final EIS should be more consistent. (154)

Similarly the following statement on sealing technology

> "Sealing Technology. Abandoned exploration and monitoring drill holes extending into the disposal formation, together with the injection well, consititute possible pathways to the biosphere. These penetrations of the containment formation are particularly critical for the deep well liquid injection concept where the waste is in a pressurized mobile form. Until techniques are proven for sealing drill holes, care must be exercised in drilling candidate areas. In particular, all drill holes must be accurately surveyed, both at the surface and by down-hole instruments, and records of drillings, casing losses, caving strate, hole closure and backfilling must be maintained.

is likewise inconsistent with the extensive discussion of this problem in Section 1.3 where the waste is not in a pressurized mobile form. (154)

Response

Section 6.1 of the final Statement has been significantly revised and improved with the purpose of facilitating comparative assessment between alternative concepts and to establish consistency within the Statement. However, because of the relatively lower state of development of the eight alternatives to that of the mined repository, equal depth of treatment

is not possible. Section 6.2 of the final Statement addresses the issue of technical uncertainity in its presentation of comparative assessment of alternatives.

Draft p. 3.8.24

Issue

Has reverse well injection in salt beds been considered? Salt is not mentioned among media under consideration. It has been found to be amenable to bedding plane fracture. (218-DOI)

Response

Reverse well injection in salt has not been considered since the methods generally involve use of water which is normally considered incompatible with a salt host medium to be used for waste disposal.

Draft p. 3.8.25

Issue

Under Data Needs the statement

"Data Needs. Present geological knowledge is adequate for generic studies and identification of a number of candidate sites. Site-specific studies will require more detailed investigations, in particular the stratigraphy and lithology of the disposal and containing formation, geochemistry of strata and fluids, and structural features."

is not consistent with similar discussions in Section 3.1. (154)

Response

Section 6.1.6.3 of the final Statement discusses the status of technical development and R&D needs for the well injection concept. Under the heading Development of Criteria for and Categorization of Siting Opportunities present geologic knowledge is judged suitable only for preconceptual generic studies and identificaion of candidate site (emphasis added).

Draft p. 3.8.29

Issue

In view of grout injection experience at ORNL and liquid chemical injection at other U. S. Government locations, the statement made in paragraph 4 concerning the lack of adequate monitoring data is not appropriate. (124)

ALTERNATIVE DISPOSAL CONCEPTS

Response

In veiw of grout injection experience at ORNL and liquid chemical injection experience at other U. S. Government locations, some monitoring data are available. However, the lack of data completeness and lack of consensus on data interpretation at these well sites supports the Statement's position.

Issue

Reverse-well Disposal involves the injection of solutions or slurries without the great expense of verification and encapsulation. A shortcoming of the concept is that the boundaries of the repository are determined by the local characteristics of the shale and will not be precisely predictable. If, however, the solution or slurry were pumped into a mined cavern that had been carefully inspected and tested this shortcoming would be avoided. If the reprocessing plant were constructed directly above the repository, the risks of waste handling and transport would be minimized. (6)

Response

The use of a slurry in mined cavern would be a variation on the waste form from which would be used in mined disposal. This waste form would probably not be compatible with the multibarrier concept for the conservative design of waste package systems. For a discussion of the requirements for one waste form and waste package, see Section 5.1.2 of the final Statement.

Transmutation [a]

Draft Section 1.3.9 and 3.9

Issue

Section 1.3.9 (and Section 3.9) describes an option for partitioning and transmutation. A variant of this, which could be utilized near term would be pre-solidification treatment and separate packaging of the more highly radioactive species (e.g., Cs, Sr, Te, etc.). This should be discussed in the GEIS, since it does not require the development of transmutation technology, and would facilitate the recovery of the many useful resources in the waste. (198)

(a) This concept was referred to as "Partitioning and Transmutation" in the draft Statement. The discussion of partitioning as a predisposal treatment alternative can be found in final Section 4.3.2.

Response

Utilization of separated constituents from spent fuel waste has been studied for many years and no practical demand has developed. There appears to be no urgent current reason to separate unsalable fractions. The concept of partitioning highly radioactive species can be applied in conjunction with the space disposal option, as discussed in Section 6.1.8.

Draft Section 3.9.1

Issue

Several commenters noted that in a discussion of the disadvantages of the transmutation option, the Statement did not make a clear presentation of the pros and cons of the concept. (58, 124)

Response

In the preparation of the final Statement, efforts were made to provide a balanced discussion of the advantages and disadvantages of the concept using the most current information available in the technical literature.

Draft Section 3.9.1

Issue

In Section 3.9.1.2 the disadvantages of increased thermal loading is misleading. In fact, it may be advantageous to separate the high heat producing isotopes (e.g., dilution to control volumetric heat generation of such nuclides). It is suggested that the counter argument to this disadvantage be included in the list of advantages. (124)

Response

The statement was misunderstood here. Partitioning certain high level isotopes reduces the bulk waste heat generation rate. Partitioning of long-lived transuranics reduces the time at which the bulk wastes are radiologically significant. Disadvantages, as pointed out in the Statement, center on the added costs and risks to both occupational groups and general population.

Draft Section 3.9.2

Issue

It is difficult to recognize the future importance of transmutation. Since the authors of the EIS have apparently utilized availability as an important parameter for applicability in disposing of nuclear waste, it is a foregone conclusion that transmutation cannot be taken seriously. (124)

ALTERNATIVE DISPOSAL CONCEPTS

Response

This factor is an important reason for the low potential indicated in Section 6.2 of the final Statement. A number of other apparent deficiencies are also inherent to the concept as presented in Section 6.1.7.

Draft Section 3.9.2

Issue

This very well written section throughout puts partitioning and transmutation into reasonable perspective. It clearly notes in several places (for example at page 3.9.1) that

> "partitioning may be a pre-disposal option, but it can never be a final disposal option by itself."

In this sense the discussion is out of place in the same way that Section 3.2 is. Neither is a disposal option and they should not be presented in the Final EIS on the same level as alternatives which might become disposal options.

The only quarrels we have at all with this section as written are:

1) It should be reglated to a Predisposal Option Appendix.

2) It should state the obvious conclusion which comes through at nearly every page--this predisposal option has no usefulness in the near (30 years) term and its likelihood of every being cost-beneficial is very close to zero. (154)

Response

The comments are well taken. Transmutation as treated in the revised Section 6.1.7, however, does have some potential as a disposal option in the elimination of the long-lived actinides but has a number of drawbacks. Practical achievement of this potential appears questionable. The discussion of partitioning is now in Section 4.3.2.1 on predisposal options of the final Statement.

In the revised version of the GEIS, Section 6.2, Comparative Assessment of Disposal Alternatives, relegates Transmutation to a very low order of priority as an alternative for ultimate waste disposal. This evaluation and its presentation essentially confirm the comment.

Draft Section 3.9.2

Issue

Partitioning and Transmutation - not applicable because of transportation costs, increased cost of waste treatment, and it does not eliminate the need for final disposal of the waste. (88, 121)

Response

The factors enumerated certainly would need to be considered in evaluating partitioning and transmutation. If the long-lived actinides could be fully eliminated in a reasonable time period, the approach might be worth the cost. It does not appear, however, that we can achieve that goal.

Draft Section 3.9.2

Issue

The last sentence in the first paragraph should be changed to read "may require." The certainty of the statement depends on potential uses of transmuted wastes. Future reqirements may not have been adequately analyzed at this time. (124)

Response

The certainty of the original statement still seems appropriate, since the residual product of actinide transmutation remains a mixture of fission products. Although some of these may find uses in the future, the bulk of them will have to be isolated securely from the environment.

Draft Section 3.9.3

Issue

It is difficult to verify that decommissioning and disposal of hazardous reagents create additional complicated radionuclide logistics. Keeping programs in perspective, decommissioning impacts for reference fuel cycles are highly speculative, and thus to discuss nuclear waste streams as being a disadvantage is highly speculative (from a decommissioning standpoint) and should be omitted. (124)

Response

It is agreed that little practical experience exists for decommissioning of fuel cycle facilities. However, the intent of the statement was to point out, at least indirectly, that an effective transmutation program requires a considerable number of reactor recycles to completely transmute the candidate radionuclides, since only 5 to 7 percent are transmuted in a typical cycle. Thus the number of fuel cycle facilities which must ultimately be decommissioned is considered larger than other concepts. Also since the chemical processes used for separation (partition) of nuclides prior to re-cycle are complex, an increased volume of contaminated reagents, relative to most other processes will be generated. Similarly, different waste systems are introduced by the processing complexity.

Therefore, the conclusion drawn was that the number of facilities, increased volumes and greater diversity of waste streams would imply a more complicated waste management program.

Draft Section 3.9.5

Issue

The length of this secton (3.9.5) could be reduced to that of the last paragraph since most of the remaining information has been previously discussed. (124)

Response

A revised version of the section on partitioning and transmutation appears as Section 6.1.7, Transmutation. This revision should be found more succinct. In particular, secondary impacts from partitioning are reflected in an expanded section, 6.1.7.4, Impacts of Construction and Operation (Preemplacement).

Draft p. 3.9.9

Issue

The discussion of iodine partitioning is somewhat misleading. Partitioning is accomplished by air-sparging of the dissolver solution to force the last few percent of iodine into the off-gas. The Iodox process is one of several possible methods for recovery of iodine from the off-gas. The hazard posed by the 1% or less that is not removed from the solution should be quantified and put in perspective.

The consideration of the disposal of recovered iodine appears to have failed to include consideraton of isotopic dilution as an added protection against hazards arising from possible release from geologic confinement at some time in the "distant future." Emplacement of iodine wastes, either in seabed sediments or salt depositories (assuming iodine content similar to seawater), would provide a high degree of protection against the possibility of significant future up-take of ^{129}I by any individual. (58)

Response

The discussion of iodine partitioning now appears in Section 4.3.4.2, Gaseous Radionuclide Recovery. The new Transmutation Section 6.1.7 deals with actinide partition and transmutation. Accordingly, there is no specific treatment of the I^{128} hazard, but the general treatment in 4.7.2.3, Radiological Effects of Reprocessing Fuel Cycle Waste Management, is considered adequate to the purpose of the GEIS. The points made pertaining to mitigation of the potential hazard of iodine release are certainly valid.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.9.11

Issue

It appears that the concern expressed over escape of ^{14}C from a geologic repository at some time in the "distant future" is more qualitative than quantitative. The basis for such concern should be qualified in relationship to natural ^{14}C background, including consideration of half-life, isotopic dilution, and biological uptake. It would appear that disposal options affording isotopic dilution (e.g., seabed sediments) would warrant more serious consideration than space dipsosal. (58)

Response

The consequences of C^{14} release are treated in Section 4.7.2.3 of the final Statement, Radiological Effects of Reprocessing Fuel Cycle Waste Management. Since the population exposure appears relatively minimal, a more detailed treatment does not appear warranted.

Draft p. 3.9.19

Issue

Since the actinide recycle gives higher neutron activities, it would appear to create more problems than it solves. (35)

Response

It was pointed out in the Statement that the enhanced neutron activity in recycled actinides does exist and could be a problem. Whether it creates more problems than it solves would need to be analyzed in greater depth.

Space Disposal

Draft p. 1.30

Issue

Leaving the waste in a solar orbit or disposing of it on the moon still leaves the waste available for future exposure to man. Would not direct injection into the sun be preferable? (218-DOI)

Response

Although it would be technicaly feasible to inject the waste into the Sun, this is not possible with present launch vehicles. Alternatively, indirect flight to the Sun from the

Earth could be accomplished with present vehicles by using planetary swing-by trajectories. However, this approach is considered not practical because of limited opportunities to launch from the Earth.

It is highly unlikely (see Section 6.1.8 of the final Statement) that waste successfully placed in a solar orbit situated halfway between that of the Earth and Venus and inclined to the plane of the ecliptic would pose significant hazards to the Earth's environment and to human health and safety.

Draft p. 3.10.1-48

Issue

This well written section makes it clear that this option cannot be used soon enough to be a candidate for initial disposal and the Final EIS should so state. It is unfortunate that the candid admission from page 3.9.9 "However, there is no firm technical basis at this time for asserting that the disposal of any or all of these elements in geologic form (Section 3.1) is either inadequate or undesirable" was not included in this section also. (154)

Response

The commenter's points are well taken. The reader is referred to Section 6.2 of the final Statement for a comparative assessment of the attributes of the alternative concepts and the mined repository.

Draft p. 3.10.1

Issue

Ohio has previously indicated its dissatisfaction with this aspect of the report. It should be added that experimental data should exist on plutonium dispersion from space due to the SNAP reactor breakdown in the early sixties, and, from upper atmospheric bomb testing data from about the same period. (35)

Response

Specific experimental or empirical information collected from atmsopheric dispersal of radioactive materials following nuclear weapons tests; or following the accidental reentry and burnup of a plutonium heat source in the 1960's; or following the recent reentry of the Russian Cosmos satellite, was not used directly in the preparation of Section 6.1.8 of the final Statement. The reader is referred, however, to Section 6.1.8.4 for a discussion of the impacts of accidents, including accidental reentry and launch pad accidents, that might cause atmospheric dispersal of radioactive materials.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.10.1

Issue

The waste mix information provided in Figure 3.10.1 is confusing; (a) Zircaloy should not be included in Mix 2; (b) it is not clear if Zircaloy hulls are mixed with HLW subsequent to reprocessing. (124)

Response

It is agreed that the presentation of waste mix information might be confusing. Zircaloy hulls should not be considered as a part of the waste that would be disposed of in space. These hulls may contain a significant fraction of high-level and transuranic wastes which would be disposed of through use of another alternative concept (e.g. the mined repository). Alternatively, new processing technology would be needed to strip the high-level and transuranic waste from the Zircaloy so that these wastes could be reasonably disposed of using the space disposal concept.

Draft p. 3.10.2

Issue

The last sentence in Section 3.10.1.1 should be modified to include cost considerations, if applicable. If cost was not considered, then the sentence should indicate that the conclusions refer to technical considerations only. (124)

Response

Cost considerations for the space disposal concept are discussed in Section 6.1.8.6, Cost Analysis, in the final Statement. Section 6.2 of the final Statement considers cost attributes in the comparative assessment of the alternate concepts and the mined repository.

Draft p. 3.10.9

Issue

Based on basic experience with the space program, it seems possible and highly desirable to discuss the cost and natural resource utilization needed for this alternative along with other information for the upper stage operations presented on Page 3.10.9 (124)

Response

Cost and resource utilization information has been included in Section 6.1.8 of the final Statement. Due to the limited current state of development of the space disposal concept, this information applies to the overall concept and is not broken down for detailed elements of that concept.

ALTERNATIVE DISPOSAL CONCEPTS

Draft p. 3.10.18

Issue

Space disposal - too costly - $22 million per launch - the danger of launch pad and reentry accidents. (88, 121)

Response

The commenter makes reference to two important considerations for the selection of an acceptable alternative for the disposal of radioactive waste. For a comparative analysis of the attributes, including costs and disadvantages, of alternative concepts and the mined repository concept, the reader is referred to Section 6.2 of the final Statement.

Draft p. 3.10.23

Issue

The last sentence in the second paragraph of Section 3.10.2.6 (Page 3.10.23) should be modified to indicate that, based on the disposal methods and from the information presented in the EIS, space disposal cannot at this time be justified from an economic or risk standpoint. (124)

Response

Section 6.1.8 of the final Statement presents information that reflects the current state of knowledge regarding the space disposal concept. Section 6.2 of the final Statement presents an assessment of the alternative concepts, including space disposal, using a comparison of attributes and related performance standards. Both Section 6.1.8 and Section 6.2 address the issues of costs and risks in providing comparative information regarding the concepts considered.

Draft p. 3.10.23

Issue

The third paragraph under 3.10.2.6 should also include in the total integrated system risk, nonradiological risks associated with space facility construction, as well as all manufacturing and support phases required for the additional launchings dictated by the space disposal option. It appears highly doubtful that the incremental gains afforded by the isolation of space disposal can outweigh the total risks involved in achieving that isolation. (58)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The revised space disposal section of the final Statement discusses both facility construction environmental impacts and routine operation nonradiological impacts in Section 6.1.8.4. This section does not specifically mention all manufacturing and support phases required for the additional launchings dictated by the space disposal option, but it does conclude that environmental impacts from normal operations or nonradiological accidents from a space disposal option are not expected to be significant.

Draft p. 3.10.26

Issue

The fourth paragraph should be expanded to indicate that all necessary precautions, including conservative engineering design, will be implemented to ensure that the probability of an accident will be small and the consequences less. (The last statement in that paragraph can be interpreted as meaning that calculations will be performed to show that the probability is vanishingly small.) (124)

Response

Several sections of the final Statement address various aspects of the accident issue. In Section 6.1.8.3 the final Statement states that the major technology requirements are in design for safety. This section also points out that initial R&D should include an assessment of unique safety and environmental aspects of the space disposal concept (e.g., launch pad fires and explosions affecting the waste package). Section 6.1.8.4 is concerned with impacts of construction and operation (preemplacement), including risks unique to this concept and the types of reliability data needed for risk assessments.

Draft p. 3.10.26

Issue

Note this understatement of the section: Moreover, legal concerns may lengthen the amount of time needed to actually execute a space disposal option. (154)

Response

Many, likely fordmidable, legal and institutional issues would require resolution before this concept could be implemented. Currently available information is, however, insufficent to ascertain the complexity of these issues. The statements of concern to the commenter remain in the final Statement to ensure that this important area is addressed. In addition, Section 6.2 of the final Statement presents a comparative assessment of the alternative concepts and the mined repository that compare attributes, including legal and institutional factors, of these concepts.

Draft p. 3.10.27

Issue

The socioeconomic aspects discussed on the top of p. 3.10.27 should be quantified. Most other EIS documents have included these types of data. (124)

Response

The Socioeconomic Impacts discussion in Section 6.1.8.4 of the final Statement notes that a detailed assessment of these impacts would require more accurate employment estimates, information on the industrial sectors affected by capital expenditures, and identification of the specific geographic areas involved; and, that these types of detailed information would not be available unless the definition of this concept were further advanced. This discussion does note, however, that the current estimate of launch rates suggest that the support of the entire space transportation system would require 25,000 to 75,000 employees. The range of these estimates reflects the present level of definition of this concept.

Draft p. 3.10.28

Issue

It is recommended that the data in Table 3.10.5 be modified with less precise percentage results. Per the supporting documentation, it seems that presentation with such precision is unjustified. (124)

Response

This information is presented with more general estimates in the final Statement, Section 6.1.8.4.

Draft p. 3.10.30

Issue

Processes for the production of calcine waste have indeed been demonstrated on an engineering scale with radioactive material for many years at Idaho Chemical Reprocessing Plant. (154)

Response

Although processes for production of certain waste forms (e.g. calcine) have been demonstrated on an engineering scale as stated by the commenter, the selection of specific

waste components and incorporation of those components into a suitable waste form for space disposal has not been done. For additional discussion of R&D needs for this topic see Section 6.1.8.3.

Draft p. 3. 10.30

Issue

The added R&D required for glass forms identifed in the ninth paragraphs should be rationalized and quantified. One would be forced to conclude that the concerns over glass stability must be related to post-abort status. If this is the case, it would appear that quantification of the overall risk would either show aborts to be of overriding concern or the potential instability problems of glass to be insignificant. (58)

Response

The revised presentation, Section 6.1.8.4, identifies high altitude reentry and burnup with potential dispersion of the payload as particles in the atmosphere as an important accident, to be considered with regard to radiation exposure to the general public. These potential conditions would establish requirements for waste form characteristics, and possible waste form R&D. R&D requirements are discussed in Section 6.1.8.3.

Draft p. 3.10.37

Issue

The U and/or Pu disposal method defined should be clarified (Section 3.10.5.2). Per information presented on p. 3.10.4, these isotopes are disposed in space. (124)

Response

Section 6.1.8 of the final Statement provides discussion of the wastes that are best suited for disposal in space. Clarification is made of the possible use of space disposal as a component of a total waste management system. Such a system would necessarily include another disposal alternative (e.g. mined geologic repositories) for those wastes which, for a number of reasons, would likely not be suitable for disposal in space.

Draft p. 3.10.46

Issue

The R&D requirements seem quite modest compared to estimates for other alternatives. Surely much of the potential cost is not stated. (154)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The full cost of R&D that would be required to implement the space disposal concept has not been determined. Section 6.1.8.3 of the final Statement presents a summary of the efforts thought to be necessary to provide a basis for such a cost estimate. The efforts required to provide the basis are estimated to cost $20 million.

Draft p. 3.10.46

Issue

Per review of Table 3.10.6, this disposal mode is not being seriously considered as a viable alternative to terrestrial disposal. If it is to be considered as a likely alternative, additional funds would be necessary for engineering design and safety assessments. (124)

Response

Section 6.1.8.3 of the final Statement presents a discussion of the status of technical development and R&D needs for the space disposal concept. Noteworthy is the fact that current information is considered insufficient to support a meaningful estimate of the full cost of R&D that would be required to implement this concept.

Draft Appendix R

Issue

This is an interesting discussion but the state of development of the technology does not permit more than qualitative information. (113-EPA)

Response

Although the current state of development of the space disposal concept is considered to be insufficient to provide quantitative estimates of many important performance characteristics, there are data available in the literature to provide limited quantification of impacts and some costs. This information is presented in Section 6.1.8 of the final Statement.

Issue

The National Aeronautics and Space Administration (NASA) submitted many comments on the space disposal concept in the draft Statement. In general, the comments suggested rephrasing or revising the text to better represent the current status of the development of the space disposal concept. (200)

ALTERNATIVE DISPOSAL CONCEPTS

Response

The comments were taken into consideration in preparing the final Statement, Section 6.1.8.

HEARING BOARD REPORT AND RESPONSES

This section presents the Hearing Board Report and responses to issues raised in this report. The Hearing Board Report represents oral testimony presented by interested persons, organizations and agencies through a series of public hearings held to air comments on the Draft Environmental Impact Statement of April 1979 "Management of Commercially Generated Radioactive Waste." As a result of this testimony the Hearing Board identified issues that should be addressed during preparation of the final Statement.

For the convenience of the reader, this section is structured such that the responses are shown opposite the issues raised in the report.

HEARING BOARD CHARTER

The principal responsibility of the Hearing Board was to conduct a series of public hearings giving interested persons, organizations, and agencies the opportunity to comment on the Department of Energy (DOE) Draft Environmental Impact Statement of April 1979, "Management of Commercially Generated Radioactive Waste." Based on public testimony briefings, and supplementary documents, the Board was to prepare a report to DOE identifying issues that should be addressed during preparation of the final Environmental Impact Statement.

Other than the Chairman, the Hearing Board was composed of distinguished scientists. None of the hearing board members were employees of DOE; they were contracted as consultants to conduct public hearings and identify to DOE those issues requiring consideration or revision during preparation of the Final Environmental Impact Statement. Furthermore, none of the hearing board members were involved in the preparation of the Environmental Impact Statement and were thus disinterested, impartial reviewers.

HEARING BOARD MEMBERS

Professor George T. Frampton served as the Hearing Board Chairman for the public hearings. Professor Frampton, a lawyer, specializes in the field of atomic energy law and has taught and performed research in this area for many years. He has also written articles dealing with this specialized area of law. Professor Frampton's past experience in the nuclear field includes serving on the Illinois Atomic Power Investigating Commission, and being a consultant to the U.S. Joint Congressional Committee on Atomic Energy, to the National Committee on Radiation Protection and Measurements (regarding legislative control of ionizing radiation), and to the Atomic Energy Commission and its successor agency, the Energy Research and Development Administration.

Another board member, Dr. Dorothy K. Newman, is a sociologist, a socioeconomist, and a distinguished author. She received her Ph.D in Sociology from Yale University. She was director of the Energy in People's Lives study, for the Energy Policy Project of the Ford Foundation. She has been a socioeconomist with the U.S. Department of Labor in matters relating to construction of housing, consumer economics and issues of the disadvantaged. She has been Director of Research for the National Urban League; Director of the Project on Race and Social Policy, supported by the Carnegie Corporation; and she recently completed a book entitled "Protest, Politics and Prosperity, Black Americans and White Institutions, 1940 to 1975." She is presently a consultant and lecturer.

Another board member, Dr. Clifford V. Smith, is Vice-President for the Administration at Oregon State University and Professor of Environmental Engineering. He received his Bachelor of Science in Civil Engineering from the University of Iowa, his Masters of Science in Environmental Engineering and his Ph.D in Radiological Science and Environmental Engineering at Johns Hopkins. He is a Registered Professional Engineer. He has 26 years of experience in all facets of environmental engineering with industry, government and universities. He was formerly Director of the Office of Nuclear Materials, Safety and

Safeguards of the Nuclear Regulatory Commission and a member of the interagency Review Group, which in 1979 completed an extensive study of nuclear waste management for the President of the United States. Dr. Smith's past experience includes being a Regional Administrator of the Environmental Protection Agency in the Pacific Region, Deputy Regional Administrator in New England, and he has been associated with environmental issues related to nuclear power going back to the Shippingport Nuclear Power Plant in 1959.

Dr. Hubert L. Barnes, another board member, is the author of about 70 technical papers and books on the geochemistry of mineral resources, including a book on "Uranium Prospecting." He has been a Guggenheim Fellow at the Geochemistry Institute of the University of Goettingen, Exchange Scientist of the U.S. National Academy of Sciences to the Russian Academy of Sciences, and Chairman of the United States National Committee for Geochemistry. He is a Fellow of the Geological Society of America and of the Mineralogical Society of America. He is also a Professor of Geochemistry, and Director of the Ore Deposits Research Institute at The Pennsylvania State University. Past experience includes geochemical research on the origin of hydrothermal ore deposits at the Geophysical Laboratory of the Carnegie Institute of Washington, and extensive consulting on geochemical problems in environmental pollution and in the search for mineral resources. He also is the inventor of patented methods of air pollution control and of crystal growth. He has held several distinguished lectureships at universities in the United States and in Europe and now with the Society of Economic Geologists.

Another hearing board member was Dr. Melvin W. Carter who received his Bachelor's and Master's of Science Degree at Georgia Institute of Technology, and his Ph.D at the University of Florida. He is currently at the Georgia Institute of Technology as Director of the Center for Radiological Protection and Professor at the School of Nuclear Engineering. He has had more than 29 years of experience in the radiation protection field as an environmental engineer and health physicist. He worked for the United States Environmental Protection Agency. He has been assigned major responsibilities including Director of the Southeastern Radiological Health Laboratory, and the Director of the National Environmental Research Center, Las Vegas. In addition to numerous articles and books, he has been coauthor of a monograph and also editor of Environmental International. He has served as a consultant to federal and state agencies, as well as major industrial concerns and international organizations, and belongs to a number of professional and honorary organizations, including the Health Physics Society, the National Council on Radiation Protection and Measurements, and the International Radiation Protection Association.

HEARINGS AND TESTIMONY

The Board conducted hearings in five major cities: Washington, DC (June 26-27, 1979); Chicago, Illinois (August 8-9, 1979); Atlanta, Georgia (September 25-26 1979); Dallas, Texas (October 2-3, 1979); and San Francisco, California (October 8-9, 1979). Notice of public availability of the Statement appeared in the Federal Register of April 20, 1979. Later

notices in the Federal Register (June 1, July 3, and July 18, 1979) provided hearing dates and places, invited written comments, and gave other information about public participation.

A total of 142 witnesses testified before the Board. In addition, the Board reviewed more than 200 written comments, some of which were extensive. These were submitted instead of or as an extension of oral testimony. Most of the presentations were by individuals expressing their personal views. Many respondents had technical, scientific or medical expertise. Many represented concerned citizens groups, state or local governments, nuclear research and service organizations, utilities, and trade associations. Several federal agencies submitted extensive written reviews. Transcripts of the hearings are available for public inspection at certain local and regional offices of the Department of Energy and at its Headquarters in Washington, DC.

Based on public testimony, review of supplemental documents and briefings, the following report was prepared.

HEARING BOARD REPORT

on the

DEPARTMENT OF ENERGY

DRAFT ENVIRONMENTAL IMPACT STATEMENT

entitled

"MANAGEMENT OF COMMERCIALLY GENERATED RADIOACTIVE WASTE"
(DOE/EIS-0046-D)

February 1980

HEARING BOARD REPORT
ON THE DEPARTMENT OF ENERGY
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CONTENTS

		Page
I.	BACKGROUND: THE HEARING BOARD AND PROCEDURES	1
II.	RECOMMENDATIONS	5
	A. PURPOSE OF THE STATEMENT	5
	B. SCOPE	6
	1. Relationship of the Statement to Other Nuclear Activities	6
	2. Treatment of Alternatives	7
	3. Sequence of Comparative Environmental Analyses by Stages, Beginning with Spent Fuel	9
	4. Testing and Experimental Programs	9
	5 Humanistic Concerns and Consequences	10
	6. Other Nuclear Power Projections	12
	C. STATEMENT PRESENTATION	12
	1. Length	12
	2. Summary	13
	3. Conclusions and Recommendations	13
	4. Editorial and Terminological	14
	D. SPECIFIC SUBJECTS	15
	1. Risk-Benefit Analysis	15
	2. Reprocessing	17
	3. Schedules and Timing	17
	4. Costs	18
	5. Types and Characteristics of Host Rock	19
	E. PUBLIC NOTIFICATION PROCEDURES	21
	F. MISCELLANEOUS ITEMS REQUIRING REVIEW	23
III.	CONCLUSIONS	25
IV.	BACKGROUND REFERENCES: REPORTS PROVIDED TO THE BOARD BY THE U.S. DEPARTMENT OF ENERGY	26

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I. BACKGROUND: THE HEARING BOARD AND PROCEDURES

The Board's main responsibilities were to conduct a series of public hearings to give interested persons, organizations, and governmental agencies an opportunity to comment on the Deparcment of Energy Draft Environmental Impact Statement of April 1979, "Management of Commercially Generated Radioactive Waste", (called the "Statement" in this Report), and to prepare a report to the Department identifying the significant issues that should be addressed in preparing a final statement.

The Department of Energy selected the members of the Hearing Board with the intention of obtaining the public's views through an outside, impartial, diverse group with substantive knowledge and experience about energy and the environment. Professor George T. Frampton, Sr., Professor of Law and formerly a Vice-Chancellor of the University of Illinois, chaired the Board. Other members were Dr. Hubert L. Barnes, Professor of Geochemistry and Director of the Ore Deposits Research Institute of the Pennsylvania State University; Dr. Melvin W. Carter, Professor of Nuclear Engineering and Director of the Center for Radiological Protection at the Georgia Institute of Technology; Dr. Dorothy K. Newman, socio-economist and author of studies about the energy consumer and other citizen concerns for the U. S. Department of Labor, for the National Urban League as former research director, and for Carnegie Corporation of New York as Director of the Project on Race and Social Policy; and Dr. Clifford V. Smith, Professor of Environmental Engineering and Vice President, Oregon State University, and former Director of the Office of Nuclear Materials, Safety, and Safeguards of the Nuclear Regulatory Commission.

The Board conducted hearings in five major cities: Washington, D. C. (June 26-27, 1979); Chicago, Illinois (August 8-9, 1979); Atlanta, Georgia (September 25-26, 1979); Dallas, Texas (October 2-3, 1979); and San Francisco, California (October 8-9, 1979). Notice of public availability of the Statement appeared in the "Federal Register" of April 20, 1979. Later notices in the "Federal Register" (June 1, July 3, and July 18, 1979) provided hearing dates and places, invited written comments, and gave other information about public participation. These issues of the "Federal Register" are cited in the Background References at the end of this report.

The regional offices of the Department of Energy advertised the subject of the hearing and its time and location in news media of each region before the first day of each hearing. The Department also made extensive mailings to various public interest groups and organizations in an effort to elicit their views.

A total of 142 witnesses testified before the Board. In addition, the Board reviewed more than 200 written comments, some of them extensive. These were submitted instead or in extension of oral testimony. Most of the presentations were by individuals expressing their personal views. Many respondents had technical, scientific or medical expertise. Many represented concerned citizens' groups, state or local governments, nuclear research and service organizations, power companies, and trade associations. Several Federal agencies submitted extensive written reviews. Transcripts of the hearings are available for public inspection at certain local and regional offices of the Department of Energy and at its Headquarters in Washington, D. C.

The Board members attended a briefing in June 1979 by the Department of Energy Division of Waste Isolation and by Pacific Northwest Laboratories of the Battelle Memorial Institute, which prepared the draft statement for the Department of Energy. In further preparation, Board members read the Statement (Volume 1) "Management of Commercially Generated Radioactive Waste" (about 700 pages) and its supporting "Appendices" (Volume 2), about 650 pages. Further backup volumes to the draft statement were submitted later for the Board's review. These include five volumes on "Technology for Commercial Radioactive Waste Management" (DOE/ET-0028) and three volumes on "Environmental Aspects of Commercial Radioactive Waste Management" (DOE/ET-0029). The ten volumes total more than 5,000 pages.

Associated documents that came to the Board's attention were "Nontechnical Issues in Waste Management: Ethical, Institutional, and Political Concerns" (PNL-2400) and "Safety Indices and Their Application to Nuclear Waste Management Safety Assessment" (PNL-2727). The Board also reviewed other documents relevant to the draft environmental impact statement, including the "Report to the President by the Interagency Review Group on Nuclear Waste Management" (March 1979, TID-29442). Dr. Smith, a member of this Hearing Board, served on the Interagency Review Group.

Other reports submitted to the Board members for their information were the report by the Comptroller General of the United States on "The Nation's Nuclear Waste--Proposals for Organization and Siting" (June 21, 1979, EMD-79-77), the two-volume "Draft Environmental Impact Statement, Waste Isolation Pilot Plant" (April 1979, DOE/EIS-0026-D), and the Waste Isolation Pilot Plant Hearing Board report of November 6, 1979, on its series of public hearings. Other environmental impact statements came to the Board's attention because they illuminated parts of the waste management problem. These are about power reactor spent fuel, including the storage of foreign power reactor spent fuel, and the program plan for defense waste management. These and other documents (cited in the Background References at the end of this report) are within the scope of the Department of Energy's total "Nuclear Waste Management Program" (April 1979, DOE/ET-0094). Particularly important for assessing the place of the environmental impact statement about the management of commercially generated nuclear waste is the "Commercial Waste Management Multi-Year Program Plan" (August 1979).

II. RECOMMENDATIONS

The Board observes that the Department and its contractors have prepared a statement of substantial depth and breadth, made efforts at its wide distribution, and solicited public participation in deliberations about the Statement. However, on the basis of the public testimony and briefings, and supplementary documents, the Board identifies the following issues for development or modification in the final generic environmental impact statement.

A. PURPOSE OF THE STATEMENT

The Board recommends that the Department of Energy define the purpose of the Statement more clearly at the outset to avoid the obvious confusion reflected in the oral testimony and written comments.

The purpose of the "Draft Environmental Impact Statement" is unclear at the outset and requires clarification. The Foreword states: "This Generic Environmental Impact Statement (GEIS) is intended to provide environmental input" for the "decision" "of selecting an appropriate programmatic strategy leading to the permanent isolation of commercial radioactive wastes in a fashion that provides reasonable assurance of safe, permanent isolation of the material." The term "generic" (and its effect on the entire document) is not defined or explained, but it becomes part of the acronym, "GEIS", adopted by the Department of Energy.

Response

Chapter 2.0 (Introduction) of this document has been modified to more clearly identify this Statement's purpose and need. This chapter also addresses the "generic" nature of the document with revisions made to explain the use of this term.

Further, this sole statement of purpose confused some people by covering, but failing to distinguish between, two important purposes of an environmental impact statement. One purpose is to demonstrate that the environmental consequences of a proposed federal action have been considered by identifying and describing them and comparing them with the consequences of alternative courses of action. The other purpose is to subject that demonstration to public review and comment, thus affording broad participation in a decision before action is taken. While the statement of purpose of the document does not, on its face, cover the second purpose, use of the word "input", and the process of distributing the documents and holding hearings, are evidence of the Department of Energy's intention to encompass both purposes.

B. SCOPE

1. RELATIONSHIP OF THE STATEMENT TO OTHER NUCLEAR ACTIVITIES.

The Statement should reveal early how its limited scope relates to other waste management operations and to the processes of nuclear technology here and abroad.

The title of the Statement does not limit the discussion to the sole problem of finding a strategy for permanent and safe isolation of commercially generated radioactive wastes. The broad term "management" was included in the title "Management of Commercially Generated Radioactive Waste", and the term "high-level" was excluded. Many witnesses and readers, therefore, expected to find information about the total system, all wastes, and explicitly, various techniques for disposal and their environmental impacts.

Response

Section 2.2 (Relationship to other Waste Management Decisions) was added to this Statement's Introduction to inform the readers in a general way about the total waste management system and how this environmental impact statement relates to this system.

2. TREATMENT OF ALTERNATIVES

Only the most viable alternative strategies should be assessed in detail. Less viable alternatives should be ranked for feasibility, and the fullness of their treatment should be commensurate with that ranking.

The Statement identifies ten alternative strategies for waste isolation. Two--chemical resynthesis and transmutation--are not techniques for waste isolation, but are methods of waste treatment. They are not, therefore, alternative courses of action. Furthermore, even if transmutation were a method of waste treatment, it is not technologically or economically feasible in the foreseeable future (twenty years) and thus could have been treated less comprehensively on that basis alone.

Of the remaining eight options, only those with some reasonable prospect of relatively short-term economic and technical feasibility should require fully detailed analysis. Less detailed treatment of other disposal options, while not ignoring any positive findings of current research, should indicate the critical factors that reduce feasibility in this century. None of the alternatives is entirely without merit, especially in changed economic or political circumstances. At present, however, near-term feasibility is a vital consideration but is in doubt for certain options. Examples are: for space disposal, risk and costs; for ice sheet disposal, international jurisdictional and treaty obstacles; for seabed disposal, current legal restrictions, (e.g. the Marine Sanctuary Act of 1972), and transportation risk; for island disposal, geologic instability and transportation risk; for deep hole disposal, costs; for rock melting, potential release of volatiles; and for well injection, seismic risk. Furthermore, nonretrievability is an additional concern to all the above except island disposal.

Response

The section on the Comparison of Disposal Technologies was revised so that the reader can more easily distinguish between disposal technologies. Restructuring the section also aids the reader in determining the feasibility of disposal options and identifies which options should receive further program emphasis. Part of this restructuring consisted of placing "Chemical Resynthesis" and "Partitioning" in Section 4.3 (Waste Treatment and Packaging).

Not even those in the scientific community and in federal or state agencies, and few among the general public, knew about the Department of Energy's comprehensive waste management plan and schedule, the numerous radioactive waste management environmental impact statements already written or in progress, and the extent of experimental work under way. It is no wonder that countless hours at the hearings were spent on issues that were not pertinent to the isolation of commercially generated high-level waste. If the Statement at the outset had informed readers in a general way, as introduction, about the total management system, considerable confusion would have been avoided. For example, readers need an early explanation of the difference between low-level and high-level wastes and how and where they are handled and stored, the programs for handling defense wastes and their relationship to commercial waste management, experimental work under way in all spheres, issues surrounding waste arriving from abroad, what happens to nuclear waste generated by medical and research activities, what happens to non-nuclear waste from commercial nuclear facilities, and what happens upon the decommissioning of a nuclear facility. After such an exposition the focus of the Statement about commercially generated high-level radioactive waste would be in context, as would the concern--frequently expressed--that testing or experimental work on nuclear waste was insufficient or lacking.

Response

The Introduction (Chapter 2.0) presented in the final Statement was revised to provide the reader with a general overview of the total waste management system and identifies those areas of this total system which are addressed by this Statement. Discussion of the various waste types and methods for handling and storage of these wastes are presented in Section 4.1. A perspective of the impacts from handling defense wastes in relation to those from commercial waste management is presented in the Summary of the final Statement.

3. SEQUENCE OF COMPARATIVE ENVIRONMENTAL ANALYSES BY STAGES, BEGINNING WITH SPENT FUEL

The entire chain of environmental consequences of managing commercially generated high-level wastes should be treated consistently and compared for each viable alternative course of action, beginning with spent fuel at the reactor.

The Statement does not provide information at each appropiate stage of the entire spent fuel cycle about environmental consequences, beginning with on-site storage and going through chemical treatment, encapsulation, handling, transportation, site selection, testing, emplacement, and storage.

4. TESTING AND EXPERIMENTAL PROGRAMS

Since the feasibility of proposed options must be verified by appropriate experiments, the Statement should disclose more fully and explain the nature and extent of the testing and experimentation now under way and planned.

Experimental work already under way in this country and abroad, including the extent of U.S.-international cooperation, should be more adequately treated in the final Statement. In addition to the work in Sweden mentioned in the Statement, experiments are also under way in India, West Germany, France, Great Britain, Canada, Japan, and the Soviet Union, among others.

Response

The draft Statement did analyze the entire cycle of post-fission waste management activities. However, to ensure that the reader understands the scope of the analysis carried out, the final document is structured such that the predisposal activities (waste treatment and packaging, waste storage, waste transportation, and decommissioning) are presented first (see Chapter 4.0) and disposal activities are then outlined in subsequent chapters (Chapters 5.0 and 6.0).

Response

Ongoing and planned research and development efforts in this country and abroad have been addressed in a revised section on Technical Feasibility (Section 5.2). Where deemed appropriate, experimental work in other countries has been mentioned in this Statement.

An international exchange of information is provided through a cooperative program with the United States, Canada, Sweden and West Germany as the participants. Ongoing and planned research and development efforts in this country and abroad have been addressed in a revised section on Technical Feasibility (Section 5.2) of the final Statement.

A common misconception is that holes drilled into a potential repository would destroy its integrity permanently. Therefore, discussion is necessary of how such holes are effectively sealed by cementing or grouting and how permeability tests by injecting water at high pressure are used to assess the final repository conditions.

Abandoned mines, which provide a wide variety of rock types as possible repository hosts, with presumably limited environmental consequences, have been suggested by the U. S. Bureau of Mines for testing, and are used for that purpose in Sweden and West Germany. Information about the present use or consideration of such mines should be provided.

5. HUMANISTIC CONCERNS AND CONSEQUENCES

Ecological, social, psycho-social, political, and economic consequences should be given more prominence and receive more professional attention.

The significance of social concerns and their political influence is apparent in the testimony of witnesses ranging from the pro-nuclear to the anti-nuclear. Witnesses emphasized, and the Board concurs, that the degree to which human concerns are taken into account could result in the success or failure of any waste management plan.

Response

The structure for Volume 1 was revised to draw information relevant to nontechnical issues relating to waste management in general from several places in the draft together into one section (Section 3.5). In addition, the Technology Comparisons section (Section 6.2) uses domestic policy considerations and international policy conflicts as criteria upon which the disposal options were examined and evaluated. Nontechnical issues relevant to the site selection process are covered briefly in Section 5.1.

The Statement, however, deals inadequately with the humanistic effects of each stage in the process of each alternative management system, especially with those stages before waste reaches a final site. The Statement deals with social and economic consequences of constructing and operating a storage facility more fully, but even in this instance the treatment is sketchy. For instance, insufficient attention is given to the interaction with waste management operations of alternative employment and unemployment projections nationally and regionally, of migration streams, and of easily demonstrable demographic changes, to mention a few conditions considered too summarily or not at all. Neglected for each option are occupational opportunities, training requirements, and hazards involved in handling, shipping, encapsulating, and inserting and recovering wastes.

Even in addressing issues surrounding only site selection and operation, detail is lacking on how participation by State and local governments and the public takes place in the experimental or final site selection. The Statement is sketchy on environmental surveillance, monitoring, and managing each kind of site. The problems to be encountered in clean-up in the event of decommissioning or serious accident,as well as possible evacuation, require more detailed analysis taking into account comparative environmental effects before and after the event, for each option, with emphasis on behavioral and biological science approaches.

Response

In considering social impacts, unemployment and employment projections, migration streams and demographic changes were taken into account in estimating the demographic impact of various waste management and disposal facilities. Great effort was made in selecting different reference environments so that these factors could be considered. The impacts of decommissioning waste management facilities were also analyzed to ensure greater clarity. All of these discussions were placed in a single section (Section 5.4).

Specific plans relating to institutional arrangements for control of disposal sites were not offered because such plans are site specific and no site has been selected. However, Section 3.5 offers discussions of general institutional arrangements which could apply to any site.

In summary, humanistic considerations and consequences require much more sophisticated development and more social imagination.

6. OTHER NUCLEAR POWER PROJECTIONS

The Statement should take account of the environmental effects of managing waste generated by other projections of nuclear power production.

Additional projections beyond those now considered and which require attention are (a) that all commercially generated nuclear power production would cease in 1980; and (b) that nuclear power production by present facilities or those currently licensed would be permitted only until their normal decommissioning dates.

C. STATEMENT PRESENTATION

1. LENGTH

The Statement is unnecessarily wordy and voluminous. It should be reorganized and cut drastically by judicious rewriting and editing, with the aim of reducing the basic volume to less than 300 pages.

Much of the Statement treats methods in inordinate detail, thus obscuring the findings and the central ideas that went into models. It relies

Response

The Statement quantitatively analyzed the waste management impacts of the following five scenarios:

1. Present inventory (equivalent to industry shutdown).
2. Present capacity to retirement (equivalent to licensing no new reactors).
3. Installed capacity of 250 GWe in year 2000 and declining to zero in year 2040.
4. Installed capacity of 250 GWe in year 2000 and continuing at 250 GWe to year 2040.
5. Installed capacity of 250 GWe in year 2000 and growing to 500 GWe in year 2040.

These scenarios bound the range of possible reactor futures that are presently thought to be reasonable.

Response

An effort was made to increase the overall clarity and readability of the document by reducing the number of pages, being consistent in the use of terminology, utilizing summary tables where possible, and relegating supporting or more detailed data and information to the Appendices.

heavily on jargon, acronyms, convoluted sentences and bulky tables and figures, much of which could be dispensed with by distillation into simple English. Many parts of the Statement are redundant, confusing, and sometimes conflicting. Reorganization could follow in part the guidelines for environmental impact statements of the Council on Environmental Quality.

2. SUMMARY

After revising the Statement, a short, clear, concise, accurate and readable summary should be prepared that is comprehensive and reflects the findings of the Statement as a whole. An even shorter summary should also be prepared aimed at fuller comprehension by the general public.

Many who testified or wrote comments had read only the Statement Summary from Volume 1. It appeared to the Board that few read Volume 1 and fewer Volume 2. Almost none had seen the other eight volumes. It is important that a short summary carry the essential message clearly.

3. CONCLUSIONS AND RECOMMENDATIONS

Conclusions or recommendations should be recognizable as such, without equivocation or hedging.

The conclusions and recommendations should be presented in a positive and straightforward manner, thus assisting the reader in determining what is important, what is known, the degree of that knowledge, and the major thrusts of the Statement.

Response

In preparation of the final Statement, the Department of Energy (DOE) has taken several steps to be responsive to the recommendations on the organization and presentation of the draft Statement. The structure of Volume 1 was modified to focus on the proposed Federal action and to make more evident the systems aspects of the Statement.

This was accomplished by:

1. Outlining the purpose and need of the Statement (Chapter 2). This chapter discusses the intent of the document, the proposed Federal action, and the "decision territory covered."
2. Identifying programmatic alternatives (Chapter 3) including a statement of a no-action alternative which the draft Statement did not do.
3. Developing Chapter 4, which discusses predisposal options and systems.
4. Emphasizing the proposed action (mined geologic repository) by discussing in a separate Chapter (5) with the presentation of disposal alternatives in Chapter 6.
5. Including a new Chapter 7, which discussed tradeoffs between the proposed action and the two alternative actions on a complete system basis.

The Summary chapter was extensively revised in order that the material would be more easily understood by the general public. In revising this chapter DOE was sensitive to the comments that the significant conclusions be highlighted in the Summary and that they be substantiated by the material in the text. An effort was also made to increase the overall clarity and readability of the document by reducing the page length, being consistent in the use of terminology, utilizing summary tables whenever possible, and relegating supporting data or information to the appendices.

4. EDITORIAL AND TERMINOLOGICAL

The Board recommends:

—Minimizing the use of acronyms and defining them when first used and in the glossary.

—A simple page-numbering system without competing section numbers.

—A clear, well-organized table of contents.

—A comprehensive index.

—A complete glossary with readable definitions.

—Identifying the key persons involved in preparing the Statement.

—Distinguishing clearly between "containment" and "isolation."

—Not using the title "Conventional Geologic Disposal" to denote a disposal not yet "conventional". More accurate would be "Disposal in Mined Repositories".

—Using "Well Injection" instead of "Reverse Well Disposal"

—Not calling spent fuel "waste", since spent fuel has intrinsic energy value.

—Changing the phrase "Geologic Emplacement Following Chemical Synthesis" to "Waste Solidification".

—Distinguishing between individual radiation dose equivalents and accumulative dose to populations. An amount of man-rem per individual, for example, is a contradiction in terms.

Response

Editorial and terminological recommendations made by the Board were considered during preparation of the final Statement and the appropriate changes were made.

D. SPECIFIC SUBJECTS

1. RISK-BENEFIT ANALYSIS

The Statement should acknowledge and define the special problems of undertaking risk-benefit analysis in this unusual area, pursue the analysis in an orderly fashion, and recognize and include nontechnical values, by integrating political and social concerns with technical consideration.

Frequent criticisms and misperceptions communicated to the Board involved the analysis of risk. Many thought risks unduly minimized; many thought the opposite. Such a range of views results from fragmentation of the analysis of risk in the Statement, an overly simplistic technical approach, and lack of sufficient accommodation to nontechnical considerations.

Traditional assessment of environmental consequences attempts to analyze hazards and risks quantitatively in relation to benefits. The limitations and difficulties of such quantification in this area, however, require special caution and consideration which do not appear to have been brought to bear in preparing the Statement. A wider range of risks should be assessed, including some ordinary, realistic situations as well as some least expected. Some worst case accidents used for analysis (the meteorite, for example) are too extreme.

Response

Section 3.4 of the final Statement provides the reader with some perspectives on the concepts of "risk" as it pertains to radioactive waste management. If proper comparisons are made, the reader is given a perspective of the relative impacts of radiological wastes versus the hazards of other materials in the environment. Such comparisons are not intended to justify the potential impacts from radioactive waste management.

This Statement presents radiological impacts of unintended events first from a consequence viewpoint. The frequency of occurrence of the particular event is then identified so that if one desires to determine the expected impact from such an event one may do so. However, the consequences of an event (in the absence of the frequency of occurrence) are an upper-bound estimate of the impacts. The document also identified other criteria in Section 6.2 (in addition to radiological impacts) that the "decision-maker" would consider in evaluating the various disposal options.

For the disposal technologies analyzed, this Statement presents radiological impacts under the sections titled "Environmental Analysis of Construction and Operation" (5.4, 6.1.1.4, 6.1.2.4 . . . 6.1.8.4) and "Environmental Analysis Over Long Term" (5.5, 6.1.1.5, 6.1.2.5 . . . 6.1.8.5). Radiological impacts of predisposal activities are addressed in Sections 4.7 and 4.8. Chapter 7.0 outlines radiological impact for entire waste management systems.

Several views of comparative risk need airing and reconciliation. One view suggests that risks from commercially generated radioactive waste and its management activities are additive (cumulative) so that comparison with other risks masks a true danger. This view requires consideration.

At the other extreme, but necessary, is more complete comparison of radiation exposure from high-level radioactive waste with risk from other conditions or materials. It should include more information about the waste exposure with that from the original ore, natural background at varying elevations, and with other minerals or poisons (as with pesticides, nitrates from fertilizers, sulphur dioxide from flue gases, and the like). At this level of analysis, comparative dosage rates and a definitive basis for evaluation are critical.

In another dimension is the desirability of comparing the risks from the radioactive waste management system with the risks from other waste-generating systems, such as coal, metal mining, or logging, for examples.

Assessment of total risk for each alternative waste-isolation option is necessary and is lacking. More imaginative concepts or analogies are required when specific data are not available. In the case of marine transport for island disposal, automobile shipment could be used as an analogy for marine transport of cask-sized units. Comparison would then be possible with continental disposal, for which transport is over land near sizeable populations, whether by rail or by truck.

2. REPROCESSING

The final Statement should summarize in one place the comparative waste management implications both of continuing and of discontinuing the present moratorium on reprocessing.

The consequences of the present moratorium against reprocessing of spent fuel elements are not explicitly summarized. A change in this reprocessing policy, viewed by many as inevitable, would make portions of the Statement obsolete. The costs and benefits, risks, and time associated with planned retrievability should be included in the Statement.

The high-level wastes associated with possible breeder reactors should also be described in comparison with those from other sources.

Response

Chapter 7.0 of the final Statement examines waste management impacts from a systems viewpoint. System impacts are outlined for various nuclear growth scenarios, repository availability dates, and commercial fuel cycles (i.e., once-through--no reprocessing, U and Pu recycle--reprocessing).

Retrievability is designed for increasing assurance of program safety, not for the purpose of recovery for future reprocessing. The only materials which are to be placed in a repository are those which have been fully characterized as waste. A determination as to whether spent fuel is a waste product or a resource will be made prior to a repository becoming operational.

3. SCHEDULES AND TIMING

The Statement should make consistent and clear the estimated time during or at which certain events will occur.

How long will spent fuel be stored before disposal? How long does it take for radioactive waste to become a "nominal" risk? There should be a consistent use of half-lives or time intervals (not a variation among 500, 600, 1,000 and 10,000 years, for example) when evaluating hazards from radioactivity.

Response

Various spent fuel storage methods and associated storage periods are examined in Section 4.4 of the final Statement. The initial storage interval permits decay of short-lived radionuclides which results in a lower heat generation component. This Statement examines initial storage periods from 20 years up to 100 years. However, the time period for which spent fuel will require storage prior to disposal ultimately depends on issues such as environmental considerations, storage capacity and respository availability.

The DOE Position Paper to the NRC rulemaking hearings on nuclear waste storage and disposal[a] places the first repository availability date between the years 1997 and 2006 depending on the outcome of future decisions.

Section 3.4.1 of the final Statement examines risk and risk perspectives. For this issue "nominal" risk is assumed to be the risk represented by the original uranium ore used to produce the fuel. Spent fuel's relative toxicity index decreases by 550-fold in the first 500 years from reactor discharge and then decreases 20-fold in over 999,000 years remaining to one-million years out of reactor. The toxicity of spent fuel can be compared to that of the original uranium ore that was mined to produce the fuel. A typical ore contains 0.2% U_3O_8; some 3400 tons (or 1200 m^3) is mined to produce one ton of fuel. The toxicity of Spent fuel is 14-fold above this at 1000 years. The HLW toxicity equals the toxicity of the ore that produced it at 1500 years.

The text has been thoroughly revised with attention paid to such consistency. The "500 year" and "700 year" numbers are from the referenced work of other authors. The value used in this Statement is 1000 years.

(a) Department of Energy Statement of Position to the NRC Rulemaking on Nuclear Waste Storage and Disposal, Apr 1980.

The Statement does not clarify the time frame in which a failure or inability to implement a "permanent" solution to the waste isolation problem will begin to alter the environmental consequences of the present "temporary" isolation by on-site storage. The uncertainty on this matter left witnesses free to speculate that a long-continued resort to on-site storage would have effects ranging from none in the next few years to a foreseeable exhaustion of on-site facilities and a consequent shutdown of nuclear power production.

4. COSTS

The cost analysis in the Statement should be more comprehensive, and should relate to the whole system of each alternative so as to provide a basis for cost comparisons.

Costs should be more fully analyzed to take into account the entire system for every viable isolation alternative. They should include administration, research and development, interim storage, encasement and the cost of encasement materials, vehicles, transport, training, labor, negotiations leading to site selection, risks and risk insurance, land, construction, final emplacement, institutional surveillance, and emergency preparedness.

Response

The basis for the analysis of costs is explained in Section 3.2.8 of this final Statement. The estimates which are intended to represent the ultimate cost to the consumer of electric power are the systems costs given in Section 7.0 of the Statement and summarized in the executive summary. These costs are intended to be as comprehensive as is possible in keeping with the generic nature of the statement. For the purpose of clarity, the final Statement presents predisposal cost estimates in Section 4.9 and repository cost estimates in Section 5.6. Cost estimates for the alternative concepts are presented in Sections 6.1.1.6 through 6.1.8.6. Included in the predisposal and final disposal costs estimates are land acquisition, construction and decommissioning, labor, encasement and other materials, utilities, vehicles and other transportation costs, administration and other overhead, insurance, taxes (where applicable), permits, licenses, financing, and allowances for contingencies. Costs of any continuing repository surveillance that may be required are insignificant in relation to the rest of the waste management costs developed here. Complete waste management system costs are presented in Section 7.6.

Since current costs in developing and producing a feasible waste isolation program could be perceived as a nuclear power subsidy, comparative analysis with other regulated systems and large-scale enterprises could be made as, for example, railroads, airlines, and automobiles.

Costs are affected by the availability of materials here and abroad. In the array of materials proposed as canisters, for example, there may be problems of cost and access to necessary quantities of such metals as titanium, zirconium, gold, platinum, nickel and others.

5. TYPES AND CHARACTERISTICS OF HOST ROCK

The final statement should be modified to reflect that an objective evaluation has been made for all potential host rocks.

More present information about one alternative over another does not necessarily translate into a clear-cut technological advantage nor support a preference for, or emphasis on, any one rock type. The present Statement, moreover, reflects an emphasis on salt which may not be supported even by all the facts currently available.

Types

The advantages and disadvantages of all host rocks as repositories, including salt, should be compiled and compared objectively.

Response

This final Statement has been revised to reflect more clearly the objective evaluation of candidate disposal media. It is pointed out that salt has had relatively more investigation than other candidate media at this time, but as with the others, it is only recommended for further investigation. This Statement considers that repositories are potentially feasible in all media. However, medium selected based on its physical properties will have to be in a favorable and safe geological environment.

The discussion of the four rock types presented in this Statement is not intended to exclude any geologic media as a repository host rock, but rather to be representative of the potential geologic disposal media. Tuff will therefore receive consideration as a potential disposal medium. Examination of the four rock types (salt, shale, granite and basalt) provide the foundation for determining the suitability of geologic media for nuclear waste storage and disposal as well as providing a focus for a research and development program for geologic disposal.

Factors that might be considered in evaluating salt include: thermal conductance, fluid migration toward warm canisters, high acidity when hot, high plasticity, low sorptive capacity, susceptibility to radiation damage, permeability evidenced by breccia pipes, and environmental problems associated with surface storage or disposal of salt.

A fifth rock type, tuff, should be added to the other four--granite, basalt, shale and salt--as a possible candidate host rock for repositories. If anhydrite is included, its large volume change on hydration should be considered.

Mobility

The mobility of wastes in various rock types deserves greater emphasis in the Statement. Should a canister be breached, the viability of the host rock as a backup barrier directly depends on this mobility. Solubility under reducing conditions is likely to be dominant in limiting the long-term migration of components from a breached canister.

Sorption

Since the sorption characteristics and reactivity of host rocks to radioactive solutes are among the most important properties of the

multiple barrier concept, they should be more clearly developed. In this connection, shales could be superior to other proposed rock types provided that there is not large-scale lateral migration of ground water through the shale.

Permeability

Large-scale permeability is of concern for all rock types. Thus, Table 3.1.1 should be revised to show only bulk properties. Shale across bedding is much less permeable than typical broken basalt flows or ash beds.

E. PUBLIC NOTIFICATION PROCEDURES

When the U. S. Department of Energy holds further hearings, it should consider major modifications in the public notification procedures used for these hearings.

Although the Board recognizes that substantial effort was made to circulate the Statement and obtain public comment on it, the Board nevertheless recommends critical review of the Department's entire notification and mailing procedures. Its mailing lists should reach a more diversified group. Advertising, if used at all, should be more effectively designed and placed. Copies of impact statements should be available farther in advance of hearing dates.

Response

Recommendations by the Hearing Board to modify public notification procedures to reach a more diversified group will be considered by the DOE and where applicable will be implemented.

While the hearings on the Statement were under way, the Board was surprised to learn from witnesses that hearings were taking place at a nearby location on the environmental impact statement on the Waste Isolation Pilot Plant (WIPP), a proposed facility which would be used to test some of the uncertainties related to this Statement. Both the timing and the locations of those hearings competed for the attention of interested persons.

There seems also to be lack of consistency and consideration in time given for thoughtful public reaction to the Statement as compared with its preparation. For example, evolution of the Statement has taken several years during which a number of related waste management program documents have been prepared, received, and in one case, withdrawn. In contrast to the time taken in those processes, the limited period--days or weeks--given to interested persons to prepare comments in writing or orally on this massive technical document has imposed an unnecessary condition of undue haste on public participation.

These procedural deficiencies offset the earnestness with which many individuals in the Department of Energy sought wider public participation and designed a hearing process for doing so. The deficiencies also created the unfortunate impression at times that effective public participation is not regarded as a serious part of revising the Statement or of decision-making in the nuclear waste management program.

F. MISCELLANEOUS ITEMS REQUIRING REVIEW

1. Maps.

Maps of the United States showing the distribution of salt deposits and granites omit areas of their respective rock types and should either be deleted or more carefully compiled. Because several types of metamorphic rocks could behave toward waste in a similar manner to granites, perhaps they might also be identified on the map of granites. The map should clarify whether it refers only to granites or also to granodiorites and similar rocks, since granites are rarely homogeneous in composition. The map of basalts also omits many areas of basalt in the west and the Appalachians, for example.

2. Chemical Resynthesis.

The indication in the Statement that chemical resynthesis is for the purpose of achieving equilibrium with the host rock needs revision.. The foreign compounds of the waste cannot be in true equilibrium with the host rocks in the thermodynamic sense. Actually, the goal of resynthesis is to achieve minimum kinetic mobility of waste components in the host.

3. Retrievability from Wells.

After well injection, widespread dispersal of the waste fluid down the hydrologic gradient occurs, so that no significant fraction of the fluid is likely to be recovered by pumping. Furthermore, the reaction of other components of the host rock to neutralize any acid flush would thwart efforts to leach radioactive solutes lost by reaction with the host rock.

Response - Item 1

Maps showing the distribution of salt, granite and basalt have been revised to show extensive deposits of these rock types in the United States and are intended to give the reader a feeling for the spacial orientation of these rock types in this country. Additional revisions were made, where deemed necessary, to clarify the material being shown by the maps.

Response - Item 2

The Department agrees and has revised portions of this section to more accurately explain the goal of chemical resynthesis.

Response - Item 3

This Statement points out under the discussion of well injection, that utilization of this alternative would preclude waste retrievability.

4. Erosion Rates.

For most of the United States, erosion rates are only a few centimeters per thousand years, so that, contrary to the discussion of erosion rates in the Statement, erosion is no threat to mined or similarly deep repositories.

5. Geothermal Gradients.

The effect of geothermal gradients on the emplacement depth of waste canisters should be addressed because of the effects on heat loss from canisters and on rock plasticity.

6. Canister Rupturing.

Canister integrity can be affected by circumstances other than chemical corrosion or tectonic events. Some of such circumstances are puncturing and mechanical stress caused by differential compaction of the host rock on the canister overpacking.

7. Risk from Rock Falls.

The statement that "accidents that threaten human life are rarely caused by failure of the rock itself" does not square with the fact that rock falls, not rock bursts, are the typical causes of mining fatalities. These falls occur generally at joints or faults that have caused local weaknesses in the host rock.

Response - Item 4

It is generally agreed that erosion is not likely to be a threat to a deep repository. Much of the Statement is deliberately conservative to overly conservative in approach, particularly the accident scenarios.

Response - Item 5

The geothermal gradient has not received detailed consideration in this Statement. The contribution to the total heat of the system is a small fraction of that generated by the waste and would therefore not be a significant consideration when assessing the effects of heat loss from canisters and on rock plasticity.

Response - Item 6

Canister rupturing can occur in ways other than those discussed in this Statement. However, the Department feels that the mechanisms identified and described in this Statement adequately cover the range from potential mechanical to chemical failure of the canister.

Response - Item 7

Agree. The text has been changed to reflect that rock falls are the typical cause of mining fatalities.

III. CONCLUSIONS

Subject to the above recommendations, suggestions, and comments, the Hearing Board concludes that:

1. The Statement seriously and impressively analyzes the environmental impacts of proposed actions for solving the problem of disposing of commercially generated high-level radioactive waste.

2. The Statement has served effectively as a vehicle for public comment and for indicating and generating changes that should be made in the final statement.

3. The Statement supports the conclusion, in principle, that commercially generated high-level radioactive waste can be disposed of by one or more alternative strategies with minimal and acceptable environmental consequences, and that the present preferred disposal option is a deep, mined geologic repository.

The Board is concerned that the longer the delay in implementing an appropriate strategy to solve the problem of high-level radioactive waste disposal, the greater the erosion of political, scientific, and public support essential for such a strategy.

IV. BACKGROUND REFERENCES: REPORTS PROVIDED TO THE BOARD BY THE U.S. DEPARTMENT OF ENERGY

Battelle, Nontechnical Issues in Waste Management: Ethical, Institutional, and Political Concerns. Seattle, WA, Battelle, May 1978. 106 pp. PNL-2400. UC-70.

Ad Hoc Population Dose Assessment Group, Population Dose and Health Impact of the Accident at the Three Mile Island Nuclear Station. (A preliminary assessment for the period March 28 through April 7, 1979). Washington, D.C., U.S. Government Printing Office, May 10, 1979.

Analytic Sciences Corporation, A Status Report on Risk Assessment for Nuclear Waste Disposal. Palo Alto, CA, Electric Power Research Institute, October 1979. EPRI NP-1197. Interim Report.

Council on Environmental Quality. National Environmental Policy Act: Implementation of Procedural Provisions; Final Regulations. Washington, D.C., Federal Register, Vol. 43, No. 230, Wednesday, November 29, 1978, Part VI.

Federal Register. Vol. 44, No. 11 Friday June 15, 1979. pp. 34466-68. Nuclear Regulatory Commission 10 CFR Part 73 Physical Protection of Irradiated Reactor Fuel in Transit. Interim final rule.

Federal Register. Vol. 44, No. 78, Friday, April 20, 1979, pp. 23569-70; Vol. 44, No. 107, Friday, June 1, 1979, pp. 31699-31700; Vol. 44, No. 129, Tuesday, July 3, 1979, pp. 38994-95; Vol. 44, No. 139, Wednesday, July 18, 1979, pp. 41953-54. (About "Management of Commercially Generated Nuclear Wastes", Draft Generic Environmental Impact Statement)

Federal Register, Vol. 44, No. 208, Thursday, October 25, 1979, pp. 61372-61375. Nuclear Regulatory Commission, 10 CFR Parts 50 and 51. Storage and Disposal of Nuclear Waste. Notice of Proposed Rulemaking.

Interagency Review Group. Report to the President by the Interagency Review Group on Nuclear Waste Management. Washington, D.C., U. S. Department of Energy, March 1979. TID-29442.

President's Commission on the Accident at Three Mile Island. The Accident at Three Mile Island: The Need for Change: The Legacy of TMI. Washington, D.C., The Commission, October 1979, 79 pp. and Supplemental Views by Members of President's Commission on the Accident at Three Mile Island. October 25, 1979. 17 pp.

Public Law 91-190. 91st Congress, S. 1075. January 1, 1970. National Environmental Policy Act of 1969.

Rockwell Hanford Operatins, Basalt Waste Isolation Program Plan. Richland, WA, Rockwell Hanford Operations, May 15, 1979. RHO-CD-132 REV 3.

Science Applications Inc., Status Report on the EPRI Fuel Cycle Accident Risk Assessment. Palo Alto, CA, Electric Power Research Institute, July 1979. EPRI NP-1128. Interim Report.

United States Atomic Energy Commission. Operational Accidents and Radiation Exposure Experience. 1943-1975. Washington, D.C. U. S. Atomic Energy Commission, Fall 1975. 150 pp. WASH 1192.

U. S. Department of Energy, Commercial Waste Management: Multi-Year Program Plan. FY 1980. Washington, D.C. U. S. Department of Energy, August 1979. 60 pp.

_____, Defense Waste Management: Multi-Year Program Plan. FY 1980. Washington, D.C. U. S. Department of Energy, July 1979. Draft. 58 pp.

_____, Draft Environmental Impact Statement. Charge for Spent Fuel Storage. Washington, D.C., U. S. Department of Energy, December 1978. DOE/EIS-0041-D.

_____, Draft Environmental Impact Statement. Management of Commercially Generated Radioactive Waste. Washington, D.C., U. S. Department of Energy, April 1979. Vol. 1 and Vols. Appendices, DOE/EIS-0040-D.

_____, Draft Environmental Impact Statement, Management of Commercially Generated Radioactive Waste. Summary. Washington, D.C. U. S. Department of Energy, April 1979. 36 pp. DOE/EIS-0046-D. Summary.

_____, Draft Environmental Impact Statement, Storage of Foreign Spent Power Reactor Fuel. Washington, D.C., U. S. Department of Energy. December 1978. DOE/EIS-0046-D.

_____, Draft Environmental Impact Statement Storage, of U. S. Spent Power Reactor Fuels. Washington, D.C., U. S. Department of Energy. August 1978. DOE/EIS-0015-D.

_____, Draft Environmental Impact Statement Supplement, Storage of U. S. Spent Power Reactor Fuel. Washington, D.C., U. S. Department of Energy, December 1978. DOE/EIS-0015-DS Supplement.

_____, Draft Environmental Impact Statement, Waste Isolation Pilot Plant. Washington, D.C. U. S. Department of Enegy, April 1979. Volume 1 and Volume 2 (Appendices). DOE/EIS-0026-D.

_____, Environmental Aspects of Commercial Radioactive Waste Management. Washington, D.C., U. S. Department of Energy. May 1979. Volumes 1, 2, 3. DOE/ET-0029.

_____, Office of Nuclear Waste Isolation. National Waste Terminal Storage Program: Office of Nuclear Waste Isolation Technical Program Plan. Vol. 1, Technical Overview. Washington, D.C., U. S. Department of Energy, February 16, 1979. ONWI-19.

_____, Nevada Nuclear Waste Storage Investigations: FY 1979 Project Plan. Las Vegas, NV, U. S. Department of Energy, Nevada Operations Office, March 1979. NVO-196-9.

_____, Nuclear Waste Management. Washington, D.C., U. S. Department of Energy, Office of Communications, July 1979, 4 pp.

_____, Nuclear Waste Management Program: Summary Document. FY 1980. Washington, D.C., U S. Department of Energy, April 1979. DOE/ET-0094.

_____, Nuclear Waste Management Public Policy. Washington, D.C., U. S. Department of Energy, October 1979. (Draft #6. By K. Schmitz).

_____, Public Hearing Record on the Public Hearing Held by DOE on "Management of Commercially Generated Radioactive Waste", DOE/EIS-0046-D, Held in Atlanta, Georgia, on September 25-26, 1979. Washington, D.C., U. S. Department of Energy, November 1979. Volumes 1, 2, 3.

_____, Public Hearing Record on the Public Hearing Held by DOE on "Management of Commercially Generated Radioactive Waste", DOE/EIS-0046-D Held in Chicago, Illinois, on August 8-9, 1979. Washington, D.C., U. S. Department of Energy, August 1979. Volumes 1 and 2.

_____, Public Hearing Record on the Public Hearing Held by DOE on "Management of Commercially Generated Radioactive Waste", DOE/EIS-0046-D Held in Dallas, Texas, on October 2-3, 1979. Washington, D.C., U. S. Department of Energy, November 1979. Volumes 1, 2, 3, 4.

_____, Public Hearing Record on the Public Hearing Held by DOE on "Management of Commercially Generated Radioactive Waste", DOE/EIS-0046-D, Held in San Francisco, October 8-9, 1979. Washington, D.C., U. S. Department of Energy, November 1979.

_____, Public Hearing Record on the Public Hearing Held by DOE on "Management of Commercially Generated Radioactive Waste", DOE/EIS-0046-D, Held in Washington, D.C., June 26-27, 1979. Washington, D.C., U. S. Department of Energy, July 1979.

_____, Hearing Board. Report of the Panel Identifying Significant Issues on the Draft Environmental Impact Statement on the Waste Isolation Pilot Plant DOE/EIS-0026-D. Washington, D.C., U. S. Department of Energy, November 6, 1979. 18 pp.

_____, Spent Fuel Storage Programs: Multi-Year Program Plan. FY 1980. Washington, D.C., U. S. Department of Energy, Draft, May 1979, 29 pp.

_____, Technology for Commercial Radioactive Waste Management. Washington, D.C., U. S. Department of Energy, May 1979. Volumes 1, 2, 3, 4, 5. DOE/ET-0028.

U. S. Enviromental Protection Agency. Proposed Environmental Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes. (Invitation to Comment. Limited Distribution.) Washington, D.C., U. S. Environmental Protection Agency, October 9, 1979. Working Draft No. 7, Documents 1779A-Disc 0059A and Document 1815A-Disc 0059C.

U. S. General Accounting Office. Report by the Comptroller General of the United States. The National Nuclear Waste--Proposals for Organization and Siting. Washington, D.C., U. S. General Accounting Office, June 21, 1979, 19 pp.

U. S. Department of Energy and U. S. Geological Survey. Earth Science Technical Plan for Mined Geologic Disposal of Radioactive Waste. Washington, D.C., U. S. Department of Energy and U. S. Geologic Survey, January 1979. Draft. 151 pp. TID-29018.

Voss, J.W., Safety Indices and Their Application to Nuclear Waste Management Safety Assessment. Richland, WA, Battelle, April 1979. DNL-2727. VC-70.

REFERENCES

Armstrong, R. L. et al. 1977. "Rb-Sr Geochronometry of Mesozoic Granitic Rocks and Their Sr Isotopic Composition, Oregon, Washington and Idaho." Geol. Soc. Am. Bull., 88:397-411.

Atomic Energy Commission. 1972. Environmental Study of Transportation of Radioactive Materials to and from Nuclear Power Plants, WASH-1238. Washington, D.C.

Bishop, W. P. 1975. Seabed Disposal Program--A First Year Report, December 1974, SAND74-0410. Sandia Laboratories. Albuquerque, New Mexico.

Bond, F. W. and F. E. Kaszeta. 1979. Paradox Basin Sensitivity Analysis, PNL-3184. Pacific Northwest Laboratory. Richland, Washington (unpublished data)

Bott, M. H. P. 1971. Physics of the Earth's Interior. Edward Arnold. London.

Brandshaw, R. L. et al. 1971. Project Salt Vault: A Demonstration of the Disposal of High Activity Solidified Wastes in Underground Salt Mines, ORNL-4555. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Clairborne, H. D. and F. Gera. 1974. Potential Containment Failure Mechanisms and Their Consequences at a Radioactive Waste Repository in Bedded Salt in New Mexico, ORNL-TM-4639. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Code of Federal Regulations, Title 10, part 20.

Code of Federal Regulations, Title 10, part 23.

Code of Federal Regulations, Title 10, part 50, Appendix I.

Code of Federal Regulations, Title 10, part 60.

Code of Federal Regulations, Title 10, part 71.

Code of Federal Regulations, Title 10, part 190.10.

Code of Federal Regulations, Title 10, part 1022.

Code of Federal Regulations, Title 40, part 190.

Code of Federal Regulations, Title 40, part 173.398.

Code of Federal Regulations, Title 40, part 1502.20.

Code of Federal Regulations, Title 40, parts 1503.4, 1506.6

Code of Federal Regulations, Title 49, parts 170-189.

Davis, S. N. and R. J. M. DeWiest. 1967. Hydrogeology. J. Wiley and Sons, Inc. New York, New York. pp. 159-160.

Ekren, E. B. et al. 1974. Geologic and Hydrologic Considerations for Various Concepts of High-Level Radioactive Waste Disposal in Conterminous United States. USGS Open-File Report 74-158, U.S. Geologic Survey, Washington, D.C.

Elder, H. K. et al. 1978. An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck, PNL-2588. Pacific Northwest Laboratory. Richland, Washington.

Feldmenn, K. L. (ed.) 1976. Radiological Quality of the Environment, EPA/520-1-76-010, Environmental Protection Agency, Washington, D.C.

Hebert, J. A. et al. 1978. Nontechnical Issues in Nuclear Waste Management, PNL-2400. Battelle, Human Affairs Research Center. Seattle, Washington.

Interagency Review Group. 1978. Draft Report to the President by the Interagency Review Group on Nuclear Waste Management, United States Government Printing Office, Washington, D.C.

Interagency Review Group (IRG). 1979. Report to the President by the Interagency Review Group on Nuclear Waste Management, TID-29442. United States Government Printing Office.

Jenks, G. H. 1979. Effects of Gaseous Radioactive Nuclides on the Design and Operation of Repositories for Spent LWR Fuel in Rock Salt, ORNL-5578. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

Jenks, G. H. 1980. Review of Information on the Radiation chemistry of Materials Around Waste Canisters in Salt and Assessment of the Need for Additional Experimental Information, ORNL-5607. Oak Ridge National Laboratory. Oak Ridge, Tennessee.

McVey, D. F. et al. 1980. Thermal, Chemical and Mass Transport Processes Induced in Abyssal Sediments in the Emplacement of Nuclear Waste. Experimental and Second International Ocean Dumping Symposium. Woodshole, Massachusetts.

National Council on Radiation Protection and Measurements (NCRP). 1975. Natural Background Radiation in the United States, NCRP-45. Washington, D.C.

O'Brien, M. T. and H. P. Pratt. 1979. Very Deep Hole Concept: Evaluation of an Alternative for Nuclear Waste Disposal, LBL-7089. Lawrence Berkeley Laboratory. Berkeley, California.

Office of Nuclear Waste Isolation (ONWI). 1979. The Status on Borehole Plugging and Shaft Sealing for Geologic Isolation of Radioactive Waste, ONWI-15. Battelle Memorial Institute. Columbus, Ohio.

Office of Nuclear Waste Isolation. 1980. NWTS Criteria for the Geologic Disposal of Nuclear Wastes: Site-Qualification Criteria, ONWI-332). Battelle Memorial Institute. Columbus, Ohio.

Office of Waste Isolation. 1977. Contribution to Draft Generic Environmental Impact Statement on Commercial Waste Management: Radioactive Waste Isolation in Geologic Formations, Y/OWI/TM-35. Union Carbide. Oak Ridge, Tennessee.

Office of Waste Isolation. 1978. Technical Support for GEIS: Radioactive Waste Isolation in Geologic Formations, Y/OWI/TM-36. Union Carbide, Oak Ridge, Tennessee.

Perry, J. H. 1950. Chemical Engineers' Handbook, Third Edition, Second Impression. McGraw-Hill Book Company, Incorporated. New York, New York.

Peto, P. and R. L. Armstrong. 1976. "Strontium Isotope Study of the Composite Batholith Between Princeton and Okanogan Lake." Can. Jour. of Earth Science, 13:1577-1583.

Ramspott, L. D. 1978. Waste Isolation Projects--FY-1977, UCRL-50050-77. Lawrence Livermore Laboratory. Livermore, California.

Raymond, J. R. et al. 1980. Test Case Release Consequence Analysis for a Spent Fuel Repository in Bedded Salt, PNL-2782. Pacific Northwest Laboratory. Richland, Washington.

Rhoads, R. E., et al. 1977. A Safety and Economic Study of Special Trains for Shipment of Spent Fuel, BNWL-2263. Battelle Pacific Northwest Laboratories. Richland, Washington.

Rhoads, R. E. and P. L. Peterson. 1978. Conceptual Design of a Shipping Container for Transporting High Level Waste by Railroad, PNL-2244. Pacific Northwest Laboratory. Richland, Washington.

Russo, A. J. 1979. "Prediction of the Migration of Several Radionuclides in Ocean Sediment with the Computer Code IONMIG: A Preliminary Report," SAND79-1656. Sandia Laboratories. Albuquerque, New Mexico.

Sandia Laboratories. 1980a. Subseabed Disposal Program Plan, Volume 1: Overview, SAND80-0007/1. Albuquerque, New Mexico.

Sandia Laboratories. 1980b. Subseabed Disposal Program Plan, Volume II: Fiscal Year '80 Budget and Subtask Work Plans, SAND80-0007/11. Albuquerque, New Mexico. pp. 61-62.

Savannah River Laboratory. 1978. Economics of Water Basin Storage of Spent LWR Fuel, DPST-ISFS-78-1. Aiken, South Carolina.

Talbert, D. M. 1976. Seabed Disposal Program Annual Report, January-December 1975, SAND76-0256. Sandia Laboratories. Albuquerque, New Mexico.

Talbert, D. M. 1977. Seabed Disposal Program Annual Report, January-December 1976, SAND77-1270. Sandia Laboratories. Albuquerque, New Mexico.

Talbert, D. M. 1979. Seabed Disposal Program Annual Report, January-December 1977, SAND78-1359. Sandia Laboratories. Albuquerque, New Mexico.

Talbert, D. M. 1980. Seabed Disposal Program Annual Report, January-December 1978, SAND79-1618. Sandia Laboratories. Albuquerque, New Mexico.

U.S. Department of Energy. 1978a. Analytical Methodology and Facility Description--Spent Fuel Policy, DOE/ET-0054. Washington, D.C.

U.S. Department of Energy. 1978b. Conceptual Design Report for the Away From Reactor Spent Fuel Storage Facility, DOE-3547. Washington, D.C.

U.S. Department of Energy. 1979a. National Waste Terminal Storage Public Information Plan, DOE/NE-0008. Washington, D.C.

U.S. Department of Energy. 1979. Technology for Commercial Radioactive Waste Management, DOE/ET-0028. Washington, D.C.*

U.S. Department of Energy. 1979. Environmental Aspects of Commercial Radioactive Waste Management, DOE/ET-0029. Washington, D.C.*

U.S. Department of Energy. 1980a. Department of Energy Statement of Position to the NRC Rulemaking on Nuclear Waste Storage and Disposal, DOE/NE-0007. Washington, D.C.

U.S. Department of Energy. 1980b. U.S. Spent Fuel Policy, DOE/EIS-0015. Washington, D.C.

U.S. Department of the Interior. 1972. Minerals Yearbook. Washington, D.C. p. 1229.

U.S. Energy Research and Development Administration. 1975. Final Environmental Impact Statement Liquid Metal Fast Breeder Reactor Program, ERDA-1535. Washington, D.C.

U.S. Energy Research and Development Administration. 1976a. Final Environmental Statement Light Water Breeder Reactor Program, ERDA-1541. Washington, D.C.

U.S. Energy Research and Development Administration. 1976b. Alternatives for Managing Wastes from Reactors and Post Fission Operations in the LWR Fuel Cycle, ERDA-76-43. Washington, D.C.

U.S. Environmental Protection Agency. 1977. Technical Support of Standards for High Level Radioactive Waste Management, EPA 520/A-79-007B. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1976a. Final General Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors, NUREG-ES-0002. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1976b. Potential Releases of Cesium from Irradiated Fuel in a Transportation Accident, NUREG-0069. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1978a. Handling and Storage of Spent Light Water Power Reactor Fuel, NUREG-0404. Washington, D.C.

* Supporting documentation for DOE/EIS-0046.

U.S. Nuclear Regulatory Commission. 1978b. Shock and Vibration Environments for a Large Shipping Container During Truck Transport (part 2), NUREG/CR-0128. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1978c. Technology, Safety and Costs of Decommissioning a Reference Pressurized Water Reactor Power Station. Main Report, NUREG/CR-0130. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1979a. Final Generic Environmental Statement on Handling and Storage of Spent Light Water Power Reactor Fuel. NUREG-0575. Washington, D.C.

U.S. Nuclear Regulatory Commission. 1979b. Information Base for Waste Repository Design, NUREG/CR-0495. Washington, D.C.

APPENDIX A

LIST OF RESPONDENTS TO DOE/EIS-0046D

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LIST OF RESPONDENTS TO DOE/EIS-0046D

Appendix A contains the names of individuals, organizations and agencies that submitted written comments on the draft Statement. A number has been assigned to each letter. These numbers appear following each issue stated in the text of Volume 3, as a means of indicating the respondents concerned with that issue.

To assist the reader, two lists are presented. The first list is ordered by letter number which correspond to the sequence in which the letters were recieved by the Department. The second list is an alphabetized list of the names, organizations and agencies which responded to the draft Statement with written comments. This second list is divided such that private individuals and organizations appear first, followed by State and Federal Agencies. This list was alphabetized by name for individuals and organizations responding, by agency for Federal respondents and by State and agency for State respondents.

COMMENTER	DATE RECEIVED
1. Mr. R. C. Baxter Allied-General Nuclear Services P.O. Box 847 Barnwell, SC 29812	05-31-79
2. Ms. Edith Roth 6029 Oakdale Avenue Woodland Hills, CA 91367	06-06-79
3. Mr. Terry Kubicek Natural Resources Coordinator State Office of Planning & Programming Box 94601, State Capital, Room 1321 Lincoln, NB 68509	06-27-79
4. Mr. Aarne O. Kauranen Regional Engineer Federal Energy Regulatory Commission Regional Office 730 Peachtree Street, N.E. Atlanta, GA 30308	06-27-79
5. Mr. W. J. Mecham Argonne National Laboratory 9700 South Cass Avenue Argonne, IL 60439	06-27-79
6. Mr. W. P. Bebbington 905 Whitney Drive Aiken, SC 29801	07-03-79
7. Mr. William P. Dornsife, P.E. Bureau of Radiation Protection Department of Environmental Resources P.O. Box 2063 Harrisburg, PA 17120	07-03-79
8. Mr. William A. Lochstet 119 E. Aaron Dr. State College, PA 16801	07-06-79
9. Chrys Baggett, Director State Clearing House North Carolina Department of Administration 116 W. Jones Street Raleigh, NC 27611	07-06-79
10. Mr. Donald Orth Savannah River Laboratory P.O. Box A Aiken, SC 29801	07-10-79
11. Mr. Ted Breitmayer 148 Draeger Drive Moraga, CA 94556	07-10-79

COMMENTER	DATE RECEIVED
12. Ms. Edith M. McKee 416 Maple Street Winnetka, IL 60093	07-10-79
13. Mr. W. S. Geiger 741 Woodhill Drive Lakeland, FL 33808	07-10-79
14. Ms. Pam Demo-Rybus Division of Budget, Policy Planning and Coordination Executive Office of the Governor State Clearinghouse State House Boise, ID 83720	07-10-79
15. Mr. Paul Kiepe 2141 1st Avenue S. Payette, ID 83661	07-11-79
16. Mr. Max Eisenberg, Acting Director Environmental Health Administration Department of Health and Mental Hygiene P.O. Box 13387 201 West Preston Street Baltimore, MD 21203	07-11-79
17. Mr. Arvind Srivastava Kaiser Engineers Inc. 300 Lakeside Drive Oakland, CA 94666	07-11-79
18. Mr. Edward Gabriel Council of Energy Resource Tribes One Thousand Connecticut Avenue, N.W. Suite 610 Washington, DC 20036	07-11-79
19. Ms. Emily Neary State of Vermont Office of the Governor State A-95 Clearinghouse Montpelier, VT 05602	07-11-79
20. Mr. T. J. Crossley 16 Loma Linda Lane Lakeland, FL 33803	07-11-79
21. Mr. Robert K. Kunita 4234 Lake Ridge Drive Raleigh, NC 27604	07-11-79
22. Mr. Donald E. Harley Office of the Governor Executive Office Building 411 West 13th Street Austin, TX 78701	07-11-79

COMMENTER	DATE RECEIVED
23. Mr. Sidney R. Galler United States Department of Commerce The Assistant Secretary for Science and Technology Washington, DC 20230	07-11-79
24. Mr. Mike Nolan Governor's Office of Planning Coordination Capitol Complex Carson City, NV 89710	07-12-79
25. Mr. Paul W. Levy Brookhaven National Laboratory Associated Universities, Inc. Upton, NY 11973	07-12-79
26. Mr. Robert H. Moen 6602 Tam O'Shanter Drive San Jose, CA 95120	07-12-79
27. Mr. Daniel Hunt National Science Foundation Washington, DC 20550	07-12-79
28. Mr. Derek Wallentinsen Albuquerque Group Sierra Club 3131 Quincy NE Albuquerque, NM 87110	07-13-79
29. Mr. John E. Schulte 1916 Marconi Road Wall, NJ 07719	07-13-79
30. Mr. Marvin I. Lewis 6504 Bradford Terrace Philadelphia, PA 19149	07-13-79
31. Mr. Paul DeGaeta Department of Administration Division of State Planning and Research Fourth Floor--Mills Building 109 W. 9th Topeka, KS 66612	07-16-79
32. Mr. Lawrence Schmidt, Chief Office of Environmental Review Department of Environmental Protection P.O. Box 1390 Trenton, NJ 08625	07-16-79
33. Mr. B. Jim Porter Office of Conservation P.O. Box 14690 Baton Rouge, LA 70808	07-16-79

COMMENTER	DATE RECEIVED
34. Mr. D. L. Renberger Assistant Director of Technology Washington Public Power Supply System P.O. Box 968 3000 George Washington Way Richland, WA 99352	07-16-79
35. Ms. Judith Y. Brachman Administering Officer State Clearinghouse 30 East Broad Street 39th Floor Columbus, OH 43215	07-17-79
36. Chrys Baggett, Director (Duplicate of 9) State Clearinghouse North Carolina Department of Administration 116 West Jones Street Raleigh, NC 27611	07-18-79
37. Mr. J. B. Jackson, Jr. Administrator Commonwealth of Virginia 903 Ninth Street Office Building Richmond, VA 23219	07-19-79
38. Mr. J. A. McBride Box 192 Merrifield, VA 22116	07-23-79
39. Mr. Thomas M. Webb, Director Natural Resources Planning Tennessee State Planning Office 660 Capitol Hill Building 301 Seventh Avenue, North Nashville, TN 37219	07-23-79
40. Mr. Joel Yellin Harvard University John F. Kennedy School of Government 79 Boylston Street Cambridge, MA 02138	07-25-79
41. Dick Hartman State Planning Coordinator Wyoming Executive Department Cheyenne, WY 82001	07-27-79
42. J. S. Sherman Department of Environmental Regulation Twin Towers Office Building 2600 Blair Stone Road Tallahassee, FL 32301	07-31-79
43. Lee Sherman Dreyfus Governor, State of Wisconsin State Capitol Madison, WI 53702	08-06-79

COMMENTER	DATE RECEIVED
44. Joseph M. Sorboro NEFCO 137 South Main Street Suite 300 Delaware Building Akron, OH 44308	07-29-79
45. James Mulloy Department of Water and Power 111 North Hope Street Los Angeles, CA 90012	08-08-79
46. Donald E. Harley, Manager (Addresses wrong EIS) Economic and Natural Resources Budget and Planning Office Office of the Governor Executive Office Building 411 West 13th Street Austin, TX 78701	08-08-79
47. Mrs. Lawrence Lewis 3206 Columbia Parkway Cincinnati, OH 45206	08-09-79
48. Harold V. Larson (Addresses wrong EIS) Battelle, Pacific Northwest Laboratories P.O. Box 999 Richland, WA 99352	08-14-79
49. J. H. Kittel Argonne National Laboratory 9700 South Cass Avenue Argonne, IL 60439	08-14-79
50. Mr. Gerald R. Day, Executive Director Illinois Commission on Atomic Energy Lincoln Tower Plaza 524 South Second Street--Room 415 Springfield, IL 62706	08-15-79
51. Mrs. Lawrence Lewis (Additional comments to 47) 3206 Columbia Parkway Cincinnati, OH 45206	08-17-79
52. Albert H. Quie Governor of Minnesota State of Minnesota St. Paul, MN 55155	08-20-79
53. Charles L. Pater Belden Corporation 2000 South Cass Avenue Geneva, IL 60134	08-21-79

COMMENTER	DATE RECEIVED
54. Edward Hennelly Savannah River Laboratory Aiken, SC 29801	08-30-79
55. Catherine Quigg, Research Director Pollution & Environmental Problems, Inc. Box 309, Palatine, IL 60067	09-05-79
56. John Dilday 200 Hillsboro St. Cary, NC 27511	09-07-79
57. Ermont M. Lawrence 5241 S.E. 115th Street Belleview, FL 32620	09-10-79
58. Lyle L. Zahn, Jr., Manager Spent Fuel Services Operation General Electric Company 175 Curtner Avenue San Jose, CA 95125	09-10-79
59. J. R. Buford 237 Leland Way Hanford, CA 93230	09-12-79
60. Paulette Oakes 1118 Ingra Anchorage, AK 99501	09-12-79
61. Carl Groff 200 Bolinas RD #81 Fairfax, CA 94930	09-12-79
62. Brandt Mannchen 4055 South Braeswood #303 Houston, TX 77025	09-12-79
63. Louis B. Carrick 365 Beechwood Drive Athens, GA 30606	09-18-79
64. Walter E. Wallis Wallis Engineering 1954--R Old Middlefield Way Mountain View, CA 94043	09-18-79
65. Agnes S. Easterly 1100 University Street Seattle, WA 98101	09-19-79
66. Robert F. Davis 2706 N. Chamberlain Chattanooga, TN 37406	09-19-79

COMMENTER	DATE RECEIVED
67. Roland Livernois Livernois Enterprise 1231 Kenyon Road Lake City, GA 30252	09-19-79
68. Ron Fahs, Director (Duplicate of 42) Intergovernmental Coordination State of Florida Office of the Governor Tallahassee, FL 32301	09-19-79
69. L. E. Lantaff, I.I.C U.S. Department of Agriculture Food Safety and Quality Service Meat and Poultry Inspection Program 1400 S. Green Street, P.O. Box 744 Henderson, KY 42420	09-20-79
70. Herbert L. Harper Executive Director and State Historic Preservation Officer Tennessee Department of Conservation Tennessee Historical Commission 4721 Trousdale Drive Nashville, TN 37220	09-20-79
71. David K. Brooks P.O. Box 16929 Jackson, MS 39206	09-20-79
72. Mr. Ben Cornwell 1795 Magnolia Tree Germantown, TN 38138	09-20-79
73. David DeBus, PhD. 425 Bonair Street La Jolla, CA 92037	09-20-79
74. Linda Baziuk Route 3, Box 438 Yadkinville, NC 27055	09-20-79
75. David Shields 419 Oakdale Rd. N.E. Atlanta, GA 30307	09-19-79
76. Arden A. Richards 3305 East Skylane Drive Florence, SC 29501	09-20-79
77. Edward L. Jones Route 4, Berry Road Taylors, SC 29687	09-20-79
78. Bob Brister 4308 Rhodes Avenue Memphis, TN 38111	09-20-79

COMMENTER	DATE RECEIVED
79. Walter Julius Weems 3599 Saturn Drive Northwest Atlanta, GA 30331	09-20-79
80. Paul Grier 10460 S.W. 111 Street Miami, FL 33176	09-21-79
81. Mr. J. P. Moore 6107 Main Avenue Tampa, FL 33611	09-21-79
82. Kenneth Yonovitz 4206 Washington Road West Palm Beach, FL 33405	09-21-79
83. Marjorie King Carolina Nutrition Corner, Inc. 2514-A. E. North Street, Ext. Burns Corner (E. North St. & Pelham Rd) Greenville, SC 29607	09-21-79
84. Leo Benson, III 1274 Sledge Avenue Memphis, TN 38104	09-21-79
85. Harry A. Galliher 250 West Artesia Pomona, CA 91768	09-24-79
86. William J. McClusky 4317 Rhodes Memphis, TN 38111	09-24-79
87. Daniel Kaminsky Savannah River Galleries 309 Bull Street Savannah, GA 31401	09-24-79
88. Zelia Jensen, R.N. Route 1, Box 86A Grandview, TN 37337	09-25-79
89. Chris Findlay 235 Stone Avenue Lexington, KY 40508	09-25-79
90. Lorane H. Minis 4142 Amsterdam Circle Savannah, GA 31405	09-25-79
91. Mrs. Marge Nejedly 109 W. Kennedy Drive Holiday, FL 33590	09-26-79

COMMENTER	DATE RECEIVED
92. Fred L. Lemon Highway 90 and Church Street Ocean Springs, MS 39564	09-26-79
93. Beth E. Buzzard 2016 E. State Avenue Olympia, WA 98506	09-26-79
94. Dr. Leo Pocuis, M.D. The Doctors Clinic 2512 Wheaton Way Bremerton, WA 98310	09-26-79
95. Charles W. Larimer, Jr. 1308 60th St. Ensley Birmingham, AL 35228	09-26-79
96. Nadine A. Vesel 6237 N. Winthrop Chicago, IL 60660	09-26-79
97. George Busbee Office of the Governor Atlanta, GA 30334	09-26-79
98. Gloria C. Rains Manasota--88 5314 Bay State Rd. Palmetto, FL 33561	09-26-79
99. Mrs. Irma Ragan Holland 2210 Creston Road Raleigh, NC 27608	09-26-79
100. Calvin P. Ragan Route 1--Box 323 New Hill, NC 27562	09-26-79
101. Yvonne Brunton 120 Leatnice Lane Vicksburg, MS 39170	09-26-79
102. Elizabeth Briggs 10 Bliss Avenue Woodland, CA 95695	10-02-79
103. Jeanette Cool 30 Langton San Francisco, CA 94103	10-02-79
104. Marie Pnazek 2208 Knob Creek Rd. Johnson City, TN 37601	10-02-79
105. James V. Keilman Moon Lake Volunteer Fire Dept. P.O. Box 914, Moon Lake Estates New Port Richey, FL 33552	10-02-79

COMMENTER	DATE RECEIVED
106. Edward E. Rice 1819 Lagoon View Drive Tiburon, CA 94920	10-02-79
107. William Dreskin 245 Los Angeles Boulevard San Anselmo, CA 94960	10-02-79
108. Sherman Stein 811 Oak Avenue Davis, CA 95616	10-02-79
109. John M. Bailey, Jr. 625 Huntleigh Drive Lafayette, CA 94549	10-02-79
110. John F. Doherty 4438-1/2 Leeland Houston, TX 77023	10-02-79
111. Ethelyn Brooks 727 Saddlerock Wenatchee, WA 98801	10-02-79
112. Mike Barrett Concerned Texan and Opponent to Nuclear Power and Waste 1505 West Third Avenue Corsicano, TX 75110	10-02-79
113. William N. Hedeman, Jr., Director Office of Environmental Review U.S. Environmental Protection Agency Washington, DC 20460	09-27-79
114. Myra A. Cypser 5743 Leverett Court Alexandria, VA 22311	10-02-79
115. Albert Bates, Project Director PLENTY Shutdown Project 156 Drakes Lane Summertown, TN 38483	10-04-79
116. Ellery W. Newton American Small Farm Institute Mercer Island, WA 98040	10-04-79
117. Naomi M. Proett 1200 Norfolk Avenue W. Sacramento, CA 95691	10-04-79
118. Mrs. Robert Lawton 1403 Randolph Circle Tallahassee, FL 32312	10-04-79

COMMENTER	DATE RECEIVED
119. Frank Jantlick 1306 Driftwood Drive New Port Richey, FL 33552	10-04-79
120. Jim McGarr 303 E. College Street Clinton, MS 39056	10-04-79
121. Zelia Jensen, R.N. (Duplicate of 88) Route 1, Box 86A Grandview, TN 37337	10-04-79
122. William J. McClusky (Duplicate of 86) 4317 Rhodes Memphis, TN 38111	10-04-79
123. Michael Griffin 2885 Naples Drive Winter Park, FL 32789	10-04-79
124. Edwin Wiggin Atomic Industrial Forum, Inc. 7101 Wisconsin Avenue Washington, DC 20014	10-04-79
125. Lynne Bowman 4030 Montwood Drive Dallas, TX 75229	10-04-79
126. Robert Leverant P.O. Box 9444 Berkeley, CA 94709	10-04-79
127. Louise Wilson 235 Churchill Avenue Palo Alto, CA 94301	10-04-79
128. Dorothy Newmeyer Perkins Biology Department Stanford University Stanford, CA 94305	10-04-79
129. Mrs. W. W. Schaefer, Chairman Radioactive Waste Management Study Committee Lake Michigan Federation c/o 3741 Koehler Drive Sheboygan, WI 53081	10-04-79
130. R. Marriner Orum 2389 Floral Hill Drive Eugene, OR 97403	10-04-79
131. Matt Edwards 3743 Texas Street San Diego, CA 92104	10-05-79

COMMENTER	DATE RECEIVED
132. Mrs Victor N. Tolpegin 11 Eugene Street Mill Valley, CA 94941	10-05-79
133. Mrs. C. R. Nicewonger 80 Codornices Road Berkeley, CA 94708	10-05-79
134. W. R. Flores 5210 Wilson Drive Riverside, CA 92509	10-05-79
135. Winifred A. Many 1063 Euclid Avenue Berkeley, CA 94708	10-05-79
136. Emory L. Ellis P.O. Box 195 Kernville, CA 93238	10-05-79
137. (No name given)	10-05-79
138. Lois and Harold Mills 7660 Morella Avenue North Hollywood, CA 91605	10-05-79
139. Rep. W. J. Tauzin Louisiana House of Representatives Committee on Natural Resources Box 44012, Capitol Station Baton Rouge, LA 70804	10-05-79
140. Cindy and Arthur Scott 8 Athlone Way Menlo Park, CA 94025	10-05-79
141. Julia Corliss P.O. Box 247 Fairfax, CA 94930	10-05-79
142. Phyllis Luckman 668 Fairmount Avenue Oakland, CA 94611	10-05-79
143. H. F. Longway 905 Camelia Avenue Roseville, CA 95678	10-05-79
144. Walbridge J. Powell 4314 Island Crest Way Mercer Island, WA 98040	10-05-79
145. David R. Wallace 4289 A Piedmont Avenue Oakland, CA 94611	10-05-79

COMMENTER	DATE RECEIVED
146. Ariadne Rogers Wright 2206 Spring Creek Drive Austin, TX 78704	10-05-79
147. Robert E. Evans 468 W. Melrose, Apt. 351 Chicago, IL 60657	10-05-79
148. Mrs. Barbara Yendle 939 S. Royall Palestine, TX 75801	10-05-79
149. William Klitz 21321/2 Derby Berkeley, CA 94705	10-05-79
150. Donald J. Purinton 1312 Apache Drive Richardson, TX 75080	10-05-79
151. Karl Knute Kresie 555C Stanford Avenue Palo Alto, CA 94306	10-05-79
152. D. G. Mason, Programs Director Fuel and Waste Management Rockwell International Atomics International Division Energy Systems Group 8900 DeSoto Avenue Canoga Park, CA 91304	10-05-79
153. Dabney K. Johnson Rt. 3, Wheeler Rd. Apt. 22 Louisville, TN 37777	10-05-79
154. Lowenstein, Newman, Reis, Axelrad and Toll 1025 Connecticut Avenue, N.W. Washington, DC 20036	10-09-79
155. Mrs. Wendell W. Ray 8755 Junipero Avenue Atascadero, CA 93422	10-09-79
156. Boyce R. Wells Environmental Review Coordinator Commonwealth of Kentucky Department for Natural Resources and Environmental Protection Office of the Secretary Office of Policy and Program Analysis Capital Plaza Tower Frankfort, KY 40601	10-09-79

COMMENTER	DATE RECEIVED
157. Frances Pavlovic 111 Datonia Bellaire, TX 77401	10-09-79
158. Norman Gelfand 5640 S. Ellis Avenue Chicago, IL 60637	10-09-79
159. Mr. Wendell W. Ray 8755 Junipero Avenue Atascadero, CA 93422	10-09-79
160. Larry Gaffin First Congregational Church S. Palouse and E. Alder Street Walla Walla, WA 99362	10-09-79
161. John C. Lanigan, Jr. Department of Geology Kent State University Kent, OH 44242	10-09-79
162. Mary A. Stewart 6212 S. El Camino Drive Tempe, AZ 85283	10-10-79
163. Bennie Wooten 27087 Twenty Mule Team Road Boron, CA 93516	10-10-79
164. Murray Solomon SOLCO 11 Vineyard Road Newton, MA 02159	10-10-79
165. Florence Klinger 072 Green Street Martinez, CA 94553	10-10-79
166. Martin E. Fate, Jr. Executive Vice President Public Service Company of Oklahoma P.O. Box 201 Tulsa, OK 74102	10-10-79
167. Jan Clucas, Chairman Santa Lucia Chapter Sierra Club 1727 Corralitos Avenue San Luis Obispo, CA 93401	10-10-79
168. John E. Arthur, Chief Engineer Rochester Gas and Electric Corporation 89 East Avenue Rochester, NY 14649	10-10-79
169. Charity Cone 3000 Pecho Valley Road Los Aros, CA 93402	10-10-79

COMMENTER	DATE RECEIVED
170. Mrs. Edith W. Liu 32 Parkside Drive Davis, CA 95616	10-10-79
171. Robert D. Postar 359 Half Moon Lane #314 Daly City, CA 94015	10-10-79
172. C. R. Nicewonger (Additional comments to 133) 80 Codornices Road Berkeley, CA 94708	10-10-79
173. Mrs. Edith M. Hoyt 3316 Villanova Dallas, TX 75225	10-10-79
174. John Castleberry 2400 Lawndale Plano, TX 75023	10-10-79
175. C. E. Glover Rt. 2 Box 319-A Palestine, TX 75801	10-10-79
176. Kathleen Jensen 122 Cypress Street Alameda, CA 94501	10-10-79
177. Clark L. Moore Resource Consultant 1180 Ash Street Arroyo Grande, CA 93420	10-10-79
178. John B. Gordon, PE 1007 Green Meadow Round Rock, TX 78664	10-10-79
179. David Woolson Rt. 1 Box 26 Medical Lake, WA 99022	10-10-79
180. Jack C. Wells Central and Southwest Services, Inc. 2700 One Main Place Dallas, TX 75250	10-11-79
181. D. S. Webster, Deputy Director Argonne National Laboratory 9700 South Cass Avenue Argonne, IL 60439	10-11-79
182. W. N. Thomas, Vice President Fuel Resources Virginia Electric and Power Company Richmond, VA 23261	10-11-79

COMMENTER	DATE RECEIVED
183. R. A. Langley, Jr. 80 Lansdale Avenue San Francisco, CA 94127	10-11-79
184. Saralee W. Terry, Resource Analyst (Duplicate of 39) Tennessee State Planning Office 660 Capitol Hill Building 301 Seventh Avenue, North Nashville, TN 37219	10-11-79
185. Shelley J. Hegge P.O. Box 10307 Anchorage, AK 99511	10-11-79
186. Marion Stuart 2428 Jefferson Street Berkeley, CA 94703	10-16-79
187. Murray Soloman (Duplicate of 164) SOLCO 11 Vineyard Road Newton, MA 02159	10-12-79
188. Boyd Weeks 27000 N. HWY. 1 Fort Bragg, CA 95437	10-16-79
189. Roy G. Post, Professor The University of Arizona College of Engineering Department of Nuclear Engineering Tucson, AZ 85721	10-16-79
190. Donald J. Stierman Assistant Professor of Geophysics University of California Riverside, California 92521	10-16-79
191. W. W. Schaefer, M.D. Chairman, Committee on Environmental Health The State Medical Society of Wisconsin 330 East Lakeside Street P.O. Box 1109 Madison, WI 53701	10-16-79
192. No name	10-16-79
193. Nancy N. Kroe 3711 West Tilden Place Seattle, WA 98199	10-16-79
194. Linda Hoyt 172 A. Downey Street San Francisco, CA 94117	10-16-79

COMMENTER	DATE RECEIVED
195. Dr. and Mrs. Jack M. Troy The Whiting Clinic, Inc. 2075 Indianapolis Blvd. Whiting, IN 46394	10-16-79
196. M. Peter Lanahan, Jr. First Deputy Commissioner State of New York Department of Environmental Conservation Albany, NY 12233	10-16-79
197. Robert A. Phillips 263 Via Cima Ct. Danville, CA 94526	10-16-79
198. M. T. Johnson, General Manager Advanced Energy Systems Division Westinghouse Electric Corporation Box 10864 Pittsburgh, PA 15236	10-18-79
199. S. A. Gray, Jr. 41 E. Liberty Street Waynesboro, GA 31564	10-18-79
200. Phillip R. Compton NASA	10-18-79
201. Frank L. Parker Vanderbilt University Nashville, TN 37235	10-18-79
202. Charles Custard, Director Office of Environmental Affairs Department of Health, Education and Welfare Office of the Secretary Washington, DC 20201	10-18-79
203. James Sharp 307 Granville Rd. Chapel Hill, NC 27514	10-19-79
204. Charleston Chapter of the Palmetto Alliance P.O. Box 582 Charleston, SC 29402	10-19-79
205. Mrs. Helen M. Serenka 319 Los Pinos Way San Jose, CA 75248	10-21-79
206. Linda Oshman 7614 Lairds Lane Dallas, TX 75248	10-21-79
207. Lawrence E. Davis 735 Monssex Parkway Dallas, TX 75224	10-21-79

COMMENTER	DATE RECEIVED
208. John B. Martin, Director Division of Waste Management U.S. Nuclear Regulatory Commission Washington, DC 20555	10-29-79
209. Watson Totus, Chairman Yakima Tribal Council Confederated Tribes and Bands Yakima Indian Nation P.O. Box 151 Toppenish, WA 98948	10-29-79
210. Sara Morabito 909 University AV 10 Los Gatos, CA 95030	10-29-79
211. Bryan L. Baker Education and Research Committee Mockingbird Alliance 900 Lovett Blvd.--Suite 207 Houston, TX 77006	10-29-79
212. James R. Schofield 2440A Fulton San Francisco, CA 94118	10-29-79
213. Thomas G. Griffith Griffith & Brister Suite 6F, Lubbock National Building Lubbock, TX 79401	11-01-79
214. Michael Gersick, Deputy Director Department of Conservation Division of Mines and Geology Division of Oil and Gas Sacramento, CA 93814	11-08-79
215. Paul F. Levy, Director Arkansas Department of Energy 3000 Kavanaugh Little Rock, AR 72205	11-16-79
216. Merry Jo Hill Life of the Land 404 Piikoi Street Honolulu, HI 96814	11-19-79
217. Emilio E. Varanini, III Energy Resources Conservation and Development Commission 1111 Howe Avenue Sacramento, CA 95825	11-19-79
218. James Rashlin U.S. Department of the Interior Office of the Secretary Washington, DC 20240	11-20-79
219. National Research Council Commission on Natural Resources 2101 Constitution Avenue Washington, DC 20418	05-18-80

COMMENTER	DATE RECEIVED	LETTER NUMBER
John E. Arthur, Chief Engineer Rochester Gas and Electric Corporation 89 East Avenue Rochester, NY 14649	10-10-79	168
John M. Bailey, Jr. 625 Huntleigh Drive Lafayette, CA 94549	10-02-79	109
Bryan L. Baker Education and Research Committee Mockingbird Alliance 900 Lovett Blvd.--Suite 207 Houston, TX 77006	10-29-79	211
Mike Barrett Concerned Texan and Opponent to Nuclear Power and Waste 1505 West Third Avenue Corsicano, TX 75110	10-02-79	112
Albert Bates, Project Director PLENTY Shutdown Project 156 Drakes Lane Summertown, TN 38483	10-04-79	115
Mr. R. C. Baxter Allied-General Nuclear Services P.O. Box 847 Barnwell, SC 29812	05-31-79	1
Linda Baziuk Route 3, Box 438 Yadkinville, NC 27055	09-20-79	74
Mr. W. P. Bebbington 905 Whitney Drive Aiken, SC 29801	07-03-79	6
Leo Benson, III 1274 Sledge Avenue Memphis, TN 38104	09-21-79	84
Lynne Bowman 4030 Montwood Drive Dallas, TX 75229	10-04-79	125
Ms. Judith Y. Brachman Administering Officer State Clearinghouse 30 East Broad Street 39th Floor Columbus, OH 43215	07-17-79	35
Mr. Ted Breitmayer 148 Draeger Drive Moraga, CA 94556	07-10-79	11

COMMENTER	DATE RECEIVED	LETTER NUMBER
Elizabeth Briggs 10 Bliss Avenue Woodland, CA 95695	10-02-79	102
Bob Brister 4308 Rhodes Avenue Memphis, TN 38111	09-20-79	78
David K. Brooks P.O. Box 16929 Jackson, MS 39206	09-20-79	71
Ethelyn Brooks 727 Saddlerock Wenatchee, WA 98801	10-02-79	111
Yvonne Brunton 120 Leatnice Lane Vicksburg, MS 39170	09-26-79	101
J. R. Buford 237 Leland Way Hanford, CA 93230	09-12-79	59
Beth E. Buzzard 2016 E. State Avenue Olympia, WA 98506	09-26-79	93
Louis B. Carrick 365 Beechwood Drive Athens, GA 30606	09-18-79	63
John Castleberry 2400 Lawndale Plano, TX 75023	10-10-79	174
Jan Clucas, Chairman Santa Lucia Chapter Sierra Club 1727 Corralitos Avenue San Luis Obispo, CA 93401	10-10-79	167
Phillip R. Compton NASA	10-18-79	200
Charity Cone 3000 Pecho Valley Road Los Aros, CA 93402	10-10-79	169
Jeanette Cool 30 Langton San Francisco, CA 94103	10-02-79	103
Julia Corliss P.O. Box 247 Fairfax, CA 94930	10-05-79	141

COMMENTER	DATE RECEIVED	LETTER NUMBER
Mr. Ben Cornwell 1795 Magnolia Tree Germantown, TN 38138	09-20-79	72
Mr. T. J. Crossley 16 Loma Linda Lane Lakeland, FL 33803	07-11-79	20
Myra A. Cypser 5743 Leverett Court Alexandria, VA 22311	10-02-79	114
Lawrence E. Davis 735 Monssex Parkway Dallas, TX 75224	10-21-79	207
Robert F. Davis 2706 N. Chamberlain Chattanooga, TN 37406	09-19-79	66
Mr. Gerald R. Day, Executive Director Illinois Commission on Atomic Energy Lincoln Tower Plaza 524 South Second Street--Room 415 Springfield, IL 62706	08-15-79	50
David DeBus, PhD. 425 Bonair Street La Jolla, CA 92037	09-20-79	73
John Dilday 200 Hillsboro St. Cary, NC 27511	09-07-79	56
John F. Doherty 4438-1/2 Leeland Houston, TX 77023	10-02-79	110
Mr. William P. Dornsife, P.E. Bureau of Radiation Protection Department of Environmental Resources P.O. Box 2063 Harrisburg, PA 17120	07-03-79	7
William Dreskin 245 Los Angeles Boulevard San Anselmo, CA 94960	10-02-79	107
Agnes S. Easterly 1100 University Street Seattle, WA 98101	09-19-79	65
Matt Edwards 3743 Texas Street San Diego, CA 92104	10-05-79	131
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COMMENTER	DATE RECEIVED	LETTER NUMBER
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Martin E. Fate, Jr. Executive Vice President Public Service Company of Oklahoma P.O. Box 201 Tulsa, OK 74102	10-10-79	166
Chris Findlay 235 Stone Avenue Lexington, KY 40508	09-25-79	89
W. R. Flores 5210 Wilson Drive Riverside, CA 92509	10-05-79	134
Mr. Edward Gabriel Council of Energy Resource Tribes One Thousand Connecticut Avenue, N.W. Suite 610 Washington, DC 20036	07-11-79	18
Harry A. Galliher 250 West Artesia Pomona, CA 91768	09-24-79	85
Mr. W. S. Geiger 741 Woodhill Drive Lakeland, FL 33808	07-10-79	13
Norman Gelfand 5640 S. Ellis Avenue Chicago, IL 60637	10-09-79	158
Michael Gersick, Deputy Director Department of Conservation Division of Mines and Geology Division of Oil and Gas Sacramento, CA 93814	11-08-79	214
C. E. Glover Rt. 2 Box 319-A Palestine, TX 75801	10-10-79	175
John B. Gordon, PE 1007 Green Meadow Round Rock, TX 78664	10-10-79	178
Larry Gaffin First Congregational Church S. Palouse and E. Alder Street Walla Walla, WA 99362	10-09-79	160
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COMMENTER	DATE RECEIVED	LETTER NUMBER
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Carl Groff 200 Bolinas RD #81 Fairfax, CA 94930	09-12-79	61
Shelley J. Hegge P.O. Box 10307 Anchorage, AK 99511	10-11-79	185
Edward Hennelly Savannah River Laboratory Aiken, SC 29801	08-30-79	54
Merry Jo Hill Life of the Land 404 Piikoi Street Honolulu, HI 96814	11-19-79	216
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Mrs. Edith M. Hoyt 3316 Villanova Dallas, TX 75225	10-10-79	173
Linda Hoyt 172 A. Downey Street San Francisco, CA 94117	10-16-79	194
Mr. Daniel Hunt National Science Foundation Washington, DC 20550	07-12-79	27
Mr. J. B. Jackson, Jr. Administrator Commonwealth of Virginia 903 Ninth Street Office Building Richmond, VA 23219	07-19-79	37
Frank Jantlick 1306 Driftwood Drive New Port Richey, FL 33552	10-04-79	119
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COMMENTER	DATE RECEIVED	LETTER NUMBER
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Dabney K. Johnson Rt. 3, Wheeler Rd. Apt. 22 Louisville, TN 37777	10-05-79	153
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Edward L. Jones Route 4, Berry Road Taylors, SC 29687	09-20-79	77
Daniel Kaminsky Savannah River Galleries 309 Bull Street Savannah, GA 31401	09-24-79	87
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Mr. Paul Kiepe 2141 1st Avenue S. Payette, ID 83661	07-11-79	15
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Florence Klinger 072 Green Street Martinez, CA 94553	10-10-79	165
William Klitz 21321/2 Derby Berkeley, CA 94705	10-05-79	149
Karl Knute Kresie 555C Stanford Avenue Palo Alto, CA 94306	10-05-79	151
Nancy N. Kroe 3711 West Tilden Place Seattle, WA 98199	10-16-79	193

COMMENTER	DATE RECEIVED	LETTER NUMBER
Mr. Robert K. Kunita 4234 Lake Ridge Drive Raleigh, NC 27604	07-11-79	21
R. A. Langley, Jr. 80 Lansdale Avenue San Francisco, CA 94127	10-11-79	183
John C. Lanigan, Jr. Department of Geology Kent State University Kent, OH 44242	10-09-79	161
L. E. Lantaff, I.I.C U.S. Department of Agriculture Food Safety and Quality Service Meat and Poultry Inspection Program 1400 S. Green Street, P.O. Box 744 Henderson, KY 42420	09-20-79	69
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Harold V. Larson (Addresses wrong EIS) Battelle, Pacific Northwest Laboratories P.O. Box 999 Richland, WA 99352	08-14-79	48
Ermont M. Lawrence 5241 S.E. 115th Street Belleview, FL 32620	09-10-79	57
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Fred L. Lemon Highway 90 and Church Street Ocean Springs, MS 39564	09-26-79	92
Robert Leverant P.O. Box 9444 Berkeley, CA 94709	10-04-79	126
Paul F. Levy, Director Arkansas Department of Energy 3000 Kavanaugh Little Rock, AR 72205	11-16-79	215
Mrs. Lawrence Lewis 3206 Columbia Parkway Cincinnati, OH 45206	08-09-79	47
Mrs. Lawrence Lewis (Additional comments to 47) 3206 Columbia Parkway Cincinnati, OH 45206	08-17-79	51

COMMENTER	DATE RECEIVED	LETTER NUMBER
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Mr. Paul W. Levy Brookhaven National Laboratory Associated Universities, Inc. Upton, NY 11973	07-12-79	25
Mrs. Edith W. Liu 32 Parkside Drive Davis, CA 95616	10-10-79	170
Roland Livernois Livernois Enterprise 1231 Kenyon Road Lake City, GA 30252	09-19-79	67
Mr. William A. Lochstet 119 E. Aaron Dr. State College, PA 16801	07-06-79	8
H. F. Longway 905 Camelia Avenue Roseville, CA 95678	10-05-79	143
Lowenstein, Newman, Reis, Axelrad and Toll 1025 Connecticut Avenue, N.W. Washington, DC 20036	10-09-79	154
Phyllis Luckman 668 Fairmount Avenue Oakland, CA 94611	10-05-79	142
Brandt Mannchen 4055 South Braeswood #303 Houston, TX 77025	09-12-79	62
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Mr. J. A. McBride Box 192 Merrifield, VA 22116	07-23-79	38
William J. McClusky 4317 Rhodes Memphis, TN 38111	09-24-79 10-04-79	86, 122

COMMENTER	DATE RECEIVED	LETTER NUMBER
Jim McGarr 303 E. College Street Clinton, MS 39056	10-04-79	120
Ms. Edith M. McKee 416 Maple Street Winnetka, IL 60093	07-10-79	12
Mr. W. J. Mecham Argonne National Laboratory 9700 South Cass Avenue Argonne, IL 60439	06-27-79	5
Lois and Harold Mills 7660 Morella Avenue North Hollywood, CA 91605	10-05-79	138
Lorane H. Minis 4142 Amsterdam Circle Savannah, GA 31405	09-25-79	90
Mr. Robert H. Moen 6602 Tam O'Shanter Drive San Jose, CA 95120	07-12-79	26
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Sara Morabito 909 University AV 10 Los Gatos, CA 95030	10-29-79	210
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Mrs. Marge Nejedly 109 W. Kennedy Drive Holiday, FL 33590	09-26-79	91
Dorothy Newmeyer Perkins Biology Department Stanford University Stanford, CA 94305	10-04-79	128

COMMENTER	DATE RECEIVED	LETTER NUMBER
Ellery W. Newton American Small Farm Institute Mercer Island, WA 98040	10-04-79	116
Mrs. C. R. Nicewonger 80 Codornices Road Berkeley, CA 94708	10-05-79	133
C. R. Nicewonger (Additional comments to 133) 80 Codornices Road Berkeley, CA 94708	10-10-79	172
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Paulette Oakes 1118 Ingra Anchorage, AK 99501	09-12-79	60
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Frank L. Parker Vanderbilt University Nashville, TN 37235	10-18-79	201
Charles L. Pater Belden Corporation 2000 South Cass Avenue Geneva, IL 60134	08-21-79	53
Frances Pavlovic 111 Datonia Bellaire, TX 77401	10-09-79	157
Robert A. Phillips 263 Via Cima Ct. Danville, CA 94526	10-16-79	197

COMMENTER	DATE RECEIVED	LETTER NUMBER
Marie Pnazek 2208 Knob Creek Rd. Johnson City, TN 37601	10-02-79	104
Dr. Leo Pocuis, M.D. The Doctors Clinic 2512 Wheaton Way Bremerton, WA 98310	09-26-79	94
Roy G. Post, Professor The University of Arizona College of Engineering Department of Nuclear Engineering Tucson, AZ 85721	10-16-79	189
Robert D. Postar 359 Half Moon Lane #314 Daly City, CA 94015	10-10-79	171
Walbridge J. Powell 4314 Island Crest Way Mercer Island, WA 98040	10-05-79	144
Naomi M. Proett 1200 Norfolk Avenue W. Sacramento, CA 95691	10-04-79	117
Donald J. Purinton 1312 Apache Drive Richardson, TX 75080	10-05-79	150
Catherine Quigg, Research Director Pollution & Environmental Problems, Inc. Box 309, Palatine, IL 60067	09-05-79	55
Calvin P. Ragan Route 1--Box 323 New Hill, NC 27562	09-26-79	100
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Mr. Wendell W. Ray 8755 Junipero Avenue Atascadero, CA 93422	10-09-79	159

COMMENTER	DATE RECEIVED	LETTER NUMBER
Mr. D. L. Renberger Assistant Director of Technology Washington Public Power Supply System P.O. Box 968 3000 George Washington Way Richland, WA 99352	07-16-79	34
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Mr. John E. Schulte 1916 Marconi Road Wall, NJ 07719	07-13-79	29
Cindy and Arthur Scott 8 Athlone Way Menlo Park, CA 94025	10-05-79	140
Mrs. Helen M. Serenka 319 Los Pinos Way San Jose, CA 75248	10-21-79	205
James Sharp 307 Granville Rd. Chapel Hill, NC 27514	10-19-79	203
David Shields 419 Oakdale Rd. N.E. Atlanta, GA 30307	09-19-79	75
Murray Solomon SOLCO 11 Vineyard Road Newton, MA 02159	10-10-79 10-12-79	164, 187

COMMENTER	DATE RECEIVED	LETTER NUMBER
Joseph M. Sorboro NEFCO 137 South Main Street Suite 300 Delaware Building Akron, OH 44308	07-29-79	44
Mr. Arvind Srivastava Kaiser Engineers Inc. 300 Lakeside Drive Oakland, CA 94666	07-11-79	17
Sherman Stein 811 Oak Avenue Davis, CA 95616	10-02-79	108
Mary A. Stewart 6212 S. El Camino Drive Tempe, AZ 85283	10-10-79	162
Donald J. Stierman Assistant Professor of Geophysics University of California Riverside, California 92521	10-16-79	190
Marion Stuart 2428 Jefferson Street Berkeley, CA 94703	10-16-79	186
W. N. Thomas, Vice President Fuel Resources Virginia Electric and Power Company Richmond, VA 23261	10-11-79	182
Mrs Victor N. Tolpegin 11 Eugene Street Mill Valley, CA 94941	10-05-79	132
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COMMENTER	DATE RECEIVED	LETTER NUMBER
Nadine A. Vesel 6237 N. Winthrop Chicago, IL 60660	09-26-79	96
David R. Wallace 4289 A Piedmont Avenue Oakland, CA 94611	10-05-79	145
Mr. Derek Wallentinsen Albuquerque Group Sierra Club 3131 Quincy NE Albuquerque, NM 87110	07-13-79	28
Walter E. Wallis Wallis Engineering 1954--R Old Middlefield Way Mountain View, CA 94043	09-18-79	64
D. S. Webster, Deputy Director Argonne National Laboratory 9700 South Cass Avenue Argonne, IL 60439	10-11-79	181
Boyd Weeks 27000 N. HWY. 1 Fort Bragg, CA 95437	10-16-79	188
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Edwin Wiggin Atomic Industrial Forum, Inc. 7101 Wisconsin Avenue Washington, DC 20014	10-04-79	124
Louise Wilson 235 Churchill Avenue Palo Alto, CA 94301	10-04-79	127
David Woolson Rt. 1 Box 26 Medical Lake, WA 99022	10-10-79	179
Bennie Wooten 27087 Twenty Mule Team Road Boron, CA 93516	10-10-79	163
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COMMENTER	DATE RECEIVED	LETTER NUMBER
Mr. Joel Yellin Harvard University John F. Kennedy School of Government 79 Boylston Street Cambridge, MA 02138	07-25-79	40
Mrs. Barbara Yendle 939 S. Royall Palestine, TX 75801	10-05-79	148
Kenneth Yonovitz 4206 Washington Road West Palm Beach, FL 33405	09-21-79	82
Lyle L. Zahn, Jr., Manager Spent Fuel Services Operation General Electric Company 175 Curtner Avenue San Jose, CA 95125	09-10-79	58
District of Columbia:		
Mr. Sidney R. Galler United States Department of Commerce The Assistant Secretary for Science and Technology Washington, DC 20230	07-11-79	23
James Rashlin U.S. Department of the Interior Office of the Secretary Washington, DC 20240	11-20-79	218
John B. Martin, Director Division of Waste Management U.S. Nuclear Regulatory Commission Washington, DC 20555	10-29-79	208
Charles Custard, Director Office of Environmental Affairs Department of Health, Education and Welfare Office of the Secretary Washington, DC 20201	10-18-79	202
William N. Hedeman, Jr., Director Office of Environmental Review U.S. Environmental Protection Agency Washington, DC 20460	09-27-79	113
Florida:		
J. S. Sherman Department of Environmental Regulation Twin Towers Office Building 2600 Blair Stone Road Tallahassee, FL 32301	07-31-79	42

COMMENTER	DATE RECEIVED	LETTER NUMBER
Ron Fahs, Director (Duplicate of 42) Intergovernmental Coordination State of Florida Office of the Governor Tallahassee, FL 32301	09-19-79	68
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George Busbee Office of the Governor Atlanta, GA 30334	09-26-79	97
Mr. Aarne O. Kauranen Regional Engineer Federal Energy Regulatory Commission Regional Office 730 Peachtree Street, N.E. Atlanta, GA 30308	06-27-79	4
Idaho:		
Ms. Pam Demo-Rybus Division of Budget, Policy Planning and Coordination Executive Office of the Governor State Clearinghouse State House Boise, ID 83720	07-10-79	14
Kansas:		
Mr. Paul DeGaeta Department of Administration Division of State Planning and Research Fourth Floor--Mills Building 109 W. 9th Topeka, KS 66612	07-16-79	31
Kentucky:		
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Rep. W. J. Tauzin Louisiana House of Representatives Committee on Natural Resources Box 44012, Capitol Station Baton Rouge, LA 70804	10-05-79	139

COMMENTER	DATE RECEIVED	LETTER NUMBER
Mr. B. Jim Porter Office of Conservation P.O. Box 14690 Baton Rouge, LA 70808	07-16-79	33
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Mr. Max Eisenberg, Acting Director Environmental Health Administration Department of Health and Mental Hygiene P.O. Box 13387 201 West Preston Street Baltimore, MD 21203	07-11-79	16
Minnesota:		
Albert H. Quie Governor of Minnesota State of Minnesota St. Paul, MN 55155	08-20-79	52
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Mr. Mike Nolan Governor's Office of Planning Coordination Capitol Complex Carson City, NV 89710	07-12-79	24
New Jersey:		
Mr. Lawrence Schmidt, Chief Office of Environmental Review Department of Environmental Protection P.O. Box 1390 Trenton, NJ 08625	07-16-79	32
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M. Peter Lanahan, Jr. First Deputy Commissioner State of New York Department of Environmental Conservation Albany, NY 12233	10-16-79	196

COMMENTER	DATE RECEIVED	LETTER NUMBER
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Mr. Thomas M. Webb, Director Natural Resources Planning Tennessee State Planning Office 660 Capitol Hill Building 301 Seventh Avenue, North Nashville, TN 37219	07-23-79	39
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W. W. Schaefer, M.D. Chairman, Committee on Environmental Health The State Medical Society of Wisconsin 330 East Lakeside Street P.O. Box 1109 Madison, WI 53701	10-16-79	191

COMMENTER	DATE RECEIVED	LETTER NUMBER
Wyoming:		
Dick Hartman State Planning Coordinator Wyoming Executive Department Cheyenne, WY 82001	07-27-79	41

APPENDIX B

INDEX FOR COMMENT LETTERS

Appendix B identifies the topic area(s) discussed in a particular comment letter, as well as the location of the comment in this volume. This appendix is structured such that a list of the letter numbers is presented along with the topic areas (under Policy and Technical categories) and page numbers(s) on which the letter has been cited and for which responses have been provided.

Letter	Topic Area	Pages
1	Costs	195
2	Waste Management Program	6, 10
	Siting Issues	16
	Foreign Wastes	19
	Attribution of Costs/Risks	22
	Organization and Presentation	28
	Waste Management Operations	139, 178
	Geologic Considerations	206
3	Waste Management Program	7, 10
	Licensing and the Decision-Making Process	11
	Attribution of Costs/Risks	22
4-FERC	Siting Issues	15
6	Siting Issues	16
	Alternative Disposal Issues	23
	Risk Perspectives	136, 137
	Waste Management Operations	143, 144, 147, 152, 184
	Fuel Cycles	189
	Geologic Considerations	207, 212
	Multibarriers for Disposal	281
	Alternative Disposal Concepts	394
7	Waste Management Program	8
	General Comments	24
	Organization and Presentation	28
	Scope	36
	Consequence Analysis	108
	Socioeconomic/Sociopolitical Issues	290
8	Attribution of Costs/Risks	22
	Radiological Issues	45
	Dose Calculations	114, 117, 119
	Risk Perspectives	132
9	Waste Management Program	8
	Attribution of Costs/Risks	22
	Alternative Disposal Issues	23
	Multibarriers for Disposal	278
	Alternative Disposal Concepts	320, 321
10	Radiological Issues	47
	Geologic Considerations	267
11	Alternative Disposal Issues	23
	Geologic Considerations	206
	Comparative Assessment	301, 303
	Alternative Disposal Concepts	385
12	Waste Management Program	10
	Geologic Considerations	269
	Reference Environments	296
13	Waste Management Program	10
	Organization and Presentation	28
	Dose Calculations	126
	Waste Management Operations	143
	Costs	197
	Geologic Considerations	206

APPENDIX B

INDEX FOR COMMENT LETTERS

Letter	Topic Area	Pages
14	Scope	36
	Costs	193
15	Siting Issues	16
	General Comments	24
	Socioeconomic/Sociopolitical Issues	292
17	Waste Management Program	10
	Licensing and the Decision-Making Process	11
	Long Term Storage	21
	Radiological Issues	48
	Consequence Analysis	108
	Geologic Considerations	224
	Multibarriers for Disposal	277
	Socioeconomic/Sociopolitical Issues	283
18	Socioeconomic/Sociopolitical Issues	291
19	Licensing and the Decision-Making Process	12
20	General Comments	24
	Socioeconomic/Sociopolitical Issues	293
21	Waste Management Program	6, 7, 10
22	Waste Management Program	6
	Licensing and the Decision-Making Process	12
	Foreign Wastes	19
	Fuel Cycle Issues	20
	Growth Scenarios	204
23-DOC	Alternate Disposal Issues	23,
	Alternative Disposal Concepts	347, 349, 352, 356, 361, 363, 364, 371
25	Geologic Considerations	268, 269
26	Scope	34
27	Waste Management Program	7, 10
	General Comments	24
	Waste Management Operations	186
28	Waste Management Program	6, 8, 10
	Licensing and the Decision-Making Process	11, 12
	Siting Issues	15, 16
	Alternative Disposal Issues	23
	Consequence Analysis	111
	Dose Calculations	114
	Waste Management Operations	152
	Comparative Assessment	311
29	Waste Management Program	9
	General Comments	24
30	Waste Management Program	6
	Alternative Disposal Issues	23
	Radiological Issues	40, 52
	Consequence Analysis	67, 73, 74, 91
	Dose Calculations	116
	Risk Perspectives	131
	Waste Management Operations	158
	Growth Scenarios	204

Letter	Topic Area	Pages
30 (Contd)	Geologic Considerations	224, 226
	Resource Requirements	295
31	Siting Issues	15
32	Waste Management Program	9, 10
	Risk Perspectives	131
	Fuel Cycles	188
33	Waste Management Program	10
34	Waste Management Program	10
	Organizaton and Presentation	27, 28
	Scope	34, 38
	Consequence Analysis	62
	Dose Calculations	115
	Geologic Consideration	210
	Multibarriers for Disposal	272
	Resource Requirements	294
	Comparative Assessment	303
	Alternative Disposal Concepts	339, 377, 384
35	Waste Management Operations	9, 10
	Siting Issues	16
	Long Term Storage	21
	Alternative Disposal Issues	23
	General Comments	24
	Organization and Presentation	28
	Consequence Analysis	76
	Waste Management Operations	147, 152, 172, 176, 178
	Fuel Cycles	189
	Growth Scenarios	204
	Geologic Considerations	257
	Multibarriers for Disposal	278
	Socioeconomic/Sociopolitical Issues	291
	Alternative Disposal Concepts	326, 336, 399, 400
36	Waste Management Operations	8
	Attribution of Costs/Risks	22
	Alternative Disposal Issues	23
	Multibarriers for Disposal	278
	Alternative Disposal Concepts	320, 321
37	Licensing and the Decision-Making Process	12
38	Organization and Presentation	28
	Scope	38
	Consequence Analysis	111
	Risk Perspectives	128, 133, 137
	Socioeconomic/Sociopolitical Issues	291
	Comparative Assessment	311
39	Siting Issues	15
	Fuel Cycle Issues	20
40	Radiological Issues	39
	Consequence Analysis	67, 72, 75, 89, 91, 92, 108
	Risk Perspectives	131
	Waste Management Operations	139, 171, 175
	Safeguards	199
	Growth Scenarios	204, 205
	Geologic Considerations	243

Letter	Topic Area	Pages
40 (Contd)	Socioeconomic/Sociopolitical Issues	284, 287, 288
	Alternative Disposal Concepts	320
41	Waste Management Operations	10
	Licensing and the Decision-Making Process	12
	Risk Perspectives	131
	Socioeconomic/Sociopolitical Issues	283
42	Waste Management Program	8
	Attribution of Costs/Risks	22
	General Comments	24
	Waste Management Operations	142
	Growth Scenarios	204, 205
	Geologic Considerations	263
43	Licensing and the Decision-Making Process	12, 13
	Siting Issues	15, 16
	Alternative Disposal Issues	23
	Organization and Presentation	26
	Scope	34, 36
	Radiological Issues	40, 49, 59
	Consequence Analysis	75, 111
	Dose Calculations	119, 122
	Waste Management Operations	169, 178, 180
	Costs	195, 197
	Growth Scenarios	204
	Geologic Considerations	214, 216, 229, 262, 264, 266
	Multibarriers for Disposal	274, 276, 277, 281
	Socioeconomic/Sociopolitical Issues	283, 284, 285, 291
	Resource Requirements	294
	Reference Environment	296
	Alternative Disposal Concepts	316, 318, 319, 323, 334, 378, 381, 382, 383, 387
44	Licensing and the Decision-Making Process	11
45	Waste Management Program	6, 7
	Long Term Storage	21
49	Waste Management Program	10
52	Siting Issues	16
53	Waste Management Program	10
55	Waste Management Program	10
	Long Term Storage	21
	Attribution of Costs/Risks	22
	General Comments	24
	Radiological Issues	46
	Consequence Analysis	109
	Waste Management Operations	139, 140, 149, 155
	Safeguards	202
	Growth Scenarios	204
	Geologic Considerations	206
	Multibarriers for Disposal	279
	Socioeconomic/Sociopolitical Issues	284, 293
56	Long Term Storage	21

Letter	Topic Area	Pages
57	General Comments	24
58	Organizaton and Presentation	28
	Consequence Analysis	67, 76, 79, 111
	Risk Perspectives	137
	Waste Management Operations	149, 170, 178
	Multibarriers for Disposal	273, 281
	Socioeconomic/Sociopolitical Issues	287
	Comparative Assessment	311
	Alternative Disposal Concepts	319, 326, 335, 337, 346, 349, 365, 376, 379, 389, 391, 395, 398, 399, 402, 405
59	General Comments	24
60	General Comments	24
62	Foreign Wastes	19
	Fuel Cycle Issues	20
	Alternative Disposal Issues	23
	Scope	37
	Radiological Issues	40
	Consequence Analysis	64, 65
	Waste Management Operations	139, 146, 147, 171, 172
	Growth Scenarios	204, 205
	Geologic Considerations	252, 264
	Socioeconomic/Sociopolitical Issues	283
	Alternative Disposal Concepts	317
63	Licensing and the Decision-Making Process	12
	Foreign Wastes	19
	Alternative Disposal Issues	23
	General Comments	24
	Growth Scenarios	204
64	Waste Management Program	10
65	General Comments	24
67	General Comments	24
68	Waste Management Program	8
	Attribution of Costs/Risks	22
	General Comments	24
	Waste Management Operations	142
	Growth Scenarios	204, 205
	Geologic Considerations	263
69	General Comments	24
70	Siting Issues	15
71	Siting Issues	16
72	General Comments	24
	Safeguards	202
73	Geologic Considerations	261
74	Siting Issues	16
	Attribution of Costs/Risks	22
	General Comments	24

Letter	Topic Area	Pages
76	General Comments	24
77	Attribution of Costs/Risks	22
78	Long Term Storage	21
	General Comments	24
82	General Comments	24
	Alternative Disposal Concepts	316
83	General Comments	24
84	Alternative Disposal Issues	23
86	Waste Management Program	10
	Long Term Storage	21
	Alternative Disposal Issues	23
87	Siting Issues	16
88	Alternative Disposal Issues	23
	Alternative Disposal Concepts	320, 330, 340, 355, 378, 388, 396, 402
90	General Comments	24
91	General Comments	24
93	Siting Issues	16
	General Comments	24
94	Siting Issues	16
95	Licensing and the Decision-Making Process	11
96	Waste Management Program	7
	Alternative Disposal Issues	23
	General Comments	24
	Geologic Considerations	206
	Reference Environment	296
97	Licensing and the Decision-Making Process	12, 13
	Siting Issues	16
	Fuel Cycle Issues	20
	Organization and Presentation	26
	Scope	36
	Consequence Analysis	96, 99, 111
	Risk Perspectives	137
	Geologic Considerations	206, 262, 266, 267
	Multibarriers for Disposal	277, 281, 282
	Alternative Disposal Concepts	316
98	Waste Management Program	8
	Licensing and the Decision-Making Process	12
	Foreign Wastes	19
	General Comments	24
	Risk Perspectives	137
	Geologic Considerations	266
99	Siting Issues	16
100	Siting Issues	16

Letter	Topic Area	Pages
102	General Comments	24
103	General Comments	24
104	Radiological Issues	58
105	General Comments	24
106	General Comments	24
108	General Comments	24
	Consequence Analysis	68
109	General Comments	24
110	General Comments	24
111	Foreign Wastes	19
	General Comments	24
112	Siting Issues	16
	Attribution of Costs/Risks	22
113-EPA	Siting Issues	15
	Alternative Disposal Issues	23
	Organization and Presentation	32
	Scope	38
	Radiological Issues	40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 55, 56, 57, 58
	Consequence Analysis	63, 67, 70, 71, 72, 76, 82, 83, 84, 85, 86, 88, 89, 93, 94, 95, 97, 98, 99, 111
	Dose Calculations	113, 117, 118, 119, 121, 123, 125, 126
	Risk Perspectives	129, 132, 133, 134, 135, 136
	Waste Management Operations	145, 149, 152, 168, 177, 179, 180
	Costs	192, 194, 196
	Growth Scenarios	205
	Geologic Considerations	208, 213, 217, 221, 224, 230, 232, 234, 235, 236, 237, 238, 249, 250, 251, 253, 256, 258
	Multibarriers for Disposal	271, 273, 275, 277, 279, 280, 281
	Socioeconomic/Sociopolitical	283, 285, 287, 289 290, 292
	Reference Environment	297, 298
	Comparative Assessment	301
	Alternative Disposal Concepts	314, 318, 325, 353, 355, 356, 357, 361, 362, 364, 365, 366, 368, 369, 373, 374, 375, 377, 406
114	Consequence Analysis	67, 68, 73, 90
	Multibarriers for Disposal	281
	Socioeconomic/Sociopolitical Issues	291, 292

Letter	Topic Area	Pages
115	Siting Issues	16
	Radiological Issues	60
	Geologic Considerations	266
116	Siting Issues	16
	Attribution of Costs/Risks	22
117	General Comments	24
118	General Comments	24
119	Alternative Disposal Issues	23
120	Alternative Disposal Issues	23
121	Alternative Disposal Issues	23
	Alternative Disposal Concepts	320, 330, 340, 355, 378, 388, 396, 402
122	Waste Management Program	10
	Long Term Storage	21
	Alternative Disposal Issues	23
123	Licensing and the Decision-Making Process	12
	Alternative Disposal Issues	23
	General Comments	24
124	Organization and Presentation	28
	Consequence Analysis	111
	Risk Perspectives	128, 132, 137
	Waste Management Operations	170
	Safeguards	199, 201
	Geologic Considerations	217
	Multibarriers for Disposal	274, 281
	Alternative Disposal Concepts	321, 341, 342, 343, 347, 348, 354, 358, 359, 361, 363, 367, 374, 378, 379, 380, 381, 386, 389, 393, 395, 397, 398, 401, 402, 403, 404, 405, 406
125	General Comments	24
126	Scope	36
127	General Comments	24
128	Waste Management Programs	6, 10
	General Comments	24
	Consequence Analysis	64
	Risk Perspectives	131
	Safeguards	199
	Geologic Considerations	208
	Comparative Assessment	303
129	Licensing and the Decision-Making Process	12
	Waste Management Operations	140
	Geologic Considerations	206
	Reference Environment	296
131	General Comments	24

Letter	Topic Area	Pages
133	Waste Management Programs	10
	Long Term Storage	21
134	General Comments	24
	Risk Perspectives	137
135	Siting Issues	16
	General Comments	24
136	Siting	16
	Fuel Cycle Issues	20
137	General Comments	24
138	General Comments	24
139	Waste Management Programs	6
	Licensing and the Decision-Making Process	12
	Siting Issues	15, 16
140	Alternative Disposal Issues	23
	General Comments	24
141	Alternative Disposal Issues	23
	General Comments	24
	Geologic Considerations	218
	Multibarriers for Disposal	281
142	General Comments	24
	Consequence Analysis	67, 68
	Waste Management Operations	173
	Safeguards	199
	Multibarriers for Disposal	281
143	General Comments	24
144	Waste Management Program	6
	Alternative Disposal Issues	23
	Scope	35, 37
	Dose Calculations	114
	Risk Perspectives	131
	Waste Management Operations	162, 173
	Geologic Considerations	206
145	General Comments	24
	Scope	36
	Risk Perspectives	131
146	General Comments	24
147	Licensing and the Decision-Making Process	13
	General Comments	24
	Scope	35, 37
	Radiological Issues	40, 44
	Dose Calculations	116
	Risk Perspectives	128, 131
	Waste Management Operations	139, 146, 147
	Geologic Considerations	206
	Comparative Assessment	303
	Alternative Disposal Concepts	385
148	Siting Issues	16

Letter	Topic Area	Pages
149	Alternative Disposal Issues	23
	General Comments	24
151	Waste Management Program	7
	Attribution of Costs/Risks	22
152	Waste Management Program	8, 9, 10
153	Waste Management Program	9, 10
	General Comments	24
	Geologic Considerations	262
154	Waste Management Program	6, 10
	Licensing and the Decision-Making Process	13
	Organization and Presentation	28, 29, 31
	Scope	34, 35, 37, 38
	Radiological Issues	43
	Consequence Analysis	67, 68, 76, 83, 85, 91, 92
	Dose Calculations	118, 120, 121
	Risk Perspectives	128, 131, 132, 137
	Waste Management Operations	141, 150, 152, 153, 156, 159, 160, 163, 170, 172, 173, 181, 183
	Fuel Cycles	189
	Costs	193, 194
	Safeguards	201
	Growth Scenarios	204
	Geologic Considerations	207, 209, 211, 212, 214, 215, 216, 218, 222, 227, 228, 229, 233, 234, 235, 236, 240, 241, 245, 246, 247, 248, 249, 250, 256
	Multibarriers for Disposal	274, 275, 277, 281
	Socioeconomic/Sociopolitical Issues	283, 284, 286, 291
	Comparative Assessment	301, 302, 303
	Alternative Disposal Concepts	313, 317, 328, 333, 339, 340, 344, 345, 346, 351, 353, 354, 360, 364, 366, 369, 375, 376, 379, 380, 384, 385, 389, 390, 391, 392, 393, 396, 400, 403, 404, 405
155	Fuel Cycle Issues	20
	Attribution of Costs/Risks	22
	General Comments	24
	Scope	37
156	Licensing and the Decision-Making Process	12
157	Siting Issues	16
	Fuel Cycle Issues	20
	Long Term Storage	21
158	Waste Management Program	10
	Long Term Storage	21
	Alternative Disposal Issues	23
	General Comments	24
159	General Comments	24

Letter	Topic Area	Pages
160	General Comments	24
162	Siting Issues	16
	General Comments	24
163	Attribution of Costs/Risks	22
164	Waste Management Program	7, 9, 10
	Alternative Disposal Issues	23
	Geologic Considerations	268
165	General Comments	24
166	Waste Management Program	6, 10
	Radiological Issues	39
	Consequence Analysis	90
	Dose Calculations	113
	Risk Perspectives	128, 131, 133
	Geologic Considerations	206
167	Waste Management Program	10
	Foreign Wastes	19
	Organization and Presentation	28, 32
	Scope	38
	Risk Perspectives	136
	Growth Scenarios	205
	Comparative Assessment	304
	Alternative Disposal Concepts	315
168	Waste Management Program	10
	Consequence Analysis	66
169	General Comments	24
170	Risk Perspectives	131
171	General Comments	24
	Socioeconomic/Sociopolitical Issues	283
172	General Comments	24
173	Siting Issues	16
	General Comments	24
174	Siting Issues	16
	General Comments	24
175	Siting Issues	16
177	Waste Management Program	10
	Alternative Disposal Issues	23
	General Comments	24
178	Risk Perspectives	138
	Geologic Consideratons	262
179	Siting Issues	16
180	Waste Management Program	6, 10
	Siting Issues	16
	Alternative Disposal Issues	23
	General Comments	24

Letter	Topic Area	Pages
181	Licensing and the Decision-Making Process	13
	Siting Issues	16, 17
	General Comments	24
	Organization and Presentation	26, 27, 28, 32
	Dose Calculations	114
	Waste Management Operations	139, 140, 141, 142, 147, 148, 150, 151, 152, 156, 157, 158, 159, 162, 167, 170, 172
	Fuel Cycles	188
	Safeguards	200
	Geologic Considerations	206, 239
	Multibarriers for Disposal	276
	Socioeconomic/Sociopolitical Issues	283
	Alternative Disposal Concepts	317, 321
182	Waste Management Program	10
	Organization and Presentation	28
183	Waste Management Program	10
184	Siting Issues	15
	Fuel Cycle Issues	20
185	General Comments	24
186	Foreign Wastes	19
	General Comments	24
	Socioeconomic/Sociopolitical Issues	283
187	Waste Management Program	7, 9, 10
	Alternative Disposal Issues	23
	Geologic Considerations	268
190	Geologic Considerations	209, 210
191	Waste Management Program	10
	Licensing and the Decision-Making Process	12
192	Alternative Disposal Issues	23
193	Attribution of Costs/Risks	22
194	Alternative Disposal Issues	23
	General Comments	24
195	Waste Management Program	10
	General Comments	24
	Risk Perspectives	132
196	Waste Management Program	7, 10
	Fuel Cycle Issues	20
	Alternative Disposal Issues	23
	Scope	38
	Consequence Analysis	111
	Dose Calculations	114
	Risk Perspectives	133
197	General Comments	24
	Scope	36
	Risk Perspectives	130
	Geologic Considerations	264

Letter	Topic Area	Pages
198	Waste Management Program	9
	Licensing and the Decision-Making Process	13
	Fuel Cycle Issues	20
	General Comments	24
	Organization and Presentation	28, 32
	Radiological Issues	43, 47
	Consequence Analysis	68, 80, 86
	Risk Perspectives	128, 130
	Fuel Cycles	188
	Geologic Considerations	206
	Multibarriers for Disposal	276
	Socioeconomic/Sociopolitical Issues	291
	Comparative Assessment	301
	Alternative Disposal Concepts	394
199	Waste Mangement Program	10
	Attribution of Costs/Risks	22
	General Comments	24
200	Alternative Disposal Concepts	406
201	Organization and Presentation	28, 31, 32
	Comparative Assessment	301
202-HEW	Licensing and the Decision-Making Process	11
	Organization and Presentation	31
	Radiological Issues	43
	Consequence Analysis	111
	Dose Calculations	127
203	Waste Management Program	9
204	Licensing and the Decision-Making Process	12
	Siting Issues	16
	General Comments	24
205	Waste Management Program	7, 9, 10
	Attribution of Costs/Risks	22
	General Comments	24
206	Siting Issues	16
	General Comments	24
207	Siting Issues	16
208-NRC	Licensing and the Decision-Making Process	12, 13
	Siting Issues	17
	Organization and Presentation	26, 27, 28, 33
	Scope	34, 35, 38
	Radiological Issues	39, 49, 50, 52, 59,
	Consequence Analysis	61, 62, 64, 65, 66, 69, 71, 73, 75, 77, 78, 79, 80, 81, 83, 86, 87, 88, 93, 100, 101, 102, 103, 105, 107, 108, 109, 112
	Dose Calculations	113, 115, 116, 117, 121, 122, 123, 124, 125, 126
	Risk Perspectives	128, 129, 135

Letter	Topic Area	Pages
208 (Contd)	Waste Management Operations	140, 143, 144, 145, 146, 148, 153, 154, 155, 156, 157, 159, 160, 161, 163, 164, 166, 167, 168, 171, 172, 173, 174, 175, 176, 177, 178, 181, 182, 183, 184, 185, 186, 187
	Costs	190, 193, 197
	Safeguards	200, 202, 203
	Growth Scenarios	204
	Geologic Considerations	206, 208, 212, 213, 214, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 232, 234, 236, 237, 238, 239, 240, 241, 243, 244, 246, 247, 249, 250, 252, 253, 254, 255, 259, 260, 261, 263, 264, 265, 270
	Multibarriers for Disposal	271
	Socioeconomic/Sociopolitical Issues	284, 285, 286, 288
	Resource Requirements	294, 295
	Reference Environment	296, 298
	Comparative Assessment	300, 301, 302, 303, 305, 306, 307, 308, 309, 310
	Alternative Disposal Concepts	313, 316, 317, 322, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 348, 349, 350, 351, 354, 355, 346, 357, 358, 359, 360, 361, 365, 371, 372, 373, 379, 387, 388
209	Siting Issues	16
	General Comments	24
210	Waste Management Program	10
211	Risk Perspectives	130, 132
	Geologic Considerations	206
212	Alternative Disposal Issues	23
	General Comments	24
213	Alternative Disposal Issues	23
	General Comments	24
	Consequence Analysis	69
	Waste Management Operations	173, 178
	Costs	192
	Geologic Considerations	206, 218
	Socioeconomic/Sociopolitical Issues	283
214	Licensing and the Decision-Making Process	13
	Organization and Presentation	32
	Radiological Issues	43
	Consequence Analysis	90
	Geologic Considerations	226, 229, 231, 239, 242, 251, 255
	Multibarriers for Disposal	281

Letter	Topic Area	Pages
215	Waste Mangement Program	10
	Scope	36
216	Alternative Disposal Issues	23
	General Comments	24
	Scope	36
	Costs	198
	Socioeconomic/Sociopolitical Issues	283
217	Waste Management Program	10
	Licensing and the Decision-Making Process	13
	Fuel Cycle Issues	20
	Organization and Presentation	26, 28, 32
	Scope	37
	Consequence Analysis	61
	Risk Perspectives	132, 134, 137
	Costs	195
	Comparative Assessment	302, 304, 310, 311
218-DOI	Waste Management Program	6, 9, 10
	Licensing and the Decision-Making Process	12, 14
	Siting Issues	15, 16, 17
	Foreign Wastes	19
	Organization and Presentation	26, 28, 32
	Radiological Issues	41
	Consequence Analysis	61, 62, 63, 72, 73, 74, 75, 78, 82, 87, 88, 89, 96, 109
	Risk Perspectives	128, 132, 133, 134
	Waste Management Operations	180, 183, 186
	Fuel Cycles	188, 189
	Safeguards	200, 203
	Geologic Considerations	206, 208, 211, 212, 214, 218, 219, 222, 224, 226, 229, 230, 233, 238, 242, 245, 247, 252, 257, 258
	Multibarriers for Disposal	271, 272
	Socioeconomic/Sociopolitical Issues	283, 284
	Comparative Assessment	301, 302, 304
	Alternative Disposal Concepts	315, 317, 320, 322, 323, 324, 325, 328, 333, 338, 344, 346, 352, 363, 369, 370, 371, 376, 382, 383, 384, 390, 393, 399
219	Organization and Presentation	28, 31
	Consequence Analysis	62, 108, 110
	Waste Management Operations	172
	Geologic Considerations	268
	Multibarriers for Disposal	281, 282
	Socioeconomic/Sociopolitical Issues	293
	Comparative Assessment	311
	Alternative Disposal Concepts	315

APPENDIX C

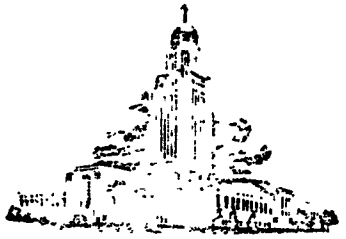
FEDERAL AND STATE COMMENT LETTERS

APPENDIX C

STATE AND FEDERAL AGENCY COMMENT LETTERS

This appendix contains reproductions of those letters submitted by federal agencies (Department of Commerce, Department of Health, Education, and Welfare, Department of Interior, Environmental Protection Agency, Federal Energy Regulatory Commission, and Nuclear Regulatory Commission) and cover letters of those comments submitted by state governments.

[illegible] TELEPHONE
[illegible]



STATE of NEBRASKA

STATE OFFICE OF PLANNING & PROGRAMMING
BOX 94601, STATE CAPITOL, ROOM 1321
LINCOLN, NEBRASKA 68509
(402) 471-2414

June 21, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
Department of Energy
Washington, D. C. 20545

Dear Dr. Heath

Under the provisions of OMB Circular A-95, Part I, this agency has completed a state level review of the draft environmental impact statement for Management of Commercially-Generated Radioactive Waste (DOE/EIS-C046-D).

The enclosed comments were received from the State Department of Health and the State Department of Environmental Control and should be considered by the Department of Energy in the development of the final statement.

Sincerely

Terry Kubicek

Terry Kubicek
Natural Resources Coordinator

Tkmp
Enclosures
cc: Richard Beck
Dan Drain

DON STENBERG
DIRECTOR

North Carolina Department of Administration

116 West Jones Street Raleigh 27611

James B. Hunt, Jr., Governor
Joseph W. Grimsley, Secretary

Division of State Budget and Management
John A. Williams, Jr., State Budget Officer
(919) 733-7061

July 13, 1979

MEMORANDUM

TO: Dr. Colin A. Heath, U.S. Dept. of Energy

FROM: Chrys Baggett, Director, State Clearinghouse

SUBJECT: File #145-79; Draft EIS - Management of Commercially Generated Radioactive Waste

Attached are additional comments which were submitted following our clearance letter on your

_____ Notification To Clearinghouse Of Intent To Apply For Assistance

_____ Application For Funding

XXXXX Environmental Impact Statement

_____ Environmental Review

If you have questions regarding these comments please contact me at (919) 733-7061

mw

Attachment(s)

C.2

State Of Idaho

DIVISION OF BUDGET, POLICY PLANNING AND COORDINATION

EXECUTIVE OFFICE OF THE GOVERNOR

STATE CLEARINGHOUSE
JULY 3 1979

JOHN V. EVANS
Governor

Statehouse
Boise, Idaho 83720

DR COLIN HEATH
DIVISION OF WASTE ISOLATION M/S B-107
US DEPT ENERGY
WASHINGTON, D.C. 20545

DR HEATH,

THE IDAHO STATE CLEARINGHOUSE HAS COMPLETED REVIEW OF THE US DEPT OF ENERGY'S DEIS, MANAGEMENT OF COMMERCIALLY GENERATED RADIOACTIVE WASTE (OUR SAI #00692465) DOE/EIS-0046-D. THE FOLLOWING STATE AGENCIES AND AREAWIDE CLEARINGHOUSES RECEIVED COPIES OF THE DRAFT AND WERE ASKED TO SUBMIT COMMENTS:

PANHANDLE AREA COUNCIL (COEURD'ALENE)
CLEARWATER ECONOMIC DEVELOPMENT ASSOCIATION (MOSCOW)
ADA PLANNING ASSOCIATION (BOISE)
REGION IV DEVELOPMENT ASSOC (TWIN FALLS)
SOUTHEAST IDAHO COUNCIL OF GOVERNMENTS (POCATELLO)
IDAHO OFFICE OF ENERGY
NATURAL RESOURCES BUREAU (DIVISION OF BUDGET, POLICY PLANNING & COORDINATION)

THE AREAWIDE CLEARINGHOUSE, CLEARWATER ECONOMIC DEVELOPMENT ASSOCIATION HAS FORWARDED COMMENTS FROM THE NEZ PERCE TRIBE OF IDAHO. TRIBAL PLANNER, MICHAEL PENNEY HAS EXPRESSED CONCERN FOR THE POTENTIAL HAZARDS OF STORING & TRANSPORTING RADIOACTIVE WASTES. THE TRIBE FINDS THE POTENTIAL DAMAGE POSSIBLE FROM STORAGE AS PARTICULARLY HARMFUL TO HUMAN AND WILDLIFE POPULATIONS. IN SUMMARY, "THE NEZ PERCE TRIBE OF IDAHO IS VERY CONSCIOUS OF THE IMPACT ON THE ENVIRONMENT". THE STATE CLEARINGHOUSE STRONGLY URGES YOU TO ADDRESS THIS ISSUE OF CONCERN TO THE NEZ PERCE. PLEASE FORWARD SUFFICIENT COPIES OF THE FINAL STATEMENT TO THE STATE CLEARINGHOUSE WHEN THE PUBLICATION IS AVAILABLE. THANK YOU FOR PROVIDING US WITH COPIES OF THE DRAFT.

SINCERELY,

PAM DEMO-RYBUS
COORDINATOR

0908

CC:CEDA;MPENNEY
NEZ PERCE TRIBE

EQUAL OPPORTUNITY EMPLOYER

OFFICE OF THE GOVERNOR

WILLIAM P. CLEMENTS, JR.
GOVERNOR

July 3, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U.S. Department of Energy
Washington, D.C. 20545

Dear Dr. Heath:

The draft environmental impact statement entitled "Management of Commercially Generated Radioactive Waste", has been reviewed by the Budget and Planning Office and interested State agencies. Agency comments are enclosed for your information and use.

The Budget and Planning Office appreciates the opportunity to review this document. If we can be of any further assistance during the application process, please do not hesitate to call.

Sincerely,

Donald C Harley

Donald E. Harley, Manager
Economic and Natural Resources
Budget and Planning Office

DEH:jl

Enclosures: Comments by -
Railroad Commission
Parks and Wildlife Department
State Department of Highways and Public Transportation
Air Control Board
State Soil and Water Conservation Board
Department of Water Resources
Texas Department of Community Affairs

C.3

EXECUTIVE OFFICE BUILDING • 411 WEST 13TH STREET • AUSTIN, TEXAS 78701

OFFICE OF THE GOVERNOR

STATE A-95 CLEARINGHOUSE

STATE OF VERMONT

MONTPELIER, VERMONT 05602

STATE PLANNING OFFICE

AREA CODE 802-828-3326

MEMORANDUM

To: Dr. Colin A. Heath, Division of Waste Isolation
Mail Stop B-107, U. S. Dept. of Energy
Washington, D. C. 20545

From: Emily Neary, A-95 Coordinator

Date: July 3, 1979

Re: Dept. of Energy, Draft Environmental Impact Statement
"Management of Commercially Generated Radioactive Waste" - 2 volumes

---

As the State Clearinghouse under OMB Circular A-95 we have notified other public agencies with a possible interest in your: draft environmental impact statement.

Copies of comments received are attached: from the Division for Historic Preservation.

:enclosure

STATE OF NEVADA

GOVERNOR'S OFFICE OF PLANNING COORDINATION

CAPITOL COMPLEX

CARSON CITY NEVADA 89710

(702) 885-4865

July 5, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U.S. Dept Energy
Washington D.C. 20545

RE: SAI NV # 79300067 Project: DOE/EIS 0046-D
79300068 DOE/EIS 0026-D

Dear Dr. Heath:

Attached are the comments from the following affected State Agencies: Division of Environmental Protection,and Dept. of Energy concerning the above referenced projects.

These comments constitute the State Clearing house review of this proposal. Please address these comments in the final or summary report.

Sincerely,

Mike Nolan for
Robert M. Hill
State Planning Coordinator

RMH:md

Enclosures

C.4

STATE OF KANSAS

Department of Administration

DIVISION OF STATE PLANNING AND RESEARCH

4th Floor—Mills Building
109 W. 9th
Topeka, Kansas 66612

July 10, 1979

Dr. Colin A. Heath
Div. of Waste Isolation
Mail Stop B-107
U. S. Department of Energy
Washington, D. C. 20545

Re: DOE/GEIS-Mgmt Of Commercially Generated Radioactive Waste. No. 7207

The referenced project has been processed by the Division of State Planning and Research under its clearinghouse responsibilities described in Circular A-95.

The Management of Commercially Generated Radioactive Wastes presents many special problems, not all of which have been addressed in this Draft GEIS, particulary since this draft statement is not site specific. This condition makes it difficult to determine which program strategies, if any, would be most appropriate for Kansas. Our review agencies have reviewed this statement in a general nature. If, for example, a specific strategy for mangaging radioactive waste for a future plant in Kansas (possibly Wolf Creek) was addressed, our agencies would have made more specific comments.

I have included agency comments for your information. I hope you will address our expressed concerns in the final environmental impact statement in the spirit and intent of the National Environmental Policy Act of 1969.

Should you have any questions please contact this office. Please refer to the State Application Identifier (SAI) Number above in all future correspondence.

Sincerely,

Paul V DeGaeta
Paul V. DeGaeta
A-95 Coordinator

PVD:jc

Attachment
cc: Ruth Clusen, Ass't Sec. for Environment

TENNESSEE

STATE PLANNING OFFICE

660 CAPITOL HILL BUILDING
301 SEVENTH AVENUE, NORTH
NASHVILLE, TENNESSEE 37219
615-741-1676

July 6, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U. S. Department of Energy
Washington, D. C. 20545

Dear Dr. Heath:

Enclosed please find comments from the Tennessee Historical Preservation Officer and the Department of Public Health.

Your consideration of these comments will be appreciated.

Sincerely,

Thomas M. Webb

Thomas M. Webb, Director
Natural Resources Planning

TMW:brs

Enclosure

C.5

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DANIEL J O HERN COMMISSIONER
P. O. BOX 1390
TRENTON, N.J. 08625
609-292-2885

June 29, 1979

Dr. Collin A. Heath
Division of Waste Isolation
Mail Stop B-107
U.S. Department of Energy
Washington, D.C. 20545

Dear Dr. Heath:

The State of New Jersey has reviewed DOE/EIS-0046-D, the Draft Environmental Impact Statement: Management of Commercially Generated Radioactive Waste. The sheer volume of the report is indicative of the thorough examination of the issue of radioactive waste disposal which is being pursued by federal agencies, especially the Department of Energy. Careful examination of the volumes shows the thorough study which has gone into this issue and the painstaking detail with which the nuclear fuel cycle and its relation to the generation of radioactive waste have been studied. The various forms of waste (glass, ceramics, etc.) are also reviewed in extensive detail.

And yet, what is the subject of the report? It is essential that a hazardous substance; namely radioactive waste, be isolated from the environment. Perhaps there are ten methods available, as described in the present document, or by a slightly different classification system, six, as described in the Interagency Review Group (IRG) Reports, the State's review of which was transmitted December 4, 1978. Many of the comments which applied to the IRG Reports apply to the present volumes.

We would recommend that the errata sheet which replaces page 1.3 be disposed of and the original page reinstated. In particular, the original words:

> "The first disposal facilities for HLW will be mined repositories. Several geologic environments possessing a wide variety of emplacement media should be examined."

are superior to the new language:

> "...near-term program activities should be predicated on the tentative assumption made for interim planning purposes that the first disposal facilities will be mined repositories."

The kindest thing that can be said about the second statement is that it is weak and indecisive. In any case, it is not representative of the positive leadership this country needs in resolving the issue of radioactive waste disposal.

It is necessary to continue R&D in other means of radioactive waste disposal as an alternative of mined repositories develop more problems than their competitors. Eventually, a superior method may be found. In the meantime, it is essential to develop an operational facility. The discussion in 1.1.1 shows a much more pragmatic approach. It is stated that the first thousand years of disposal are most critical and that, based on our own knowledge of the languages of earlier investigations, it is reasonable to expect that the inhabitants of earth will recognize repository markers for millenia.

The relative toxicity of plutonium and lead, discussed on page 3.1.65 should be more widely promulgated. Although it does not mean that concern for plutonium be reduced, it does put the problem in better perspective.

On page 3.1.75, it is stated that "The majority of nuclear wastes are residuals from defense programs." Is this a measurement of volume, which could be reduced by evaporation, or is the measurement based on curies of activity?

This report, like the many which have preceded it, indicates that a large body of knowledge of how to treat radioactive wastes exists now. All of the problems haven't been solved but it is unlikely that much more will be learned until large scale pilot projects are begun. The position of the State of New Jersey is that now is the time to begin construction of such pilot projects, and as soon as feasible, a full-scale radioactive waste depository. It may be that the best type of facility and waste form will not be used but it would be best to begin work with the second or third best types now then to put this problem off indefinitely.

Very truly yours,

Lawrence Schmidt, Chief
Office of Environmental Review

C.6

100% RECYCLED

State of Louisiana

R.T. SUTTON
COMMISSIONER

OFFICE OF CONSERVATION

B. JIM PORTER
ADMINISTRATOR
NUCLEAR ENERGY DIVISION

July 9, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U. S. Department of Energy
Washington, D.C. 20545

Dear Dr. Heath:

This is to acknowledge receipt of DOE/EIS-0046-D, "Management of Commercially Generated Radioactive Waste", Volumes I and II. We have reviewed the documents and found them to be very extensive and comprehensive in nature, covering all aspects of potential environmental consequences related to the disposal of high level and transuranic radioactive waste from the commerical nuclear fuel cycle.

It is felt that since the United States will have to depend upon nuclear energy as a power source until other sources are feasible, it is imperative that there be a national program to ensure a solution to the problem of nuclear waste management and storage. While we agree that the approach to permanent disposal of nuclear waste should proceed on a step wise basis in a technically conservative manner, we also feel that additional delays such as have been experienced in the past, will have a detrimental affect on the establishment of a sound energy policy and on the nation's future energy outlook.

Basically, we agree with the analysis presented in the Draft GEIS by the DOE, that (1) the disposal of radioactive waste in geological formations likely can be developed and applied with a minimum environmental consequence; and (2) the program's emphasis, therefore, should be on the establishment of mined repository as the disposal technology for nuclear waste. As you know, the Louisiana Office of Conservation has been designated by Governor Edwards as the official liaison with DOE in the high level waste disposal investigations currently being conducted in and around Vacherie and Rayburn salt domes located in North Louisiana. We have in the past, and will continue to closely monitor the activities of the DOE, Division of Waste Isolation and its major contractor, the Batelle Memorial Institute, Office of Nuclear Waste Isolation in relation to ongoing studies in Louisiana, and will

P.O. BOX 14690 BATON ROUGE, LOUISIANA 70808 . PHONE (504) 925-4518

provide comment on state concerns where appropriate. While the provisions of Act 650 of the 1978 Louisiana Legislature Regular Session do not allow the location of a storage facility within the State, we look forward to the development of a national strategy which addresses the technical and socio-political issues necessary for selection of repository sites and bringing repositories into operation within a reasonable period of time.

Thank you for the opportunity to comment on this vitally important issue.

Sincerely,

B. Jim Porter
Administrator
Nuclear Energy Division

BJP:pfd

C.7

WYOMING
EXECUTIVE DEPARTMENT
CHEYENNE

ED HERSCHLER
GOVERNOR

July 10, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop 13-107
U. S. Department of Energy
Washington, D.C. 20545

Re: Department of Energy's Draft Environmental Impact Statement for the Management of Commercially Generated Radioactive Wastes

Dear Dr. Heath:

In compliance with the National Environmental Protection Act of 1969, Office of Management and Budget Circular A-95 (revised) and the Wyoming State Review Procedures, the State of Wyoming has completed its review of the subject draft environmental impact statement. Comments from the Wyoming Department of Environmental Quality are enclosed for your review and inclusion in the final statement.

Wyoming is not geologically suitable for the underground disposal of nuclear wastes. The salt and shale deposits within the state are located in the midst of valuable uranium, trona and petroleum deposits. The state's granite deposits are not only highly fractured and jointed but located near water tables.

The decisions made with regard to the isolation of nuclear wastes from the biosphere will be unprecedented in human history in terms of their lasting potential impacts on human health and the environment. Therefore, the uncertainties and risks associated with nuclear waste are of concern to every state.

The Department of Energy's desired goals of credibility and objectivity in the formulation of a nuclear waste strategy are hampered by the fact that the agency responsible for examining the feasibility of nuclear waste isolation is also responsible for the development of nuclear energy policies (and heretofore, the encouragement of the nuclear option).

With this credibility handicap in mind, it is surprising that the Department of Energy's environmental conclusions and feasibility analysis appear to rely so heavily on convoluted logic and faulty, simplistic analogies. The fact that we run a greater risk of lethal contamination from the environmental presence of arsenic or cyanide than from high-level radioactive wastes will not assuage the public's concern over the safe disposal of these wastes (p.1.16). Similarly, the fact that some of the pyrimids are still standing and that we can decifer Egyptian hierog lyphics is no assurance that a nuclear waste depository will shield future generations from the hazards of strong doses of radiation (p. 1.6; 3.6364).

The final environmental statement should confront candidly the fundamental dilemma associated with nuclear waste management as well as implied policy objectives. The goals of nuclear waste management (i.e. the long-term protection of human health and the environment) cannot be ensured due to technical uncertainties. The feasibility of long-term isolation of nuclear wastes cannot be proved or disproved on the basis of expermentation, prototype testing or prior experience. Yet, the worst management alternative is to do nothing, allowing the radioactive wastes to remain exposed and saddling future generations with the burden of our neglect.

The Department of Energy, therefore, should make it clear that, due to our present state of technology, nuclear waste management will have to proceed on a step-by-step, trial-and-error basis. Permanent "disposal" of these wastes is not possible at this time.

The statement should also examine thoroughly the relationship between program strategy, environmental and health goals, and environmental/design standards. The draft statement fails entirely to examine this crucial relationship. The text of the draft implies that DOE expects standards to be set according to specific technical capabilities.

The final report should examine the feasibility and desirability of basing standards on health and environmental effects instead of on present technology. Even though standards based on health effects would have to consider the present state-of-the-art, the Department of Energy should consider health standards as being technology-forcing. Such

an interpretation would buttress the necessity of a cautious step-by-step approach and the initial retrievability of the wastes.

I urge your careful consideration of these comments.

Sincerely,

Dick Hartman

Dick Hartman
State Planning Coordinator

DH/ld

Attachment

TWIN TOWERS OFFICE BUILDING
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301

BOB GRAHAM
GOVERNOR

JACOB D. VARN
SECRETARY

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL REGULATION

July 27, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
Department of Energy
Washington, D.C. 20545

Dear Sr. Heath:

Please consider this public document. As a systems analyst, it expresses a number of my own concerns regarding the Draft EIS DOE/EIS-0046-D.

Sincerely,

J. S. Sherman

JSS/js

Enclosure

C.9

original typed on 100% recycled paper

STATE OF WISCONSIN
OFFICE OF THE GOVERNOR
STATE CAPITOL
MADISON, 53702

LEE SHERMAN DREYFUS

Telephone Number
(608) 266-1212

July 27, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U. S. Department of Energy
Washington, D.C. 20545

Dear Dr. Heath:

Re: DOE/EIS-0046-D-Management of Commercially Generated Radioactive Waste

The State of Wisconsin is aware of the sometimes conflicting, but urgent, issues related to the nuclear industry since we rely on nuclear power plants to provide 30 percent of our electrical energy.

While we recognize the primary Federal role in these issues, the problem of nuclear power and radioactive waste disposal are also state concerns and we will accept our responsibilities in these matters.

Wisconsin has a long history of accountable government involvement in proposals affecting the welfare of its citizens. I intend to maintain and improve this trust especially for nuclear waste disposal because of its serious implications to the energy and environmental future of Wisconsin and the Nation.

The responsibility over nuclear power and disposal of radioactive wastes must be a state and federal partnership. The Federal Government must make a special effort to recognize and comprehensively involve the states, local units of government and citizenry in all phases of the nuclear decision-making process.

The information contained in this Draft Environmental Impact Statement has serious overtones toward the future of our state, region and the Nation. The attendant problems will require our full and thorough attention. In order to begin a partnership approach of resolving these problems, I have directed several state agencies to provide my office with an interdisciplinary review of this Draft Environmental Impact Statement. These comments are attached.

Our review of the DEIS identified several serious inadequacies.

I feel the objectives to provide evidence supporting a specific program have not been substantiated by the information provided in this text.

I am confident that our comments will prove useful in preparing a final document which will be considered adequate within the spirit and intent of the National Environmental Policy Act, case law and the guidelines of the President's Council on Environmental Quality.

We are prepared to assist in any way possible to fulfill our obligations in this matter.

Sincerely,

Lee Sherman Dreyfus
GOVERNOR

Attach.

cc: Honorable Jimmy Carter, President
Harold R. Denton, Director, Nuclear Regulatory Commission
Honorable Albert Quie, Governor of Minnesota
Members of National Governors Association
Douglas Costle - EPA, Washington
John McGuire - EPA, Region V, Chicago
Honorable Gaylord Nelson
Honorable William Proxmire
Members, Wisconsin State Legislature
Stanley York - PSC
Donald C. Percy - H&SS
Robert Durkin - H&SS
Lowell Jackson - DOT
Mike Early - DLAD
Ken Lindner - DOA
M. E. Ostrom - Geo. & Natural History
Honorable Bronson LaFollette - Attorney General
John Stolzenberg - Leg. Council Office
Anthony Earl - DNR

OFFICE OF THE GOVERNOR

WILLIAM P. CLEMENTS, JR.
GOVERNOR

July 31, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U. S. Department of Energy
Washington, D. C. 20545

Dear Dr. Heath:

The Budget and Planning Office recently conducted a review of the draft environmental impact statement entitled "Management of Commercially Generated Radioactive Waste" prepared by your office.

Subsequent to the completion of that review, the enclosed comments from the Texas Department of Agriculture were not included with those of the other reviewing agencies. Those comments are being forwarded to you at this time for your use in the preparation of the final environmental impact statement.

I hope that the delay in the receipt of these comments will be of no inconvenience to you.

Sincerely,

Donald C. Harley

Donald E. Harley, Manager
Economic and Natural Resources
Budget and Planning Office

DEH:jl

Enclosure

EXECUTIVE OFFICE BUILDING • 411 WEST 13TH STREET • AUSTIN, TEXAS 78701

TENNESSEE DEPARTMENT OF CONSERVATION
TENNESSEE HISTORICAL COMMISSION
4721 TROUSDALE DRIVE NASHVILLE 37220
615/741-2371

September 17, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U.S. Department of Energy
Washington, D.C. 20545

Re: Draft Environmental Impact Statement-Management of Commercially Generated Radioactive Waste

Dear Dr. Heath:

The Tennessee Historical Commission, a state agency, has reviewed the above project in accordance with the provisions of OMB Circular A-95. Based on the information supplied, we conclude that the project as planned will not affect the plans or priorities of our office as a state review agency.

In addition to and separate from our A-95 review, the Executive Director, in his role as State Historic Preservation Officer, has also reviewed the undertaking with regard to National Historic Preservation Act compliance by the participating federal agency or its designated representative. Compliance procedures are set forth in the Advisory Council on Historic Preservation procedures for the protection of historic and cultural properties (36 CFR Part 800).

Our only recommendation at this time is that selection of specific waste treatment construction sites in our area should be coordinated with the State Historic Preservation Officer. Such coordination insures the proper identification of architectural, historic, archaeological and cultural properties included in or eligible for inclusion in the National Register of Historic Places as prescribed at 36 CFR 800.4 (see enclosure).

Please contact our office for assistance. Nick Fielder or Suzanne Whittenburg will be glad to address any questions or comments that you may have. Your cooperation is appreciated.

Sincerely,

Herbert L. Harper

Herbert L. Harper
Executive Director and
State Historic Preservation Officer

HLH:SDW:sh
xc: Thomas M. Webb, State Clearinghouse

ALBERT H. QUIE
GOVERNOR

STATE OF MINNESOTA
OFFICE OF THE GOVERNOR
ST. PAUL 55155

Mr. Jack Halzman
Department of Energy
175 West Jackson Boulevard
11th Floor
Chicago, Illinois 60604

Dear Mr. Halzman:

RE: Draft Environmental Impact Statement:
Management of Commercially Generated Waste
DOE/EIS 0046 D
April, 1979
Public Hearing Comments
State of Minnesota
Chicago, Illinois
August 8, 1979

I appreciate this opportunity to present the State of Minnesota's position on the draft environmental impact statement for the management of commercially generated radioactive waste (DOE/EIS 0046 D) and request that this letter be made a part of the record of this public hearing.

The State of Minnesota has had a continuing interest in the affairs surrounding nuclear power. We have, in the past, participated in rulemaking and licensing proceedings. Correspondingly, Minnesota has an interest in the question of nuclear waste disposal. This interest is heightened by the interpretation of the Wisconsin Department of Natural Resources that equates one of the reference sites in the EIS to the specific geological makeup of an area in central Minnesota

In 1977 the Minnesota Legislature enacted statutory restrictions on the importation of radioactive wastes into the State and the siting of a radioactive waste management facility in Minnesota (Minn. Stat. §116C 71-74). Although the statute was signed by my predecessor, Governor Perpich, it enjoys my full and complete support. I oppose the siting of a radioactive waste disposal facility in the State of Minnesota, except that which may be needed and feasible to store wastes from Minnesota's own nuclear generating plants.

AN EQUAL OPPORTUNITY EMPLOYER

The Draft EIS does a commendable job in identifying several potentially useful disposal strategies. The range of factors to be addressed is complete.

However, the EIS should present an analysis of the methods to be used by the Department of Energy in combining and weighing all factors in order to reach decisions on actual disposal sites for radioactive waste.

In sum, the State of Minnesota supports and encourages efforts by the federal government to address the problems of radioactive waste disposal. As Governor of Minnesota, I am opposed to the siting of a radioactive waste facility in this State except for wastes generated within our own State and only following thorough and intensive exploration at the national level of all alternatives available to solve this problem.

Sincerely,

Albert H. Quie
Governor of Minnesota

C.12

Office of the Governor

Atlanta, Georgia 30334

George Busbee
GOVERNOR

September 24, 1979

Ms. Ruth Clusen
Assistant Secretary for Environment
U. S. Department of Energy
Washington, D. C. 20585

Dear Ms. Clusen:

The State of Georgia appreciates the opportunity to review and comment on the Department of Energy's draft "Generic Environmental Impact Statement on the Management of Commercially-Generated Radioactive Waste," DOE/EIS-0046-D.

This Draft Environmental Impact Statement (DEIS) has serious implications upon the welfare of future generations and the quality of the environment in our State, the Region and the Nation. The stated strategy that "program emphasis should be on the establishment of mined repositories (in geologic formations) as the operative disposal technology" is of particular concern to the State of Georgia. It is appropriate to reiterate our position on this matter: We are unalterably opposed to those waste management operations which could result in the eventual contamination of groundwater sources. Although this DEIS acknowledges that groundwater "is a valuable and widely used resource" and "presumes that a repository should not affect the quality or availability to an unacceptable level," it concludes, however, that the migration of wastes into groundwater is potentially very high. Acceptance of any contamination of these resources would be irresponsible. The DEIS statement (p. 3.1.49) "Site selection will probably avoid areas of known major aquifers initially" should be responsibly changed to read: "Site selection must avoid any areas of aquifers." Our great natural groundwater resources are vital to the projected orderly growth and development of Georgia.

Our review of the DEIS identified several other serious inadequacies. These comments, compiled by Georgia's Environmental Protection Division, are attached.

Whereas, the State of Georgia is not opposed to the general concept of geologic disposal, the State is unalterably opposed to the specific concept relevant to a waste management strategy involving bedrock storage at the Savannah River Plant because of the potential contamination of the Tuscaloosa aquifer. It is quite apparent that DOE is proceeding to further develop a bedrock storage facility at the Savannah River Plant. Although the USEPA and the National Academy of Sciences have opposed this SRP waste disposal concept and the State of Georgia has stated its position on numerous occasions regarding this specific issue, it is the position of the State of Georgia that the Department of Energy has been neither sensitive nor responsive to Georgia's concerns in this matter. The State of Georgia will exercise all available options relative to this issue in order to protect its natural resources and the health and safety of the citizens of our State.

Sincerely,

George Busbee

GB:rpj

cc: Dr. C. A. Heath
Division of Waste Isolation, USDOE

C.13

LOUISIANA HOUSE OF REPRESENTATIVES
COMMITTEE ON NATURAL RESOURCES
Box 44012, Capitol Station
Baton Rouge, Louisiana 70804
Telephone: (504) 342-2350

October 3, 1979

COMMITTEE MEMBERS
REP. W. J. "BILLY" TAUZIN
CHAIRMAN
REP. J. CHRIS ULLO
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REP. FRANK J. PATTI
REP. EDWARD C. SCOGIN
REP. JOHN W. SCOTT
REP. LAWRENCE A. SHERIDAN
REP. JOHN J. SIRACUSA
REP. ARTHUR W. SOUR

Division of Waste Isolation (ET-960)
Mail Station B-107
U.S. Department of Energy
Washington, D. C., 20545

RE: Statement on the draft Environmental Impact Statement
Management of Commercially Generated Radioactive Waste

We appreciate this opportunity to comment on the environmental impact statement which we have received on the management of commercially generated radioactive waste. It is apparent that the Department of Energy is now moving in the direction of making decisions that will be of enormous concern to the people of this country involving the permanent disposal of commercially generated radioactive waste. In no place does that issue concern the average citizen more than it does in Louisiana. The citizens of our state are raising this issue during this election in Louisiana in a manner that impresses upon elected officials the concern that our citizens are feeling.

As elected officials, it is our responsibility to represent the wishes of our constituency and we also feel that because we are given opportunities to obtain information not available in all instances to the average citizen, it is our responsibility to provide leadership and to take a position on controversial and confusing issues.

Therefore, the Louisiana Legislature has taken a strong and forceful stand on the issue of disposal of radioactive waste and that stand is incorporated in Act 650 of 1978 which prohibits the disposal of radioactive waste in Louisiana's salt domes. It further prohibits the testing of geologic structures in Louisiana for their suitability for storage unless notice is given to the local parish governing body, the natural resources committees of the House and Senate of the legislature and the secretary of the Department of Natural Resources and anyone of those entities may cease the testing by objecting in writing. The test results must be made available to the House and Senate Natural Resources Committees upon completion of the testing.

The passage of this legislation was not intended to be vain and useless, but was intended to protect to the greatest extent possible the health and welfare of the citizens of our state and to prevent them from becoming guinea pigs. It was intended to assure that we are given the opportunity to question and probe any action the DOE may take to use Louisiana salt domes for the storage of radioactive waste. Whether or not this legislation is constitutional and enforceable, we feel that it will serve notice on those persons who make the fianl decision as to the site for any storage of waste, that Louisiana citizens must be a part of that decision making process in all respects.

Louisiana, has as a matter of state policy favored the development of nuclear energy and two nuclear power plants are presently being constructed within our state. We expect that those plants will some day provide electricity to our citizens and that those two plants will also generate waste which must be disposed of. We realize that on-site disposal will be available for only a few years and therefore, the natural resources committee recognizes the urgent need for permanent and safe disposal facilities. We support the idea of regional siting of repositories as opposed to one site or sites in all states with nuclear power plants. We realize that it would be impossible to require each state to handle its own waste and yet we feel that no one state should be required to be a dumping ground for the rest of the country.

We realize that a permanent facility will be needed within a few years

as storage facilities begin to reach their capacity. We would urge you to seek input from local and state governments as well as ordinary citizens in a more aggressive manner by holding hearings in the specific areas that are being considered and by seeking out the advice of a broad range of local and state officials. Holding hearings in Atlanta, Washington, New York, or Dallas just simply does not allow input by the people most affected. We hope that you will then reflect on the advice you will receive and give equal weight to the advice of state officials as well as federal.

Regardless of the type of storage medium or technology used, the most difficult issue to resolve will be the siting of each facility. Although this EIS does not address specifically each site under consideration, we have seen the ONWI summary characterization and recommendation of study areas for the Gulf Interior Region issued in May, 1979, and we realize that there are two salt domes in Louisiana under consideration by DOE.

Although we can't claim expertise in the various scientific disciplines which are discussed in the EIS, we do have expertise in the assessment of Louisiana's political, economic, and psychological environment. In considering the site of a repository, more must be considered than the geologic or surface utilization of the area involved. The decision makers must consider the political, economic, and psychological effects of their actions. We would urge that when specific sites are under consideration that informed local and state officials must be a part of the process of choosing a site or of determining that a site is inappropriate. In the past, most decisions made by DOE and other federal agencies involving our state have not allowed sufficient local input and that is probably one of the main reasons that many of these programs have run into trouble. A prime example is the Strategic Petroleum Reserve Program in which the DOE has taken several of our salt domes and converted them to oil storage facilites. In their haste to get this program under way, they have ignored Louisiana citizens and their elected representatives and have ignored concern

for our gragile ecology.

In addition, Louisiana has experienced a number of environmental problems in the past several years. The ONWI report ignores some of the most important environmental and economic issues concerning our citizens. It makes no mention of the fact that Louisiana has been the dumping ground of the nation for hazardous waste. Louisiana is the first state in the nation to implement a strict hazardous waste permitting program. During the past year, we discovered that there are numerous illegal and in some cases abandoned chemical waste dumps across the state. The clean up of the abandoned facilities will be a financial burden for our state. It is expected that we will have to deal with this environmental problem for quite some time before we finally get it under control.

Our waterways are experiencing the stress of our economic growth and of our agricultural production. In north Louisiana we have had serious problems with pesticide contamination of our lakes, rivers and streams. In both north and south Louisiana we have areas that are non-attainment for certain air pollutants.

In north Louisiana, we have recently discovered that we have millions of tons of lignite coal deposits which we will soon be mining. We will undertake a program to allow surface mining along with reclamation programs to follow so that we can make this coal available as a fuel for our industries. The production of coal will mean greater industrial development and expansion all across that area of our state with both power plants and other support facilities expected to be constructed close to the mining area.

We are a state of approximately 4,000,000 people living on 48,506 square miles of land and water. This means there are more than 81.8 people per square mile. In Webster Parish where the Vacherie dome is located there are 42,068 people living on 620 square miles or 67.9 people per square mile. In Bienville

Parish where the Rayburn dome is located there are 17,226 people living on 858 square miles or 20.1 people per square mile. Those areas are populated and at present are primarily agricultural. The people of these areas have historically been poor people and in particular the minority groups have suffered economic deprivation. Louisiana has moved into a period of prosperity for all our citizens because of our status as an energy producer for the rest of the country. With the aggressive mining of coal, reclamation, and the industry which will develope in the coal producing area, these people will be able to look forward to a prosperity that they have never known. A radioactive waste repository will probably put an end to their dreams of prosperity and to their expectations of a better way of life.

With all the environmental problems that I have mentioned, it is clear that Louisiana cannot accept the additional environmental burden of storing radioactive waste in our salt domes within the near future. We have willingly accepted the environmental problems of producing energy for our nation and we feel that our citizens have done more than their share in the area of shouldering the energy needs of the rest of the country.

We are further concerned that our salt domes are an important natural resource and may be useful for many better purposes than storage of radioactive waste which use would eliminate all alternate uses known and yet to be discovered. We would encourage additional research as to the nature and alternative uses of salt domes. We would not want to foreclose other alternative uses which might be of greater benefit to our citizens.

Regardless of the outcome of any EIS, as to the environmental suitability of an area, the most important environmental factor to be considered is the acceptance of the people living in the area. Without that acceptance, no facility will possibly be safe and useful. Whether the facility is harmful to the bodies of our citizens or not, we must be assured that it is not

harmful to their minds as well and that they will be able to lead normal and anxiety free lives. We believe that wherever the repository is located, compensation to both the residents and the governments of the area should be made to reduce the economic and environmental burdens imposed.

The Department of Energy signed a letter of agreement last year with our governor, agreeing not to use our salt domes for radioactive waste disposal without the states permission. We would hope that the department under this and any new administration will continue to honor that agreement.

Thank you for this opportunity to make these comments which I hope will give you some guidance as you prepare to make decisions regarding the first of the repositories for storage of radioactive waste.

Yours truly,

Rep. W. J. Pauzin
Chairman, House Natural Resources Committee

C. Frank Haroscher, III
Secretary

COMMONWEALTH OF KENTUCKY
DEPARTMENT FOR NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION
OFFICE OF THE SECRETARY
OFFICE OF POLICY AND PROGRAM ANALYSIS
CAPITAL PLAZA TOWER
FRANKFORT, KENTUCKY 40601
PHONE (502) 564-7320

October 2, 1979

Department of Energy
Division of Waste Isolation
M.S. B-107
Washington, D. C. 20545

RE: Management of Commercially Generated Radioactive Waste

Dear Sirs:

The Draft Environmental Impact Statement prepared on the Management of Commercially Generated Radioactive Waste has been circulated to the Kentucky Environmental Review Agencies for their comments. Attached are the comments that have been returned by them. Any late arriving comments will be forwarded to your attention.

Sincerely,

Boyce R. Wells

Boyce R. Wells
Environmental Review Coordinator

BRW:bsc

Julian M. Carroll
Governor

TENNESSEE
STATE PLANNING OFFICE

600 CAPITOL HILL BUILDING
301 SEVENTH AVENUE, NORTH
NASHVILLE, TENNESSEE 37219
615-741-1676

October 4, 1979

Dr. Colin A. Heath
Division of Waste Isolation (ET-960)
U. S. Department of Energy
Mail Station B-107
Washington, D.C. 20545

Dear Dr. Heath:

Enclosed are comments regarding the EIS for the Management of Commercially Generated Radioactive Waste.

If this office can be of further assistance please do not hesitate to contact me.

Sincerely,

Saralee W. Terry (pbw

Saralee W. Terry
Resource Analyst

SWT:pbw

Enclosure

C.17

STATE OF NEW YORK
DEPARTMENT OF
ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK 12233

M. PETER LANAHAN, JR.
FIRST DEPUTY COMMISSIONER

U.S. Dept. of Energy
Attn: Div. of Waste Isolation
MSB-107
Washington, D.C. 20545

Gentlemen:

The State of New York has completed its review of the draft Generic Environmental Impact Statement (GEIS) "Management of Commercially Generated Radioactive Waste" (DOE/EIS-0046-D), issued April 1979.

We must commend the DOE staff on its objectivity and thoroughness in the preparation of this document. We concur with the DOE position that conventional geological disposal is the option which is best understood and provides the best means for monitoring and control of the waste. Due to the urgent need for a national waste repository, this should be the option of first choice.

Thank you for the opportunity to comment on the GEIS. We hope our attached comments will be useful in the preparation of your final report.

Sincerely,

M. Peter Lanahan, Jr.
First Deputy Commissioner

attachment

FEDERAL ENERGY REGULATORY COMMISSION
REGIONAL OFFICE
730 Peachtree Street, N. E.
Atlanta, Georgia 30308
June 20, 1979

Dr. Carlin A. Heath
Division of Waste Isolation
Mail Stop B-107
U. S. Department of Energy
Washington, D. C. 20545

Dear Dr. Heath:

This refers to the Draft Generic Environmental Impact Statement (GEIS) on management of commercially generated radioactive waste, received by the Atlanta Regional Office on May 30, 1979.

The Commission's principal area of responsibility is the regulation of the electric power and natural gas industries. Therefore, it is concerned with the possible impact of radioactive waste disposed on the construction and operation of bulk electric power and natural gas facilities. Since at the present there are commercially operated nuclear generating units interconnected into the power system, and other units under construction, we too are concerned with the ultimate disposition of radioactive wastes.

In reviewing the study, we note that there are potential geologic burial areas located throughout the contiguous United States as illustrated in Figures 3.1.1, 3.1.2, 3.1.3, and 3.1.4. Since the FERC has licensed hydroelectric generating facilities located throughout the U.S., of particular concern to us are the problems resulting from both routine operations and accidental spills over watershed areas upstream of FERC licensed hydroelectric projects that may affect generation. In addition, when selecting geologic waste disposal areas, attention should be given to the effects upon potential hydro sites which may be, or become, economically feasible to develop.

We appreciate the opportunity to comment on the GEIS.

Very truly yours,

Aarne O. Kauranen
Regional Engineer

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230
(202) 377-4335

July 6, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U.S. Department of Energy
Washington, D.C. 20545

Dear Dr. Heath:

This is in reference to your draft environmental impact statement entitled, "Management of Commercially Generated Radioactive Waste." The enclosed comments from the National Oceanic and Atmospheric Administration and the Maritime Administration are forwarded for your consideration.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving ten (10) copies of the final statement.

Sincerely,

Sidney R. Galler

Enclosures from: Mr. Gordon Lill
National Ocean Survey
NOAA

Mr. F. Chew
Environmental Research Laboratories
NOAA

Mr. Douglas M. LeComte
Environmental Data and Information Service
NOAA

Capt. George Steinman
Maritime Administration

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md. 20852

OA/C52x4:CWC

TO: PP - Richard L. Lehman

FROM: OA/Cx1 - Gordon Lill

SUBJECT: DEIS #7904.32 - Management of Commercially Generated Radioactive Waste

The subject statement has been reviewed within the areas of NOS responsibility and expertise, and in terms of the impact of the proposed action on NOS activities and projects.

The following comments on Section 3.6, The Sub-seabed Geologic Disposal Concept, are offered for your consideration.

More emphasis should be placed on understanding the nature of transport of materials in the water column in areas under study for waste disposal. Ongoing programs in quantifying biological pathways should be expanded and a comprehensive program of physical, chemical and biological measurements should be undertaken and models developed for deep ocean layers. It is essential to quantify what will happen in the case of accidental breakage or unexpected leakage in terms of the water column serving as an emergency barrier.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL RESEARCH LABORATORIES
AOML/PhOL
15 Rickenbacker Causeway
Miami, Florida 33149

Date: May 25, 1979

To : R. Lehman, PP/EC
Office of the Administrator, NOAA, Washington, D.C.

From: F. Chew, AOML/NOAA

Subj: Comments and suggestions on the physical oceanographic aspects of DEIS 7904.32 - Management of Commercially Generated Radioactive Waste

As instructed by Dr. D. Hansen, Director (Acting), AOML, this is in reply to your memo of April 26, 1979.

A. Island Disposal

1. Page 3.5.21, line 13 from top:

   The hydraulic gradient and the stability of freshwater lens may also be affected by sea level slope induced by coastal currents and topographic focusing of surface and internal gravity waves.

2. Page 3.5.23, line 9 from bottom:

   Sea level slope is another factor in the stability of freshwater lens.

3. Page 3.5.24, line 8 from top:

   Factors of importance to sediment patterns and movements include tides, land discharges, coastal circulation, littoral currents induced by surface gravity waves, and direct wave actions during storm and Tsumani.

4. Page 3.5.25, line 13 from top:

   Replace the sentence beginning with "However", on line 13 with: However, their natures and time variant behaviors, particularly of subsurface currents, are incompletely understood.

5. Page 3.5.25, line 15 from bottom:

   Replace the sentence beginning with "Similar" on line 15 with: For oceanographic data there is need for both intensive and extensive observations over a long period in order to resolve the time and space scales of the coastal, littoral, and other flows.

B. Sub-seabed Disposal

1. Page 3.6.1, line 23 from top and page 3.6.4, line 18 from bottom:

   A surface current gyre is a partially closed circulatory (not circular) system of surface and upper layer waters.

2. Page 3.6.6, line 6 from bottom (including footnote):

   Supposing the correctness of the assumptions, the breakthrough time, T, is not a million years, but is

   $$T = D^2/A = (100\ m)^2/(3 \times 10^{-6} cm^2/yr) = 3 \times 10^{13}\ yrs.$$

3. Page 3.6.7, line 19 from bottom:

   The bottom flow is not uniform and plate-like. The mean flow is thought to be slow, but there is a transient component that is related principally to the tides. Within about 5 m of the bottom there is a boundary layer that is thought dynamically analogous to the lowest 2 km in the atmosphere. See Wimbush, M. and W. Munk (1970): The Benthic Layer in THE SEA, Vol. 4, pt. 1, A. E. Maxwell, Editor.

4. Page 3.6.7, line 17 from bottom:

   Delete estimates of barrier properties, or add "if any" to read: to allow estimates of the barrier properties, if any, of the water column,....

5. Page 3.6.17, line 1 from top:

   Replace sentence beginning on line 1 with: The long-term stability of the patterns suggests a weak current regime.

6. Page 3.6.20, line 10 from bottom:

   Replace "a poor" with "no" in the sentence beginning on line 10 so so that it reads: For reasons given, the water column is likely to be no barrier against large quantities of nuclides....

7. Page 3.6.30, line 16 from top:

   Replace "deep physical circulation and biological processes" with all relevant processes. Delete footnote on same page.

C. Icesheet Diaposal

This part is adequate.

cc: Dr. D. V. Hansen

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL DATA AND INFORMATION SERVICE
Washington, D.C. 20235

June 21, 1979 OA/Dx61

TO: PP/EC - R. Lehman

FROM: OA/Dx61 - Douglas M. LeComte

SUBJECT: DEIS 7904.32 - Management of Commercially Generated Radioactive Waste

Page 3.7.21, Global and Polar Climatology: Mention should be made of recent research which shows that continued use of fossil fuels for energy production could increase atmospheric carbon dioxide levels to the extent that the resulting enhanced "greenhouse effect" would significantly raise global air temperatures. Studies of nuclear waste disposal in polar ice should consider that global circulation models which assume increased CO-2 levels indicate that the largest warming trends would be in Polar regions. An increase in annual mean temperatures by 12°C or more well before the end of the next century is possible, according to these models. A climate change of such a large magnitude would likely cause significant changes in the depth of Polar ice and snow, especially in the Northern Hemisphere.

C.21

UNITED STATES DEPARTMENT OF COMMERCE
Maritime Administration

May 30, 1979

MEMORANDUM FOR: Dr. Sidney R. Galler
Deputy Assistant Secretary for Environmental Affairs

Subject: U.S. Department of Energy - Draft Environmental Impact Statement (DEIS) concerning Management of Commercially Generated Radioactive Waste (April 1979)

The subject generic DEIS has been reviewed as requested by your memorandum of April 24, 1979. This Statement examines ten alternative methods for disposal of nuclear wastes and evaluates their anticipated environmental impacts. Based on the analysis presented, the Department of Energy (DOE) proposes that (1) the disposal of radioactive wastes can likely be developed and applied with minimal environmental consequences and (2) the program emphasis should be on the establishment of mined repositories as the operative disposal technology. DOE further recommends that R&D on technical operations other than mined repositories should be performed for the nearer-term approaches (i.e., deep ocean sediments and very deep holes) so that they may be adequately evaluated as potential competitors.

Our comments address the disposal of high level radioactive wastes by deep ocean emplacement. Although this at-sea disposal method is currently prohibited by international treaty and national law, this disposal option should continue to be evaluated, but on a priority basis, for future use. The sub-seabed geologic disposal concept using the central regions of sediment-covered subocean tectonic plates offers potential advantages, not the least of which are tectonic stability, environmental stability, absence of resources, and remoteness from man's activities. A special element of this disposal option is the development of a safe transport/emplacement ship system. Preliminary design and safety analyses of this transport/emplacement ship system, as well as the related port facility, should be initiated to parallel other technical and environmental feasibility studies.

George C. Steinman

GEORGE C. STEINMAN
Chief, Environmental Activities Group
Office of Shipbuilding Costs

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

SEP 27 1979

Dr. Colin A. Heath, Director
Division of Waste Isolation, MS B-107
Department of Energy
Washington, D.C. 20545

Dear Dr. Heath:

The Environmental Protection Agency (EPA) has reviewed the Department of Energy's (DOE) Draft Environmental Impact Statement (DEIS) for "Management of Commercially Generated Radioactive Was' .," (DOE/EIS-0046-D). Our detailed comments are enclosed.

There are a number of serious deficiencies in the analysis which should be corrected in the Final EIS. They are: (1) failure to consider the time-integrated population dose as an important parameter in evaluating the impact from the waste disposal; (2) failure to consider individual dose to ground water users; (3) acceptance of a level of exposure comparable to background radiation (identified in the DEIS as 120 millirem per year) as a permissible additional dose to individuals; (4) lack of a sensitivity analysis showing which parameters in the risk analysis are important; (5) use of outdated, questionable, and/or one-sided radiobiology references; (6) occasional improper consideration of waste chemistry and geochemistry; (7) incomplete economic analysis; and (8) failure to relate radiation doses to health effects. Also, some information is lacking, making a good comparison of options for disposal of radioactive waste incomplete.

It is to be noted that "Sub-seabed disposal" would be subject to the dumping requirements of the Marine Protection, Research, and Sanctuaries Act of 1972 and that the dumping of high-level waste is prohibited by the Act. The Final EIS should reflect these facts.

In addition, in preparing the Final EIS, reference is needed to the present development by EPA of Federal guides for radioactive waste management and standards for high-level radioactive waste. DOE should consider the requirements stated in the proposed criteria p blished in 1978 (43 F.R. 53262 et seq.). The proposed criteria are under review

C.22

for promulgation as Federal guides and are scheduled to be published before the end of 1979. We will also publish our high-level waste standards in draft form in several months. These general guides and specific standards will identify what must be accomplished in waste management activities to provide assurance of public health protection and environmental preservation.

With proper attention to the above concerns, we believe the Final EIS can support a continuing program to develop a safe disposal system for high-level radioactive waste.

However, because we have reservations concerning the environmental effects of certain aspects of the proposed program, we rate this Draft EIS ER-2. This rating will be published in the Federal Register.

Should DOE have questions about our comments, please call Betty Jankus (NEPA matters - 755-0770) of my staff.

Sincerely yours,

for

William N. Hedeman, Jr.
Director
Office of Environmental Review (A-104)

Enclosure

Detailed Comments of the

United States Environmental Protection Agency
on the
United States Department of Energy's
Draft Environmental Impact Statement

"Management of Commercially
Generated Radioactive Waste"
DOE/EIS-0046-D

Summary

The U.S. Environmental Protection Agency (EPA) has reviewed the U.S. Department of Energy (DOE) Draft Environmental Impact Statement (DEIS) for "Management of Commercially Generated Radioactive Waste" (DOE/EIS-0046-D). This DEIS replaces one (WASH-1539) that was issued in September 1974, by the Atomic Energy Commission (AEC) and withdrawn in April 1975, by the Energy Research and Development Administration (ERDA). It is clear that the comments of EPA regarding WASH-1539 were seriously considered by those who prepared this Draft EIS. After correction of the errors we believe the Final EIS will support a program leading to the safe, long-term disposal of radioactive waste.

We agree with DOE that the option selected for implementation appears to be the best of those considered; however, we believe that more information should be presented on the other nine options. We believe that the DEIS has many errors; nevertheless, we doubt that the correction of these errors will show that any other option is preferable to the mined, geologic repository. It is also unlikely that there would be any viable alternative available in the near future. For this reason we believe DOE's program should be vigorously pursued.

General Comments

1. Other Options Need Fuller Treatment.

The document Draft Environmental Impact Statement on "Management of Commercially Generated Radioactive Waste" considers ten alternative methods for disposal of high-level nuclear waste. However, all of the alternatives considered, except the mined, geologic repository alternative, are presented only in a general fashion. It is impossible to compare the options adequately, because detailed information is presented on only one of the options. Regulations developed by the Council on Environmental Quality specifically require agencies to "Rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated" (40 CFR 1502.14 (a)). The difficulty is clearly displayed by the nature of Section 4.0, "Comparative Analysis of CWM Options." The DEIS appears inadequate to support decisions which would eliminate alternatives from the scope of a permanent disposal strategy. For example, Table 4.5.1 suggests that the "Very Deep Rock" concept is preferable to "Geologic with Resynthesis" for virtually all decision criteria. This would suggest dropping the resynthesis alternative. However, we do not feel that there has been sufficient analysis to justify such a conclusion. The final EIS should improve the comparative analysis as much as possible and should specify to what extent the program will pursue the nine alternatives other than the mined, geologic repository option, which has been selected for implementation. DOE should also consider changing the title of the Final EIS to "Management of Commercially Generated High-Level and TRU Radioactive Waste," in order to better reflect the thrust of the document.

A "no action" alternative should be presented. Although this alternative is neither socially nor environmentally acceptable, it would be useful to present this option. To some extent this alternative is discussed as the delayed decision options in Section 3.1. This specific alternative is required by 40 CFR 1502.14(d).

We believe the "Chemical Resynthesis" approach deserves further detailed consideration. The possibility of using a waste form which is thermodynamically stable, does not form metamicts over time, and is almost entirely insoluble in a wide range of geological liquids offers advantages over other waste forms, because the population dose from all events except intrusion and catastrophic releases (volcanism, meteorite breach, etc.) is very low. Several references in this field have been

published since the Draft EIS was prepared (for example, those of Ringwood, McCarthy, and Roy). As noted in the EIS, this option is really a variation of the geologic disposal option.

2. Sensitivity Analysis is Needed.

In describing the impact from the mined geologic repository, the DEIS uses probability and consequence parameters which are currently very uncertain. The impacts calculated in the DEIS are frequently more pessimistic than results we have obtained in our program to develop environmental standards for HLW. Different assumptions about many parameters may have significant impact on the projected health risk. Consequently, we strongly recommend that the Final EIS contain sensitivity analyses to indicate the range of impacts which may result from varying these parameters. The uncertainties in these analyses should also be identified and discussed.

3. Dose Calculations Need Improvement.

There are substantial problems in the calculation of radiation doses and health effects to the public. The time-integrated population dose is frequently neglected. Furthermore, population doses are not always expressed as fatal, non-fatal, and genetic health effects; we think that they should be. The DEIS suffers technically from old references, occasional misquoting of data, and some lack of balance in presenting radiobiological concepts. The use of old estimates of natural background in developing risk perspective and the use of dated and/or questionable references coupled with a lack of balance in presenting radiation risk coefficients result in a less than satisfactory draft for public decision making. Additionally, the methodology used for the impact assessment is in need of improvement. (See specific comments for Appendices C, D, E, H, and I.)

The Draft EIS appears to indicate that the major hazards occur in the first few hundred years while Sr-90 and Cs-137 are present. As a result, long-lived nuclides, such as Tc-99 and I-129, are neglected despite the fact that they can be geochemically mobile under some circumstances. One of the major shortcomings is the fact that only one set of sorption constants has been used in this work. (This assertion is supported by a caveat on page 3.1.160.) Sensitivity analyses performed in our high-level waste program indicate that changes in sorption constants and other parameters lead to significant changes in time-integrated population dose and dose to maximum individual. Recent work suggests that the impact of some nuclides is controlled more by solubility considerations than by sorption considerations (See, for example: Bondietti and Francis, Science,203, pp. 1337-1340, 1979). A range of sorption constants and solubility limitations for specific elements should be used.

4. EPA will soon publish Criteria and Standards.

Our approach to the problems of radioactive waste disposal is to use as many independent barriers as feasible to reduce the environmental impact, taking into account social, technical, and economic factors. We are presently preparing criteria and standards for radioactive waste management. The criteria (applicable to all radioactive waste) were published in draft form last year (43 F.R. 53262 et seq.). The comments received from other agencies and the public are presently being analyzed for final publication in several months. The high-level waste standard now under development will also be published in draft form in several months. These criteria and standards will be applicable to any disposal of high-level waste or spent nuclear fuel.

Economic Comments

1. The Effects of Costs Are Not Considered.

A major fault in the DEIS is that the potential economic impact resulting from the cost of commercial waste management is not addressed. Since payment of these costs will be made by the consumers of nuclear-generated electricity, it is necessary to determine what the impact will be on electricity customers. The DEIS estimates the cost of waste management but does not evaluate the economic consequences of incurring such costs. Analysis of both the microeconomic and macroeconomic impacts should be performed. Within the micro framework, the direct impacts on customers' electric rates and fuel bills should be investigated. Macroeconomic considerations should include the degree of secondary impacts stemming from a rate increase to commercial and industrial electric users which can influence the cost of producing other goods and services in the economy. The economic impacts of the cost of waste management also need to be discussed on a regional basis since they depend on each area's relative reliance on nuclear-generated electricity. The potential for these costs to influence the selection of power plant type should also be addressed. In light of the relatively detailed analysis of the localized socioeconomic impacts associated with the siting of waste management facilities which was presented in the DEIS, the lack of an economic impact analysis of the cost of waste management is a serious omission in the report.

2. Impacts on Nuclear Power Growth Are Not Addressed.

Another fault of the DEIS is the stated intent to exhibit neutrality regarding nuclear growth in connection with analysis of the effect of deferring the repository startup date to the year 2000. By assuming that there is no relationship between deferral of the repository startup and nuclear power growth, the analysis generates misleading results about the impacts of the deferral. By recognizing the existence of administrative and legislative obstacles to nuclear expansion, which are tied to the absence of a demonstrated waste management plan (e.g., the California moratorium), one must conclude that the deferral of a repository startup date for 15 years should result in a lower forecast of nuclear activity. As the DEIS indicates, different levels of nuclear activity produce different degrees of environmental and economic impacts. There is no objection, per se, to determining the respective impacts of two different situations which use the same nuclear power forecast but different repository startup

dates. The objection arises when the inference is made that the effect of the deferral is simply the differences in the estimated parameters for each situation. The differences in these two cases should not be interpreted as representing the impact of deferring the repository startup date, since deferral necessitates a different (lower) level of nuclear activity with its accompanying level of environmental and economic values. Thus, the true impact of deferral must be estimated by varying the nuclear power forecast from the base case (1985 startup date).

The DEIS misleads the reader since the impact of deferral is presumed to be estimated from Table 3.1.84 which summarizes the environmental effects for alternative repository startup dates of 1985 and 2000 (see page 4.42, second paragraph). On page 4.45, second paragraph, it is stated that the variations in health and safety effects as well as cost impacts by different strategies, which include deferral of repository startup date, are small. Despite the caveat stated in the foreword about neutrality regarding nuclear growth, by utilizing this neutrality in the estimation of the environmental effects the DEIS has incorrectly estimated the impact of deferral. A proper estimation procedure must address the fact that the forecast of nuclear power growth is dependent (among other things) on the repository startup date.

Specific Comments

1. (Page 1.5, last paragraph, line 8) The bentonites referred to are sodium montmorillonites which lose water when heated to 100°C. Although the adsorption of metals is high in bentonites, the water release is an undesirable property in proximity to canisters. Perhaps illite could be utilized in lieu of bentonite to the assured 100°C isotherm.

2. (Page 1.9) Why is the statement made that "in either event, the HLW contains fission products, uranium, plutonium, and the balance of the TRUs?" In both the recycle options most of the uranium is removed, and in the U-Pu recycle most of the plutonium is removed as well. Furthermore, if one assumes U & Pu recycling, sooner or later one reaches the point where fuel elements no longer have sufficient fuel value to be worth recycling. This case should be considered.

The volatile materials and TRU elements separated in fuel processing and captured in accordance with the uranium fuel cycle standards (40 CFR 190) are omitted in this discussion. They should be included.

3. (Page 1.11) In comparing natural and manmade doses person-rem is the sum of doses to individuals in the population and so is a function of both individual doses and population size. The extra 260,000 person-rem in Colorado compared to Louisiana is meaningless in that population size selection was arbitrary. Why not use New York and Hawaii? Moreover, the data base is now obsolescent, see NCRP-45.

4. (Page 1.12) Media properties: This section appears to consider only the properties of a medium which make it possible to construct a mine in it. For example, ground water is discussed only in terms of the necessity to remove water from repository shafts and rooms. Ground water is more important as a potential way for the radionuclides to move in the geosphere.

5. (Page 1.15) Again bentonite is considered despite the limitations expressed above.

Under human institutions: Human back-up of the "carefully engineered geologic system" for periods of hundreds of years is not enough. Back-up for thousands of years, if not many thousands, would be necessary. It is for this reason that the proposed EPA criteria (43 F.R. 53262 et seq., November 15, 1978) recommend against reliance on institutional controls for more than one hundred years.

The hazard indices discussed in Section 3.1.3.4 and mentioned here are at best crude estimates. The hazard of a material is based on three factors--(a) the quantity of the materials available, (b) the toxicity of the materials, and (c) the pathways between the materials and human beings. Hazard indices which do not consider all of these (and it is difficult to think of a generic hazard index which would be useful for specific pathways) are not particularly useful.

6. (Page 1.19)-Accident analysis: The impacts associated with accidents after closure of the repository have been improperly assessed. The most suitable assessment measure is the time-integrated population dose over the time of interest which, for many accidents involving ground water flow, would be a very long time. Maximum individual doses would probably be associated with the ingestion and use of ground water; this was not calculated.

The chemical nature of the waste and of the geosphere appears to be largely ignored. Much of the reduction of radiation dose appears to occur as a result of the delay of radionuclides by sorption from the ground water. The sorption of radionuclides depends on several factors, including the oxidation-reduction state of the nuclide, the presence or absence of complexing or chelating agents, and the nature of the specific geological materials present. In some cases, particularly if large and rather exotic containment canisters are postulated, the ion exchange requirements of the canister materials may be quite significant and might overload the exchange capacity of the media in which the waste was emplaced.

7. (Page 2.2.1, Section 2.2.1.1) The document neglects to mention overall guidance provided by the FRC: Radiation Protection Guidance for Federal Agencies, 25 F.R. 4402 et seq. (5/18/60), for which 10 CFR 20 is one of several implementing regulations.

8. (Section 2.2.1.2, page 2.2.3 et seq.) There is no mention of EPA's regulations developed under the regulatory authority of the Marine Protection, Research and Sanctuaries Act of 1972 (Public Law 92-532). This authority should be referenced in this section.

9. (Page 2.2.3) Under EPA Uranium Fuel Cycle Standards, the last sentence in this section is in error. The effective date for application of 40 CFR 190 can be found in 40 CFR 190.12. This error should be corrected.

10. (Page 2.2.3) The way in which the EPA drinking water regulations would be applied, if at all, is not made clear. These regulations are not directly appropriate to the disposal of radioactive waste since they do not control the contamination of the environment. They are

directed toward a water supplier and applied to monitoring and corrective treatment regardless of the source of the contamination. The Draft Environmental Impact Statement relates to activities of persons whose contamination of the environment is being limited.

11. (Page 2.2.4, Line 6): This should be corrected to read: (b) Gross alpha particle activity (including radium-226 but excluding radon and uranium)--15 pCi/1.

12. (Page 2.2.5) Under "Clean Air Act Amendments of 1977" the text states: "The administrative and legal problems arising from the potential conflict with NRC regulatory authority and procedures originating in the Atomic Energy Act of 1954 have not been resolved. However, it is unlikely that existing EPA radiation standards will be changed, although administrative requirements may." This statement is presumptuous and does not reflect the major effort underway at EPA to develop regulations under the Clean Air Act, as amended. The text should be revised in the Final EIS.

13. (Pages 2.3.2 and 2.3.3, Tables 2.3.1 and 2.3.2) Both of these tables are taken from an obsolescent reference (ORP/CSD 72-1). More appropriate references would be EPA report ORP/SID 72-1 (reference 21, Section 2.3) with the cosmic ray doses augmented by the new information in NCRP Report #45 (reference 10, Section 2.3).

14. (Page 2.3.4, Section 2.3.2.2, 2nd paragraph, last three lines) The dose estimates for radon are obsolete. Currently, dissolved radon in the body would give a dose of about 2 to 3 mrem/yr and the range of estimated dose from inhaled radon and daughters at 0.7 pCi/liter would be 130 mrem/yr to 1800 mrem/yr. See United Nations Scientific Committee on the Effects of Atomic Radiation Report (UNSCEAR) for 1977 for a more complete treatment of the question, also NCRP #45.

15. (Page 2.3.5, Section 2.3.2.2, Table 2.3.3)-The data in this table is obsolete, see UNSCEAR 1977 or NCRP 45 for current data.

16. (Page 2.3.5, Section 2.3.2.2, Table 2.3.4) - This table is obsolete. NCRP 45 summarizes natural background as follows:

Annual Exposure in Millirem/year

Source	Gonads	Lung	Bone Surface	Bone Marrow	GI Tract
Cosmic	28	28	28	28	28
Cosmogenic	0.7	0.7	0.8	0.7	0.7
Terrestrial	26	26	26	26	26
Inhaled	--	100	--	--	--
Radionuclides in Body	27	24	60	24	24
TOTAL	80	180	120	80	80

17. (Page 2.3.6, Section 2.3.3, 2nd paragraph, last line) The use of the Congressional Research Service (reference 23) estimate of 200,000 defective children per year does not agree with current estimates of 9.5 percent to 10.5 percent incidence of genetic disorders in newborn (see UNSCEAR 1977, p. 519). The UNSCEAR estimates suggest that this estimate of 200,000 is at least a factor of 2 low.

Estimates of malignancies occurring each year are better obtained from the American Cancer Society annual publication "Cancer Facts and Figures--19xx." For example, estimates have been: 395,000 deaths, 765,000 cases of cancer--1979; 390,000 deaths, 700,000 cases--1978; 385,000 deaths, 690,000 cases--1977; etc.

18. (Page 2.3.6, Section 2.3.3, 3rd paragraph, last sentence) The use of Frigerio and Stowe as a reference should be put in context. Aside from using the same obsolete reference of natural background used in this DEIS which inflates the probable difference in background between areas of the country, the authors neglect to consider the potential effects of other carcinogens in the work place and the environment. Some of these problems are highlighted in multiauthor sections on "Demographic Leads to High-Risk Groups" and "Environmental Factors" in the volume Persons at High-Risk of Cancer (J.F. Franmeni, Jr., editor, Academic Press, New York, 1975). Little support is given for the assertions in the referenced paper.

In a more complete report by the same author (N.A. Frigerio, K.F. Eckerman, and R.S. Stowe, "Carcinogenic Hazard from Low-level, Low-rate Radiation," ANL/ES-26, 1973) where all methods and assumptions are given, there are several flaws. A major flaw is the assumption that "all forms of cancer show very similar doubling doses and closely similar increases in mortality rate per rad." This assumption is made

contrary to the evidence in ICRP, UNSCEAR, BEIR, and other reports that variations in the susceptibility of tissue to induction of different forms of cancer by irradiation are quite large and not necessarily related to the marked variations in natural incidence of the diverse types of cancer.

There are also problems in the statistical analysis in ANL/ES-26: misuse or misinterpretation of the t-statistic, failure to use Scheffes' test or calculations of variance ratio to check the significance of the series of t-tests, and use of gross averages in the analysis.

In reality, the paper can be shown to be erroneous by inspection of Frigerio et al.'s source of cancer mortality data, NCI Monograph 33, Patterns in Cancer Mortality in the United States: 1950-1967. In Monograph 33, Burbank presented an analysis of Dynamic Geographic Distribution for each cancer. The complex pattern of increasing and decreasing cancer mortality by state and cancer show that factors other than background are the major driving force in cancer mortality rates and that natural background radiation is not.

Indeed, in a later publication (Jacobson, A.P., Plato, P.A., and Frigerio, N.A. "The Role of Natural Radiations in Human Leukemogenesis," Am. J. Public Health, 66, p. 31-37, 1976), a more reasonable major conclusion was reached: "It appears that conditions relative to populations and their environment could mask a radiation effect, if in fact one is present."

19. (Page 3.1) The main reason that the waste management system evaluation was emphasized on deep geological disposal in salt formations was that this alternative received the most study. We suggest other geologic media and other disposal methods receive adequate scrutiny.

20. (Page 3.1.3) The concept of the equilibrium release fringe does not appear to have significance for long-term isolation, considering the potential for disruption of the containment.

21. (Page 3.1.4, last paragraph) We recommend that the last paragraph on this page (mid-paragraph) address the fact that most of the intense tectonic activity and virtually all of the volcanic activity of the North American continent occur along the global plate boundaries.

22. (Page 3.1.6, sixth paragraph) This discussion of resource potential of the host rock is incomplete. It treats only the loss of resource through use of the area for a repository. In fact, such loss of resource potential cannot be maintained indefinitely since eventual loss of control over this site must be expected. The real problem with resource potential of the host rock is that it will tend to attract future human intrusion and so increase the probability that the repository integrity can be breached by man's activities.

23. (Page 3.1.8, last paragraph) We recommend that the low water content and drier nature of salt domes resulting from the diapirism process be cited as a particular advantage over bedded salt.

24. (Page 3.1.14 - Table at bottom of page) There should be two categories of salt, Bedded Salt and Salt Domes, so that the difference in moisture content can be emphasized. Salt Domes have lower moisture content which is a major consideration.

Plasticity, ion exchange capacity, and linear discontinuities should be added to the properties for the rock types. Plasticity values would have the following relative scale values: Bedded Salt (3), Salt Domes (3), Granite (1), Shale (2), and Basalt (1). Ion exchange capacity would have values of 1, 1, 2, 3, and 2, respectively. Linear discontinuities would have values of 3, 3, 2, 3, and 1, respectively.

25. (Page 3.1.16, third paragraph) This statement is too vague to be useful in the site selection process. It is necessary to make a determination as to the period of time for which high-level radioactive waste must be kept isolated from the biosphere and also for how complete such isolation must be. Complete isolation for all time is probably not achievable and certainly cannot be assured in advance.

26. (Page 3.1.17) Somewhere it should be emphasized that global plate boundaries should be excluded as locations for potential repository sites because most of the catastrophic geologic events of this planet occur along these well defined linear features.

27. (Page 3.1.17) Several uncertainties exist in the projected behavior of the system, such as the philosophy for radionuclide containment, waste form, the host rock, etc. We suggest there also be a discussion as to how these uncertainties can be overcome.

28. (Page 3.1.20) How important is climatic change in determining the evaluation of the hydrologic environment? Increased precipitation might fill up an unsaturated aquifer, but how would it affect the permeability or porosity of an aquifer in the zone of saturation?

29. (Page 3.1.22, first paragraph) The first sentence should substitute volcanic activity for magmatism and a sentence immediately following should cite the fact that unlike other catastrophic events 98 percent of all volcanism on earth is confined to regions of global plate boundaries. Since this is a known fact, the reference to magmatism in line 11 should be deleted. A sentence following line 11 (with magmatism deleted) could state that volcanism (magmatism) is predictable since it is virtually confined to the region of global plate boundaries. In any case volcanism (magmatism) should be clearly separated from tectonism and this has not been accomplished on page 3.1.22.

30. (Page 3.1.22) Isotopic date provinces have been delineated in the Precambrian basement rock (Dott and Batten, Evolution of the Earth, 1976, p. 165), and the importance of these boundaries may be second only in significance to the global plate boundaries in site selection. While these boundaries are exposed in the Canadian Shield they are buried beneath sedimentary rocks in the rest of the North American continent; however, the extension of the Grenville isotopic boundary beneath the sediment has been correlated with major seismic events in the eastern portion of the North American continent. It is recommended that the isotopic date boundaries be addressed in site selection considerations.

31. (Page 3.1.23, third paragraph) It should be recognized that both climate and hydrologic gradients may change in the course of time.

32. (Page 3.1.24, middle) There is a reference to a nonexistent section 3.1.1.3.

33. (Page 3.1.24, seventh paragraph) It is not necessarily true that the primary geological barrier to waste migration will be the repository host rock. Intrusions by man or overriding natural processes and events may throw the primary dependence onto other geological formations.

34. (Page 3.1.25, bottom half) This material is of concern only in the short term.

35. (Page 3.1.26, third paragraph) This appears to be largely a list of problems, with only speculative solutions. How does DOE intend to cope with these problems?

36. (Page 3.1.27, line 19) The spelling of "instrusive" rocks should be corrected to "intrusive."

37. (Page 3.1.28, first paragraph) The measurement of the equivalence of the hazards of waste repositories and natural ore is a complex subject. Many of the hazard indices are concerned only with the amount of radioactive material and its toxicity, without consideration of routes by which the activity can reach man.

38. (Page 3.1.32) The discussion of ground water flow appears to be concerned only with maintaining a dry repository during the construction period. It is necessary to consider the ground water after the closure as a possible means of transport of the radioactivity.

39. (Page 3.1.35, fourth paragraph) There is an implication in this paragraph that the unknown problems listed will have an effect only on the cost of the repository, requiring generally greater spacing and therefore a larger, more expensive repository. The question of reduction of the effectiveness of the repository, for example by fracturing rock, is not addressed.

40. (Page 3.1.38, first paragraph) This paragraph suggests that the fission product problem terminates with the decay of strontium-90 and cesium-137. While this may be substantially true for the production of heat and for acute radiation hazard, it is not true for the significance of the waste as a health hazard. Doses from technetium-99, iodine-129, and cesium-135 are not negligible over a long time frame. This problem is repeated in the last sentence of the next paragraph.

41. (Page 3.1.38, fifth and sixth paragraphs) In the early phases, actinide elements, particularly plutonium-238 and plutonium-241, are significant. Tritium may also be significant. In the long time frame cesium-135 and carbon-14 might also be significant.

42. (Page 3.1.40, licensing) Does the waste package design refer to the container alone, the container plus waste form, or the entire system? It does not seem that the waste container and form problems are more difficult from a licensing standpoint than the other barriers.

43. (Page 3.1.40, physical protection) This part makes sense if it refers to physical protection during the operational phase of the repository. The first paragraph on page 3.1.41 is self-contradictory. It states that the waste would be essentially unavailable after placement in the geological repository. Because the operational controls will cease to exist long before any appreciable decay of plutonium-239, the protection must be inherent in the inaccessibility of the waste in the repository and the massive effort that would be required to remove it.

44. (Page 3.1.41, third bullet) Comparison of acceptable consequences from radiation in comparison with those from automobile accidents is invalid. There are two primary aspects to the establishment of bases:

1. How much will society accept on an absolute basis;
2. How much better than this can the technology provide?

45. (Page 3.1.41, last bullet) The use of adsorption coefficients from one set of Hanford subsoils, measured under laboratory conditions, is not an adequate basis for scoping the effect of adsorption. There are some substantial differences between the adsorption coefficients of the Hanford Subsoil and of those given on page K-20 of the Waste Isolation Pilot Plant EIS (DOE/EIS-0026-D), for example.

46. (Page 3.1.47 - 5th paragraph, last sentence) Isotopic age province boundaries should be added to the list of areas to be avoided in the preliminary selection of repository areas.

47. (Page 3.1.48, near bottom) The first statement under ground water implies that a repository can be sited in conjunction with a useful ground water source without affecting its quality. Since EPA analysis has shown that ground water can be significantly contaminated by a single drilling event, it is important that the repository should not be situated where it can affect a useful ground water resource.

48. (Page 3.1.49) The chemical nature of any aquifers around a repository should be briefly discussed. Reducing aquifers greatly limit the solubility of U, Pu, Np, and Tc. Sorption of these elements would provide a further reduction in the amount of nuclides reaching people, and sorption of the reduced states of these elements is higher than sorption of the oxidized states. This oxidation-reduction consideration should be briefly discussed.

49. (Page 3.1.49, third paragraph) "Flow rates and velocities of ground water that are insignificant over a 50 year period will have to be considered in terms of hundreds to thousands of years." This statement should be further discussed.

50. (Page 3.1.52, item four) It seems unreasonable to limit the search for an optimal site to areas with "availability of title". Surely this is an area where eminent domain is appropriate.

51. (Page 3.1.52, last sentence) There is an unwarranted belief that all problems can be solved by major efforts. Investigations into a basic research area, such as this appears to be, do not necessarily have satisfactory outcomes. The research must first be performed before opinions as to its results are valid.

52. (Page 3.1.54, item two) The chemically separated high-level waste to be considered must include the iodine-129 (and the other volatiles and transuranics) which are excluded from discharge to the atmosphere from the fuel reprocessing plant by EPA's Uranium Fuel Cycle regulations (40 CFR 190.10(b)).

53. (Page 3.1.54, item three, last sentence) Unless the actinides from chemically separated high-level waste are recycled, they must be disposed of as waste and would still require consideration in this Environmental Impact Statement. Even if one assumes recycling of uranium and plutonium, one eventually reaches the point where recycling is not economically feasible and the transuranics must then be disposed as waste.

54. (Page 3.1.55, second paragraph) The leach rates of spent fuel in room temperature deionized water are irrelevant. The leach rates of spent fuel in typical ground waters at temperatures to be expected in spent fuel repositories are more important.

55. (Page 3.1.59, second paragraph) The canister could prevent ground water intrusion for a period provided that there was no disruptive event which would destroy the canister. Such disruption would be expected in gas, oil, or mineral exploration. It therefore seems that it would be impossible to maintain canister integrity from credible accidents for a significant time period.

56. (Page 3.1.59, third paragraph) Reliance on the canister alone for long-term containment seems unwarranted, as indicated in the previous comment. This does not mean that canisters which would be durable in the absence of an intrusive event or traumatic geological events should not be developed.

57. (Page 3.1.62, first paragraph) The likelihood that oxygen will be introduced into the repository when it is constructed and therefore be available to the ground water should be considered in evaluating canisters. The mobility of some nuclides is also increased by the presence of oxygen. The possibilities that the copper would be a resource which would attract human intrusion should also be considered.

58. (Page 3.1.62, fourth paragraph) The misspelling of alumina should be corrected.

59. (Page 3.1.62, Section 3.1.3.3) This section appears to assume long-term institutional functioning. Expectation that institutions will continue over thousands of years (or even that they will maintain their control over hundreds of years) is not well-founded.

60. (Page 3.1.64, first paragraph) The first century after closure of the repository would be critical for "hands on" corrective action only if the monitoring program established some deficiency in the repository. Although the radioactivity of the repository has been reduced substantially after 700 years, the threat is by no means negligible.

61. (Page 3.1.64, second bullet) What evidence is there that technical information can be maintained for a very long time? What constitutes "a very long time"?

62. (Page 3.1.64, fourth paragraph) The definition of risk as "the sum product of the magnitude of losses and the probability that the losses will occur" is questionable. There is a tendency for aversion of high consequence accidents, which would imply a valuation other than a strict p-c product.

63. (Page 3.1.64, seventh paragraph) This whole paragraph is very questionable. Hazard indices are not based on estimates of societal risks compared to other societal risks, in general. There is also the question of whether the hazard of the waste after several hundred years of decay, considering nuclides and pathways, is less than the hazard of the ores.

64. (Page 3.1.64, last paragraph) Consequence analysis for any release is the estimation of the effect of that release. It is not restricted to postulated worst cases.

65. (Page 3.1.65, fourth paragraph) The total quantity of radioactivity in curies is irrelevant. The nature of the radionuclides and their pathways to man are significant.

66. (Page 3.1.67, first paragraph) Are these probabilities best estimate probabilities, upper bound probabilities, or what?

67. (Page 3.1.67, second paragraph) Is ^{229}Ra a misprint for ^{226}Ra?

68. (Page 3.167, third paragraph) Since the long-term behavior of the parameters is uncertain, risk assessment should be based on upper estimate predictions as well as on "reasonable" predictions.

69. (Page 3.1.71, seventh paragraph) Sorption of radionuclides is controlled by the site-specific geology. It seems unlikely that radionuclide behavior data from one site can be applied to another site.

70. (Page 3.1.100, first paragraph) The destruction caused by a meteorite striking one of our large metropolitan areas is irrelevant to this consideration. We have no control over where a meteorite will fall; therefore, one place is as good as another, and the possiblity of a meteorite strike does not become a consideration in the location of cities. The probability that a meteorite will disperse materials from a deep geological repository is controllable in that the probability of a meteorite large enough to cause disruption is a function of depth and can be reduced as much as desired by going deep enough.

71. (Page 3.1.100, sixth paragraph) The regional population for the types of releases considered most likely in the long term in waste disposal is the population in a river basin rather than the population within an eighty kilometer radius of the plant.

72. (Page 3.1.101, second paragraph) Why is bone an organ of principal interest? According to the BEIR work, more health effects would be expected from a dose to red marrow than from the same dose to bone. It is also probable that the liver should be considered a significant organ.

73. (Page 3.1.105, first paragraph) The Arthur D. Little work for EPA found that spent fuel heat loadings should be about the same for granite and salt. This seems reasonable considering that the salt has a higher conductivity than the hard rocks and is surrounded by shale which is not a good conductor. We would like to correct this discrepancy between the DOE and A.D. Little heat loading models.

74. (Page 3.1.106, third paragraph) There is no discussion of the air content of the repository following backfilling. The mobility of several significant radioelements, plutonium, neptunium, uranium, and technetium, are affected significantly by their oxidation state. (In some schemes for the in situ solution mining of uranium, air is used as the source of O_2 and is the oxidizing agent of the uranium.) The air content should be briefly discussed.

75. (Page 3.1.111, last paragraph) There should be some consideration of the possible interaction of the various wastes with each other. If the transuranic waste contains organic material, these may contain chelating materials, which could have an effect of mobilizing other waste.

76. (Page 3.1.129) Social service demands (Table 3.1.21) were derived by applying factors "to the project in-migration values" (Table 3.1.19). Therefore, the level of forecasted social service demands by individual site should be proportional to the estimated level of project in-migrants for each site. From Table 3.1.19, under the maximum impact condition the respective estimates for the number of project in-migrants for 1985 indicate the lowest value for the Midwest site (5800), followed by the Southeast site (8600) and the Southwest site (15,000). However, in Table 3.1.21, also under the maximum impact condition, some of the social services--physicians and dentists, and hospital and nursing care beds--indicate values for 1985 which reverse the relative position of the Midwest and Southeast sites. This apparent error occurs in similar tables throughout the DEIS.

77. (Page 3.1.129) The following statement appears to be incorrect in light of the information presented in the accompanying tables:

"Although the numbers of in-migrants are smaller, the potential for impacts in the Southeast maximum impact condition is quite similar to the potential in the Southwest site under maximum conditions. This is the case because the base population in the Southeast is roughly twice that in the Southwest site; therefore the Southeast is capable of absorbing greater population influx, other things being equal."

It appears that the words "Southeast" and "Southwest" should be reversed, since if the number of in-migrants for site A is half the number of site B, and the number of in-migrants stated as a percent of each site's base population is the same for each site, then the base population of site B must be twice the base population of site A. Site B would be more capable of absorbing population influx.

The identical statement is repeated in other portions of the DEIS (p. 3.1.180 and p. 3.1.194) in referring to other estimates of the numbers of in-migrants associated with different types of waste management facilities.

78. (Page 3.1.137, last paragraph) The ground water releases did not appear to include the "two aquifer case," which is most significant for ground water releases. This case involves a hydrologic connection between two aquifers through a repository, with subsequent ground water transport. The analysis also appears to consider only release of the total radionuclide content, which does not appear to be a credible or useful form of analysis.

79. (Page 3.1.138, second paragraph) The presence of salt would probably not preclude the use of the water as a source of food or recreation. The salt would be diluted to acceptable levels by any reasonable amount of water far more quickly than the radioactivity.

80. (Page 3.1.139, third paragraph) What are the bases for assuming that 10 percent of the particulates suspended are of respirable size?

81. (Page 3.1.140) How is the uranium-238 depleted by so much over a period of one thousand years?

82. (Page 3.1.147, fourth paragraph) A meteorite of the described size would undoubtedly produce a local disaster area. The impact of the meteorite, however, would also disperse radioactive materials into the atmosphere from which they would impact over an extended area. It is the additional impact of this radioactive material that is significant. It is not likely that the impact would be local or that it could be controlled by local monitoring.

83. (Page 3.1.148, fourth paragraph) This scenario does not appear to be a particularly bad case because of the limitation of the contact for one year. Such a limitation, together with slow leaching, results in a minimal release of radionuclides. What is the effect of continued erosion?

84. (Page 3.1.149, table) A leach rate of 10^{-4} g/cm^2/day, applied to a one centimeter cube of density 2, would result in a leaching rate of 3×10^{-4} per day, or approximately 0.1 per year. Is this the value that was used in the analysis?

85. (Page 3.1.150, fifth paragraph) Doses to a maximum individual are not the best measure of the impact of this accident. Total population

dose and integrated population dose are more significant. It might be noted that the emergency dose limits of 100 rem and 25 rem apply implicitly to the case where only one or a few people are exposed.

86. (Page 3.1.155, last paragraph) This is an improper combination of probabilities. If the probabilities are multiplied together, as has been done here, the result is the probabilty of all three conditions occurring in the same year. If the probabilities are taken over 10,000 years, for example, the probability of a fault intersecting the repository is 4×10^{-7}. The probabilities of failure of waste containment, or of aquifer intersection, over this period are likely to be one, each. The total probability is therefore about 4×10^{-7}, not 4×10^{-15}.

87. (Page 3.1.157, table) Dose commitments of 10^8 person-rem are estimated to result in 2×10^4 fatal cancers. The risk associated (including the probability) is much less.

88. (Page 3.1.161, second paragraph) The conclusion drawn from the comparison with the ore body would be improved if some analysis were provided.

89. (Page 3.1.162, last paragraph) Distribution of the waste would lower the maximum and regional individual doses, but would increase the probability of the event by a factor equal to the number of repositories.

90. (Page 3.1.163, second paragraph) It is not proper to assume doses to the regional population from a ratio basis with total body dose.

91. (Page 3.1.164, second paragraph) Diverting the entering stream until it is diluted by another stream does not change the population dose. It merely means smaller doses to more people.

92. (Page 3.1.165, third paragraph) The overall probability of a contaminated drilling event can exceed 0.005, since there is a chance of more than one drilling event over a period of time.

93. (Page 3.1.191, table) The quantity of krypton-85 released to the air should be related to gigawatts of electicity produced for comparison with uranium fuel cycle standards.

94. (Page 3.1.119) There is an inconsistency in the unit cost of spent fuel storage stated in Table 3.1.82 and the text (2nd paragraph)

on p. 3.1.119. In Table 3.1.82, the cost for the cooling of spent fuel is based on 75 percent of the spent fuel being stored in reactor basins at \$30/kg. On p. 3.1.229, it is reported that 75 percent of spent fuel storage requirements are provided by power plant basins at an average cost of \$6/kg HM-yr, which would amount to \$36/kg for six years. Recalculating the spent fuel storage cost based on the assumption stated on p. 3.1.229, the cost of six-year cooling of spent fuel in Table 3.1.82 should therefore be \$44/kg instead of \$39/kg.

95. (Page 3.1.229, bottom) There is a brief discussion on the effects of using present worth costs as opposed to undiscounted costs. It should be mentioned that the relative ranking of the fuel cycle alternatives by their total costs is significantly different according to which set of costs is used. As indicated by Tables 3.1.89 and 3.1.90, the U & Pu Recycle under the Deferred Fuel Cycle Decision has the highest total cost, about 50 percent higher than the least expensive case, on the basis of undiscounted costs, while this same case possesses the lowest total cost of any alternative when discounted (at a 7 percent rate) costs are used.

96. (Page 3.1.242, third paragraph) The study of rock-waste interactions should include the geochemistry. Mobility of a number of radionuclides is strongly affected by the geochemistry (particularly the oxidation-reduction potential of the repository and ground water) and by the potential presence of complexing agents. These should be included in the proposed research program.

97. (Page 3.2, Section 3.2) This entire section appears to be largely speculative. The comment as to the speculative nature of the discussion applies to Sections 3.2, 3.3, 3.4, and, in fact, all the rest of Chapter 3.

98. (Page 3.2.2, 3rd paragraph, line 11) The word pegmatite should be replaced by migmatite. The reference (Leonardos, 1974) specifically states that "pegmatite contribution to monazite deposits are trivial" (p. 1126). On 1127, Leonardos states "migmatites have supplied the material for the bands within the quartzite". Thus, migmatite is the term required to support the reference.

99. (Page 3.2.3, second paragraph) This paragraph does not consider the effect of radiation damage in the glass. This should be mentioned.

100. (Page 3.3.13, seventh paragraph) The possibility that oxygen introduced with the waste will change the reducing conditions should be considered.

101. (Page 3.6.1) The first paragraph of this section should state that at present it is illegal to put high-level wastes in, on, or under the seabed and that legislative action would be required before implementation.

The fourth paragraph states that a ship will monitor the emplaced wastes for an "appropriate length of time." How long (or short) is this "appropriate length of time?"

102. (Page 3.6.2) In mid gyre there is little benefit from deposition of sediments since this process is very slow there. The document states that less than .01 percent of the ocean floor would be used for disposal. What total area does this represent?

The last bullet under "Advantages" suggests that an advantage to seabed disposal is the lack of need to resolve Federal-State relations problems. This is not so because problems would surely arise from port use and the loading and transportation of waste to the port.

103. (Page 3.6.5, Table 3.6.1) The biological productivity of seamounts should be included in the table.

104. (Section 3.6.2.3, Page 3.6.5) There should be a mention that the philosophy behind this approach is isolation of the waste. This approach is required by EPA regulations.

105. (Page 3.6.7) Why would one expect low nuclide concentrations around a waste canister? If the canister failed, one would expect high levels.

106. (Page 3.6.7) Under "Water Column," there is a statement that bottom currents are slow and uniform. However, in Section 1.3.6 the DEIS says bottom currents are weak and variable. This inconsistency should be corrected.

107. (Page 3.6.7) Under "Basement Rocks," the fractured nature of the basalts could provide lenses for the transport of radionuclides. This should be mentioned.

108. (Page 3.6.8) Under current EPA regulations the canister must act as a barrier until the material decays to innocuous levels. The conservative calculational assumption, that the canister will release its entire inventory of wastes, does not reflect this regulatory requirement.

109. (Page 3.6.10, Section 3.6.2.8) Seabed disposal refers to a disposition of wastes and as such falls within EPA regulatory authority for the disposal of radioactive waste in, on, or beneath the ocean floor. The seabed disposal option for HLW is not legal under current domestic law. However, we think DOE should continue to study this option to see if this is an environmentally acceptable option.

Additionally, in Section 3.6.3.6, on page 3.6.22, the DEIS states, "implementation of a sub-seabed disposal program for non-HLW is now possible under EPA's ocean disposal permit program." DOE apparently believes ocean dumping and sub-seabed emplacement are intrinsically different for high-level waste and identical for low-level waste. We believe there is no legal difference between ocean dumping and sub-seabed emplacement and any difference between the two is purely semantic.

110. (Page 3.6.14) Bottom sediments in the mid-plate areas have extensive animal tracks. Furthermore, fish in these areas make extensive vertical and lateral migrations; this indicates that there is a possible pathway from the waste to people.

111. (Pages 3.6.22 and 3.6.23, Section 3.6.3.6) See comments for page 3.6.10, Section 3.6.2.8. Sub-seabed emplacement must comply with EPA regulations promulgated under authority given exclusively to EPA under Public Law 92-532, the Marine Protection, Research and Sanctuaries Act of 1972.

The fourth paragraph of this section perpetuates the notion that sub-seabed emplacement is not ocean dumping. We consider the difference between the two to be semantic.

Should high-level waste be released, it most certainly will affect other nations, contrary to the suggestions in the fifth paragraph.

112. (Page 3.6.24, Section 3.6.4.5) Port accidents occurred in the 60's during the loading of 55 gallon drums. This issue should be presented.

Is it proposed that several canisters go into one hole in the seabed, or will each penetrometer drop wherever it may, to be followed by monitoring of 9000 different holes per year?

113. (Page 3.6.25) Several ports have banned the shipment or receipt of spent fuel. Does the proposal include use of dedicated port facilities?

114. (Page 3.6.26) What is the range of error in the results of the "unverified, theoretical model" in projecting impact?

115. (Page 3.6.30, first paragraph) Is the $15 million mentioned for R&D costs? If not, what costs does that figure represent?

116. (Page 3.6.31) Again we find the semantic difference between ocean dumping and sub-seabed emplacement. "Dumping" and "Dump" should not be in quotation marks. It is defined in the Marine Protection, Research, and Sanctuaries Act of 1972 as a disposition of materials. This misleading section should be corrected in the Final EIS.

117. (Page 3.6.32, third paragraph) The sixth option should be clarified. Considering the dollar input, what is the intent and what will be the output?

118. (Section 3.6) Somewhere in this section several other matters should be briefly considered:

How deep would the projectiles be sent? What distance beneath the sediment surface, and how far from the rock beneath? What about the concept of recovery, if unforeseen dangers are found to exist?

119. (Page 4.12) Figure 4.4.1 had been omitted. It should be included or the reference to it should be removed.

120. (Appendix C) This appendix is grossly unsatisfactory. It concentrates heavily on doses to individuals and does not appear to recognize that more recent standards, although they may be expressed in terms of dose to the maximum individual, have population dose as part of their basis. Among such regulations are:

1. Limitations on releases of effluents from power reactors (Appendix I to 10 CFR 50);

2. The uranium fuel cycle standards (40 CFR 190); and

3. The drinking water standard (40 CFR 141).

The limitations on releases of krypton-85, iodine-129, and transuranic elements, in 40 CFR 190, are explicitly based on population dose.

The general thrust of this appendix is that population dose is not a concept suitable for radiation standards. This is incorrect because the concept of ALARA usually involves balancing the cost against the reduction in population dose. It is perhaps significant that this appendix does not include any of the BEIR reports but limits itself to the 1969 BEAR reports of the National Academy of Sciences. For currency, the appendix should consider additional references, e.g., references 1, 2, 10, and 16 from Appendix E, to bring the appendix up to 1977 at least.

121. (Page C.2, 1st and 2nd paragraphs) The paragraphs ending the section on "Background" and initiating "As Low As Reasonably Achievable Application" reflect some bias and a lack of candor in describing the use of risk coefficients in radiation protection. Almost all government agencies, particularly the EPA but including the NRC and the MSHA, have used or are using risk coefficients to estimate impact of radiation exposure. The ICRP (reference 11) has gone entirely to a risk based radiation protection system, using estimates of risk in optimizing radiation protection. ICRP has stated, "These risk factors are intended to be realistic estimates of the effects of irradiation at low annual dose-equivalents (up to the Commission's recommended dose-equivalent limits)" (ICRP publication No. 28, 1978). The NCRP (reference 15) seems to stand alone in its position discounting the use of linear, nonthreshold risk coefficients in radiation protection.

122. (Page C.3, Table C.1) While the table is titled "Comparison Chart of Radiation Standards," it then lists "Standards or Criteria" and references ICRP and NCRP values or reports. ICRP and NCRP reports are recommendations or suggestions which may or may not be adapted or modified and adopted by national regulatory agencies. The references to ICRP and NCRP should be deleted from the table.

It should be noted, however, that there are ICRP reports pertinent to health effects. ICRP publication 26 (reference 11) and publication 27 ("Problems Involved in Developing an Index of Harm," 1977), both provide recommendations on "acceptable" numerical risk estimates for radiation workers.

123. (Appendix D) While the calculational models employed may be adequate, in light of the uncertainties inherent in the input data, they are not state-of-the-art, as claimed. For example, the calculation of the 5 cm gamma dose as the total body dose for air immersion could be improved by the use of an existing code which specifically yields organ doses. Again, while the DACRIN code used employs the TGLD model, it does not explicitly treat the daughter products formed after inhalation as do more complete codes.

124. (Page D.8) - The model used to estimate the population dose commitment from carbon-14 is too conservative (i.e., overestimates the impact). If dilution by the Suess effect is not considered and the total number of health effects is integrated over all time, the release of 1.4 MCi (from Table 3.1.68) would result in about 5×10^6 deaths, assuming a stable world population of 6.4×10^9 people. It might be more realistic to make a comparison to the natural production of carbon-14 and associated health risk.

125. (Page E.1, last paragraph) The bias in selection of references is obvious. While the last sentence quotes the NCRP and its dislike of linear nonthreshold risk and its use in radiation protection, to maintain balance the ICRP's use of risk factors as realistic estimates (see comment on Appendix C, page C.2) for radiation protection and their use in ICRP publications 26 and 27 should also be documented. EPA's policy statement, 41 F.R. 28409 (1976), should also be noted.

126. (Page E.3, first paragraph) In the discussion of BEIR risk estimates, emphasis is put properly on the range of uncertainty. However, it should be mentioned that the BEIR Committee did report (reference 1, p. 168), "With this limitation in mind, the Committee considers the most likely value to be approximately 3,000-4,000 cancer deaths (or a 1 percent increase in the spontaneous rate)" (emphasis added).

127. (Page E.3, second paragraph) The paragraph considers only EPA's Uranium Fuel Cycle documents and states that the risk estimates there continue to be used by EPA. In reality EPA risk estimates have continued to change as new data becomes available. In addition to papers published by staff (e.g., Ellett, Nelson, and Mills, "Allowed Health Risk for Plutonium and Americium Standards as Compared with Standards for Penetrating Radiation," pp. 587-601 in Transuranium Nuclides in the Environment, IAEA, Vienna, 1976), various EPA reports (e.g., A Computer Code for Cohort Analysis of Increased Risks of Death, EPA 520/4-78-012, 1978, or Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment, EPA 520/4-77-016, 1976, etc.) show updated risk estimates and how they were derived.

128. (Pages E.3 and E.5, discussion of the Reactor Safety Study, WASH-1400.) EPA's dissatisfaction with the health effects estimates in the Reactor Safety Study (RSS) is documented in reference 53. Recent

literature has done nothing to dispel our belief that the use of a dose rate reduction factor is ill advised as is the minimal plateau duration (30 years) used in the RSS.

The UNSCEAR 1977 Report suggests (except for leukemia) a 50-year expression period unless the period has been shown to be shorter or longer for a specific cancer (reference 2, par. 12, page 363).

In particular, the two major human cancers associated with radiation, lung and breast, are considered to elevate risk for the duration of lifespan following exposure (Land, C.E. and Norman, J.E., "The Latent Periods of Radiogenic Cancers Occurring Among Japanese A-Bomb Survivors," Late Biological Effects of Ionizing Radiation, 1, IAEA, Vienna, pp. 29-47, 1978; Archer, V.E., Radford, E.P., and Axelson, O., "Radon Daughter Cancer in Man: Factors in Exposure-response Relationships," Health Physics Society Annual Meeting, June 1978).

The dose reduction factor in the RSS report appears to be derived from an analysis by Mays, et al. considering ten sets of animal data from nine studies. If an additional two studies (that happen to show a reverse effect) are included in the analysis, the dose reduction factor becomes 1.7 ± 4.5 instead of the 0.22 ± 0.20 reported by Mays, et al. As UNSCEAR 1977 points out, most of the existing animal carcinogenesis data comes from observations at doses above 50 rads and that each tumor-model system has peculiarities which prevent generalizations across multiple organ systems and cancers. See reference 53 of this appendix for comments on the dose reduction factor in the RSS.

As has been pointed out by Crump, et al. (Crump, K.S., Hoel, D.G., Langley, C.H., and Peto R., "Fundamental Carcinogenic Processes and Their Implications for Low Dose Risk Assessment," Cancer Res., 36, pp. 2973-2979, 1976): "It is likely that the error in the acceptable dose associated with a simple linear extrapolation will be much less than that associated with species to species extrapolation to man from the laboratory animal data. The BEIR Report (ref. 16) recommended linear extrapolation on pragmatic grounds. The theoretical conclusions of the present paper are that linear extrapolation to low dose levels is generally valid as a realistic yet slightly conservative procedure" (emphasis added). That carcinogenesis by an external agent acts additively with any ongoing process is accepted by Crump, et al. and by Hilberg (Hilberg, A.W., "Low-Level Ionizing Radiation: A Perspective with Suggested Control Agency Options," in 10th Annual National Conference on Radiation Control, HEW Publication (FDA) 79-8054, pp. 386-391, 1979) in his allusion: "And, conversely because man is living in an environment of chemical additives and pollutants, these may set the stage for action of a very small amount of radiation exposure."

Most of the argument on the RSS report centered on low dose rate, low LET radiation. Alpha radiation dose response curves are usually characterized as both linear and dose rate independent (BEIR, 1972; UNSCEAR, 1977) or as possibly providing underestimated effects at low doses (Martin Brown, J., "Linearity vs. Non Linearity of Dose Response for Radiation Carcinogenesis," Health Physics, 31, pp.231-245, 1976; Archer, V.E., Radford, E.P., and Axelson, O.; "Radon Daughter Cancer in Man: Factors in Exposure-Response Relationships," Health Physics Society Annual Meeting, June 1978). No reports except the RSS report consider a threshold curve a viable concept.

129. (Page E.4, Table E.1) A column in Table E.1, headed "Environmental Protection Agency," purports to be the risk estimates used by EPA. They are actually averages for various risk models used by EPA in reports and therefore are not directly comparable to the other risk estimates in the table.

The estimates of 54 leukemia deaths/10^6 person-rem listed in the table were extracted from EPA 520/9-73-003-B (reference 4). As stated in that report (p. A-14), the risk conversion factors are average values for absolute and relative risks in the BEIR Report, 1972. Moreover, they apply only to the dosimetric models used in EPA report 520/9-73-003-B.

The EPA risk for thyroid listed in Table E.1, 15 thyroid cancer deaths/10^6 person-rem, is referenced to EPA 520/4-76-017 (reference 6). That risk estimate cannot be found the cited reference. However, on p. 96, ibid., it states "...., a population age weighted value of 60 thyroid cancers per million rems to the thyroid was used." A similar risk estimate is shown in Tables 45 and 46 of EPA report 520/9-73-003-C, Environmental Analysis of the Uranium Fuel Cycle. Part II - Nuclear Power Reactors, 1973. Note that these thyroid risk estimates refer to cases, not fatalities, and so do not fit into Table E.1.

130. (Page E.7, last paragraph and page E.8, Table E.3) Newcombe's estimate of ten genetic effects based on a normal incidence rate of 0.1 percent for autosomal dominant disorders has not been supported by other studies. Current incidence estimates are about 1 percent autosomal dominant and X-linked disorders, the estimate in UNSCEAR, 1977.

The genetic effects estimates attributed to the BEIR report and EPA in Table E.3 are not comparable to those given in the 1977 UNSCEAR report since they assume a 30-year reproductive generation time. To compare the BEIR and EPA estimates with those of UNSCEAR, the BEIR and EPA estimates should be multiplied by a factor of about 0.6 to adjust for a 30-year population generation vs. the current, approximately 50-year population generation. More recent EPA estimates have been adjusted for the current population generation (EPA 520/1-76-010), to yield 200 genetic effects, close to the UNSCEAR 1977 estimate.

131. (Page E.9, Table E.4) The column titled "Mays(19)" may contain an error. Mays, et al. (reference 19) estimated 200 bone cancer deaths/10^6 person-rads. Using a Q of 10, this would be equivalent to 20 bone cancer deaths/10^6 person-rem. In a contemporary paper (Mays, C.W., Estimated Risk from ^{239}Pu to Human Bone, Liver and Lung, pp. 373-384 in Biological and Environmental Effects of Low-Level Radiation, Vol. II, IAEA, Vienna, 1976), Mays estimated (again assuming a Q of 10) 20 lung cancer deaths, 20 bone cancer deaths and 10 liver cancer deaths per 10^6 person-rem.

EPA in its guidance on transuranium elements (EPA 520/4-77-016) provided an analysis of the health impact of exposure to transuranium elements in the environment which includes both risk and dose-rate estimates for a cohort of 100,000 exposed since birth. This guidance is supplemented by technical reports, Technical Report EPA 520/4-78-010 and Technical Note CSD-78-1, which provide background information for the basic guidance document. Since the health impact calculated in these reports is based on lifetime exposure and risk coefficients for specific organs, the results are not directly comparable with Table E.4 but they are a more realistic estimate of health impact from transuranium elements in the environment.

132. (Page E.10, paragraph 6) Although BEIR, 1972 did not provide a risk estimate for skin cancer, the 1978 Stockholm meeting of ICRP suggested if a skin cancer risk is required, an estimate of 1 fatal cancer per 10^6 person rem could be used. Averaging the risk estimates in UNSCEAR, 1977, the skin cancer incidence is around 0.5 cases per year per 10^6 person-rem; with a 5 percent mortality this would be about 2 fatal skin cancers per 10^6 person-rem. The 1977 UNSCEAR Report suggests alpha risk might be higher.

133.(Appendix F) The description of the geology at the bottom of page F.2 would be improved if there were some indication of the depth of the basement rocks and of the general nature of the overlying rocks.

If the maximum flood of record was 3 meters above the normal river stage, and the one in a thousand year flood would be expected to be 5 meters above normal river stage, under what conditions would the "maximum probable flood" which is 10 meters above normal river stage be expected? Is this a once in a million year flood?

There is a short paragraph on ground water, but nothing as to the nature of the aquifer--permeability, hydraulic gradients, or retardation factors. This should be included.

134. (Appendix H) This appendix could well be omitted. Many of the hazard indices quoted are of no value as indices, and there is no information to enable one to select which, if any, of the indices are useful.

Although purporting to be a basis for determining the "hazard index," the material as presented in the appendix does not even approximate the potential hazard. The MPC is derived on the basis of dose to a "critical organ" rather than on the risk related to a given intake of isotope. The cumulative risk from intake of isotopes should be used as the basis for deriving a comparative "hazard index" since organ sensitivities are the controlling factor as noted in ICRP 26.

135. (Appendix I) This appendix is deficient. It is based on leaching of the entire repository by ground water, passage of the nuclides through a rather freely flowing aquifer, and discharge into a large surface stream (10,000 cubic feet per second or 8.9×10^{12} liters per year). If we apply the generic density of population in terms of river flow from our forthcoming dose assessment report, which is 3.3×10^{-7} person years per liter, the river is capable of being a water supply for about 3 million people, a great many of whom would receive close to the maximum individual dose.

There is an apparent conflict between the basic assumptions in the main text and Appendix I. The main text stated that "...disposal in salt has been emphasized..." (Page 3.1). However, the assumptions made in Appendix I (Page I-9) for an earlier analysis (which was the basis of the current version of the impact statement) assumed that the repository is in a non-salt media. Furthermore, some of the details of the model should be briefly summarized in the appendix. The statement, "Detailed descriptions of these models are found in references 1-7" (Page I.4), is not sufficient. There should be a brief description of GETOUT (Page I.10), as well.

The consequence analysis as it bears on geological repositories appears to be too subjective. For example, the draft continually relies on a holdup period of about 1,000 years. Yet an independent study (EPA/520/4-78-004) by an Ad Hoc Panel of Earth Scientists concludes that "The containment cannot be relied upon to effect any significant (longer than 10 years) retardation of the release of the high-level waste." While it is obvious that finite numbers must be used as input for the programs employed in this appendix, the large variation possible in much of the input data suggests that incorporation of an uncertainty analysis and sensitivity analysis in such calculations would permit a clearer understanding of possible consequences.

The criterion for public acceptability of 120 millirems per year to the maximum individual is not defensible, and population dose needs primary consideration. If the approximately 3 million people who could be supported by the river were each to receive 120 millirems per year, the population dose would be 350,000 person-rems per year or approximately 70 health effects per year using the BEIR-I whole body estimate. Although all the postulated 3 million people would not receive the maximum individual dose and although these nuclides would not produce whole body doses, there is no reason to believe that the concentration of nuclides in the river would decrease substantially as the nuclides moved down river.

The analysis uses unquoted sorption equilibrium constants. These are probably the Battelle desert soil values which may be unreasonably high. The text on page I.6 refers to "5 miles of western U.S. subsoil," which is reminiscent of the Battelle "desert soil." These sorption constants are not necessarily typical of all soils and rocks and, in any case, should be listed in tabular form.

Just as it is improper to neglect population dose in the river, it is improper to neglect individual dose to users of ground water. This is completely omitted in this section. Since the ground water velocity is stated to be equal to one foot per day, or a little over 100 meters per year, the aquifer would be expected to be a good water provider and

comparable to the aquifer of Appendix F which is stated as supporting "numerous shallow wells supplying residences and farms" and also a "public water supply well" for A City. Population dose from use of the aquifer may very well be significant in addition to individual doses.

The discussion of compensating for a poor site by an extremely durable waste container in the last paragraph of page I.2 is irrelevant, since human intrusion cannot be ruled out.

The concentration on individual dose rather than population dose is again shown in the fourth paragraph on page I.3 which speaks of reducing the iodine-129 dose by a factor of 10 by reducing the release rate by a factor of 10. Population dose would not be changed.

136. (Figure I.2) Why are there zero's on a logarithmic plot?

137. (Page I.7) The leach rate figures used throughout and specifically in Figure I.3 are unrealistically low. The "hypothetical waste management system characterization" is about a factor of ten better than the values we have been given by our consultant, Arthur D. Little, Inc., and contrast strongly with the estimate of the EPA geologist panel: "There is no evidence that incorporation into a glass will ensure resistence to significant leaching over time scales over a decade." (page 7, EPA 520/4-78-004).

138. Figure I.4 appears to require a leach time of 100,000 years for "satisfactory" (less than 120 millirems per year) operation. This may not be possible for all contained nuclides, since some nuclides are geochemically mobile.

139. (Page I.10) The notion that the dose from Ra-226 can be reduced by limiting the leaching of U-238 is incorrect. It is doubtful that U-238 migration could be controlled over its half-life (4.5 billion years).

We believe that the impact analysis is in a premature stage in this section. The analyses stated in Appendix I are divided into two categories: past work and present work. Since the present work is only partially complete, the results presented in the DEIS may be revised when the present work is completed. This may change results in the stated conclusions in the DEIS. We believe the present work should include an error analysis and sensitivity analysis.

All the references to this appendix are from Battelle Pacific Northwest Laboratories work. Has any of this work been performed elsewhere?

140. (Appendix J) Figure J.1 should be explained. Its applicability is unclear.

141. (Appendix L) The statement that devitrified glass is stronger than ordinary glass and will resist further fracturing is not as important as the potential greater leaching from devitrified glass.

In this Appendix, and in Appendix M, there appears to be no consideration of any accidental releases other than sabotage.

142. (Appendix M) The accidents leading to releases of radionuclides (Tables M.3 and M.8) are not characterized, so it is impossible to understand what is involved. The basis for release of 0.1 percent of total krypton-85 (page M.52) is not given. The total releases of 22 Megacuries of krypton-85 should be compared with the permissible 40 CFR 190 values. There is no consideration of possible radionuclide releases from accidents in a spent fuel storage facility in Table M.52. There is some discussion in Table M.61 but there is no basis for judgment as to the releases or selection of accidents. For example, there is no discussion of the effect of loss of coolant in water basin storage through failure of the tank or through sabotage.

Note also that the risk estimates, pp. M.6, M.33, M.53, M.81, M.87, etc., will require revision if numerical risk coefficients are changed since all are derived from the risk coefficients developed in Appendix E.

143. (Appendix N) Estimated costs are given for transportation of spent fuel and waste, but there is no indication as to how these costs were found. The bases for these estimates should be presented or referenced in the Final EIS.

144. (Page N.13) "Doses to the maximum individual...and population dose are comparable." This statement does not make sense, since there is a 10,000 times difference between the maximum individual dose and population dose in Table N.12. This should be clarified in the Final EIS.

145.(Appendix O) The 1,000 year storage and surveillance assumptions used in the calculations are in conflict with proposed Criteria for Radioactive Wastes (43 F.R. 53262 et seq., November 15, 1978) developed by EPA. The appendix should be revised using the proposed period of storage and surveillance of no more than 100 years.

146. (Appendix P) Ringwood and co-workers have identified a suite of minerals for use in waste disposal. Their work should be referenced and seriously considered.

147. (Appendix Q) This is a rather interesting appendix although the development of the field does not appear to be sufficiently advanced for any convincing environmental impact analysis. There seems to be a contradiction between Tables Q.4 and Q.5. In Table Q.4 a 1 meter barrier is reported to retain strontium-90 and cesium-137 for about 30 years, or about one-half life for these nuclides. In Table Q.5 a 1 meter barrier is said to retain them for 30 half lives.

The possible competition for ion exchange sites on added minerals (or natural minerals for that matter) should be noted. Canister materials are elements of the transition series, notably iron, nickel, chromium, or titanium. In Sweden, lead and copper have been suggested for canisters. The ion exchange capacity of any added materials must be enough to handle the nonradioelements as well as the radioelements.

148. (Appendix R) This is an interesting discussion but the state of development of the technology does not permit more than qualitative information.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER 79/397

NOV 1 4 1979

Honorable Ruth Clusen
Assistant Secretary for Environment
Department of Energy
Washington, D.C. 20545

Dear Ms. Clusen:

Thank you for your letter of April 19, 1979, transmitting copies of the Department of Energy's draft environmental impact statement for the Management of Commercially Generated Radioactive Waste. Our comments are presented according to the format of the statement, or by subject.

General

From a NEPA and FLPMA viewpoint, we believe the draft statement will have to be substantially revised and supplemented in order for this Department to make use of it in support of any future land withdrawal decisions we may wish to make. Thus, our specific concerns are discussed in each of the sections below with a view that the final statement will take into account our concerns, especially those concerns under FLPMA. We will be pleased to work with you in the revision of the final statement to the extent that we have the capability to do so.

We believe the principal conclusion in the draft statement, that our technology is much further advanced in conventional geological disposal than in any other viable option, is stated as a premise to justify the cursory, qualitative treatment given all the other options relative to geologic disposal. The attention given to the other nine options has not ensured a genuine comparison of advantages and disadvantages. The statement implies that it is not really valid to compare conventional geologic disposal with the other options at this time because inadequate knowledge is available on the other options. Nevertheless, the statement proceeds to make these comparisons.

We recognize that a trade-off takes place between the degree of detail in analyses and the comprehensiveness of the documentation. Sometimes less detail is necessary to gain understanding. In this statement, the latter course might have proved useful. The constant use of technical jargon seriously weakens the analysis regardless of its scientific merits. This is especially true with regard to the discussion of potential design failures related to the transport of nuclear waste across the country to a repository.

One important issue, the possibility of deliberate reopening of a radioactive waste disposal site, should be presented in the final statement. Such sites should be secure and guarded over the long-term to prevent future release of radioactivity.

Relationship to the IRG Report

The President has recognized the immediate and long-term problems of nuclear waste management. In March 1978 he established a Federal Interagency Review Group (IRG) for nuclear waste management. The task force released its recommendations in a draft report in March 1979. This report also contained IRG's responses to the extensive public comment on the subject.

The IRG's summary statement appears to be more candid than this EIS. On page 42 of the final report (TID-29442) the IRG stated:

> "Present scientific and technological knowledge is adequate to identify potential repository sites for further investigation. No scientific or technical reason is known that would prevent identifying a site that is suitable for a repository provided that the systems view is utilized rigorously to evaluate the suitability of sites and designs, and in minimizing the influence of future human activities. A suitable site is one at which a repository would meet predetermined criteria and which would provide a high degree of assurance that radioactive waste can be successfully isolated from the biosphere for periods of thousands of years. For periods beyond a few thousand years, our capability to assess the performance of the repository diminishes and the degree of assurance is therefore reduced. The feasibility of safely disposing of high-level waste in mined repositories can only be assessed on the basis of specific investigations at and determinations of suitability of particular sites. Information obtained at each successive step of site selection and repository development will permit reevaluation of risks, uncertainties, and

> the ability of the site and repository to meet regulatory standards. Such reevaluations would lead either to abandonment of the site or a decision to proceed to the next step. Reliance on conservative engineering practices and multiple independent barriers can reduce some risks and compensate for some uncertainties. However, even at the time of decommissioning, some uncertainty about repository performance will still exist. Thus, in addition to technical evaluation, a societal judgment that considers the level of risk and the associated uncertainty will be necessary." (Emphasis added)

A discussion of these issues should be included in section 3.1.6, Research and Development Needs, in the final statement.

Technological Issues

The statement is an impressive encyclopedic compilation of information on radwaste generation and disposal. It presents the state-of-the-art for high-level and transuranic waste-disposal technology and is markedly superior to earlier documents. The major conclusion that disposal of radwastes in mined repositories is, for the near-term, the preferred approach is in keeping with conclusions reached by the Interagency Review Group (TID-29442).

However, the statement appears biased in its technological optimism. Unlike the IRG's measured optimism regarding the feasibility of geologic disposal of radwaste, this document leaves the reader with the impression that all existing uncertainties are solvable, given time and money. While we agree that radwaste can, with rigorous application of the systems approach, and with generated implementation procedures, be safely isolated from the biosphere for a few thousand years, this report implies that such an outcome will be the normal result of existing and as-yet-to-be-developed technology. The final statement should recognize that:

a) Radwaste disposal is a new technology which, like all preceding technologies, will develop over the course of decades in response to experiences which in all likelihood could include some failures;

b) Successful design of systems in the geotechnical fields differs markedly from that in other engineering fields, as succinctly stated recently by C. H. Dowding: "The process of exploring to characterize or define small-scale properties

of substrata at construction sites is unique to geotechnical engineering. In other engineering disciplines, material properties are specified during design, or before construction or manufacture, and then controlled to meet the specification. Unfortunately, subsurface properties cannot be specified; they must be deduced through exploration" (1979, Site characterization and exploration: Amer. Soc. Civil Engr., p. 1). Similarly, prediction of the synergistic effects of geologic, hydrologic, and geochemical processes on a radwaste repository over millenia is not a straightforward modeling process. As much has been admitted by H. C. Burkholder whose pioneering modeling studies form the basis for the EIS's optimistic conclusions that repositories pose no significant risk to man. (See closing statement in Burkholder, H.E., et al., 1977, Safety assessment and geosphere transport methodology for geologic isolation of nuclear waste materials, in Risk analysis and geologic modeling in relation to disposal of radioactive wastes into geological formations: Proc. of workshop organized jointly by OECD Nuclear Energy Agency and the Commission of European Communities, Ispra, Italy, p. 216-229);

c) Catastrophic failures have recently occurred even in well-advanced technologies, for example, Apollo 6, Apollo 13, the collision of two 747's on Tenerife Island (Canary Islands), Teton Dam, and the DC-10 pylon issue.

Site Selection

Of the 10 alternative methods described in the EIS for disposal of nuclear wastes, the first one--geologic disposal using conventional mining techniques--appears to have the most potential for impacting lands administered by our Bureau of Land Management (BLM) in Oregon and Washington. The Columbia River basalt geologic formation, which covers substantial portions of northeastern Oregon and southwestern Washington, is one of the formations given prime considerations for disposal sites under this alternative. Substantial acreage of BLM-administered public lands are located on this basaltic formation. Because this programmatic statement is completely non-site-specific, we wish to draw your attention to potential impacts on public lands should nuclear waste facilities be located there. The final statement should respond to the following information even though it is not possible to identify site-specific conflicts at this time.

An important criterion for suitable geologic host formations is that they have not been extensively drilled, mined, or altered by the hand of man. This is also a prime characteristic for existing and potential wilderness areas. BLM is reviewing public lands for potential wilderness values under Section 603 of the Federal Land Policy and Management Act of 1976 (43 U.S.C. 1782), and Section 2(c) of the Wilderness Act of 1964 (16 U.S.C. 1131). BLM's wilderness review process must be taken into consideration in any discussion of the environmental impacts associated with alternative geologic formations considered for nuclear waste disposal sites.

Our Bureau's greatest concern is that the site selection, characterization, and evaluation process will involve many potential locations on public lands with subsequent application for withdrawals for future sites which might affect the wilderness selection process. These issues must be addressed in order to comply with FLPMA. The final statement should recognize that a potential conflict with the designation of wilderness areas may occur for specific sites on public lands. In addition, we strongly urge that you include sufficient detailed information in the final statement that would outline those requirements of FLPMA that pertain to withdrawal of public lands for a waste disposal site. This inclusion is necessary because hundreds of miles of public right-of-way in the West are bounded on either side by vast tracts of public land. Any release of nuclear waste could impact public lands and programs.

To enable Bureau of Land Management to meet NEPA requirements, the discussion should indicate that public lands throughout the West have uses which could be in conflict with a nuclear waste disposal facility, and the degree of impacts to public lands and resources would vary from site to site, and from region to region. The most significant impact would be on the long-term productivity of the affected environment as all uses not directly supporting the nuclear waste disposal facility would be eliminated from the thousands of acres necessary to secure the site. These above and below ground uses include, at a minimum: water resources, range land use for livestock, wildlife, and wild horses and burros; forestry; recreation, and cultural resources; wilderness and areas of critical environmental concern; oil and gas exploration, and extraction; nonenergy minerals, etc. In addition, since BLM's capabilities for multiple-use management of the public lands are prescribed by law, we recommend the trade-offs between storage of nuclear waste and existing uses of public lands be given more attention in the final statement.

The final statement should address the requirements for withdrawals of public lands for any alternative involving storage of nuclear waste in geologic formations, or the Outer Continental Shelf. Environmental hazards or conflicts of Outer Continental Shelf storage, with regard to Outer Continental Shelf oil and gas exploration and production, need to be addressed. The issue of irreversible loss of resources at any site should also be included as the result of preemption of an area for geologic disposal of radioactive wastes. In particular, salt domes may contain oil, gas, sulfur, potash, or other commercial minerals. Exploratory drilling of the proposed site would be the most desirable means for obtaining the subsurface data necessary for determining the location and extent of possible economic mineral deposits. However, we recognize that any such drilling program would adversely affect the geologic integrity of the site, and evaluation of its mineral potential must, therefore, be based on other sources of information that may be available.

Lastly, the draft statement tends to avoid discussion or use of site-selection, evaluation, and qualification criteria, apparently because NRC has not issued formal criteria yet. However, there are general published criteria available (such as those of the National Academy of Science and the U.S. Environmental Protection Agency) which might cover the generally agreed-upon major issues. Criteria could be used to more effectively present the advantages, disadvantages, and unresolved technical, sociological, political, and esthetic issues involved with the various disposal options.

Land Use and Transportation Considerations

The final statement should delineate willingness to minimize environmental impacts which may be precipitated by the proposed action on the Nation's cultural, natural and recreation resources. Therefore, the final statement should address statutory environmental requirements, e.g., the National Historic Preservation Act, as amended; Section 6(f) for the Land and Water Conservation Act, as amended; provisions of the Instrument of Transfer for surplus property; and Executive Order 11593, which further the Federal Government's policy to preserve, restore and maintain the historic and cultural environment. The final GEIS should include clear, coherent identification and analysis of the environmental impacts which may be reasonably expected to disturb or affect the Nation's cultural and natural and recreation resources. This Department's Heritage Conservation and Recreation Service would be pleased to provide technical assistance in this subject area upon request.

The final statement should stress that the interim storage, permanent storage, and transport of commercial radioactive wastes will be carried out in a manner that has no potential for adversely affecting units of the National Park System, the Wild and Scenic River System, and the National Trail System. Further, as trustee for Indian trust lands, we require that Indian communities (1) be fully aware of the permanent hazards and potential dangers the placement of such materials will have upon them, (2) the effect upon their future generations, and (3) their full support and agreement for emplacing the radiological materials. At present we favor the exclusion of such activities from areas which could affect Indian trust lands.

The final GEIS should indicate that such areas would be specifically precluded at the program level from consideration as potential disposal sites, and would be bypassed in all transportation operations.

Ecosystems

Above-ground industrial-type facilities could occupy lands used for production of forage for various animal species. This would be a relatively small area and, depending on the specific site, would probably have minimum impacts on the total vegetation and soil resource. However, there might be significant impacts in the surrounding buffer zone of 10,000 to 20,000 acres.

Since significant and varied impacts on ecosystems are potentially associated with the management of commercially generated radioactive waste, the final statement should at least identify what these potential impacts are rather than indicating in section 4.5.8 on page 4.22 that there is not sufficient information to allow impact evaluation. Such an addition would ensure the fullest possible disclosure of impacts and, thus, strengthen the final statement.

Appendix S describes the Ecosystem Impact criterion for assessment of the impacts of alternatives. The discussion is limited, however, to pre-emption of ecologically productive land and does not relate to the short- or long-term effects on the soils, plants, or animals occupying the potential sites, nor of adjacent off-site lands. The criterion should be expanded to consider the radiological effects on plants and animals in addition to humans.

Modeling of Groundwater Migration

We believe the comprehensive model used in the safety analysis is not applicable on a generic basis. The modeling efforts of H.C. Burkholder and his colleagues at Battelle are pioneering and commendable. However, in Appendix I the assumptions used in the model analysis are clearly spelled out on page I.9. Among these assumptions are: a) that "the repository is located in a non-salt formation surrounded by a geology with nuclide retention properties similar to those for a particular Hanford Reservation subsoil;" and b) "the ground water flows into a surface stream with a flow rate of 10,000 ft^3/sec (1/10 the flow rate of the Columbia River near the Hanford Reservation) where the nuclides are further diluted." This flow is equivalent to the average flow of the Delaware River at Trenton. With these and other simplifying assumptions, the model predicts a benign outcome. However, the problems are multiple.

First, although dilution of the radionuclide-bearing ground water by a 10,000 ft^3/sec river is one plausible scenario for radwaste dissolved in Hanford ground waters, a 10,000-fold concentration might occur in other environments, for example, in areas where ground water flow is toward marshes or wet playas. Second, what is the dose to man if the ground water were tapped by a future town well-field upgradient from discharge into the river? Third, the Kd's for Hanford subsoil are unlikely to be applicable to fractured media.

Briefly, the model is acceptable for one HLW scenario in Hanford alluvium. It is unacceptable for other scenarios at Hanford, and certainly unacceptable for any other rocks and waste types. It follows that the seemingly comprehensive tables comparing health effects from radwaste disposal in salt, granite, shale, and basalt are difficult to justify. The draft EIS itself in several places follows the IRG in emphasizing the importance of site-specific studies. Therefore, we suggest the presentation of considerable numerical data in Section 3.1.5.2 is not warranted; this should be resolved in the final statement.

Ground-water transport

If a systems approach is to be used in siting and engineering mined repositories, we believe the consequence analysis should consist of a systematic consideration of failure of each element in the system. It has been stated many times (e.g., IRG Subgroup, 1978, TID-288/8, app. A, p. 16) that transport by moving ground water is the most likely means by which toxic radionuclides may reach the biosphere. The multiple barrier approach is designed to avert this eventuality. Yet, the consequence analysis in the EIS treats this possibility in less depth than four other "worst case" scenarios--meteorite impact, diversion of a surface or underground river into the repository, drilling, and solution mining

of salt. Emphasis on these unlikely release mechanisms seems unbalanced and could cause undue apprehension as to the risks involved. Ground-water transport is treated at greater length in appendix I but this material clearly should be up front. Even appendix I does not analyze for variation of key parameters such as retardation, porosity, and permeability.

There are additional reasons for laying more stress on release by moving ground water in the main part of the statement. Although this is a generic statement and values for hydrologic parameters are site-specific, the possible ranges of these parameters are relatively well known. A credible consequence analysis would, therefore, show the effects of varying porosity, permeability, hydraulic head, path length, retardation, release rate, etc., over reasonable ranges. For environments in granite, basalt, and shale relatively rapid flow through fractures should be included in the analysis. One of the key parameters to be considered is retardation. The present analysis uses values for the Hanford subsoil--highly site-specific and uncertain, inasmuch as values determined by various laboratories continue to differ by significant amounts. An analysis that shows the effects of a range of retardation values is therefore especially critical.

Another reason for stressing variation in hydrologic parameters in the consequence analysis is that, while the ranges of these are known, the probabilities of initiating events (with the exception of meteorite impact) are much more uncertain. It will be argued below that the probability used for faulting is unsupported; and the probabilities assigned to human activities sometime in the distant future are generally conceded to be meaningless (IRG Subgroup, 1978, TID-28818, app. A, p. 50, 52). The most likely result of human intrusion (aside from serious effects to a few individuals) is release to ground water, again emphasizing the need for analysis for all barriers to nuclide migration.

There is a danger that, like the consequence analysis performed by EPA in its standard-setting procedure, the attempt to be "conservative" will lead to acceptance of repository site characteristics that violate the multiple barrier approach. The ground-water transport analysis in the main body of the statement uses a path length of only 10 km, apparently in an attempt to show that consequences would not be drastic. The interagency effort to find acceptable sites now going forward will certainly not consider sites with such a short path. The analysis should use a longer flow path for the base cases and discuss consequences of shortening of the path due to tectonic and/or climatic change.

The release rates used in the ground-water transport analysis in the main body of the report jump strangely from 100%/yr to 0.1%yr. The base case should clearly be for the low rates, but results for intermediate release rates should be presented. The consequence analysis should consider solubility limits of the various radionuclides in the ground-water system under consideration; the present analysis assumes varying source terms for nuclide transport, some of which may not be physically possible.

Long-term surface storage

Long-term (30-60 year) surface storage of radwaste should be considered in the final statement as a means of decreasing uncertainties of geologic disposal. The final statement should discuss the utilization of extended (30-60 year) surface storage of HLW prior to disposal as a means of reducing major rock mechanics uncertainties created by the heat pulse. Such storage would reduce the heat pulse by one-half to three-quarters. The omission of this alternative is surprising in light of the extended discussion in section 3.2 of chemical synthesis which, similarly, is a way to reduce geochemical uncertainty in geologic disposal. We recommend the final statement consider long-term surface storage as a viable alternative.

Multiple barriers

The multiple barrier concept and the systems approach to mined repositories, elaborated in the IRG reports, do not occupy the central role envisioned by the IRG in this EIS. Words that include these concepts appear in the statement, but they are obviously last-minute additions and include major errors in places. For example, on page 3.1.1, "multiple barriers" are listed as one of six characteristics of conventional geologic disposal when, in fact, three of the other five characteristics are themselves important barriers to nuclide transport. Apparently, what is meant by multiple barriers here is only the hydrologic systems beyond the host rock. However, the desired properties of the hydrologic system are not necessarily the same as those of the disposal medium. Indeed, since predictability of the system is important, it might be advantageous to have part of the hydrologic flow system include a porous medium in which transport is relatively well understood as opposed to a relatively impervious medium subject to flow-through fractures, which is much less well understood.

Clearly, the draft EIS has not given sufficient thought to the total system of containment, but considers its components separately.

Radiological safety

The draft statement employs a consequence analysis; events with the worst possible outcomes are postulated and the subsequent radiological health effects described. These effects are considerable for some events, but the discussion tempers this outcome by introducing the concept of risk. Serious consequences, it is argued, have a low probability of occurring so the net risk (probability x consequence) is judged to be qualitatively small.

It should be noted that the risk need not be zero and will not be zero for any waste-management option or energy system. Also, it is not necessary, for the purposes of this statement, that a complete risk analysis be presented--only that enough be understood about the risk to justify continuing with the option. This GEIS can be considered adequate when viewed in this light. It makes clear that the earth has a potentially high retentive capacity and that properly sited and engineered repositories should lead to a relatively low risk. Whether this risk will be acceptable (i.e., judged safe) is for society to decide.

Faulting

The value of 4×10^{-11}/yr for the probability of faulting or fracturing (Claiborne, H.D., and Gera, F., 1974, Potential containment failure mechanisms and their consequences at a radioactive waste repository in bedded salt in New Mexico: Oak Ridge National Laboratory, ORNL-TM-4639) used in risk considerations is outdated and its uncritical acceptance is a major shortcoming of the draft EIS. This is not to say that the values for faulting or fracturing probabilities ultimately used for a site-specific risk assessment will not be some low number such as this, but these probabilities will have to be determined on a sound basis. Research to do this should be identified in the section on research and development needs.

Claiborne and Gera (1974) assumed that faulting would be random within a given region and that the rate of fault initiation for the Delaware Basin could be approximated by assuming a constant rate over post-Permian time. Both assumptions are highly unlikely in the light of recent tectonic thinking. It is now realized that most tectonic strain is taken up on existing faults as long as the tectonic regime remains the same. When the tectonic regime changes, existing faults will continue to take up much of the strain; but new faults may form depending on the new stress state and its relation to existing discontinuities. The new faults probably form over a relatively short time as the new tectonic regime is established.

Reasonable bounds for these rates can be formulated with data now in hand from the geologic record, but a research effort to do so should be put in place.

The discussion in the EIS uses the probabilities for faulting and fracturing interchangeably, but they will not necessarily be the same. Clairborne and Gera (1974) treated the problem of major fault development across the repository. Fracturing could be induced by distant seismic events or by the presence of the repository itself. Whether fractures can remain open in salt long enough for transport to take place remains an open question that needs emphasis in the EIS.

Values for southeast New Mexico should not be used in a generic statement. Certainly, faulting rates of 10^{2}/yr, typical of the San Andreas system, could be avoided. A reasonable, "conservative" upper bound for this analysis might be 10^{-4}/yr. The discussion on page 3.1.156 would then conclude that the risk from repository breach by faulting and flooding would be no greater than the risk from lightning, assuming the rest of the analysis is correct--not definitely seven orders of magnitude less.

Another possible effect of geologic storage of radioactive wastes is the increase in underground pressure as a result of entrapment of gases (helium, radon, etc.) released through radioactive decay schemes. This increased pressure, if not properly relieved, could lead to the development or reopening of fissures that would result in the escape of radioactive materials to the surface. The final statement should address this potential event.

Decision grid

The use of the decision grid approach may be premature and unjustified at this stage. It invites invalid, quantitative comparisons of options to be made. Even though the report warns against this, there will always be those readers who tend to seize the numbers and use them improperly. Other concerns with the decision grid approach are also expressed in the attachment.

Other options

Other options such as seabed disposal and deep-well disposal also have to be considered promising for the future and should be pursued simultaneously with conventional geologic disposal. If properly pursued, one of the other options may eventually prove to be superior to conventional mined repositories, in which case it should be adopted. This need for continued pursuit of other technologies should be more heavily stressed in the final statement.

We hope these comments will be helpful to you in the preparation of a final statement.

Sincerely,

James Rothenberg

Special Assistant to
Assistant SECRETARY

Attachment

SPECIFIC COMMENTS

The title of the report appears somewhat inappropriate because low-level wastes and mill tailings, which are major components of commercially generated wastes, are not addressed. Therefore, this title should specify "high-level and transuranic radioactive wastes" instead of its more general connotation.

Page iii, line 5: Change "reasonable" to "greatest" or "high."

Page 1.1, par. 3: It certainly has not been established that mined geologic repositories are the best option--only that they may be an acceptable option for the first phase of disposal. Therefore, (2) does not follow from (1). Proposal (2) implies that work on promising options other than conventional mined repositories will be dropped. Perhaps insertion of the word "first" before "...operative disposal technology" will help.

Page 1.12. Second sentence under Media Properties. This sentence is not correct because rock falls account for a large number of injuries and facilities in the mines.

Page 1.27 (2nd paragraph). If there is sufficient heat to modify the red clay of the ocean floor, there may be sufficient heat to initiate convection currents in the overlying water. If sufficiently large in areal extent, this would cause an upwelling, bringing to the surface material from the lower depths of the ocean and possibly from the ocean floor. This material could be nutrients, inert material, or if a canister ruptured on impact, radioactive material.

Page 1.33. Fuel cycle compatibility is left out of the table.

Page 1.3.7. Leaving the waste in a solar orbit or disposing of it on the moon still leaves the waste available for future exposure to man. Would not direct injection into the sun be preferable?

Page 1.5, par. 1, line 10: This paragraph implies that foreign spent-fuel or reactor wastes are not currently being sent to this country. We are under the impression that some foreign spent fuel is coming into the country now. Is this true?

Page 1.5, par. 3, line 1: Insert "should" after "systems."

Page 1.5, par. 4, line 7: A type of canister should depend primarily on disposal medium, waste form, and buffer-backfill conditions. Suggest striking "and exposure" and substituting "waste form and other..." The word "Absorptive" should be "Adsorptive."

Page 1.5, par. 4, line 10: Change "absorptive" to "adsorptive." "(V)ery deep hard rock formations" is not a specific medium and should be deleted.

Page 1.6, par. 1: It appears that too much emphasis is being put on institutional controls. Although works of many ancient civilizations are evident today, many others have been obliterated and lost. There is still much speculation on the purpose of many Inca and Mayan structures, not to mention Stonehenge. We have still failed to locate many dwellings, cities, and other work known to have been in existence somewhere. It is also clear that many ancient works have been the object of vandalism, destruction, probing and plundering (i.e., Great Pyramids). It is not reasonable to expect repository markers to remain evident for millenia. In that time period, they could easily become stolen, destroyed, or covered by sedimentation or other works of man.

Page 1.6, par. 2: This conclusion has not yet been established by evidence in the report and is out of place.

Page 3.1.7. Next to the last sentence. This sentence implies that the only difficulty with temperature is fracturing the overlying rock. Whether the overlying rock could be fractured in this manner would depend on the depth of burial, as well as rock properties, and it might be expected as a second order effect of shallow repository site. The first order effect of temperature would be the spalling and other failures of the cavity skin.

Page 3.1.10. In the last paragraph it is indicated that igneous rocks closely related to granite might not be suitable because of trace element and mineralogic composition. However, the "Sierra Nevada granites" are shown in figure 3.1.2. These are predominantly quartz monzonites and would this eliminate them from consideration?

Page 3.1.13. Third paragraph. In discussing basalts and jointing, they have left out the fact that basalts are layered with discontinuities, volcanic ash, "soil," sandstones, etc., between the layers. The zone between layers ranges in permeability from opened to sealed.

Pages 3.1.1 to 3.1.8. The geothermal temperature gradient has been left out of the discussion on geologic siting considerations. At 500 meters depth, it would probably not be important. However, at depths greater than 1,000 meters, the natural rock temperatures will be high enough to consider in the heat flow analyses. Also, the rock temperature comes into any calculations that are made for ventilation requirements during construction and operation of the facility.

Page 3.1.28. Fifth paragraph, last sentence, is not correct. More people are injured and killed from falling rocks in coal and noncoal mines than are injured by rock bursts. The shale environment that is considered as one of the potential repository sites will have problems of ground support similar to those in coal mines.

Page 3.1.30. Third paragraph, first sentence. Timber is more common than steel for use in sets with lagging. This sentence should be changed to read ". . . . to (timber or steel sets with lagging)."

Third paragraph, second sentence. This sentence is not completely correct. It should be modified to read ". . . .drilled into the rock and either mechanically anchored or grouted to the rock."

Third paragraph, fourth line. The sentence starting on this line should read: "Steel wire mesh, metal sheets, or beams are. . . ."

Third paragraph, seventh line. The sentence starting on this line should read "Timber or steel sets are structural. . . ."

Page 3.1.30. Footnote. Comment on shale strength. Most shales are layered and their properties perpendicular to the layering are much different from those parallel to the layers. Hence, any number on shale properties should reference its orientation.

Page 3.1.31. Second paragraph, fourth line. The statement "(sometimes called rock bursting)" should be removed because it propagates confusion on the true meaning of rock burst. It is not necessary to the sense of the sentence which will read, with its removal, "Slabbing during construction can sometimes be sudden and hazardous."

Page 3.1.35. Last paragraph. The resins used with resin grouted bolts are polyester, not epoxy.

Page 3.1.36. Paragraph on seismic loads. Third line in that paragraph. Remove the word "explosions" relative to rock burst, and let the sentence read ". . . . seismicity (earthquakes), rock bursts, and other phenomena."

Page 3.1.123. Fourth paragraph. Nonradiological Accidents. A common fatal/nonfatal accident rate was used for surface construction activities which seems reasonable. However, a common rate was also used for the underground construction. This rate was derived from underground mining other than coal. To be closer to the truth in this area, the accident rates for more representative industries should be used. For the salt repository, the accident statistics from salt mining and potash mining should be used. For granite and basalt, underground metal and nonmetal hardrock mining is more appropriate, and for shale, use the coal mine accident statistics.

Page 3.1.137. Line 7. This line contains the first mention of phosphates. What is the tie-in with salt repositories that might be constructed?

Page 3.1.147. Second line from bottom, typo on sentence starting "Such scenarios. . . ."

Page 3.1.178. Fifth line from the bottom, typographical error on involves.

Page 4.27. Third dot item. Has ISF been defined prior to this use? The ISF, intermediate scale facility, is defined on page 4.34.

Page 5.8. First paragraph, last line. ". . . 3) use of nuclear parts as a safeguard measure. Should parts be parks?

ISF is not listed in the glossary.

Page 1.6, par. 3, sentence 2: It should be pointed out that we know little of the actual geochemical and hydrologic conditions prevailing during the Oklo nuclear reactions, making it difficult to relate those phenomena to any present environments; nor do we know much of the history of conditions which prevailed in the millenia after the reactions were sustained.

Page 1.12, par. 4: There is too much emphasis on the 600 m depth here and in other places in the report. That is an apparently arbitrary depth. The actual optimum depth is dependent not only on rock type but geohydrologic conditions and other site and waste characteristics.

Page 1.12, par. 5: The four media mentioned are not "representative of all geologic media." They are only examples of the types being considered for repositories; suggest rewording to that effect.

Page 1.13, par. 3, last sentence: Not all of shale's properties are "intermediate"--perhaps only its thermo-mechanical and hydraulic properties. Its adsorptive properties are probably superior to the other three media and its hydraulic properties could be comparable or superior in some cases.

Page 1.13, par. 4, line 10: Not only hydraulic gradients should be measured in situ but other hydraulic and geochemical parameters such as permeability, porosity, and sorptive properties.

Page 1.13, last par.: This is a gross understatement of the current deficiencies in the data base. Specific gaps in rock-property knowledge should be itemized. The interaction between waste and host rock is a major area of deficiency and thus should not be passed off matter-of-factly. Other major unresolved issues should be mentioned: shaft and borehole sealing technology; development of adequate nondestructive in situ geophysical techniques; demonstrations of adequate large-scale, in situ measurements of solute transport phenomena (characterizations of sorption and other reactions and dispersion coefficients, especially for far-field analyses); quantitative methods to analyze and model ground-water flow and solute transport in fractured rocks; development of adequate method to measure hydraulic properties of very-low-permeability rocks and fractured rocks; ability to predict geologic and climatic processes.

Page 1.14, par. 1, last sentence: This is an overstatement; suggest striking "assure" and substituting "will be used to provide high assurance."

Page 1.14, par. 2: The data base for granite is rapidly approaching that for salt, thanks to the recent work in Sweden, Canada, U.K., and U.S. We know considerably more about granite than basalt or shale.

This paragraph again understates the deficiency in the geologic data base. It stresses media deficiencies and fails to mention inadequate technology

in nondestructive, in situ testing and other problems mentioned in our comments for the previous page. The problems of predictive geology are not adequately expressed in the final sentence of the paragraph. There are at least as many deficiencies in the geologic data base as in "Waste Form;" yet "Waste Form" is allotted five times as much space as "Geology."

Page 1.14, par. 4, lines 7-9: These two sentences indicate an attempt to dismiss a real problem. Presumably, water will eventually enter any mined repository, except perhaps one above a deep water table in an arid western basin. Leachability is still an unresolved issue.

Page 1.15, par. 3: The proposed Swedish canister is not "highly" sophisticated; it is a simple copper can with lead fill. The engineered sorption barriers are not part of the canister but part of the backfill buffer around the canisters. In the last sentence it is not clear what "redox materials" are.

Page 1.16, par. 2, line 11: Many toxic organics will degrade biologically or chemically with time; we therefore suggest inserting "might" before "remain."

Page 1.16, table 1.3: This table could be misleading, in the sense of comparing apples to oranges. Chlorine gas, for instance, will rapidly deteriorate in most environments because of its high reactivity. Phosgene and amonia are also non-persistent. Most of these substances can easily be treated to render them relatively harmless.

Page 1.17, par. 1: The difference between a "major disaster" and a "primary event" is not clear.

Page 1.17, par. 2, lines 6-7: We disagree; uncertainty of geologic predictions <u>does</u> limit the application of risk assessment. If the probability of a certain geologic event occuring is not known, how can a reliable risk assessment be calculated to include the potential impact of such an event?

Page 1.18, par. 5: It would seem that different disposal options and media would involve different canister and buffer materials. This might have a major impact on certain materials such as stainless steel, copper, and bentonite.

Page 1.21, par. 3: The basis for calculating the frequency of stream invasion of a repository is not clear. Appropriate references should be cited.

Page 1.22, par. 1: It is not "unreasonably pessimistic" to assume that such markers would be stolen, moved, maliciously destroyed, covered by natural sedimentation, or other works of man.

Page 1.23, par. 2: The material used for the canister might also be valuable enough in the future to attract invasion of the repository. Copper, stainless steel, titanium, and even gold have been mentioned by some as canister material.

Page 1.23, par. 3: Institutional controls cannot be relied upon for more than several decades.

Page 1.23, last par. line 2: Why 600 m?

Page 1.23, last par. line 4: Suggest inserting "chemical" before "thermodynamic."

Page 1.23, last par. line 5-6: Nothing is absolutely chemically inert in any ground water, so it is unrealistic to suggest that the waste form might be so rendered.

Page 1.23, last par. line 8: Suggest substituting "approaching" for "in" before "thermodynamics."

Page 1.24, par. 3: The economic feasibility of the synthetic-mineral waste form must also be assessed.

Page 1.23, last par. last line: Suggest substituting "might" for "would."

Page 1.25, par. 2-3: There are major problems with this option, if the hole is lost (collapses or is otherwise rendered unuseable) during the waste emplacement or backfilling-sealing stages. We would end up with the waste in the wrong place or irretrievably placed in an unsealed hole, both of which are probably unacceptable. These potential problems should be pointed out.

Page 1.26, par. 2: Other unresolved problems or disadvantages that should be mentioned regarding island disposal are: greater probability of disruptive geologic events (faulting, earthquakes, volcanism, etc.); perhaps greater erosion rates; more subject to higher rainfall rates, tropical storms, and tsunamis.

Page 1.26, par. 7, line 2: Suggest substituting "appear to be" for "are" before "abyssal."

Page 1.26, last par.: Suggest inserting "sub-seabed" before "geologic media."

Page 1.27, par. 2, line 4: Suggest substituting "possible" for "the" before "thermal-related."

Pages 1.28 and 1.32: The discussion and assessment of the reverse well injection alternative should include at least general consideration and evaluation of the vertical separation of individual plates or sheets of injected waste-bearing grout. Consideration of the impacts of the alternative should

also include at least generalized assessment of effects of possible deviation of sheets from bedding planes and possible unplanned or unscheduled accumulation of wastes in any given zone.

Page 1.28, par. 5, last line: Suggest inserting "chemical" before "precipitation."

Page 1.28, par. 6, line 2: Suggest inserting "most probably" before "be by ground water."

Page 1.28, last par.: Although grout injection technology is rather well established, long-term durability-reliability of grout seals is unknown. It appears that considerable effort is needed to develop grout types and sealing techniques that can be relied upon with confidence for many millenia.

Page 1.29, par. 2: It should also be stated that radioactive-waste disposal of any kind is prohibited or severely restricted in several states.

Page 1.29, par. 3, line 3: Suggest substituting "isotopes" for "wastes."

Page 1.34, table 1.8: As pointed out in the "General Comments" above, we have major reservations with the use of this type of approach in this EIS. First of all, not all experts would agree that the most important criteria and attributes have been included. For instance, a category for foreign policy conflicts is included, but not one for internal political controversy or State-local conflicts. This would be significant in the case of sub-seabed disposal which suffers from a low-rating in international conflicts, but would enjoy a high rating in a category for State political controversy.

We are of the opinion that the data base for the criterion of long-term radiological safety is insufficient to make national rankings in all options and all attributes at this time. It is inconsistent to make estimates (which are subjective value judgments) for some criteria and not others, such as "Socioeconomic Impact," "Aesthetic Impact," and "Ecosystem Impact."

Perhaps it would be better for this exercise to be based on a more widely accepted, or independently generated, set of criteria such as those of the National Academy of Sciences, EPA, or IAEA.

Many of the rankings are really value judgments by the "panel of experts." In section 4.1 and appendix S, it is emphatically stated that the matrix approach was used to minimize value judgments. Yet most of the rankings in this matrix can be considered value judgments. Therefore, the table is highly subject to influence of the bias and prejudices of the "experts." According to appendix S, all 14 members of the panel of experts are associated with prime DOE contract organizations. This means they could be suspect of bias toward DOE preferences because they are undoubtedly working on some aspect of radioactive waste disposal (directly or indirectly) that

is financed by DOE. For example, there probably are people at each of those institutions working on some aspect of conventional geologic repositories. If the panel were comprised of these investigators, the results would probably be biased toward that option. The panel should be comprised of a significant number of experts outside the pro-nuclear industrial-government sector (NAS, NRC, EPA, USGS, academic institutions, environmental groups, State agencies, etc.).

The very fact that one option, which has been studied considerably, is being compared to others with much weaker data bases would tend to bias the procedure immediately. Most experts would tend to rank the better understood options higher than the lesser understood options, even if the latter has more promise.

We would disagree with several of the numerical rankings given in the table (again reflecting value judgments and bias).

Page 1.36, lines 1-2: Just because a factor is a good discriminator, does not mean it is necessarily an important one. The fact that some attributes showed little discrimination could mean they were misjudged.

Page 2.1.16 and 2.1.18: It was noted in the Department of Energy's recent draft environmental statement for the Waste Isolation Pilot Plant in Eddy County, New Mexico, that drilling into the stored spent fuel 100 years after burial could expose the geologist on the drilling crew to a whole-body dose of about 90 rems, which is 18 times the annual occupational exposure that is now considered permissible (p. 1-7 in WIPP statement). It would be useful to show graphically for comparative purposes how such exposure levels would decline over the first several hundred years and at what point they reached levels closely comparable to exposures that would result from drilling into various uranium ore deposits. Possibly such a graph would help dispel public concern for the long-term fate of buried radioactive waste. If a date can be established at which the two consequences are considered truly comparable, it would be useful to show that date on graphs and tables whenever appropriate, or alternatively to show the levels of radioactivity considered truly comparable to natural ore deposits. For example, it would be particularly useful to show such levels of radioactivity on such tables as 2.1.9 and 2.1.11. Under the uranium and plutonium recycle option it is noted that the total radioactivity of actinides and daughters actually increases slightly from 100,000 to 1 million years after waste disposal (table A.38), but if the level is below that of typical uranium ore deposits, it would appear to be of little significance.

Page 2.1.24: It would be helpful to provide a readily understandable summary of the energy values present in the uranium, plutonium, and thorium in the radioactive waste, and particularly in the spent fuel, in order to clarify what would be thrown away under the three fuel-cycle options. There are

brief references to the fact that deferred disposal or reprocessing of spent fuel would maintain "future options to recover the energy values represented by the uranium and plutonium contained in the spent fuel elements" and would "permit a more informed decision on the advisability of reprocessing the spent fuel" (par. 2). However, we found no quantification of what those energy values actually are, and we believe that in order to promote a more informed decision on those questions it would be helpful to include a clear appraisal of the amounts of potential energy that would be wasted by irretrievable disposal, possibly expressed in units comparable to barrels of oil or tons of coal. It might also be useful to show these values of potential energy obtainable under various fuel cycles including uranium recycle, uranium-plutonium recycle, various breeder fuel cycles, and thorium-based cycles.

Page 2.2.2, item (2): The formula given for allowable whole body radiation dose should be checked for possible error. It is given as 5 (N-18), N being age. For a 48-year-old, this appears to give a dose of 150 rems, suggesting that it might be a lifetime dose limit. In any case, the meaning is unclear.

Pages 2.1.1 to 3.1.46: Sections 3.1.1 and 3.1.2 in particular are redundant and contain some errors of fact, significant omissions, and numerous juxtapositions of unrelated subject matter. These chapters appear to have been put together by culling material from a variety of cources. The length of these chapters can be considerably reduced and their value increased many fold if subjected to detailed review by earth science editors.

Page 3.1.1, par. 1: Why not cite published, well accepted general geologic criteria such as those of NAS? Criterion No. 6 should indicate that a long, slow flow path is one of the barriers. Low rainfall (aridity) is an additional desirable feature.

Page 3.1.1, last par., last 2 lines: Suggest inserting "topography and rock properties" after "Climate;" substitute comma for "and" after "wind", and insert "and chemical thermodynamics" after "gravity."

Page 3.1.2, par. 1: The validity and methods of relating paleoclimatic conditions to future variations and erosion rates has not been established. This area requires more research.

Page 3.1.3, par. 2, last line: Suggest inserting "and rock properties" at the end of the sentence, because they, too, control erosion rates.

Page 3.1.3, par. 4: It should be noted that these depositional processes can obliterate repository location markers.

Page 3.1.4, par. 2: There are no completely <u>insoluble</u> radioactive compounds (or other compounds).

Page 3.1.4, par. 3: Porosity is just as important as permeability in determining rates of ground-water flow. This should be so stated.

Page 3.1.5, par. 1, last sentence: This sentence is not necessarily true; future tectonism may not be reflected in past tectonic history. This factor will probably have to be a probability-based estimate.

Page 3.1.5, par. 2: The terms "permeability" and "hydraulic conductivity" are somewhat different in meaning and should be defined. (They are not in the glossary.)

Page 3.1.5, par. 2, line 5: Suggest substituting "dissolve" for "assimilate."

Page 3.1.5, par. 3, line 2: Suggest inserting "chemical precipitation reactions" after "radioactive decay."

Page 3.1.5, par. 3, sentence 2: The term "convection" is misused here. Convection in ground-water flow means mass flow along any head gradient. <u>Thermal</u> convection would imply convection induced by temperature gradients.

Page 3.1.5, par. 3, line 4: Suggest substituting "through" for "into" after "ions."

Page 3.1.5, par. 3, last sentence: "Sorption" processes do not generally include chemical precipitation and filtration processes.

Page, 3.1.5, par. 3: We suggest that the appropriate definition of dispersion should be included with the definitions given for major mechanisms related to nuclide transport. Dispersion may be especially important in hydrogeologic environments where diffusion may be too slow to be significant in the distribution of contaminants, e.g., where fracture permeability is a factor or where relatively high hydraulic gradient and low recharge may be controlling influences.

Page 3.1.5, par. 4, line 1: Suggest inserting "quantities" after "types."

Page 3.1.5, last par. line 9: Suggest inserting ", 3) and most importantly the <u>rate</u> of flow" after "flow."

Page 3.1.6, par. 1: It should be pointed out that fractures and joints may also be important permeability features of shale.

Page 3.1.6, par. 2, lines 6-8: Core analyses are <u>not</u> satisfactory for permeability of the medium, especially if it is fractured.

Page 3.1.6, par. 2, last sentence: Field testing techniques are not yet developed to make adequate determinations for very low permeability or sparsley fractured media.

Page 3.1.6, par. 3, line 2: A difference in "hydraulic head," not pressure, is necessary to induce ground-water flow. Suggest substituting "hydraulic head (pressure plus gravitational component)" for "pressure (hydraulic gradient)" after "difference in."

Has the possible significance of a density gradient been considered among the inducements to fluid movement?

Page 3.1.6, par 3, line 7: Suggest inserting "generally" after "medium is." This entire section on Hydrology of Host Rock (p. 3.1.5-6) needs more emphasis on ground-water velocity, porosity, dispersion, and fracture-flow problems.

Page 3.1.6, par. 6, last line: It should be mentioned that fuel elements or other high Pu-content wastes might be considered a desirable resource in the future.

Page 3.1.6, par. 7, line 3: The multiple barriers should not "act together" but <u>independently</u>, so that if some fail the others compensate.

Page 3.1.6, lines 4-5: The multiple barrier components include: waste form, canister, buffer material, length of ground-water flow path (far-field), adsorption and other reactions. These should be added to the sentence.

Page 3.1.7, par. 2, line 7: Substitute comma for "and" after "strength" and insert ", chemical (sorptive)" after "thermal."

Page 3.1.7, last par., line 1: Substitute "conduct" for "dissipate" and insert "away" after "heat."

Page 3.1.8, par. 1: It should be mentioned that degree of anisotropy and heterogeneity are also important considerations.

Page 3.1.8, par. 3, line 7: Insert "and high permeability" after "porosity."

Page 3.1.9, table 3.1.1: Basalt or granite do not always or even usually have a permeability of "nil." Shale minimum permeability is much lower than 10^{-4}, perhaps 10^{-11} or 10^{-12} ft/yr. Moreover, the key hydrogeologic parameter for evaluating these rocks, as repository hosts, is transmissivity, not permeability. Yet, this parameter is omitted.

Page 3.1.9, par. 1, lines 4-7: The plasticity of salt can also be an undesirable feature if diapirism is reactivated in a salt dome or initiated in a bedded deposit.

Page 3.1.9, par. 1: The assertion is made that water incorporated in salt beds when the beds were formed does not migrate. This should be qualified by reference to effects of elevated temperatures on migration of brine. Also, in the last paragraph on this page, it should be mentioned that one of the problems with salt is that brine contained within the deposit tends to move toward heat sources, such as radioactive waste. These hot brines can be highly corrosive to some canister materials and waste forms.

Page 3.1.10, par. 1, line 2: Insert "generally" after "It is" and "principally" after "composed."

Page 3.1.10, par. 1, line 3: Insert "fairly" after "generally."

Page 3.1.10, par. 1, line 7: Substitute "very deeply rooted" for "relatively bottomless."

Pages 3.3.11-3.3.12: It appears that in the context of the duration of periods under consideration in repository planning, the discussion of rock strength needs to include at least in a general way changes in rock strength and characteristics that may occur with increasing time and their effects on permeability.

Page 3.1.11, last par.: Some mention should be made of sorption characteristics of granites. The significant recent work on granite at the Stripa Mine and other areas of Sweden, should be cited, as well as British work on granite. The Canadians have also made significant studies recently, which should be cited.

Page 3.1.12, par. 2, line 4: The sentence "Voids are ..." is inaccurate. Suggest substituting "because of the extremely fine pore size of shales, intergranular permeability is generally very low. However, fractures and joints in some shales substantially increase bulk permeability."

Page 3.1.12, par. 4: The main advantages and disadvantages of shales should be summarized in a final paragraph.

Page 3.1.13, par. 1, line 1: Insert "Columbia River" after "Generally." Many other basalt flows do not have large areal extents.

Page 3.1.13, par. 1, line 3: Delete portion of sentence after "because of" and substitute "their high permeability."

Page 3.1.13, par. 2, line 1: Insert "commonly" after "basalt is."

Page 3.1.13, par. 2, line 1: Again, the omission of mention of the transmissivity of basalt is inexcusable. The statement on the low permeability of basalt is a half-truth, misleading to a reader without hydrogeologic training.

Page 3.1.13, par. 3, end: Insert "Joints are unfavorable because of their relatively high permeability, low surface area, and potentially high ground-water flow rates."

Page 3.1.13, par. 4, item 2: The category of "general crystalline rocks" would also include basalts, which are listed separately.

Page 3.1.14, par. 2 and table: It should be stated who made the ratings, since they are value judgments. We believe the table is misleading and oversimplistic. Any of the media listed can have a wide range of properties

indicated, ranging from excellent to poor. High porosity is not necessarily undesirable because, for equal permeability, a rock with high porosity will have slower ground-water flow rates than one with low porosity. Thermal conductivity of basalt is much greater than shale; hence the numbering given is backwards. Again, no mention is made of the transmissivity of the media considered even though this parameter, unlike permeability, would permit a separation of media on a scale of 1-3 (salt would rate 3, granite 2, shale 2, and basalt 1). Other important properties were left off the table. These might include:

Plastic properties

Sorption properties

Page 3.1.16, par. 3: It is stated that "High-level radioactive wastes must be kept isolated from the biosphere for a long time period, perhaps hundreds of thousands of years," but previously it had been stated that "The HLW must be managed...to isolate the uranium, plutonium, the balance of the TRUs, amd some fission products for several millennia, and probably up to one million years" (p. 1.9, par. 2, last 4 lines). It would be desirable to state these time periods consistently and to add any necessary qualifications such as may relate to the form of the waste.

In order to avoid unwarranted public concern it is imperative to avoid any appearance of a reluctance to acknowledge the full time period that the wastes will be potentially of appreciable hazard to man. Since any inconsistency in describing the duration of the potential hazard tends to give this appearance, we feel that all references to the required duration of isolation should be completely consistent, carefully qualified (by reference to waste form, disposal method, fuel cycle option, hazard level, etc.), and should relate the radioactivity levels or potential hazards to familiar natural sources of radioactivity whenever possible (such as uranium ores, monazite sands, cosmic radiation at high altitudes, etc.). Some comparisons presented in the EIS appear to deserve more emphasis in order to dispel unwarranted concern and put the potential hazard of radioactive waste into proper perspective. For example, the total toxicity of plutonium projected to be wasted in the year 2000 is comparable to the toxicity of lead wasted in 1973, but the plutonium will gradually decay while the lead will persist indefinitely (p. 3.1.65, next-to-last par.). If the required period of isolation of the radioactive waste actually proves to be a full 1 million years, this period of time should not in itself cause great concern if the waste were either in a stable form or well isolated; concern for the 1-million-year duration might be dispelled by comparison with natural phenomena, such as the several-billion-year age of the earth, the fact that the earth's crust contains an entire group of rocks more than 2.5 billion years old, and the fact that

1 million years is the amount of time required for our spiralling galaxy to rotate through less than 2 degrees of arc (based on one rotation in approximately 200 million years).

Page 3.1.16, par. 6, line 3: Substitute "should be capable of being adequately" for "can be quite well" after "of an area."

Page 3.1.17, last par.: Who should set the criteria?

Page 3.1.18, par. 2, line 3: Whose criteria?

Page 3.1.20, par. 1, line 4: Substitute "is injected into" for "injects" after "mobile care."

Page 3.1.20, par. 1, line 14: Insert "tectonic" after "the."

Page 3.1.21, fig. 3.1.8: Stage II data base should also include regional geophysics survey (resistivity and seismic profiles, magnetics, and gravity).

Page 3.1.22, par. 1, line 6: Insert "It appears that" before "Some aspects of."

Page 3.1.22, par. 1, line 7: Substitute "might" for "can" after "million years."

Page 3.1.22, end of par.: Insert "The driving mechanisms for plate tectonics are presently not understood."

Page 3.1.23, par. 3, line 6: Substitute "low flow velocities" for "low hydraulic gradients."

Page 3.1.23, par. 4: Some mention needs to be made that considerable work is needed in the fields of measuring and modeling fracture-flow hydrology, measuring very low permeability, and other field-scale or in situ measurement of hydraulic and solute transport parameters.

Page 3.1.23, par. 6, last line: Strike "impermeable;" no rocks are impermeable.

Page 3.1.26, par. 3, line 2: The reference to "thousands of "years" should be to "probably up to a million years" or to "hundreds of thousands of years" for consistency with statements on pages 1.9 and 3.1.51.

Page 3.1.26, p24. 3, lines 10-13: The question of predicting future resource value is understated. How can we know what will be valuable 1,000 years or more from now? Who would have guessed 200 years ago that uranium or even petroleum would be a valuable resource?

Page 3.1.26-28: The section on Deficiencies in Data Base is much too general and non-specific. For example, it fails to mention lack of data on long-term

shaft and borehole sealing; large-scale sorption measurements; long-term verification of models; large-scale dispersivity measurements; and other deficiencies.

Page 3.1.27, par. 2, line 5: The large increase in volume of gypsum from anhydrite could cause detrimental stresses in a repository; this should be mentioned.

Page 3.1.28, par. 1: Because of the great public concern over hazards of radioactive waste from commercial nuclear power reactors, we believe that considerable effort would be justified toward the objective of translating levels of radioactivity of the waste into terms that are readily understandable to the public, and that facilitate a comparison with naturally radioactive materials or with natural sources of radioactivity. In the present statement, considerable effort appears to have been made in accomplishing this type of comparison in the area of routine and accidental exposures to radioactivity from artificial sources such as radioactive waste by comparison with natural sources such as the earth, the cosmos, and the human body. However, it would be helpful to make similar comparisons between the radioactivity of the disposed waste (for example, as permanently buried in a geologic repository) and the radioactivity of various typical uranium ore deposits, at various times after disposal of the waste. The brief discussion here (p. 3.1.28) is not in sufficient detail to be useful in evaluating probable consequences of drilling into buried waste canisters at various future dates by comparison with drilling into typical uranium ore deposits.

Page 3.1.29, par. 3, line 4: Insert "and hydraulic head gradient" after "mass."

Pages 3.1.29, par. 3, last 4 lines: The inflow of such high quantities of ground water would probably disqualify the site.

Page 3.1.29, last par., last line: After last sentence insert "However, there would be wide variation in these spacings from place to place."

Page 3.1.32, par. 2, line 2: Insert "per unit head gradient" after "unit time."

Page 3.1.29, par. 2, lines 6-9: It seems highly unlikely that criteria would allow a repository in an area with such high ground-water inflow.

Page 3.1.29, par. 4: At end of paragraph, insert "However, studies in Sweden, Great Britain, and Canada indicate that considerable fracturing can be found in granites at postulated repository depths."

Page 3.1.29, par. 6, lines 3-4: The questions of shaft and borehole plugging apply to all media, not just salt.

Page 3.1.35, par. 1: It should be mentioned that heat sources in salt draw water toward them.

Page 3.1.39, par. 3, line 3: Substitute minimal for "no" after "transport pathways."

Page 3.1.39, par. 3, line 4: Substitute "increase flow of" for "introduce flowing" after "changes could."

Page 3.1.39, par. 3, line 5: Insert "and through" after "ground water to." Substitute "should" for "will" after "geologic medium."

Page 3.1.41, par. 5: Interception of an aquifer would certainly violate repository criteria and would preclude the option of backfilling emplaced waste.

Page 3.1.44: Somewhere in section 3.1 a discussion should be included on the present problems and uncertainties of long-term borehole, shaft, and tunnel backfill and sealing technology. If the shafts and disturbed zones around them are not adequately sealed for the time required, they would act as a dangerous short circuit from the repository to the biosphere.

Page 3.1.47, par. 3, lines 2-3: Hydrology should also be a prime consideration in geologic site selection.

Page 3.1.47, last par: The possible value of spent fuel as a resource should also be mentioned for consideration.

Page 3.1.48, par. 1, line 5: Insert "and to provide as long a pathway to the surface as feasible" after "surface phenomena."

Page 3.1.48, last par., last sentence: This sentence is an overstatement. We do not have adequate, accepted techniques for testing fractured rocks or rocks with extremely low permeabilities or high degrees of anisotropy and heterogeneity. We are especially lacking in nondestructive field techniques (those which do not require a lot of wells directly in the repository areas).

Page 3.1.49, par. 2, sentence 1: Add transmissivity, storage coefficients, boundary conditions, and porosity to list of factors needed.

Page 3.1.49, par. 2, line 3: Substitute "available" for "one of several" after "From."

Page 3.1.49, par. 3, line 1: Substitute "very low" for "low to no" after "The areas of." Every place has some ground water.

Page 3.1.49, par. 3, lines 6-8: Laboratory methods are not satisfactory for measurement of in situ hydraulic parameters in any type of media (especially fractured). This section should be deleted.

Page 3.1.49, par. 5, line 2: Insert "even in salt or very tight clayey shale" after "the repository." Delete the following sentence.

Page 3.1.50, par. 1: Mention should be made in this paragraph that satisfactory borehold sealing techniques (for very long periods) have not yet been developed.

Page 3.1.50, par. 2, lines 3-5: This is an overstatement: these techniques are not "well in hand." Nondestructive testing techniques, for example, are not adequately developed.

Page 3.1.51, par. 5: Again, this is an oversimplified, over-confident statement, without technical basis.

Page 3.1.50, par. 7: The two sentences in this paragraph are contradictory and constitute over-simplified rationalizations.

Page 3.1.52, par. no. 3, last line: "Sorption characteristics" should be inserted after "rock units."

Page 3.1.53, par. 6, line 7: Change "silica" to "silicate."

Page 3.1.63, last par., line 4: It should be noted also that man invaded the Egyption "repositories" (pyramids) before he knew what the hieroglyphics said.

Page 3.1.64, par. 1, line 1: There are many more examples of institutional and political systems that have not survived more than a few centuries, than have survived.

Page 3.1. 64, par. 5, last line: Insert "United Kingdom" after "France."

Page 3.1.64, par. 7, line 4-5: It is stated that "after several hundred years of decay, the wastes do not exceed the natural radioactivity of the ores from which they came" (p. 3.1.64). This statement is confusing, because it gives the impression that drilling into an underground waste repository after several hundred years would have consequences no more severe than drilling into the ore deposits from which the uranium was mined. If that were strictly true, it should be more clearly explained whether, and how, the wastes differ in their potential hazard from natural uranium ores after several hundred years, and to explain in a manner clearly understandable by the public why it is considered that high-level wastes must be managed for isolation for "probably up to one million years" (p. 1.9). If the comparability with natural uranium ores after several hundred years is not strictly valid, insofar as potential hazard is concerned, it would be advisable to explain significant differences.

Page 3.1.65, Hazard Indices: This section contains several specious arguments culled from various sources. Either the arguments should be presented in detail or the whole section should be eliminated. In fact, the closing paragraph of the section on page 3.1.66 itself suggests that the preceding page is devoid of meaning.

Page 3.1.65, par. 4: See criticisms of same table on page 1.16.

Page 3.1.67, par. 2, line 4: ^{229}Ra should be ^{226}Ra.

Page 3.1.68, Lithosphere/Biosphere Transport: While the reader is correctly advised that "Some ground water and transport models have been calibrated," he is not told that modeling of flow through fractured aquifers is in its infancy.

Page 3.1.68, par. 5, second sentence: This is not true for fractured media.

Page 3.1.68, par. 5, line 8: An additional, more relevant model calibration was done by J. B. Robertson (1974, Digital modeling of radioactive and chemical waste transport in the Snake River Plain Aquifer at the National Reactor Testing Station, Idaho: U.S. Geological Survey Open-file Report (AEC-22054)).

Page 3.1.70, par. 3: The last sentence in this paragraph contradicts the first two sentences.

Page 3.1.71, Consequence Analysis: It should be pointed out that all numerical models will require more satisfactory verification on a variety of real field problems before they can confidently be applied to very long-term and large-scale predictions.

Page 3.1.76, par. 2: There is a brief reference to the issue that "We should delay implementing geologic isolation until we are more certain that the wastes have no practical value now or in the future." Nowhere in the EIS have we found any discussion of the pros and cons of that issue, or the pertinent data to support an informed decision. Because of increasing scarcity of energy sources and other natural resources, it would appear that the statement should at least briefly assess the very-long-range impacts of ultimate and irretrievable disposal of commercially generated radioactive waste on the basis of any conceivable future utility to the human environment.

A related matter, that could only be discussed in general terms prior to selection of tentative disposal sites, is the potential impact on recovery of leasable or other minerals that may be found at a disposal site.

Page 3.1.83, par. 1, lines 6-7: It is stated that "Required activities are described for four possible fuel cycles," while previously it was stated "Three fuel cycle alternatives are considered" (p. 1.7, par. 4).

Page 3.1.106, par. 3: What will the rooms, shafts, and tunnels be backfilled with? They can potentially serve as ready avenues for ground-water flow.

Page 3.1.114, par. 5: There can be potential problems from placing low-level wastes next to high-level wastes if the low-level waste has significant organic constituents or other chemical incompatibilities.

Page 3.1.123, par. 1: It does not seem credible for water inflow through shale to be ten times that through granite; granite is not necessarily less permeable than shale as table 3.3.1 (p. 3.3.7) points out.

Page 3.1.149, table 3.1.35: What is the source of the listed leach rate ($1x10^{-4}$ gm/cm^2/day) for intermediate-level and low-level wastes? What waste form(s) is (are) involved?

Page 3.1.225, par. 4: See our comments on the same subject for page 1.6 (par. 1).

Page 3.1.238, par. 5, line 4: Delete "core" after "require."

Page 3.1.238, par. 6: It should also be pointed out here that satisfactory shaft and tunnel sealing techniques have not yet been developed.

Page 3.1.239, par. 2, end: Add the sentence "However, such in situ tests have not yet been fully developed or proven."

Page 3.1.240, par. 3, last line: Insert "and sorptive properties" after "inter-crystalline fluids."

Page 3.1.241, par. 3, line 4: Insert sentence "By necessity, some foreign material such as cement or benetonite will be added to the backfill to make it more compact and less permeable" after "possible."

Page 3.1.243, par. 2: It should be pointed out here that sorption phenomena (or "Kds") are not yet well understood and characterized. Considerable fundamental and field research is needed in these areas for both near- and far-field analyses and modeling.

Page 3.1.243, par. 5, sentence 3: It is approaching late CY 1979 and the Presidential policy statement has not yet been made.

Page 3.2.1-3.2.23: Section 3.2, Geologic Emplacement Following Chemical Resynthesis, and the relevant appendix P represent, on the whole, original and innovative work on this promising concept. However, mineralogists and geochemists of the U.S. Geological Survey noted numerous misspellings of

mineral names and incorrect formulae, as well as some errors of fact and interpretation in these sections. Rather than detail these deficiencies here, we suggest that the authors of these sections set up a consultant group from universities and the USGS to review the concept and go over these sections thoroughly for accuracy and completeness. Although the concept is technically immature, the presentation in the EIS should make use of available expertise.

Page 3.3.3, par. 2: It should be reemphasized here that satisfactory backfilling-sealing techniques have not yet been developed and proven.

Page 3.3.7, par. 1, lines 3-4: In terms of fluid and solute migrate, fracture porosity might be the most important in many host rocks including basalt, granite and shale. Although there may be very few fractures, their permeability can be several orders of magnitude greater than that of the pores.

Page 3.3.7, par. 2, lines 7-8: Although fractures may be only a few meters long, they are often interconnected with others making a continuous flow network; therefore, the statement in the report is misleading.

Page 3.3.7, last par., lines 6-7: This sentence appears misleading or erroneous; oil companies have tested many wells below depths of 500 m for permeability. If the reference is only to crystalline rocks, that should be made clear.

Page 3.3.8: It should be pointed out here that permeability measurements for one well in a sparsely fractured medium have little transfer value to the surrounding bulk medium. Measurements on many wells drilled at different angles are needed (which might compromise the site) or some new nonpenetrating method is needed (not yet developed).

Page 3.3.29: The quantity "(1,000 ft.)" should read "(11,000 ft.)".

Page 3.3.37: Reference 23 appears to be incorrect. R. E. Goodman's article is entitled, "The deformability of joints." It is on pages 174 through 196 of ASTM Special Publication 477, published in 1970.

Pages 3.4.4 and 3.4.12: Probable ground-water migration and circulation patterns associated with the rock-melting alternative need further consideration and discussion, preferable in conjunction with effects of thermal cracking.

Page 3.5.16, par. 3: The reference to measurements in deep artesian wells seems inconsistent with the concept of a floating freshwater lens, because conditions in a confined or artesian aquifer might not necessarily reflect the freshwater/saltwater ratio. Influences other than differences in density can be effective in confined aquifers.

Page 3.5.21, par. 5: Another disadvantage should be mentioned. Islands are often more associated with resources and more subject to faulting, seismicity, volcanism, erosion, effects of sea-level changes, extreme storms, and tsunamis than mainland areas.

Page 3.6.6, table 3.6.2: The sorption coefficients listed are credible although they could easily be 1 or 2 orders of magnitude in error. Their source should be properly explained and cited. They should not be used for transport-time calculation.

Page 3.6.14, par. 1, last sentence: This statement requires documenting evidence or a reference.

Page 3.6.18, last par.: Appropriate references on these sorption coeffieicnts need to be cited here.

Page 3.6.19, line 1: This statement appears in error; ^{54}Mn shows more than a factor of 10 spread.

Page 3.6.19, fig. 3.6.8: These sorption coefficients mean very little unless their exact measurement conditions (chemical and physical) are described. This would include as a minimum: ionic strength and composition of the solution, initial exchange conditions of the clay, pH and Eh of the solution, surface area of the clay, sorption equilibrium time, and solid-to-liquid ratio.

Page 3.6.19, last par., lines 4-5: Although organic complexes might be insignificant, there is a chance that carbonate (or other inorganic) complexing might be significant. This should be pointed out.

Page 3.6.29, par. 5-6: Measurements of molecular diffusion coefficients will be needed for near- and far-field transport analysis.

Page 3.7.10: Disposal of wastes in an ice sheet would probably entail loss of control of spacing of waste containers. Flow velocities and perhaps even flow directions might change over long periods. Possible impacts should be evaluated.

Page 3.7.10, par. 4: This statement should mention that there is one more handling and transportation step in ice disposal than in seabed disposal--from the unloading dock to the ice disposal site.

Page 3.7.10, sec. 3.7.1.6, first item: This statement is debatable; the fact that these remote areas are relatively unexplored for resources might attract considerable exploration in the future as some of the last frontiers for new discoveries.

Page 3.8.11, Canditate Geologic Environments: Effects of local stresses and conditions--such as varying topographic load and joint patterns--on uplift

resulting from reverse well injection should be further examined in the course of testing suitable monitoring methods that would not penetrate the individual waste sheets.

Page 3.8.24, sec. 3.8.3.1: Has reverse well injection in salt beds been considered? Salt is not mentioned among media under consideration. It has been found to be amenable to bedding plane fracture.

Section 3: It would be useful to provide concise summaries of advantages and disadvantages for the three subsections now lacking them: chemical resynthesis (sec. 3.2), very deep hole concept (sec. 3.3), and space disposal (sec. 3.10).

Section 4: See our comments for pages 1.31-1.35.

Page 4.2, par. 2: We believe that all the ratings used in this system require some degree of value judgment.

Page 4.25, par. 3: We believe that greater clarity could be achieved in expressing the several ideas included in the following sentence: "Further effort to improve knowledge of the performance of each CWM option with respect to the decision attributes and their parent criteria will also aid the decision makers in establishing important weighting factors needed to combine the attribute assessments into a composite figure of merit for each CWM option, for it has been demonstrated that the importance attached to an attribute or criterion depends not only upon the intrinsic nature of the criterion but also upon the expected performance of the decision alternatives with respect to that criterion."

Page 4.25, last par., last line: Add a sentence: "This does not imply, however, that conventional geologic disposal is environmentally the best option available."

Section 6, Glossary: Many important key terms are missing that should be included, such as: intermediate-level waste, permeability, hydraulic conductivity, Kd, sorption coefficient, distribution coefficient, beta activity, porosity, hydraulic head.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

OCT 25 1979

Dr. Colin A. Heath
Director, Division of
Waste Isolation
U.S. Department of Energy
Washington, D.C. 20545

Dear Dr. Heath:

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the Department of Energy's Draft Environmental Impact Statement on the Management of Commercially Generated Radioactive Waste, DOE/EIS-0046-D, April 1979 (hereafter referred to as the GEIS). We have found many areas where modifications or additions to the statement are necessary. On the basis of our review, the staff offers the following general observations. Detailed comments on the GEIS are enclosed.

1. The conclusion drawn appears to be more comprehensive than can be supported.

The principal conclusion appears to be that "(1) the disposal of radioactive wastes in geologic formations can likely be developed and applied with minimal environmental consequences, and (2) therefore, the program emphasis should be on the establishment of mined repositories as the operative disposal technology" (GEIS, page 1.1, paragraph 3). However, information presented in the GEIS and its supporting documents does not appear to provide firm support for this comprehensive conclusion.

A number of critical areas have not been adequately dealt with. These include:

- long-term hydrogeologic transport of radionuclides from a geologic repository.
- effects on long-term repository isolation capability of repository construction and emplaced waste (thermal and radiological effects).
- potential effects of accidents during repository operation on the ability to properly backfill and seal the repository or safely remove the wastes already emplaced.

It may be that based on currently available information, such a comprehensive conclusion cannot be completely supported. If so, consideration should be given to restructuring the GEIS to support a more modest conclusion, perhaps similar to the following conclusion reached by the IRG (IRG report, page 42, para. 3).

"Present scientific and technological knowledge is adequate to identify potential repository sites for further investigation. No scientific or technical reason is known that would prevent identifying a site that is suitable for a repository provided that the systems view is utilized rigorously to evaluate the suitability of sites and designs, and in minimizing the influence of future human activities....The feasibility of safely disposing of high-level waste in mined repositories can only be assessed on the basis of specific investigations at and determinations of suitability of particular sites. Information obtained at each successive step of site selection and repository development will permit re-evaluation of risks, uncertainties, and the ability of the site and repository to meet regulatory standards."

This would provide support for a DOE program designed to proceed systematically to develop the most promising disposal options and as part of this program to proceed with the next logical step in development of mined geologic disposal, i.e., selection and characterization of potential sites in a variety of geologic media. We believe that DOE should proceed promptly with such development.

Such an approach explicitly recognizes the gaps in present knowledge and proposes a program designed to eliminate these gaps while proceeding toward development of an operative disposal technology.

2. Environmental comparison of alternative strategies for developing geologic repositories should be presented.

The Interagency Review Group on Waste Management (IRG) discusses several alternative strategies for developing geological repositories. The IRG left it up to the Department of Energy GEIS to do the full environmental analysis and comparisons of these strategies. The GEIS states that the various strategies will be assessed. However, the GEIS does not contain such an assessment.

The GEIS should examine each of the national strategies discussed (and any others deemed reasonable) in an explicit manner which permits an environmental comparison of the alternatives.

3. Environmental aspects of alternative timing strategies for commitment of waste to the repository should be examined.

In Sections 1.1 and 4.7.3, the GEIS concludes that the impacts of later implementation are insignificant. However, throughout the document, the implicit assumption exists that permanent disposal of the accumulated waste as soon as possible is an attribute of dominant importance.

Although we agree that a repository should be developed and tested as soon as possible, it is not clear that there is a pressing need to rapidly commit existing inventories of high-level waste to the repository. A number of European countries, for example, are proposing long-term (40-50 year) surface storage of spent fuel or high-level waste prior to geologic emplacement. This is an important alternative to evaluate because (1) it provides ready retrievability should a reprocessing policy be adopted, and (2) the reduced thermal output of the waste will provide for either a smaller repository area requirement or a greater margin of safety with the same area. The environmental aspects of this alternative should be examined in the comparative assessment discussed in 2. above.

Therefore, we recommend that the environmental aspects of such delayed commitment of wastes to the repository be discussed in the final GEIS.

4. Comparison of alternatives is incomplete.

The abbreviated multi-attribute evaluation presented in chapters one and four is incomplete and of little value in comparing the alternatives presented in this report. The reported lack of sufficient data for comparison for several of the environmental factors and the absence of discriminative character of others has resulted in a comparison apparently based primarily on policy, rather than environmental considerations. This is inappropriate for an environmental impact statement.

Table 3.1.95 implies there is "no data" in a number of key areas essential to an analysis based on environmental considerations. If this table is correct, there is in fact no real environmental basis for comparison of the alternatives.

5. Decisions and decision processes should be identified.

The decisions and decision processes (i.e., who will make the decisions, how and on what schedule) which the GEIS is to support are not clearly identified in the GEIS. Such information should be included in the GEIS so that a reasonable assessment can be made whether the GEIS meets the requirements of NEPA.

6. The GEIS needs extensive technical and organization revision.

Our review has identified a number of apparent errors, over-simplifications, unsupported assertions, questionable assumptions, inconsistencies, and uses of outdated information in the GEIS. In addition, lack of proper documentation and referencing makes it difficult to check the technical accuracy of data presented. Although there is a wealth of valuable information in the GEIS and its back-up documents, information is difficult to locate and arguments difficult to follow.

The GEIS and its supporting documents should represent the present state of knowledge concerning the disposal of long-lived radioactive wastes. Every effort must be made to assure the GEIS is technically sound in all areas, reflects the most up-to-date information available and is meticulously documented.*

John B. Martin, Director
Division of Waste Management

Enclosure:
As stated

*The Commission plans to conduct a rulemaking proceeding to assess its confidence that high-level radioactive waste can be safely disposed of. It is expected that DOE will be a principal party to this rulemaking proceeding and that the GEIS, if available in final form, will provide valuable input to this rulemaking proceeding.

COMMENTS ON

DRAFT ENVIRONMENTAL IMPACT STATEMENT

FOR THE

MANAGEMENT OF COMMERCIALLY GENERATED RADIOACTIVE WASTES
(U.S. DEPARTMENT OF ENERGY, DOE/EIS-0046-D)

APRIL 1979

BY

THE STAFF OF THE
U.S. NUCLEAR REGULATORY COMMISSION

OCTOBER 1979

INDEX TO GEIS COMMENTS

		Page
1.	GENERAL	1-1
2.	FUEL CYCLE	2-1
	a. Energy Projections	2-1
	b. Waste Generation	2-1
	c. Waste Storage and Treatment	2-3
	d. Transportation	2-5
	e. Safeguards	2-19
	f. Other Fuel Cycle Alternatives	2-20
3.	CONVENTIONAL GEOLOGIC DISPOSAL	3-1
	a. Siting	3-1
	b. Waste Form and Packaging	3-7
	c. Design and Operation	3-7
	d. Safeguards	3-17
	e. Short-Term Environmental Impacts	3-19
	f. Long-Term Effects of Repository Construction and Operation	3-23
	g. Long-Term Radiological Effects - Environmental Transport	3-25
	h. Long-Term Radiological Effects - Geology/Hydrology	3-26
	i. Long-Term Radiological Effects - Accident Analysis	3-35
	j. Research and Development	3-40
	k. General	3-40
4.	ALTERNATIVE DISPOSAL CONCEPTS	4-1
	a. Geologic Emplacement Following Chemical Resynthesis	4-1
	b. Very Deep Hole Concept	4-1
	c. The Rock Melting Concept	4-2
	d. Island Disposal	4-4
	e. The Sub-Seabed Geologic Disposal Concept	4-6
	f. The Ice Sheet Disposal Concept	4-11
	g. Reverse Well Disposal	4-12
	h. Omitted Concept	4-12
5.	COMPARISON OF ALTERNATIVES	5-1

Comment Number

1. GENERAL

1.1 The comparison of alternatives does not give sufficient consideration to environmental factors.

Table 4.5.1 indicates that insufficient data is available to compare ecosystem, aesthetic, and critical resource consumption impacts. These are among the most basic and fundamental, true environmental impacts. The majority of the remaining criteria are better described as policy considerations than as environmental factors, e.g., status of technology, cost of construction, policy and equity considerations. Thus, it appears that the final comparative analysis in this environmental impact statement drops out environmental factors and is based on the policy considerations. Environmental impacts, other than dose assessments, such as hydrologic impacts including water use and availability and impacts of construction and operation of the repository need more detailed discussion.

.2 The comparative analysis procedure is not carried to completion.

The GEIS is self contradictory on whether or not it is recommending a particular decision or decisions. In some sections it appears a certain course of action is being recommended. In particular on page 1.36, after eliminating most other factors as unimportant, it is stated, "Thus, state of technology stands out as a major decision factor, and the geologic disposal option has an edge over other options as regards the technology status." On page 1.1 it is stated: "DOE proposes that (1) disposal of radioactive wastes in geological formations can likely be developed and applied with minimum environmental consequences, and (2) therefore the program emphasis should be on the establishment of mined repositories as the operative disposal technology."

However, as indicated on page 1.31, the comparative analysis is intentionally not completed to "avoid value assumptions--more appropriately the responsibility of the decision maker." On page 1.35 is found: "It is

Comment Number

emphasized that the scores in Table 1.8 cannot be combined without careful consideration of the relative importance of the attributes and of the criteria." The relative importance was not determined. Further, page 4.1 states that "No attempt is made to identify specific CWM options for further research and development." Page 4.24 reiterates that weighting factors have not been assigned and decisions not recommended.

The GEIS should not terminate the comparative analysis midway before assigning weighting factors, disclaim the making of a recommendation, and then proceed to make such recommendations as are found on pages 1.36 and 1.1. In deciding on which course of action to follow DOE should consider the CEQ regulations (40 CFR 1502.14 (e)) which require the identification of any preferred alternatives in the draft statement.

1.3 Time estimates for repository licensing schedules are too short.

The times allowed to complete licensing and construction of a repository are much shorter than those estimated by NRC. Figures 7.5.13 and 7.4.14 in DOE/ET-0028 show seven years from preliminary design to operation with one year between submission of a PSAR and construction approval. NRC estimates 10 to 12 years from preliminary design to a decision on operating approval. These longer times should be used in establishing repository availability dates as these delayed availability times may affect conclusions on the impacts of waiting until alternate methods are developed.

1.4 References to supporting materials are inadequately designated.

Although there is a wealth of information in the GEIS and its supporting documents, information is difficult to locate and arguments difficult to follow. References should be to specific page numbers in the supporting documents. It takes a substantial effort to find sources of GEIS information in the supporting documents. Many of the references are contractor reports. Where these reports relied on other sources, the prime reference should be given.

Comment Number

.5 The reference environment approach to generic evaluation is used improperly.

Inasmuch as the GEIS is a programmatic statement, a site-specific description of an environment is not necessary; however, development of data that will be required in a specific evaluation is appropriate, and the GEIS incorporates a reference environment to evaluate source terms on a generic basis. However once having determined the significance of an impact on the reference environment, the GEIS fails to remind the reader that conclusions reached relate only to those particular conditions. Indeed, statements in the GEIS indicate that even its writers do not fully appreciate these limitations. Effects on the reference environment are presented as the impacts of an alternative without recognition of the fact that the impacts could be much different for a different reference environment. For an example of how to prepare a GEIS with detailed discussions of siting options and impacts, see the FES on floating Nuclear Plants (NUREG-0056).

1.6 The use of a linear thermomechanical analysis for the design of the reference repository is salt is an inadequate approximation.

A conclusion that readily retrievable conditions in a repository in salt would prevail in storage rooms for at least five years is based on linear thermomechanical analyses. The time behavior of salt under thermal and mechanical loading cannot be approximated as a linear relationship. The GEIS makes an allowance of two feet to accommodate expected closures. Project Salt Vault, ORNL-4555, Chapter 12, presents several figures (Figure 12.36, etc.) that describe pillar behavior as a function of mechanical and thermal loading and time. The behavior exhibited is not linear and a significant underestimation of closure will be obtained if a linear approximation is used. If later studies have been used to discount the results of Project Salt Vault, they have not been identified in GEIS. Consideration of the creep behavior of salt under thermomechanical loading is important for the design of a respository in salt because it will affect the short- and long-term stability of storage rooms and access

Comment Number

ways. If stability is compromised, the integrity of the impermeable barrier between the salt bed and overlying aquifers that is assumed by GEIS, may be compromised.

1.7 Retrievability of the emplaced waste is expected to be a requirement during the early years of the conventional geologic repository. Based on various discussion within Section 3.1.2, it appears that many uncertainties and attendant much higher costs are introduced into almost every media as a result of waste thermal effects. Intermediate temporary storage of the waste for sufficient time to permit cooling to manageable temperature would seem to deserve considerable attention. The waste could, for example, be stored in large vaults at some minimal depth, then transferred to the final repository depth once acceptable temperatures had been attained. Perhaps either nonhigh-level waste could then be stored in the vacated temporary high-level storage area or the vaults could be filled with excavated rock from lower levels to minimize the surface environmental effects associated with disposal of some types of waste rock (such as salt).

1.8 The summary comparative analysis in Chapter 1 appears to be an attempt to justify conventional geologic disposal. Some of the alternatives still appear to have significant merit and, as indicated in the report, will receive further study by DOE. Conventional geologic disposal only happens to currently be at a more advanced stage than other technologies. The summary section should concentrate on the recommendations for the entire program, justifying each part of the continuing range of alternatives. This is a programmatic DOE decision and responsibility.

1.9 From the analysis presented it appears that nonradiological environmental impact considerations will not influence the selection among the six geological disposal options for a given fuel cycle option. However, even if this is true, consideration of environmental impacts will be important in site selection for any of the geological options selected. It is not readily evident whether one geological option should be selected before a

C.63

Comment Number

comparison of alternative sites is made or whether, indeed, at a later date the site selection will include consideration of different geological options. Considerations of this type should be part of the "programmatic strategy" selection to be supported by the GEIS.

1.10 It seems inconsistent to identify some symbols, abbreviations and acronyms as footnotes and others in the glossary, e.g., Tables A-18, A-20, A-21, A-27 and A-28. Some are inconsistently and arbitrarily identified within the text, e.g., GWe, which is used throughout the draft, is defined in the first paragraph of section 1.2 on page 1.7.

1.11 General

The Table of Contents (pp. vii to xi) is too brief for such a large document (over 700 pages plus appendices).

1.12 p. 1.1

Clarify the definition of "radioactive wastes" discussed in this document. Traditionally, HLW does not include TRU-intermediate and low-level wastes from the reprocessing plant.

1.13 pp. 1.3, 4.22, 4.38

Clarification of the meaning of short-term and long-term as preclosure and post-closure of the repository should be made when the terms are first used. The difference between short-term and near-term is not clear either. On page 1.3, third and fourth paragraphs, the meaning of the "near-term" and "nearer-term" nomenclatures is not clear. On page 4.38, near-term and long-term consequences are mentioned. The explanation for near-term in this paragraph is the same as that given for short-term on page 4.22.

1.14 p. 1.3

In presenting the IRG's, "key characteristics of a near-term interim strategic planning base for high-level waste disposal" parts omitted from the "key characteristics" seem significant and should be included.

Comment Number

It is unnecessary to present the "key characteristics" from both the IRG draft report and the final report (see the FORWARD).

- The first statement should read (words that are underlined were omitted):

  Near term program activities should be predicated on the tentative assumption made for interim planning purposes that the first disposal facilities for HLW will be mined repositories. Several geologic environments possessing a wide variety of emplacement media will be examined Once the NEPA process has been completed, program activities can be tailored accordingly.

- The footnote on the second statement was deleted. It reads:

  The earliest date for operation of a licensed repository, whose site was selected by this process, and using an identical schedule, would be 1992. Actual operation, recognizing reasonable possible deviations from the ideal, could be up to 3 year later.

This says that the actual operation of the repository will be at least 7 years and perhaps as many as 10 years later than the starting date for the first commercial repository (1985) assumed for this study.

1.15 p. 1.13

The last sentence in the first paragraph under Site Selection mentions sociopolitical factors as siting constraints to be addressed early in Stage III. What criteria will be used for site screening based on such considerations?

Comment Number

..16 p. 1.16

"The conclusion is that the available lethal doses in radioactive waste are far less than the available lethal doses in toxic nonradioactive chemicals now being handled routinely by society as shown in Table 1.3. Further, radioactive wastes decay with time whereas toxic chemicals have no half-lives and hence their quantities remain unchanged with time."

a. Is the value in Table 1.3 for radioactive waste based on deaths due to the radiotoxicty or the chemical toxicity?

b. How does this value behave with time?

c. Provide references for Table 1.3.

d. Available Lethal Dose is defined as (the number of) potential deaths if dose is uniformly administered."
   - o What does this mean?
   - o What "dose" is uniformly administered?
   - o Administered to what population?

e. How many available lethal doses result from the eventual stable daughter products of the radioactive waste.

1.17 pp. 1.15, 3.1.62-64

The section entitled Human Institutions calls attention to the merit of setting up such institutions in the long run control of nuclear wastes. It would be helpful to address whose responsibility it would be to establish and maintain such institutions.

1.18 p. 1.17

The difference between "major disasters" and "primary events" is unclear.

1.19 p. 1.19

Some of the main conclusions given in the summary concerning radiological impacts are not readily traced back to the supporting text, e.g., p. 1.19,

Comment Number

lines 14 to 17. The text in the summary section (Section 1.3) states that, "Calculated radiation dose to the total population from routine operations including transportation, assuming that all facilities are located in the same region (a highly conservative and unlikely scenario) amount to no more than about 0.3% of the dose the population would receive from naturally occuring sources and differs by a factor of less than 15 among fuel cycle options." Although the summary gives no reference to where the supporting text for this conclusion is, it appears that the supporting data base is in Tables 3.1.84 to 3.1.87 (summarizing environmental effects from routine operations). However, several entries (e.g., see U and Pu Recycle column on p. 3.1.215) give regional population doses (6×10^4 man-rem) that are greater than 0.3% of background as quoted above.

1.20 p. 1.34

Table 1.8. The section entitled Socioeconomic Impact mentions that the impacts were not converted to a 1-5 scale; refers the reader to Table 4.5.2 and states that the impacts are small for all options. It would be helpful to discuss why the 1-5 scale was not used and what rationale was used in both tables to conclude that the impacts would be small. These conclusions appear to be at variance with the statement made on page 1.22 (line 19) which states: "...socioeconomic impacts...could be either small or significant."

Also refer to the statement on page 3.1.47 (lines 10 and 11) which points out that socioeconomic and political factors may eventually play a determining part in repository site selection.

1.21 p. 2.2

Four impact statements on TRU waste are mentioned as being in preparation by DOE (SRP, INEL, RL, and LASL). Data from DOE received by NRC in conjunction with the DOE licensing study showed TRU waste to exist at ORNL. Will there be an environmental statement for ORNL?

Comment Number

.22 p. 3.1.43
In the case of enforcement against private organizations, criminal penalties could be imposed.

1.23 p. 3.1.51
The statements that some issues may not be resolved with the necessary degree of certainty seems to conflict with the very next sentence which states that uncertainties can be reduced to acceptable levels.

1.24 p. 3.1.60
Line 8 up: The quote of 10 CFR 50, Appendix F, is in error. The regulatory policy stated therein is that liquid wastes at a reprocessing plant must be converted to a dry solid which is "...chemically, thermally, and radiolytically stable to the extent that the equilibrium pressure in the sealed container [required before shipping] will not exceed the safe operating pressure for that container during the period from canning through a minimum of 90 days after receipt (transfer of physical custody) at the Federal repository."

1.25 Section 3.1.1
This section deals in general terms with geologic considerations. Its deficiencies are mainly in the choice of references used to support the material presented. Seven of the twelve references are contractor reports which have not received proper peer review by the scientific community. One is a working paper by the Interagency Review Group, and two others are elementary geology textbooks. Of these, the one used for data on the chemical composition of rocks was last revised on October 30, 1946, and the other is eleven years old. In most cases, it would have been very easy to use the original references upon which the contractor reports were based. Finally, it would be helpful to cite pages with the references. It would facilitate review of the GEIS.

Comment Number

.26 p. A-48
On page A-48, there is an explanatory paragraph on the notations used in the tables. The clarification would not be necessary if powers of 10 were consistently used in all the tables. If this correction is "impossible," the clarification should be made as soon as the first computer print-out, (Table A-14), is used.

1.27 Appendix C
Appendix C - The discussion of the "as low as reasonably achievable" principle in this appendix is misleading in that it treats ALARA dose levels as fractions of maximum permissible dose levels for individuals. Instead, ALARA is primarily an analysis of risks to an entire affected population and of the cost-effectiveness of reducing that population risk. While ALARA individual dose limits can be derived for specific activities (e.g., operating nuclear power plants), the most basic ALARA judgment concerns the cost-effectiveness of reductions in overall population risk (e.g., $1,000 per man-rem in Appendix I).

1.28 p. S.1
Specialties of experts that assessed a number of effects are given but it is not stated what the specialties of experts that assessed ecosystem impacts were.

1.29 p. S.19
Under Ecosystem Impact it is stated that significant ecological effects may occur from construction of buildings, etc. There is no basis given for this conclusion.

C.66

Comment Number

2. FUEL CYCLE

a. Energy Projections

2.a.1 pp. 1.10, 2.1.2

Considering the growth scenarios on page 2.1.2 and elsewhere (225-400 GWe by the year 2000), would the lower growth scenario change the DOE's approach to repository siting and development? What affect would the lower growth scenario have on the selection of alternatives? Table 1.2 on page 1.10 should also present the repository acreage requirements for a 6300 GWe yr economy.

b. Waste Generation

2.b.1 p. 1.9

Although the number of waste containers shown in Table 1.1 of the GEIS are not unreasonable, some aspects of the table require clarification. First, some of the numbers cannot be derived from Tables 2.1.8, 2.1.10, 2.1.11 and 2.1.13. Secondly, the heading of the third column, or the footnote, should indicate that hulls and hardware are included in TRU intermediate-level waste, if that is the case. Lastly, the last column should indicate that the low-level waste is TRU contaminated.

2.b.2 p. 2.1.4

The GEIS does not address the question of the final disposition of very long-lived fission or activation products, such as ^{129}I, ^{59}Ni, and ^{99}Tc which are separated from TRU or high-level wastes. To help develop national policy for the disposal of these isotopes, cost/benefit estimates of including them with the HLW and TRU wastes should be addressed in the GEIS.

2.b.3 DOE/ET-0028, Section 8

The preliminary information offered by the DOE in Section 8 of the back-up document DOE/ET-0028 is obsolete and does not accurately reflect the

Comment Number

Pacific Northwest Laboratory studies of decommissioning for the NRC as stated on page 8.1. The NRC information should be properly referenced and the DOE should provide current estimates of the TRU wastes to be expected from all decommissioning activities.

2.b.4 pp. 2.1.3 and 2.1.4

The description of the once-thru fuel cycle is presented. The narrative should address the repository startup and shutdown schedules, i.e., how many will be needed and on what schedule.

2.b.5 pp 2.1.17, 2.1.18, 2.1.19

A review of Tables 2.1.10, 2.1.11, and 2.1.12 shows that the maximum average concentration of LLW at 500 years to be: 2 m Ci/cm^3 for fission and activation products and 0.15 m Ci/cm^3 for actinides and daughters. It is not apparent that it is necessary to send LLW to deep geologic disposal for safe disposal. In view of the large impact the LLW has on repository volume, careful consideration should be given to the need for such disposal and the rationale clearly explained.

2.b.6 p. A.17

Although not implicitly stated, it appears that the inventory in Table A.14 was based on a charge of 3.8×10^5 MTHM. However, the mass associated with the Th-232 (+2 daughters) given in the 1,000,000 year column is 5.8×10^6 MT. There is an obvious error in the program used to generate this table. This single, obvious error brings into question all output generated by the computer program which was used to generate Table A.14.

2.b.7 p. A.58

On page A.58 of the appendix, Table A.52 shows 5760 metric tons of plutonium in spent fuel in the U + Pu recycle mode. Our calculations indicate that this quantity of plutonium indicates an extremely high mix of spent fuel

Comment Number

from plutonium recycle as compared with UO_2-enriched uranium only fuel. As averaged over the entire time span to the year 2040, the MOX to UO_2 fuel ratio we calculate is 60/40. Please provide your basis for this estimate.

2.b.8 p. A.49

Table A.43, presents the inventories of spent fuel in storage and isolation for the delayed repository availability. By taking the difference between the entries for succeeding years, one should be able to determine the tonnage of spent fuel that is discharged for each year, and from that, the total number of canisters discharged for each year. The following results were obtained:

Year	MTHM	Canisters*
1983	1669	5,619
1985	2979	10,030
1986	1960	6,599
1987	2950	9,932
1988	3430	11,548

*Using 0.297 $\frac{MTHM}{CAN}$ per Table 2.1.8

Explain the erratic discharge rates.

Detailed information on the nuclear growth scenario assumed should be provided, including; numbers and types of reactors that come on line each year; and the annual waste streams from the plants, including spent fuel, and low-level waste (volume and activity).

c. Waste Storage and Treatment

2.c.1 p. 1.1

The GEIS should include interim storage facilities in the general description of the fuel cycle since it is apparent from the discussions in the statement that these facilities will be built.

Comment Number

2.c.2 p. 2.1.22

The assumption that spent fuel will be stored after packaging rather than prior to packaging while awaiting shipment to a respository should be justified. Economics may dictate this procedure and it should be based on a cost effectiveness analysis.

2.c.3 pp. 2.1, 2.2

The NRC Final EIS on spent fuel storage, NUREG-0575, should be cited. The NRC Draft GEIS on Uranium Milling, NUREG-0511, April 1979, has been issued for comment.

2.c.4 p. 3.1.184

On page 3.1.184, the following statement is made: "During planned operation of the ESFSF (dry caisson option) no releases of radioactivity would occur." Provide support for this statement.

2.c.5 It appears that all of the below terms refer to the same facility. Terms should be used consistently throughout to avoid confusion and to facilitate comparisons.

packaged spent fuel storage facility (p. 2.1.22)
storage (p. 2.1.22)
offsite storage facilities (p. 2.1.22)
extended storage facility (p. 2.1.25)
storage facility (p. 2.1.25)
(ESFSF) Extended Spent Fuel Storage Facilities (p. 3.1.181)
dry caisson storage facility (p. 2.1.184)
SURF (p. 3.1.184), (p. 3.1.186)

2.c.6 The basis for assuming that two Independent Retrievable Waste Storage Facilities would be needed to serve the needs of the reprocessing industry if repositories are available beginning in the year 2000 should be given. In particular, if economics is the basis, i.e., facility versus transportation costs, such a discussion would assist in any cost/benefit analysis.

Comment Number

d. Transportation

2.d.1 p. 1.19
The GEIS says transportation risks are the same for all options. However, estimates of risk in the tables in the supporting documents do not seem to support this conclusion.

2.d.2 P. 1.19
It would be useful to provide any available risk (consequence x probability) estimates for the transportation accident being discussed. This will allow a comparison to be made with the risks for the other accident scenarios.

2.d.3 p. D.4
On page D.4, it is stated that the methodology used to calculate the direct radiation dose to persons along the shipping route follows that developed in WASH-1238. Subsequent to the issuance of WASH-1238 an environmental statement on transportation of radioactive material has been published by the NRC. This statement is NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes." The latter document uses a more realistic demographic model in determining population density along the transport route and an improved method for evaluating integrals used in the model. We recommend this refined methodology be used in the GEIS in assessing the radiological impact to the population residing near the transport route.

2.d.4 p. D.5
Population density assumptions used in determining the radiological consequence of transporting radioactive wastes are given on page D.5. Here it is stated that a value of 330 persons per square mile is used for the Eastern U.S. and California and 110 persons per square mile is used for the Western U.S. The environmental aspects presented in DOE/ET-0029, page 4.1.7, use a population density of 90 person per square km (230 persons per square mile). If this is a weighted average, the weighting factors should be given so that their validity can be evaluated.

Comment Number

2.d.5 Appendix N
Some discussion should be given of the industry's ability to meet the demand for spent fuel casks at the rate they will be required.

2.d.6 Appendix N
The largest accident consequences presented in the GEIS occur during the transportation of radioactive wastes. In the opening paragraph of Appendix N it is stated that much of the detailed analysis is contained in DOE/ET-0029. An examination of these two documents reveals that accident release fractions, curie amounts of isotopes that may be released, and doses to affected individuals are provided. However, some important details concerning accident assumption are not given. These detailed assumptions involve the fraction of released material that is aerosolized and in respirable form. Also missing are resuspension factors. In Appendix B to DOE/ET-0029, reference is given to other reports and computer codes that may contain these factors. These assumptions need to be outlined directly in DOE/ET-0029 so that the degree of realism of the accident analysis can be more easily evaluated and the conclusions compared to other study results.

2.d.7 Appendix N
Throughout Appendix N, the total body radiation dose from the routine transport of radioactive materials is given in various tables. These tables show the dose to the population residing along the transport route and to members of the transport work force. The tables omit the dose to occupants of vehicles using the same route in the case of truck transport. It is not clear whether the dose that results from a delay in transit of the radioactive shipment has been included. These delays could occur from a traffic jam or a stop at a truck stop in the case of truck transport. For rail transport, a delay can be caused by adverse track conditions or a mechanical breakdown.

2.d.8 Appendix N
Some discussion should be included concerning the useful life of spent fuel casks. The analysis appears to assume the casks used in the early

Comment Number

time frame under consideration, 1980s, will be available for use during the peak years, 2010 to 2020.

2.d.9 Appendix N

Our comparison of the impacts presented in the GEIS with those in DOE/ET-0029, examined spent fuel shipments only. Since it is apparent that in converting results from one document to another several errors have been made, it is recommended that the remaining transportation sections in Appendix N be similarly reviewed.

2.d.10 p. N.1

Table N.1 does not show movement of spent fuel from reactor directly to reprocessing plant which would occur for the recycle options. However, the GEIS states, on page 2.1.5, second paragraph, that it is assumed that storage requirements can be met by power plant storage basins for the recycle options.

2.d.11 p. N.2

It is stated that about 50% of operating reactors do not have rail spurs at the site. The reference system given on page N.3, line 5, shows 90% by rail and 10% by truck. Is this 50% by rail, 40% by intermodal rail and truck, and 10% by truck? Note: On p. N.5, a 45%/45%/10% breakdown is given.

2.d.12 p. N.2

Availability data is out of date. Our most recent information indicates that five NLI-1/2 casks, two TN-8 casks, one TN-9 cask, and two NLI10/24 casks have been built.

2.d.13 p. N.3

line 3: On page 1.11, Section 1.2.2, it is stated that 0.1 rem per year will be used as the background dose rate. Over 70 years this will result in an exposure of 7.0 rem. One percent of this exposure is 0.07 rem. The 0.1 rem the maximum individual receives as a result of transportation is greater than 1% of background exposure, not less than 1% as stated in the GEIS.

Comment Number

2.d.14 p. N.3

The impacts presented in Tables N.3 and N.4 the GEIS are based on a shipping scenario where 100% of all shipments are transported either by rail or by truck. It is not clear whether these impacts are presented only for comparison purposes or whether the scenerios upon which these impacts are based are alternatives to be considered in addition to the reference case. If the latter is true, then the impact of building rail spurs to the 50% of reactors that do not have these spurs should be given in the GEIS. For the reference case, it appears that the impact of transporting the spent fuel by truck from these reactors to the nearest rail siding has not been included in the analysis.

2.d.15 p. N.3, N.4

Impacts presented on page N.3 (Tables N.3 and N.4) and on page N.4 are based on the assumption that all spent fuel is shipped by either rail or truck. Values given in DOE/ET-0029 are based on the reference case of 90% of the spent fuel being shipped by rail from reactors to ISFSFs and 10% by truck with 100% of the shipments from ISFSFs to the final repository being transported by rail. We recommend converting the results presented in Tables N.3 and N.4 and on page N.4 to the reference case so that actual resource commitments can be known and comparison of the GEIS with the back-up documentation can be facilitated.

2.d.16 p. N.3, N.4

It is not clear that the impacts shown in the GEIS have been correctly obtained from DOE/ET-0029. The following discussion develops ratios which can be applied to the results in DOE/ET-0029 to convert them into results that would be obtained if 100% of all shipments are transported by either rail or truck. Following this ratio development discussion is a table outlining some cases where impacts presented in the GEIS appear to have been improperly obtained from DOE/ET-0029.

Comment Number

Table 26.2.3 of DOE/ET-0028 shows 7370 packaged PWR assemblies and 11,340 packaged BWR assemblies needing shipment from ISFSF to a final repository in the year 2000. In the reference case these assemblies would be shipped by rail in a modified NLI 10/24 cask which can accommodate only 7 packaged PWR assemblies or 17 packaged BWR assemblies. (Normally this cask can handle 10 PWR or 24 BWR assemblies.) For truck cask normally only 1 PWR and 2 BWR assemblies can be accommodated. Assuming a modified truck cask can be developed that can accommodate 1 packaged PWR assembly or 1 packaged BWR assembly, the number of truck shipments, for the year 2000, from an ISFSF to a final repository would be 7370 + 11,340 = 18,710 truck shipments. Table 4.1.1-3 of DOE/ET-0029 indicates a ratio of 120,000 to 1700 for the total number of shipments through the year 2050 compared to the number for the year 2000. Applying this ratio to the 18,710 truck shipments results in a total of about 1.3×10^6 truck shipments through the year 2050 for movement of packaged spent fuel from an ISFSF to a final repository. To determine the total number of truck shipments, the number of truck shipments from reactors to ISFSFs must be added to this value of 1.3×10^6 truck shipments. Table 4.1.2-1 shows 8.9×10^4 truck shipments through the year 2050 for the reference system. Since this reference system is based on only 10% of the reactor shipments being transported by truck, a total of 8.9×10^5 truck shipments would occur if 100% of the shipments were transported by truck. Thus the total number of truck shipments of all types through the year 2050 would be $1.3 \times 10^6 + 8.9 \times 10^5 = 2.2 \times 10^6$ truck shipments. Impacts presented in the GEIS for 100% of all shipments by truck should be $(2.2 \times 10^6) \div (8.9 \times 10^4) \cong 25$ times greater than the impacts given in DOE/ET-0029.

A ratio can also be developed for rail shipments. The reference system has 100% of shipments from ISFSFs to the final repository being transported by rail and no conversion to a 100% rail system is needed here. For shipments from reactors to ISFSFs, the reference system has 90% of all shipments transported by rail. Table 4.1.1-3 of DOE/ET-0029 shows 89,000 reactor shipments, through the year 2050, transported by rail. Since this is 90% of all shipments, an all-rail shipment scenario would have about

Comment Number

99,000 rail shipments. To this total must be added the 120,000 rail shipments from ISFSFs to final repositories, also shown in this table, for a total of 219,000 shipments for an all-rail scenario. For the reference system, the total number of rail shipments is 89,000 + 120,000 = 209,000 shipments. Thus, the ratio of the number of rail shipments for an all rail shipping scenario to the number of rail shipments in the reference scenario is 219,000 ÷ 209,000 = 1.05. Impacts presented in the GEIS for rail shipments should therefore be 1.05 times greater than impacts given in DOE/ET-0029.

A comparison of some of the GEIS results with those presented in DOE/ET-0029 indicates that the ratios developed in the above discussion are apparently the values used in converting impacts from one document to another. For example, on page 4.1.15 of DOE/ET-0029, Table 4.1.2-3 gives a value of 3.1×10^2 man-rem for the dose to the population living along the transport route, through the year 2050, for spent fuel truck shipments. Using the ratio derived in the above discussion, the impact presented in the GEIS, for an all truck shipping scenario, should be 25 times greater giving a value of 7.8×10^3 man-rem and indeed the result given in the GEIS is 8×10^3 man-rem. There are some values, however, that do not agree after this ratio is applied. Cases where there is a lack of agreement between the two documents are outlined in a table which follows the discussion of rail shipments.

For rail shipments, it is more difficult to determine if results for the reference system given in DOE/ET-0029 have been properly converted to an all rail system which is used as the basis for impacts in the GEIS. The difficulty arises because the two systems are so similar and only differ by the 10% of shipments from reactor to ISFSFs that are transported by rail. It is difficult to determine if the ratio of 1.05 derived above has been used or whether a ratio of 1.11 has been used. The 1.11 ratio is obtained from the fact that the reference system has 90% of shipments from reactors to ISFSFs transported by rail, and this may have been improperly applied to the total system to include shipments from ISFSFs to final

Comment Number

repositories which for both systems are 100% by rail. In addition, both ratios are close to 1.0 and some results presented in the GEIS have been rounded off, making it difficult to determine which ratio, if any, has been used. For example, the amount of diesel fuel needed through the year 2050 is given in Table 4.1.1-5 of DOE/ET-0029 as 1.7×10^6 m^3. On page N.3 of the GEIS, it is stated that 2×10^6 and m^3 of diesel fuel is needed for an all rail shipping scenario. It is therefore difficult to determine what, if any, ratio was applied to obtain this result. The following table outlines cases where the impacts presented in the GEIS are substantially different than properly converted values obtained from DOE/ET-0029. Values given in parentheses are the results that would be obtained if DOE/ET-0029 values are multiplied by the appropriate conversion factor developed in the above discussion, i.e., 25 for truck shipments, 1.11 for rail shipments. It should be noted that there is one impact where apparently the incorrect ratio of 1.11 was used instead of 1.05. This is the result for nonradioactive effluents released through the year 2050 for spent fuel rail shipments. Table 4.1.1-6 of DOE/ET-0029 shows, for example, that 4.8×10^3 MT of particulates will be released under these circumstances. Applying the incorrect ratio of 1.11 gives a result of 5.3×10^3 MT and this agrees with the result presented in Table N.4 of the GEIS. If the proper ratio of 1.05 had been used, the GEIS result would be 5.0×10^3 MT. This improper ratio has been applied to all the nonradioactive effluents. Since the results are not substantially different and are within the uncertainty of these types of calculations, improper conversions of this type are not included in the following table. It is recommended, however, that for accuracy and consistency, the values given in the GEIS be properly converted.

2.d.17 p. N.4

Repeated reference to discussion of trucker's dose on P. N.4 is misleading. The reference on p. 13 indicates the discussion on p. N.4 explains the overestimate of the dose and the reference on p. N.16 indicates the discussion on p. N.4 is based on experience. The actual discussion on p. N.4 satisfies neither of these descriptions.

Comment Number	Impact	DOE GEIS Value	DOE GEIS Location	DOE/ET-0029 Value	DOE/ET-0029 Location	Remarks
	Resource commitments, spent fuel rail casks through the year 2050	Values given are identical to those in DOE/ET-0029 90% of shipments by rail	Table N.3 pN.3	Values given are for reference case of 90% of shipments by rail	Table 4.1.1-2, p.4.1.5	Values in GEIS need to be corrected by factor of 1.11
	Resource commitments, spent fuel truck cask through the year 2050 (MT)		Table N.3 pN.3		p.4.1.13	It appears that some ratio different than 25 was used for these resource commitments although no explanation can be found in the document
	Stainless steel	2500 (3000)		120		
	Chromium	450 (550)		22		
	Nickel	200 (240)		9.6		
	Lead	17000 (20000)		800		
	Dose to transport work force through the year 2050, rail shipment, spent fuel (man-rem)	2×10^2 (2.8×10^3)	pN.4	2.5×10^3	Table 4.1.1-7, p4.18	

Comment Number

2.d.18 p. N.4

Lines 5 & 6: Did this result take into account the growth of population along the transport route during the 70 year period?

2.d.19 p. N.4

Paragraphs 3 & 4: An inconsistency exists between these two paragraphs. In the third paragraph, it is stated that population doses are calculated based on the permissible limit of radiation. Individual doses given in the fourth paragraph are taken from WASH-1238 which used dose rate values derived from experience rather than permissible limits. In addition, these WASH-1238 numbers were obtained from considering average exposures resulting from the transport of fuel and waste from a power reactor. Since the discussion on page N.4 of the GEIS concerns transportation of spent fuel, it would be better to examine the WASH-1238 analysis of exposures due to transport of spent fuel which can be found on pages 40-42.

2.d.20 p. N.4

A reference to NRC/DOT/State surveillance program results would be useful for adding realistic perspective and credibility to the estimates of maximum driver and handler exposure in transportation. See "Summary Report of the State Surveillance Program on the Transportation of Radioactive Materials," NUREG-0393.

2.d.21 p. N.4

The transportation accident consequences presented on page N-4 of the GEIS are based on accident number 6.2.8 described in Table 6.2.6 of DOE/ET-0028. Releases of cesium are based on vaporization mechanisms as reported in Supplement II to WASH-1238. A study conducted by Battelle's Pacific Northwest Laboratory, "An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck," PNL-2588 indicates that other mechanisms can cause additional releases of cesium and other isotopes. These mechanisms involve either oxidation or leaching of the fuel. Releases of radioactive material resulting from these mechanisms can occur in addition to the releases used

Comment Number

Impact	DOE GEIS Value	DOE GEIS Location	DOE/ET-0029 Value	DOE/ET-0029 Location	Remarks
Dose to transport work force through the year 2050, truck shipment, spent fuel (man-rem)	2×10^5 (3.5×10^5)	pN.4	1.4×10^4	Table 4.1.2-3 p4.1.15	
Dose to maximum individual from severe truck accident, spent fuel shipment (rem)	24	pN.4	10	Table 4.1.2-9 p4.1.19	Accident doses should agree regardless of the percentage of shipment by truck or rail
Nonradioactive effluents, spent fuel rail shipments through the year 2050 (MT)					
Alderydes	No value given for these effluents	Table N.4 pN.3	1.1×10^3 1.4×10^3	Table 4.1.1-6 p 4.1.7	
Organic Acids					

Comment Number

in accident number 6.2.8. The probability of accidents occurring where several release mechanisms operate is less than the probability associated with accidents where only a few release mechanisms operate. Thus the risk may be greater for the latter accident than the one involving many release mechanisms. Recommend the GEIS address these accidents that involve several release mechanisms and show that either the risks involved are less than those of accident number 6.2.8 or if the risks are greater, this more severe accident should be used as the umbrella source term for severe accidents.

2.d.22 p. N.4

Although the radiation dose to the maximum individual from postulated accidents are given, the total population dose to persons in the vicinity of the accident is not given. Since this is an important environmental impact, it should be included in the GEIS in context with accident frequencies.

The actual value for this population dose can be found on page 4.1.10 of DOE/ET-0029. The 70 year dose commitment is given as 140 man-rem. Although the analysis uses a population density of 90 persons per square km for routine radiological impacts, the population density used for the accident analysis is 130 person per square km. Note that population densities in suburban or urban areas can be at least an order of magnitude higher than this population density. A severe accident occurring in a suburban or urban area would, therefore, have a substantially greater environmental impact than the accident consequences presented in the GEIS. In order that all relevant impacts be included in the GEIS, recommend including the consequences of severe accidents in high population density areas.

The largest accident dose reported in the GEIS results from a severe accident involving a rail shipment of spent fuel. The resulting whole body dose to the maximum individual is given as 120 rem for a one year period following the accident. The dose is based on the amount of radionuclides released to the atmosphere as given in Table 4.1.1-12 of DOE/ET-0029. The amounts given in this table are based on release fractions

Comment Number

given in Table 6.2.6 for accident number 6.2.8 in DOE/ET-0028. An examination of the release fractions and cask inventories given in DOE/ET-0028 indicates that the amount of radionuclides given in DOE/ET-0029 and hence the dose reported in Appendix N are in error. There are three sources of error. Mixed fission products and actinides have been excluded from the release, the amount of Kr^{85} released is underestimated, and the amount of Cs^{137} released has been overestimated.

Finally, the following discussion shows that the amount of Cs^{134} and Cs^{137} released for accident number 6.2.8 has been overestimated. The discussion on page 6.2.14 of DOE/ET/0028 indicates that 6×10^{-4} of the cesium inventory may be available for release as a result of fuel rod perforation in a high temperature environment. This result is taken from Supplement II to WASH-1238. According to Table 6.2.6 of DOE/ET-0028, the availability fraction is divided in half between Cs^{134} and Cs^{137}. Table 3.3.8 of DOE/ET-0028 shows a cask inventory of 1.7×10^5 curies and 9.4×10^4 curies per MTHM for Cs^{134} and Cs^{137}, respectively. Since a cask contains 4 MTHM, this results in 6.8×10^5 curies of Cs^{134} and 3.8×10^5 of Cs^{137} in a cask. Applying the availability fraction of 3×10^{-4} for each isotope yields 204 curies of Cs^{134} and 114 curies of Cs^{137} available for release. Since in accident number 6.2.8, 50% of fuel rods are perforated, this results in 102 curies of Cs^{134} and 57 curies of Cs^{137} being released in this accident. Table 4.1.1-12 of DOE/ET-0029 shows 200 curies of Cs^{134} and 110 curies of Cs^{137} being released. Perhaps the fact that only 50% of the rods are perforated was not taken into account.

We recommend that the radiation dose to the maximum individual resulting from this accident be reevaluated in light of the above comments.

2.d.23 p. N.4

The consequences presented in page N.4 for severe accidents are based on the dose received by persons from radionuclides released to the atmosphere. Since severe accidents may cause a reduction in shielding efficiency, doses resulting from radiation emanating directly from the cask should

Comment Number

also be evaluated. The description of severe accidents in Table 6.2.6 of DOE/ET-0028 indicates a small opening will exist in the cask.

Accident number 6.2.8 is based on number 6.2.7. Number 6.2.8 assumes that no emergency action is taken to cool the cask involved in the 6.2.7 accident. This results in 50% of the fuel rods being perforated in number 6.2.8 instead of only 1% being perforated in number 6.2.7, in addition to 100% of the coolant being released in both accidents. Thus, release fractions in number 6.2.8 should be 50 times higher than in number 6.2.7. Indeed, for Kr^{85}, I^{129}, and H^3 the release fractions given are 50 times higher for number 6.2.8 than for 6.2.7. However, although mixed fission products and actinides are reportedly released in number 6.2.7, only Cs^{134} and Cs^{137} are reported as being released in number 6.2.8. This can also be seen in Tables 4.1.1-10 and 4.1.1-12 of DOE/ET-0029 which gives the actual number of curies released. Note that Table 4.1.1-10 gives the curies released for accident number 6.2.6, a moderate accident in which only 5% of the cavity coolant is released and only 0.25% of the fuel rods exhibit cladding failure. The table shows fission products such as Sr^{90} and Nb^{95} and the actinides such as Pu^{239} and Cm^{242} being released. Table 4.1.1-12, which lists the radionuclides released for accident number 6.2.8, the severe accident, does not contain any of the additional fission products or actinides listed for the less severe accident. Is this simply an oversight or is the contribution to the dose from these nuclides negligible compared to the dose resulting from the nuclides that are listed?

A study conducted by Battelle's Pacific Northwest Laboratory, "An Assessment of the Risk of Transporting Spent Nuclear Fuel by Truck," PNL-2588 uses release fractions for actinides and fission products other than gases that are significantly higher than those derived from the accidents described in DOE/ET-0028. As previously shown the release fractions for actinides and mixed fission products in accident number 6.2.8 should be 50 times higher than those used in accident number 6.2.7. Table 6.2.6 of DOE/ET-0028 shows a release fraction of 1×10^{-8} for actinides and mixed fission products for accident number 6.2.7. The release fraction for accident number 6.2.8

Comment Number

should therefore be 5×10^{-7}. Table B.2 of PNL-2588 shows a release fraction of 2×10^{-5} for actinides and other fission products. Note that both of these release fractions are for accident scenarios that involve creep rupture of fuel rod cladding. Since in accident number 6.2.8 it is assumed that 50% of the rods fail the release fraction for actinides and other fission products should be 1×10^{-5} if the results of PNL-2588 are used. Recommend the basis for the release fractions used in DOE/ET-0028 be reexamined and any discrepancies with the fractions used in the PNL study be resolved.

The following discussion shows that the amount of Kr^{85} released for accident number 6.2.8, the most severe accident, has been underestimated. Table 6.2.7 of DOE/ET-0028 indicates that 30% of the Kr^{85} will exist in fuel rod void spaces. Accident number 6.2.8 assumes that 50% of the fuel rods are perforated so that the release fraction reported in Table 6.2.6 of DOE/ET-0028 is 0.15. This table also indicates that the cask inventory given in Table 3.3.8 of DOE/ET-0028 should be used for determining the actual number of curies released. Table 3.3.8 indicate 9.5×10^3 curies per MTHM. Since Table 6.2.6 indicates that a cask will contain 4 MTHM, this means a total inventory of 38×10^3 curies of Kr^{85}. With a release fraction of 0.15, this results in 5.7×10^3 curies of Kr^{85} being released. Table 4.1.1-12 of DOE/ET-0029 shows only 5.3×10^3 curies of Kr^{85} being released.

2.d.24 p. N.5

Paragraph 3: Some discussion should be included describing the composition of a special train and the advantages and disadvantages resulting from its use. Is it a safer mode of transport? Does it have better safeguard features?

2.d.25 p. N.6

Line 23: Can an aerial radiation survey detect a spent fuel cask that has not been breached and is located inside a building?

Comment Number

2.d.26 p. N.7

The statement on prime considerations may be misconstrued. The prime safety considerations in transportation packaging are containment, shielding, and subcriticality. Heat dissipation is not a prime safety consideration but is important to the performance of the other safety features.

2.d.27 p. N.7

Why is the cask maximum thermal design load set at 50 kW?

2.d.28 p. N.9

Last paragraph: The accident postulated here results in 37 rem to the total body. Table 3.1.88, page 3.1.224, shows the results of the worst design basis accident, which for SHLW - severe impact and fire is 7 rem.

2.d.29 p. N.13, 16, 21

On pages N.13, N.16, and N.21 reference is made to page N.4 and a discussion on dose to truckers. The reference on page N.13 indicates the discussion on page N.4 explains the overestimate of the dose and the reference on page N.16 indicates the doses discussed on page N.4 are based on experience. These references are misleading since the discussion on page N.4 satisfies neither of these descriptions. Is the reference intended to apply to WASH-1238 which is the basis for the truckers dose given on page N.4?

e. Safeguards

2.e.1 General

The uranium-only fuel cycle is not addressed from a safeguards standpoint although the health, safety and environmental aspects of the U-only fuel cycle are discussed. In addition, although the basic purpose of a safeguards system is identified, there is no discussion of the concepts or elements of safeguards systems potentially applicable to each waste form and storage mode. Also, the draft GEIS does not identify how much effort would be needed to mine the waste nor does it address the issue of how the repository management would assure the public that all waste material is in its

Comment Number

authorized location if faced with a blackmail threat after closure of a repository. Finally, the draft GEIS should make clear the kind of adversary that is considered when a safeguards system is designed.

2.e.3 p. N.6

The NRC has promulgated an interim rule on physical protection of spent fuel shipments (Federal Register 44, 34466 (June 15, 1979). Accordingly, the footnote is no longer valid.

f. Other Fuel Cycle Alternatives

2.f.1 p. 1.10

Allusion to Alternate Fuel Cycle

On page 1.10 (and elsewhere) the statement is made that a separate and distinct nuclear fuel cycle might be in existence to receive 1300 metric tons of plutonium by the year 2040. This "Alternative" fuel cycle would also produce radioactive waste. Although this disposition may appear to be possible, the more prudent approach would be to consider this excess plutonium to be TRU waste requiring safe disposal in a repository. However, if credit is to be taken for use of the plutonium in this "alternative" fuel cycle, the disposal of radioactive wastes from this fuel cycle should be discussed.

2.f.2 p. 3.1.226

The discussion on page 3.1.226 of other fuel cycle alternatives is out of place in the section on geologic disposal impacts. There is no relationship drawn between the impacts shown in this section and this discussion of other fuel cycles.

Comment Number

3. CONVENTIONAL GEOLOGIC DISPOSAL

3.a Siting

3.a.1 p. 1.5

The discussion of multiple barriers should also indicate the barrier-like effect of the liquid transport processes that result in dilution and dispersal of radioactive material. While these processes are technically not barriers, they serve almost the same function by reducing the amount of material reaching a specified point and by increasing the time for a specific quantity of material to reach a location.

3.a.2 p. 3.1.5

The section on Hydrology of Host Rock is highly simplified. For more detailed explanations standard reference works such as the following should be cited:

Bear, J., Dynamics of Fluids in Porous Media, American Elsevier, New York, 1972

Bear, J., Hydraulics of Groundwater, McGraw-Hill, New York, 1979.

Bouwer, H., Groundwater Hydrology, McGraw-Hill Book Co., New York, 1978

Davis, Stanley N. and R. J. M. DeWiest, Hydrogeology, J. Wiley and Sons, New York, 1966.

DeWiest, Roger J. M., Flow Through Porous Media, Academic Press, New York, 1969.

Domenico, Patrick A., Concepts and Models in Groundwater Hydrology, McGraw-Hill, New York, 1972.

Freeze, R. Allan and John Cherry, Groundwater, Prentice-Hall, 1979.

International Association for Hydraulic Research, Fundamentals of Transport.

Phenomena in Porous Media, Elsevier Publishing Co., New York, 1972.

Johnson Division, Universal Oil Products Co., Ground Water and Wells, St. Paul, Minnesota, First Edition, 1966, 2nd Printing, 1972.

Comment Number

Lohman, S. W., Ground Water Hydraulics, U.S.G.S. Professional Paper 708, U.S. Government Printing Office, Washington, D.C., 1972.

Polubarinova-Kochina, P. Ya., Theory of Groundwater Movement, Princeton University Press, Princeton, New Jersey, 1962.

Walton, W. C., Groundwater Resource Evaluation, McGraw-Hill, New York, 1970.

3.a.3 p. 3.1.10

The reference cited (#8) for Figure 3.1.1 is incorrect for this figure. The information is not found in that report. However, there is an identical map in Y/OWI/TM 36/3. This was derived from USGS Bulletin 1148. The original reference should be used especially since it is readily available to the public whereas the contractor report is not.

3.a.4 p. 3.1.11

An explanation should be provided as to why the areas shown in Fig. 3.1.2 are favorable granitic sites. Certainly there are many other areas of the U.S. where granitic rocks are either at, or close to the surface, e.g., St. Francois Mts. of Missouri, Llano uplift of Texas, Wasatch and Uinta Mts. of Utah, the Big Horns of Wyoming, and the shallowly buried part of the Nemaha Ridge.

3.a.5 p. 3.1.11

The reference cited for Fig. 3.1.2 is incorrect and it could not have been developed from the information found in Reference 9. However, it appears in Y/OWI/TM 36/3 and is based on a diagram in OWI-76-27. Original sources should be used.

3.a.6 p. 3.1.12

p. 7.2.9, DOE/ET-0028

It would be better to use either a more recent reference than Pirsson's 1947 book or to be more selective in the data excerpted from Pirsson. For example, the silica content of the granite is rather high. It turns out

Comment Number

that this represents a single sample from Pikes Peak (Pirsson, pg. 169) It would have been better to use Tschirwinsky's average of 90 analyses (Pirsson, pg. 169) which results in a significantly different chemical composition for an "average" granite. An alternate source of information is Clark, S.P., 1966, "Handbook of Physical Constants," Geol. Soc. of Amer.

3.a.7 p. 3.1.13
p. 7.2.10, DOE/ET-0028
Figure 3.1.3 does not appear in Reference 10 as indicated in GEIS. Apparently it was adopted from a similar but slightly different diagram in Y/OWI/TM 36/3 which was adapted from OWI-76-26 and Tourtelot 1962. The orginal references should have been used. The figure's caption implies that it shows all the shale formations (sic) in the U.S.. However, there are a number of significant omissions such as the thick shales found in the Appalachian foldbelt, the Ouachita Mts., Anadarko Basin, and the Midland, Marfa, and Delaware Basins of West Texas.

3.a.8 p. 3.1.14
The table is very important since it is a direct numerical comparison of major host rock types. Therefore, the selection of numerical ratings for each characteristic of each rock type should be discussed.

3.a.9 p. 3.1.14
p. 7.2.13, DOE/ET-0028
Figures 3.1.4 and 7.2.4 are incorrectly referenced, are incorrect and misleading:

1. They fail to show some of the other basalt areas which should be assessed as candidates for deep geological burial of HLW, e.g., Colorado Plateau, Rio Grande Valley, San Juan Mts. of Colorado, Snake River Plains, Triassic Basins of the Carolinas, Virginia and Pennsylvania.

Comment Number

2. The Keweenawan Series is misplotted as is the Triassic of N.J. and Connecticut. This is not surprising as the map of the Keweenawan which was supposedly used in compiling this map (Y/OWI/TM 36/7, Figure 3-1) is illegible.

3. Reference Y/OWI/TM 36/7 is cited as a source of information for the location of the Triassic "Lavas." There is no information on the Triassic in this publication.

4. The expression Keweenawan and Triassic "Lavas" is misleading, as many of these basalts are not extrusive igneous rocks, e.g., Palisades Sill.

5. Figure 7.2.4 could not have been developed from information found in Y/OWI/TM-44.

3.a.10 p. 3.1.32
The first paragraph does not reflect fissure and joint permeability differences, and induced characteristics due to construction. The final paragraph makes an assertion that is not supported; i.e., no bases have been provided to support the conclusion that groundwater inflow can always "...be controlled by state-of-the-art engineering technology."

3.a.11 p. 3.1.67
The age of the earth is given as 10 billion years. The current geologic estimate of the age is 5 billion years.

3.a.12 p. 7.2.2, DOE/ET-0028
The statement that: "The repository should not be sited in or near an area in whch igneous or volcanic activity has occurred during the post-Pleistocene" should be assessed and actively discussed by DOE. An assessment should be made of the potential for volcanic activity and its impact

Comment Number

on repository performance. The assessment should estimate the actual effects, detrimental or beneficial, on repository performance by different types of eruptions.

3.a.13 P. 7.2.3,DOE/ET-0028

The credibility of section 7.2.2 is weakened by either a lack of documentation for the statements (e.g., see pg. 7.2.6 Southwest Florida) or the use of very old references (e.g., see 7.2.6 para. 3 on the Supai Formation of the Holbrook Basin of Arizona) when more recent material should be available.

3.a.14 p. 7.2.3, DOE/ET-0028

Figure 7.2.1. was adapted from Y/OWI/TM-44, which was adapted from Pierce and Rich, USGS Bulletin 1148. The original source should have been used in developing this figure.

3.a.15 p. 7.2.3, DOE/ET-0028

The geologic term "Formation" is misused throughout the GEIS. Although this appears to be a minor editorial comment, it may have legal ramifications. The term is defined in the American Code of Stratigraphic Nomenclature which is to be found in the Bulletin of the American Association of Petroleum Geologists (1961, pp. 645-660). Basically, a formation is a specific rock unit which has distinctive lithologic characteristics which allows it to be mapped. Sandstone, limestone, shale, granite and basalt are not formations, whereas rock bodies such as the Dakota Sandstone, Salem Limestone, Pierre Shale, and Louann Salt are.

3.a.16 p. 7.2.8/7.2.9, DOE/ET-0028

The statement that the "mineral components of granite are almost inactive chemically under ambient temperature and pressure conditions" is misleading. Granite does decompose at surface temperatures and pressure as evidenced by well developed regoliths found on top of many granites.

Comment Number

3.a.17 p. 7.2.9, DOE/ET-0028

The statement that igneous rock "...range in chemical and mineralogical composition from granite to closely related rocks such as granodiorite" is technically true but misleading. The range goes far beyond granodiorite through gabbro to pyroxenite and dunite.

3.a.18 p. 7.2.9, DOE/ET-0028

The statement that granite has "...little ability to deform under stress..." is not true. Under varying combinations of the following: (1) high confining pressure, (2) elevated temperatures, or (3) when the stresses are applied for long time spans, granite will deform.

3.a.19 p. 7.2.9, DOE/ET-0028

The statement that "granite is mostly composed of silica and mica" is misleading. Mica makes up a small percent of most granites and quartz rarely exceeds 30%. Mention should be made of other minerals common in granite such as the feldspars and ferromagnesian minerals.

3.a.20 p. 7.2.10, DOE/ET-0028

The basic references of Pirsson 1947 and Gilluly, Woodford, and Waters, 1968 should be replaced by reference to one of the following: Robert L. Folk's Petrology of Sedimentary Rocks (Hemphill's, Austin, Texas), Blatt, Middleton, and Murray's Origin of Sedimentary Rocks Prentice-Hall or Pettijohn's Sedimentary Rocks, Harper Brothers, N. Y.

3.a.21 p. 7.2.10, DOE/ET-0028

Contrary to line 5, Table 7.2.1 gives no direct information on the mineral content of shales.

3.a.22 p. 7.2.12, DOE/ET-0028

The statement that basalt is an "extrusive volcanic mafic (high in magnesium rock silicates) rock" is doubly misleading: (1) Not all basalts are extrusive, e.g., Palisades Sill, and (2) the mafic minerals are not limited to magnesium silicates.

Comment Number

3.a.23 p. 7.2.12, DOE/ET-0028

Section 7.2.2.4 leaves the impression that basalt has a low permeability. There are many situations in which this is not the case, e.g., Idaho Falls, or the domestic water sources on the Hawaiian and Canary Islands.

3.b Waste Form and Packaging

3.b.1 p. 4.1.30

The 3rd paragraph states that fluid bed calcination was identified in a previous report (ERDA 76-43, Vol. 2, Chapter 6) as being the most well-developed calcination process and, therefore, has been selected as the reference calcination process for this report. However, page 4.1.4 states that the reference vitrification processs is spray calcination/in-can melting. The report should clarify why one calcination process is referenced to make glass waste form and another to make a calcine waste form.

3.c Design and Operation

3.c.1 p. 1.9/1.10

The staff has attempted to corroborate the numerical values given in Tables 1.1 and 1.2. In attempting to understand the bases for the tables and the connection between them, other parts of the GEIS and the supporting documents were searched. Neither the numerical values nor the relationship between the two tables could be substantiated. Therefore, we recommended that you provide a detailed explanation in the GEIS text of the method whereby the numberical values of Tables 1.1 and 1.2 were developed. It would be helpful if intermediate tables were prepared which indicate how Table 1.1 relates to Table 1.2. The headings (or footnotes) on Table 1.1 should clearly indicate what HLW or TRU wastes are included in each column.

3.c.2 p. 2.1.22

The rates of receipt of spent fuel at the repository are presented. The maximum receipt rate of 12,000 MTHM/yr converts to 40,400 canisters/yr (assuming 0.297 MTHM/canister per Table 2.1.8).

Comment Number

According, to Section 7.4.5 of DOE/ET-0028, the repository is operating around the clock for a total of 175 days/year or 4200 hours/yr. This means that canisters are disposed of at a rate of 10 per hour, when 12,000 MTHM/hr are received. Considering the remote handling required these rates appear unrealistically high. The design of handling systems to accomplish this should be presented.

3.c.3 p. 3.1.30 and 3.1.116

GEIS states that: "The effects of rock discontinuties on rock strength are difficult to evaluate..." "A structural system of grounded rock bolts, wire mash and shotcrete effectively support this type of ground (shale)." "The shale surfaces can be protected...to prevent slaking" (p. 3.1.30).

Ground support in a shale repository at depths of about 600 m is likely to be a major and costly problem. It is more likely that reinforced concrete shields will have to be used extensively in all main corridors, crusher rooms and places that have to be kept open for retrievability. Support system will likely be similar to that used in the Washington Metro or in the Clear Creek Tunnel. The support costs on p. 3.1.116 for shale are clearly underestimated.

3.c.4 p. 3.1.31

"Under high stresses and temperatures the room closure rates may be high... engineered support would be necessary... A support system can be provided...."

Since closure rates are expected to be high, the GEIS should describe the support systems and expected closure rates and the effectiveness of the support systems.

3.c.5 pp. 3.1.35, 3.3.12, K.2, K.3, K.11
pp. 7.3.6, 7.3.12, 7.4.2; DOE/ET-0028

The GEIS evaluates the impacts of 5 year and 25 year retrievability. Given the uncertainties concerning geologic emplacement in mined repositories raised by the IRG and the GEIS which must be addressed by site specific

Comment Number

in-situ tests, it appears prudent to provide capability for retrievability of the wastes for the normal operating life of the repository and for as many years thereafter as may be needed to retrieve the emplaced wastes. The GEIS should address retrievability in a fashion that the potential for such retrievability can be properly assessed.

The following examples are cited:

A conclusion that readily retrievable conditions in a repository in salt would prevail in storage rooms for at least five years is based on linear thermomechanical analyses. The time behavior of salt under thermal and mechanical loading cannot be approximated as a linear relationship. The GEIS makes an allowance of two feet to accommodate for expected closures (expected closures are not specified).

Project Salt Vault, Chapter 12 presents several figures (Figure 12.36, etc.) that describe pillar behavior as a function of mechanical and thermal loading and time. A 50% shortening of a pillar is expected when subjected to a load due to 8000 psi stress and 100°C temperature during a period of 200 hours. Similar results presented are 28% shortening under 6000 psi at 22.5°C for 30,000 hours and 45% shortening under 200 psi at 200°C for 500 hours. The behavior exhibited is not linear and a significant underestimation of closure will be obtained if a linear approximation is used.

If later studies have been used to discount the results of Project Salt Vault, they have not been identified in GEIS. Consideration of the creep behavior of salt under thermomechanical loading is important for the design of a repository in salt because it will affect the short (operational) and long (retrievability) term stability of storage rooms and access ways. If stability is compromised, the integrity of the impermeable barrier between the salt bed and overlying aquifers that is assumed by GEIS, may be compromised. This would lead to problems associated with groundwater movement in salt that have not been addressed.

Comment Number

Based on Project Salt Vault data (ORNL-4555, Chapter 12) the mine layout design postulated by GEIS for a repository in salt would therefore be inadequate. This would necessitate a different design that would consider the thermomechanical effects on salt mass behavior. Extraction ratios may have to be reduced, room and pillar dimensions changed, etc.

3.c.6 pp. 3.1.28, 3.1.36, 3.1.41, 3.1.120, 8.4.7

The subject of occupational radiation exposure is not adequately addressed in the GEIS. It should be considered in connection with short term environmental impacts and the probability of various accidents occurring during the handling and emplacement of waste canisters.

3.c.7 p. 3.1.36

The statement is made in the fourth paragraph that the costs for additional support necessitated by the reduction in rock strength due to radiation, are not expected to be significant. The basis for this conclusion should be presented.

3.c.8 p. 3.1.37

The statement, ".... maintaining retrievability longer than needed to reasonably assure repository operation increases the occupational and general populace risk." is unsubstantiated.

3.c.9 pp. 3.1.104, 3.1.107, 3.1.110, 3.1.112, K.17, K.113, K.115
pp. 7.2.22, 7.4.4; DOE/ET-0028

A major deficiency in the design of the repositories in granite, shale, and basalt is that they have been designed as if the host rock were salt. The repositories in the four geologic media should not be of similar design. For instance, the inherent structural characteristics of granite have not been taken into consideration. The design of a mine in hard rock is substantially different from that in salt. Where, by the nature of the material, a repository in salt is confined to a single level, a repository in massive granite need not be. The long term stability of large rooms in granite is well known. Transportation could be by track systems - either

Comment Number

conventional or suspended on roof mounted tracks; manually operated or remote controlled. Rooms could be in the traditional orthogonal pattern as presented or they could take on different configurations. The alternative repository layout possibilities in granite are not addressed in TM-36. In general, the preconceptual repository design procedure is not clear, and lacks a logical, consistent argument. Little attempt is made to evaluate the design either in part or in total, in terms of the risks associated with nuclear waste storage, particularly the long-term containment aspects. Therefore, it is difficult to judge the adequacy of proposed design measures and safety features.

3.c.10 p. 3.1.116

It is difficult to comment on the resource requirements presented in Table 3.1.11 without having access to their back-up. It is, however, strange that construction steel, lumber and concrete costs per MTHM for granite are greater than those for salt. Granite is structurally far superior to salt, has no creep characteristics and relatively lower risk of being inundated by water from an overlying aquifer. Retrievability in granite should be easier.

Support requirements in salt, in order to maintain access to the storage rooms during the retrievable period is expected to be considerably greater than in granite and basalt. The problem in salt is compounded by a high level of uncertainty regarding the behavior of the salt rock mass when subjected to thermal and mechanical loading.

It appears that the resource requirements are biased in favor of salt due to poor design of repositories in other media. The differences between the unit resource figures for salt and those for granite and basalt are not adequately justified.

3.c.11 p. 3.1.133

The statement that "granite unit costs are less than those for shale" is inconsistent with the data presented in Table 3.1.28 on page 3.1.134.

Comment Number

.c.12 p. K.5, Appendix K

The design of the repository used in the GEIS is a single level room and pillar mine for all media and waste types. Thermal criteria are then used to set capacities for each medium and fuel cycle. Optimization of the design for a given waste type in a particular medium would likely result in different capacity estimates.

3.c.13 P. K.8

Figure K.6 shows a smaller temperature increase after emplacement of waste for a repository in shale (Figure K.6, page K.8) than for a repository in salt (Figure K.2). The opposite should be true because the temperature increase should be inversely proportional to the thermal conductivity and shale has a lower thermal conductivity than salt as shown in Tables 7.2.6 and 7.2.3, respectively.

3.c.14 p. K.19, Appendix K

It is stated that 25-year retrievability requires lower thermal densities. For salt and shale the decrease is a factor of 2 while for granite and basalt it is 2.5. Hence costs increase by the same factor. The reason given is the need to maintain room and pillar stability for 25 years. Why is the effect greater for granite and basalt?

3.c.15 p. 7.1.2 and 7.2.18, DOE/ET-0028

"...there were no immediate detrimental effects on the stability of salt as a result of exposure to heat or radiation"

"The physical behavior of salt is drastically affected by temperature. ...for a rise in temperature from 20°C to 100°C the strain increased by a factor of seven."

The GEIS should discuss whether retrievability in salt can be guaranteed under the expected thermal loadings. It should also discuss whether the integrity of seals in the salt repository can be maintained following closure.

Comment Number

.c.16 pp. 7.2.4, 7.3.16; DOE/ET-0028

"(Creep) is difficult to stablize in tunnel openings."

"From experiments....equations can be developed to describe the creep behavior of salt"

Since equations have been developed which describe the behaviour of salt a posteriori, the GEIS should discuss whether or not they can predict the behaviour of salt under thermomechanical loading conditions?

3.c.17 pp. 7.4.24/25; DOE/ET-0028

Several potential occupational and environmental hazards are associated with the ventilation design as described in DOE/ET-0028 and in Y/OWI/TM-36. The following questions need to be considered:

- What are the risks of escape of radionuclides via the fresh airway as a consequence of a transportation accident underground?
- How will the integrity of seals between fresh airways and storage rooms be maintained if closures of up to 2 feet are expected in a repository in salt?
- What are the risks associated with backfilling and retrieval operations?
- What measures will be taken to reduce respirable dust to acceptable concentrations? Note that mining in granite will have an associated health hazard due to the siliceous type of dust generated. What are the expected health effects due to dust?

3.c.18 p. 7.4.30, Table 7.4.11, DOE/ET-0028

No estimate of occupational risk is included in the accident analyses nor is there any discussion of possible impacts on continued repository operation, repository closure or retrieval of waste already emplaced. For example what will such impacts be for accident 7.5 or 7.6.

Comment Number

For Accident 7.6, the safety system is a failsafe wedge type braking system on the cage. What is the maximum allowable braking distance of the cage for the expected release?

3.c.19 Appendix 7A, DOE/ET-0028

The tables in this Appendix present the mining and construction costs for a repository and its support facilities (surface). Operating and decommissioning costs for a repository should also be given and taken into account in comparing the alternatives. The GEIS should consider all costs that will be incurred through repository closure.

3.c.20 Y/OWI/TM-36

TM-36 lacks supporting analyses for salt. For example:

Hydrology: Volume 21 "Ground Water Movement and Nuclide Transport" addresses granite, shale and basalt - no salt.

Thermomechanical: Volume 20 "Thermomechanical Stress Analysis and Development of Thermal Loading Guidelines" addresses granite, shale and basalt - no salt.

3.c.21 General Comment

The problems associated with retrievability have not been adequately discussed in GEIS. The following are specific areas of concern regarding retrievability.

- Occupational hazards associated with retrieval options. Depending on the time delay between retrieval and emplacement operations and the geologic medium of the repository, some canisters may be corroded, damaged or stuck (due to deformation or spalling host medium) such that there will be a risk of exposure to the workers involved in the retrieval operations. There could also be a risk of escape of radionuclides into the biosphere if the integrity of seals separating main airways from storage rooms have not been maintained.

Comment Number

If overcoring is necessary to remove canisters, activation of the disposal media may result in radioactive dust. Occupational exposures should be estimated.

- o In order to have retrievability, all main entries (corridors), storage rooms and exhaust airways need to be kept open. Based on present day mining technology, this should not be a problem in granite and basalt. However a repository in shale will require massive support requirements to maintain retrievability and retrievability in salt is questionable. There is significant evidence that salt rock behavior under thermal and mechanical stress is such that rapid closure rates can be expected. It may be impossible to maintain integrity of seals under such closure rates. (Closures of 2 feet may reasonably be expected - TM-44, Table 5.12).

3.c.22 General Comment

The rationale for the thermal and thermomechanical limits on which repository designs are based is missing from GEIS and should be provided.

3.c.23 General Comment

The statement is made that criteria for the performance of the mined repository have not yet been established. Instead several local criteria such as limits on thermal loading, limits on area of the repository, limits on geometry (single level repository) etc. have been imposed on the design process. This appears to be a process of local optimization. It appears that imposing these limits on different geologic media results in noncomparable containment of the waste. For example: With the design process and argument presented in GEIS, would a repository in granite 200 m below the surface contain the wastes with the same level of effectiveness as the repository in salt at a depth of 580 m? Given the knowledge that large chambers in granite are feasible, different repository designs and waste storage designs should be considered.

Comment Number

3.c.24 General Comment

The discussion of costs and capacities for each medium and fuel cycle is confusing. Some of the data appears contradictory. For example:

Table 1.5 (GEIS)
Unit power costs (5 year retrievability) mill/kwh

	Spent Fuel	U + Pu recycle
Salt	0.45	0.50
Granite	0.51	0.58
Shale	0.46	0.59
Basalt	0.53	0.63

Table 3.1.26 (GEIS)
Construction Costs Including Decommissioning 10^6 $ (1978)

	Spent Fuel	U + Pu recycle
Salt	1000	1200
Granite	2600	2000
Shale	1300	1300
Basalt	3100	2300

Table 1.2 (GEIS)
Total Repository Acreage Required for 10,000 GWe-y Economy

	Spent Fuel	U + Pu recycle
Salt	16,000	12,000
Granite	6,000	12,000
Shale	12,000	20,000
Basalt	6,000	12,000

Comment Number

Comment #1 - The unit power costs do not appear to reflect the construction costs. Consider the U + Pu recycle case in which, according to Table 1.2, salt, granite and basalt each require 12,000 acres. The construction costs for granite and basalt are almost double that of salt but the unit costs reflect only 20 percent changes.

Comment #2 - The difficulties of mining in granite and basalt are comparable. Why does a repository in basalt cost $500 million more than in granite?

Comment #3 - If we compare construction costs and note that the only apparent difference is that fewer holes will be required in the U and Pu recycle case, then Table 3.1.26 is puzzling. Why, for example, does salt cost $200 million more, granite cost $600 million less, basalt costs $800 million less and shale has no difference?

3.d Safeguards

d.1 p. 1.23
First sentence, second paragraph, and the last sentence, third paragraph are assertions that are not backed up by analyses in this section or in later sections. They should be substantiated.

3.d.2 p. 1.23
Second sentence, second paragraph. From a sabotage standpoint, high-level waste without plutonium might also be an attractive material and should be included in the list of material in this sentence.

3.d.3 p. 4.16
Section 4.5.4, Safeguards and Security is incomplete for several reasons. The GEIS has been prepared for decision makers and the public. The uranium-only recycle has not been addressed in this draft GEIS from a safeguards standpoint. This and other cycles could have significant safeguards implications. In addition, this section attempts to identify the purpose of proposed safeguards systems but does not provide the decision maker or

Comment Number

public with a discussion of the concept or elements of proposed systems for specific forms of waste. It will be difficult to form a judgment on the adequacy of any safeguards system without this information.

3.d.4 p. 4.16
The footnote at the bottom of page 4.16 is not accurate. The Nuclear Regulatory Commission is studying this problem but has not yet published safeguards requirements specifically applicable to waste repositories.

3.d.5 p. 5.7, Appendix S
The uranium-only cycle should be included in the discussion and factors of attractiveness should be identified for this cycle. Because of the presence of plutonium in this cycle the sabotage and the theft susceptibilities should be analyzed separately.

Consequences and environmental impacts of successful acts of dispersal, sabotage or theft have not been considered in establishing the susceptibility index. These factors could have a bearing on the level of safeguards required in factor number 3 in the short-term susceptibility to encroachment case.

The level of safeguards appropriate for a type of waste appear to be based upon an evaluation concerning the types of wastes which would be attractive for theft or sabotage. This attractiveness criterion is inherently conjectural and should not be used as a basis for determining safeguards requirements. The appropriate considerations in this area are the potential consequences to public health and safety and common defense and security that result from successful theft or sabotage of each specific type of waste.

3.d.6 p. 5-11, Appendix S
Table S.3 "Proposed Safeguards Requirements" does not include any material control and accounting requirements. Safeguards requirements for a high-level waste repository might include some form of accountability requirements

Comment Number

during the period prior to final closure, particularly in the case of the uranium-only fuel cycle where significant quantities of plutonium would be present.

3.d.7 Appendix S

The Safeguards and Security section of Appendix S is incomplete for several reasons. The section does not address safeguards requirements for the uranium-only cycle although the GEIS includes discussions of this cycle in other areas of the statement. In addition, although a safeguards group evaluated and ranked various waste management systems from a safeguards susceptibility standpoint, there is no discussion of the methodology used by the group to arrive at the group conclusion. Thus, the work of the group cannot be evaluated.

3.e Short-Term Environmental Impacts

3.e.1 p. 3.1.41

The listed impacts are essentially written off without any perceived bases. For example, storage and disposal of mined mineral on the surface is a visual as well as potential biological impact. These impacts should be fully considered and analyzed in a generic manner, and not be left for a later determination.

3.e.2 p. 3.1.115

The surface storage of mined material is not sufficiently evaluated as an environmental impact. A more detailed impact analysis of surface storage should be provided and cross referenced whenever it is discussed.

3.e.3 p. 3.1.115-3.1.136

No discussion of the hydrologic design criteria of the surface facilities is given. If the site is to be designed to withstand the Probable Maximum Flood, so state and discuss. If not, discuss the consequences of a flood more severe than the design criteria.

Comment Number

3.e.4 p. 3.1.116

Table 3.1.11 purports to give estimates of resources needed for construction and operation of waste repositories in various geologic formation for different fuel cycle options. It also compares effluents for the various options. However, no basis for any of the numbers listed is given. The basis for such estimates should be included.

3.e.5 p. 3.1.118

Table 3.1.12 presents total quantities of effluents released to the atmosphere during construction and operation of a geologic repository. The potential effects of these effluents on ecosystems should be evaluated.

3.e.6 p. 3.1.120

There is little or no discussion of the potential hydrologic implications of repository construction and operation. For example, what would be the effects on surface drainage and downstream water quality of excavated material stored on the surface? Would the material be laid out on level surfaces, would low spots be filled in, would streams be diverted or dammed? What would happen during heavy rain and/or floods? Where would water needed for construction/operation be obtained? A description of a typical site, its construction and the hydrologic and water use impacts is needed.

3.e.7 p. 3.1.120

A more detailed discussion of the ultimate disposal of excavated material is needed. In some ways this problem is analogous to the disposal of dredged material. The volumes (tens of millions of cubic yards) are similar to those involved in large dredging operations. It cannot be dismissed out of hand without more detailed discussion.

3.e.8 p. 3.1.120

It is stated that the regional population dose for a geological resposi-tory during construction and operation is 100 man-rem. However, no reference is given to the basis for this estimate. For example, how much radon is estimated to be released during construction and operation at the repository.

Comment Number

.e.9 p. 3.1.123

Provide justification for all the assertions in the discussion of a tornado strike. Specifically: the dimensions of the salt pile, the size of the pieces, the probability of the tornado, its maximum wind speed, the amount of material removed and the resultant concentration in air.

In addition, no reason is given for discussing this accident. Is it the worst nonradiological accident possible, is it the only one considered, or is there another reason for its choice? What about other accidents? No conclusions are presented. Should measures be taken to protect salt piles from tornados? Has a cost-benefit analysis been made?

3.e.10 p. 3.1.126-132, 3.1.179-181, 3.1.184-186, 3.1.193-195, 3.1.200

GEIS is characterized as generic and not site specific (page 3.1.98). The document further states that the ability to identify socioeconomic impacts increases as one proceeds from a generic to a site-specific situation. However, a model was employed which provided and compared very specific social service demands anticipated for each of the reference sites. It is unclear why the analysis, which used actual site specific population, employment, education and housing information to estimate social service demands, did not relate the demands to existing capacities to indicate net impacts.

The reference sites are compared and the comparison reveals a range of different conditions and anticipated social service demands. Are these reference sites being presented as being representative of sites to be found in the Southeast, Southwest and Midwest areas of the country? How much variability can one expect to find among sites within the geographical boundaries of each of the above areas (Southeast, Southwest and Midwest)? If large differences are expected within each of the geographical areas, to what use is the reviewer to put comparative information presented in GEIS?

Comment Number

While a considerable amount of useful information is presented in terms of manpower needs and expected social service demands for the three reference sites, the demands are not related to the infrastructure capacities of the expected impacted communities to ascertain net impacts. The subjects of compensation, payments in lieu of taxes, and mitigation in general, need considerably more development.

3.e.11 pp. 3.1.179, 183, 188, 203

No basis for any of the values of resources committed shown in Tables 3.1.55, 62, 65, 78 are given. In addition, no units are given for operational water use, concrete, propane and electricity in Table 3.1.55.

3.e.12 p. 3.1.223

The third paragraph suggests that water use will not be a problem. The basis for the statement was the assumption that the facilities could all be located near the "R" river, which had adequate flow. However, the statement should recognize that water use could be a significant environmental impact for a repository which cannot be located near a convenient water source.

The resource commitments listed include annual water use for the once-through fuel cycle option. The total annual use is about 1% of the annual mean flow of the "R" River, a small amount when water is plentiful. However, in the semi-arid west where river flows can be less than 100 cfs (one-fiftieth that of the R River) and where water is fully allocated, this is a significant amount of surface water use.

3.e.13 p. 3.1.226

The 2nd paragraph states that there will be 10's of millions of tons of salt "whose final disposition is yet undecided." It is not clear where this fits into the analysis, or if it is taken into account, where in comparing environmental impacts in the various geological media does this occur.

Comment Number

.f Long-Term Effects of Repository Construction and Operation

3.f.1 pp. 3.1.5, 3.1.6, 3.1.19

One area of serious concern which appears to be neglected is the effect of repository construction and operation and the thermal effects of the emplaced waste on the effectiveness of the geohydrologic barriers to long-term transport of radioactive materials from the repository. The following examples are cited:

Construction is likely to increase hydraulic conductivity of the rock mass. There is no evidence presented in GEIS to show that such factors have been considered. This is a serious deficiency.

Rock fractures, joints and fissures are potential paths for increased groundwater flow. Mine construction and testing may induce local fracture conditions that may or may not be identified in sample permeability testing. However, the in situ extent of fractures, joints, and fissures could produce increased groundwater flow in other than direct downgradient directions. Have such factors been considered and what conclusions have been drawn?

3.f.2 pp. 3.1.9, 3.1.13, 3.1.14

pp. 7.2.15, 7.2.18, 7.2.22, 7.2.26; DOE/ET-0028

Permeabilities of granite and basalt, while low, are not nil. If they were, the repositories in granite and basalt could be located a few meters beneath the weathered layer. There seems to be no appreciation that values of permeability determined in the laboratory differ quite frequently from effective (rock mass) permeability by several orders of magnitude.

3.f.3 p. 3.1.24

Thermal uplift around the repository is expected as a result of the thermal loading. This may increase effective hydraulic conductivities of the host rock and may even result in the creation of a flow path between overlying aquifers and the repository.

Comment Number

.f.4 p. 3.1.32

The first paragraph does not reflect fissure and joint permeability differences, and induced characteristics due to construction.

3.f.5 p. 3.1.124

What the GEIS is really discussing is the creation of flowpaths by creating fractures or opening fractures that already exist. The question then is how does the predictive model treat the flow of liquids and transport of dissolved radionuclides through fractures? Both flow and transport could be significantly different in fractures than in porous media. We know that retardation is less and, also, that retardation is the most important attenuation mechanism that has been modeled. The term "thermally induced permeability" does not convey the difference between porous flow and fracture flow.

3.f.6 pp. 3.1.228, 3.3.22, 3.3.27, 3.3.30

pp. 7.4.6, DOE/ET-0028

The general impression conveyed regarding the sealing of shafts, bore holes and canister holes into an underground repository is that no significant problems of leakage are expected. This contrasts with the discussion of the same activities associated with disposal of wastes by the very deep hole concept. If anything, the maintenance of the integrity of shaft seals, room seals and canister seals in an underground repository (particularly in salt) would be expected to pose significantly greater problems than in deep hole disposal.

3.f.7 p. 7.3.5; DOE/ET-0028

The unit cell used to analyze the maximum temperature of the waste canister is described on page 7.3.5. It has a sleeve and an air gap. At the bottom on page 7.4.6 it is stated: "After the readily retrievable period, use of sleeves in emplacement holes is discontinued and holes are backfilled with crushed rock after canister placement." Emplacement of waste canisters without the sleeves does not appear to be considered in the thermal analysis.

Comment Number

3.f.8 p. 7.3.12; DOE/ET-0028

Linear thermomechanical analysis is applied to a repository in salt. Such an analysis can result in significant error in predicting thermomechanical effects (see discussion under comments on retrievability). Even with this analysis a surface uplift up to 1.5m is predicted. The important question not addressed in the GEIS is what effect will this have on shaft and borehole seals, thermally driven convection and breccia pipe formation?

3.f.9 General Comment

The GEIS does not address the important and complex problem of groundwater mass transport and how it is affected by joints and fractures. Rock will fracture and a series of joints will be created or opened in the surrounding rock as a result of mining of the repository. Effective permeabilities (hydraulic conductivities) will be increased. The effect of these processes on long-term repository performance need to be addressed.

3.g Long-term Radiological Effects - Environmental Transport

3.g.1 p. 1.20

Some of the numerical values on page 1.20 (e.g., maximum individual dose) cannot be traced to Section 3.1.5.

3.g.2 p. 3.1.66

Describe how the estimate of $1x10^{-6}$ for the "annual fatalities estimated due to isolated waste" is determined. Specifically, explain and justify the use of the "annual transfer probability for an atom of radium to enter the body from the geosphere."

3.g.3 General Comment

Define "health effects" and assumptions for "translating" $1.8x10^{8}$ man-rem into $1.8x10^{4}$ to $1.4x10^{5}$ health effects.

Comment Number

3.g.4 General Comment

Although the section on radiological models (Appendices D & F) indicates that all pathways were considered, the contribution of various pathways to the total dose is not given in the document. Additional information on the radiological analysis for scenarios (e.g., source terms, concentrations of nuclides for different locations, solubility classifications of particulates, etc.) would help document the major conclusions concerning radiological impacts.

3.g.5 General Comment

Appendix I to the EIS and Appendix G to DOE/ET-0029 present impacts at time periods of 10^{2} yr., 10^{5} yr. and 10^{6} yr. Sometimes 10^{4} years is discussed. Since preliminary versions of the EPA standard for high-level waste specifically reference the 10^{4} year period, it would be prudent to present cumulative dose calculations for this time period for all cases studied.

.g.6 General Comment

The several appendices which support the long-term impact assessment need to be coordinated so that their results are directly comparable. Some cumulative doses are for 50 yr., some for 70 yr. Different times are referenced. The total picture is confusing and leaves many questions about the internal consistency of the supporting calculations.

3.h Long-Term Radiological Effects - Geology/Hydrology

3.h.1 p. 3.1.2

The four climatic factors listed to be considered in assessing the long-term isolation of waste are not sufficient. Precipitation patterns (temporal and spatial) and man induced changes must also be considered.

3.h.2 p. 3.1.5

It is stated that "The major mechanisms related to nuclide transport through the disposal media are thermal convection, diffusion and dispersion, sorption, and radioactive decay." Also important can be the advection of nuclides with the local groundwater flow.

Comment Number

3.h.3 p. 3.1.5

The definition of convection is incorrect. Convection signifies the transport of a contaminent by a moving fluid. Thermal differences may produce fluid motions, and thermally driven convection must be considered in the analysis of a radioactive waste repository. The usual driving force for groundwater flow is the head gradient (where the head is due to elevation and pressure). The velocity and direction of flow are governed by a combination of fluid properties, rock properties and head gradients.

3.h.4 p. 3.1.6

Line 2: To group geologic materials into two categories, either aquifers or aquitards is misleading. A whole continuum of both permeability and porosity exists which can describe an aquifer (high permeability and high porosity), aquitard (low permeability), and aquiclude (very low permeability but may contain appreciable porosity) also known as an impervious horizon or an aquifuge (very low permeability and very low porosity). The local site conditions generally determine how you would classify the hydrostratigraphic unit since these terms are often relative.

3.h.5 p. 3.1.6

Line 4: A discussion is needed of piézometric levels, leakage between confined, unconfined, and various combination hydrostratigraphic units, and how a unit may change from a phreatic, to a confined, leaky, or artesian aquifer.

3.h.6 p. 3.1.6

A discussion of steady state versus transient flow conditions and their implications on hydrostratigraphic unit storage is needed. The variability of parameters governed by the matrix plus secondary features such as faults, joints, structure, and alterations also need discussion.

Comment Number

3.h.7 p. 3.1.23

It is stated that interior drainage is a favorable hydrologic characteristic in selecting a burial site. An example given is the Great Basin of Nevada and Utah. However, one characteristic of interior drainage is that during wet climatic periods they can become almost completely water-covered. This has happened in the recent geologic past in the Great Basin. Consequences of the potential for such drastic changes in the surface and subsurfaces water regime should be more carefully investigated before asserting that interior drainage is favorable. Interior drainage is again favorably mentioned on page 3.1.27.

3.h.8 p. 3.1.8

Because of the complexity and nature of deep geologic and hydrologic investigations, simple analysis using permeability, porosity, and hydraulic gradients are not sufficient. Appropriate parameters for evaluation of hydrologic regimes are:

fluid properties
- density
- compressibility
- thermal expansion/heat capacity
- viscosity

matrix properties
- longitudinal and transverse dispersities
- vertical permeability
- density
- compressibility
- storage and leakage factors along with permeability and porosity.

In addition one needs to assess the difficulty in determining these parameters, their uncertainties and extent to which and time required for a hydrologic model to be validated and calibrated. The above items may contribute significantly to uncertainty in predicting future safe performance. They could also impact the date for initial emplacement.

C.90

Comment Number

3.h.9 pp. 3.1.24, 3.1.33, 3.1.235

Several comments have been made about the "self-healing" properties of salt:

p. 3.1.33 - "Fractures tend to self-heal, thus reducing...water ingress..."

p. 3.1.24 - "A key problem will be preservation of low permeability. Preliminary thermal loading analyses indicated that tensile forces will be induced near the outer margins of the repository. Thus, thermal expansion could create potential pathways for work migration by fracturing or by opening pre-existing fractures. For salt strata this is not a problem; salt is expected to deform plastically and heal internal fractures. However, the problem is that if the surrounding strata were breached by fracturing, salt could be vulnerable to rapid solution by groundwater. Therefore, it appears that th ermally induced permeability will be an important consideration for all host rock media."

p. 3.1.235 - "...generally accepted...salt tends to heal any opening"

It may not be realistic to depend on this "self-healing behavior" to produce an impermeable seal around the repository. The repository design should consider worst case behavior. Worst case behavior would be the opening of thermally or mechanically induced fractures around the repository to water flow from an overlying aquifer. The water under greater pressure due to depth could keep the fractures open and increase the dimensions of the fractures as a result of the flow.

3.h.10 p. 3.1.26

The great deficiency in the hydrogeologic data base is actual field studies and methods for obtaining rock dispersivities. Also lacking are in-situ sorption studies for a variety of geologic, hydrologic and geochemical environments. (Note: The Canadians are doing work in this area at the Chalk River Nuclear Laboratories (CRNL)).

Comment Number

.h.11 p. 3.1.33

The GEIS states that "Mines in Canadian Shield Granite appear to be tight and free from circulating groundwater below depths of about 3000 ft." We recognize that granite has a low hydraulic conductivity and that seepage rates are low enough to appear negligible by visual inspection. However, it is likely that groundwater inflow into operating mines is evaporated by ventilation airflow. In the long time frame of a repository, this inflow is expected to be significant.

3.h.12 p. 3.1.41

Groundwater nuclide transport is not included among the issues needed to be resolved to determine post-operational impact of the repository (p. 3.1.41). On page 3.1.48 and 49 it states that groundwater movements that are insignificant over the short term could be a problem where considered over the long term. Groundwater movement in a salt repository is considered to be negligible.

Table 3.1.49 on page 3.1.164 implies that there could be an unacceptable 50 year body dose as a result of the groundwater transport of radionuclides by the year 2050. Is this in contradiction to other passages discounting the effects of mass transport?

3.h.13 p. 3.1.41

Operational difficulties which may prevent sealing the repository have not been discussed. It is difficult to see how one could do an adequate job of either backfilling or retrieving if a repository becomes flooded. The point to emphasize is that operational problems may impact long-term performance. The effects of contaminating the repository in an accident, which may affect both occupational safety and long-term performance, are not addressed.

3.h.14 p. 3.1.47 to 3.1.76

For a repository in salt, a discussion of brine migration is missing. There was no mention of the possibility that sorption of the effluent of a

Comment Number

salt repository may not be the same as for other media, due, for example, to competition for sorption sites by NA^{++}, Mg^{++}, and Ca^{++}.

3.h.15 p. 3.1.67

Uncertainties and the method for determining them should be consistently included with probability and consequence estimates. Although there is some discussion of uncertainties in isolated cases, they are usually not included with point values, e.g., the probability of faulting through the repository is estimated at 4×10^{-11} year (pg. 3.1.67) with no indication of associated uncertainties.

3.h.16 p. 3.1.98 and Appendix I

It is stated that "...methods and detailed results for groundwater transport of radionuclides are presented in Appendix I." However, Appendix I contains no detailed discussion of groundwater transport models. That appendix is primarily a discussion of radiological consequences of leaching of waste in a repository. The hydrologic assumptions stated and presumably used in the modeling (which is not discussed) are simple (e.g., constant velocity). There is no discussion of the effects of different hydrologic characteristics, i.e., no sensitivity analysis.

3.h.17 p. 3.1.120 to 3.1.123

The discussion in GEIS under "routine releases of radioactive materials" does not address the problem of radionuclide contamination of groundwater and run-off water. This could happen as a result of accidents, clean-up operations in storage rooms, decontamination operations during the retrieval cycle, etc.

In the section titled "Ecological Effects" seepage and water inflow from overlying strata for repositories in granite and in shale are discussed. The estimated inflow of water in a granite repository ranges from 550 to 1550 m^3/day. The estimated maximum inflow during the last stages of operation will range from about 3,800 to 19,000 m^3/day (50000 gpd). There appear to be two implications by omission from the discussion:

Comment Number

- o No continued water inflow is expected in the repositories in granite and in shale after the last stage of operation.
- o No water inflow is expected in the repositories in salt and in basalt.

The generic stratigraphy for salt includes possible aquifers overlying the salt bed. An area of uncertainty in state-of-the-art technology is whether the effects of mining a repository in salt and of the thermal loading are such as to create fractures that would connect the aquifer bed to the repository. TM-36/21 (p. c-1) discounts this in assuming that the permeability for salt remains at zero. No justification is provided.

3.h.18 p. 3.1.136

Justification is needed for the stated maximum surface temperature rise and uplifts.

.h.19 p. 3.1.148-3.1.155

Discuss the reasons for the choice of 2.8m^3/sec (100 cfs) for water flow through the breached repository. Identify the flow rate of hypothetical river "R" used in transport and dilution calculations.

3.h.20 p. 3.1.158

Provide a reference for ten dilution factors given and discuss the cause of the 50 fold differences shown.

3.h.21 p. F.3, Appendix F

The hydrology of the hypothetical site is presented with no explanation or discussion of its appropriateness for general sites. No discussion of other hydrologies is given. Considering the great length of discussion that is given throughout the document to effects of comparatively small changes in the characteristics of the waste, an apparent lack of appreciation of the effects of the sites hydrologic characteristics is manifested by this treatment.

Comment Number

3.h.22 Appendix I

Appendix I discusses the possibility of release of radionuclides to the biosphere through groundwater mass transport. The impression given is that container life will be about 1000 years and that no significant release is expected for one million years. This is in apparent contradiction to results given in TM-36/21 (p. xiv, 8-5 and 8-6). What is the expected rate of corrosion of the canister and the sleeve in salt brine or in fresh water? What are the values (or ranges) of effective hydraulic conductivity, porosity, retardation factors and hydraulic gradients of the rock mass surround the repository that were used to obtain Tables I.1 to 1.12?

3.h.23 Y/OWI/TM-36/21

Pages 4-7 assume that the effective vertical permeability of basalt between the repository level and the alluvium near the surface (a thickness of 600 feet) is $5x10^{-8}$ cm/s resulting in a downward flow through this layer into the repository of approximatedly 150 gpm (216000 gpd). In addition a maximum upward flow of 230 gpm into the repository is calculated.

The GEIS should address and discuss the following with regard to radionuclde transport: Are repositories in granite, basalt, salt and shale expected to have any water inflow after the last stages of operation?

3.h.24 Y/OWI/TM-36/21

The results of simplified calculations given in Y/OWI/TM-36/21 show ^{99}Tc exceeding acceptable concentrations 3 miles from the center of the repository 400-600 years after recharge. To quote from page 8-5: "^{99}Tc, due to its long half life and unity retardation coefficient exists in all layers of the generic stratigraphic columns studies (shale, granite and basalt) at concentrations near or equal to the source activities. The maximum source activity for ^{99}Tc used in this study is approximately 0.2-0.3uCi/ml (section 7.0) which is at least 10^3 times greater than an acceptable level. The first arrival of ^{99}Tc occurs in the near surface layers between 400-600 years after repository decommissioning and resaturation and at

Comment Number

concentrations near or equal to that of the repository source activity." This would appear to indicate unacceptable repository performance. An explanation should be given of how this will be remedied or why this analysis is not believed to indicate a problem.

3.h.25 Y/OWI/TM-36/21

Y/OWI/TM-36/21 addresses only three host rock media - granite, basalt and shale. No basis for the apparent conclusion that groundwater movement in salt is negligible has been presented in either GEIS or in TM-36. Note also that the permeabilities of granite and basalt presented in the GEIS (Table 3.1.1, p. 3.1.9) are nil and therefore the repositories in granite and basalt could presumably be located at depths significantly less than salt and shale.

3.h.26 General Comment

Measures of performance used in the GEIS and its supporting documents make it difficult to judge statements that claim "no deleterious effects." For example:

1. Dose received by maximum individual. This seems to be someone using a water supply separated by 10 miles of porous flow from the respository. Note that fracture flow with its lower retardation factor is not considered.

2. Concentration at 3 miles from boundary. This was used in TM-36 volume 21. In this case, Tc-99 occurs near the surface at 400-600 years and exceeds maximum permissible concentrations by one thousand (Tm-36/21 pgs. xiv, 8.5-8.6).

3.h.27 General Comment

One of the assumptions that makes mined geologic disposal feasible is that radioactive sources placed in a hydrologic environment with slow-moving groundwater will take long periods of time to be transported to the biosphere. Furthermore, retardation effects will slow down (relative to groundwater velocity) the movement of certain species. This basic characteristic is common to all forms of geologic disposal.

Comment Number

The GEIS and its supporting documents fail to analyze flowpaths other than porous flow through intact media. The possible creation of high-velocity flow paths by mining operations or fractures created by the thermomechanical response of the rock mass are not considered. Fracture flow driven by thermal convection deserves more attention than meteorite impact or nuclear war as mechanisms for establishing communication between the repository and the biosphere.

3.i Long Term Radiological Effects - Accident Analysis

3.i.1 p. 1.16

In the definition of risk, "magnitude of the loss" is better expressed as "consequences of the event." This will also make the definition of risk consistent with that used in footnote e to Table 1.4 and the footnote on page 1.21.

3.i.2 pp. 1.16 and 1.20

We note that a risk assessment requires the identification of a broad spectrum of event probabilities and consequences. It is not limited to worst case consequence assessments as is indicated in Tables 1.3 and 1.4.

3.i.3 p. 1.19

A credible event missing from the discussion is the possibility of a water well drilled into adjoining hydrostratigraphic units that could disrupt regional flowlines and equipotentials such that radionuclide migration may be enhanced. Leakage through overlying aquitards into more permeable units could significantly speed the movement of radionuclides to the biosphere. The pumping well in this scenario would not be pulling radionuclides directly into its cone of depression since most water wells are not at that depth nor would the repository be located in a productive aquifer of potable grade water. Further, the discussion on solution mining and the missing scenario on deep drilling activities such as natural gas and oil exploration ignore the potential for groundwater hydraulic and pollution effects.

Comment Number

3.i.4 p. 1.20

Table 1.4, Item 1: Although the person closest to the repository will be killed, there still exists a maximum individual who receives the largest dose as a result of the release.

3.i.5 p. 1.20

In Item 3 of Table 1.4, the regional natural radiation dose is calculated for 3 generations. In Item 2, doses are calculated for only 1 generation (70 yr. total body) resulting in an inequitable basis for comparison.

3.i.6 p. 1.20

Table 1.4 - (a) The potential for a dose due to airborne dispersion caused by a meteorite impact does not appear to have been considered, (b) the units of "Health Effects," e.g., acute fatalities, morbidities should be defined, (c) the units of "Risk," e.g., total health effects, health effects per year should be defined, and (d) a description of how "accident probabilities" were arrived at and an associated uncertainty should be presented, e.g., both the probability for metorite impact and the probability for fault fracture and flooding were given as 3×10^{-13}. Including uncertainty in the estimates of probability is also important since point estimates of probabilities as low as 10^{-13}, are difficult to justify when little data is available.

3.i.7 p. 1.21

Artifacts survive but if they have value as collector's items or useable resources (e.g., high grade steel) there may be considerable motivation to move or destroy them. The problem is not only one of designing a marker that will last and be understandable but also one that will stay put without being defaced.

3.i.8 p. 3.1.2

Only erosion is mentioned as a hazard associated with glaciation. Omitted are faulting and deformation well below the eroded rock/soil surface. These potential hazards should also be considered when evaluating the effects of glaciation.

Comment Number

8.i.9 p. 3.1.2

Considering the multitude of variables and unknowns, it would seem extremely difficult to predict the lower depth of glacial erosion at any particular site with any degree of certainty. A more acceptable approach would seem to be that, if the decision has been made to seriously consider a repository within a previously glaciated area that the repository designer would simply assume surficial erosion (deposition and various deformation/faulting features) to occur within, say the upper 65 to 100 m of the surface. Other than probably uniform crustal depression, a repository located at the 500-600 m depth should be relatively unaffected by direct glacial processes. It would seem to be overly-conservative to assume that a postulated future glacial front would advance beyond the areas formerly occupied by continental glaciers.

3.i.10 p. 3.1.65

It is stated that "containment times of 500 years are the most important." However, on page 3.1.59 it was stated that a significant release" could occur at 1000 years and on page 3.1.64 it stated that after "700 years, the radioactivity in the repository poses a greatly reduced threat." Some consistency should exist in the document for the period of concern and basis for arriving at this time should be clearly delineated.

3.i.11 p. 3.1.67

Table 3.1.3 - It is stated that the Poisson process is used to model the occurrence of geologic events, based on past observation. It is not clear, however, whether this table presents the probability that one event occurs for the "interval" of concern or, more properly, that one or more event occurs during this period. From $P(x) = \frac{e^{-(gQ)}}{x!}$, the probability of one or more events occurring is (1 - the probability of zero occurrences) = $(1 - P(0)) = 1 - e^{-gQ}$. This formulation, however, produces somewhat higher probabilities than those listed in Table 3.1.3, e.g., for the "number of occurrence years" equal to 10^6 years, and an "interval" equal to 10^4 year, the probability that one or more geologic event occurs is 9.95×10^{-3} as compared to 6.9×10^{-3}. Thus, more explanation of the probabilities in Table 3.1.3 is needed.

Comment Number

.i.12 p. 3.1.125

Individual and population doses, as well as health effects, are calculated and presented in the GEIS for certain postulated accidents. The potential decontamination cost and property damage associated with the same postulated accidents should also be evaluated.

3.i.13 p. 3.1.125

Uncertainties in doses predicted by models is misleading. The discussion should indicate the uncertainty to be expected when a critical parameter has a range of values such as the magnitude of earthquakes, floods, etc.

3.i.14 p. 3.1.125

The discussion in the section entitled "Land Use and Transportation Considerations" focused on some possible land use conflicts and refers the reader to a body of literature, some of which is described as speculative. It would be useful for the GEIS to summarize this information and to present it for review.

3.i.15 pp. 3.1.136-172

In this section several scenarios resulting in the release to the biosphere of large amounts of radioactivity are postulated. Because of the generic nature of the repositories and the lack of specific data needed in the calculation, many of the parameters controlling the physical transport of the radionuclides are not even known to order of magnitude certainty. The resulting dilutions that are used in the dose models have even larger error bands. Therefore, breaking down the resulting doses by reprocessing procedure and rock type makes little sense, when the differences between them are much less than the error band due to transport-dose modeling.

3.i.16 p. 3.1.136

Section 3.1.5.2 is entitled, "Potential Impacts Associated with Respository Wastes in the Long-Term." Although this section gives population doses due to different accident scenerios, it does not discuss the problem of land contamination due to these accidents.

Comment Number

3.i.17 p. 3.1.137

The section on long-term impacts is devoted entirely to accidents that may breach the repository, most of which are presented as being so improbable that they are unlikely to ever occur. There is no discussion presented of expected long-term impact. If the facility is sited, filled and sealed according to plan, what will the long-term consequences of this action be in the absence of unlikely accidents? This question is discussed partially in Appendix I but the discussions are not presented in the text of the GEIS as projected impacts of the action.

3.i.18 p. 3.1.137

Releases are estimated for four hypothetical accident sequences. The numbers associated with the releases are presented by the GEIS as "what if" calculations, without discussion of why these sequences are important except to say that they are "believed most representative" of release events. How these events were chosen and why they are believed to be representative and to bound the impact of long-term consequences should be discussed.

3.i.19 p. 3.1.138

References relevant to this discussion and not cited include:

1. K.A. Solomon, R.C. Erdmann and D. Okrent, "Estimate of Hazards of a *Nuclear Reactor from the Random Impact of Meteorities*," Nucl. Technical, 25. 68 (1975).

2. K.A. Solomon, R.C. Erdmann, T.E. Hicks and D. Okrent, "Estimates of the Hazards to a Nuclear Reactor from Random Impact of Meteorities," USCL-NEG-7426, University of California at Los Angeles (March 1979).

3.i.20 p. 3.1.150 to 3.1.155

"The annual doses to a maximum individual associated with the breach of a salt repository are three to ten times the permissible annual dose for occupational exposures ... Thus the calculated doses and consequences

Comment Number

seem most unlikely to occur in practice .... the calculated number of health effects attributable to this accident would range from $1x10^4$ to $3x10^5$."

GEIS goes on to multiply these figures by 1/100 as the probability of failure of waste containment and by $4x10^{-11}$/yr as the probability of a new fault intersecting the repository to arrive at insignificant risk levels. The probability of an existing fault becoming permeable should also be considered.

3.j Research and Development

3.j.1 General Comment

It would seem advisable, if not already considered, to gather information regarding the long-term stability of boreholes, wells, and other deep rock penetrations in regions considered favorable for repository location. These observations can provide additional clues on assessing the stability of the repository location. This would be useful in assessing the host media as well as that of the overlying and underlying formations especially when considering the Very Deep Hole concept of waste isolation. Pertubations of the earth's near-surface are readily detectable in both cased and uncased holes through sheared, ruptured, and squeezed boreholes and casings.

3.j.2 p. 3.1.237

There is no discussion of research needs in the hydrologic transport aspects of geologic disposal. Of prime importance are the chemical and thermal interactions involving dissolved wastes and the natural rock.

3.k General

3.k.1 p. 1.3

The underground firing of nuclear explosives results in the formation of vitrified debris, due to the solidification of molten and vaporized rock. Thousands of tons of such vitrified debris have been in place for periods of up to 25 years, mostly in tuff at the Nevada Test Site, but also in

C.96

Comment Number

granite, shale (Gas Buggy), and salt. This experience bears directly upon the proposed long-term storage of vitrified high level waste, and should be discussed.

3.k.2 p. 1.3

The need for additional in situ testing to obtain site specific information should be stressed in the GEIS. For example, acceptability of a shale as the host media at one location does not imply that a shale at another location is necessarily acceptable since nonlithologic parameters such as tectonic setting, in situ stresses, hydrology, and other variables are undoubtedly different.

3.k.3 p. 1.12

Why are salt, basalt, granite and shale considered to be representative of all geologic media? Some explanation should be given.

3.k.4 p. 3.1.8

Rock structure and texture are not interchangable terms. A glossary of geologic terms used in the GEIS, such as structure, texture, lithology, bedding, and joint may eliminate confusion concerning the usage of standard terms and should be provided.

3.k.5 p. 3.1.8

The confining earth pressures whose release cause joints should be characterized. For example, glacial retreat and thermal contraction should be named as causes of jointing in rock.

3.k.6 p. 3.1.8

Salt domes may deform overlying strata without penetrating them. Therefore, "deform" should be substituted for "penetrate" in the 6th sentence.

3.k.7 p. 3.1.9

The statement, "...the water incorporated in them (salt beds) was trapped when the beds were formed and does not migrate," is erroneous. Fluid inclusions in salt migrate along thermal gradients.

Comment Number

3.k.8 p. 3.1.9

The statement, "Joints can be ..." is too vague. Are joints usually, often, or seldom anhydrite-filled, near vertical, unopen, moderately spaced, and generally extensive?

3.k.9 p. 3.1.11

Does "hard" refer to hardness (as in scratch test) or strength? Geologic terms such as strength and hardness should be used in accordance with their standard definitions.

3.k.10 p. 3.1.21

References for the statement "...shaking ...due ...to earthquakes is not expected to have serious effects on the repository at depth..." should be provided.

3.k.11 p. 3.1.23

Groundwater may constitute the major potable water supply of many western states. This aspect of groundwater importance should be addressed.

Comment Number

4. ALTERNATIVE DISPOSAL CONCEPTS

4.a Geologic Emplacement Following Chemical Resynthesis

4.a.1 Chemical resynthesis is not an alternative waste disposal concept but rather an alternative waste form which would be a candidate for a number of disposal alternatives presented in this document. The designs of deep geologic repositories place major (if not total) reliance for containment of radionuclides on the surrounding geology (See Section 3.1.1). Reliance on the waste form itself and its packaging to prevent radionuclide release over the long term has not received intense emphasis. For example, Section 3.1.4.2 points out that the reference solidification process for conventional geologic disposal is conversion to glass, as the alternative waste forms are less well developed.

4.b Very Deep Hole Concept

.b.1 On page 3.3.1
It is stated:

> "In summary, the deep hole concept cannot be evaluted as a nuclear waste alternative without more information on the deep groundwater system, rock strength under increased temperatures and pressures due to decay of wastes, and the sealing of the holes over long periods of time."

These are three areas that have also been identified under the research and development needs section (Section 3.1.6) for Conventional Geologic Disposal.

a. Why does the evalution of deep hole disposal as an alternative depend on obtaining this information, while it is taken for granted that conventional Geologic Disposal is a viable alternative?

b. If this information is obtained for conventional geologic disposal, would it apply to deep hole disposal?

Comment Number

.b.2 Some discussion of retrievability from deep holes should be provided.

4.b.3 p. 3.3.33
It is stated that, "It will be necessary to locate sites in strong, unfractured rock of low water content." This will exclude such media as shale and salt because of strength, and most other media because of fracturing. Why hasn't this same site selection criterion been applied to conventional geologic disposal?

4.b.4 p. 3.3.33
The section on the thermomechanical behavior of rocks does not acknowledge that a significant body of information has been published on studies of hydrothermal alteration of natural rock bodies. The time, temperature, and the nature of ion migration in hydrothermally altered rocks has been studied for years by igneous/metamorphic petrographers, geochemists and mining companies.

.b.5 p. 3.3.37
The citation for Reference 27 is inadequate. Provide information whereby Mr./Ms. Stevens can be contacted.

4.c The Rock Melting Concept

4.c.1 General
The Rock Melt Concept discussed in Section 3.4 assumes that the cavity is loaded over a period of years. This prolonged loading time has at least two disadvantages. First, the physical integrity of access and venting shafts must be maintained for the duration of the loading. Second, the cooling water itself will be contaminated and must be carefully contained and eventually the contamination must be disposed of as yet another waste.

Another loading scheme should be considered. The waste could be stored at the surface until the full load for the cavity has been accumulated. The waste could then be rapidly loaded into the cavity and the cavity quickly sealed.

Comment Number

It appears that the quick loading of the cavity is a practical alternative to the prolonged loading suggested in the GEIS. Further variations should also be considered, such as the use of an array of cavities (a few to maybe 10's of cavities). This would reduce the loading rate (in the case of the quick load) and distribute the heat load over a large volume.

4.c.2 General

The treatment of "Rock Melt" in the GEIS misleads the reader as to the depth of investigation which has been completed. For example in the first paragraph on page 3.4.4 of the GEIS, it is stated: "The concept has been assessed and reviewed (4,5) and preliminary laboratory scale investigations have been performed (6,7)." The workshop referred to as Reference 5, as productive as it may have been, fell far short of assessing "Rock Melt." The laboratory scale investigations were designed to study the descent of solid containers by rock melting, not the molten cavity concept.

4.c.3 p.1.25

The introductory writeup on the rock melting concept does not present the disadvantages for this alternative, which were presented for the very deep hole concept, sub-seabed geologic disposal, etc. Equal treatment of all alternatives should be demonstrated in the final EIS.

4.c.4 p. 3.4.5

It is stated that retrieval of waste following emplacement would be difficult. This is understated, and not adequately addressed.

4.c.5 p. 3.4.6

It is stated that the consequences of seismic activity appear minimal with proper facility design. Discuss the effects of seismic activity on surface facilities supplying cooling water and cleaning up the steam, and on the reliable supply of cooling water to the waste.

Comment Number

4.c.6 p. 3.4.10

Figure 3.4.4 does not present the temperature profiles that are necessary to completely characterize the extent and duration of the thermal load on the host media. The maximum increase in temperature at the earth's surface can occur hundreds of thousands of years later than shown. (Numerical models can be very costly to run for long times and distances required, however an analytic model is available. See Reference 3 of Appendix C of TID-28818 (Draft), "Subgroup Report on Alternative Technology Strategies for the Isolation of Nuclear Waste.)

4.c.7 p.3.4.17

The post sealing period environmental effects are assumed to be "the same for (nonsalt) conventional and Rock Melt repositories." The basis for this assumption should be given. If the thermal barrier effect protects the HLW from groundwater leaching for possibly a few thousand years, might not the post sealing performance be superior to that for conventional geologic disposal?

4.c.8 A shortcoming of the description of the rock melt alternative is that no mention is made of the need for or availability of the water that's necessary for this alternative. Provide an estimate and discussion of the water requirements.

4.c.9 In the event that the cooling system for the waste fails while still needed, it will be very difficult to repair because of its proximity to the waste.

Information on the possible failure of the cooling system, mitigative actions, and environmental impacts should be provided.

4.d Island Disposal

4.d.1 Section 3.5

The discussion in Section 3.5 indicates that two options for island disposal are being seriously considered. One option is disposal in

Comment Number

oceanic islands for which relatively long sea voyages for transporting the radioactive wastes will be necessary. The other option is disposal in continental islands. For this option, the transport time at sea is small with the possibility of using a ferry-type transport system, facilities at the embarkation and receiving port could be simplified. Table 4.2.1 indicates that an offshore continental island has been chosen as the reference system. The two options should continue to be treated separately and additional information concerning environmental impacts and accident risks be developed for both options. Note that although the offshore continental island option appears to be the option with the least transportation environmental impact, it also has associated with it the least benefits. Section 3.5.1 states that the concept of the island disposal is being considered because of the benefits derived from this disposal option. Benefits such as location in a separate hydrogeological zone, seawater dilution of radioactive leaks, enhanced security of a remote location, and a site with international jurisdictional status would all be minimized if the offshore continental island option is chosen. It is important to continue to explore both options with the ultimate choice being left to a risk-benefit analysis after more complete information is developed.

4.d.2 Section 3.5

The ability to dewater a site is an extremely important site characteristic Dewatering with the attendant equipment may impose such an economic burden that an otherwise suitable site may be ultimately rejected. The dewatering problem may, in the end, result in the rejection of the island arc and oceanic island locations. In addition, the retrievability of waste placed in any island watery environment, particularly salt water, is questionable considering the effects of corrosion on dewatering equipment.

4.d.3 p. 1.25

Section 1.3.5 states that "Salt deposits are unlikely to be available at island sites; the most probable disposal formation (sic) is crystalline

Comment Number

rock." From this statement one would conclude that crystalline rock was the most common rock type exposed on islands. This is not the case, e.g., the Antilles, the Japanese and Philippine archipelagos, New Guinea, Bikini, Bermuda, etc.

4.d.4 p. 1.26

The statement on line 9, that island arcs are highly active seismically and volcanically is not necessarily correct as there are tectonically inactive island arcs.

4.d.5 p. 3.5.1 (also on page 3.5.5)

The assumption of a "practically static" salt water system below the fresh water lens should be approached with reservation. The stability depends upon many factors some of which are mentioned in the text (p. 3.5.18), some aren't. Examples of these factors are: amount of rainfall, frequency of rainfall, water usage (pumping regimes), tides, sea level fluctuations, and erosion.

In what sense is the ocean considered to provide an additional barrier?

4.d.6 p. 3.5.12

The statement that 85 percent of the world's earthquake energy is released in the Pacific margins should be documented.

4.d.7 p. 3.5.12

Figure 3.5.6 does not show major basement rock types. There is a figure showing major basement rock types in Reference 5 (Bayley and Muehlberger; 1968), which has Figure 3.5.6 as an inset, titled "Principle Basement Provinces."

4.d.8 p. 3.5.18

The discussion of sorptive phenomenon is not sufficiently covered. A comparison of the sorptive properties associated with island disposal with

Comment Number

those associated with conventional geologic disposal should be presented, to determine if the multibarrier approach has been effectively utilized.

4.d.9 p. 3.5.19
It should be noted that dispersion and diffusion may be very active in this type of system, especially in combination with a natural zone of dispersion along the saltwater/freshwater interface.

4.d.10 p. 3.5.23
Under Section 3.5.2.2, some estimate should be provided of the probability of accidents on the sea lanes, which might lead to loss of the radioactive cargo. Cost estimates should also be provided.

4.d.11 p. 3.5.27
It should be noted that current models are not able to accurately predict flow through fractured media, which will be normally encountered in islands of volcanic origin.

4.d.12 p. 3.5.29
Section 3.5.6.3 identifies research and development areas that need to be explored in order to resolve uncertainties in island disposal. One area is the level of risk associated with extended sea transportation paths. Since the complexity of port facilities varies with the island disposal option being considered the level of risk, both in terms of routine occupational exposure and exposures due to accidents should also be considered as an area needing development.

4.d.13 p. 4.15
It is not accurate to state that the insular geologic surroundings are of inherently dynamic nature. This is not so especially for the east coast continental islands. East coast islands are probably less likely to contain, or be near, valuable resources than some of the west coast islands, thus lessening the possibilities of repository intrusion.

Comment Number

.d.14 p. 4.20
Table 4.5.2 presents preliminary estimates of the socioeconomic impact of the waste management options. An assumption stated under island disposal is that dockside shipping facilities will be constructed in a well established port area. For the no recycle option, packaged spent fuel will be shipped to the island disposal area. The recent NRC interim rule for safeguarding spent fuel shipments may prevent the use of well established port areas so that the conclusion reached, that the incremental impact is small, may not be valid.

4.e Sub-Seabed Geological Disposal Concept

4.e.1 p. 3.6.1
It is stated that the goal "to aid in solving national and international legal and political problems" will be started only after the technical and environmental feasibility is demonstrated. Has this been factored into the schedule that has been developed for this program? What lead time and resources have been planned? Has the DOE participated in any international discussions of this problem. A description of the programs of other countries interested in seabed disposal would be helpful.

4.e.2 p. 3.6.2
The "difficulty of documenting a repository's location for future generations" is presented as a major disadvantage of the seabed concept. Explain why this would be any more difficult to do for seabed than for conventional geologic disposal?

4.e.3 p. 3.6.3
Two study areas were identified as having been chosen in the central North Pacific. Where are these study areas located? (Locate on a map.)

4.e.4 p. 3.6.3
The statement, "This region (the continental margin) is therefore unsuitable for consideration as a possible waste disposal site." is too

Comment Number

final for such a large region and cannot be justified without detailed discussion.

A much more reasonable and specific statement is that made for fracture zones in the mid-ocean ridge: "On the basis of present knowledge, therefore, the fracture zones are not probable candidates as study sites."

Similarly the statement, "The abyssal plains...are therefore unacceptable for further consideration." should be modified.

4.e.5 p. 3.6.4

It is stated that: "Bottom currents in the MPG areas of the North Pacific are generally weak and variable." A reference should be provided. How weak and variable bottom currents affect emplacement, radionuclide migration, heat transfer, etc. should be discussed.

4.e.6 p. 3.6.4

The sediment thickness is reported to be 50 to 100 meters, while in Table 3.6.1 it is given as 100 to 300 meters.

4.e.7 p. 3.6.4

A statement is made regarding waste disposal in trenches: "...a plate being subducted would have moved only tens of kilometers during that time (250 to 500 thousand years) and would not be subducted fast enough for waste disposal purposes." This conclusion does not follow from the discussion proceeding it in the same paragraph.

a. How far would the waste have to move during that time to be subducte fact enough for waste disposal purposes? Reference?

b. What might the impact be of the waste not being subducted fast enough?

Comment Number

4.e.8 Section 3.6.2.3

This section starts off with the identification of the barriers to the movement of radionuclides, then fails to discuss two of them: "any controlled modification of the medium," and "the benthic boundary layer." A discussion of these barriers should be provided.

4.e.9 p. 3.6.7

Previous reports on the U.S. seabed disposal program have not included the water column as a design barrier. Is it the program's intention to now identify the water column as a primary design barrier to radionuclide migration, or rather to investigate its properties as a barrier only for unexpected releases? In other words, do the conceptual plans allow for radionuclides to enter the water column during the period when they may present a hazard to man or the ecosystem? What is meant by inadvertant release? Scenarios leading to inadvertant release should be described.

4.e.10 p. 3.6.20

Under the discussion of the water column, it should be recognized that while the water column may not provide a barrier to migration, its enormous capability to dilute such releases below significant concentrations cannot be overlooked as a mitigative feature (See comment 4.e.9).

4.e.11 p. 3.6.21

The research and development costs to support the penetrometer emplacement concept are quoted as $250 million, on page 3.6.21, and as $60 million on page 3.6.31. The components of each figure should be given. What is the meaning of "state-of-the-art" (Figure 3.6.1) referring to penetrometer emplacement, given the quarter of a billion dollar research and development cost estimate?

4.e.12 p. 3.6.24

It should be made clear that tsunamis could pose no danger to a ship that was not in shallow, near shore waters, or near the source of tsunami. Even a large tsunami would probably not be noticed by a ship in mid-ocean

Comment Number

because of the long wave length (typically hundreds of kilometers) and relatively small oceanic wave heights (usually less than a meter). A minor storm or just rough seas would pose greater danger in mid-ocean.

4.e.13 The basis for the following cost estimates should be provided (including the components and assumptions for each):

a. "The resulting order-of-magnitude figure is $200 million for the capital cost of handling 1800-3600 MTHM/hr" (p. 3.6.21).

b. The $25 million/year operating cost (p. 3.6.21).

c. "It is estimated that the program can be completed in 25 years at an overall cost of about $560 million including construction of one ship and a port facility" (p. 2.6.27). Details on the 25 year schedules should also be provided.

d. Each of the estimated costs of the multibarrier research and development program (Section 2.6.6.2).

4.e.14 Section 3.6.6.1
This section is labeled "Site Selection and Preparation" but nothing is mentioned of site preparation. What is involved in preparing a seabed site for use?

4.f The Ice Sheet Disposal Concept

4.f.1 p. 3.7.10
Under Section 3.7.1.5, the risks, hazards, and impacts of transporting HLW over ice in polar climates should be presented.

Comment Number

4.g Reverse Well Disposal

4.g.1 p. 3.8.1
A brief paragraph on retrievability appears. There is no assurance that the liquid waste, once pumped into a porous medium, is totally retrievable. Invariably, a certain fraction of the waste will remain "captive" within the host rock. Total recovery, at any cost, is likely not attainable. A more detailed discussion focusing on the impact of partial recovery should appear.

4.g.2 p. 3.8.2
One suggested storage media is depleted hydrocarbon reservoirs. There are obvious problems with this, as additional hydrocarbon reservoirs are often found beneath depleted fields. Recovery from the underlying reservoirs would necessitate penetrating the liquid waste reservoir. As improved hydrocarbon recovery techniques are continually being developed, utilization of depleted hydrocarbon reservoir area storage medium may preclude recovery of otherwise-available natural resources.

Are there any other examples of porous fractured strata that could be used for deepwell injection that would give a more balanced treatment to this concept?

4.h Omitted Concept

4.h.1 p. 3.1.33
This section states "Thus, cost considerations dictate that the depth of emplacement should be minimized, whereas isolation requires that the depth be maximized." The first part of that statement is sufficiently clear. However, it is not clear that the second part of the statement is correct or if correct, significant. The support for this part of the statement is qualitative and intuitive rather than quantitative and rigorous.

Geological Survey Circular 779 states: "The suggestion of Winograd (1974) that waste be placed at relatively shallow depths (30 to several hundred

Comment Number

meters) in the thick (as thick as 600 m) unsaturated zones of the arid Western United States deserves consideration." We concur.

The Teknekron, Inc. report prepared for PNL, "A Cost Optimization Study for Geologic Isolation of Radioactive Wastes," May 1979, does not indicate any significant advantages to great depths of burial except the reduced probability of repository disruption. If the large meteorite strike is truly improbable and if erosion and glaciation can be avoided (at least during the first 10's of thousands of years) then there may not be any advantages to great burial depths, only disadvantages.

The following questions should be addressed:

1. Are there regions of the U.S. otherwise suitable for a repository which can provide a safe environment for the waste at relatively shallow depths without a meaningful threat of interruption by natural events?

2. If so, what is the reduction of risk between such a repository and a deep repository (and what is the increase in cost)? What is the potential for an increase in confidence which could result in a more complete site characterization and simpler modeling of a shallow versus deep repository?

3. If not, what is the quantitative reduction in risk as a function of depth for a deep repository?

Comment Number

5. COMPARISON OF ALTERNATIVES

5.1 General

Chapter 4 does not supply an adequate summary of the results of the first three chapters, much less a comparative assessment of the ten options in Chapter 3, and gives little if any guidance for judging the relative environmental and social impacts of the possible courses of action.

5.2 General

Analyses have been done for 1985 and 2000 when the first repository won't likely be operational until well after 1990. DOE/ET-0028 pg. 2.3, paragraph 4, states: "...these dates are not critical to waste management costs or environmental effects." This is probably true. However, they could have a significant effect on the comparison of conventional geologic disposal with other disposal options. This should be addressed in the GEIS.

5.3 General

The only alternative that is covered in any degree of detail is deep geologic disposal. While it is realized that less information is available for other alternatives, it appears they could be considered in more detail than these have been. For example, transportation impacts vary widely among alternatives yet generally are dismissed without much discussion as being insignificant. (See e.g., discussion for island and seabed on 3.6.24-3.6.25 and ice sheets on 3.7.10.)

5.4 General

As a document addressing various possible disposal media (i.e., siting options) on a generic basis, the GEIS does not provide the detailed discussions necessary to give the reviewer confidence in the conclusions drawn. Too much of what purports to be discussion of siting is in reality discussion of waste handling and processing. As an example of a GEIS with detailed discussions of siting options and impacts, see the Final Environmental Statement on Floating Nuclear Plants (NUREG-0056).

Comment Number

5.5 p. 1.31

The names and qualifications of the people who comprised the "panel of experts" who were involved with the comparative assessment of the alternatives should be discussed.

5.6 pp. 1.31, F.6

The significance of the comparative analysis is clouded by the use of scales that are nonlinear with no relative scaling distributions given and nonindicative of acceptability (e.g., page 4.10 contains a statement that "...'five' the maximum rating does not necessarily represent a 'good' situation...")

5.7 pp. 3.1.136, 3.3.3

Where there exist areas of uncertainty common to different alternatives they should be equally treated. For example on page 3.3.3 it states, "Information to satisfactorily assess the feasibility of the very deep hole concept is inadequate. This is not to say that the concept is not feasible, but there is not sufficient knowledge at present to confirm that radioactive waste can be isolated deep enough...to avoid transport of radioactive material to the biosphere. The main uncertainty is the lack of information about porosity, permeability and water conditions at great depths. "On page 3.3.1 of the GEIS it states that very deep hole disposal is considered flawed because more information is needed on groundwater systems, rock strength and sealing of holes over long periods of time. On the other hand it is argued on page 3.1.136 that "No long term significant impacts are expected to result from waste repositories described previously in this statement whether located in salt, granite, shale or basalt formation." It would appear the information needs stated for deep hole disposal would also exist for conventional geological disposal.

The technology for long-term sealing which has not been demonstrated for any of the three options, also does not receive uniform evaluation in the GEIS. For example, on page 3.3.28, of the GEIS it states: "Placement of an adequate plug within the hole does not constitute an adequate seal

Comment Number

because fracturing of the host formation during boring or shaft sinking may lead to a highly permeable annulus around the hole." Mined repositories and very deep holes share this problem. Hence, it should also be identified as a serious potential problem in the mined repository.

5.8 p. 3.1.246

In the last paragraph on page 3.1.246 it is stated that "Table 3.1.95 presents for conventional geological disposal the data used as a basis for scalar quantities in the comparative analysis discussion. Table 3.1.95 implies that there is "no data" in a number of key areas for making a comparative analysis. Based on this it would appear that (1) no substantive basis exists for making a rational comparison among disposal options and (2) there may not even be a sufficient basis for assessing the expected environmental impacts from conventional geological disposal.

5.9 p. 4.2

There seems to be a contradiction between the statement on page 4.2, second paragraph, which says: "Value judgments were required in at least two areas: 1) judgments relative to selection of the decision criteria and 2) judgments relative to selection of appropriate methods of measuring effects on criteria," and the statement in the footnote on page 4.2 which says: "Because these questions relate to the values of society and individuals they are avoided here where possible."

5.10 p. 4.4

Table 4.2.1 indicates that "nonhigh-level" TRU wastes cannot be disposed of by, among others, the very deep hole, island disposal, and subseabed disposal methods. It is not apparent why this is so. The GEIS should either present a rationale for requiring separate disposal methods or include "nonhigh-level" wastes in the wastes to be disposed of by those disposal methods. This is important because the current GEIS assumptions require that if disposal of HLW by the above methods is used, disposal in mined cavities in bedded salt also be an acceptable method.

Comment Number

.11 p. 4.7

Beginning on page 4.7 eleven decision criteria are presented and discussed. One is called Ecosystem Impact and consist of two attributes. No rationale is given for selecting these particular measures as criteria. On p. 4.11, Table 4.5.1 states that available information on the physical and operating characteristics of the commercial waste management options is not sufficient to permit comparative assessment of these attributes. Appendix F does not give any primary production information. While Table 3.1.95 presents data used as a basis for scalar quantities in comparative analysis. They give a value of 5×10^{10} g dry organic matter for reversible ecological effects. There is no explanation of where this number comes from or why it is used except that on page 5.19 a formula is given for determining primary production.

5.12 Determining net primary production has no value in deciding which CWM option should be selected nor in making decisions at other levels in the CWM program, e.g., among geological substrates or particular sites within geological substrates.

5.13 "Years until operational" is picked as the major decision factor in selecting technology (page 1.36, 4.11). But, a basis for considering this to be an important factor, that is a near-term need, is not articulated. On page 5.1, it is indicated that alternatives have been ranked with respect to the ease and likelihood of implementation by "the design target date" to evaluate development status of technology. What this target date is is not revealed. This approach is backwards in any event as the GEIS should present information to support the determination of a need date or of need as a function of time and not evaluate options by assuming a need date.

5.14 p. 4.11

Table 4.5.1 indicates that insufficient data is available to compare ecosystem, aesthetic, and critical resource consumption impacts. These are among the most basic and fundamental, true environmental impacts. The

Comment Number

majority of the remaining criteria are better described as policy considerations than as environmental factors, e.g., status of technology, cost of construction, policy and equity considerations. Thus, it appears that the final comparative analysis in this environmental impact statement drops out environmental factors and is based on the policy considerations. Environmental impacts, other than dose assessments, such as hydrologic impacts including water use and availability and impacts of construction and operation of the repository need more detailed discussion.

5.15 p. 4.44

There are references to: "some argue that public confidence would be lost..." and on the first paragraph, page 4.45: "some people argue that..." Are these people DOE staff, results of public survey, comment letters? Who "some people" are should be specified.

July 26, 1979

Dr. Colin A. Heath
Division of Waste Isolation
Mail Stop B-107
U.S. Department of Energy
Washington, D.C. 20545

Dear Dr. Heath:

Attached are HEW's comments on the Draft Environmental Impact Statement on the Management of Commercially Generated Radioactive Waste (DOE/EIS-0046-D).

Please feel free to contact the respondent agencies directly if you wish to discuss their comments further.

Sincerely yours,

Charles Custard
Director
Office of Environmental Affairs

OEA:CUSTARD:am:7/26/79

C.107

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July 3, 1979

Dr. Vernon Houk
Principal Environmental Officer/H
Center for Disease Control
Atlanta, Georgia 30333

Dear Dr. Houk:

The following are comments on the radiation aspects of the Draft Environmental Impact Statement (DOE/EIS-0046-D) for Management of Commercially Generated Radioactive Waste, dated April 1979.

1. In contrast to the impact statement for the WIPP project (DOE/EIS-0026-D) DOE in this DEIS has discussed applicable existing standards (section 2.2) and in Appendix G has described the relationship of existing standards. The discussions cited cover the current radiation protection practices but have not clearly stated the criteria that DOE would apply to operation of the high-level waste respository for routine operation, accidents, transportation of high-level waste, the sealing of the repository and the post implacement period. Further, no mention is made of the role of the Environmental Protection Agency in setting general environmental protection standards applicable to the management of high-level wastes.

2. Models used in the DEIS are described in Appendix D, Appendix E, and Appendix I. Since the estimation of population exposure from specific radionuclides and from environmental pathways are based on computer codes, a statement should be made on the uncertainty of the data bases. Buried in the DEIS on page 3.1.137 is a statement that because of model uncertainties the range of accuracy of doses is estimated to be such that a given dose result for a regional population may be underestimated as much as a factor of 10 and may be overestimated as much as a factor of 100. In order to help the reader of the DEIS understand the uncertainties these qualifying factors should be included in Appendices D, E, and I. Also as footnotes to each Table that presents regional population doses. For example, Tables 3.1.84 to 3.1.87.

The environmental analysis of the total systems involved in waste disposal in geologic respositories is described in Section 3.1.5. In assessing the public health and radiation aspects of the various options under consideration it is evident from the DEIS that there are many tables and statements in the text that present 70-year dose estimates for the various waste management options and accident situations. Each table presented represents the radiation impact for the particular consideration

being analyzed. The radiation safety of waste repository operations could be critical consideration in the selection of a waste management option. It would be helpful if DOE could provide summary tables that would show the range of environmental impacts for the conventional geologic disposal presented in section 3.1. For example, it is possible to identify the range of radiation dose and health effects from routine operation from repositories in salt, granite, shale and basalt using Tables 3.1.84 - 3.1.87. For repository startup in 1985 the regional population doses (70-year total body) ranges from 3×10^3 to 6×10^4 man-rem and health effects range from 6 to 50 (no health effects are shown for the once-through option). A similar range for the repository start-up in the year 2000 shows that the regional population dose ranges from 3×10^3 to 2×10^4 man-rems and that the health effects range from 6 to 50. From the above, there is only a factor of 20 difference in regional population dose for the various options for year 1985 start-up and a factor of 6 difference for year 2000 start-up.

Radiation dose summaries in a separate section of the DEIS could provide a better understanding of the health impact from the various waste management options. Furthermore, in view of the public awareness of radiation dose and health effects as a result of the Three Mile Island accident this aspect of the DEIS should be reexamined to assure that the radiation and public health aspects have been adequately assessed and presented in a form that the public would understand.

We have no specific comments on the alternate for final disposal described in sections 3.2 through 3.10. For assessment of long-term radiological safety sufficient data were not available to use the hazard index methodology for any of the commercial waste management (CWM) options according to the statement in section 4.5.3 (page 4.14). However, the comparative analysis in section 4.5 as summarized in Table 4.5.1 states that the comparative assessments were based on estimates by a panel of experts.

Sincerely yours,

/s/ Charles L. Weaver
Consultant
Bureau of Radiological Health

cc: Dr. Kenneth Taylor, HFV-2